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MARKET POWER AND INTEGRATED REGIONAL MARKETS OF ELECTRICITY: A SIMULATION OF THE MIBEL

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Abstract:

We consider a partial equilibrium model where we study the integration of two oligopolistic markets that are not symmetric (in number of firms, in demand or market dimension). We present a simulation for the integration of the Iberian wholesale electricity market (MIBEL) and show how the exercise of market power will evolve with regional full integration. The simulation results show that, as expected, market power is lower after full integration. However, even after full integration, market power is still a feature of the market. There fore, the full benefits of liberalisation and integration are not seized by the consumers since wholesale prices persist to be higher than marginal costs.

Keywords:

MIBEL, Market Power, Cournot Simulation Model

JEL Classification: L94, L49, L11

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1. Introduction

One of the proclaimed aims of economic integration of the European Union (EU) is the liberalization and integration of national energy markets (for gas and electricity). After the first EU electricity directive that came into force in 1997, almost all European countries have already involved in the process of creating an Internal Electricity Market.

Gradual integration of regional markets is a European Commission (EC) intermediate target to achieve greater integration since regional markets work as experimental fields to infer advantages and disadvantages of integration. Some examples of integrated regional markets in EU are the (first) Nord Pool (Norway, Sweden, Finland and Denmark) and MIBEL (Iberian Electricity Market), between Portugal and Spain. Given its specific characteristics, the MIBEL may be used to follow the EC purpose, namely studying pro-competitive and anticompetitive effects of the integration of electricity markets. Moreover, the promotion of good governance in the market, according to free competition, is one of the main principles of the MIBEL protocol. Therefore, studying concerning questions in MIBEL will enable to learn from its experience and help the process to achieve the Single Electricity Market.

While the benefits of the electricity sector reform have been substantial, the Report on Progress in creating the internal gas and electricity market (EC 2005, 2007) claimed that in most Member States a high level of concentration persisted in generation, which created a scope for market power from incumbent generators and significant efforts are still needed to create a competitive common market for electricity (and energy in general). Thus, even a liberalized market for electricity is prone to the exercise of market power.

According to the literature, the opening of any market to greater competition should deliver greater efficiency and, over the long term, lower market power than otherwise would be without competition. However, the structure of the market and the special features of electricity may mean that the benefits of integration may not be maximized. The major generation companies are large enough to be able to influence prices using their generation capacity and thus prevent the potential gains of integration to be fully realized. Therefore, it is important to study the evolution of electricity markets in Europe with respect to exercising market power in this regional integrated market and its influence on the advantages of restructuring.

The purpose of this paper is to contribute to the existing literature on market power and restructure of electricity markets by studying the integration of two oligopolistic markets that are not symmetric (in number of firms, in demand or market dimension). Our purpose is to discuss the achievement of all aims of full integration of electricity markets in Europe. The model applied in our research is a partial equilibrium one where the behaviour of generation firms after integration will be based on a Cournot model with a competitive fringe. Following Borenstein and Bushnell (1999), we compare simulated market outcomes on four days of 2004, with no integration and with full integration. Even though the literature has extensively explored the question of how integration affects the welfare properties of electricity markets, more results and conclusions on market performance and on the exercise of market power are needed under realistic assumptions and considering the special features of electricity markets. Our paper analyses the evolution of market outcomes and market shares from the Iberian integration and questions if market power will decrease, as expected, after integration and thus infers by how much it will decrease discussing who wins and who loses with the integration process.

Our results show that market power, using the Lerner Index (LI) and the concentration Herfindahl-Hirschman index (HHI), will be lower, or at least not higher, after integration, as expected, but the exercise of market power by electricity generators will still be a feature of the market. A key finding is that larger firms might use market power in all periods (on peak and off peak). There is also market power on some off peak periods, surprisingly, where the LI assumes higher values. This is due to the presence of nuclear plants in the market that postpone the use of thermal plants, namely in periods of low demand.

The rest of the paper is organized as follows. In Section 2 we discuss the existing literature on market power analysis and present the paper approach. Section 3 describes the Iberian market MIBEL (Portugal and Spain), before and after integration. In section 4, we describe our model setup covering the specification of costs and demand. Following we discuss the results of the simulation approach, with static and dynamic perspective. In section 6, we conclude and suggest policy implications and avenues for future research.

2. Market power analysis

A first question for the analysis of market power is the identification of the geographic scope of the market or the relevant market (Werden, 1996). In our analysis, the relevant market is the Iberian Peninsula, considering absence of transmission constraints after integration (all the problems of interconnections are assumed to be solved) inside the Iberian market.

The effects of market integration have been studied before, either in partial equilibrium literature or in general equilibrium literature. In either theoretical or empirical studies, there is a standard assumption that integration of markets will promote competition.

In partial equilibrium, several literature was concerned with examining the relation between integration and market power of firms. Ishikawa (2004) refers to a model with a monopolis- tic firm producing for two markets and claims the existence of pro-competitive effects of eco- nomic integration, under oligopoly (see also the static models of Venables (1990) and Venables (1990b)). Dynamic models can also be reported to study pro-competitive effects of integration (see Colonescu and Schmitt, 2003, Fung, 1992 and Lommerud and Sørgard, 2001).

Previous work assesses various aspects of an integrated electricity market in several countries based on a model on the existing generating infrastructure. The study by Berger et al. (1991) evaluates the cost savings from electricity trade in the American-Canadian Northeast. The general approach is similar to Amundsen and Tjøtta (1997) but in the former research, they consider that demand is totally price inelastic and they apply linear programming to find the equilibrium solution in a long run model. Bergman and Andersson (1994) study a more complex conjectural variation model restricted to the Swedish electricity market. Amundsen *et al.* (1994) consider some Northern countries in their long run model in order to determine both transmission and generation capacity.

Market power is one of the subjects that was most often studied in all markets and, in particular, on wholesale electricity markets. Several methods have been used in industrial organization to measure market power in electricity markets which basically involve the simulation of market outcomes using the available cost data and oligopoly equilibrium concepts. According to these models, market power is present when there is difference between oligopolistic price and competitive price. These models can be divided into either Cournot (simulation) approach or Supply Function Equilibrium (SFE) approach.

It is commonly accepted in the literature that Cournot quantity setting is not perfect to model reality in electricity market, but the existence of generation capacity constraints (at least during peak periods) in these markets and the presence of increasing marginal costs of producing electricity justify the choice. Another fact that justifies the use of this approach is the existence of a centralized price mechanism in electricity markets. The capacity constraints on generation are significant in both the medium term and the short term when plants are turned into "unavailable" due to maintenance or other reliability considerations. Short term constraints are more relevant in our study, since the capacity investment of the major players have already taken place. Therefore, Cournot competition seems to represent (fairly) realistically firm behavior in an electricity market where generators are competing with relatively "steep" marginal costs and where capacity constraints exist. There have been numerous studies of oligopoly behavior in restructured electricity market, which rely on the Cournot framework to infer market power. For the Californian wholesale market, Borenstein *et al.* (1996) and Borenstein and Bushnell (1999) use a Cournot model with competitive fringe. The inefficiencies due to deregulation of the wholesale market was also studied in the same framework through the application of a Cournot model in Borenstein *et al.* (2002). The question of the impact of strategic hydro scheduling on market power may also be analyzed using this approach, as Bushnell (2000) did. Adding to the Californian market, also the Spanish market (Ocaña and Romero, 1997) and the Swedish market (Andersson and Bergman, 1995) were simulated with this approach.

The alternative approach, the SFE, is based on the assumption that under uncertainty firms adopt supply functions[1] as strategic variables rather than prices or quantities. The most important advantage of SFE approach is the better representation of firms' behavior when they have to bid a single curve that will be applied to different demand states. However, the supply function model also has a weakness that may limit its usefulness particularly when applied to certain electricity markets: the inability to combine the model with detailed production costs data. Generally, the studies using SFE make use of stylized representations of generators costs to develop smooth continuous curves, because solving for supply curve equilibria requires relatively well-behaved cost and revenue functions. Klemperer and Meyer (1989) have developed the first model using the SFE approach. Some of the most important literature in this vein is concerned with market power on wholesale spot market, particularly after deregulation in several different countries. Green and Newbery (1992) apply this approach to the British Electricity spot market, assuming a sectorial structure dominated by two firms and considering an affine demand function and linear marginal cost to construct the corresponding bid curves. It can be also found some attempts to overcome some disadvantages pointed out before, namely incorporating the role of a market for futures and/or forward contracts to mitigate market power in electricity markets (Newbery, 1998).

The papers above show the flexibility of the Cournot simulation to study electricity markets. Moreover, in some markets, trade does not occur exclusively, or even primarily, through a supply function bid process. Bilateral trading of specified quantities is usual in many restructured markets as are in future markets and in different forms of spot markets. According to its features, SFE models are not well suited to markets where these situations happen or where competitive characteristics vary between different periods, as Bushnell (2000) pointed it[2].

In our analysis, the Cournot simulation approach seems to be more appropriate since (i) the role of marginal cost curves of each firm is very important (notice that one of our concerns is the accuracy on the assumptions about costs[3]), (ii) in MIBEL, firms will bid supply curves, but they are permitted to bid a different supply curve for each hour of the day and (iii) according to the features of each market and the expected evolution of the integrated market, the model should include the existence of a competitive fringe. Thus, the SFE approach is accurate in one important aspect of restructured electricity markets related with the rule of bidding, but it is not as flexible as the Cournot approach in incorporating other institutional aspects of the market.

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[1] In SFE models, firms compete by bidding supply functions that state the relationship between the price and the supply offered by a firm at that price.

[2] Additionally, the SFE approach does not feature well in markets where there is a competitive fringe. This is because supply function models are based on the assumption that the slope of the demand function does not vary across periods. The introduction of a significant price-taking fringe results in demand curves that are kinked at the points at which these constraints become binding. The slope of demand does not only change as demand increases, but this change is endogenous to the output decisions of the strategic firms.

[3] We use detailed production data that lead to steep functions and do not assume smooth and well-behaved cost curves that are not convenient for solving with a SFE approach.

3. The market: Iberian Electricity Market (MIBEL)

Our paper focus on a specific market, the Iberian Electricity market (MIBEL). The constant trend of deregulation and integration of electricity markets in the last years is common to several parts of the world. This market is a good example of a larger trend of market integration all over the world since two mostly independent markets became a strongly integrated single market.

The success of any integration process depends on the coordination between individual participants. MIBEL is a regional integration within Europe between two very different countries: Portugal and Spain.

The liberalization of the Portuguese electricity market started in 1995, through a series of decree laws. The Portuguese wholesale and retail market was divided into two subsystems: Public Electric System (PES) and non-binding electric system (NBES). A special regime system (PRE) was also created for renewable energy sources and cogeneration, under which producers benefited from feed-in-tariffs with buy back obligation by the network operator. The PES was responsible for the majority of the electricity purchased in the market. The NBES was formed by independent generators and generators from the special regime and promotes supply to non- binding consumers.[4]

In the beginning of the previous decade, Portugal was not an organized market in Portugal, i.e., the spot market or forward market or intra-daily market were inexistent and all the trans- actions were made through bilateral private contracts between generators and REN (National Electricity Grid). The prices for the PES were fixed by law (regulated tariffs), according to several criteria such as fuel prices and payments for CO2 emissions.

Since 1999, by royal law, liberalisation and deregulation in generation and supply of electricity was established in Spain. Transmission was still regulated and dominated by REE (Red Eléctrica de España). In this system created with the liberalisation, generators sell electricity to a pool and the prices are set in a competitive bidding process. The structure of the market included the day ahead market, the intra-day market, the ancillary services market and physical bilateral contracts.

The electricity sector in Portugal was, in 2004, dominated by the incumbent Electricidade de Portugal (EDP), with a production market share of approximately 62% of total Portuguese consumption. In Spain, the electricity market can be considered more competitive than in Portugal. Nevertheless, because of merger and acquisition transactions carried out in the 90’s, Endesa, the largest Spanish generator, had around 42% of all electricity generated in Spain. Together with Iberdrola and Union Fenosa, they had a market share of around 84%. The Hirshman Herfindahl Index (HHI)

[4] Non-binding consumers are consumers that, given the permission from the electricity regulator may freely choose their supplier.

and Concentration Ratio of the three major firms (CR3) showed that concentration was higher in Portugal, compared with Spain. When considering the integrated market, the concentration level was lower, as expected, than within each country separately.

In 2004, the total installed capacity in Portugal was, in 20104, dominated by the incumbent

The prices of purchasing electricity have always been one of the main differences between Portugal and Spain. For values of December of 2004, prices in Spain were in average 20% lower than Portuguese prices.

The convergence of the Portuguese and Spanish electrical systems was formally initiated with the signing of the "Protocol for collaboration between the Portuguese and Spanish Ad- ministrations for the formation of an Iberian Electricity Market", in November 2001. MIBEL and the market coupling between Portugal and Spain started in 2007 with one single exchange centralizing the spot power trading for the two countries, after several years of negotiations.

With 29 million consumers and around 280 TWh of annual consumption, MIBEL became the 5th largest electricity market in the EU dominated by five business groups that control a high percentage of electricity generation and a number of smaller companies from the two countries, which may constitute a competitive fringe.

4. Simulation for the MIBEL

4.1 Oligopoly simulation model

Following Borenstein and Bushnell (1999) analysis of California's power pool to infer market power after deregulation, we assess the exercise of market power after regional market integration. The electricity market is modelled at the level of the wholesale markets, as in Amundsen *et al.* (1994). Our main difference from Borenstein and Bushnell (1999) is that, in our model, the market size increases as both electricity markets integrate. The benefits of enlarging the geographical scope of power markets are, according to economic theory, increasing economic efficiency and lowering market concentration.

The simulation will have, essentially, three steps as in a merger assessment. First, it is necessary to choose the nature of competitive interaction between the firms in both separate markets, before integration. According to the features of each oligopolistic market described above, we assume for Portugal a model of leadership with competitive fringe and for Spain, a Cournot model with competitive fringe.[5]

[5] According to Scherer (1970, 164), a "Dominant firm price leadership occurs when an industry consists of one firm dominant on the customary sense of the word", i.e. controlling at least 50% of the total industry output — plus a competitive fringe of firms, each too small to have influence on price through its individual output decisions. Since EDP had, in 2004, more than 60% of the total electricity in Portugal and we infer from market information that the remaining firms do not have any ability to change prices with their actions or decisions the choice for the model of a leader with a competitive fringe for

As for the integrated market, the MIBEL, we assume also a Cournot model with a competitive fringe. After integration, we assume that only the five largest firms present in both markets behave strategically as Cournot competitors (Endesa, Iberdrola, Union Fenosa, EDP and Hidrocantábrico). All other producers (from both countries) are assumed to behave competitively and are modelled as a competitive fringe, taking market price as given. Secondly, we specify the demand function considering the available information on marginal costs and installed capacity for each firm. To calibrate the parameters of the model we use the specification for the demand function and substitute data on current wholesale prices and quantities into the model. Lastly, we determine prices and quantities before and after integration and identify the changes occurred with the integration process.

We follow Wolfram (1999), Borenstein *et al.* (2002) and Joskow and Kahn (2002) by measuring market power by the difference between simulated oligopoly market prices and estimates of competitive prices. We compare four time periods in 2004 considering two cases: without integration (two separate markets) and with full integration.[6] The equilibrium at the demand levels is determined for four Wednesdays: two in December (15th and 22nd) and two in June (16th and 30th).[79] For each of these days, we chose market price and quantities for two representative hours: a peak demand hour and an off peak demand hour. Each day is traditionally divided in three periods: peak, mid-peak and off peak. The definition of each period depends on the year's season (summer or winter). The summer season is May through October and the winter season is January through April and November and December. Table 1 shows the definition for both countries of peak hour time and off-peak hour time.

Table 1

Definition of peak hours and off peak hours, Portugal and Spain

		Peak hour	Off peak hour
Portugal	*Summer*	9h15 to 12h15	2h to 6h
	Winter	9h30 to 12h 18h30 to 21h	2h to 6h
Spain	*Summer*	8h to 16h	0h to 6h
	Winter	16h to 23h	0h to 6h

Source: ERSE, CNE

Portugal is justified. In Spain, the four major firms have similar importance on production and installed capacity and the remaining firms with less than 5% of the market compose the competitive fringe. Thus, the use of Cournot model with competitive fringe is appropriate.

[6] The year chosen was 2004 because it was, according to hydrological conditions, the most recent year that could be considered as "normal" (not too dry or too wet). The choice of a normal hydrological year allows us to identify base case for comparison. However, the simulation conclusions may be extended to allow for years with different hydrological conditions.

[7] Wednesday is the weekday usually described in the generators' reports as having typical features. The selection of the month was made to account for seasonal variations in availability of hydro generation capacity.

The following table presents the real values for the market outcomes for both countries in the chosen days.[8]

Table 2

Market prices and quantities, Portugal and Spain, 2004

		WINTER				SUMMER			
		15th Dec		22nd Dec		16th June		30th June	
		on peak	off peak	on peak	off peak	on peak	off peak	on peak	off peak
		20h	3h	20h	3h	11h	3h	11h	3h
Portugal	MWh	7617.1	4486.7	7558.6	4576.8	6657.5	4083.1	6703.1	4094.7
	cent€/KWh	5.243				5.243			
Spain	MWh	29797	22272	26006.4	21486	27201	19408	27263	22142
	cent€/KWh	5.846	3.077	3.994	1.955	2.7	1.452	3.5	2.437

Source: EDP and OMEL

4.2.1 Specification of demand of electricity

For the estimation of the electricity demand function, we assume an appropriate functional form considering each period anchor point and a price elasticity of demand.9 The functional forms specified for the electricity demand equations have mostly been the double logarithmic form and the linear form.[10]

Following Green and Newbery (1992), we set the demand for electricity in each market with a constant elasticity demand function of the double log form, where Q_t would represent the total demand, P_t the price and ϱt the own price elasticity of demand. The function is fully specified if the value of parameters at and ϱt are known,

$$\ln Q_t = a_t - \varrho_t \times \ln P_t$$

where we pre-set the price elasticity of demand and then determine the values of slope ϱ and at according to real data of demanded quantities and market prices. Therefore, at and ϱ_t are positive parameters determined by a calibration process.[11] The slope parameter (ϱ_t) is calculated such that it equals the price elasticity at the demand level and the intercept at is calculated to fit the anchor-pair quantity- price. Both parameters are different, depending on the period analyzed.

The chosen price elasticities are used to define the specification for demand functions on peak and on off peak times for the chosen days in 2004. Therefore, different

[8] A more detailed description of the data may be supplied under request.

[9] Given that there is only one pair for each period, it is not possible to directly estimate the electricity demand function.

[10] The log-log form is more common since the parameter estimation measures elasticity directly, while linear form is preferred when the elasticities are not constant at all price levels.

[11] The calibration process determines the parameters in such a manner that the market prices match market quantities for the given own price pre-set elasticities.

demand specifications for each period considered are available for the simulation model.

The demand for electricity has been the focus of numerous econometric studies and the price elasticity of electricity demand is one of the main concerns found. As in Andersson and Bergman (1995) and Borenstein and Bushnell (1999), we survey the previous European electricity markets results on price elasticity of electricity demand in order to choose the appropriate parameters in their demand specification. The wide interval (ranging from -1.0 to zero) reflects differences in the geographic regions examined, as well as considerable variation in data quality and statistical techniques.

According to our knowledge, there is no available research on electricity demand for Portugal. Therefore, we decided to find a European country similar to Portugal concerning the dimension of the market (total consumption of electricity). According to these criteria, Portugal may be similar to Greece and Switzerland. In what concerns research on Greek electricity demand, we can find several results. However, the interval of estimates is, even in this case, large. The short run elasticity goes from -0.51 to -0.21 and in the long run takes values on the interval -0.85 to -0.24.The range of price elasticities estimated in some of these studies is shown in Table 3.

Table 3

Review of own price elasticity estimates for electricity demand for Greece

Greece			
		Short run	**Long run**
Vlachou and Samouilidis (1986)	ind	-0.31	
Donatos and Mergos (1991)	res	-0.21	-0.58
Caloghirou et al (1997)	ind	-0.51	- 0.77
Christodoulakis et al (2000)		-0.23	-0.24
Hondroyiannis (2004)	res	inel	-0.41
Rapanos and Polemis (2006)	res	-0.31	-0.60
Polemis (2007)*	ind	-0.35	-0.85

Note:* also estimates an oil demand function separately.

Due to the large variation of price-elasticities estimates available in the literature, the usual approach followed in the literature is to report the results of the model for different value of elasticities.

For our research, we choose to pre-set the price elasticity for each country reflecting our survey of previous literature and the conclusions above. The values assumed, displayed in Table 4, are measured at the anchor points and in line with the widespread perception that electricity demand is not very sensitive to own price changes.

Table 4

Choice of own price elasticities for the demand specification

	Portugal	Spain
Short run	0.3	0.25
Long run	0.6	0.5

4.2.2 Firm's marginal costs

The total cost of any good is the sum of all expenses to produce it. To generate electricity, a generation plant and fuel is needed. Consequently, the marginal cost of generation includes fuel consumption and operational and maintenance expenses. To estimate the marginal cost of production for each firm, we need data on all generation plants by source of generation. Transportation or distribution costs will not be included in the relevant costs, because the purpose is to study the wholesale market and we do not need to account for the costs in the distribution sector.

An inverted L is the typical shape of the cost function of generators, with each step corresponding to a different fuel for generation. This means that generators have constant marginal costs up to the capacity constraints, where the costs increase very rapidly.

Following Borenstein and Bushnell (1999), three categories of generation plants must be considered, taking into account the specific generation mix of the firm: fossil fuel generation, nuclear generation and hydroelectric generation. This separation is essential to accurately determine generation marginal costs, since the treatment of marginal costs on each of them is different. We assume that marginal cost are the same as the average variable costs, and can be divided into costs of fuel and operational and maintenance (average) costs.

The cost of fuel comprises the major component of the marginal cost of fossil fuel generation. Therefore, each firm's marginal cost curve is specified using fuel prices for electricity production, efficiency rates of each fuel and heat rate of each fuel.

To compute the marginal cost of each type of fuel we should add the operational and maintenance cost per KWh to the fuel cost. The cost of each KWh is divided in three components: fuel, operational and maintenance costs.

Hydroelectric plants are considered, usually, as zero marginal cost facilities, due to their negligible amount. Another alternative assumption that can be considered is the also tradition- ally idea that hydro energy has an opportunity cost equal to the operating cost of the thermal power plant that replaces marginally in each period. We use the first assumption for simplicity purposes.

The special regime generators (wind, solar generation and cogeneration) operate under a regulatory side agreement, thus it is always infra-marginal to the market. These facilities always operate when they physically can and the production is always acquired by the unique distributor. Consequently, we are not considering the generation from these utilities in our model. Moreover, special generation represented a small part of the supply in 2004 so this absence is not determinant for the market equilibrium.

After calculating the marginal cost per source of generation, merit order will be assumed on generation plants for each generator. This means that the firm always starts using a source with lower marginal cost before a source with higher cost and that the firm does not start using a new source before reaching "full capacity" in the previous one. According to this assumption, we are able to construct the cost function of each firm only after determining output capacity for each fuel.

The maximum output capacity must also be allocated to each firm that corresponds to the capacity constraint. Full capacity should be defined as less than the plant's engineering capacity (maximum capacity) since it may not be possible to run the plant at that theoretical engineering capacity. Each plant, by generation source, has defined an outage rate (OR), which represents the probability of an outage in any given hour. We use the total outage rate for each type of plant, reported by the generators. Therefore, according to Borenstein et al. (2002), the capacity of each firm should be determined using the concept of effective capacity, re-rating the maximum capacity using an availability factor[12].

Following this procedure, we finally achieve the usual steep marginal cost functions for each generation firm.

4.3 Results and discussion

We assume that arbitrage is possible in MIBELand that the system rules are set in order to provide the same advantages to all markets. Therefore, in our case, the price of electricity will essentially depend on firms' marginal costs and generation capacities and on demand elasticity. In order to infer potential market power, we set two further assumptions: (i) marginal costs of the firms will not change with the integration; (ii) the demand function after integration will be the sum of the individual demand functions before integration for each country. Given the pre-set price elasticities of electricity demand, we simulate the market in order to analyze the exercise of market power in the Iberian Integrated market. The existence of capacity constraints does not allow also the usual method for solving a Cournot model. Therefore, in this case, Cournot equilibrium is iteratively estimated, determining profit maximization output for each generator under the assumption that the other competitors will not change their production level decisions. This will be repeated for each Cournot firm, until equilibrium is found.

Due to the shape of the marginal cost of electricity generators, the residual demand

[12] (1-OR): Effective Capacity = maximum capacity *(1-OR).

has flat regions. Therefore, the marginal revenue curve related to the demand curve may have discontinuities. This may result in a multiple local maximum for the maximization problem. To solve the problem we use different starting points for the iteration, that means starting the iteration with different firms being the first to set output, assuming the others produce nothing and redo all the iterative process, trying to find if this change in the starting point will lead to different final solutions. If it changes, we should pick the solution that is most similar to the market data collected. If otherwise, the solution is not sensitive to that change and the equilibrium solution was found for the generated quantity of each firm and, therefore, for the market.

Our results from the simulation model focus on two different perspectives for the own price elasticity on the demand function: static (short run) and incorporating some dynamic aspects (long run).

4.3.1 Static perspective

Effect on market outcomes

In 2004 electricity prices in Portugal were set by law, and consequently the simulated outcomes (from the leadership with a competitive fringe model) do not match the real data. Even for the Spanish market, the model chosen leads to results above the real data. One of the main drawbacks of Cournot simulation models is that generators' strategies are expressed in term of quantities and not in terms of supply curves. This implies that prices are determined only by demand functions and therefore these are extremely sensitive to the demand representation. One of the consequences of this sensitivity is that calculated prices tend to be higher than observed. As we focus on analytical results, this is not such a drawback.

Table 5 shows the simulation results for the two scenarios, before and after integration, showing prices and outputs of the competitive solution, the Cournot solution and real price and quantity in each of the demand hours selected.

Based on the comparison of the simulated values, we conclude that there will be a decrease in the wholesale price after integration in both on peak and off peak hours, as expected, regardless of the hydrogeneration conditions. For on peak hours the decrease on price seems to be higher than on off peak hours for both countries. This evolution was expected, because in a fully integrated market, a decrease in prices is forecasted, also due to the increase in the dimension of the market. To this fact should contribute the availability of more diversified and efficient (Spanish) firms. Another justification for this evolution of prices is the presence of more competition in the market and the role of imports as a limiting factor to the exercise of market power.

Table 5

Market outcomes: Portugal, Spain and MIBEL *(Short run)*

			before integration				after integration	
			Portugal		Spain		MIBEL	
Winter (December)	**16th**							
			on peak	*off peak*	*on peak*	*off peak*	*on peak*	*off peak*
	Simulated	competitive price (c€/KWh)	0.00	0.00	1.10	0.00	1.07	1.07
	Simulated	Price (c€/KWh)	132.3	25.9	18.0	7.3	7.7	3.4
	Simulated	Mkt Quantity (MWh)	2527.598		16928.567	12945.444	26988.696	20411.737
	Real	Price (c€/KWh)	5.24		2.7	1.45		
	Real	Quantity (MWh)	6657.5	4083.1	27201	19408		
	30th							
			on peak	off peak	on peak	off peak	on peak	off peak
	Simulated	competitive price (c€/KWh)	0.00	0.00	1.10	1.10	1.07	1.07
	Simulated	Price (c€/KWh)	135.4	26.2	21.4	9.3	7.7	3.4
	Simulated	Mkt Quantity (MWh)	2527598.63		17344.326	15850.934	26988.696	22621.966
	Real	Price (c€/KWh)	5.24		3.5	2.44		
	Real	Quantity (MWh)	6703.1	4094.7	27263	22142		
Summer (June)	**15th**							
			on peak	*off peak*	*on peak*	*off peak*	*on peak*	*off peak*
	Simulated	competitive price (c€/KWh)	0.00	0.00	1.10	1.10	1.10	1.10
	Simulated	Price (c€/KWh)	190.7	32.7	28.8	8.6	7.06	4.04
	Simulated	Mkt Quantity (MWh)	2591.440		19998.982	17216.161	26460.724	20981.220
	Real	Price (c€/KWh)	5.24		5.85	3.08		
	Real	Quantity (MWh)	7558.6	4576.8	29797	22272		
	22th							
			on peak	off peak	on peak	off peak	on peak	off peak
	Simulated	competitive price (c€/KWh)	0.00	0.00	1.10	0.00	1.10	0.00
	Simulated	Price (c€/KWh)	185.9	34.9	15.0	7.2	4.28	2.25
	Simulated	Mkt Quantity (MWh)	2591.440		18620.458	15486.286	23666.140	18293.677
	Real	Price (c€/KWh)	5.24		3.99	1.96		
	Real	Quantity (MWh)	7617.1	4486.7	26006.4	21486		

As well as price decreasing when there is integration of markets, total production will be higher than the sum for the two markets before integration. Therefore, for consumers in both countries, there will be more electricity available for consumption, namely during peak hours. Table 6 shows the simulated values of generators' market share, before and after integration.

Table 6

Market shares: Portugal, Spain and MIBEL *(Short run)*

		before integration		after integration		before integration		after integration
		Portugal	Spain	MIBEL		Portugal	Spain	MIBEL
	On peak				**Off peak**			
Winter (December)	***16th***							
	Mkt shares (%)				Mkt shares (%)			
	firm P1	3.9		15.37	firm P1	4.91		20.32
	firm S1		21.75	22.36	firm S1		20.92	27.61
	firm S2		12.66	25.98	firm S2		9.68	28.67
	firm S3		6.25	7.74	firm S3		3.49	2.71
	firm S4		9.99	13.13	firm S4		6.79	11.13
	fringe	9.09	15.6	15.43	fringe	11.43	19.62	9.57
	Mkt quantity (MWh)	2527.598	16928.567	26988.696	Mkt quantity (MWh)	2527.598	12945.444	20411.737
	30th							
	Mkt shares (%)				Mkt shares (%)			
	firm P1	3.82		15.37	firm P1	4.13		18.34
	firm S1		21.82	22.36	firm S1		21.56	24.91
	firm S2		12.97	25.98	firm S2		11.85	25.87
	firm S3		6.25	7.74	firm S3		5.86	2.45
	firm S4		10.61	13.13	firm S4		8.77	10.04
	fringe	8.90	15.28	15.43	fringe	9.62	16.52	18.40
	Mkt quantity (MWh)	2527.599	17344.326	26988.696	Mkt quantity (MWh)	2527.599	15850.934	22621.966
Summer (June)	***15th***							
	Mkt shares (%)				Mkt shares (%)			
	firm P1	3.44		15.68	firm P1	3.92		19.77
	firm S1		22.13	23.09	firm S1		21.73	26.86
	firm S2		14.95	27.40	firm S2		12.87	27.05
	firm S3		6.21	7.85	firm S3		5.86	2.96
	firm S4		12.47	12.68	firm S4		8.65	10.71
	fringe	8.03	16.62	13.31	fringe	9.16	18.96	12.65
	Mkt quantity (MWh)	2591.440	19998.982	26460.724	Mkt quantity (MWh)	2591.440	17216.161	20981.220
	22nd							
	Mkt shares (%)				Mkt shares (%)			
	firm P1	3.67		17.53	firm P1	4.30		22.67
	firm S1		21.95	23.81	firm S1		21.42	30.80
	firm S2		13.92	27.68	firm S2		11.58	32.59
	firm S3		6.21	3.89	firm S3		4.08	3.00
	firm S4		10.41	12.22	firm S4		7.85	8.75
	fringe	8.55	17.70	14.88	fringe	10.03	20.77	2.19
	Mkt quantity (MWh)	2591.440	18620.458	23666.140	Mkt quantity (MWh)	2591.440	15486.286	18293.677

The largest firms get more advantages from integration since market shares always increase in all scenarios. For the smaller firms (fringe firms) we can see a decrease in the market share in all cases. Moreover, the new fringe of the Iberian market will have a lower market share compared with the one represented by the sum of the two separate fringes before integration. The most efficient firms may seize more benefits from the enlargement of the market. The smaller firms on the fringe seem to feel some detrimental effects from integration. The firm S3 also loses a higher percentage of market share with integration, namely in off peak hours.

There is evidence that Portugal benefits most with the integration. Not only Portuguese consumers may benefit from the decrease on prices, if benefits pass on to the final market, but also the main incumbent firm, P1, is the generator that has a higher increase on the market share, compared with before integration.

Effect on Market Power: LI and HHI

The exercise of market power is evaluated by the LI. Table 7 shows the measure of exercise of market power, before and after integration. In addition, the table presents the HHI, which infers the differences on concentration level in the markets.

Table 7

Lerner Index and HHI: Portugal, Spain and MIBEL *(Short run)*

			Lerner Index			*HHI*		
			before integration		after integration	before integration		after integration
			Portugal	**Spain**	**MIBEL**	**Portugal**	**Spain**	**MIBEL**
Winter (Decemb)	**15th**	**on peak**	1.0	0.9	0.9	5797.6	2678.58	1881.27
		off peak		1.0	0.7		2905.00	2219.58
	30th	**on peak**		0.9	0.9		2119.83	1881.27
		off peak		0.9	0.7		2111.39	2071.20
Summer (June)	**16th**	**on peak**	1.0	1.0	0.8	5799.98	2144.74	1929.00
		off peak		0.9	0.7		2137.67	2127.58
	30th	**on peak**		0.9	0.7		2130.10	2025.95
		off peak		1.0	1.0		2202.65	2615.21

Before integration, and for all scenarios, there is evidence of the exercise of market power in both countries and regardless of the hour considered. Market power is higher in Portugal for the majority of cases and even in Spain for some scenarios; the LI assumes the value one.

Our results confirm that market power is higher during high demand periods (on peak) than it is during low demand periods (off peak), except for June 30, a period of dry hydrological conditions.

After integration, we can conclude that market power will be lower, as expected. The decrease is higher for off peak times, for both countries. However, for the integrated market, higher market power seems to persist in both periods, on peak and off peak period.

Concentration measures may help to screen the potential exercise of market power. In our model, the evidence seems to confirm a relation between concentration and potential market power for most of the cases. Competition authorities in Europe regard any industry with an HHI of above 1800 as being concentrated. According to these criteria, Portugal, Spain and the MIBEL can be seen as having highly concentrated markets. Portugal is by far more concentrated than Spain. However, according to HHI there seems to exist also a huge improvement in concentration with the integration of markets, namely for on peak hours in both hydrological conditions and for both countries.

4.3.2 Incorporating dynamic aspects

In order to implicitly include some dynamic aspects in our model, we have considered also the analysis for long run (more elastic) demand functions for the four days chosen. The next three tables present these results.

Effect on market outcomes

The simulated market outcomes for the two scenarios, before and after integration, are described in Table 8. It shows prices and outputs of the competitive solution, the Cournot solution and real price and quantity in each of the demand hours selected.

Table 7

Market outcomes, Portugal, Spain and MIBEL (Long run)

				before integration				after integration	
				Portugal		Spain		MIBEL	
Winter (December)	16th			*on peak*	*off peak*	*on peak*	*off peak*	*on peak*	*off peak*
		Simulated	competitive price (c€/KWh)	3.32	3.32	2.30	1.10	1.07	0.00
			Price (c€/KWh)	10.40	4.60	3.89	2.01	2.68	1.15
			Mkt Quantity (MWh)	4408.203		23392.710	16488.364	23622.514	19752.948
		Real	Price (c€/KWh)	5.24		2.70	1.45		
			Quantity (MWh)	6657.5	4083.1	27201	19408		
	30th			on peak	off peak	on peak	off peak	on peak	off peak
		Simulated	competitive price (c€/KWh)	3.32	3.32	2.40	1.10	1.07	0.00
			Price (c€/KWh)	10.50	4.60	4.10	3.50	2.68	1.15
			Mkt Quantity (MWh)	4408.203		25178.171	19498.374	236622.514	19752.948
		Real	Price (c€/KWh)	5.24		3.50	2.44		
			Quantity (MWh)	6703.1	4094.7	27263	22142		
Summer (June)	15th			*on peak*	*off peak*	*on peak*	*off peak*	*on peak*	*off peak*
		Simulated	competitive price (c€/KWh)	3.80	3.80	3.80	1.10	2.44	1.10
			Price (c€/KWh)	12.40	5.20	6.22	3.63	3.52	2.78
			Mkt Quantity (MWh)	1814		28898.175	20505.469	32005.682	20607.430
		Real	Price (c€/KWh)	5.24		5.85	3.08		
			Quantity (MWh)	7558.6	4576.8	29797	22272		
	22th			on peak	off peak	on peak	off peak	on peak	off peak
		Simulated	competitive price (c€/KWh)	3.80	3.80	2.40	1.10	1.10	0.00
			Price (c€/KWh)	12.30	5.30	4.00	2.40	2.89	1.87
			Mkt Quantity (MWh)	1814		25824.046	19362.392	25614.454	19438.616
		Real	Price (c€/KWh)	5.24		3.99	1.96		
			Quantity (MWh)	7617.1	4486.7	26006.4	21486		

Our results show that market price decreases and the quantity of electricity traded in the market also decreases after integration. Even when considering dynamic elements, the Portuguese consumers will benefit more from the integration of the Iberian market due to a higher decrease in prices, assuming that the effect on the wholesale market is passed on to consumers. This decrease is higher in periods of higher hydrological availability (December) for off peak hours and in dry months for on peak hours. The same description can be made for the evolution of total electricity available in the market.

Table 9 presents the simulated values of the market share for each generator, before and after integration. The MIBEL improves the already important position of larger generators in the market. On one hand, for P1 the market share always increases, compared with before integration and in a higher proportion for on peak hours. On the other hand, one of the larger incumbents in generation in Spain (S2) before integration increases its market share more in off peak hours.

Table 9

Market shares: Portugal, Spain and MIBEL (Long run)

	before integration		*after integration*		*before integration*		*after integration*
	Portugal	Spain	MIBEL		Portugal	Spain	MIBEL
On peak				*Off peak*			
Winter (December)							
16th							
Mkt shares (%)				Mkt shares (%)			
firm P1	9.49		17.56	firm P1	12.63		21.00
firm S1		29.75	29.93	firm S1		26.97	28.21
firm S2		24.74	32.29	firm S2		22.82	38.62
firm S3		2.64	2.34	firm S3		1.66	2.05
firm S4		8.77	9.61	firm S4		6.79	8.10
fringe	6.36	10.92	8.27	fringe	8.46	1.92	2.03
Mkt quantity (MWh)	4408.203	23392.710	23622.514	Mkt quantity (MWh)	4408.203	16488.364	19752.948
30th							
Mkt shares (%)				Mkt shares (%)			
firm P1	8.92		17.56	firm P1	11.04		21.00
firm S1		30.48	29.93	firm S1		30.48	28.21
firm S2		27.85	32.29	firm S2		27.85	38.62
firm S3		2.64	2.34	firm S3		2.64	2.05
firm S4		8.77	9.61	firm S4		6.79	8.10
fringe	5.98	10.26	8.27	fringe	7.4	9.64	2.03
Mkt quantity (MWh)	4408.203	25178.171	236622.514	Mkt quantity (MWh)	4408.203	19498.374	19752.948
Summer (June)							
15th							
Mkt shares (%)				Mkt shares (%)			
firm P1	8.14		18.80	firm P1	10.87		20.13
firm S1		26.80	27.81	firm S1		28.57	27.34
firm S2		31.77	33.19	firm S2		22.82	37.02
firm S3		6.21	2.87	firm S3		2.75	2.66
firm S4		10.42	9.04	firm S4		8.19	10.91
fringe	5.43	11.23	8.29	fringe	7.24	8.25	1.95
Mkt quantity (MWh)	1814	28898.175	32005.682	Mkt quantity (MWh)	1814	20505.469	20607.430
22nd							
Mkt shares (%)				Mkt shares (%)			
firm P1	8.96		16.19	firm P1	11.39		21.34
firm S1		29.31	31.20	firm S1		23.58	28.99
firm S2		27.99	31.20	firm S2		22.82	39.24
firm S3		2.75	2.27	firm S3		2.75	2.82
firm S4		8.65	8.77	firm S4		6.72	5.55
fringe	5.98	12.37	10.36	fringe	7.59	12.27	2.06
Mkt quantity (MWh)	1814	25824.046	25614.454	Mkt quantity (MWh)	1814	19362.392	19438.616

For the smaller firms, S3 and the fringe firms, the integrated market decreases their market shares. In this long run analysis, the generator whose market share increases most is still the Portuguese incumbent, namely for on peak periods. However, in the long run the variations in the market share are lower to all generators, except for the fringe firms.

Effect on Market Power: LI and HHI

To evaluate the exercise of market power before and after integration in a long run analysis, Table 10 presents the LI for each of the scenarios and the HHI.

Table 10

Lerner Index and HHI, Portugal, Spain and MIBEL (Long run)

			Lerner Index			HHI		
			before integration		after integration	before integration		after integration
			Portugal	Spain	MIBEL	Portugal	Spain	MIBEL
Winter (Decemb)	15th	on peak	0.7	0.4	0.6	5195.24	3295.67	2412.88
		off peak	0.3	0.5	1.0		3633.28	2801.87
	30th	on peak	0.7	0.4	0.6	5195.24	2943.34	2412.88
		off peak	0.3	0.7	1.0		2907.52	2801.87
Summer (June)	16th	on peak	0.7	0.4	0.3	5199.95	2678.27	2386.78
		off peak	0.3	0.7	0.6		2900.93	2652.84
	30th	on peak	0.7	0.4	0.6	5199.95	2850.26	2398.58
		off peak	0.3	0.5	1.0		2785.67	2025.95

Before integration, market power is higher in Portugal for on peak hours. For Spain, the conclusion about the higher value of market power on peak cannot be supported, in a long run perspective. Our explanation is that during low demand hours, lower cost generation units, such as nuclear power and hydrogeneration plants, satisfy a large fraction of demand so that the residual demand faced by the thermal plants is very small or perhaps even zero. As a result, the thermal plants are less likely to set the price. The LI assumes higher values for off peak hours where nuclear and hydro plants are supplying the demand. Therefore, the competitive price corresponds to the marginal cost of nuclear plants.

After integration, the conclusions about market power are different according to the period considered. In general, we can conclude that considering some dynamic aspects, namely the existence of exit and entrance in the market by assuming a more elastic demand function, it is that the exercise of market power on the integrated market will be higher. The values for the LI are higher in off peak than in peak hours, always in the integrated market.

According to the HHI, there is an improvement in the concentration in the Iberian market. However, in our model, the integrated market still is highly concentrated, according to com- petition authorities' criteria. Portugal is more concentrated than Spain before integration, as expected. After the integration of the Iberian electricity market the concentration diminishes, namely, for on peak hours for both countries and considering all hydrological conditions.

As expected, in the long run perspective, market power is lower than in the short run, at least before integration. The unexpected result is the higher market power on off peak hours after integration. This is due to the presence of nuclear plants in the Spanish market and consequently on the MIBEL, after integration.

5. Conclusion and Policy Implications

Market power in the wholesale market is one of the major concerns for electricity markets. Due to the particular characteristics of electricity markets, generation firms may have significant potential market power, namely the larger incumbent firms.

To assess what will happen after integration of Iberian markets, this paper analyses how the Iberian electricity wholesale market would operate and the impact of this integration on electricity equilibrium prices and quantities, comparing them with the levels before integration and infers the likelihood of significant market power problems once the market is fully integrated, using the Lerner Index.

We use real data on plant costs, capacities, an analytical model and quantitative simulations of generators' behavior to simulate the competitive market for electricity, following integration. The most important result of this paper is the reduction of exercise of market power in the integrated market, as it was expected. Notwithstanding, the simulation shows that there is still evidence of incentives to raise prices above marginal cost, either on peak and off peak time, but it is lower than before the integration.

The simulations suggest that, in the MIBEL, there will be an average mark up of 60% on the perfect competition price, dependent on the hour of the day. Despite the decrease on the Lerner Index, there is evidence of a high difference between price and marginal costs. This means that market power is still an important feature of the regional integrated market.

The Iberian electricity market brings lower electricity prices, as expected, for both countries, and thus benefits electricity consumers, if we assume that the evolution in wholesale prices will pass through on to consumers. The Portuguese consumers are the ones that benefit the most with the integration. Moreover, it is also the Portuguese larger incumbent firm that benefits the most from integration, with the highest increase in market share. For the remaining smaller firms it seems that the effect of integration is to lose market share.

The future avenues of research include extending the model to enable the analysis of shocks on the production capacity through time and the effects of these investment decisions on the exercise of market power.

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