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# Market power analysis in the Iberian electricity market using a conjectural variations model

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ABSTRACT

In the last years the electricity industry has faced a restructuring process. Among the aims of this process was the increase in competition, especially in the generation activity where firms would have an incentive to become more efficient. However, the competitive behavior of generating firms might jeopardize the expected benefits of the electricity industry liberalization. The present paper proposes a conjectural variations model to study the competitive behavior of generating firms acting in liberalized electricity markets. The model computes a parameter that represents the degree of competition of each generating firm in each trading period. In this regard, the proposed model provides a powerful methodology for regulatory and competition authorities to monitor the competitive behavior of generating firms.

As an application of the model, a study of the day-ahead Iberian electricity market (MIBEL) was conducted to analyze the impact of the integration of the Portuguese and Spanish electricity markets on the behavior of generating firms taking into account the hourly results of the months of June and July of 2007.

The advantages of the proposed methodology over other methodologies used to address market power, namely Residual Supply index and Lerner index are highlighted.



## 1. Introduction

One of the major benefits of the electricity industry liberalization is the supply of electricity at prices that reflect more efficient economic cost, which would be accomplished by competitive wholesale markets that provide incentives for suppliers to increase the efficiency in the generation of electricity [1].

However, the benefits of the electricity industry liberalization might not be fully accomplished if generating firms exercise market power. Market power can be defined as the ability of a market participant to unilaterally influence market prices on its own profit [2]. Moreover, an increase in prices resulting from market power leads to a wealth transfer to the producers and a decrease in economic efficiency of the market due to an increase in the deadweight welfare loss [3].

Electricity has specific characteristics that make it prone to the exercise of market power. Among these, it can be emphasized the limited capacity of storage of the electricity in an economically viable way, which limits the price arbitrage between off-peak and peak periods. Due to this fact, the electricity that is produced must meet demand at all times. Moreover, the lack of demand side response causes small reductions in electricity consumption due to price increases. This point is of particular relevance for market power mitigation once the same effect of increase in market competition can be achieved by an increase in demand elasticity [4]. Also, Faruqui et al. [5] argued that demand response resources can make electricity markets more competitive and efficient by increasing the elasticity of demand, thus limiting market power. Woo et al. [6] also remarked the fact that demand response reduces market power and improves reliability.

Furthermore, electricity can be produced with a diversified mix of technologies, ranging from low variable cost technologies, such

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as renewable and nuclear, to high variable cost technologies, such as open-cycle gas turbine.[1] This makes the supply curve of the electricity market to have a positive slope and to be particularly steeper on its final portion. Once the pool pricing system in electricity markets is usually marginal pricing, that is, the price offer of the last power plant required to meet demand, a generating firm might be tempted to withdraw capacity from their cheapest power plants in order to increase the system marginal price to raise profits.

The issue of market power in electricity markets has been subject of extensive research. From the many methodologies used to address this topic, the HHI (Herfindahl–Hirschman Index) was one of the first indices applied to electricity markets. The HHI, which is a structural index, is defined as the sum of the squares of the firms' market share and is related with the potential exercise of market power. The support for the use of this index relies on the fact that the more concentrated a market is, the more prone is to the exercise of market power [7]. This index was used by Schmalensee and Golub [8] to analyze the market structure of 170 generation markets in the United States for the year 1978. More recently, Asgari and Monsef [9] used the HHI, the 4-firm and 8-firm concentration ratio and the entropy coefficient to analyze the potential for market power in the Iranian electricity market.

Despite its successful application in other industries, the use of the HHI in electricity markets has been subject to some criticism mainly because it is a static measure of concentration, not suitable for a dynamic market such as an electricity market [7]. Moreover, even in electricity markets that are not very concentrated, it is still possible for a generating firm to exercise market power. This fact was noticed by Rahimi and Sheffrin [10], which mentioned that even in markets where the largest generating firms have a net seller position smaller than 10% there is the possibility to exercise market power. Also, Asgari and Monsef [9] concluded that the Iranian electricity market presented limited competition in many hours and existence of capacity withholding, particularly in peak hours, despite HHI values had shown an unconcentrated market.

In order to integrate dynamic features of the market, such as the demand, other structural indices were proposed [7]. Among them is the RSI (Residual Supply Index), introduced by the CAISO (California Independent System Operator). As defined by Rahimi and Sheffrin [10], the RSI of a firm is the percentage of supply capacity that would remain in the market, relative to demand, if this firm available supply capacity was removed from the total supply capacity of the market, that is:

$$\mathrm{RSI}_i = \frac{\text{Total Supply} - \text{Supply}_i}{\text{Total Demand}} \tag{1}$$

If the RSI of a firm is lower than 100%, this means that the firm capacity is needed to meet demand. On the other hand, if the RSI of a firm is higher than 100%, then the demand can be supplied by the other firms.

According to the CAISO Department of Market Analysis, for a market to be fairly competitive, the RSI should be higher than 120%–150% [10].

Moreover, Sheffrin [11] proposes as a screening rule for the market competitiveness an RSI of more than 110% in 95% of the hours in a year.

Another index used to study market power is the Lerner index, which is a behavioral index. The Lerner index is defined as:

$$L = \frac{P - \mathrm{MC}}{P} \tag{2}$$

where $L$ is the Lerner index, $P$ is the market price and MC the marginal cost.

Evans and Green [12] used the Lerner index to investigate if the reason for the decrease in market prices in the England and Wales electricity market was the result of the introduction of the NETA (New Electricity Trading Arrangements). The analysis showed two contradictory results. On the one hand, results seemed to point to the reductions in concentration and to the increase in capacity to be the reasons for the fall in prices and not to the changing market rules. On the other hand, results also pointed to the fact that generating firms might have been engaged in tacit collusion, but a few months before the entry into force of the new market rules, they were unable to sustain that behavior.

However, approaches using Lerner index are questionable. In fact, the difficulty arises not only from the complexity in estimating marginal costs, but also from the fact that, even in a perfectly competitive market, the price can exceed the marginal cost of the marginal producer if the supply is constrained [3].

Other methodologies use simulation models, such as the Cournot models, where the decision variable of firms is their quantity [13]. This approach was used by Borenstein and Bushnell [14] to study the California electricity market which concluded for a market power potential in the periods of higher demand in several months of the analyzed period.

Rubin and Babcock [15] compared two pricing mechanisms for wind energy – real time market pricing and feed-in-tariff. The authors used a double-sided auction model where both load serving entities in the demand side and generating firms on the supply side behave as Cournot firm. The study showed that pricing wind energy through a feed-in-tariff mechanism reduces market power when compared with real time market pricing.

However, Cournot models are subject to criticism in what regards market outcome. Ventosa et al. [16] stated that in Cournot models equilibrium prices are highly sensitive to demand representation and are usually considerably higher than real market prices. Also, Willems et al. [17] mentioned that even for realistic values of demand elasticity, market prices are higher and quantity lower than in reality. In order to overcome these shortcomings several approaches have been proposed.

One of these approaches is the SFE (Supply Function Equilibrium), in which the equilibrium is achieved solving a set of differential equations [16]. In SFE models, the generating firms compete among each other by offering a complete supply function instead of a quantity. These models have been used in several works such as Green and Newbery [18] for the England and Wales electricity market in a symmetric duopoly context with capacity constraints. The authors showed that the strategies presented by the two generating firms led to higher markups and to significant deadweight welfare losses. They also showed that the expected entry of new generating firms would result in lower prices.

Another approach used to overcome Cournot drawbacks is the CSF (Conjectured Supply Function) models. The CSF represents the beliefs of a firm concerning how total supply from rival firms will react to the price [19].

Díaz et al. [20] computed a CSF with DC (direct current) transmission network constraints using an iterative algorithm. In that work, the intercepts and slopes of the CSF of the generating firms were determined endogenously in coherence with the network line status. The model was applied to a simplified two node system version of the MIBEL and to a meshed three node system.

CV (Conjectural variations) models also emerge to address the drawbacks of Cournot models. In the CV model concept, firms make

[1] Also the opportunity cost of hydro generation, especially in dry periods, can be high.