"COMPUTER-BASED SIMULATION OF AUCTIONS OF OPTION CONTRACTS AND OF FUTURES CONTRACTS IN THE COLOMBIAN WHOLESALE ELECTRICITY MARKET"

Final Report – Chapter 7

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Buenos Aires

Av. Leandro N. Alem 584, Piso 11
(C1001AAN) - Buenos Aires
Argentina

Madrid

C/ Orense 34, 8º
28020 – Madrid
España

Montevideo

Soriano 903, Ap. 501
C.P. (11100) – Montevideo
Uruguay

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1. GENERAL CONCEPTS ON MARKET POWER IN ELECTRICITY MARKETS

The possibility for exercising market power is perhaps the most critical issue in the development of electricity markets. Recent experiences in many countries as well as academic research show that market power can be exercised more easily in electricity spot power markets than in other commodity markets. As it will be shown later, it is possible to assume that the possibilities for exercising market power are lower in futures and options markets.

One classical definition of market power is: *"The ability to alter profitably prices away from competitive levels."* The exercise of market power results in a market price, that is greater than both the competitive price and the marginal cost of production. In a few, very particular cases, market power was used to reduce prices.

In commodity markets, some indexes or rules are useful for assessing the possibilities that some market players have to influence prices. For instance, the Herfindahl-Hirschman Index (HHI) is computed as the sum of the squares of market shares of suppliers. Market shares are always defined as the fraction of market output produced by a particular supplier. The HHI ranges from zero to one, but usually is multiplied by 10,000 because it is computed by squaring percentages instead of fractional shares.

The HHI for Colombia was computed by Hagler Bailly in a study that is referenced by TERA in its final report. The conclusion of this Report is that the Colombian spot market can be considered as a moderate monopoly.

However, though the HHI is quite useful for assessing market power in different commodity and non commodity markets, is it not so useful for electricity spot markets. While for other industries results in experimental economics suggest that 5 firms of equal size are enough to force prices close to marginal costs, the results by Rudkevich et al. (1998), in a game-theoretic framework, suggest that in an electricity spot market more than 30 firms of equal size are needed to ensure competitive pricing.

The underlying assumption for the use of the HHI for market power analysis is that it is directly correlated to market concentration. The main drawback is that in electricity markets the ability to exercise market power may depend on factors other than concentration. The use of concentration indexes in energy markets has been criticized because they do not capture the actions of agents, such as constraining energy production or demand elasticity. Also, indexes do not provide information about market variables, such as price sensitivity with respect to hydro energy production or network constraints.

Thus, the straightforward method for calculating market power impacts in electricity spot markets is by simulating the operation of these markets and directly measuring the market prices and firm's revenues as the strategic bidding or capacity withholding is carried out.

The particular characteristics of spot electricity markets that may increase the possibilities for exercising market power are:

- Electricity is not economically storable, therefore electricity users must buy at the "effective" price or not consume;
- Elasticity of demand to price is very low on a real time basis. The low elasticity stems from the impossibility for the demand of knowing prices in real time, and for responding to price soars by reducing load;
- Congestion in transmission networks reduce the number of market participants that compete for supplying some loads.
- Price signals do not impact directly on consumers whose tariffs are based on load profiles.

Steven Stoft in the chapter 4 of his book "Power System Economics" says: "***The HHI accounts for only one factor, concentration, out of five key economic factors that determine the extent of market power. The other four, demand elasticity, style of competition, forward contracting, and geographical extent of the market, can each affect the answer by an order of magnitude"***.

Therefore, it is necessary to assess how these other four factors can be measured in Colombia. Some considerations related with the scope of this study are presented below:

Demand elasticity: it is well known that the lack of responsiveness of demand in real time is a factor that increases market power. There are many evidences that small withholdings of capacity for several market players (and under some special market conditions) produced huge increases in prices in California. But derivative markets are not real time markets. Therefore, it is reasonable to expect that in this type of markets, the possibilities for exercising market power will decrease dramatically.

Nevertheless, this advantage will be partially inhibited if suppliers are obliged to participate in the options market by buying financial instruments for its total load.

Style of competition: it refers to the method that market participants use to bid, including strategies to exercise market power. There are two classical models for modeling oligopoly behavior of market participants: Cournot, withdrawing capacity, and Bertrand, soaring bid prices. The Cournot style is considered the most common method. OPEP and California suppliers have used this method for exercising market power.

Suppliers that follow this method compete by reducing their output in a quantity so that the increase in price will compensate them for the lower energy they sell. They base their choice on the assumption that the other suppliers' choices will not be affected by their decision. They assume that if they reduce their output, their competitor will not decide to produce more to maintain the price in the same level. However, there is considerable evidence showing that real competition is a more complex process.

If all the suppliers choose their output to maximize their revenues, assuming that all their competitors will follow the same strategy, a Nash-Cournot equilibrium is obtained.

Withholding can be accomplished financially by bidding a high price, or physically by not bidding at all. If a high bid does not result in withholding, it is not an exercise of market power, even though it profitably raises the market price.

The use of the Cournot model for competition had become very common between a small group of suppliers. This model assumes the suppliers act unilaterally to

maximize their profits, each assuming that the others will maintain their level of output. More general models assume a general Nash equilibrium, being the Cournot model a particular case of Nash equilibrium. Nonetheless, this models used to be very complex for practical applications.

In power auctions, suppliers bid monotically increasing supply curves. The consequence of such bidding is that if one supplier reduces the capacity offered, some other supplier, presumably more expensive, will produce more. The price will rise, but not nearly as much as if the other suppliers had held to a Cournot strategy. But if all the (oligopoly) competitors reduce their output, prices could rise dramatically.

Forward contracting: when suppliers have contracts, they are discouraged to rise prices, because they are paid at the contract price, rather than the spot price. And they are exposed to greater risk if they have to buy energy to honor the contract. So, forward contracting is an effective measure to discourage the exercise of market power.

The obligation to supply through contracts discourages the exercise of market power to increase pool prices. Brazil and California (after the crisis) are examples of pools where this approach has been used to mitigate market power of selected generators.

Under these terms, the existence of a market of options and futures will accomplish the objective of discouraging the exercise of market power.

Geographical extent: congestion reduces the size of the market, because some suppliers can not sell energy at consumers in the other side of the transmission constraint that originates the congestion. Therefore, market concentration rises in such link of the network (HHI rises), increasing the possibilities for exercising market power.

Game theory is extensively used to asses market power. Two types of games are considered, cooperative games and non-cooperative games. Within non-cooperative games, participants make no commitments to coordinate their strategies, while in cooperative games participants can make coalitions and coordinate their strategies. As mentioned above, external conditions such as network constraints, can affect perfect competition and let some participants take advantage of this situation to improve its own benefits. The Nash-Cournot equilibrium is a non-cooperative game, where every participant expects that competitors will use a strategy to maximize their profits.

2. MARKET POWER IN THE COLOMBIAN ELECTRICITY MARKET

We did not make an specific assessment on the existence of market power practices in the Colombian electricity market. Notwithstanding, we did analyze the potentials for exercising market power, based on the theoretical considerations outlined in section 1 of this chapter.

The HHI indexes, extracted from a Hagler Bailly's report dated 1999, were presented by TERA in their final report. As mentioned before, conclusions are that "*the generation activity in Colombia constitutes a moderate oligopoly*". Under the current market characteristics, we reviewed the HHI indexes and found that they did not change significantly. This means that, considering just concentration indexes as the HHI, conditions exist for the potential exercise of market power.

But there are other characteristics of the market that could enhance the potential of market power:

- Lack of responsiveness of the demand in real time. As outlined above, the potential for exercising market power is amplified when the demand does not respond in real time to changes in prices. We did not identify any responsiveness of the demand in real time, and regulation does not create tools to encourage it. Currently, only in a few existing markets (mainly in some USA pools and the Nordic Pool) there are effective responses of demand to real time prices.
- Geographical extent: there are zones where transmission constraints may introduce potential for exercising market power by plants located in those zones.

On the other hand, as the level of contracting in the Colombian electricity market is high, about 90% of the demand, it reduces incentives for plants to exercise market power.

Regarding the futures and options market (FOM), it may curb the potential for exercising market power, with the following considerations:

- Prices of futures and options are directly related to spot (la bolsa) prices. Therefore, if in this market some participants can exercise market power, they will affect the functioning of the FOM.
- For generators that sell the energy through these financial instruments, the existence of a liquid FOM ease the incentives for exercising market power. As mentioned above, the risks for generators who sold the energy by futures or options, increases when prices increases.
- As the FOM is potentially more efficient that current OTC transactions, it is expected that the higher level of transactions will curb the potential for exercising market power.