ANALYSIS OF THE COMPETITION AND MARKET POWER IN THE COLOMBIAN WHOLESALE ELECTRICITY MARKET USING AN AGENT-BASED MODEL

Camilo A. Gallego, PhD Student in Economics at the University of Massachusetts, Amherst and Fulbright Fellow +1-4132758771, cgallegoaria@econs.umass.edu]

Overview

Restructured electricity markets hinge on competition and market power mitigation strategies in order to ensure efficiency and constant innovation in wholesale electricity markets. This kind of markets convey information through the electricity spot prices which reflect inefficiencies due to market imperfections, explained in part by lack of competition and/or possible exercise of market power. This is a challenge in current wholesale electricity markets because prices above competitive levels can be transmitted to consumers of electricity, which is not a desired outcome. In particular, the policy makers in Colombia have raised concerns about market power and lack of competition in the electricity market measured as a detriment of consumer's welfare and lost in industry's competitiveness. This paper presents a methodology to calculate the extent of market power by a Power Generator Agent (PGA) in the formation of the electricity spot price in the day-ahead auction at the wholesale market. This paper goes from structural metrics (participation indices), that measures market power in a general fashion, to individual (PGA-based) analysis which measures an agent mark-up: the difference between prices above competitive levels due to unilateral actions by a PGA. The methodology of this paper proposes a novel approach in relation to the literature in two aspects: i) it takes into account real characteristics for each PGA in the market using the ex-post bids in the day-ahead auction, individual forward/hedge positions and considers real constraints that reflects the opportunity cost of electricity, in the case of hydroelectric units (major technology of energy in Colombia). And, ii) this work proposes a novel optimization method solved by a Genetic Algorithm that simulates the behavior of a PGA in the Colombian wholesale electricity market. In contrast to the related literature, these two approaches allows specific simulations that reflects the real behaviour of a PGA in the Colombian electricity market and also builds the foundations for further counterfactual analysis. The results of the paper indicate the existence of some degree of market power exercised by 4 PGAs during certain times in Colombia. Given that Colombia only has participation indices to mitigatre market power, the results from this paper play an important role in the policy-making process in order to propose mechanisms to mitigate potential market power in the Colombian electricity market. Also, the method in this paper can help in the current debate in Colombia to promote new policies to incentivize the participation of clean technologies in accordance with the national emissions commitment at COP21 in Paris. The conclusions of this paper are of importance for other electricity markets in the evaluation of competition and market power analysis.

Methods

This paper uses four sequential methods to build the results:

1. **Structural metrics** (Participation index): Classic metrics of market power such as the Herfindahl-Hirschman Index (HHI). This metrics will determine the degree of concentration of the electricity generation in Colombia as a whole, but not specific (individual) actions in determinet to the consumer and/or the industry.

2. **Statistical analysis** from public information at the Colombian Independent System Operator (ISO) of the wholesale electricity market (www.xm.com.co) can show trends on market manipulation by som PGAs in Colombia. In specific, this analysis is based on time series related to the operation of the wholesale electricity market, like installed capacity of generation, real power generation by technology, offer prices by technology, spot prices and electricity demand. Given that forward/hedge contracts are a determinant of market power [1-3], this paper analyses in detail this dimension.

3. **Optimization model**: An agent-based problem is modeled through an optimization process in which a PGA (individual under analysis) maximizes profits over a 24-hour horizon considering as given the behavior of other PGAs (competitors). The maximizing problem finds mutual best responses (Nash Equilibrium) that

allows the detection of possible escenarios of market power exercise. The profit's function is similar to the analysis in [2] and [4].

4. A **Genetic Algorithm** is performed to solve the constrained optimization method above. The restriction of the model are the balance of energy (total generation equals total demand) and real constraints like reservoir management (in case of hydroelectrcity).

Results

1. The results of the paper shows that PGAs in the Colombian wholesale electricity market are not going fully hedged in the day-ahead market. This constitute an incentive to increase prices in the daily auction and excersice of market power. A hedge index is calculated which measures the degree of exposition of a PGA in the wholesale electricity market. An index close to zero shows no hedge/constract position in the market, while 1 is considered a full contract position in relation to the real generation (not capacity). The histogram (from 2007 to 2017) at Figure 1 shows the hedge index for one of the largest PGAs in Colombia in which the mean is not on the full contract level. This indicates incentives to increase prices in the wholesale market.
2. Figure 2 shows the result of the optimization method for the same PGA above. The results shows two bounds and the real behavior of the spot price of a day in July of 2016. The mark-up is calculated as the difference between the upper and the lower bound. This mark-up indicate that in fact the Colombian wholesale electricity market is propensive to market power.

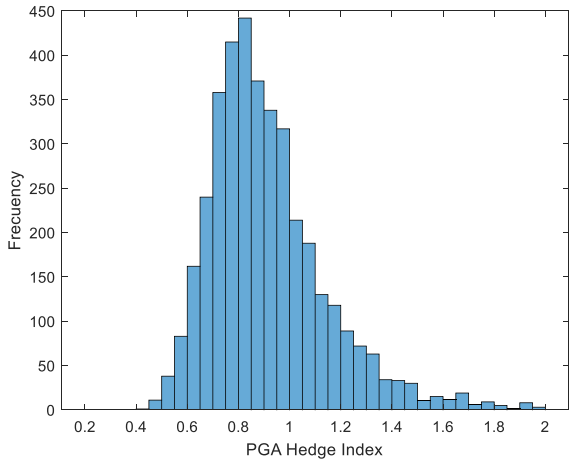

Figure 1. Hedge Index for a PGA (Agent E)

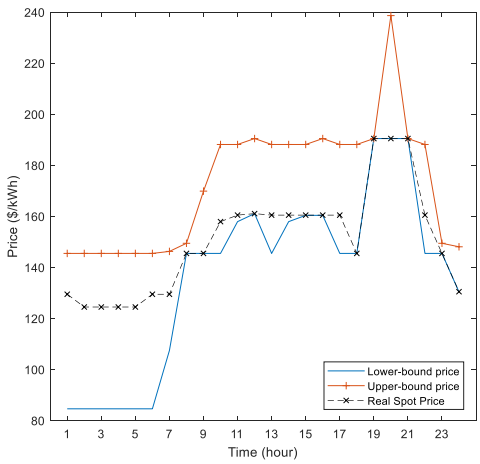

Figure 2. Spot price impacts for a PGA (Agent E)

Conclusions

This paper found evidence of initial deterioration of competition in the Colombian wholesale electricity market. Evidence shows that the three markets of electricity in Colombia needs to be improved in order to fix repeated market failures and also needs to be updated after 25 years of operation in order to consider new challenges that the electricity markets are involved like the exacerbation of climate change and governemental commitments to reduce CO2 emmissions through an increase in the participation of fossil fuels.

References

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