1. Rationale

A major objective of the restructuring or “deregulation” of the wholesale industry implemented in some parts of the world has been to reduce the electricity prices through cost cutting and increased efficiency. However, in the presence of market power by power plant owners, electricity prices may actually rise rather than decline. A potential regulatory response to suppress the exercise of such market power, both in the US and in other parts of the world, is the implementation of an “Automatic Mitigation Procedure” (AMP) that reduces the offer prices of generation owners when they violate both a “conduct screen” and an “impact screen.” In the US three of the seven “independent system operators” have implemented this kind of AMP, more specifically those of New York, New England and the Midwest (NYISO, 2010b; ISO-NE, 2010; MISO, 2010; García and Reitzes, 2007; Isemonger, 2007; Twomey et al., 2006; Helman, 2006).

This study is an experimental test of the AMP pioneered by the New York Independent System Operator (NYISO) for the New York City (NYC) zone, where concentrated ownership and frequent demand-driven transmission congestion give NYC’s generation owners market power. Furthermore, the researchers extend the analysis to a case of high market power in periods without transmission congestion. This may be the situation in many parts of the world where generation ownership is highly concentrated and severe chronic generation capacity shortages are prevalent. Similarly, increased need for off-peak charging of electric vehicles as well as increased reliance on stochastic generation such as wind and solar will likely
result in episodic generation scarcity and hence increased market power, even during times without demand-driven transmission congestion in the U.S.

2. Background

AMP mechanisms were introduced in order to regulate the level of wholesale electricity prices in the presence of concentrated ownership and frequent transmission congestion, such as in NYC. However, few studies to date have explored how effective AMPs are at controlling prices under different market scenarios. In their studies Entriken and Wan (2005) and Kiesling and Wilson (2007) tested AMPs assuming fixed reference offers. However, this approach does not allow for the possibility of so called reference creep, where power plant owners with sufficient market power may try to manipulate the reference offer by posting higher prices during uncongested rounds. Reference creep is therefore an important characteristic of conduct-and-impact AMPs to consider in practice. This study by IBECC expert Dr. Schulze et al., is the first to explicitly allow for “reference creep” in assessing the effectiveness of AMPs.

Since congestion in U.S. electricity markets is usually driven by high demand relative to available supply, the uncongested rounds in the experiment summarized here effectively represent off-peak periods. They are characterized by low demand and relatively fewer active units due to maintenance and repairs. The absence of congestion also allows more power plant owners to access the market, thereby increasing competition.

Under the current NYC AMP, tested in this study, the offers submitted by the generation owners are subject to a “conduct screen,” which applies individually, and to an “impact screen,” which applies to all offers collectively. If at least one offer violates the conduct screen and the offers in the market collectively violate the impact screen, the system operator replaces all offers violating the conduct screen with “reference offers” (Figure 1).

Figure 1: Stylized Representation of NYC and test version of AMP

\[
\text{Generation owner submits one offer per generation unit} \quad \Rightarrow \quad \text{Conduct Screen: Reference offer vs. allowable margin} \quad \Rightarrow \quad \text{Did offer pass conduct screen?} \quad \begin{cases} \text{yes} & \text{Offer accepted} \\ \text{no} & \text{Impact Screen: Difference in system-wide average marginal prices using (i) original offers or (ii) replacing offers failing the conduct screen by reference offers vs. allowable margin} \quad \Rightarrow \quad \text{Did offers collectively pass impact screen?} \quad \begin{cases} \text{yes} & \text{Offer accepted} \\ \text{no} & \text{Offer replaced by reference offer} \end{cases} \end{cases}
\]
The relevant reference offers used to evaluate the conduct screen are determined as the average (lesser of mean and median) of previous eligible offers. Offers are considered eligible if they meet the following three criteria:

i. The offer was accepted
ii. The offer was made for a non-congested (off-peak) period
iii. All offers collectively did not fail the impact screen

Note that the reference offer determines both the magnitude of subsequent offers which can pass the conduct screen as well as the replacement amount imposed if an offer fails both the conduct and impact screen. This explains the incentive for power plant operators with sufficient market power to strategically raise reference offers during non-congested periods.

3. Research Description

Given the difficulties of assessing the performance of an AMP theoretically or empirically, the researchers develop and test a version of the AMP that allows for variation of the design parameters and knowledge of the exact marginal costs of generation, using human participants. The slightly simplified AMP modeled in this experiment captures the essential features of the AMP and of electricity markets with six sellers and fixed quantity demanded in two variants: lower-market power and higher-market-power. Demand in each round is perfectly inelastic and “uncongested” rounds alternate with “congested” rounds. To simulate transmission-system congestion the six sellers are divided into two smaller markets with three sellers each. The lower-market-power variant is representative of NYC while the higher-market-power variant is used to examine the performance of this type of AMP when generation owners have high market power under uncongested conditions. Each variant is also tested under a more lax system referred to as “without AMP” where two rules (also applied in the NYC system along with the AMP) are imposed: every unit able to operate must do so, and their offer price must not be higher than an offer cap of $1000 per MWh. The results, with and without AMP, are compared with each other and with the results obtained if all generation units make offers equal to their marginal cost.

Figure 2. Experimental Design
The researchers used a two-by-two design in which the two conditions they varied were degree of market power and the presence or absence of the AMP. In the “lower-market-power treatments” the ratio of demand to generation capacity was 1:2 during each uncongested round and 5:6 during each congested round. In the “higher-market-power treatments” the ratio of demand to generation capacity was 5:6 during both uncongested and congested rounds (Figure 2). While the number of generation units per producer were lower during non-congested rounds to represent scheduled downtime and maintenance, non-congested rounds still featured more competition because there were six generation owners in each market, compared with three generation owners in each market during the congested rounds.

As mentioned above, a key feature of this study is that it is the first to calculate reference offers based on a historical average of recently accepted offers, allowing for sellers to move their reference offers over time, and making “reference creep” a possibility, as it happens in reality with the AMPs in New York, New England, and the Midwest. The researchers test the effectiveness of AMPs under these circumstances.

**How was this study conducted?**

The experiment was conducted with Cornell undergraduate economics and business students as owners of generation units who got paid in proportion to their profits. Each unit produced up to 100MW or nothing, depending on whether the owner had been successful at selling its output on each round. For each round, participants had to submit an offer per unit greater than $0 but not higher than $1000, which allowed for submission of offers below the marginal cost.

There were four treatments (2 lower-market-power and 2 higher-market-power), with thirty participants in each treatment. No individual participated more than once. The experiment alternated between uncongested and congested rounds.

**What did IBECC researchers find?**

As illustrated in Figures 3 and 4, the AMP reduced average prices in congested (on-peak) rounds and did not significantly change average prices in uncongested (off-peak) rounds in either direction. In the presence of high market power due to concentrated ownership, reference creep sets in, generation owners strategically increase offers during uncongested (off-peak) periods to raise their reference offers, and the AMP may no longer succeed in keeping prices close to marginal cost (Figures 4 and 5). The AMP did not significantly change the excess cost from out-of-merit-order use under either the lower-market-power condition or the higher-market-power conditions. In other words, the economic impact from generation owners in the experiment strategically trying to sell more production from their higher marginal cost (peak) units during uncongested (off-peak) periods in order to increase profits during congested rounds was limited.
Figure 3. Mean market price by round, LOW market power treatment

Figure 4. Mean market price by round, HIGH market power treatment

Figure 5. Experiment’s Key Findings

<table>
<thead>
<tr>
<th>Regulatory Environment</th>
<th>AMP</th>
<th>No AMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>AMP successfully keeps market prices close to marginal costs</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Reference creep: generation owners are able to raise the market price well above short-run marginal cost</td>
<td></td>
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</tbody>
</table>

AMP: Automatic Demand Response Program

On-peak: High usage of electricity during peak hours
Off-peak: Low usage of electricity during off-peak hours
What do these results mean?

Results from this experiment suggest that:

- The AMP currently employed in NYC successfully keeps market prices close to marginal costs under low market power, reducing average prices in congested rounds.
- However, this AMP does not significantly change average prices in uncongested rounds.
- In the presence of high market power, this type of AMP may be subject to “reference creep” during congested rounds as generation owners gradually raise market prices above short-run marginal costs. A different type of AMP mechanism may need to be devised for these situations.

4. Takeaways for Your Business

Key Takeaway:

Automatic Mitigation Procedures (AMP) for wholesale electricity prices may not effectively prevent the rise of market prices above short-run marginal costs in the presence of high market power.

Other Important Takeaways

- Keeping prices close to marginal costs has important implications for other aspects of electricity markets.
- Any implementation of Automatic Mitigation Procedures should therefore be accompanied by careful consideration of the following two aspects:
  - Keeping prices close to marginal costs in congested periods may prevent generation units from being profitable investments and result in generation shortages, thus additional measures need to be put in place to encourage investments.
  - Keeping prices close to marginal costs across both on-peak and off-peak periods also reduces incentives for customers facing real-time prices to actively engage in peak-shaving behavior (i.e., there is not enough of a price incentive to consume less during on-peak/congested periods so the demand response will be muted).

This is an industry-focused summary of the publication cited below.

For references cited and additional information please consult the original paper: