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An experimental test of automatic mitigation of wholesale electricity prices

Daniel L. Shawhan [a,*], Kent D. Messer [b], William D. Schulze [c], Richard E. Schuler [d]

[a] Department of Economics, Sage Lab, Rensselaer Polytechnic Institute, 110 8th St, Troy NY 12180, USA
[b] 531 S. College Avenue #226, Departments of Food and Resource Economics and Economics, University of Delaware, Newark DE 19716, USA
[c] Dyson School of Applied Economics and Management, Warren Hall, Cornell University, Ithaca NY 14853, USA
[d] Department of Economics, Uris Hall, Cornell University, Ithaca NY 14853, USA

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ABSTRACT

In several major deregulated electricity generation markets, the market operator uses an "automatic mitigation procedure" (AMP) to attempt to suppress the exercise of market power. A leading type of AMP compares the offer price from each generation unit with a recent historical average of accepted offer prices from that same unit during periods when there was no transmission-system congestion to impede competition. If one or more units' offer prices exceed the recent historical average by more than a specified margin, and if these offer prices raise the market-clearing price by more than a specified margin, the market operator replaces the offending offer prices with lower ones. In an experiment, we test an AMP of this type. We find that it keeps market prices close to marginal cost if generation owners have low market power in uncongested periods. However, with high market power in uncongested periods, a condition that may apply in many parts of the world, the generation owners are able to gradually raise the market price well above short-run marginal cost in spite of the AMP. We also test the effect of the AMP on the frequency with which high-variable-cost units are used, inefficiently, in place of low-variable-cost units.

1. Introduction

The restructuring or "deregulation" of the wholesale electricity generation industry that has occurred in some parts of the world has typically replaced a regulated monopoly or governmental supply with a reverse auction into which multiple sellers offer their generation. A major objective of this change has been to reduce electricity prices by strengthening the incentive for cost-cutting, but an unintended consequence under some circumstances is that power plant owners may instead raise prices to politically unpalatable levels through the exercise of market power. One potential regulatory response is "automatic mitigation" that reduces the offer prices of generation owners if those prices violate both a "conduct screen" and an "impact screen." Three of the seven "independent system operators" or "regional transmission organizations" in the United States have implemented an automatic mitigation procedure (AMP) of this kind, 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 type of AMP is a candidate for implementation in other parts of the world as well.

This paper presents an experimental test of the AMP that was pioneered by the New York Independent System Operator for application in the New York City zone ("NYC") of New York State. New York State ("New York") is one of many jurisdictions around the US and the world that have a deregulated wholesale electricity market. The basic auction structure of New York's market is similar to that of other deregulated electricity markets in the United States today: it clears the market at the price of the last accepted offer needed to meet demand and pays all suppliers that uniform price for the energy they supply. Furthermore, the state can be separated into up to eleven different markets or "zones," each with a different price, when transmission-system congestion causes the marginal cost of supplying electricity to differ across different parts of the state. Congestion both into and within NYC is frequent. When it occurs, it isolates NYC generation owners from competition. This is the reason that the New York Independent System Operator (NYISO) applies an AMP to the electricity offers in NYC.

An offer consists of the quantity of power the seller is willing to provide and an "offer price," which is the minimum price that the seller will accept. Under the AMP, the offers submitted by the generation owners are subject to a conduct screen and an impact screen. 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".

As will be explained later, the reference offer for a generating unit is often based on the average of recently accepted offers from that unit during time periods without transmission congestion into or within NYC. An offer fails the conduct screen if it exceeds its corresponding reference offer by more than a specified amount that we will call the

* Corresponding author. Tel.: +1 518 331 6186; fax: +1 518 276 2235.
E-mail addresses: shawhd@rpi.edu (D.L. Shawhan), messer@udel.edu (K.D. Messer), wds3@cornell.edu (W.D. Schulze), res1@cornell.edu (R.E. Schuler).

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"allowable margin." The offers collectively fail the impact screen if replacement of those offers failing the conduct screen would reduce the market-clearing price by more than the amount of the allowable margin.

It is difficult to assess the performance of an AMP theoretically, even with knowledge of the generation owners and the marginal cost of each of their generation units; since the electricity market is repeated each day by the same participants, there is a wide range of possible Nash equilibria (Tirole, 1988 pp. 246–247). Alternatively, empirical data on NYC-area electricity offers, costs, and prices could provide another means of assessing the performance of the AMP. However, much of these data are confidential. Furthermore, these data say little about how the AMP would perform if adopted in a different jurisdiction.

To assess the AMP, we instead use an experiment with human participants paid in proportion to their profits.[1] We are able to vary the design parameters and to know the exact marginal costs of generation. We test a version of the AMP that captures the salient features in two variants of a simulated electricity market with six sellers and fixed quantity demanded. In both variants, "uncongested" periods alternate with "congested" periods. Congested periods simulate transmission-system congestion by dividing the six sellers into two smaller markets with three sellers each, while uncongested periods do not. The two variants differ only in the demand during uncongested rounds, as shown in Table 2. To reduce wordiness, we shall call the variant with lower demand in uncongested rounds the "lower-market-power" condition, and the other the "higher-market-power" condition, with the caveat that, again, they differ only in the demand during uncongested rounds. We consider the lower-market-power variant to be more representative of NYC at present. We use the higher-market-power variant to examine what the performance of the NYC-style AMP might be in places or times at which generation owners have high market power even during hours without transmission congestion. This may be the case in the many parts of the world with highly concentrated generation ownership or severe, chronic shortages of generation capacity. It may also become more common everywhere as off-peak charging of electric vehicles increases off-peak demand and as increased reliance on stochastic generation such as wind and solar results in episodic generation scarcity at times without transmission congestion.

In each of the two market variants, we compare the results under the AMP to the results under a more lax system. This more lax system, which we refer to as the system "without AMP," consists only of two rules: that each unit able to operate must offer to do so, and that these units must offer to do so at some price no greater than an offer cap of $1000 per MWh. These are the other two rules that apply in NYC, along with the AMP. We also compare the results both with and without the AMP to the counterfactual results that would have occurred if all generation units had submitted offer prices equal to their marginal cost.

Our study is the first to have the important feature that reference offers are based on a historical average of recently accepted offers, as in the real AMPs used in New York, New England, and the Midwest. Consequently, in our experiment, as in reality, sellers can move their reference offers over time; "reference creep" is possible. We test the robustness of AMPs with this characteristic.

Our results, presented in section 4, indicate that the AMP can lower the average market price of electricity. It did so under both the lower-market-power and higher-market-power conditions. However, under the AMP and the higher-market-power condition, the market price, while still lower than without the AMP, rose far above what it would have been if each unit's offer price had equaled its marginal cost. The higher market power in the uncongested rounds under this condition allowed the generation owners to gradually raise prices in both those rounds and the congested rounds, since the uncongested rounds are often the basis for the reference offers and soft offer caps in subsequent rounds. This suggests that factors that result in high market power even in uncongested periods, such as concentrated ownership, chronic generation scarcity, off-peak vehicle charging, or reliance on stochastic power sources could allow prices to rise in spite of an AMP.

Two prior studies have examined an AMP. Entriken and Wan (2005) and Kiesling and Wilson (2007) test AMPs that lack the possibility of reference creep even though this is a characteristic of real conduct-and-impact AMPs. In both Entriken and Wan's simulation and Kiesling and Wilson's experiment, the reference offers are fixed. Entriken and Wan's simulation uses computer agents instead of human participants and they find that a version of AMP developed for the California Independent System Operator does reduce prices during peak demand periods. Their simulation also considers the impact of transmission congestion that effectively reduces competition during high demand periods.

Kiesling and Wilson's study uses human participants and a "general" version of AMP. They find that their AMP reduces prices in the short run. However, their study's emphasis is on the long-term effects of potential investment and of the AMP in the presence of that investment. In their experiment, participants can choose to invest in additional generation capacity. Kiesling and Wilson find that, in both their high-market-power and lower-market-power treatments, investment occurs and successfully reduces prices to near competitive levels in the long run with or without an AMP. Their AMP produces an additional long-term price reduction only in their high-market-power treatment, and it is small. They also find that their AMP has no effect on investment. Therefore, their study does not indicate that AMPs are harmful in terms of preventing investment in generation capacity. Even if it were, both their study and ours indicate that unmitigated prices would be extremely high until investment could occur[2], and policymakers are unlikely to abandon market power mitigation as a goal, so there is value in better understanding the methods.

The rest of this paper is organized as follows: Section 2 describes the regulatory regime and power generation industry in NYC. Section 3 describes our experiment. Section 4 presents the results. Section 5 concludes.

2. The AMP in NYC and in the experiment

The AMP we examine in this paper is based on an AMP adopted by the NYISO in NYC for power generation units that are located in NYC and that sell electrical energy into the NYISO wholesale electricity market (NYISO, 2010b). We reproduced this AMP in the experiment[3], with some modifications summarized in the description below.

The reason that the NYISO has imposed automatic mitigation is that concentrated ownership and frequent transmission congestion give NYC's generation owners market power. As shown in Table 1, six companies own 99% of the generation capacity in NYC. Bernard et al. (2005) have demonstrated, in laboratory experiments designed to reproduce the cost structure of electricity markets, that with perfectly inelastic demand, considerable market power is present in last-accepted-offer auctions with six generation owners who each own multiple generating units. Congestion, along with a need for local generation in order to maintain reliability and proper system operation, reduces effective competition by outside generation owners. In 2008, there was transmission congestion on the lines into NYC

[1] Experimental economists have demonstrated that laboratory experiments can successfully address issues of electricity regulation. Normann and Ricciuti (2009), Rassenti and Smith (2008), and Staropoli and Jullien (2006) provide recent surveys. Rassenti et al (2003) and Zimmerman et al (1999) address market power, but not AMPs.

[2] Generation and transmission investment typically takes years, especially in densely populated locations.

[3] Materials available from lead author by request.