IDENTIFYING MARKET POWER IN THE EEX ELECTRICITY MARKET

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INTRODUCTION

Electricity markets in many parts of the world are oligopolistic with strategic interaction between a limited number of market players. Measuring market power is therefore important, but this is a complex task in electricity markets. Traditional market concentration indicators, such as the Herfindahl-Hirschman Index (HHI), have limited validity since they do not capture the impact of transmission and operational constraints in the power system, the relatively low price elasticity of electricity demand, the complex set of rules that govern today's electricity markets, and the dynamic bidding strategies of market participants. In this paper we use agent-based modeling and simulation (ABMS) to analyze strategic bidding and market power in the European Energy Exchanges (EEX) electricity market, which covers Germany and Austria. We show how ABMS can be used to analyze strategic bidding, prices, and market power in electricity markets.

METHODS

Game theory is frequently used to model the strategic interaction between companies. However, a limitation of game theoretical models in electricity markets is that they usually build on a number of simplifying assumptions. An advantage of the ABMS approach is that it allows for a more realistic representation of the electricity market. Since the objective of ABMS is not necessarily to find an equilibrium solution, one can relax many of the simplifying assumptions usually underlying game theoretical optimization models. For instance, ABMS allows for a detailed representation of transmission constraints, different generation technologies, bidding format, and market operation. ABMS is a bottom-up simulation method, which focuses on how agents' strategies and decisions impact the overall performance of a system. By simulating different scenarios of bidding among generating companies (GenCos), from competitive production cost bidding to different types of strategic bidding, ABMS can contribute to identifying and measuring the extent of market power exercise in an electricity market.

In this paper, we use the Electricity Market Complex Adaptive System (EMCAS) model developed at Argonne National Laboratory to simulate the EEX electricity market. Each GenCo is modeled as an individual agent, which can apply a number of different bidding strategies to its generating units in order to maximize the company profit. A system operator agent clears the market and calculates hourly locational prices based on GenCos bids and the system load using a bid-based optimal power flow algorithm (DC-OPF). By simulating the daily bidding and market clearing process over time, the strategic interaction among agents is captured. The performance of the market and its individual agents, measured in terms of prices, GenCo profits, and consumer costs, is evaluated for each hour based on the market clearing prices.

RESULTS

In our analysis we simulate the EEX wholesale market for January 2006, in which the highest monthly load occurs. We model 18 GenCos in Germany and Austria with a total of more than 120 power plants. We also include an aggregate representation of the electricity markets in some of the neighboring countries. We compare the simulated prices to historical prices from EEX. The simulated market clearing prices formed by agents' production cost bidding, including the marginal cost of CO2 emission allowances, can be regarded as a benchmark for a competitive electricity market. Physical and economic withholding and other strategies are simulated to represent potential strategic bidding behaviors of the GenCo agents, and the results are compared to the production cost benchmark. The influence on the market prices of fundamental factors like fuel cost and emission allowance prices are also investigated.

The main preliminary results from the study are:

- The historical market prices tend to be above the marginal production cost during peaking hours, and below the marginal production cost during off-peak hours. The average historical price is significantly higher than the simulated production cost benchmark. Some of the difference may be explained by unit commitment constraints and costs, which are not included in the simulated benchmark price.

- Strategic bidding behaviors by certain GenCos can effectively increase market prices above the production cost level. However, the results indicate that no GenCo has the ability to increase its own profit by unilaterally applying economic or physical withholding. However, GenCo profits increase substantially in scenarios where multiple companies apply strategic bidding.

- Base load plants (coal and nuclear) make large operating profits, whereas natural-gas fired peaking plants have negative operating profits in most of the simulated scenarios.

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