DO TWO TIMES MARKET POWER MAKE IT RIGHT? OWNING STORAGE AND GENERATION CAPACITY IN IMPERFECT MARKETS

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Overview

Worldwide renewable power capacity additions have hit a new record in 2023, increasing by 36% and reaching around 473 gigawatts (REN21, 2024). As this trend is expected to continue, the intrinsic challenges of renewable generation integration, like intermittency, remain to be addressed. To mitigate this challenge, several possible solutions arise such as demand response, grid modernization, and battery storage capacity. As storage costs become more competitive, many jurisdictions, including for instance Alberta (Canada), California (U.S.), and Germany, are increasingly adopting storage solutions. Studies on the effects of storage usage have largely focused on its profitability rather than its impact on market outcomes, such as prices and generation. Current research typically assumes that storage owners charge when prices are low and discharge when prices are high. In imperfectly competitive markets, these charging practices can influence prices, especially if companies own both storage and generation capacities. Market power may lead to reduced market efficiency by artificially increasing prices of electricity and yield socially suboptimal use of storage capacity (Brown and Eckert, 2020; Bjørndal et al., 2023). This is why the effects of storage adopton remain a large extent an open question, while being highly complex.

This paper analyzes the effect of market power on the strategy of using storage in conjunction with generation capacity. The study particularly focuses on cases where firms own large shares of both storage and generation assets. This enables firms to exercise market power either independently (storage or generation) or in conjunction (storage and generation). By employing an optimization model and utilizing data from Alberta, Canada, the study examines the market dynamics and the resulting implications. It considers various firms with different levels of market share, diverse generation portfolios (including natural gas, coal, and renewables), and varying marginal costs.

Previous studies have focussed on the market power of storage as a stand-alone decision variable or with renewable energy sources (Nasrolahpour et al., 2016; Arteaga and Zareipour, 2019; Ekholm et al., 2021). This paper extends the previous literature to analyze the effect of storage market power paired with conventional (e.g., coal and natural gas) and renewable generation market power. This is particularly important in jurisdictions with large generation companies (e.g., Alberta, Texas, and Germany). Our model is based on Brown and Eckert (2020) and allows for the possibility to vary the degree of market power in both storage and generation capacity. Additionally, the study examines the impact of other factors on the ability to exercise market power, including marginal cost structure and generation portfolio.

Our preliminary results show that, in specific periods, firms that own both storage and generation capacity have incentives to charge their batteries during relatively high prices to further increase their revenues from their generation assets. This effect occurs mostly when the firm owns the marginal asset (i.e., the last asset called upon for generation) or the asset right above the marginal one. These findings suggest that careful planning is necessary from a regulator perspective, market monitoring should be implemented for storages, and the market structure needs to be considered when encouraging storage adoption to avoid unintended consequences.

Methods

The analysis bases on an optimization model that mimics the Alberta (Canada) wholesale electricity market for the year 2023. Alberta is chosen because it is largely an energy-only wholesale market, which allow us to restrict the strategic behavior of the firms to electricity generation and abstract from other influencing factors like capacity markets. Further, the Alberta wholesale makert operates as a multi-unit auction with a uniform price, allowing us to isolate the effects to a single price measure. Finally, the province has been actively adopting storage capacity, with 100 megawatts of capacity added in 2023 (MSA, 2024).

While the model is based on Brown and Eckert (2020), our focus is on the spot market and with all generation (conventional, renewable, and storage) being compensated by spot prices. We consider five large companies with different generation portfolios and storage capacity that can exercise market power. Additionally, we include a price-taker fringe that represent all other smaller firms. In total, the five large companies account for slightly more than 60% of the market share. In the spot market, firms simultaneously decide their spot quantities of conventional and renewable generation, in addition to their storage utilization for each hour of the year. Firms seek to maximize their profits subject to several constraints, including upper and lower bound of generation and storage capacities. This empirical framework includes real-world complexities, such as asymmetric marginal costs, heterogeneous firm

generation portfolios, minimum stable generation (i.e., the necessary lower bound for the safe function of coal plants), and existing renewable capacity.
The hourly input data is collected from the Alberta Electricity System Operator (AESO) from January 1, 2023, to December 31, 2013. This data set includes: quantities offered by each firm for each generating unit and the price they require, import quantities mainly from British Columbia and Saskatchewan, observed spot price and quantities per firm, transmission capacities, observed electricity demand, and the ownership of the different assets. We approximate the asset-specific marginal cost of each firm by a non-decreasing third-degree polynomial function that contain three main factors: fuel input costs, variable operating and maintenance costs (O&M), and costs related to environmental compliance. Finally, the residual linear demand function is estimated using two-stage least squares to mitigate the endogeneity of spot prices.

Results

The preliminary results indicate that during certain periods, firms with both storage and generation capacities are incentivized to charge their batteries even when prices are relatively high. This strategy helps them boost revenues from their generation assets. This effect is particularly pronounced when the firm owns the marginal asset or the asset just above the marginal one. Additionally, we observe that annual maximum and minimum prices increase and decrease, respectively, compared to an scenario with no storage. This further suggest that unusually high prices may provide incentives to firms to charge their storage units to artificially increase prices. Likewise, firms may decide to discharge during low prices when their assets are not generating, further lowering the prices.
Firm characteristics play a crucial role in the ability to exercise market power. Higher marginal costs and inflexible generation portfolios (e.g., large shares of coal assets) decrease firm's ability to exercise market power and profit from owning storage capacity. On the other hand, when firms have large shares of renewable energy in their generation portfolios, their incentives to exercise market power with the storage capacity increase. This higher incentive to exercise market power is because renewable generation is assumed to have zero marginal cost and it is always dispatched, which increases the benefits perceived by a higher spot price.

Conclusions

The increasing adoption of storage capacity in wholesale markets open new possibilities for firms to exploit dominant positions and influence market outcomes, such as prices. This study employs an optimization model that mimics the Alberta wholesale electricity market to analyze the effect of market power on the strategy of using storage together with generation capacity.
This paper extends the previous literature to analyze the effect of storage market power paired with conventional (e.g., coal and natural gas) and renewable generation market power. The analysis finds evidence of "double" market power exercise, based on strategic use of storage and generation assets. The findings indicate that regulators and governments should consider the market structure before promoting storage adoption to prevent unintended outcomes, such as increased spot prices. These unintended outcomes provide valuable input to governments when deciding about the subsidies and incentives to encourage battery storage adoption.
The optimization model developed in this study provides a realistic representation of the Alberta electricity market. However, future research should focuss on incorporating a forward market to analyze its interaction with storage capacity. This interaction is interesting because forward market can affect the incentives to exercise market power in the spot market (Brown and Eckert, 2020). Additionally, our model assumes a deterministic productivity factor for renewable capacity, known for all firms before participating in the spot market. Future research should consider a stochastic productivity factor to understand the role of uncertainty on the incentives to exercise market power.

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