Forward Contracts and Generator Market Power: How Externalities Reduce Benefits in Equilibrium

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Overview

Capacity markets for electricity provide a regulated market setting through which generating units are compensated for their contribution to power system reliability, the ability of the power system to meet peak demand. In many regulated markets, for instance in the U.S., the independent system operator (SO) sets a demand curve for capacity for the region, and then charges load-serving entities (LSEs) based on their contribution to the peak system load. As such, the capacity market essentially serves as a market for a specific type of long-term contract that consumers are required to purchase. The type of forward contract varies, but can be modeled similarly as a type of capacity certificate or reliability option, as demonstrated by an analytical comparison of forward contract types (Léautier, 2015).

While capacity markets have diverse forms and requirements, compelled participation of demand is a key feature shared in many markets: customers, or LSEs acting on their behalf, are required to engage in a specified level of contracting by paying for the forward capacity quantity that has been determined in an auction process based on the SOs demand curve. The main rationale for capacity markets is to help generators achieve revenue sufficiency in a market with price caps, which are used to mitigate generator market power. However, they also provides many of the benefits of financial forward contracts, including risk reduction.

Changing energy markets and increased penetration of variable renewable resources have strained capacity markets or led to apparent capacity shortages or excesses in some markets. This has driven increased focus on the benefits and costs of capacity markets (Bushnell et al., 2017), as well as additional efforts to define the market failures that capacity markets should and can seek to address (Cramton et al., 2013).

A rich literature suggests that forward contracting can reduce market power in electricity spot markets. Allaz and Vila (1993) provided analytical evidence that forward contracting can impel producers to offer higher quantities in real-time markets. Wolak (2000) provides empirical evidence in support of this conclusion, using data from the Australian market to show that forward hedging can reduce generator market power. Chao and Wilson (2004), Cramton and Stoft (2008), and Ausubel and Cramton (2010) argue that one of the major benefits of capacity markets using reliability options is their ability to help reduce generator market power.

However, while research suggests that one significant benefit of forward contracting is its ability to help reduce generator spot market power, this work argues that positive externalities related to forward contracting and producer market power might limit the extent of forward contracting and reduce social welfare. Arguments in favor of regulated capacity markets frequently cite their ability to reduce generator market power, but that rationale is limited because it does not present a specific market failure that must be addressed. This research helps to fill that gap by highlighting the non-excludable nature of market-power reducing benefits of forward contracting in a simplified electricity market model.

Methods

The research utilizes tools from optimization, game theory, probability theory, and economics to analyze generator behaviour in a two-stage Cournot equilibrium, where the first stage represents forward contract purchases and the second stage represents the spot market for energy. It extends results that show how forward contracting can recuce Courtnot output by producers in spot markets, by embedding the second stage production result in a two-stage model where LSEs purchase forward contracts in the first stage in order to mitigate market power in the second. We model the potential exercise of market power in both stages, and focus understanding how externalities related to forward contract procurement impact, in our simplified market model, the real-time price for electricity, the extent of forward contracting, and social welfare.

Results

The research details the Cournot equilibrium for forward contract procurement by load-serving entities (LSEs) in a competitive electricity market with forward contracting and a real-time spot market based on realizations of uncertaint demand. It shows how the equilibrium level of forward contracting is influenced by the number of LSEs, and it shows that, under certain conditions, the quantity of forward contracting is decreasing in the number of LSEs. It also shows that, given the model assumptions, a change in the level of forward contracting implies the same directional change for social welfare, defined as the sum of consumer and producer welfare. Therefore, it details conditions under which social welfare is decreasing in the number of LSEs, due to the effect of forward contracting on producer market power.

Conclusions

This research details to the externalities of consumer engagement in forward contracts, whereby the benefits of forward contracting and increased real-time supply are shared by all consumers. It describes analytically how these externalities limit the extent of forward contracting and shows that the level of forward contracting decreases in the number of load-serving entities (LSEs). Therefore, in a competitive marketplace with many load-serving entities, each of whom pursue their own forward contracts, the level of forward contracts is below the level that maximizes social welfare. This implies that regulation may be required, for instance through mandated forward contracting or participation in capacity markets, in order to achieve the optimal level of forward contracting. This argument provides more compelling support for mandated forward contracting for electricity than the oft-repeated statement that forward contracting can help reduce market power, which itself does not imply a coordination problem nor compel regulation that is intended to increase the total level of forward contracting

References

Allaz, B. and J.-L. Vila (1993, feb). Cournot Competition, Forward Markets and Efficiency. Journal of Economic Theory 59(1), 1–16.

Ausubel, L. M. and P. Cramton (2010). Using forward markets to improve electricity market design. Utilities Policy 18, 195–200.

Bushnell, J., M. Flagg, and E. Mansur (2017). Capacity Markets at a Crossroads.

Chao, H.-P. and R. Wilson (2004). Resource Adequacy and Market Power Mitigation via Option Contracts. EPRI .

Cramton, P., A. Ockenfels, and S. Stoft (2013, apr). Capacity Market Fundamentals. Economics of Energy & Environmental Policy 2(2).

Cramton, P. and S. Stoft (2008, sep). Forward reliability markets: Less risk, less market power, more efficiency. Utilities Policy 16(3), 194–201.

Léautier, T.-O. (2015). The visible hand: ensuring optimal investment in electric power generation.

Wolak, F. (2000). An Empricial Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market. International Economic Journal 14(2).