HOW TO DESIGN RESERVE MARKETS? THE CASE OF THE DEMAND FUNCTION IN CAPACITY MARKETS

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Overview

This paper studies reserve markets' design, aiming to provide producers with sufficient incentives to invest in production capacities. For some essential goods such as electricity or medical supplies, wholesale markets' private incentives are sometimes not adequate to ensure that producers make enough investments. Hence, during high-demand periods, for instance, a cold wave or a pandemic, the absence of investment in production facilities could lead to high costs for society. One solution to restore the right level of investment could be the implementation of reserve markets. On the supply side of this market, each participating producer makes a price-quantity offer for a capacity. If a producer sold a capacity, it legally forces the investment to be available over a specific period in the future. While the supply function emerges naturally from producers on those markets, the demand function is not always spontaneous.

The public-good nature of investment during high-demand periods implies that consumers are unwilling to buy capacities in reserve markets. Hence the regulator must administratively create the demand function, so the market clears and provides producers' capacity prices. To overcome this issue, regulators have proposed different options to create an ad hoc demand in the reserves market. One of the ongoing central debates amongst economists and policymakers is to know if those capacities should be bought by a single entity (the centralized design) or by each retailer (the decentralized design). This paper provides discussions on the economic impacts those two designs can have and their policy implications. While we focus on capacity markets specific to an electricity system, one can extend our analysis to any similar economic environment. In current liberalized electricity markets, most of the final consumers (such as households) buy their electricity from retailers in the retail market. Then, retailers buy electricity from producers in the energy market. Therefore, in the centralized design, the single entity, which could be an independent regulated entity or a public system operator, estimates the total consumption of final consumers, formulates a demand function in the capacity market, and allocates the purchase cost to the retailers. On the other hand, in the decentralized design, each retailer estimates its client portfolio's consumption, makes an individual demand function in the capacity market, and passes the purchase cost onto its clients.

To our knowledge, there has been no formal comparison between each market design option, especially on their implications for investment decisions. To fill the gap, we investigate in this paper how the practical implementation of the demand function of capacity markets can change the outcomes on the whole economic system. We focus on the indirect effect a reserve market design can have on the retailer's behavior in the retail market, impacting the expected revenue on the upstream wholesale market, which conditions investment decisions. More generally, we show that it can exist an endogeneity effect between a first-best solution and an economic instrument implemented to reach it. Some market designs can be considered optimal given a market failure and constraints. Other designs may approach the first best but still bring more welfare than the initial first-best solution.

Methods

We address this question by building a benchmark model with upstream and downstream agents. Producers make long-run investments in a single technology in the upstream market to produce a homogeneous good. Then, the downstream retailers aggregate and resale the electricity at no cost to the final consumers. The regulator can use an instrument, the capacity market, where upstream producers sell an availability for future transaction periods to restore the right level of investment.

The key features of the model are as follows. First, we assume three causes for underinvestment: (i) a binding price cap in the wholesale market, (ii) inefficient rationing in the retail market due to the price cap, (iii) retailers acting as a strategic agent with market power *à la Cournot* in the retail market. Although the retail market power is not the standard approach in the literature for representing the cause of underinvestment, it brings a new light on the risk of retailers' strategic actions. It could be relevant as new technology and a continuously liberalized retail market gives an increasing space for such actions. On the other hand, we assume perfect competition for producers to make the model more tractable. Second, in the continuity of the retail market's current evolution, we assume that final consumers' demand is price-elastic and stochastic (which we can also interpret as shifts in net demand due to variable renewable generation). Third, our objective is to compare different market design options. Hence, we describe practical rules associated with the centralized and decentralized model. It enables us to model the options' effect on the retailer's strategies and study the regulatory parameters used to implement the capacity market's demand function. Finally, we stress that our three markets (wholesale, retail, and capacity) and the investment are interconnected and possess allocation externalities. In other words, the allocation of goods on the market impacts agents' profits in subsequent interactions.

Results

We start by presenting the initial theory behind investment decisions with private producers. Given revenue expectation in the wholesale market, producers invest as long as the net revenue covers the fixed investment cost. At this point, most of the literature assumes perfect competition in the retail market. Therefore, there is no difference between considering retailers or not as they pass the wholesale price's cost to final consumers. On the contrary, to illustrate the effects of different capacity markets on the retailer strategies, we start assuming that retailers play à la Cournot on the retail market. Consequently, the demand addressed by retailers to producers on the wholesale market is lower. It decreases the revenue expected by producers, and thus it lowers the level of investment. A price cap on the wholesale market implies a lower expected revenue for the producers when it starts bindings, which causes part of the underinvestment. Finally, inefficient rationing acts as a public good which generates negative externalities. They under-provide the public good, as producers do not receive revenue for lowering system cost.

Our main contribution lies in representing the different market design options for the demand specification in capacity markets. We analyze how each design, and their corresponding rules, affects the demand made by retailers on the wholesale market, given the degree of competition in the retail market. For the centralized case, if the regulator decides to allocate the retailers' costs on an ex-ante basis with a pro-rata unrelated to the retail market's strategies, then the capacity market's effect depends on the method to transfer the capacity cost to consumers. When the transfer is similar to a lump-sum tax, then the capacity market is neutral for consumers. It acts as a surplus transfer between consumers and producers. While it ensures that we reach the first-best solution, we demonstrate that transferring the cost to consumers via a unitary payment can provide higher welfare. Under specific conditions, lowering consumers' demand avoids having to sustain high rationing costs. On the other hand, if the regulator chose to allocate the cost on actual market shares, this allocation forces retailers to consider capacity prices in their strategies on the retail market. Thus, they are marginally affected by the capacity market. While we do not need any assumption regarding the transfer cost of capacity, this market design implies an intermediary outcome between the ex-ante case with a lump sum payment and the ex-ante case with a unitary payment: with only two retailers, they entirely pass the cost to consumers; with perfect competition, they fully internalize the capacity price. On the other hand, this market design has significant redistributive implications as the cost is shared between retailers and consumers. We analyze how individual strategies can form an aggregated demand functions in the capacity market for the decentralized case when retailers are forced to cover their quantity sold on the retail market given a penalty system. To do so, we focus on the symmetric equilibrium. We analyze the optimal capacity asked by retailers in the capacity market. We find that decentralizing the demand function can approach the optimal level of investment under specific conditions. Indeed, the capacity market's demand function depends on the marginal value a capacity brings retailer profit. Hence, it depends on the retail market's market structure, the consumers' demand function, and the penalty system. To conclude, as the model establishes a complete framework to analyze the effect of the different market designs of capacity markets, we discuss future extensions.

Conclusions

We stress in our analysis that the design of such a market is not straightforward. When choosing the reserve market's demand function, policymakers also have to be careful about the indirect effects. We demonstrate that each design option has distinct economic implications for the demand side, which affects not only the outcomes in terms of prices and quantities traded on the economic system but also redistribution effects for consumers, producers, and retailers.

Besides providing a complete vision of the system, one of our framework's advantages relies on the possible extensions we can implement. First, we initially assumed that consumers were entirely reactive to retail prices. Such assumptions do not describe the reality yet, as most small final consumers such as households are still under fixed-price contracts. The study of final consumers' heterogeneity and its implications for investment decisions in the power system is an emerging trend in energy economics. It could shed new light on our result. Second, we assume that future final consumer demand is commonly shared between the different agents. The regulated entity and retailers could access a different quantity and quality of information.