INTERACTION OF STRATEGIC BEHAVIOUR BETWEEN DAY-AHEAD AND RESERVE MARKETS

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Overview

Reserve markets play a key role in maintaining the balance between the supply and the demand of electricity. To ensure enough reserves are always available, two types of services are procured by the Transmission System Operator (TSO). Reserve capacity is a generation capacity that is held back from the energy markets to be available in real time if needed. This service is most frequently procured before the day-ahead market in Europe (Figure 1). Reserve energy corresponds to the actual activations of reserves in real time.

Figure 1 Sequence of markets.

The massive integration of variable renewable energy (VRE) sources represents a challenge for the demand-supply equilibrium of electricity markets because of their intermittency and imperfectly predictable output. The role of flexible generation and storage is therefore important in a decarbonised power system. In energy only-markets, it has been shown that imperfect competition decreases the use of storage and thus, decreases social welfare (Sioshansi, 2014). The flexibility of storage could also be used strategically in reserve markets to increase profits. Previous studies have focused on the exercise of market power in the reserve-energy market (Boomsma et al., 2022, Poplavskaya et al., 2020). However, market power in the reserve-capacity market has not been investigated despite the influence of its outcome on the day-ahead market. Reserve markets are likely more prone to market power than energy markets. Indeed, entry barriers are more important, and the market size is smaller (Lago et al., 2021). Imperfect competition in reserve markets can have two types of consequences. The first is an increase in the cost of balancing, which is reflected in the price of electricity paid by end consumers. The second consequence is the risk of undersupply, affecting the security of the power system. The decarbonisation of the electricity mix, therefore, makes the question of strategic behaviour on reserve markets even more important. The issue of market power exercised by storage in these markets is of particular interest because of the large market share they could obtain with less flexible fossil-fuelled generation (Deman et al., 2025).

This article fills this gap by analysing the exercise of market power in the reserve-capacity market while considering the interactions with the day-ahead market. Indeed, the interdependencies between the two markets require both to be represented, since strategic behaviour in one market may have an impact on the outcome of the other. To analyse this issue, we extend the existing modelling framework of imperfect competition in energy-only markets (Crampes & Moreaux, 2001; Debia et al., 2019; Sioshansi, 2014) by adding the reserve-capacity market. Two research questions are addressed in this paper. First, we analyse the impact of capacity withholding in one market on the outcome in the other market. Second, we examine how the ability to withhold capacity in one market is affected by the competitive structure in the other market.

Methods

A stylised Cournot model with interrelated markets is used to analyse the interaction of market power exercise between the day-ahead and the reserve markets. The model extends the existing modelling framework of imperfect competition in energy-only markets (Crampes & Moreaux, 2001; Debia et al., 2019; Sioshansi, 2014) by adding the reserve-capacity market. This extension is based on cost functions tailored to represent the relationship between the energy and the reserve supply. In particular, the cost functions represent the opportunity cost of supplying reserve-capacity with respect to the day-ahead market.

Two cases study are compared to assess the role of technology characteristics on their ability to exercise market power on reserve markets. In the first case study, two conventional generators are represented, while in the second, a storage asset is added. An open-loop approach is applied to obtain analytical results without uncertainty. In the case study with two conventional generators, the model is solved for one time period since their decisions are not subject to temporal arbitrage. In the case study with storage, the model is solved for two periods, the first period being when storage is charged, and the second period representing a peak period, which is used to discharge storage.

To assess the interactions of market power between the day-ahead and the reserve-capacity markets, several cases with different combinations of competitive structures in each market are compared (Table 1). The first research question is addressed by comparing cases 1 and 3 (for the impact of reserve-capacity withholding), and cases 1 and 2 (for the impact of energy withholding). The second research question is addressed by comparing cases 3 and 4 to evaluate the impact of the day-ahead market competitive structure on reserve-capacity withholding. Similarly, cases 2 and 4 are compared to assess the impact of the reserve-capacity market competitive structure on capacity withholding in the day-ahead market.

Table 1 Competitive structures cases analysed.

		Day-ahead market	
		Perfect competition	Imperfect competition
Reserve-capacity market	Perfect competition	Case 1	Case 2
	Imperfect competition	Case 3	Case 4

Preliminary Results

The comparison of cases 1 and 3 with two conventional generators show that reserve-capacity withholding decreases the total supply in the day-ahead market. As a result, consumer surplus is decreased through a reduction in quantities and an increase in prices in both markets. The same observation can be made when comparing cases 1 and 2 with a lower reserve supply and higher reserve prices in case 2. These results suggest that market power can still be exercised in a perfectly competitive energy market through the market power in the reserve-capacity market, and vice-versa.

The comparison of cases 3 and 4 show that market power can be exercised in reserve markets, independently of the competitive structure of the day-ahead market. However, the total reserve supply is larger when the day-ahead market is also imperfectly competitive. This result is due to the relationship between the energy and the reserve-capacity supply. Some of the withheld reserve-capacity is offered to the day-ahead market, increasing profits through an increase in the supplied quantity. However, this transfer is limited by market power in the day-ahead market. Consequently, the optimal amount of withheld reserve-capacity is lower when both markets are imperfectly competitive. The comparison of cases 2 and 4 shows similar interactions of market power with a lower energy supply when the reserve-capacity market is not competitive. This result indicates that imperfect competition in the day-ahead market exacerbates the negative effects of imperfect competition in the reserve market, and vice-versa.

Conclusions

This work demonstrates interactions of market power between the day-ahead and the reserve-capacity market. The comparison of the different competitive structure cases shows the importance of a perfectly competitive reserve-capacity market on the global outcome. In addition, imperfect competition in the day-ahead market increases the market power of generators in the reserve-capacity market, exacerbating its negative impacts on consumers. Additional work for this paper will be dedicated to the case study with a conventional generator and a storage unit.

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