WHOLESALE ELECTRICITY MARKETS WITH HIGH SHARES OF RENEWABLE ENERGIES: EFFECTS OF UNCERTAINTY ON PRICES

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Overview

Recently the Regulation on Wholesale Energy Market Integrity and Transparency (REMIT, No 1227/2011) came into force in the European Union. It requires that information relating to capacity and planned and unplanned unavailability is made public in order to reduce "insider information" and "market manipulation" which is likely to affect wholesale electricity market prices. Besides, future electricity market prices may fluctuate more and thus become less predictable. This is because firstly, future electricity markets might have less dispatchable electricity generation (e.g. gas and coal) but more variable renewable generation (e.g. PV and wind). Consequently, temporary market power may arise due to asymmetric weather conditions especially in an electricity market with a high share of variable renewables. Secondly, more flexible households (e.g. with heat pumps or PV and storage) may become more active as both suppliers and consumers of electricity (possibly managed by aggregators) leading to a less predictable market demand.

On the supply side, it is conceivable that the bidding behaviour of individuals depends on his/her *perceived* market power. The perceived market power itself naturally depends on information (transparency) in the market. For example, with disparate weather conditions certain generators may have an asymmetric cost advantage, which might affect their bidding behaviour only if they are actually aware of those weather conditions. Therefore, knowledge about the supply costs and capacities of all market participants are crucial for the resulting market price and profit distribution. Analysis on the impact of the information structures on electricity generators' bidding behaviour might shed light on the actual impact of the "transparency requirements" under REMIT.

The aim of this paper is to use laboratory experiments to track down the possible effects of (in)transparency in a wholesale electricity market. Specifically, we examine to what extent information uncertainty on the supply side or the demand side will affect the suppliers to exert market power and drive prices up. Our benchmark is a full transparency setting, where all electricity traders are perfectly informed of the overall demand as well as the capacities of all other market participants. The first treatment corresponds to the situation where each trader is limited to information of their own capacity, whereas information of other producers consists of only their potential capacities and the associated probabilities. The second treatment varies the demand level among a set of options and their corresponding probabilities, which reflects a stochastic feature of the demand side.

Previous experimental studies have been successful in identifying the impact of different market rules and characteristics of the bidding behaviour of participants. Studies have, for example, assessed market power issues in electricity markets due to transmission constraints, or a limited number of market participants. As Rassenti et al. (2002) show, price peaks can be reduced significantly through increased competitiveness and demand-side bidding when market power is present. Brandts et al. (2013) study the difference of supply function equilibrium and multi-unit auctions in electricity market with pivotal suppliers. They find that prices are higher when (some) firms are pivotal and more consistent with supply function than multi-unit auction equilibrium predictions in the pivotal treatments. However, to the best of our knowledge, the impact of information and transparency on market bidding behaviour and electricity prices have not been experimentally studied in the context of electricity markets.

Methods

Similarly to biology or physics, experimental methods are now playing a central role in economics, in testing and refining theories concerned with individual behaviour or market performance. In fact, these methods have been very influential in studying and designing electricity markets (e.g. Vernon Smith was involved in designing the Australian electricity market by applying experiments) and other markets such as spectrum auctions, where it has been demonstrated that small design details can have efficiency and revenue implications in the order of billions of dollars.

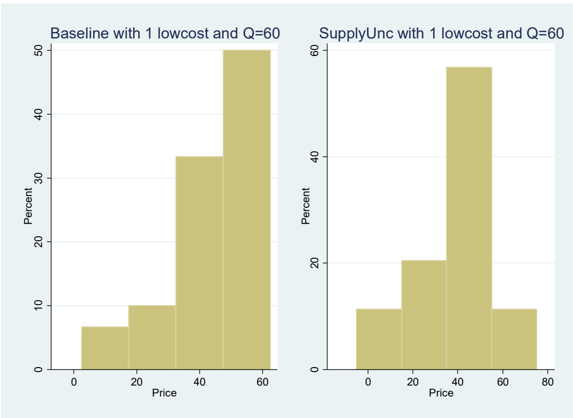
The use of this method makes it possible to implement variations of information structure with a high degree of control, allowing isolation of their effects to unravel a causal rather than a correlative relationship.

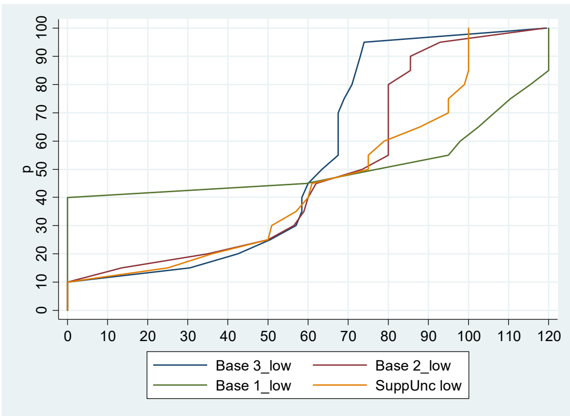
Our experimental design involves groups of three players. Each represents an electricity trader in a wholesale electricity market, selling electricity by offering supply quantities at various prices. Market prices resulted from the bidding of the groups, and groups remained unchanged throughout the whole experiment. Each player has two generation sites of different technologies. The generation sites feature different unit costs (one is cheap, and the other is expensive) and different capacities. The cheap site has a higher capacity and corresponds to variable renewables, for which availability depends upon weather conditions. The expensive technology is always available but has a lower capacity. The electricity demand varies between three levels and is randomly determined by the computer. Our benchmark treatment reveals all information on demand and supply to all players in the group.

Information transparency were reduced in the other two treatments, which allow us to attribute any observed change in behaviour to the corresponding variation in the information structure. The experiment lasted for 24 rounds and the profit of one of the 24 rounds was randomly selected and paid as an incentive. The experiment was conducted in the experimental laboratories at UNSW Australia and ZHAW.

Results

Our experimental results show that the available information and strategic behaviour are intimately related. In particular, we find that in monopoly cases (one player has abundant, cheap generation available while the two others only have limited expensive generation available) the resulting auction prices are significantly lower with supply uncertainty compared to full information (see two Graphs on left below). In the duopoly cases (one has only expensive generation while the two others have the cheap technology available, Base_2 _low) we do not find a difference and in the competitive case with full information (all have cheap technologies, Base_3_low) the resulting price is lower (see Graph on the right). Further, the data shows that the bidding of the low-cost types facing supply uncertainty (SuppUnc_low) is not a probability-weighted convex combination of the empirical bidding exerted by low-cost types in the baseline, but rather indistinguishable from low-cost baseline bidding with one low-cost competitor. With regard to demand uncertainty, we do not find any significant differences to the baseline.





Conclusions

In summary, our analysis yields the following broad conclusion: “local” or “temporal” market power due to randomness associated with variable renewables may be a substantial problem in a highly transparent market but less so in presence of market intransparency. Thus, a revision of the REMIT regulation to require transparency for short-term renewable availability may be counterproductive.

References

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