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Electricity markets: Designing auctions where suppliers have uncertain costs

EPRG Working Paper 1523

Cambridge Working Paper in Economics 1541

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An increased use of renewable electricity production, such as solar and wind power, increases the uncertainties in the wholesale electricity market. In this paper, we analyse measures that improve market performance when production costs and production capacities are uncertain. We find that improved market transparency is helpful. We also find that markets with uniform pricing often perform better than those with discriminatory pricing and that the advantages of uniform-pricing increase with more uncertainty in the production costs.

Many factors contribute to the uncertainty in wholesale electricity markets. One is the intermittent output of renewable production. Another is that a producer has private information about its own production costs. Competitors normally have less information on how the producer operates and maintains its plants. We argue that the market uncertainty is particularly large in hydro-dominated electricity markets when water is scarce in the reservoirs and inflows are small. In such cases, the alternative to produce today could be to store water for several years. Then, the opportunity cost of using water today would depend on a prognosis of the electricity prices several years later, which could be very uncertain. The uncertainty in the opportunity cost is further exacerbated by the risk of drastic and unexpected political decisions during that long storage period.

In this paper, we develop a theoretical model that predicts market prices in electricity markets with regard to market power and market uncertainties. We find that measures that improve market transparency reduce the electricity prices. This gives support to the work by the European Commissions to increase market transparency in European wholesale electricity markets. Moreover, this suggests that political risks deteriorate competition and increase the prices in hydro-dominated electricity markets. To lower this risk, such markets should have clearly defined contingency plans for intervention by the market operator and regulator under extreme system conditions. Such contingency plans could potentially mitigate the extraordinarily high priced-periods that typically accompany low water conditions in hydro dominated bid-based wholesale electricity markets such as California, Colombia, and New Zealand.

Wholesale electricity markets typically use uniform-pricing, where all electricity is traded at the same clearing price. Britain, which is one of the few exceptions, instead uses discriminatory pricing, also called pay-as-bid pricing. In such markets, producers that are

willing to sell at a low price get a worse price than producers that are only willing to sell at a high price, provided that the high-price offers are accepted in the market. We use our model to compare electricity prices in markets with uniform- and discriminatory pricing. We find that electricity prices tend to be lower for uniform-pricing and that the advantages of this market design increase with more uncertainty in the production costs.

In most wholesale electricity markets, each producer indicates how much it is willing to produce at different prices by submitting a stepped supply function to the spot market. Most markets restrict the number of steps that producers can use in their supply functions. Taken together, both a previous study and ours suggest that such restrictions improve market competitiveness, i.e. the mark-ups are lowered. These theoretical results also suggest that market performance is better with stepped supply functions as compared to piece-wise linear supply functions, which are used in the Nordic countries (Nord Pool) and France (Power Next).

Our study focuses on electricity markets, but the implications are similar for the related auctions that central banks and treasuries organize to trade securities. Unlike electricity markets, most central banks use discriminatory pricing. An important exception is the U.S. Treasury, which uses uniform-pricing. Similar to electricity markets, we predict that increased market transparency, switching from discriminatory to uniform-pricing and bidding formats that restrict the number of steps improve the market performance for security auctions.

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Publication December, 2015
Financial Support The Jan Wallander and Tom Hedelius' Research Foundations,
The Torsten Söderberg Foundation,
The Swedish Energy Agency