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The supply function equilibrium and its policy implications for wholesale electricity auctions

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In contrast to most other markets, the way price is determined is very well defined in liberalized wholesale electricity markets. Each producer submits an offer curve that specifies how much it is willing to produce at different prices. Similarly, consumers and retailers (suppliers) submit demand curves specifying how much electricity they want to buy at different prices. An auctioneer then accepts those offers and bids that ensure that demand is met at the lowest price or cost. Market regulators can influence the price formation and how competitive the market will be by their choice of auction design, the level of any price cap, incentives for contracting, and by making restrictions on the offer curves, all of which are discussed in this paper. When making any rule or design change regulators should also consider its likely impact on participants' contracting and investment incentives as these affect the ability to exercise short run market power and longer run price levels.

When electricity is sold at a price exceeding the marginal cost of production from the most expensive plant to operate, there is a deadweight loss – that is a loss to society that arises because consumers value an extra unit of the good at a higher price than it costs to produce it and as a result consume less than would be efficient. In a competitive market the price would equal the marginal cost and the equilibrium would be efficient, in that no other combination of price and output could make everyone better off. In imperfectly competitive markets producers can raise the price above marginal cost to increase profits, but with a consequent deadweight loss to society. The paper examines the size of this welfare loss in a supply function equilibrium where producers choose their supply curves to maximize their profits, given the behaviour of other producers – and in such an equilibrium no producer would wish to change his choice of supply function. The paper finds that typical electricity markets need 5 to10 identical and

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL uncontracted producers (or the equivalent) in order to keep the welfare loss below one percent of aggregate profit.

Empirical and theoretical research has shown that if a large share of electricity is sold as futures (or on forward contracts) competition is improved and the deadweight losses are reduced. This can be achieved by a regulatory framework that gives incentives to producers or consumers to sell/buy more forward contracts. The same effect can also be achieved if consumers coordinate their purchases.

Some countries divulge the individual offer curves submitted by producers, possibly with a lag, while others just publish the aggregate offers and bids. Disclosure (at the least to the regulator) simplifies monitoring competition in electricity markets since any potential mark-up can be calculated indirectly from the theory of profit-maximizing bidding that the paper sets out. In markets with hydro-generated electricity such a policy is of special relevance since the opportunity cost for these producers are based on forecasts and, hence hard to estimate directly. The choice of disclosure regime needs to take care in determining which information is relevant and the timing of disclosure. If not, opportunities for price collusion might occur.

Marginal pricing is the most common form of price setting in the electricity market – that is the auctioneer finds the lowest market clearing price and all suppliers receive the same price regardless of their offers, and all buyers pay the same price regardless of their bids. However, in 2001 Great Britain switched to pay-as-bid pricing for the balancing market (more accurately named a balancing mechanism) in which the system operator buys and sells power to balance supply and demand. In a pay-as-bid auction each accepted offer is paid according to its offer price (and similarly for bids to buy back power from the system operator). There is some theoretical evidence that pay-as-bid pricing results in lower prices for electricity, but the empirical evidence to support this conjecture is lacking. While pay-as-bid pricing supposedly reduces the risk of price collusion it also seems to increase the uncertainty facing agents as well as making it more complicated to bid, something that is especially damaging to smaller agents. This could discourage potential generators from entering the market. Deterring entry and sustaining the existing imperfectly competitive equilibrium could outweigh even the theoretical benefits of lower pay-as-bid pricing.

In order to cover fixed costs (which might amount to a half of total costs) producers need to earn a sufficient mark-up over variable costs, otherwise investment will be discouraged or delayed and will not be socially optimal. In the electricity market this can be solved by allowing the price to rise to a price cap set at a sufficiently high level on the few occasions when there is an appreciable risk of electricity shortages. Another solution would be for producers to be paid a capacity payment that is related to their available capacity (and ideally the loss of load probability). The advantage of such capacity payments would be that socially optimal levels of investments could be achieved at lower price levels (setting the price cap equal to the value of lost load and the actual payment equal to this value times the loss of load probability). This can lower producers' offer curves and improve competition. On the other hand, there is a risk that strategic producers withhold capacity from the market in order to increase the capacity payments if there are too few competing generators. Moreover, it is required that price caps and capacity payments are credible in the long term if an optimal level of investment is to be achieved. As a result we propose that these parameters are to be decided by a politically independent market regulator.

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