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COMPARING PAY-AS-BID AND SYSTEM MARGIONAL PRICING AUCTION IN AN OLIGAPOLY ELECTRICITY MARKET

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Overview

This paper concerns the compasion between a pay-as bid (PAB) auction and a system marginal pricing (SMP) auction in power market. Both PAB and SMP have been used in the balancing market for electric power worldwide. Before 2001, almost all power markets were organzied based on SMP auction. In 2001, the UK market switched from a SMP rule to the PAB auction. After the California energy crisis, a similar switch was put into consideration by many markets including the emerging power market in China. Some researchers suggested that the SMP auction should be in favor of PAB auction based on experience from auction theory and experimental evidence[1-3]. In this paper, the SMP auction and PAB auction is compared within a Supply Function Equilibrium (SFE) framework.

Methods

The SFE framework was introduced by Klemperer and Meyer [4] and developed by Green and Newbery [5]. Traditionally, the SFE framework is used only for SMP rule. In this paper, it was extended to consider the PAB auction.

For deriving the SFE under SMP rule, a firm choose its supply function $q_j(p)$ to maxmize its profit function as below:

$$\pi_i(p,t) = p(D(p,t) - \sum_{j\neq i} q_j(p)) - C_i(D(p,t) - \sum_{j\neq i} q_j(p)) \tag{1}$$

By solving the first-order conditons derived from equation (1), a SFE can be solved as follows:

$$q_i(p) = \left[p - C_i'(q_i(p))\right]\left[-\frac{dD}{dp} + \sum_{j\neq i}\frac{dq_j}{dp}\right] \tag{2}$$

Assuming a linear demand function $D(p,t) = N(t) - \gamma p$, proper cost functions and linear or affine supply function form, one can solve the Linear SFE (LSFE) or Affine SFE (ASFE).

To extend the SFE framework into PAB auction, we can change the profit function into the following form:

$$\pi_i(p,t) = \frac{1}{2} p(D(p,t) - \sum_{j\neq i} q_j(p)) - C_i(D(p,t) - \sum_{j\neq i} q_j(p)) \tag{3}$$

The demand function than can be expressed as

$D(p) = N(t) - \gamma Avg(p)$, where $Avg(p) = \dfrac{\int_0^{p^*} pdq(p)}{q(p^*)}$

is gneration weighted average price under PAB rule.

Based on the assumptions listed above, we can use the SFE framework for comparing the result of SMP auction and PAB auction in power market.

For constrain of space, the detail of deriving SFE is omitted here. For LSFE, the PAB is equatl to SMP that means average price under PAB and SMP is the same. For ASFE, the average price under PAB is slightly lower than that under SMP. A numerical example based on data from Day [6] is presented in the result section.

Results

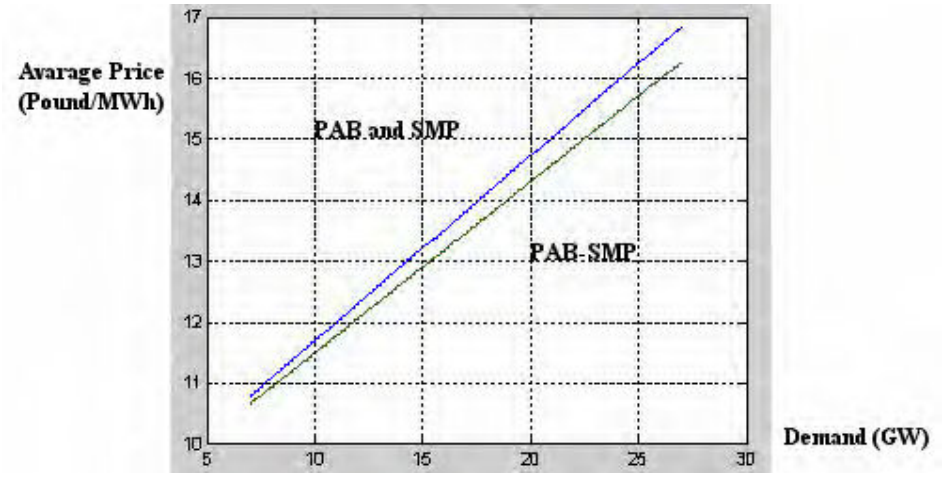

Fig. 1: Comparison of average price between PAB, SMP and PAB-SMP under LSFE

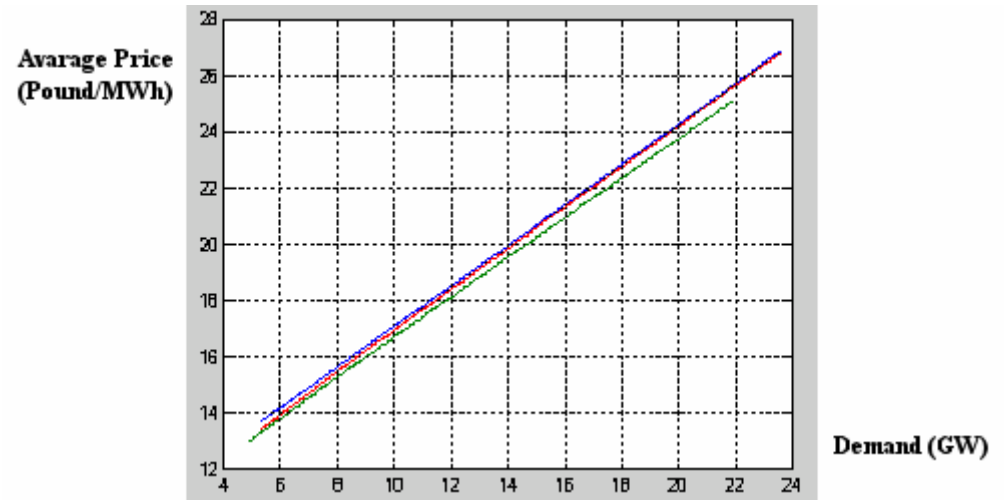

Fig. 2: Comparison of average price between PAB, SMP and PAB-SMP under ASFE: Blue for SMP, Red for PAB and green for PAB-SMP

Conclusions

Based on the SFE model and numerical example, we can conclude that the SMP and PAB auction generate almost the same market clearing output and Average pice.

Our analyis showed that, under uncertain demand, the generators maximize their expcted profit and use their supply function to achieve them. Different auction rules have no impact on these expected profits when giving the generators are risk neural, that is the SMP and PAB are revenue equivalent.