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Open versus closed loop capacity equilibria in electricity markets under perfect and oligopolistic competition

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Abstract— We consider two game-theoretic models of the generation capacity expansion problem in liberalized electricity markets. The first is an open loop equilibrium model, where generation companies simultaneously choose capacities and quantities to maximize their individual profit. The second is a closed loop model, in which companies first choose capacities maximizing their profit anticipating the market equilibrium outcomes in the second stage. The latter problem is an Equilibrium Problem with Equilibrium Constraints (EPEC). In both models, the intensity of competition among producers in the energy market is frequently represented using conjectural variations. Considering one load period, we show that for any choice of conjectural variations ranging from perfect competition to Cournot, the closed loop equilibrium coincides with the Cournot open loop equilibrium, thereby obtaining a 'Kreps and Scheinkman'-like result and extending it to arbitrary strategic behavior. When expanding the model framework to multiple load periods, the closed loop equilibria for different conjectural variations can diverge from each other and from open loop equilibria. We also present and analyze alternative con- jectured price response models with switching conjectures. Surprisingly, the rank ordering of the closed loop equilibria in terms of consumer surplus and market eficiency (as measured by total social welfare) is ambiguous. Thus, regulatory approaches that force marginal cost-based bidding in spot markets may diminish market eficiency and consumer welfare by dampening incentives for investment. We also show that the closed loop capacity yielded by a conjectured price response second stage competition can be less or equal to the closed loop Cournot capacity, and that the former capacity cannot exceed the latter when there are symmetric agents and two load periods.

Index Terms— Generation expansion planning, capacity pre-commitment, noncooperative games, equilibrium problem with equilibrium constraints (EPEC)

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