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LOCATIONAL MARKET POWER IN NETWORK CONSTRAINED MARKET

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Introduction

Market power is the ability of a firm to raise the price of a product above its fair and competitive level. Locational market power is a special kind of market power that arises when locational advantage allows suppliers to act non-competitively. For example, in case of the electricity market, binding transmission constraints can prevent adequate competition. Transmission constraints can create isolated geographic markets where generators can have local monopoly. Such constraints may occur naturally or by manipulation of transmission facilities or generator dispatch patterns [1], [2]. Generators can exert monopoly power over the local load if network topology allows no other suppliers to serve the load. Strategically placed generators or phase shifters can be operated to deliberately congest lines that are needed by the competitors [3], [4]. In this paper, we focus on the issue of locational market power arising out of transmission constraints in the electricity market. We propose a quantifiable definition of locational market power and conduct a detailed analysis of the topological cause of the market power. This study addresses questions of the following kind: (i) Does larger generation capacity imply higher market power? (ii) Can strategic collusive behavior by the generators result in higher market power? (iii) Does average market power of the generator increase with the increase in coalition size? (iv) How do the results differ for elastic demand and supply versus inelastic demand and supply curves? (v) What can the policy maker do to limit the market power of the suppliers?

Data and Methodology

Market Power Definition - Let S be the set of suppliers and B be the set of buyers in a market. For a subset of suppliers S' and a subset of buyers B', let E(S', B') be the amount of realized exchange in the market if only S' and B' participate. For any supplier s, its market power, denoted by MP(s), is defined as the decrease in realizable exchange if s does not participate in the market, i.e., MP(s) = E(S, B) - E(S-s, B). If a subset A of suppliers, called a coalition, opts out of the market, their collective market power is defined as MP(A) = E(S, B) - E(S-A, B).

Our study uses the power grid of Portland, Oregon. It includes the topological locations of generators (suppliers) and consumers, and the transmission lines along with their capacities. Portland grid has 755 lines and 662 nodes. Of these nodes, 328 are load serving nodes and 41 are generator nodes. To compute the realizable power delivery for a subset S' of generators, we connect each participating generator from S' to a source node s with link capacity equal to its generating capacity, and connect each consumer to a sink node t with link capacity equal to its demand. We then compute the maximum possible flow from node s to t. We use real generator capacity data from the US Department of Energy website, to assign capacities to the suppliers. The demand data is generated from the consumer peak demand for the summer of year 1999 available from the FERC website. We study four scenarios using elastic and inelastic demand-supply. For all scenarios, we first compute the market power of each supplier and then the market power of different coalitions. For each coalition size (up to 6), we compute the market power of each possible combination in the coalition. We compare and analyze the market power distributions of these different coalition sizes. We determine the mean and maximum market power and analyze how they change with the coalition size and market clearing price.

Results and Conclusions

The findings of our study are summarized below.

1. The large sized generators do not necessarily have the locational advantage and hence locational market power. In the presence of transmission constraints, opportunities exist even for small suppliers to exercise market power and be price makers.

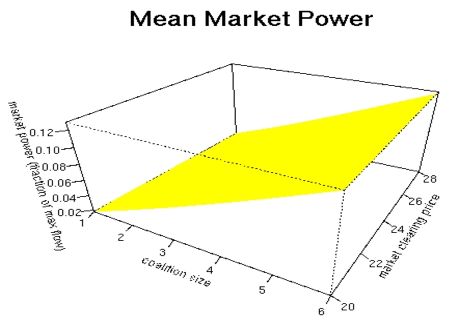
2. Strategic collusion between generators can significantly increase the size of market power. The empirical results show that in the case of Portland, a strategic coalition of just 2 generators can result in control of over 30% of the transmission flow. A coalition size of 6 generators can result in control of almost 80% of the market. Our analysis shows that a merger of even a small number of generators, none of them being very large in terms of its production capability, can create significant non-competitive conditions in the market.

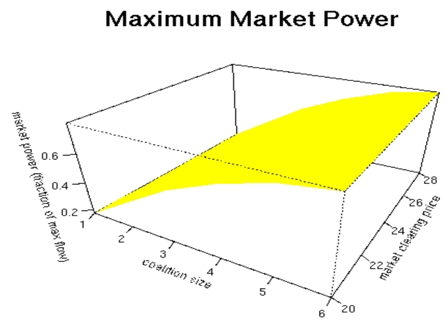
3. The mean and maximum market power always go up with the coalition size.

4. In the case of Portland, we find that the mean, median and maximum market power go up with the market clearing price. However, this may not be true for a different grid topology and market configuration.

5. Generators that belong to the most powerful size k coalition are also members of the most powerful size (k+1) coalition.

The figures below show plots of the mean and maximum market power against coalition size and the market clearing price. For interested readers, a complete set of plots and histograms have been made available at http://staff.vbi.vt.edu/chenj/market.power.plot.pdf





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