Market Power Analysis in the Presence of Transmission Constraints

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Presentation Outline

- Definition of Market Power
- How and why it is an issue?
- Competition or Regulation
- Measurement of Monopoly Power
- Model-based Approach
- Illustrative Examples
What is Market Power?

*Definition*: Ability of single firm or group of competing firms in a market to profitably raise prices above competitive levels and restrict output below competitive levels for a sustained period of time.
Mitigation of market power is essential for successful implementation of the de-regulation of the electric power industry.

Important for

- the consumers to realize the benefits of de-regulating the industry, and
- for efficient operation of generation market.
Vertical Market Power

- Same entity owns resources across production levels (generation, transmission, distribution).
- Structural solutions to vertical market power require vertical disintegration or functional unbundling (GenCo, TransCo, DistCo) while maintaining the transmission system regulated (Transmission Open Access).
- TransCos and/or ISOs are a major step in addressing vertical market power problems.
Horizontal Market Power

- Same entity owns resources at the same production level (generation).
- Transmission open access with RTOs mitigates some of the institutional horizontal market power problems (eliminate pancaking, increases competing capacity).
- There is no general structural solution that fits all areas.
- Requires detailed analysis on a case by case basis using a standard approach focusing on profitability of strategic behaviour.
Non-Cooperative Oligopoly

Definition:
- few relatively large firms
- modest or high entry barriers
- mutual interdependence of firms
- similar or identical products
Regulation vs. Market

- Regulation at its best can reach the outcome of competitive markets.

- Willing to live with less than perfect competitive markets (workably competitive) if the social welfare loss is less than the cost of regulation
  - “Choice between imperfect and costly regulation versus market imperfections”

- It is preferable to have:
  - Market-based mitigation options, and
  - Minimal residual regulation when none of market-based mitigation options work.
Structural Indices

- **Structural concentration: Herfindahl-Hirschman Index (HHI).**
  - Sum of squares of market shares
  - Acceptable levels (1000-1800)
- **Market shares (one criterion would be less than 30%)**
- **How good are these indices?**
  - do not take into account potential competition or market realities such as transmission constraints, and
  - cannot capture potential strategic behaviour.
Behavioral Indices

- Lerner Index is a measure of the prices above competitive levels (Price-Cost Margin Index):

\[ L_i = \frac{(P_i - C_i)}{P_i} = \frac{1}{\varepsilon_i^d} \]

\( \varepsilon_i^d \) is the elasticity of demand facing the firm i
Behavioral Analysis

◆ Should capture
  – Short-term as well as medium-term and long-term dynamics
  – Barriers to entry (or lack of) and other market realities
  – Transmission constraints
Profitability & Market Equilibria

- Behavioral analysis measures increase in **profitability** under different market equilibria.

- **Nash**: A player maximizing its own payoff given the strategies followed by all opposing players (General equilibrium)
  - **Cournot**: Set of outputs for which each firm maximizes profit given the outputs of the remaining firms
  - **Bertrand**: Set of outputs for which each firm maximizes profit given the prices of the remaining firms
  - **Supply Function**: Set of outputs for which each firm maximizes profit given the supply curves of the remaining firms
Strategic Bidding- Strategy One

- **Strategy One: Bid up to the next unit in the merit order.**

- This strategy increase generators profits without risking losing revenues, since same unit merit order is maintained.
Strategic Bidding- Strategy Two

- Bid up to the next owner in the merit order.
- Generation companies can increase market clearing prices without risking losing any profits since they are maintain the same company merit order.

<table>
<thead>
<tr>
<th>Quantity (MW)</th>
<th>Price S</th>
<th>Price C</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/MWh</td>
<td></td>
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</tbody>
</table>

Demand

MW

Quantity

A A
Strategic Bidding - Strategy Three

- Bid up anticipating that your competitors will follow a strategy (any of the above strategies).
Equilibrium Strategies

- The SFE approach is a sophisticated form of strategy three where the units maintain the same unit merit order.
- Cournot equilibrium involves changing the merit order and effectively withdrawing capacity.
- Prof. Hogan adds strategic behavior by transmission right owners.
Generation Capacity Withholding

- Generation companies have incentives to withhold capacity and increase market clearing prices only if they can increase their profits.

- Generation company increase their profits by withholding units only if the increase in revenues is higher than the lost opportunity costs.
Profitability for BlueCo

[$/MWh$]

Demand

Price

$/MWh$

Price

Demand

Opportunity cost

Increase in profits

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A generation company may profitably withhold capacity or strategically bid if any of the following is true:

- it owns many generating units and has a relatively large market share
- its units are strategically located on the supply curve (many base-load and marginal units)
- it can implicitly collude with other generating companies to reach a market equilibrium
Ownership of Generation Units
Load Histogram

Summer Load

Frequency (hours)

< 25000  25-30000  30-35000  35-40000  40-45000  45-50000  50-55000  > 55000

Loads

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Ownership of Marginal Units

Marginal Units

- Company 1: 1%
- Company 2: 2%
- Company 3: 0%
- Company 4: 1%
- Company 5: 11%
- Company 6: 3%
- Company 7: 0%
- Company 8: 3%
- Company 9: 0%
- Company 10: 19%
- Company 11: 8%
- Company 12: 2%
- Company 13: 5%
- Company 14: 2%
- Company 15: 0%
- Company 16: 0%
- Company 17: 0%
- Company 18: 8%
- Company 19: 3%
- Company 20: 1%
- Company 21: 28%
- Company 22: 2%
MAPS-Based Modeling

- **Hypothesis:** Company GEN$ can exercise market power by increasing its bids
  - Use a market power model (Nash equilibrium) to determine bidding strategy

- **Test Hypothesis given market, generation, transmission system and regulatory conditions**
  - Use bids provided by the market power model in MAPS
  - Determine profits and validate the strategy with transmission constraints
Overview of MAPS Modeling Process

- **TCA obtains the MAPS databases from GE and**
  - Validates against reliable, public, sources
  - Validates against the Client database

- **MAPS Database**
  - Load forecast
  - Thermal units characteristics
  - Fuel price forecast
  - Transmission system representation
  - Conventional hydro and pump storage units
  - Supply curves for neighboring systems
Illustrative Example
Identify Major Interfaces (Geographic Markets)

State A

Zone 1

Zone 2

Zone 3

Zone 4

1000 MW

500 MW

800

1000

2000

1000
Scenario Analysis

- **Base Case runs**: All units in region bid “competitively” with bids set at marginal costs.
  - to validate MAPS assumptions and outputs against practical judgement
  - also to provide detailed data for comparison and analysis of scenarios

- **Market Power and Mitigation Runs** are performed to examine the degree of market power and the ability to mitigate
  - **Market Power Case**: All non-GEN$ units bid as in base case, but GEN$ units bid higher trying to exercise market power, OR all units bid strategically. Ownership as in Base Case
  - **Mitigation Case**: GEN$ bidding continues to bid high, but some (Y%) of its plants are divested or regulated (cost-based bids or must-run contracts)
Market Power and Mitigation Effect

Margins shown are for that subset of units which is retained by GEN$ during the mitigation case, but are consistent with the results using all units.

<table>
<thead>
<tr>
<th>Avg. Margin ($/MWh)</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
</tr>
<tr>
<td>$5.42</td>
<td>$14.42</td>
</tr>
</tbody>
</table>
Energy Prices

Average Daily Prices by Zone - Base Case

Average Daily Prices ($/MWh)

Day

Zone 1

Zone 2

Zone 3

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Energy Prices by Scenario

Average Daily Prices

Average Daily Prices ($/MWh)

Day

1/1/02  2/1/02  3/1/02  4/1/02  5/1/02  6/1/02  7/1/02  8/1/02  9/1/02  10/1/02  11/1/02  12/1/02

Base Case  Market Power Case  Mitigation Case
Interface Flows

Average Daily Flows

- Base Case
- Market Power Case
- Mitigation Case

Day

Average Daily Flows (MW)
## Congested Transmission Interfaces

### Interface Loading Levels

<table>
<thead>
<tr>
<th>Interface</th>
<th>Capacity (MW)</th>
<th>INT 1</th>
<th>INT 2</th>
<th>INT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Case</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Factor 100% (% of yr)</td>
<td>0.0%</td>
<td>2.5%</td>
<td>0.8%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;80% (% of yr)</td>
<td>10.0%</td>
<td>10.0%</td>
<td>8.0%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;50% (% of yr)</td>
<td>80.0%</td>
<td>20.0%</td>
<td>20.0%</td>
<td></td>
</tr>
<tr>
<td><strong>Market Power Case</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Factor 100% (% of yr)</td>
<td>15.1%</td>
<td>0.1%</td>
<td>9.3%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;80% (% of yr)</td>
<td>70.0%</td>
<td>20.0%</td>
<td>30.0%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;50% (% of yr)</td>
<td>95.0%</td>
<td>30.0%</td>
<td>90.0%</td>
<td></td>
</tr>
<tr>
<td><strong>Mitigation Case</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Factor 100% (% of yr)</td>
<td>2.2%</td>
<td>0.5%</td>
<td>6.3%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;80% (% of yr)</td>
<td>40.0%</td>
<td>15.0%</td>
<td>30.0%</td>
<td></td>
</tr>
<tr>
<td>Load Factor &gt;50% (% of yr)</td>
<td>85.0%</td>
<td>25.0%</td>
<td>70.0%</td>
<td></td>
</tr>
</tbody>
</table>
### Detailed MAPS Results

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Market Power Case</th>
<th>Mitigation Case</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plants to be retained</td>
<td>Plants to be divested</td>
<td>Plants to be retained</td>
</tr>
<tr>
<td>Planted Plants</td>
<td>All Plants</td>
<td></td>
<td>All Plants</td>
</tr>
<tr>
<td>Sum of Generation (GWh)</td>
<td>1,050</td>
<td>1,340</td>
<td>2,390</td>
</tr>
<tr>
<td>Sum of Fuel by Gen ($K)</td>
<td>$13,535</td>
<td>$16,400</td>
<td>$29,935</td>
</tr>
<tr>
<td>Sum of O&amp;M ($K)</td>
<td>$920</td>
<td>$1,755</td>
<td>$2,675</td>
</tr>
<tr>
<td>Sum of Generation Cost ($k)</td>
<td>$14,500</td>
<td>$18,160</td>
<td>$32,660</td>
</tr>
<tr>
<td>Sum of Energy Revenue ($K)</td>
<td>$19,890</td>
<td>$24,400</td>
<td>$44,290</td>
</tr>
<tr>
<td>Sum of Energy Margin ($K)</td>
<td>$5,430</td>
<td>$6,240</td>
<td>$11,670</td>
</tr>
<tr>
<td>Avg. Revenue ($/MWh)</td>
<td>$18.94</td>
<td>$18.21</td>
<td>$18.53</td>
</tr>
<tr>
<td>Avg. Margin ($/MWh)</td>
<td>$5.17</td>
<td>$4.66</td>
<td>$4.88</td>
</tr>
</tbody>
</table>
Market-based Remedies (Mitigation)

- Regulation should be minimal
- Price caps
- Divestiture
- Must-run cost-based bids
- Control delegation (long-term operation control)
- Contract for differences
- Transmission reinforcements
- Transmission rights for load
Are Electric Generation Markets Contestable?

- Contestability: Little entry and exit costs
- Long term equilibrium: contestable markets are equivalent to Bertrand equilibrium where prices are capped at the cost of new entry or long-run average cost
- How much contestable?
- Are there barriers to entry?
- What about new generation technologies? Distributed generation?
Where is the Cutoff?

- Where do you draw the line between economic rent and market power rent?
- If the market is competitive with no significant barriers to entry would not the average price be naturally capped by the long-run cost of energy production? If it is higher, it is an invitation for new entry.
Conclusions

- An accurate representation of the electricity markets including physical, operation and market design constraints is essential for proper analysis of market power in these markets.

- Transmission constraints are very important in defining geographic markets.

- Structural indices are not a good measure of market power in the presence of transmission constraints.

- The most effective solution to market power is elimination of barriers to entry especially transmission related barriers (new interconnection and open access).