Predicting Market Power Using the Residual Supply Index

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Motivation and Objectives

Two sets of metrics to monitor market power

• Measure of Market Power Impact (Price-cost markup. Studies cited above)

• Indicators of Market Structure:
  • N-firm concentration or 20% Market Share
  • Traditional HHI
  • Pivotal Supplier Indicator, SMA indicator
  • Residual Supply Index (RSI)

What is the more accurate predictor of market power in electric markets?

• Theoretical analysis and empirical study can provide guidance
Development of Residual Supply Index

Inadequacy of HHI and n-firm concentration index for electricity markets

- HHI index below 2000 can mean significant price-cost markups
- 1-firm concentration below 20% (market based rate screen) but many firms can bid to inflate prices

Need for indicators which reflects three key factors affecting market outcomes: (1) Demand, (2) Total available supply and (3) Large suppliers’ capacity share and contract position
Pivotal Supplier Indicator

Pivotal Supplier Indicator -- A first attempt to capture the three key factors

A binary variable: whether or not a supplier is pivotal in the market given the hourly supply and demand situation. Or without this supplier, can the residual supply meet the demand?

Significant improvement in predicting market power over traditional indicators

SMA is a form of pivotal supply indicator applied to annual peak condition

Insufficiency of binary variable: ability to exercise market power when pivotal supply index close to but less than pivotal

Extract further information: The RSI index
Definition of Terms in Residual Supply Index

\[ RSI = \frac{(\text{Total Supply} - \text{Largest Seller’s Supply})}{(\text{Total Demand})} \]

Total Supply = Total in-state supply capacity + Total net import

1. Total in-state supply Capacity = Thermal capacity [P_max – outage] + Must_Take_mw
   
   Note: Must_Take_mw includes all the other generators, such as hydro, nuclear, and cogeneration. It is measured as:
   
   Max [Energy bid in the market, Metered output]

2. Total net import consists of total net hour-ahead schedule, import through real-time imbalance market, and OOM calls, and measured as: Max [Scheduled, metered]

Total demand = Metered Load + Purchased Ancillary Service

Largest Seller’s Supply: Largest Seller’s Capacity – It’s Contract Obligation to Load
Explanation of Estimation Results

Significant correlation between the Lerner Index, RSI, and actual system load
RSI compared with Pivotal Supplier Index

Pivotal Supplier Index (and SMA) shows whether the residual supply is sufficient to meet market demand (binary index of 0 or 1)

RSI shows additional information of what the ratio of residual supply relative to demand is

![Graph showing RSI compared with Pivotal Supplier Index]

- More market power
- Less market power

RSI or Pivotal

Residual supply / Demand

Pivotal Supply Index

1.0
Economic Rationale for RSI

Based on oligopoly pricing models (such as Green and Newberry, 1992)

\[ P_i - MC_i = Q_i \left( \frac{dSr(p)}{dp} - \frac{dD(p)}{dp} \right); \]

- \( P_i \): bid price for \( Q_i \) units of supply
- \( MC_i \): marginal cost for \( Q_i \) units of supply
- \( D(p) \): total demand at the price of \( p \)
- \( Sr \): supply from all suppliers other than firm i (residual supply)

- \( Q_i \) has a positive effect on price-cost markup
- Residual Supply elasticity has a negative effect on markup
- Demand elasticity has a negative effect on markup

Empirically, RSI and load are used to predict price-cost markup (demand elasticity is negligible currently, and can be incorporated later)
### Illustration of RSI Computation for Entire Market in the Peak Hour

**2000-2002**

<table>
<thead>
<tr>
<th>Year</th>
<th>Demand (MW)</th>
<th>Total Supply</th>
<th>Total Supply*</th>
<th>Largest Supplier Capacity**</th>
<th>RSI Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Demand</td>
<td>Thermal Capacity</td>
<td>Imported Energy</td>
<td>(MW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(MW)</td>
<td>(MW)</td>
<td>(MW)</td>
<td>(MW)</td>
</tr>
<tr>
<td>2000</td>
<td>50,421</td>
<td>23,995</td>
<td>17,798</td>
<td>2,386</td>
<td>47,443</td>
</tr>
<tr>
<td>2001</td>
<td>45,197</td>
<td>21,674</td>
<td>19,186</td>
<td>2,309</td>
<td>47,155</td>
</tr>
<tr>
<td>2002</td>
<td>48,070</td>
<td>21,019</td>
<td>20,036</td>
<td>7,353</td>
<td>49,474</td>
</tr>
</tbody>
</table>

* Total supply is slightly higher than the sum of musttake, thermal capacity, and imported energy because we also account for loss adjustment.

** Largest suppliers (not the same) on peak hour did not have any contract cover.
RSI Calculations for All Hours
Duration Curve for Three Years
June-September, 2000-2002

RSI indexes

RSI_2000
RSI_2001
RSI_2002

frequency
Application 1: Simple Screening Rule for Market Competitiveness using RSI

We propose an RSI screen (numbers are for discussion purpose only)

RSI must not be less than 110% for more than 5% of the hours in a year (about 438 hours); or

RSI must be more than 110% for 95% of the hours in a year

Features of the RSI Screen Test

Rather than the peak hour, RSI index is computed for all hours in a year
Application 2: Using RSI screen for market-based rate screening -- Individual supplier’s market power

FERC has used HHI to determine market based rate authority
Recently, FERC proposed Supply Margin Assessment (SMA) screen

*If a Supply is pivotal during the annual peak hours, the supply does not pass the SMA screen test*

Similar to the RSI index

Weakness of SMA

Overly restrictive and disqualifies a supplier for a single hour (peak hour)

Does not account for operating reserve margin requirement

Ignores the net buyer or seller position of a supplier and the possible collusion between suppliers
Advantages of Using the RSI Screening Test

Allows for some hours where the threshold are exceeded to leave room for price fluctuation to reflect market situation, signal for conservation and new investment.

Higher threshold of 110% accounts for possible collusion.

Nets out capacity contracted to load under long-term fixed prices.

Allows distinction between net buyers and net sellers in the markets.

Threshold can be adjusted based on actual market experience.
Application 2: Using RSI screen to assess individual supplier’s market power

An Illustration of a RSI Screen Test: % hours less than 110%

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Year 2000</th>
<th>% of Hours</th>
<th>RSI Screen</th>
<th>With 5,050 MW additional capacity</th>
<th>% of Hours</th>
<th>RSI Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier 1</td>
<td>19.5%</td>
<td>Fail</td>
<td>4.3%</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier 2</td>
<td>20.8%</td>
<td>Fail</td>
<td>4.6%</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier 3</td>
<td>21.9%</td>
<td>Fail</td>
<td>5.2%</td>
<td>Fail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier 4</td>
<td>22.6%</td>
<td>Fail</td>
<td>5.5%</td>
<td>Fail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier 5</td>
<td>23.3%</td>
<td>Fail</td>
<td>5.9%</td>
<td>Fail</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Other Applications of RSI

• Using RSI to evaluate new transmission investment
  – Compare market power impact with and without transmission upgrade based on RSI simulation

• Capacity reserve required for competitive market
  – Using RSI simulation to evaluate system with different reserve level
Summary and Future Work

The RSI Index is a simple and effective tool in monitoring market power
High accuracy in predicting market power and many applications
The RSI index has its limitations:
   No explicit consideration for the congestions within the area where RSIs are computed
Encourage more investigation on the relationship between the RSI indexes and price-cost markup in other spot markets and forward markets