Locational Market Power in Network Constrained Markets

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Quantifying transmission-level market power

"Seller i has P_i units of market power if the demand that can be supplied in the absence of i decreases by P_i."

Similarly, we can define the market power P_S of a group S of sellers by viewing them as a single entity.

Example. If demand $D = 10$

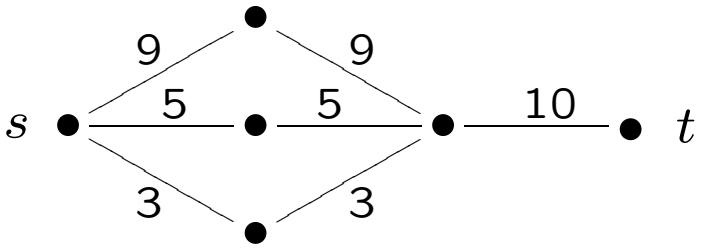
and 3 sellers can supply $s_1 = 9$, $s_2 = 5$, $s_3 = 3$,

then they have market power $P_1 = 2$, $P_2 = 0$, $P_3 = 0$,

and moreover, $P_{12} = 7$, $P_{13} = 5$, $P_{23} = 1$, $P_{123} = 10$

Theorem. Market power is supermodular.

Network Model



s is a "super-source"

t is a "super-sink"

Now, fulfilling the total demand of $D = \sum d_i$ amounts to finding a concurrent feasible network s-t flow of capacity D.

Questions

- How bad can market power get by forming coalitions?
- How does locational topology affect market power?
- How does market power behave over a real-world network?
- How does supply and demand elasticity affect market power?

Experiments

Used the power grid of Portland, Oregon.

776 lines, 662 nodes (319 load-serving, 41 generators)

Peak demand: 6986.62 MW.

4 scenerios: Each of supply and demand can be elastic or inelastic.

Inelastic supply, inelastic demand

Generators are described by two characteristics:

1. Production capacity

2. Location on the network

- A generator' production capacity and market power are surprisingly *not* strongly correlated.

- A generator's degree and market power are highly correlated (the top 8 of each are identical!)

Generator 98: Controls 15% of capacity, has 0.1% market power.

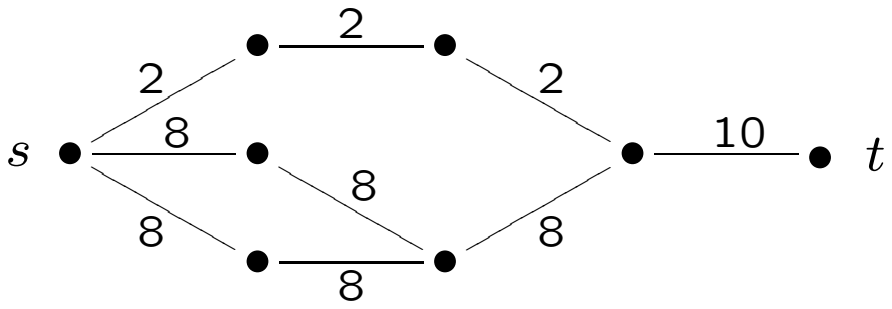
Generator 83: Controls 10% of capacity, has 60% market power.

Generator 130: Controls 1.34% of capacity, has 10.16% market power.

Market power under coalitions

Experimentally: Generators that belong to the most powerful size-k coalition are also members of the most powerful size-$(k+1)$ coalition.

This *fails* in general:



$D = 10,\ P_1 = 2,\ P_2 = 0,\ P_3 = 0$

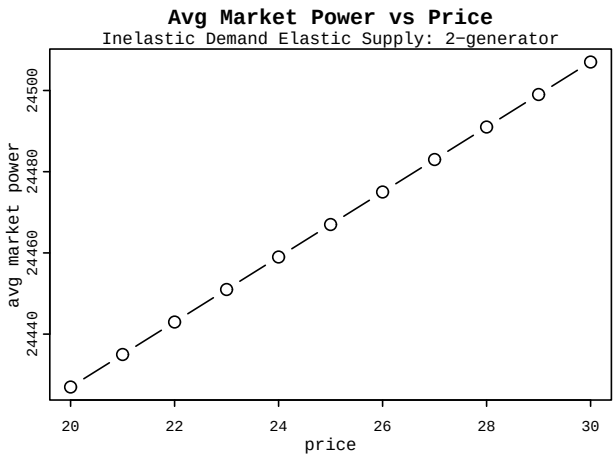
$P_{12} = 2,\ P_{13} = 2,\ P_{23} = 8$

Larger coalitions

- The top-20 size-3 coalitions all have at least 70% market power.
- The top-20 size-4 coalitions all have at least 79% market power.
- The top-20 size-5 coalitions all have at least 87% market power.
- The top-20 size-6 coalitions all have at least 90% market power.

Elasticity and market power

- Demand elasticity is negatively correlated with market power.
- Supply elasticity is positively correlated with market power.
- Supply is more elastic than demand, thus market power is positively correlated with the MCP.


Avg Market Power vs Price
Inelastic Demand Elastic Supply: 2−generator
avg market power
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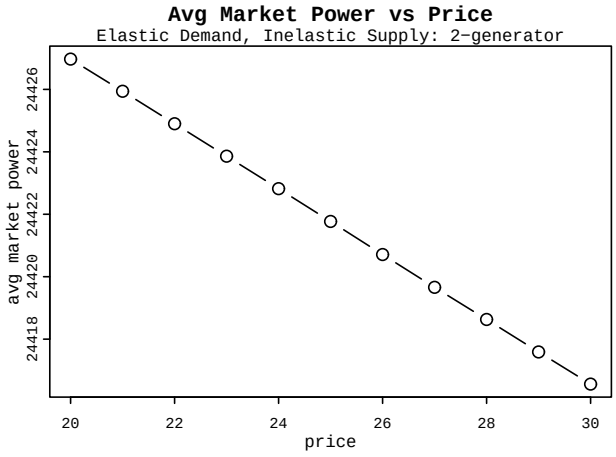
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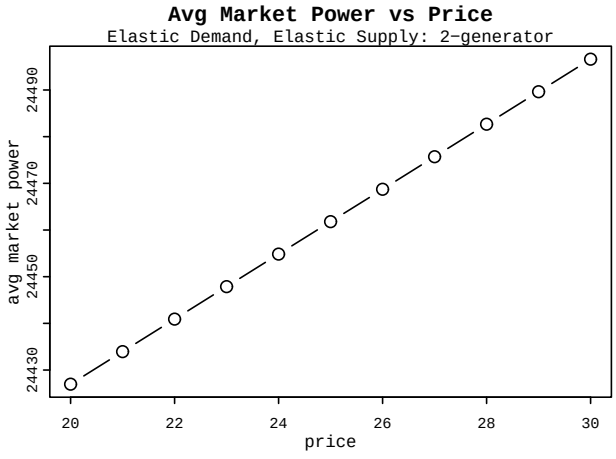
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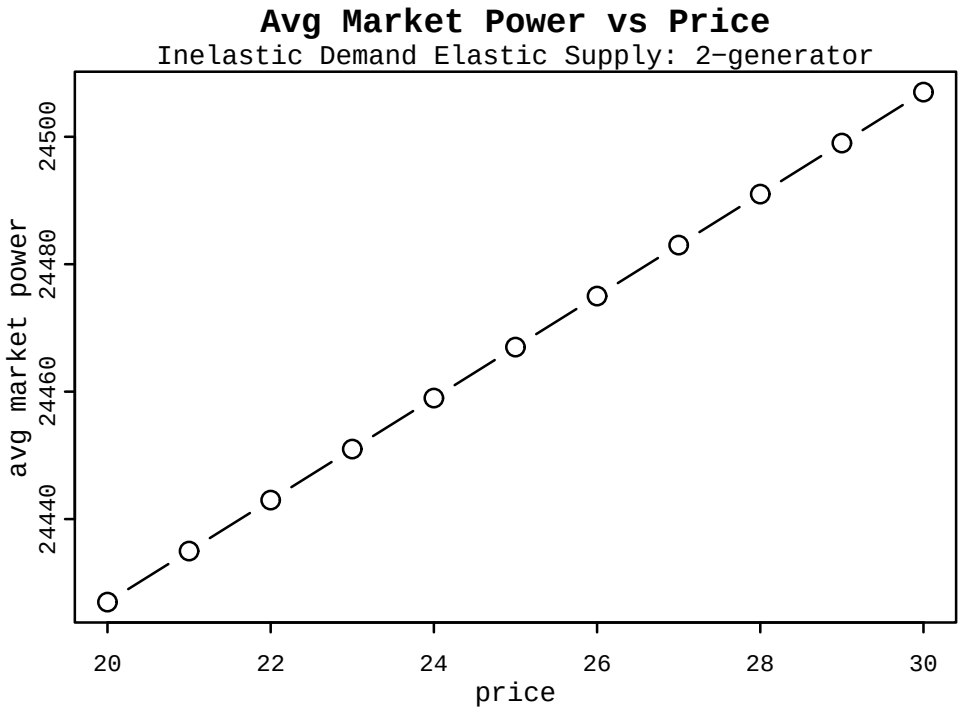
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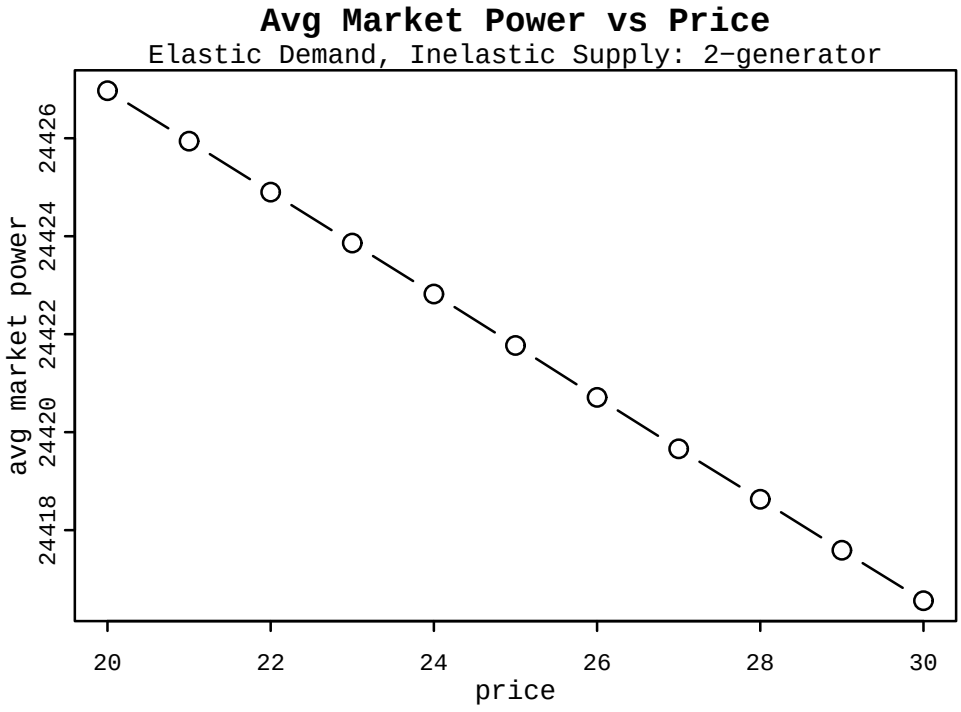
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