The Role of a Market Maker in Networked Cournot Competition

Desmond Cai

Joint work with S. Bose, A. Wierman, S. Low
Electricity markets today

$G_i$ offers supply function $c(s_i)$
$L_i$ bids demand function $u(d_i)$
Electricity markets today

\[
\text{Market operator solves:} \\
\max \sum_i (u(d_i) - c(s_i)) \\
\text{s. t.} \quad s_i = d_i + \sum_{i \rightarrow j} f_{ij} \\
\text{power flow constraints} \\
\text{capacity constraints} \\
\text{line constraints}
\]

\(G_i\) offers supply function \(c(s_i)\)
\(L_i\) bids demand function \(u(d_i)\)
Electricity markets today

Market operator solves:

\[
\max \sum_i (u(d_i) - c(s_i))
\]

subject to

\[
s_i = d_i + \sum_{i\rightarrow j} f_{ij}
\]

power flow constraints

capacity constraints

line constraints

Allocations: \(d_i^*, s_i^*\)

Locational marginal prices: \(\lambda_i^*\)
Market manipulation is costly

Market operator solves:

\[
\max \sum_i (u(d_i) - c(s_i))
\]

\[s_i = d_i + \sum_{i \to j} f_{ij}\]

s. t. power flow constraints
capacity constraints
line constraints

Allocations: \(d_i^*, s_i^*\)
Locational marginal prices: \(\lambda_i^*\)

Bid and offer curves are strategic variables – may not be truthful!
Market manipulation is costly

Market operator solves:

$$\text{max} \sum_i (u(d_i) - c(s_i))$$

s. t. $s_i = d_i + \sum_{i \to j} f_{ij}$

power flow constraints
capacity constraints
line constraints

Allocations: $d_i^*, s_i^*$
Locational marginal prices: $\lambda_i^*$

Bid and offer curves are strategic variables – may not be truthful!

Inefficiency

- 2000-01 California electricity crisis (40-45 billion)
- 2012 J.P. Morgan (125 million)
- Undetected market manipulation?
Market manipulation is costly

Market operator solves:

\[
\max \sum_i (u(d_i) - c(s_i))
\]

\[s_i = d_i + \sum_{i \rightarrow j} f_{ij}\]

s. t. power flow constraints
capacity constraints
line constraints

Bid and offer curves are strategic variables – may not be truthful!

Inefficiency

- 2000-01 California electricity crisis (40-45 billion)
- 2012 J.P. Morgan (125 million)
- Undetected market manipulation?

Allocations: \(d_i^*, s_i^*\)
Locational marginal prices: \(\lambda_i^*\)

Options:
Modify allocation function
Modify pricing mechanism (e.g. VCG)
Alternative market clearing objectives

Market operator solves:

\[ \max \sum_i (u(d_i) - c(s_i)) \]

subject to:

\[ s_i = d_i + \sum_{i\rightarrow j} f_{ij} \]

power flow constraints
capacity constraints
line constraints

Allocations: \( d_i^*, s_i^* \)
Locational marginal prices: \( \lambda_i^* \)
Alternative market clearing objectives

Market operator solves:

$$\max \sum_i (u(d_i) - c(s_i))$$

s.t. $s_i = d_i + \sum_{i\rightarrow j} f_{ij}$

power flow constraints
capacity constraints
line constraints

Allocations: $d_i^*, s_i^*$
Locational marginal prices: $\lambda_i^*$

➢ Social welfare
➢ Consumer surplus
➢ Residual social welfare
Alternative market clearing objectives

- Social welfare
- Consumer surplus
- Residual social welfare

Load pays: $P_L F$
Generator receives: $P_G F$
Alternative market clearing objectives

- Social welfare
- Consumer surplus
- Residual social welfare

Load pays: $P_L F$
Generator receives: $P_G F$
Alternative market clearing objectives

- Social welfare
- Consumer surplus
- Residual social welfare

Load pays: $P_L F$
Generator receives: $P_G F$
Alternative market clearing objectives

- Social welfare
- Consumer surplus
- Residual social welfare

Load pays: $P_L F$
Generator receives: $P_G F$
Findings
Findings

1. Equilibrium may not exist under certain market maker objectives.
Findings

1. Equilibrium may not exist under certain market maker objectives.

2. Different market maker objectives may lead to completely different market outcomes.
Findings

1. Equilibrium may not exist under certain market maker objectives.

2. Different market maker objectives may lead to completely different market outcomes.

See poster for details!