Dynamic competition and arbitrage in electricity markets: The role of financial traders

Ignacia Mercadal

Columbia University

July 24, 2018

NBER SI - EEE Workshop
The role of financial speculators is controversial

Commodity markets

- Increase liquidity and informational efficiency.
- Blamed for higher prices in oil, food, electricity.
- Accused of price manipulation in several markets.
  - US Senate investigation: Aluminum, oil, uranium
  - Electricity: Louis Dreyfus (Midwest)
  - Onion Futures Act (1958)
The role of financial speculators is controversial

Commodity markets

- Increase liquidity and informational efficiency.
- Blamed for higher prices in oil, food, electricity.
- Accused of price manipulation in several markets.
  - US Senate investigation: Aluminum, oil, uranium
  - Electricity: Louis Dreyfus (Midwest)
  - Onion Futures Act (1958)

Are financial traders bad for markets?
This paper: Are financial traders bad for consumers?

Midwest wholesale electricity market

1. Physical and financial traders in the same market
2. Quasi-exogenous variation in financial trading
3. Detailed dataset on firm behavior
This paper: Are financial traders bad for consumers?

Midwest wholesale electricity market

1. Physical and financial traders in the same market

2. Quasi-exogenous variation in financial trading
   
   Regulatory change lead to a sharp increase in financial trading.

3. Detailed dataset on firm behavior
This paper: Are financial traders bad for consumers?

Midwest wholesale electricity market

1. Physical and financial traders in the same market

2. Quasi-exogenous variation in financial trading

3. Detailed dataset on firm behavior
   - Bid data for physical and financial traders
Deregulated wholesale electricity markets

Generation
Sellers

Transmission
Market operator

Distribution
Buyers

ISO - Independent System Operator
Deregulated wholesale electricity markets

Generation

Transmission

Distribution

Sellers

Market operator

Buyers

Financial sellers

ISO - Independent System Operator

Financial buyers
Wholesale electricity markets: market operation

Sequential market

Timing

- **Forward market**: schedules production a day in advance.

- **Spot market**: balances demand and supply.
Physical and financial players

Physical sellers

- Produce electricity
- Intertemporal price discrimination (Ito and Reguant, 2016)
  - Withhold sales in the forward market
  - Results in a forward premium

Financial or virtual traders

Do not own physical assets

Compete with physical producers: "virtually" arbitrage

Forward premium

\[ \Pi = (P_F - P_S)Q \]
Physical and financial players

Physical sellers

- Produce electricity
- Intertemporal price discrimination (Ito and Reguant, 2016)
  - Withhold sales in the forward market
  - Results in a forward premium

Financial or virtual traders

- Do not own physical assets.
- Compete with physical producers: “virtually” arbitrage.
- Forward premium $\Rightarrow$ sell in the forward and buy in the spot

$$\Pi = (P^F - P^S)Q$$ (1)
Regulatory change

Before April, 2011

- Positive forward premium
- Virtual supply profits: $\pi = P_F - P_S - c$
- Changes $c$ were as high as the premium $\Rightarrow$ Arbitrage was limited
Regulatory change

Before April, 2011

- Positive forward premium
- Virtual supply profits: $\pi = P_F - P_S - c$
- Changes $c$ were as high as the premium $\Rightarrow$ Arbitrage was limited

April, 2011

- Charges significantly decreased.
- Proposal submitted on December 1, 2010 (Announcement)
Result 1: Financial trading increased
Financial traders response to the regulatory change

Monthly virtual volume

% of load

Monthly virtual volume

% of load

2009 2010 2011 2012 2013
Result 1: Financial trading increased

Financial traders response to the regulatory change

Breakpoint: April 9, 2011
Result 2: Producers withholding decreased
Result 2: Producers withholding decreased
Result 2: Producers withholding decreased

Breakpoint: Jan 10, 2011 (1/5, 1/15)  
Financial trading: April 9, 2011
Result 2: Producers withholding decreased
Result 2: Producers withholding decreased
Result 2: Producers withholding decreased

Generators withholding

- Announcement
- Implementation

GWS

2009 2010 2011 2012 2013
Hypotheses

Null: Static Nash equilibrium

- Firms play static best response to the competitive conditions they face.

- **Alternative:** Dynamic equilibrium
  - Do they exert more or less market power than under the static best response?
    1. Tacit collusion
       - Firms do not play static best response: they act as if the market were less competitive than it is.
    2. Entry deterrence
       - Firms do not play static best response: they act as if the market were more competitive than it is.
Hypotheses

Null: Static Nash equilibrium

- Firms play static best response to the competitive conditions they face.

Alternative: Dynamic equilibrium

Do they exert more or less market power than under the static best response?

1. Tacit collusion
   - Firms do not play static best response: they act as if the market were less competitive than it is.
Hypotheses

Null: Static Nash equilibrium

- Firms play static best response to the competitive conditions they face.

Alternative: Dynamic equilibrium

Do they exert more or less market power than under the static best response?

1. Tacit collusion
   - Firms do not play static best response: they act as if the market were less competitive than it is.

2. Entry deterrence
Hypotheses

Null: Static Nash equilibrium

- Firms play static best response to the competitive conditions they face.

Alternative: Dynamic equilibrium

Do they exert more or less market power than under the static best response?

1. Tacit collusion
   - Firms do not play static best response: they act as if the market were less competitive than it is.

2. Entry deterrence
   - Firms do not play static best response: they act as if the market were more competitive than it is.
Static model for a generator

Static model

- Generator deciding how to bid in a sequential market.

\[ p_F - p_S = \frac{1}{|\eta|} \]

\( p_S \) is the opportunity cost of selling in the forward market.

\( \eta \) is the elasticity of the residual demand faced by the firm.
Static model for a generator

Static model

- Generator deciding how to bid in a sequential market.

The optimal forward bid satisfies:

\[
\frac{p^F - p^S}{p^F} = \frac{1}{|\eta|}
\]

- \(\eta\) is the elasticity of the residual demand faced by the firm.
- \(p^S\) is the opportunity cost of selling in the forward market.
Test of conduct

Define the best response deviation (BRD) as

\[ BRD = \frac{p^F - p^S}{p^F} - \frac{1}{|\eta|} \]

where \( \eta \) is the elasticity of the effective residual demand. Note that:

\[ BRD = \begin{cases} 
  = 0 & \Rightarrow \text{Static model holds} \\
  > 0 & \Rightarrow \text{Consistent with tacit collusion} \\
  < 0 & \Rightarrow \text{Consistent with entry deterrence}
\end{cases} \]

They act as if the residual demand were less elastic

They act as if the residual demand were more elastic
Implementation relies on knowledge of the demand

- Demand is “almost observable”
- Hourly bid data: willingness to buy/sell at each price
Challenge: Who competes with whom

Source: MISO
Proposed solution: Split into independent markets

- Idea: prices should move together if firms are in the same market (Stigler and Sherwin, 1985).

  
  - Clustering algorithm requires to specify the number of markets.
  
  - Use bid data to select “best fitting” market definitions.
  
  - Clear each independent market using bids submitted at those locations.
  
  - Compare simulated and observed prices.
Proposed solution: Split into independent markets

- Idea: prices should move together if firms are in the same market (Stigler and Sherwin, 1985).

- Group firms according to price correlation.
Proposed solution: Split into independent markets

- Idea: prices should move together if firms are in the same market (Stigler and Sherwin, 1985).

- Group firms according to price correlation.

- Clustering algorithm requires to specify the number of markets.
  - Use bid data to select “best fitting” market definitions.
  - Clear each independent market using bids submitted at those locations.
  - Compare simulated and observed prices.
Demand and supply - market clearing
37 buyers, 6 sellers

Demand and supply for market 2 out of 14
January 15, 2011 6–7am

Observed
Simulated
Demand and supply for market 2 out of 14
January 15, 2011 6–7am

Mercadal (Columbia)
Role of financial traders
July 24, 2018   16 / 23
Test of conduct: Implementation

Best response deviation

For each hour,

\[ BRD_{t,m} = \alpha_0 \text{before} + \alpha_1 \text{interim} + \alpha_2 \text{after} + X + \epsilon_{t,m} \]

- \( BRD_t \) is the average BRD weighted by firm size.
- \text{before} the announcement of the policy change.
- \text{interim} between announcement and implementation.
- \text{after} implementation.
- \( X \): Monthly and hourly fixed effects.
Best Response Deviation

Hourly mean weighted by firm size, month and hour fixed effects.
How many firms?

- Individual regressions for each firm indicate results come from a group of 30 firms.
- All have most of their assets in the west area of the market, where most of wind units are.
- Run the BRD regression separately for the west and the rest of the market.
Best Response Deviation

Hourly mean weighted by firm size, month and hour fixed effects.
Best Response Deviation

Hourly mean weighted by firm size, month and hour fixed effects.
Forward Premium

Quantity weighted forward premium – West

Mercadal (Columbia)  Role of financial traders  July 24, 2018
Forward Premium

Quantity weighted forward premium excluding the west

$\$\$


Mercadal (Columbia) Role of financial traders July 24, 2018 21 / 23
Welfare

Consumer surplus

- For a given quantity, consumers pay 4% less.
- Save about $1,850,000 a day on average in the forward market

Productive efficiency

- Forward market: lower costs because of better production scheduling.
- Spot market: higher costs because generators exert more market power (Ito and Reguant, 2016).
  - Back out spot margins and find they did not increase.
Contribution

1. Role of financial players as competitors of producers
   - Increase consumer surplus.
   - Break tacit collusion.

2. Dynamics matter
   - Test static Nash equilibrium.
   - Reject static Nash in favor of tacit collusion.

3. Machine learning tools can be used to study market structure
   - Obtain competitive structure imposing minimal assumptions.
   - Show it accurately represents the data.
Thank you

ignacia.mercadal@columbia.edu