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

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# 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)

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Are financial traders bad for markets?

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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

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## Midwest wholesale electricity market

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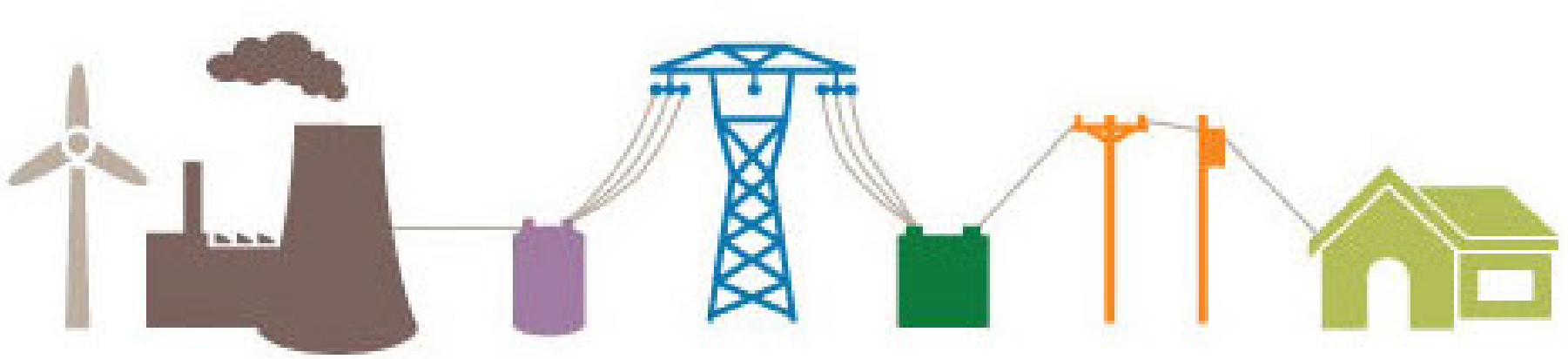
   Regulatory change lead to a sharp increase in financial trading.
3. Detailed dataset on firm behavior

# 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

Transmission

Distribution

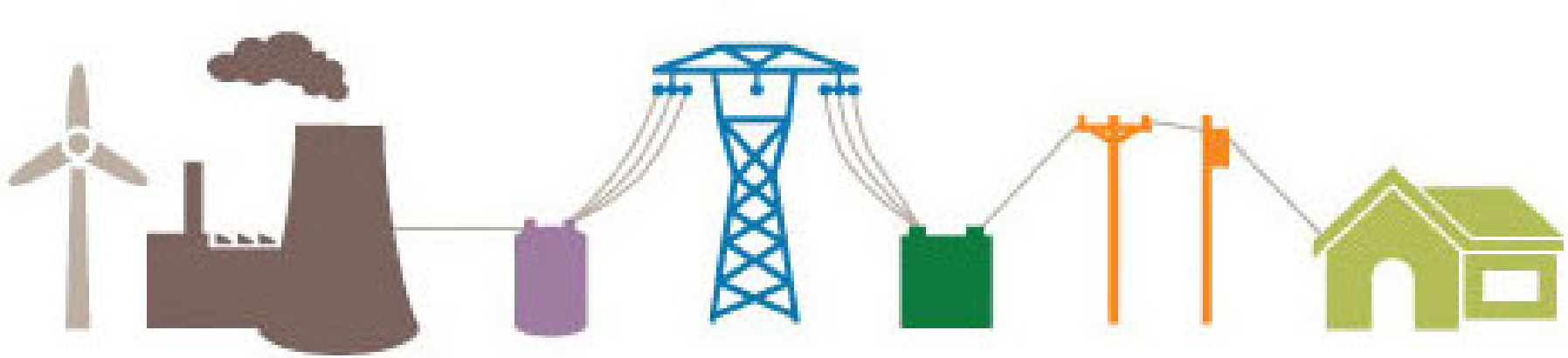
Sellers

Market operator

Buyers

ISO - Independent System Operator

# Deregulated wholesale electricity markets



| Generation | Transmission | Distribution |
|---|---|---|
| Sellers | Market operator | Buyers |
| Virtual sellers | ISO - Independent System Operator | Virtual 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

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## 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

$$\Pi = (P^F - P^S)Q \tag{1}$$

# 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

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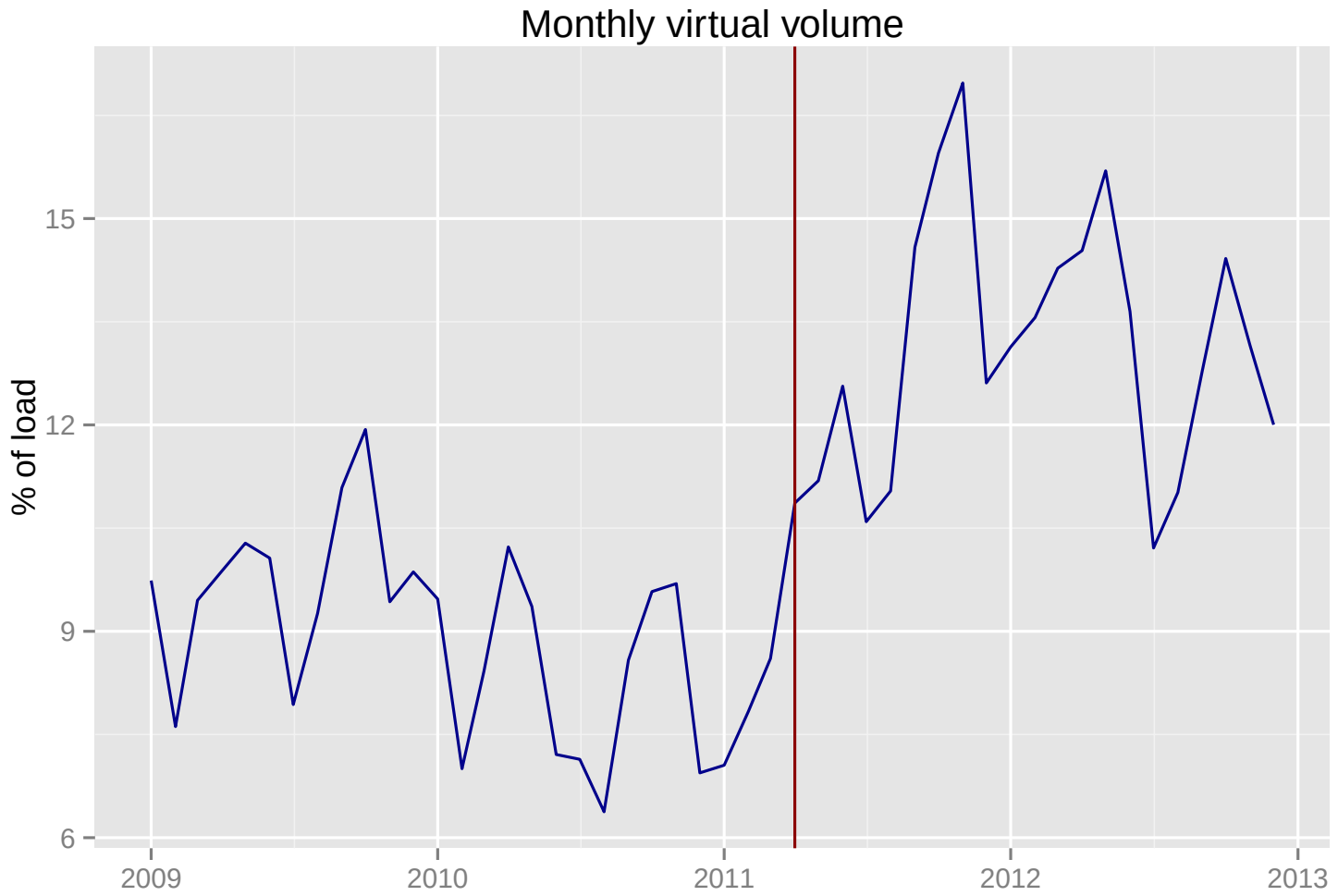
- Positive forward premium
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## April, 2011

- Charges significantly decreased.
- Proposal submitted on December 1, 2010 (Announcement)

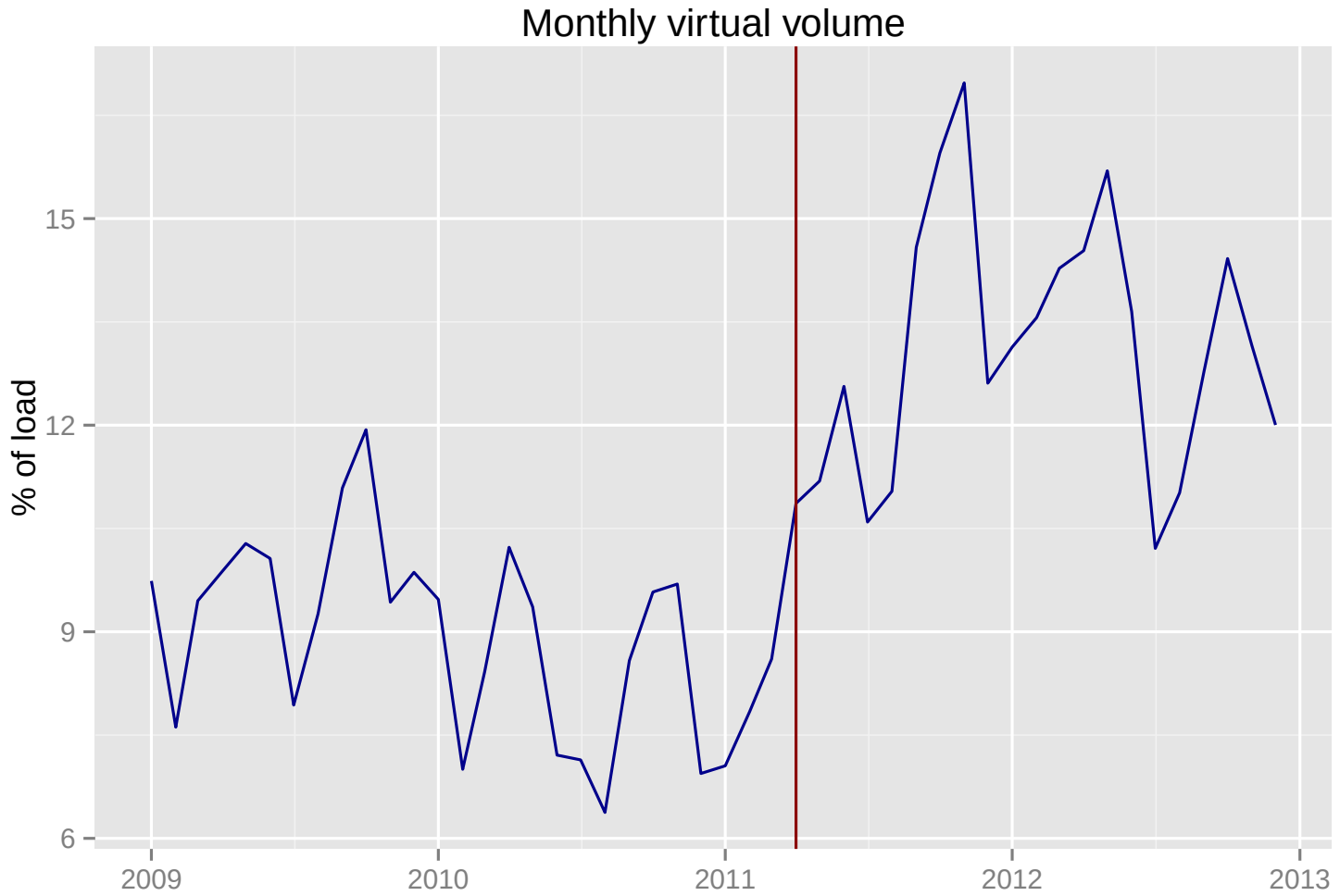
# Result 1: Financial trading increased

## Financial traders response to the regulatory change



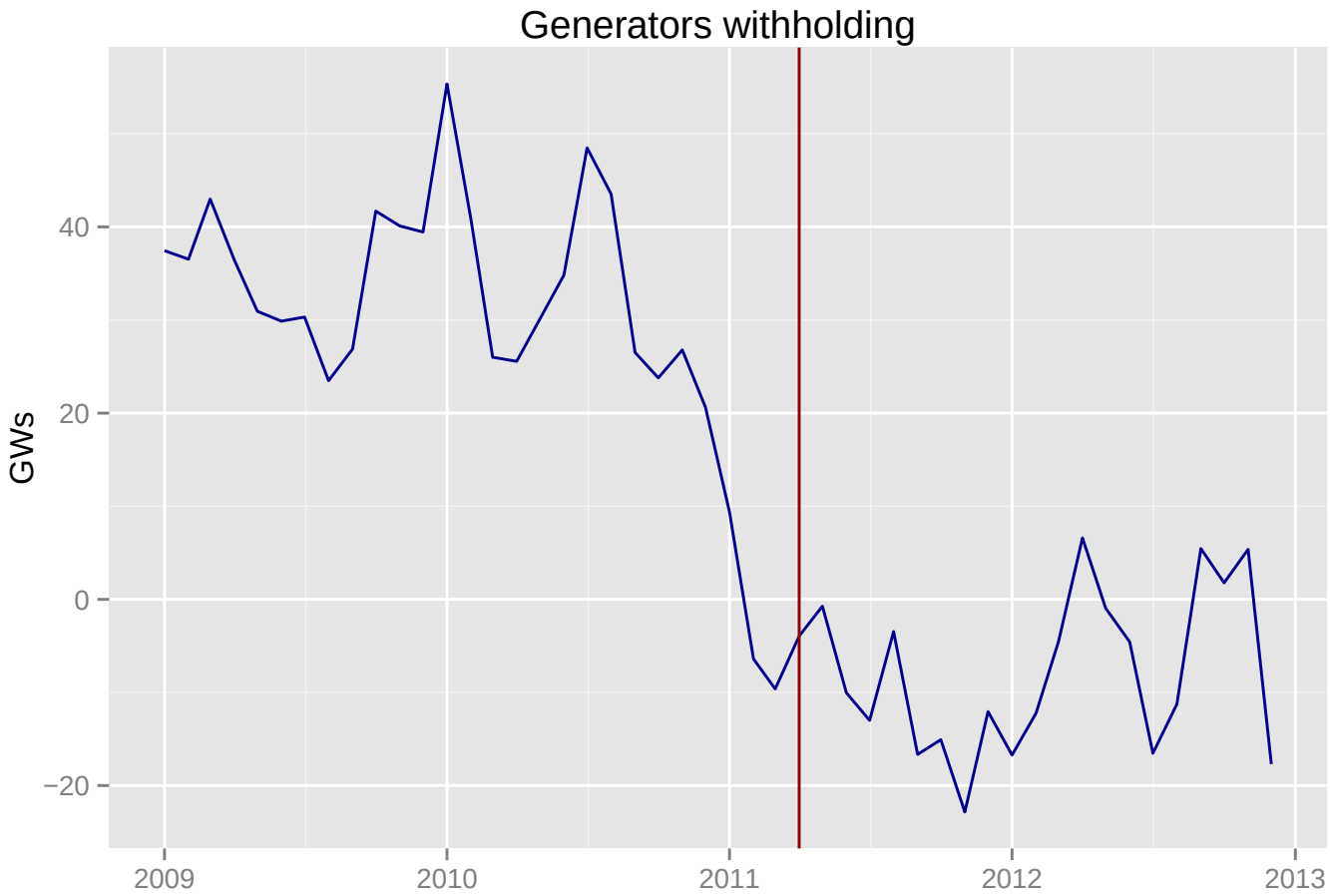
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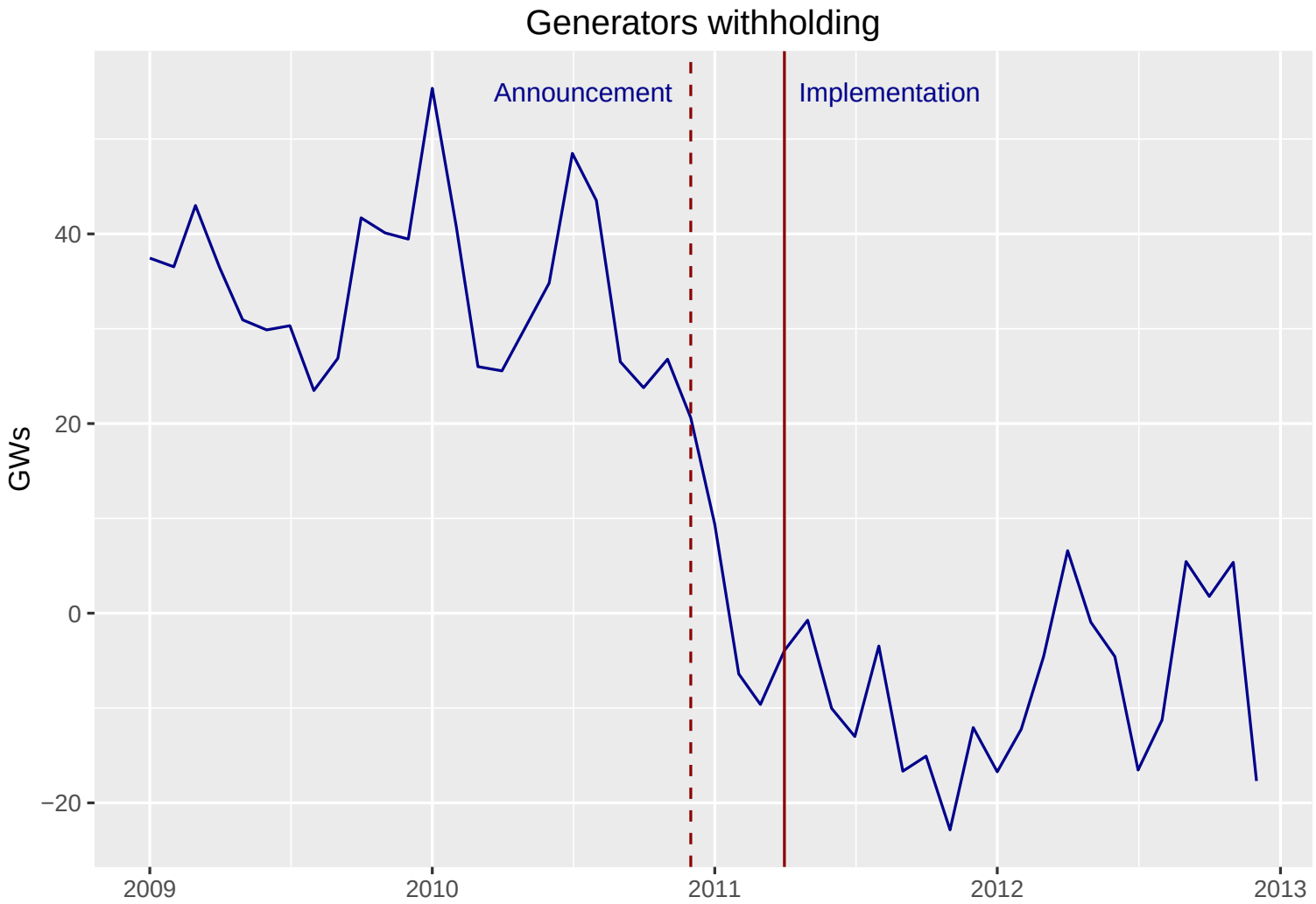



Breakpoint: April 9, 2011

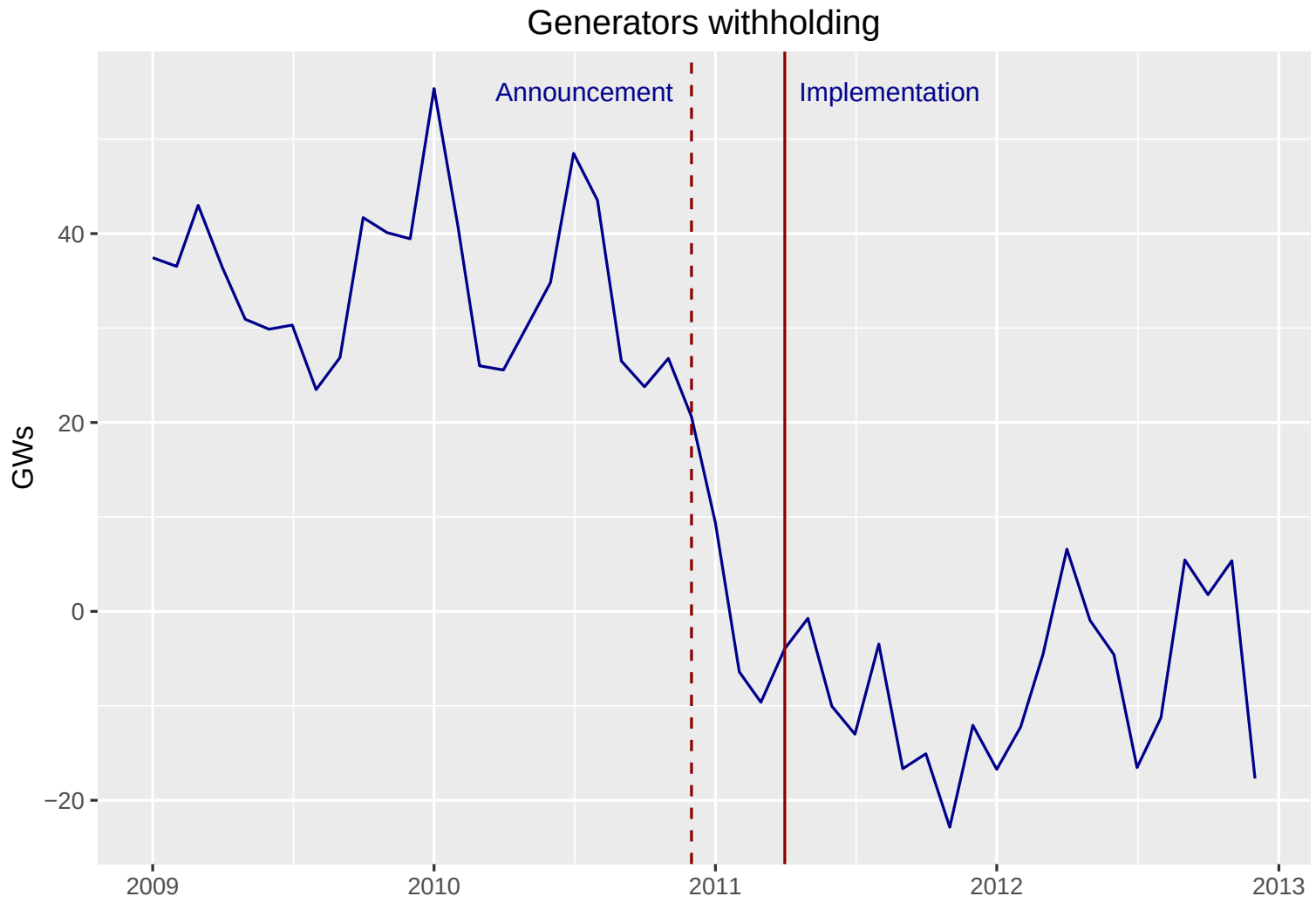
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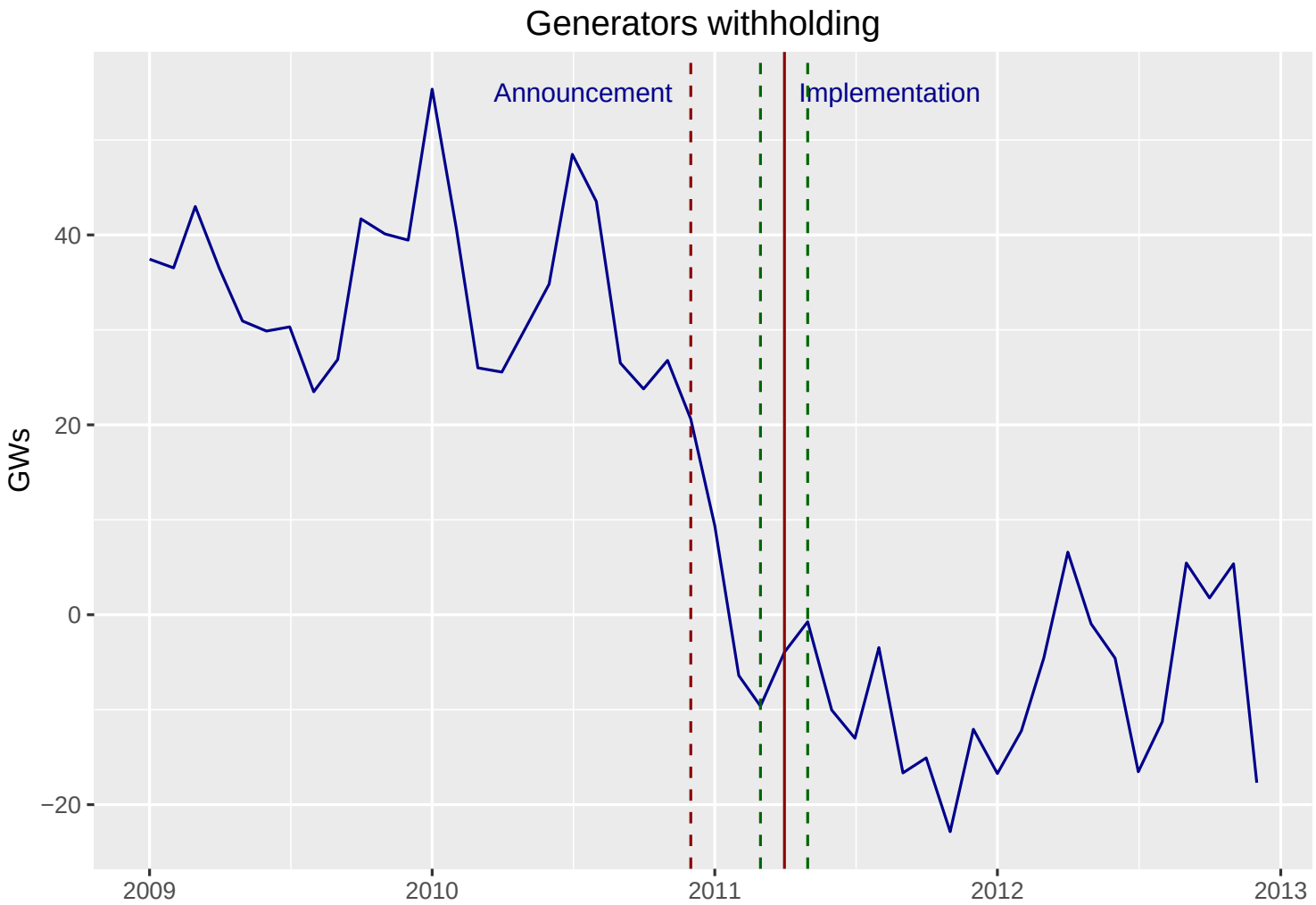


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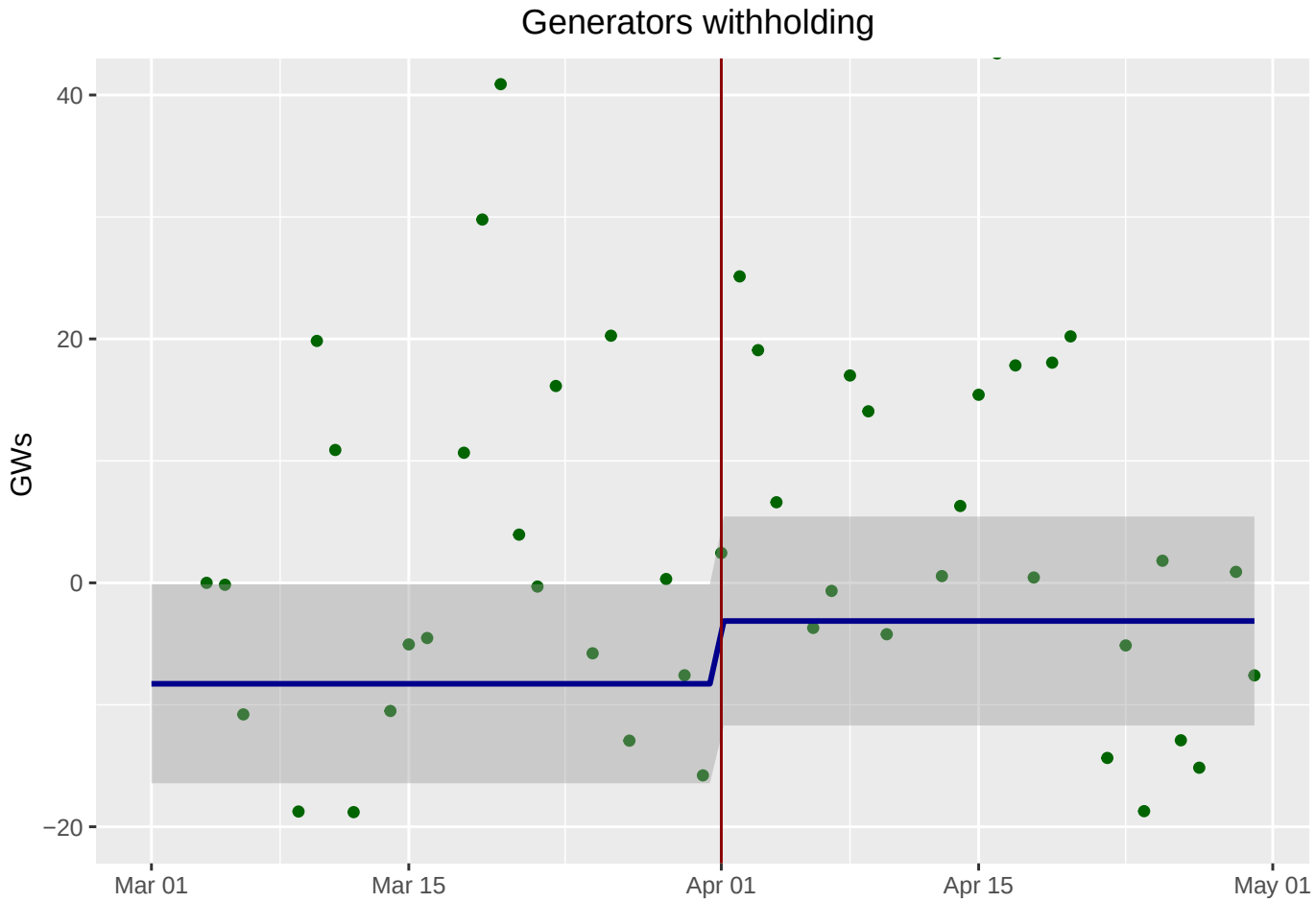



Breakpoint: Jan 10, 2011 (1/5, 1/15) Financial trading: April 9, 2011

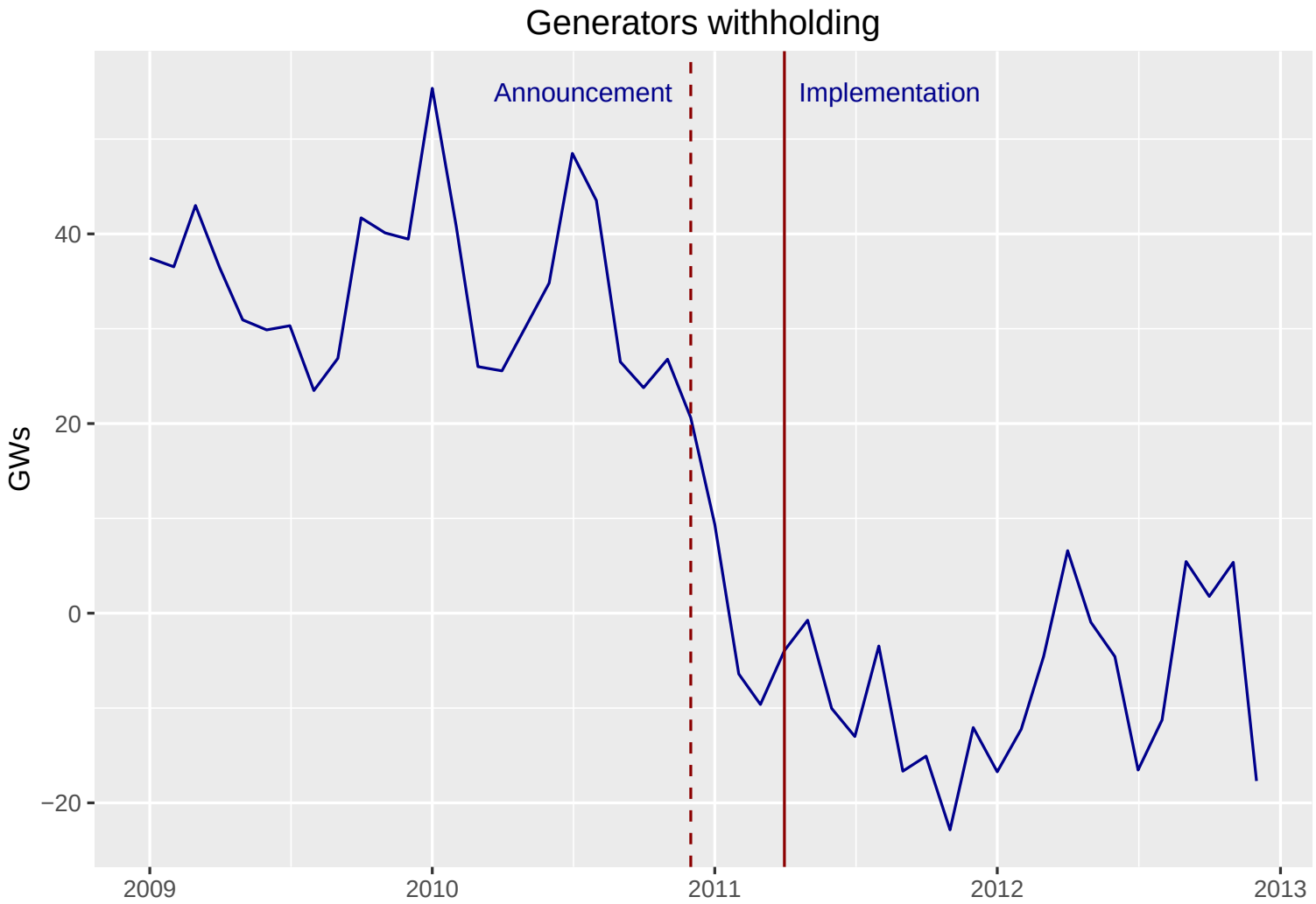
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# Hypotheses

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2. Entry deterrence

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# Static model for a generator

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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

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

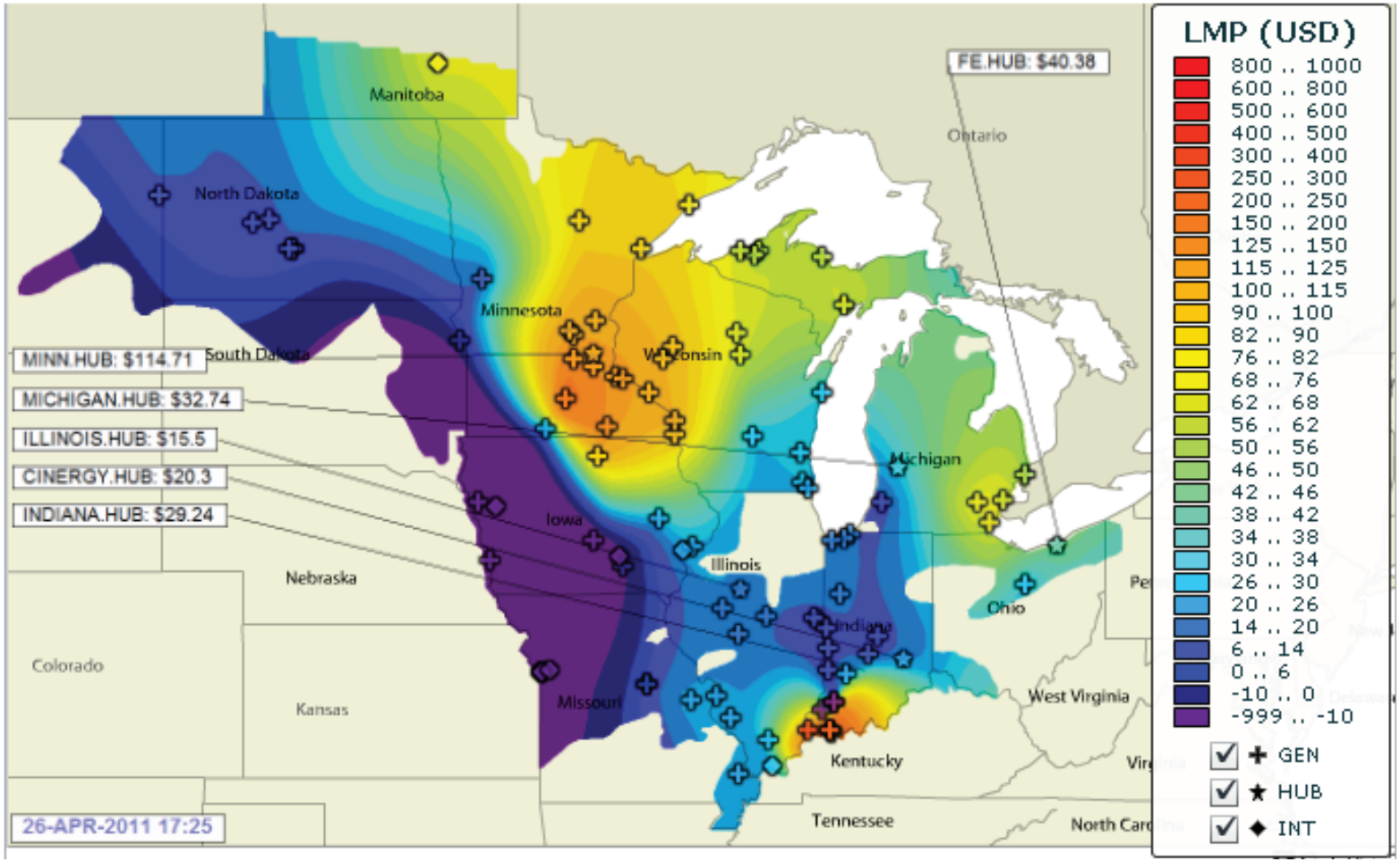
where $\eta$ is the elasticity of the effective residual demand. Note that:

$$BRD = \begin{cases} = 0 \quad \Rightarrow \quad \text{Static model holds} \\ > 0 \quad \Rightarrow \quad \text{Consistent with tacit collusion} \\ \qquad\quad\ \ \text{They act as if the residual demand were less elastic} \\ < 0 \quad \Rightarrow \quad \text{Consistent with entry deterrence} \\ \qquad\quad\ \ \text{They act as if the residual demand were more elastic} \end{cases}$$

# 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).

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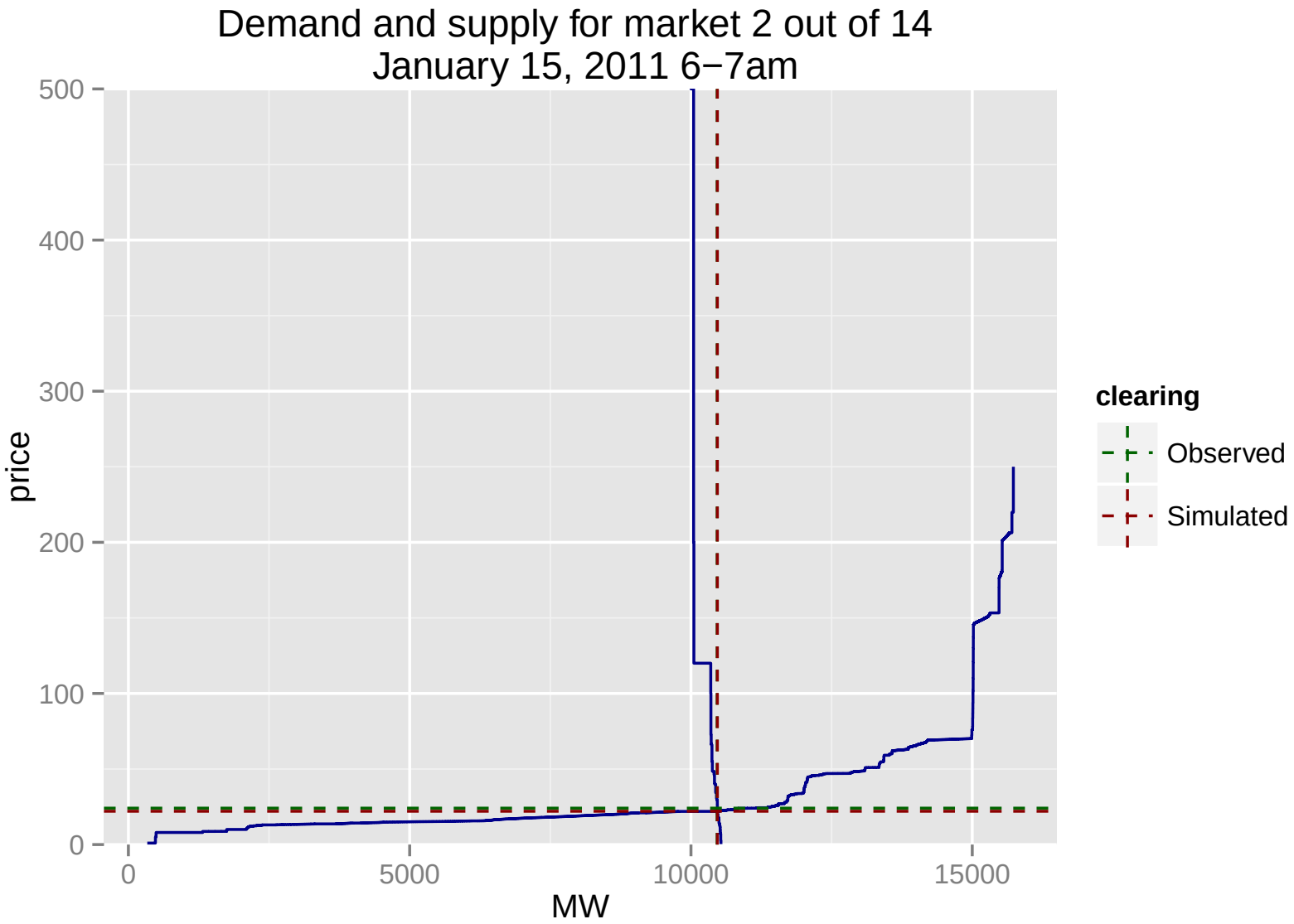
- Idea: prices should move together if firms are in the same market (Stigler and Sherwin, 1985).
- Group firms according to price correlation.
  - How? Hierarchical clustering (machine learning tool).

# 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.
  - How? Hierarchical clustering (machine learning tool).
- 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



# Test of conduct: Implementation

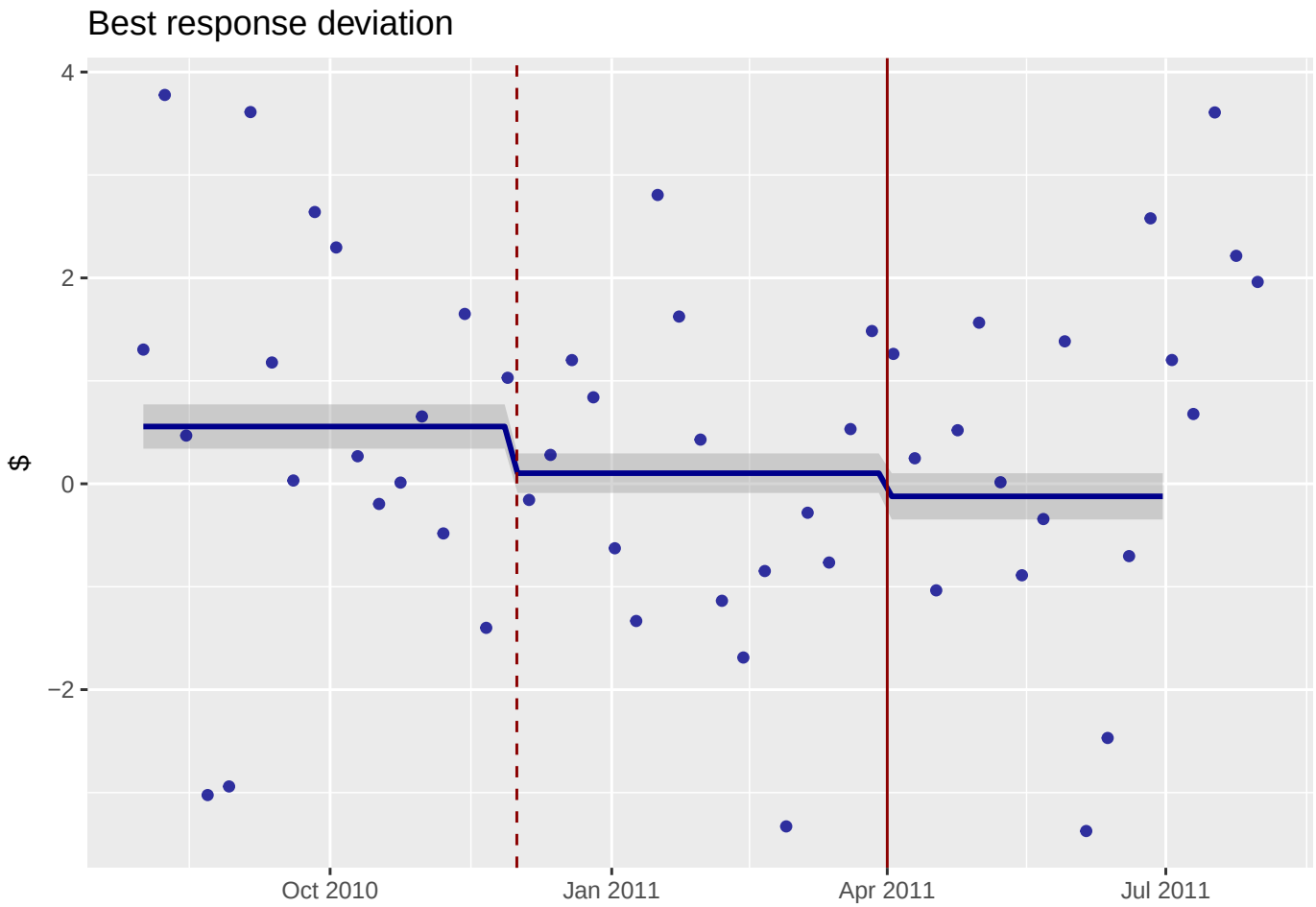
## Best response deviation

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.
- before the announcement of the policy change.
- interim between announcement and implementation.
- after implementation.
- $X$: Monthly and hourly fixed effects.

# Best Response Deviation

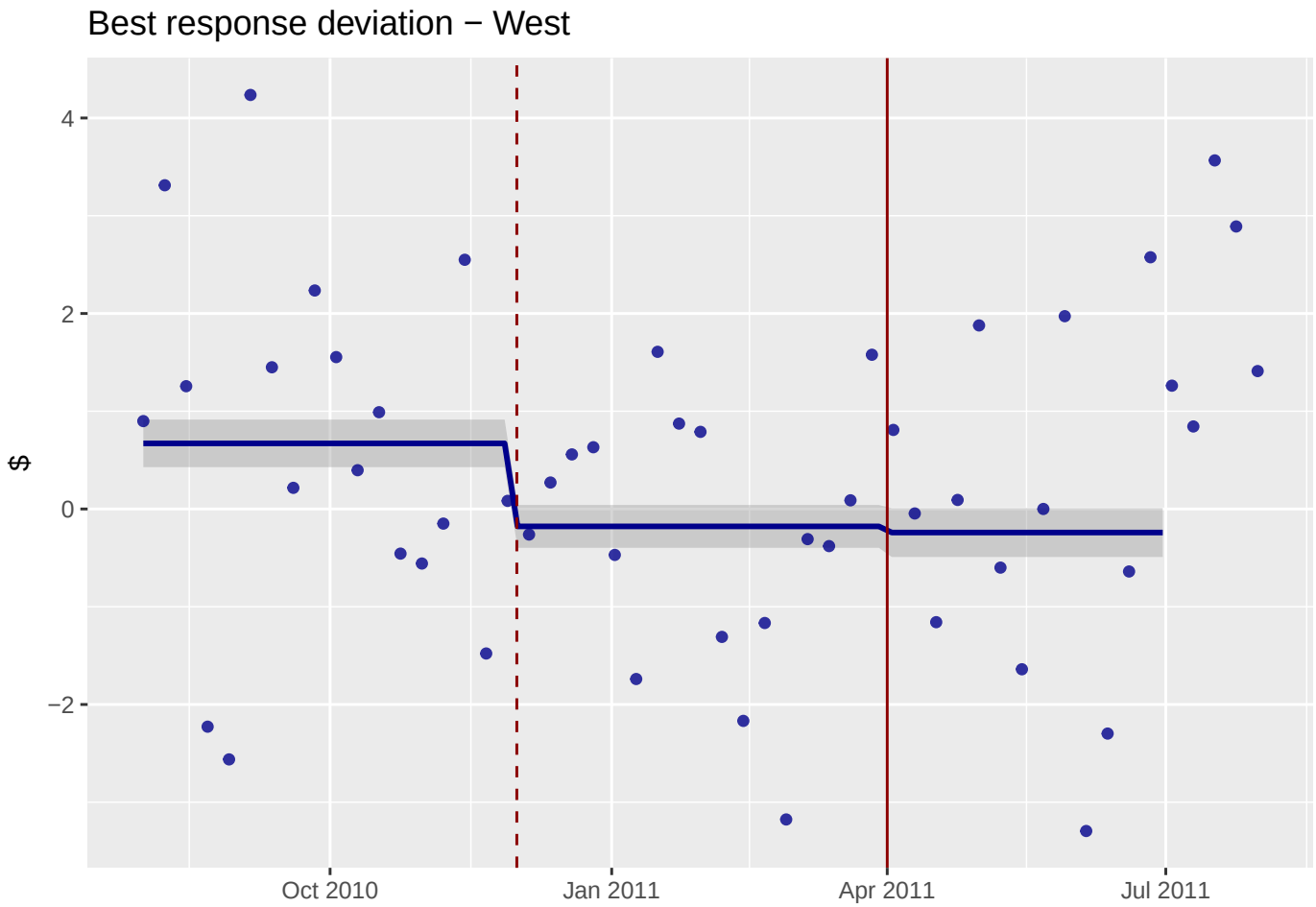



Hourly mean weighted by firm size, month and hour fixed effects.

# How many firms?

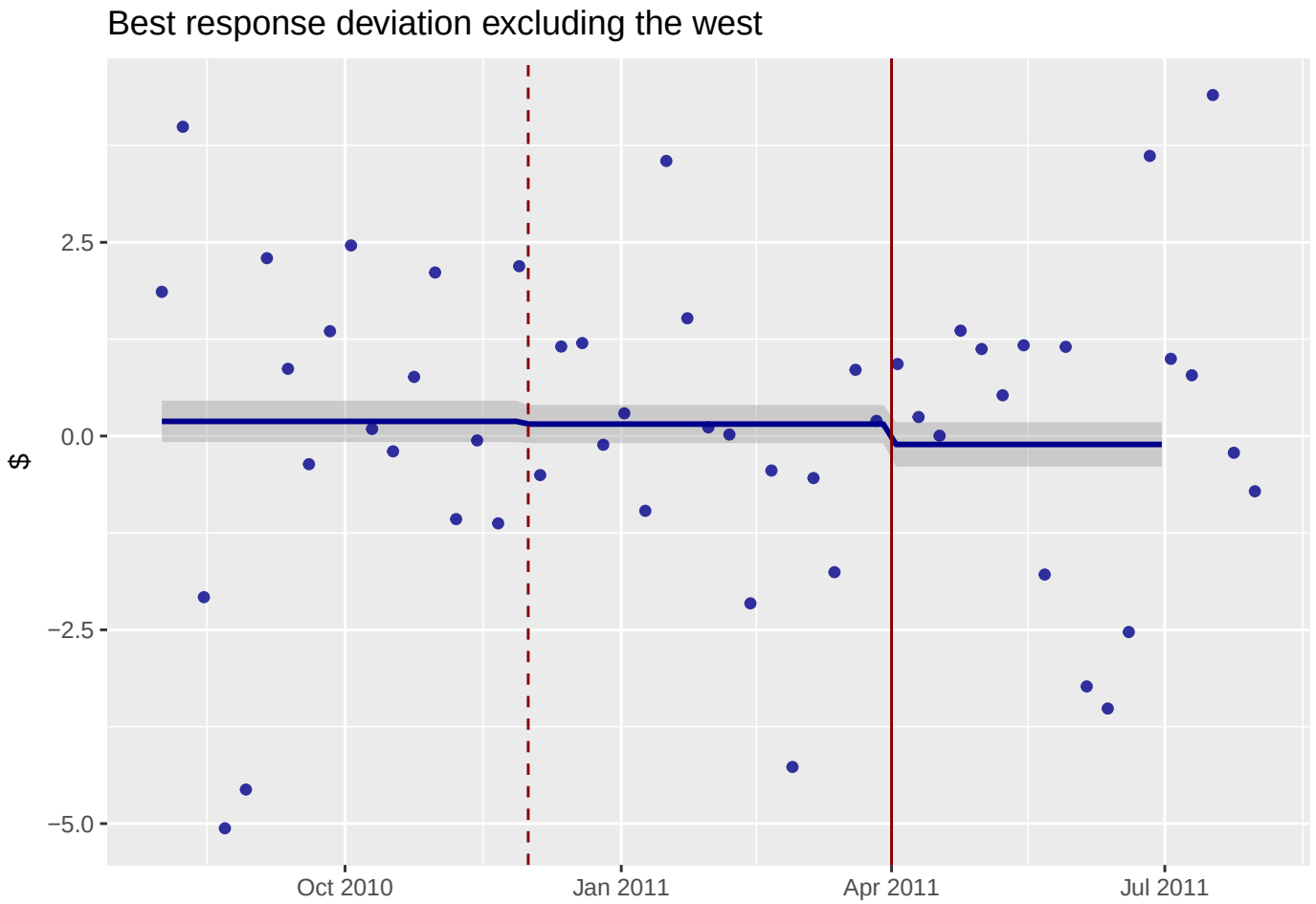
- Individual regressions for each firm indicate results come from a group of 30 firms
- All have most of their assets in the west area of the market, where most of wind units are
- Run the BRD regression separately for the west and the rest of the market

# Best Response Deviation



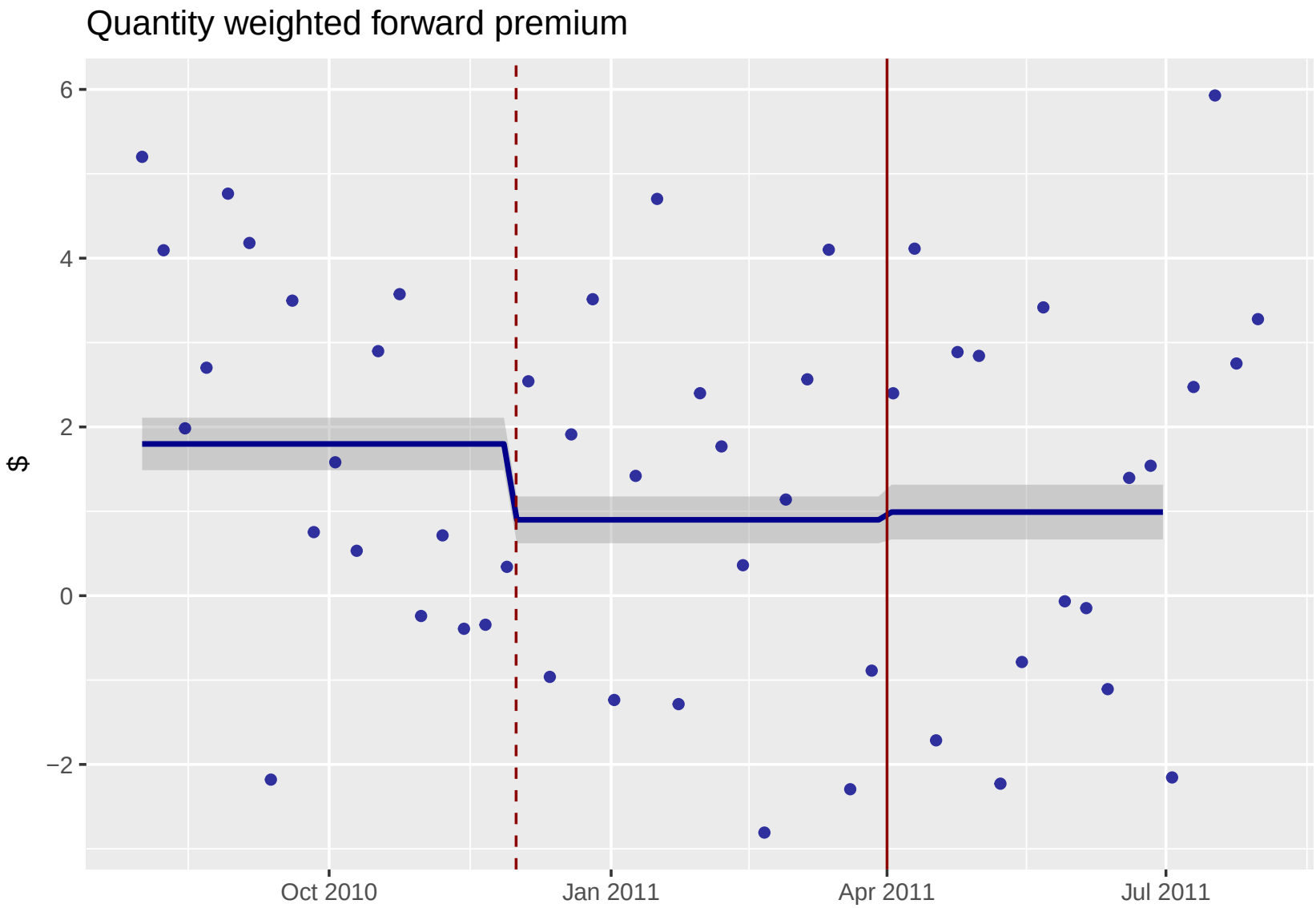

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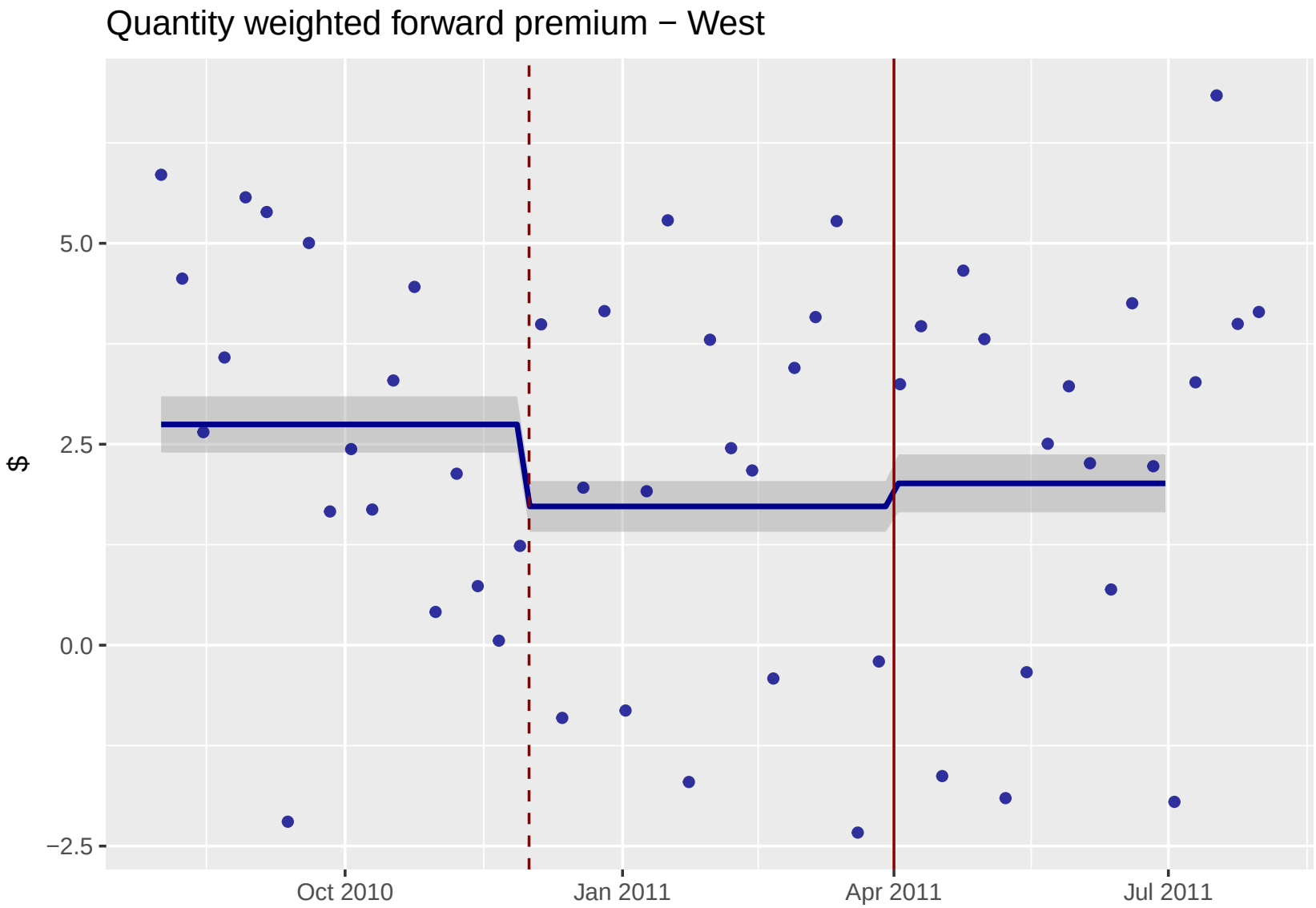



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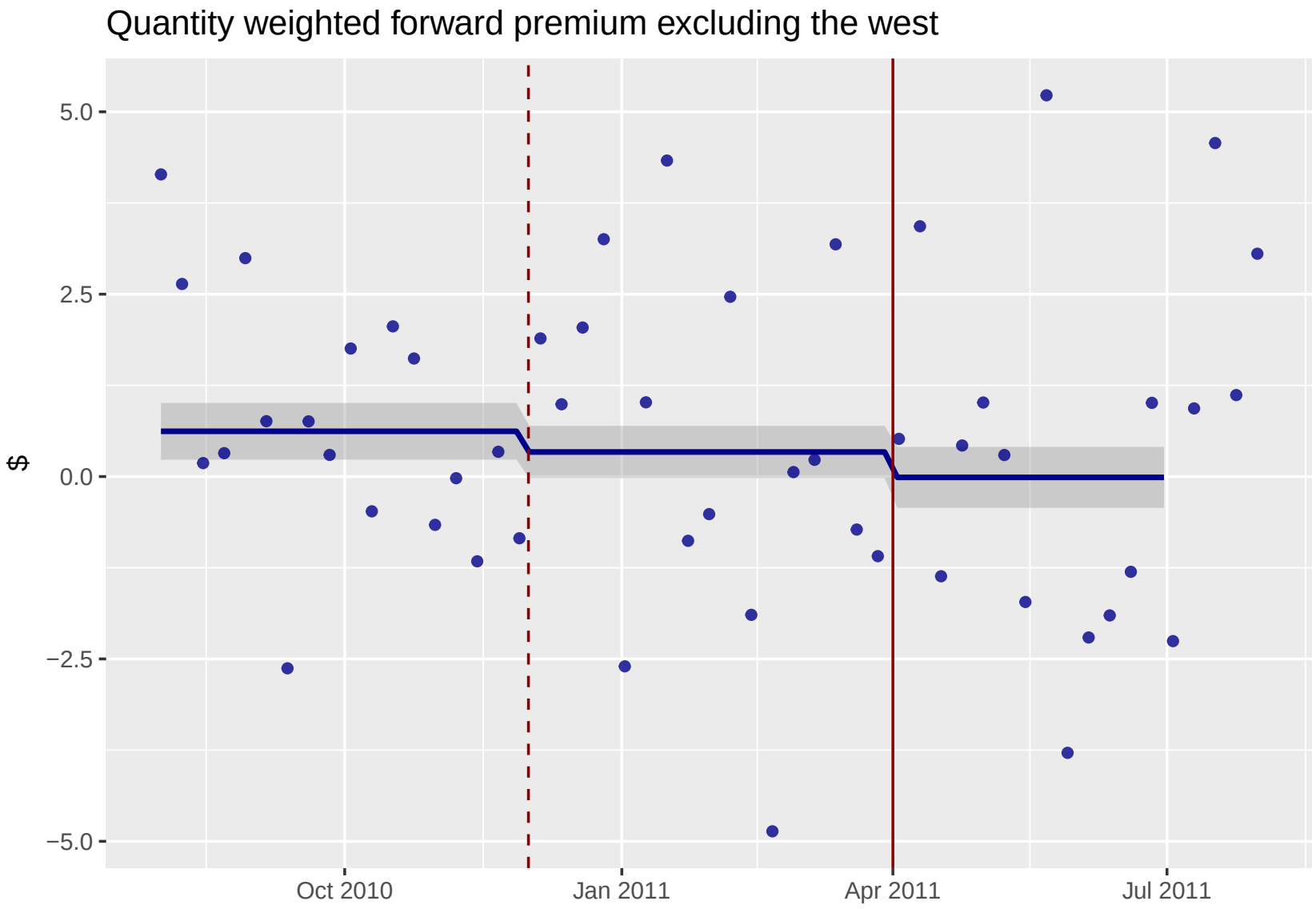
# Forward Premium



# Forward Premium



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# 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

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