Market Power and Price Discrimination: Learning from Changes in Renewables Regulation

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    - Hviid and Waddams (2012): Non-discrimination clauses in the Retail Energy Sector

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- If price differences across markets stem from market power...
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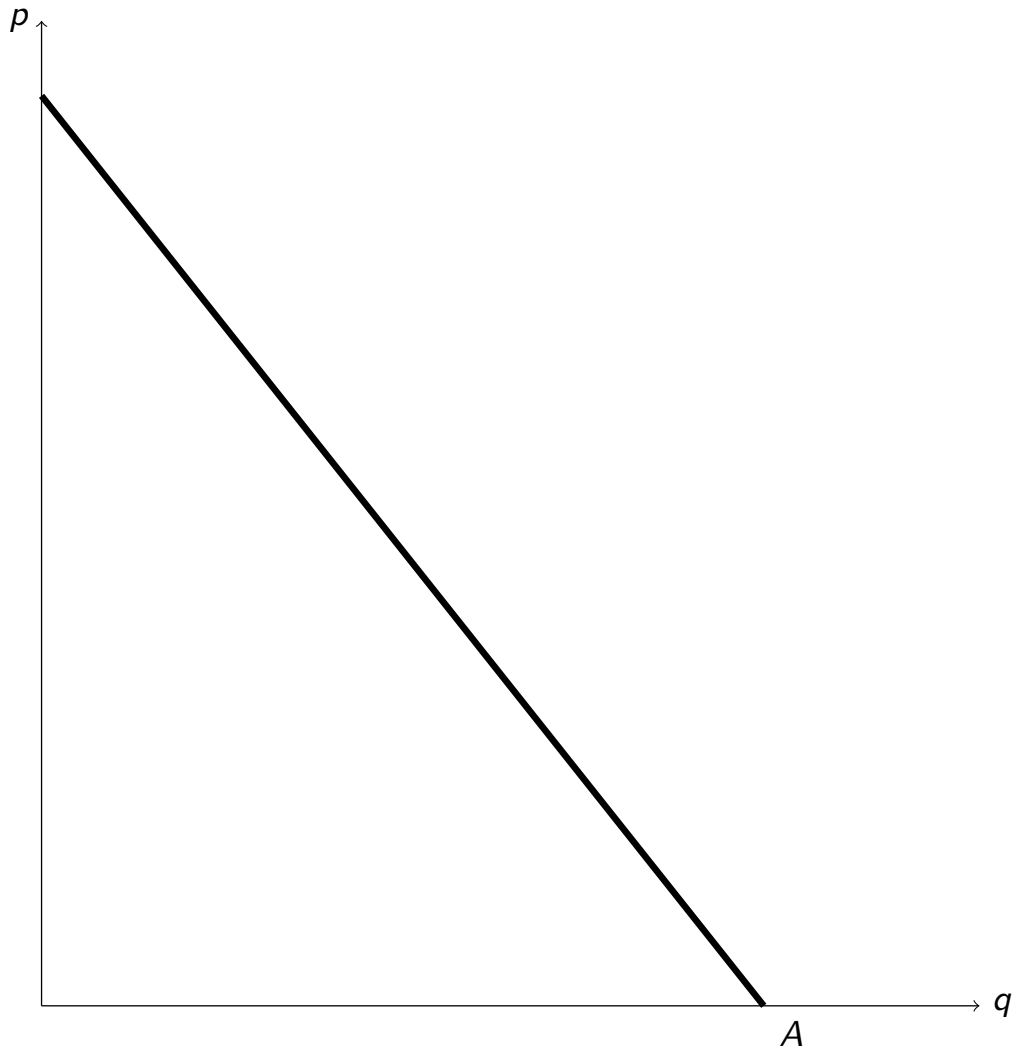
Our focus:

- Sequential markets
- Forward contracts as a tool to reduce market power

Monopoly pricing in sequential markets



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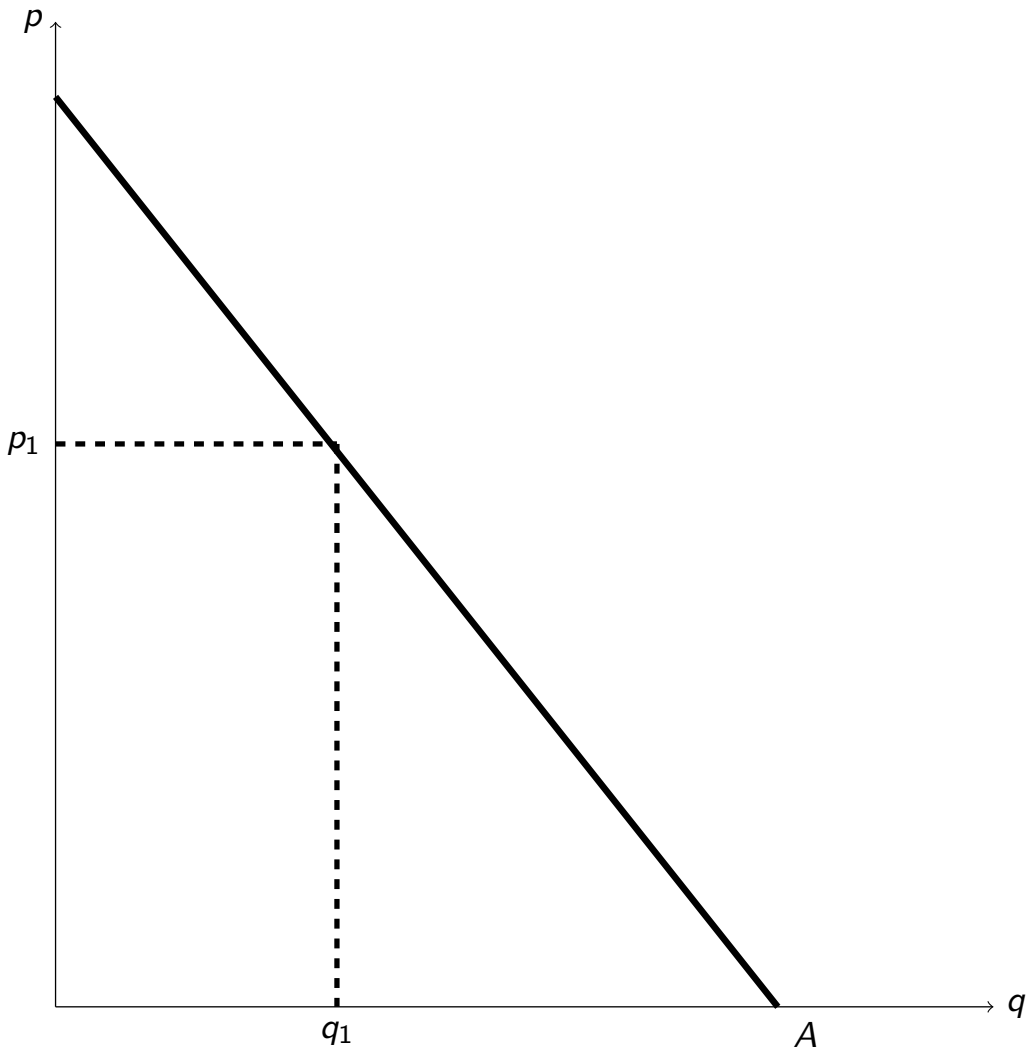

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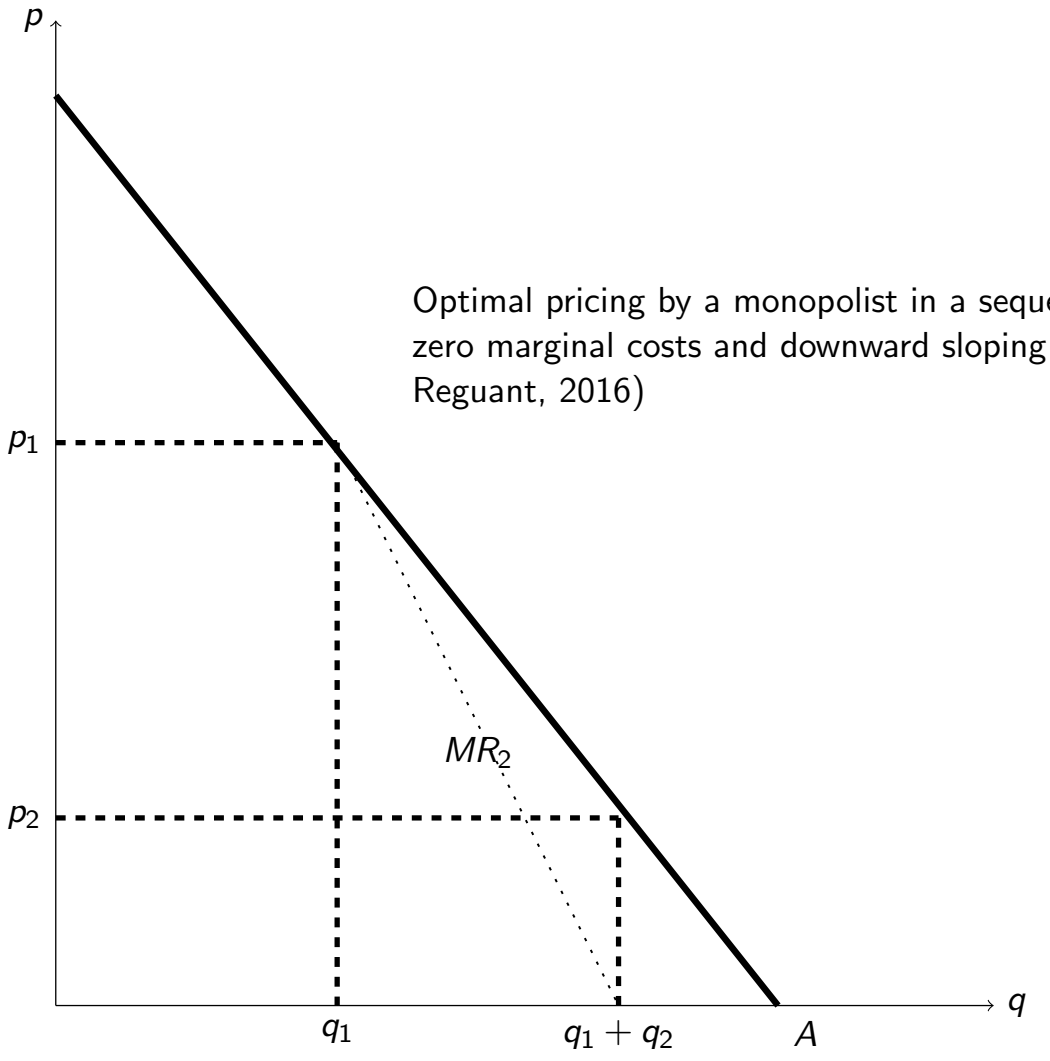

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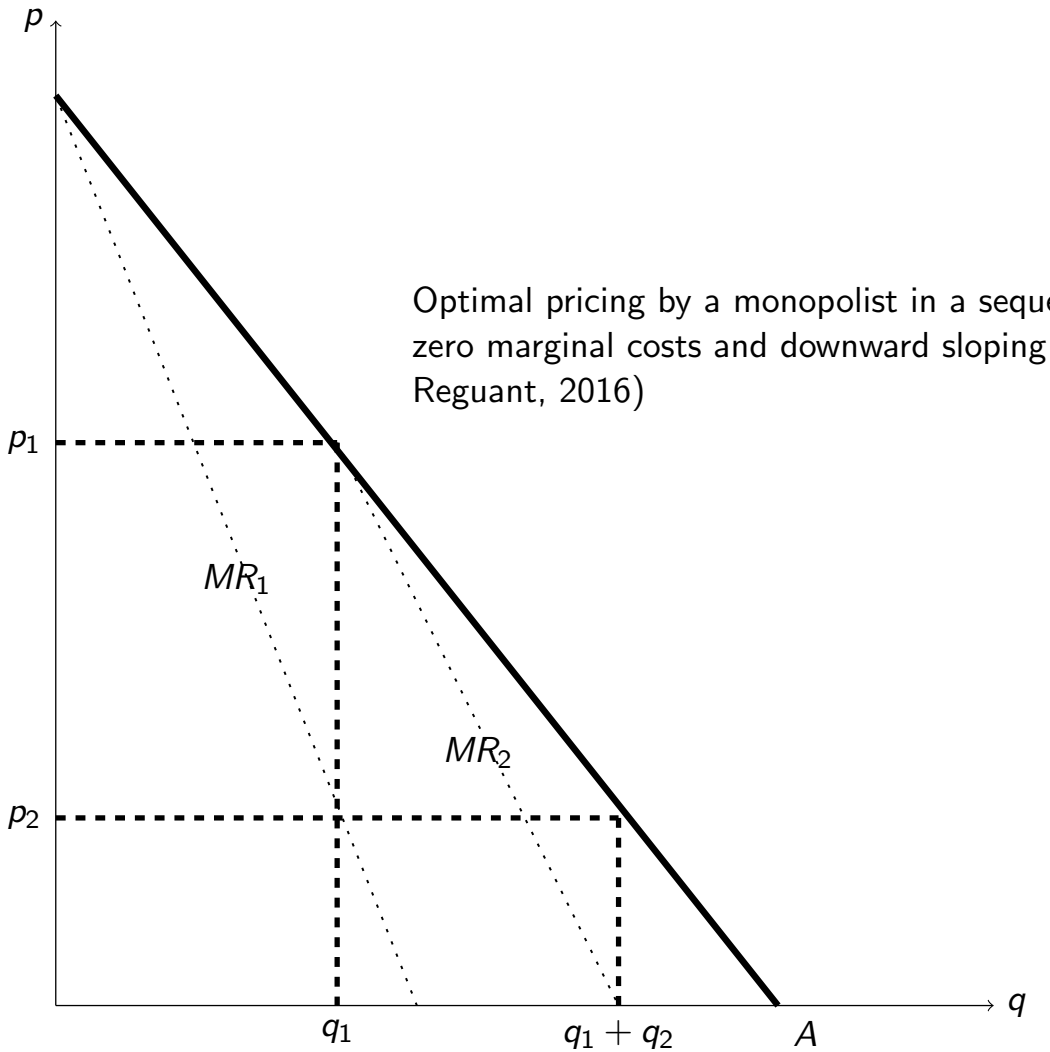

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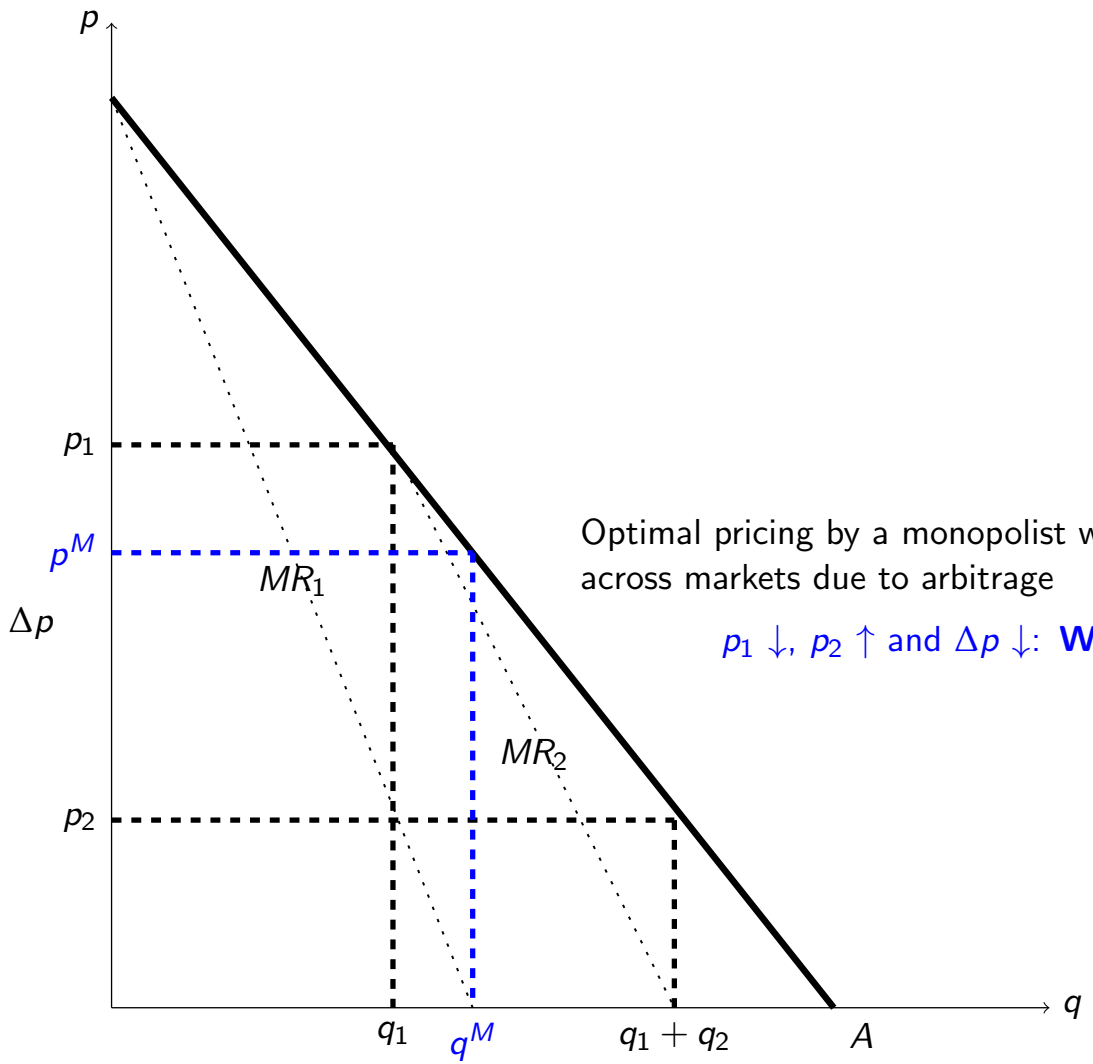
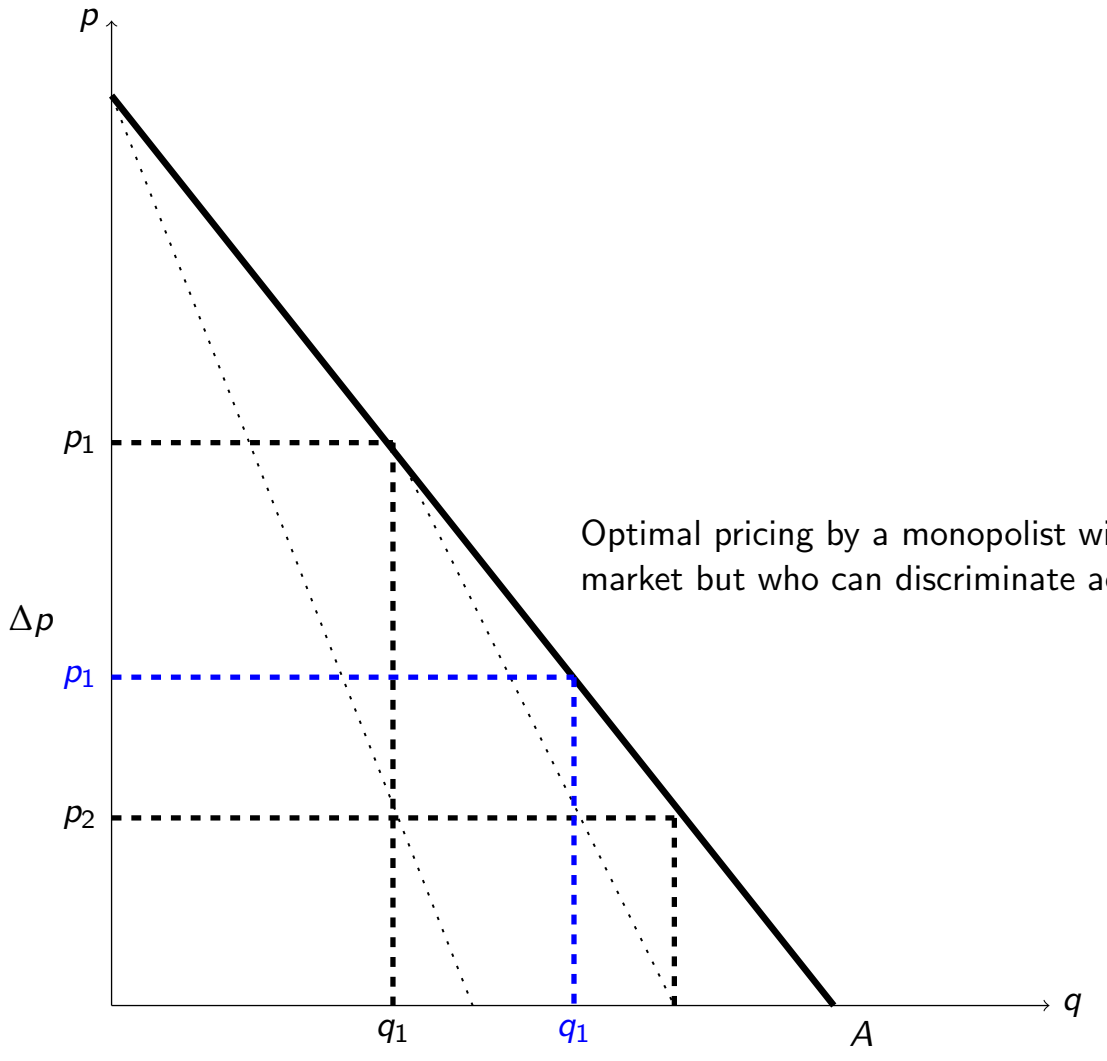
Sequential markets with full arbitrage



Optimal pricing by a monopolist who cannot price discrimination across markets due to arbitrage

$p_1 \downarrow$, $p_2 \uparrow$ and $\Delta p \downarrow$: **Welfare** $\downarrow$; Consumer surplus?

Sequential markets with market power mitigation



Optimal pricing by a monopolist with less market power in the first market but who can discriminate across markets

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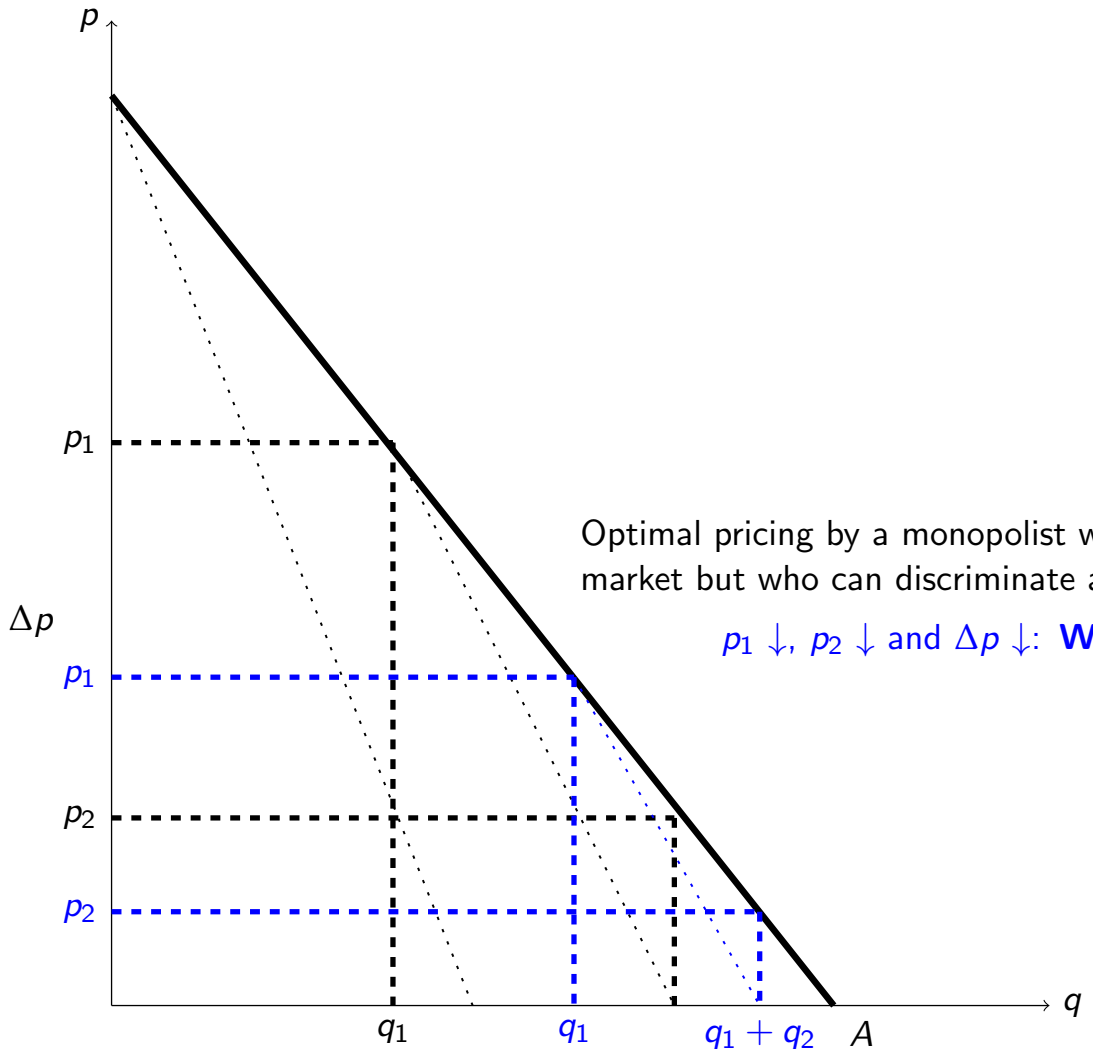

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Electricity markets: a motivating example

1. Electricity markets are organized **sequentially**:
   - Day-ahead market followed by close to real-time markets.
2. Forward-premia consistent with **market power**.
3. Arbitrage across markets allowed, but often with **limits**:
   - Transactions must be backed by physical assets.
4. Various forms of **forward contracting**, including:
   - Renewables pricing policy

How should we pay for renewables' output?

1. **Fixed prices**: Feed-in-Tariffs (FiT)
   - Prices set ex-ante by regulators or through auctions
   - Act like **forward contracts**: mitigate market power
   - Discourage renewables from arbitraging
2. **Variable prices**: Feed-in-Premia (FiP)
   - Prices in wholesale energy markets + fixed premium
   - No direct effect on market power
   - Promote **arbitrage** across markets

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This paper:

For given capacities, what are the overall market impacts of **paying renewables** according to **fixed** or **variable** prices?

Iberian electricity market: an ideal laboratory

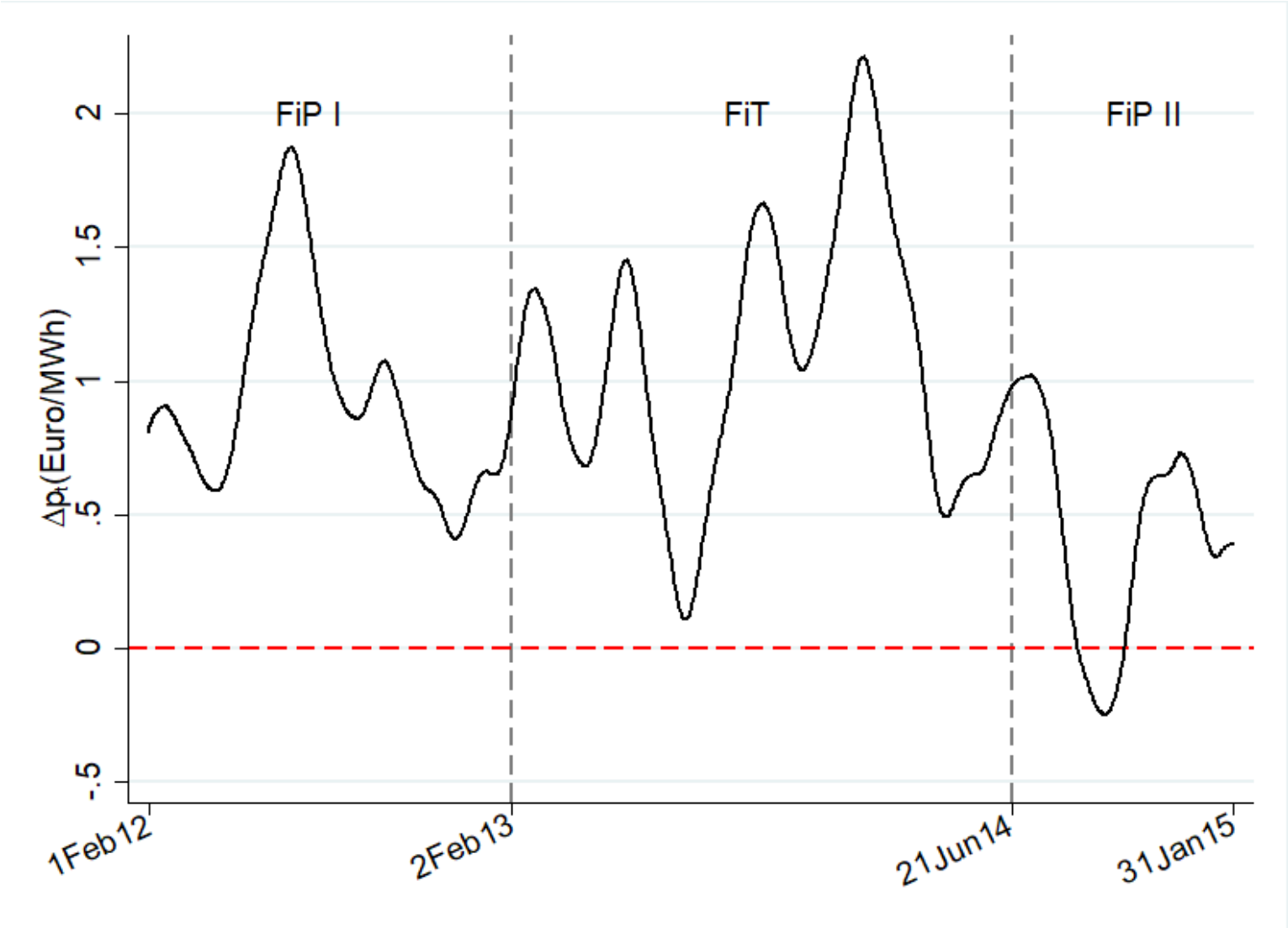
1. **Changes in wind regulation**:
   - 02/2013: variable prices $\rightarrow$ fixed prices
   - 04/2014: fixed prices $\rightarrow$ variable prices (+other changes)
   - No changes in market structure during this period

   It is possible to provide a **causal interpretation** of the impact of pricing rules on bidding behaviour and market outcomes

2. High wind penetration (covering 20-23% of demand)

   The effects are quantitatively meaningful

A first look at the data: price discrimination



Price differences between day-ahead and the first intra-day market

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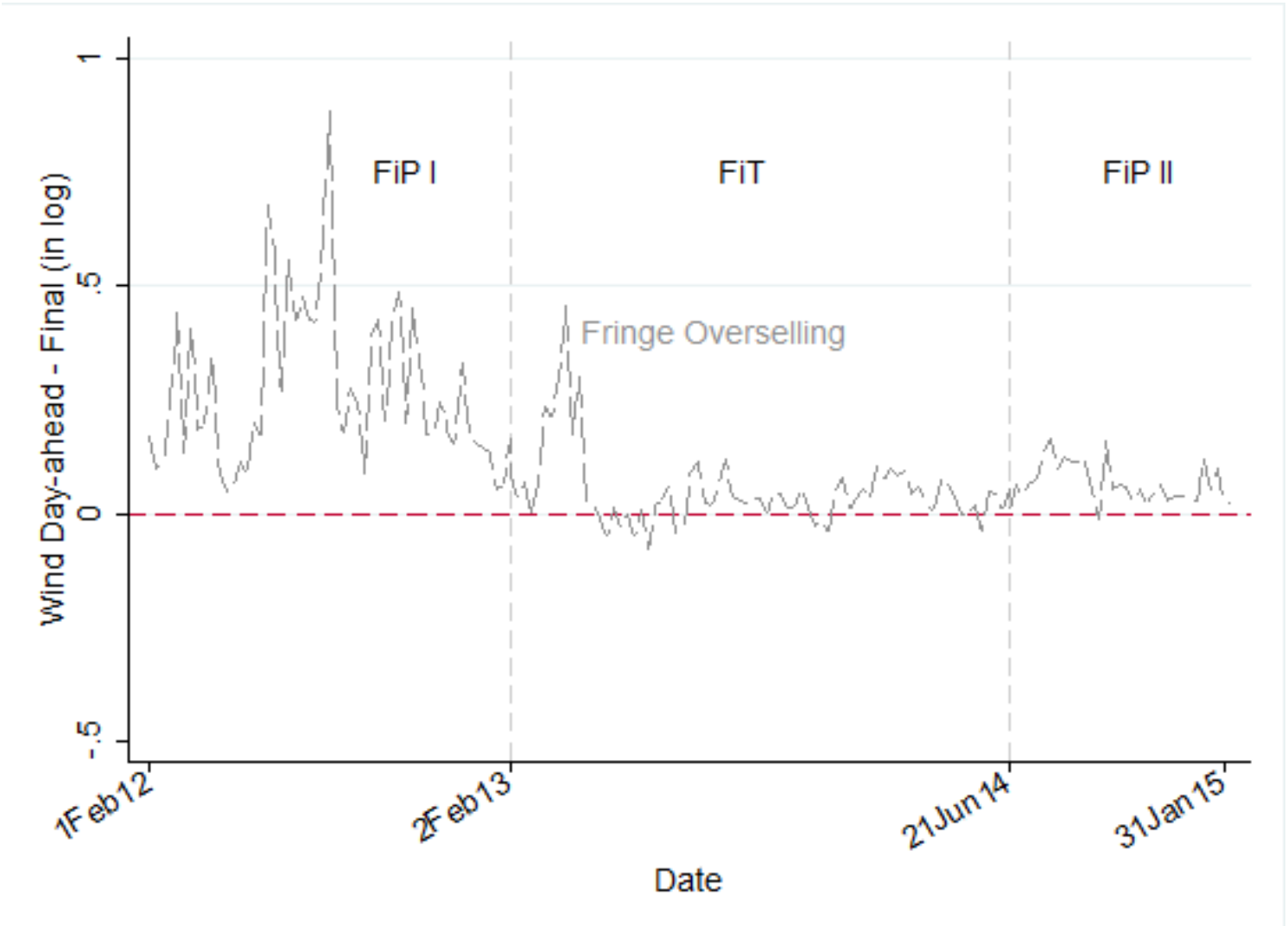

Overselling and withholding across markets by wind producers

▸ Overselling by hour

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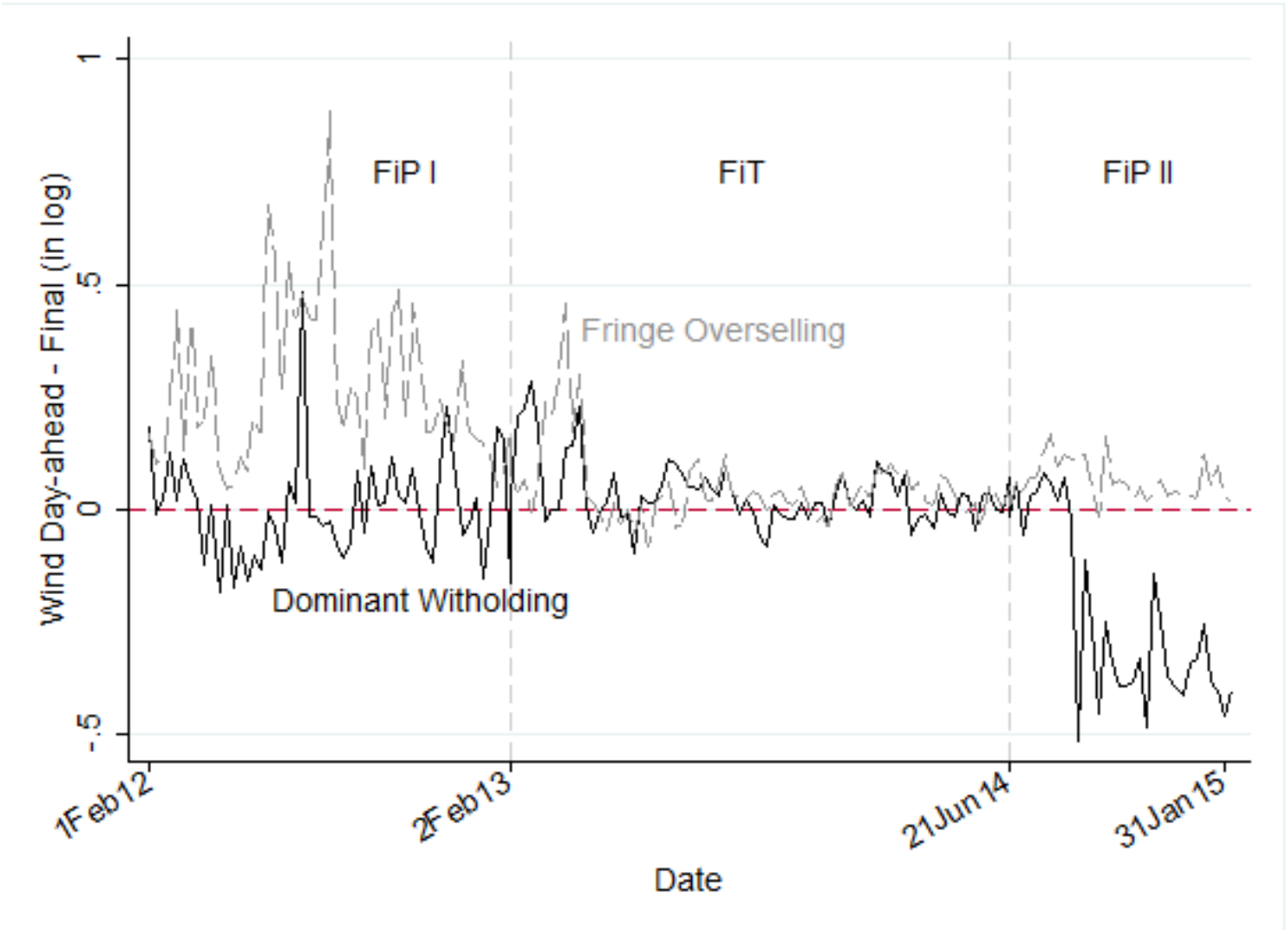

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Model Description

Markets and Demand:

- Sequential markets: day-ahead and spot markets, $t = 1, 2$
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Firms and ownership:

- Fringe firms (f) own wind [*price-takers*]
- Dominant firm (d) owns **both technologies** [*profit max*]

Baseline: variable prices + no arbitrage (B)

1. Wind producers receive **variable prices**: market price + $\underline{p}$
2. **Arbitrage not allowed**

- Residual demands faced by dominant firm:

$$\begin{aligned} q_1(p_1) &= D(p_1) - w_f \\ q_2(p_1, p_2) &= D(p_2) - D(p_1) \end{aligned}$$

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In equilibrium: Go

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Comparison across pricing rules

Comparing spot market prices:

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  [Arbitrage *vs.* forward-contract effects]

$$V: D(p_1) - w_f - (k_f - w_f) + \left(p_1 - p_2^V\right) \frac{\partial D(p_1)}{\partial p_1} = 0$$

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2. **Evidence of the arbitrage effect across markets?**
   - Wind firms arbitrage under variable prices, not under fixed
3. **Price discrimination across markets?**
   - Comparison btw pricing rules depends on market structure
   - Comparative statics wrt wind should move in opposite directions btw pricing rules
4. **Market power in the day-ahead market?**
   - Comparison btw pricing rules depends on market structure

Questions?

The Iberian electricity market

Market design and market structure:

- Day-ahead market + intra-day markets + balancing markets
- Mix of dominant and fringe firms
- Mix of vertically integrated and stand-alone firms
- Mix of various technologies

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Rich data: ▸ Summary Statistics

- Sample: 2012-2015
- Detailed bid data at the plant level, including data on:
  - net positions of vertically integrated companies
  - bilateral contracts
- Hourly data on equilibrium outcomes
- Detailed data on marginal costs at plant level

Price-setting incentives in the day-ahead market

- Dominant firms do not internalize price increases on wind output under fixed prices – **forward-contract effect**

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Profit maximization in day-ahead market:

$$p_1 = p_2 + \left| \frac{\partial DR_{i1}}{\partial p_1} \right|^{-1} (q_{i1} - I_t w_{i1})$$

where $I_t = 1$ with fixed prices and $I_t = 0$ with variable prices.

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Empirical bidding equation:

$$b_{ijt} = \rho \hat{p_{2t}} + \beta \left| \frac{q_{it}}{DR'_{it}} \right| + \theta^s \left| \frac{w_{it}}{DR'_{it}} \right| I_t^s + \alpha_{ij} + \gamma_t + \epsilon_{ijt}$$

where $\hat{p_{2t}}$ is the predicted spot price, and I_t^s is an indicator for pricing rule, s =FIP I, FIT, FIP II. ▸ Slopes Residual Demands

Price-setting incentives in the day-ahead market

	2SLS			
	(1)	(2)	(3)	(4)
$\hat{p}_{2t}$	0.75***	0.84***	0.91***	0.67***
	(0.046)	(0.055)	(0.066)	(0.15)
FiP I $\times \frac{w_{it}}{DR'_{it}}$	3.24	4.82	6.31	7.16
	(3.74)	(4.20)	(4.73)	(5.71)
FiT $\times \frac{w_{it}}{DR'_{it}}$	-13.4***	-10.8***	-7.48***	-10.1***
	(3.14)	(2.93)	(2.40)	(3.34)
FiP II $\times \frac{w_{it}}{DR'_{it}}$	-1.05	-1.52	-1.59	3.86
	(3.45)	(2.99)	(2.59)	(4.04)
$\frac{q_{it}}{DR'_{it}}$				2.56**
				(1.14)
DoW FE	N	Y	Y	Y
Hour FE	N	N	Y	Y
Observations	19,805	19,805	19,805	19,805

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- Fringe wind firms engage in arbitrage (overselling) only under variable prices – **arbitrage effect**

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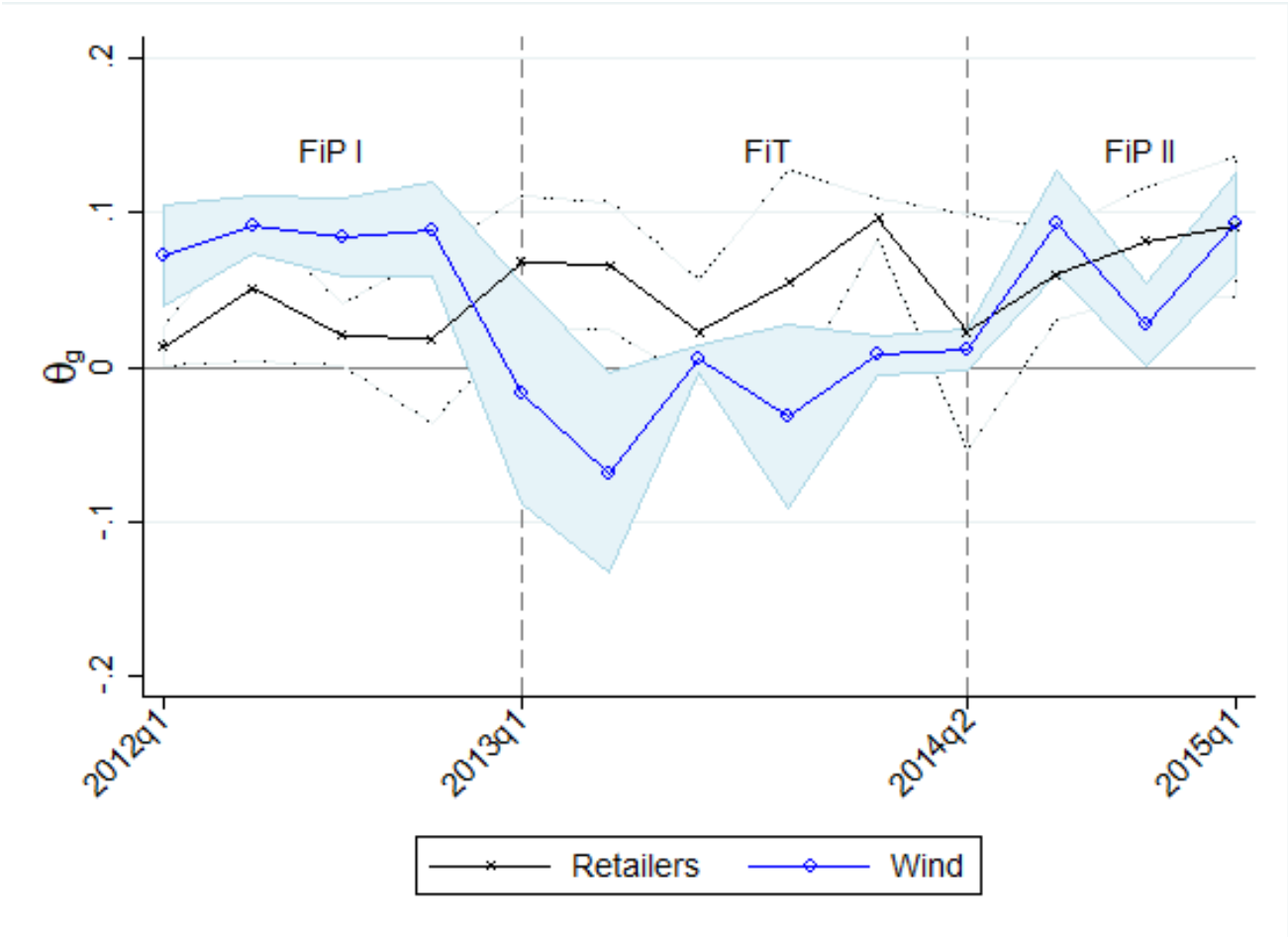
$$\Delta \ln q_{tg} = \alpha + \sum_{Q=1}^{13} \theta_g^Q \Delta\hat{p}_t + \gamma D_t^{er} + \delta w_t^{er} + \rho \mathbf{X}_t + \eta_{tg}$$

Response of overselling to predicted price premium

Figure: (1) using retailers as the control group



▸ Other renewables

Arbitrage by fringe firms: Diff-in-Diff

Two subsamples:

- $d = 1$: Feb 2012-Feb 2013 (includes FiP I $\rightarrow$ FiT)
- $d = 2$: Feb 2013-Feb 2014 (includes FiT $\rightarrow$ FiP II)

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Estimating equation (one for each sample; each control group):

$$\begin{aligned}\Delta \ln q_t =& \alpha + \beta_1 I_t^d W \Delta \hat{p}_t + \beta_2 W \Delta \hat{p}_t + \beta_3 I_t^d W + \beta_4 I_t^d \Delta \hat{p}_{ht} + \\ & \beta_5 \Delta \hat{p}_t + \beta_6 W + \beta_7 I_t^d + \rho \mathbf{X}_t + \eta_t\end{aligned}$$

- $W = 1$ treated group (Wind)
- $I_t^d = 1$ after regulatory change (I_t^1: FiTs; I_t^2: FiPs)
- Treatment effect captured by β_1

Overselling by the fringe (DID estimates)

	Non-wind renewables	Retailers	
	(1)	(2)	(3)
$\Delta\hat{p}\times$ Wind $\times$ FiT	-0.071***	-0.069***	
	(0.0068)	(0.014)	
$\Delta\hat{p}\times$ Wind $\times$ FiP			0.059***
			(0.011)
Observations	41,080	41,080	34,194

Notes: this shows that wind plants reduced (increased) their arbitrage when moved from variable prices to fixed prices (vice-versa).

▸ Full table

Questions?

Wrapping up results so far...

We have found evidence of:

1. **Forward contract effect** under fixed prices (FiTs)
2. **Arbitrage effect** under variable prices (FiPs)

Our theory model predicts that:

- Both should reduce market power and price discrimination
- Which one dominates? It depends on market structure

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What does the empirical evidence tell us?

Price discrimination across markets

- Factors than enhance market power $\rightarrow$ Price discrimination $\uparrow$
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Estimating equation:

$$\Delta p_t = \alpha + \sum_{s=1}^{2} \beta_1^s I_t + \beta_2 w_t + \sum_{s=1}^{2} \beta_3^s w_t I_t + \alpha_1 D\hat{R}'_{1t} + \alpha_2 D\hat{R}'_{2t} + \gamma \mathbf{X}_t + \epsilon_t$$

- I_t= FiP I, FiP II (FiT is reference point)
- w_t: dominant/fringe's wind share
- β_1^s: impact of pricing regimes on price discrimination
- β_3^s: impact of market structure across pricing regimes

Price discrimination across markets

	2SLS			
	(1)	(2)	(3)	(4)
$\frac{w_{dt}}{w_{ft}}$	-0.6***	-0.5***	-0.6***	-0.5***
	(0.2)	(0.2)	(0.2)	(0.2)
FiP I $\times \frac{w_{dt}}{w_{ft}}$	0.4**	0.5**	0.4**	0.5**
	(0.2)	(0.2)	(0.2)	(0.2)
FiP II $\times \frac{w_{dt}}{w_{ft}}$	0.5**	0.4**	0.5***	0.4**
	(0.2)	(0.2)	(0.2)	(0.2)
Weekend FE	N	N	Y	Y
Peak Hour FE	N	Y	N	Y
Observations	25334	25334	25334	25334

Market power in the day-ahead market

- We leverage on our structural estimates to **compute day-ahead mark-ups**:

$$\frac{p_{1t} - \hat{p}_{2t}}{p_{1t}} = \left| \frac{\partial DR_{i1t}}{\partial p_{1t}} \right|^{-1} \frac{q_{i1t} - I_t w_{i1}}{p_{1t}}$$

  for $I_t = 1$ with fixed (FiTs); $I_t = 0$ with variable prices (FiPs).

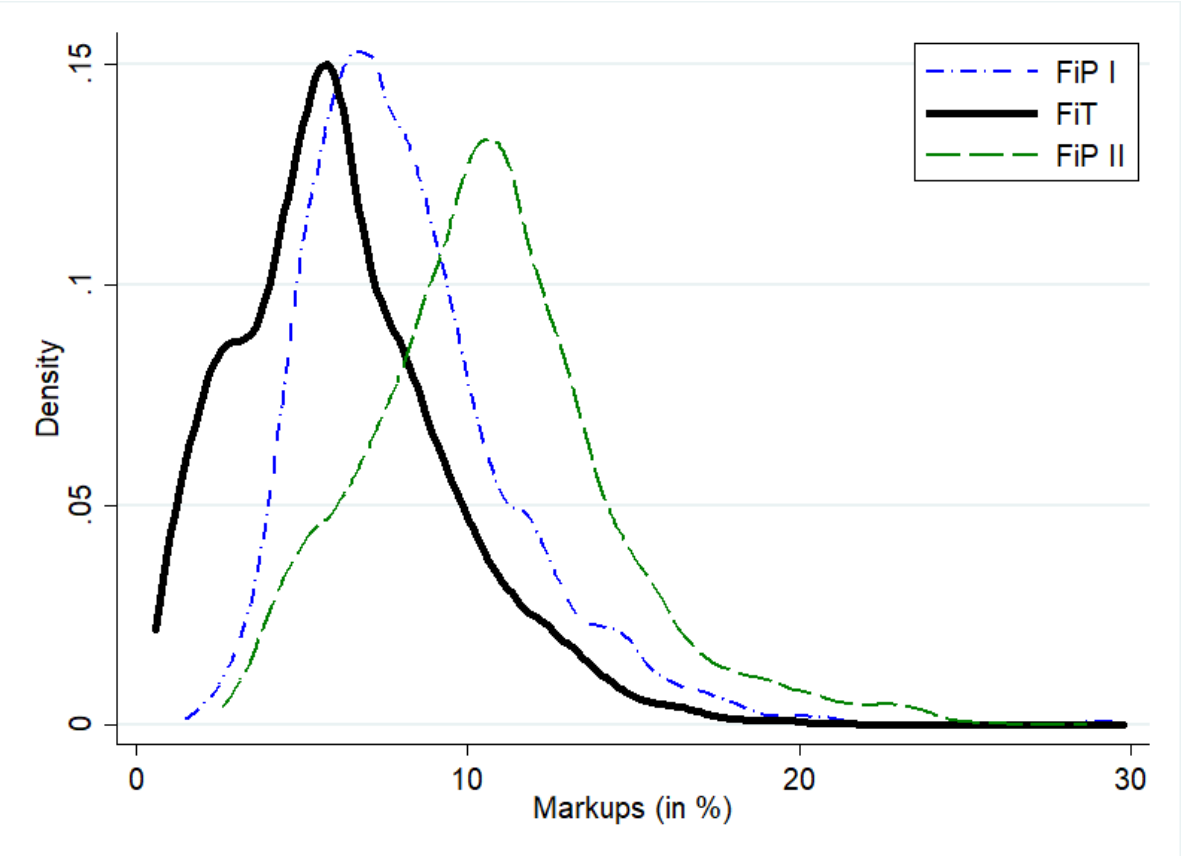
- To compute price-cost markups, we use engineering-based marginal costs.

Average markups across pricing regimes

	FiP I		FiT		FiP II	
	Mean	SD	Mean	SD	Mean	SD
Markups (in %) – Simple average						
Day-Ahead (structural)	8.3	(3.3)	6.3	(3.3)	10.7	(3.7)
Overall (engineering)	8.6	(23.1)	8.1	(29.4)	29.7	(14.0)
Markups (in %) – Demand weighted average						
Day-Ahead (structural)	8.3	(3.2)	6.4	(3.3)	10.7	(3.6)
Overall (engineering)	10.0	(22.8)	9.2	(29.6)	30.4	(13.5)
Slope of day-ahead residual demand (in MWh/euros)	524.2	(78.2)	553.6	(120.7)	418.2	(73.0)

Market power in the day-ahead market

Figure: Distribution of Day-Ahead Markups by Pricing Regime (All Firms)

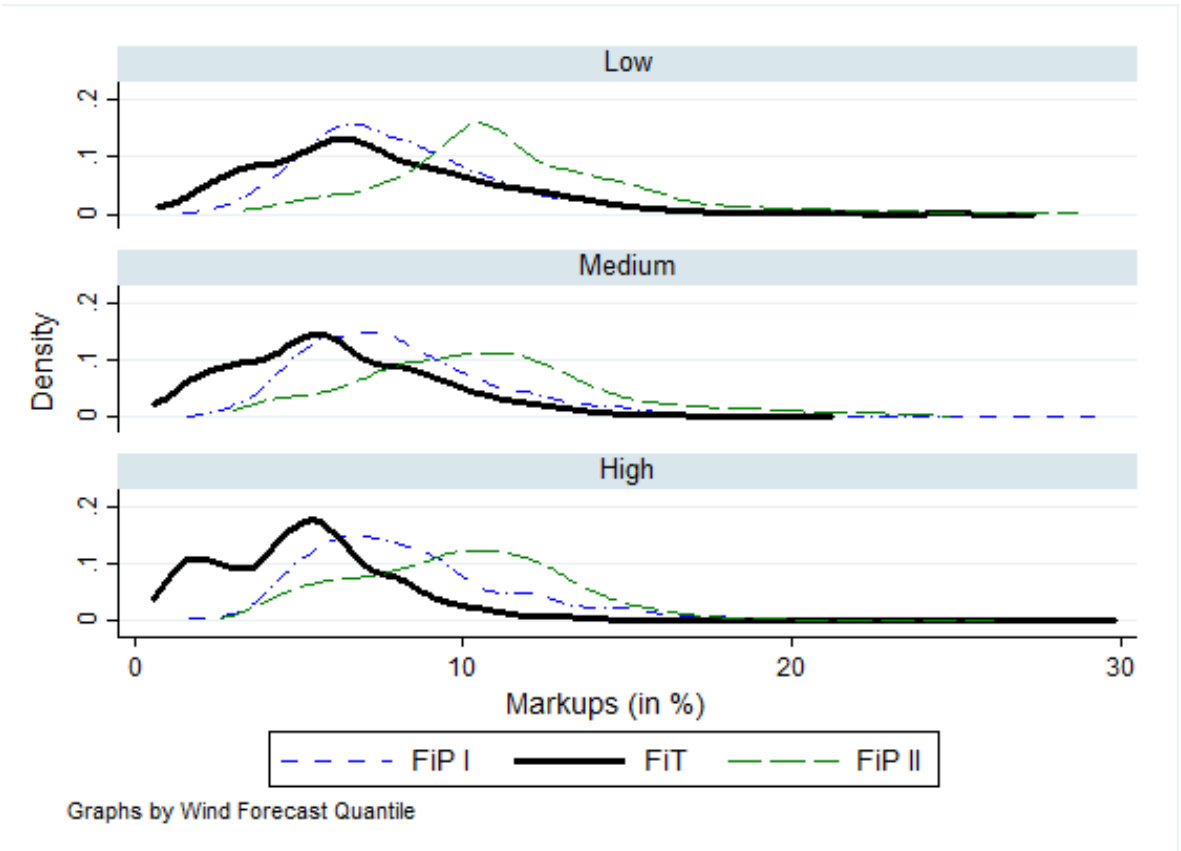


Notes: This figure plots the distributions of day-ahead markups of all firms by pricing regimes for hours with prices above 25 Euro/MWh.

▸ Table ▸ Markups by firm

Market power in the day-ahead market

Figure: Markup Distribution by Amount of Wind and Pricing Regime



Notes: This figure plots the markup distributions for all firms by amount of wind and by the pricing regimes for hours with prices above 25 Euro/MWh.

Conclusions

1. **Arbitrage** need not be the most efficient way to reduce price discrimination and mitigate market power
2. **Addressing market power directly** is more efficient
3. **Forward contracts** can play that role

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   - Fixed prices: market power $\downarrow$ and overall efficiency $\uparrow$
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Conclusions

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Policy relevant for:

- Renewables regulation
- Other sequential markets:
  e.g. emissions markets in the presence of market power

Thank you!

ENERGYECOLAB

Comments? Questions?

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Baseline: variable prices + no arbitrage

Suppose linear demand $D(p) = A - bp$

Equilibrium:

$$\begin{aligned} p_1^B &= (2(A - w_f) + bc)/3b \\ p_2^B &= (A - w_f + 2bc)/3b \\ \Delta p^B &= ((A - w_f) - bc)/3b \end{aligned}$$

Variable prices and Fixed prices

Equilibrium: (Variable prices) Back

$$\begin{aligned} p_1^V &= p_1^B - (k_f - w_f)/3b \\ p_2^V &= p_2^B + (k_f - w_f)/3b \\ \Delta p^V &= \Delta p^B - 2(k_f - w_f)/3b \end{aligned}$$

Variable prices and Fixed prices

Equilibrium: (Variable prices) Back

$$\begin{aligned} p_1^V &= p_1^B - (k_f - w_f)/3b \\ p_2^V &= p_2^B + (k_f - w_f)/3b \\ \Delta p^V &= \Delta p^B - 2(k_f - w_f)/3b \end{aligned}$$

Equilibrium: (Fixed prices) Back

$$\begin{aligned} p_1^F &= p_1^B - 2w_d/3b \\ p_2^F &= p_2^B - w_d/3b \\ \Delta p^F &= \Delta p^B - w_d/3b \end{aligned}$$

Summary of results

Relative to Baseline...	Variable prices	Fixed prices
Consumer surplus	?	$\uparrow$
Efficiency	$\downarrow$	$\uparrow$
Discrimination	$\downarrow$	$\downarrow$

Summary of results

Relative to Baseline...	Variable prices	Fixed prices
Consumer surplus	?	$\uparrow$
Efficiency	$\downarrow$	$\uparrow$
Discrimination	$\downarrow$	$\downarrow$

Comparison across pricing rules:

- **Consumer surplus** comparison depends on w_d / w_f
- **Efficiency** is higher with fixed prices
- **Price discrimination** comparison depends on w_d / w_f

Summary Statistics

	FiP I		FiT		FiP II	
	Mean	SD	Mean	SD	Mean	SD
Price Day-ahead	50.2	(13.8)	38.1	(22.2)	52.0	(11.2)
Price Intra-day 1	48.9	(14.2)	37.2	(22.1)	51.7	(11.7)
Price premium	1.2	(5.0)	1.0	(5.6)	0.3	(3.9)
Marginal Cost	47.5	(6.6)	42.3	(7.2)	37.0	(3.8)
Demand Forecast	29.8	(4.8)	28.5	(4.6)	28.1	(4.3)
Wind Forecast	5.7	(3.4)	6.5	(3.6)	5.0	(3.2)
Dominant wind share	0.6	(0.0)	0.7	(0.0)	0.6	(0.0)
Fringe wind share	0.4	(0.0)	0.3	(0.0)	0.4	(0.0)
Dominant non-wind share	0.8	(0.0)	0.8	(0.1)	0.8	(0.1)
Fringe non-wind share	0.2	(0.0)	0.2	(0.1)	0.2	(0.1)

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Testing the pre-trends assumption

Using quarterly splitted data, we regress:

$$\Delta \ln q_t = \alpha + \beta_2 W \hat{p}_t + \beta_5 \hat{p}_t + \beta_6 W + \gamma D_t^{er} + \delta w_t^{er} + \rho X_t + \eta_t$$

Coefficients of interest:

1. β_2 price response to predicted price premium.
2. **Pre-trends assumption** holds when the overselling behavior of treatment and control groups trend similarly when they face similar incentives.

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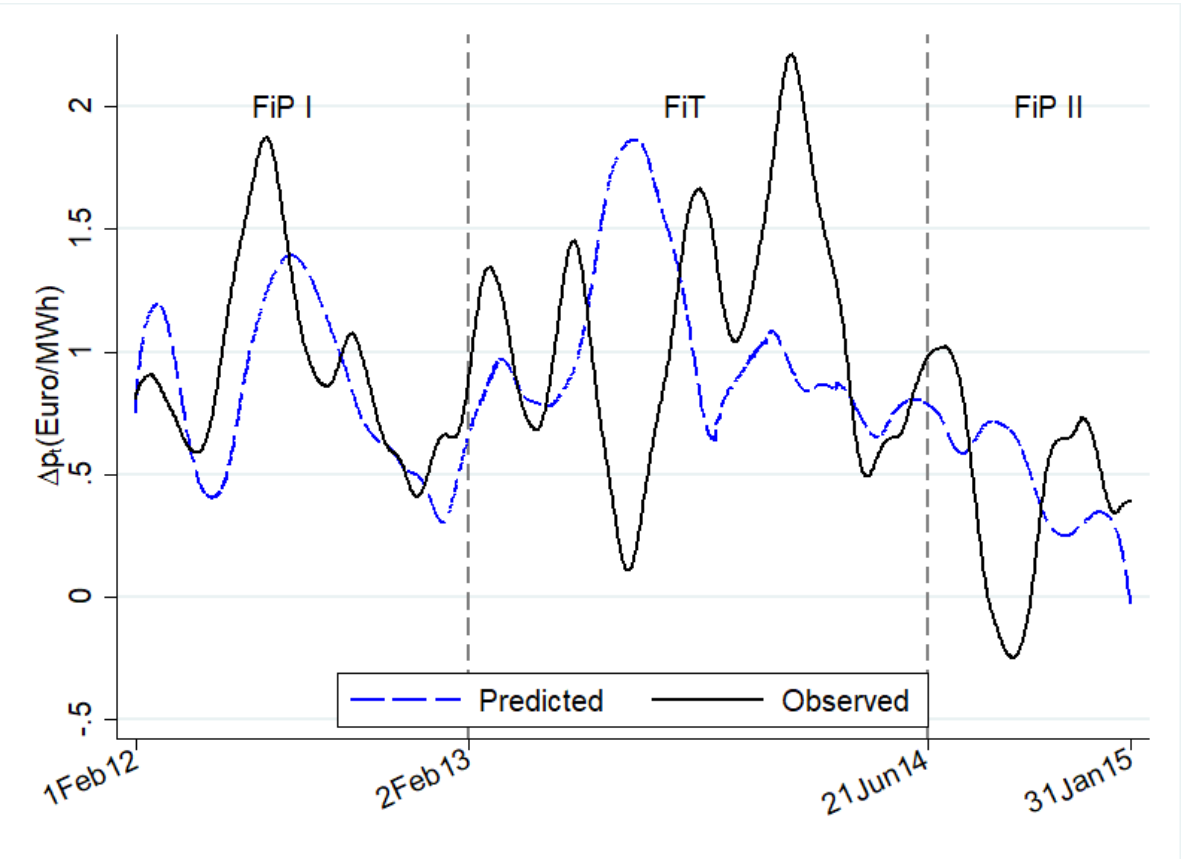
Predicted and observed price premium



Notes: This figure shows locally weighted linear regressions of $\Delta\hat{p}_t$ (predicted) and Δp_t (observed) from February 2012 to February 2015.

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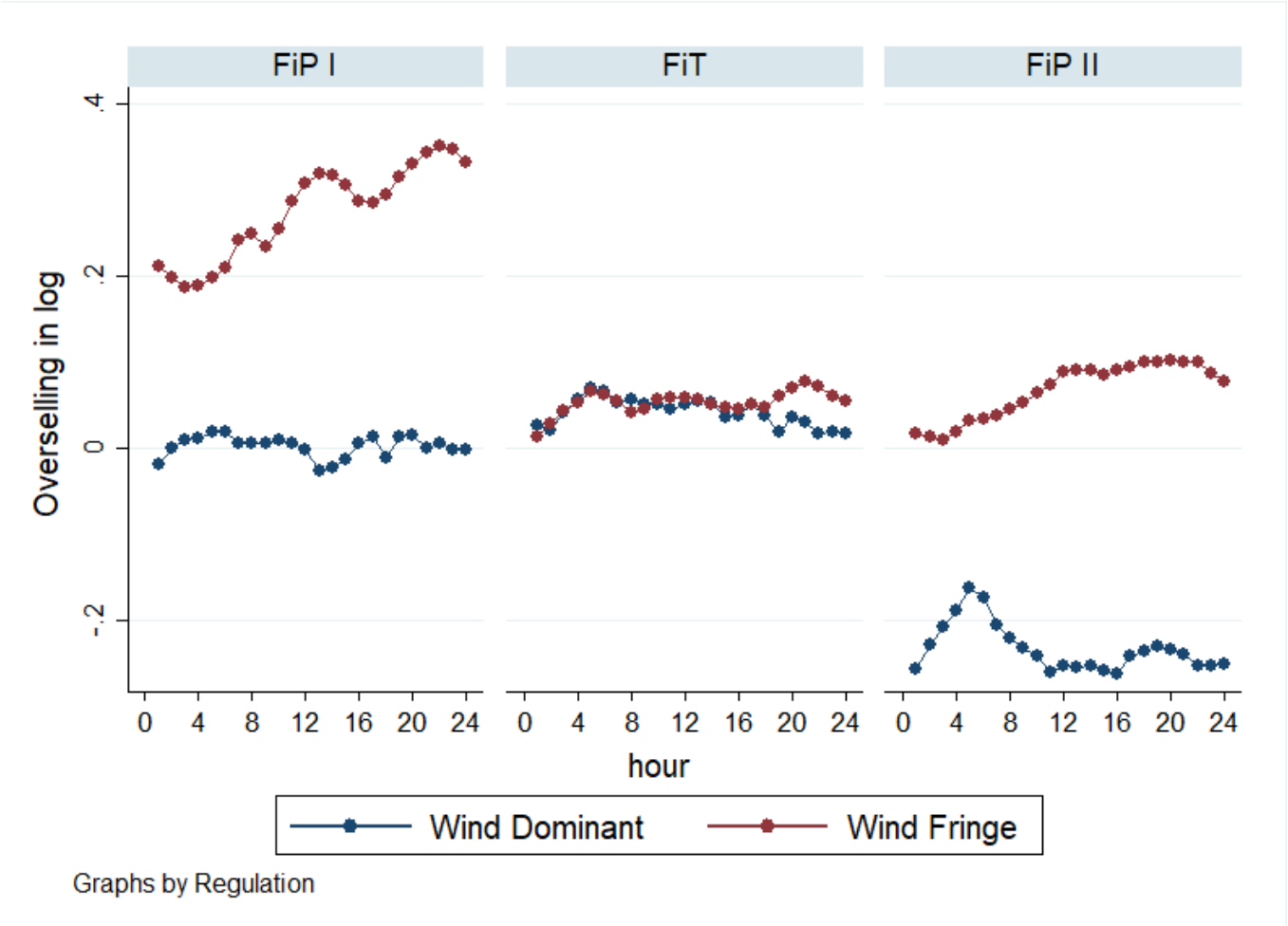
A first look at the data



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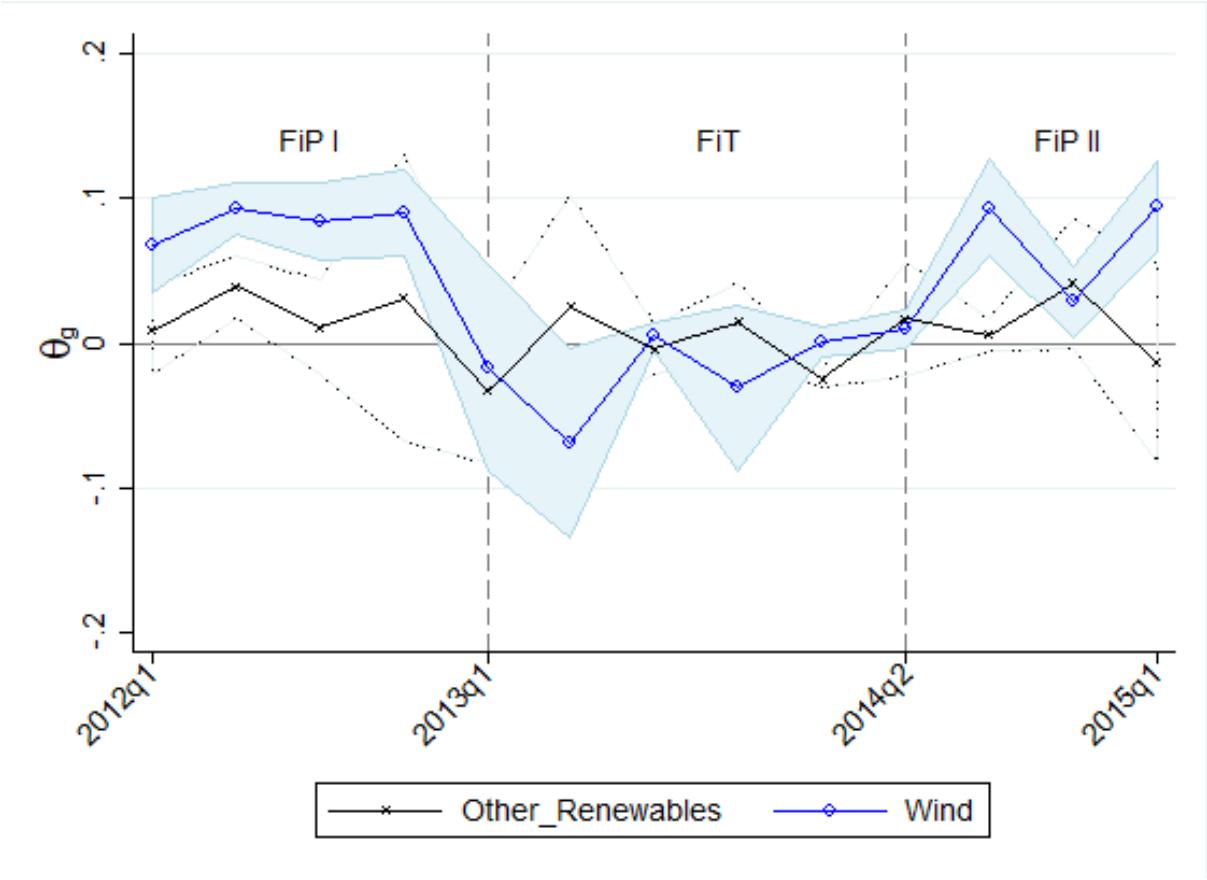
Response of overselling to predicted price premium

Figure: (2) using non-wind renewables as the control group



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Response of overselling to price premium

	Wind	Non-wind Renewables	Retailers	Diff	
	(1)	(2)	(3)	(1)-(2)	(1)-(3)
FiPI	0.064	0.008	0.079	-0.076	-0.006
	(0.000)	(0.000)	(0.000)	(0.000)	(0.529)
FiT	-0.001	-0.004	0.086	-0.005	0.063
	(0.882)	(0.004)	(0.000)	(0.151)	(0.000)
FiPII	0.032	-0.006	0.053	-0.036	0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.503)
FiPI→FiT	-0.065	-0.013	0.008	-0.071	-0.069
	(0.000)	(0.000)	(0.334)	(0.000)	(0.000)
FiT→FiPII	0.026	-0.000	-0.049	0.03	0.059
	(0.000)	(0.812)	(0.000)	(0.000)	(0.000)

Notes: This table reports the coefficient of $\Delta\hat{p}_t$ from 14 different regressions..

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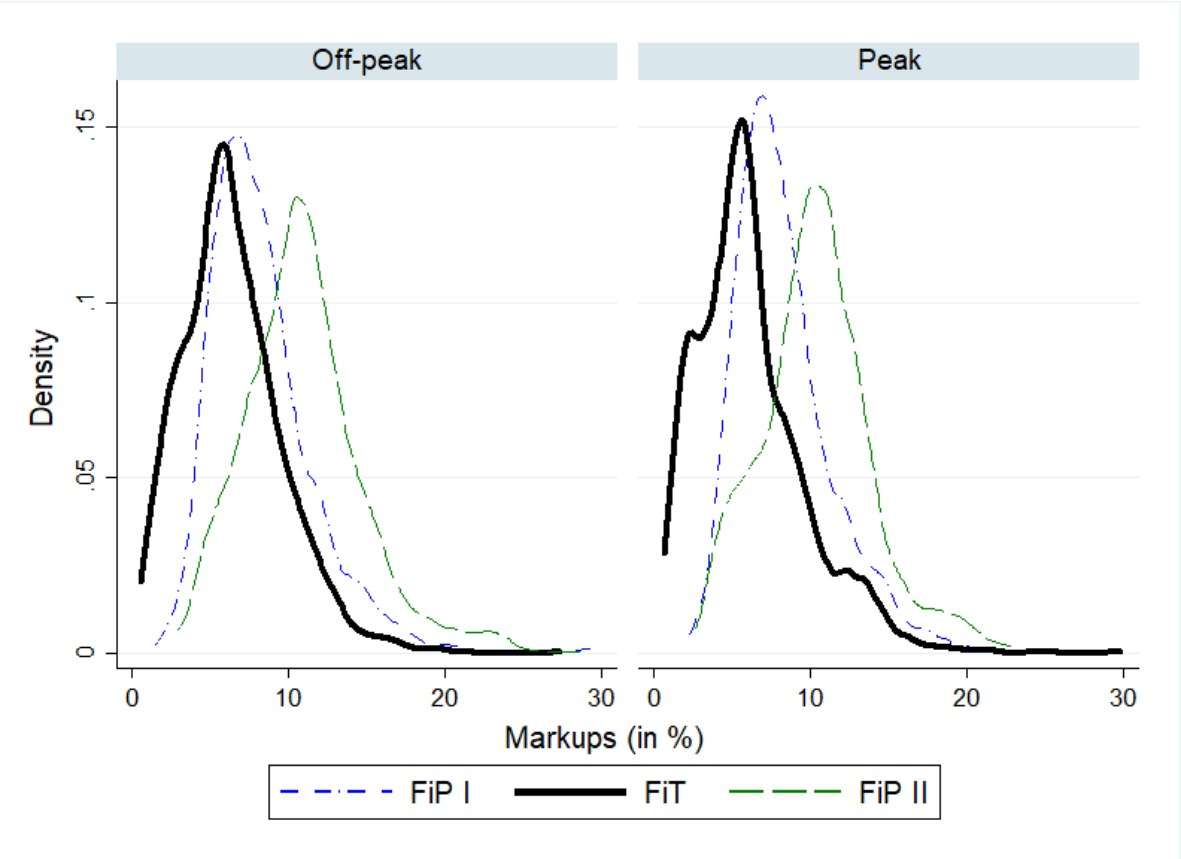
Market power in the day-ahead market

Figure: Markup Distribution by Type of Hour and Pricing Regime



Notes: This figure plots the markup distributions for all firms by peak vs. off-peak hours and by the pricing regimes for hours with prices above 25 Euro/MWh.

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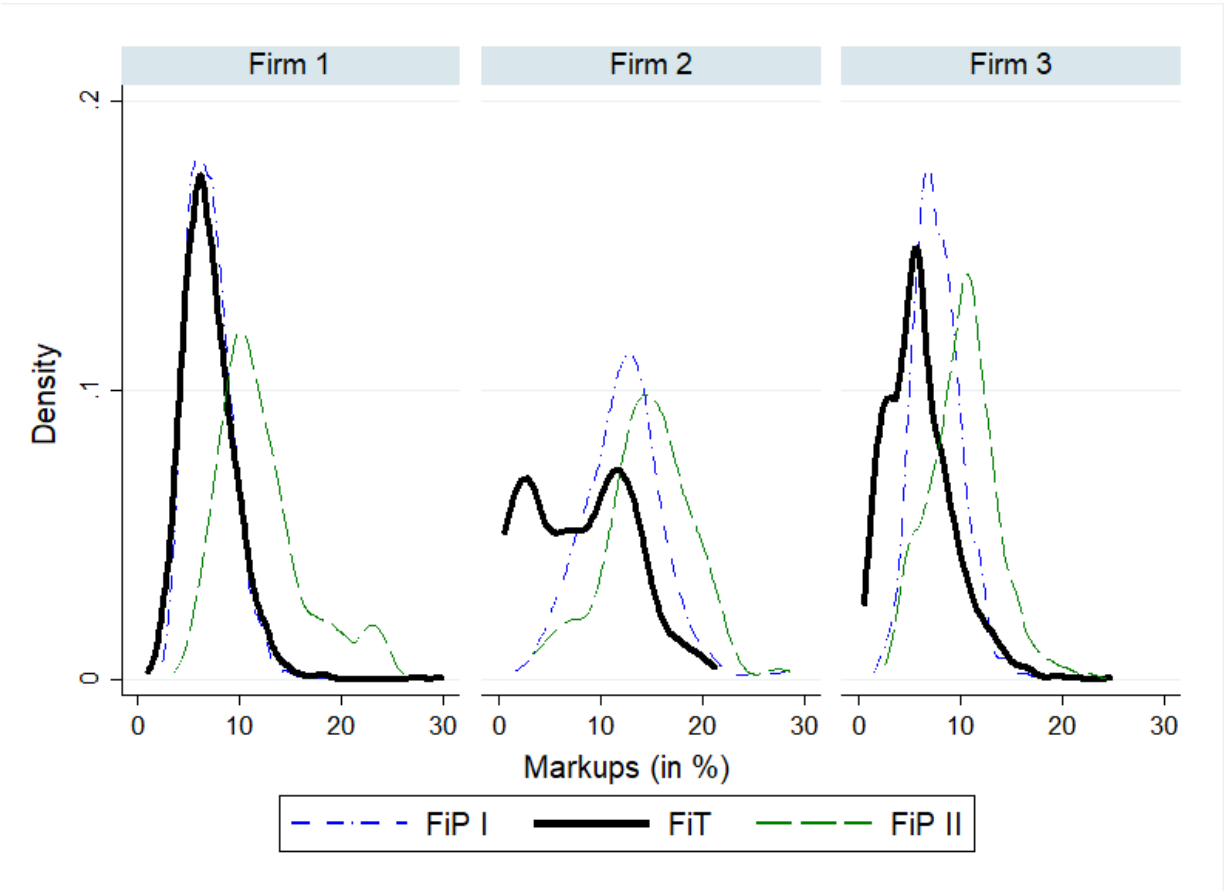
Market power in the day-ahead market

Figure: Markup Distribution by Firm and Pricing Regime



Notes: This figure plots the markup distributions for each of the dominant firms by their pricing regimes for hours with prices above 25 Euro/MWh.

▸ Peak vs. off-peak markups