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

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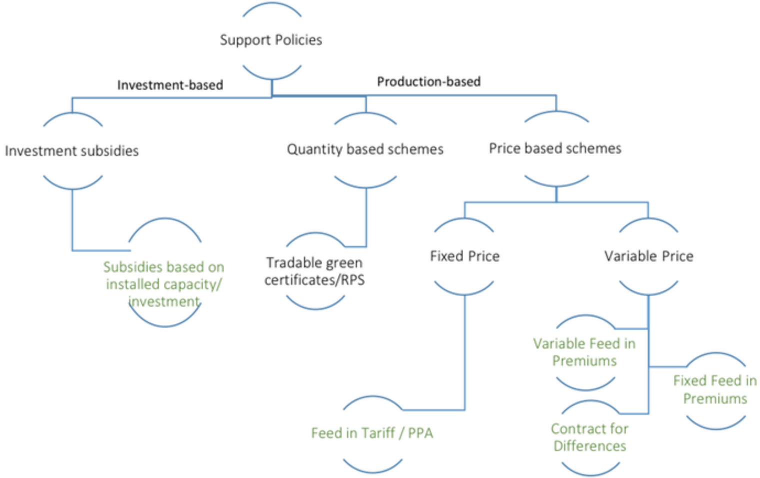
How to design support schemes for renewables?



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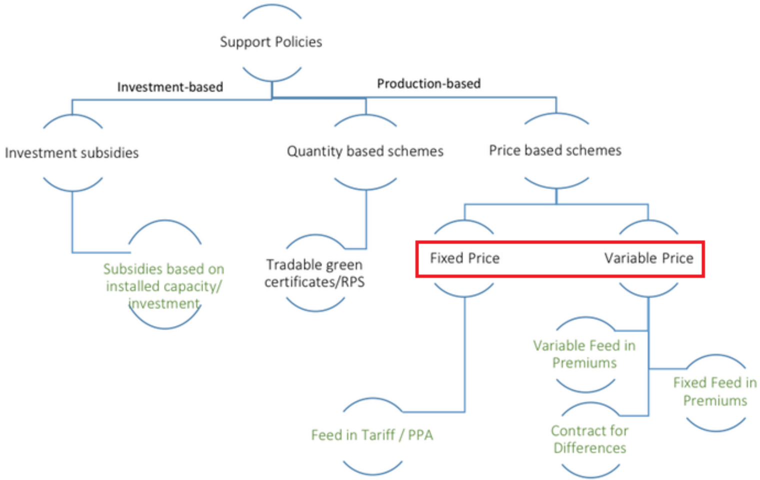

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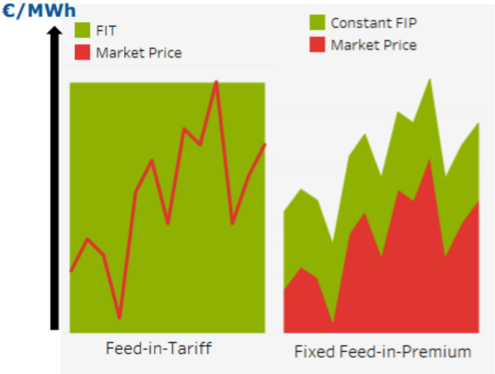

1. **Fixed prices**:
   Feed-in-Tariffs (FiT)
   - Prices set ex-ante by regulators
   - Mitigate market power directly
   - Discourage renewables from arbitraging

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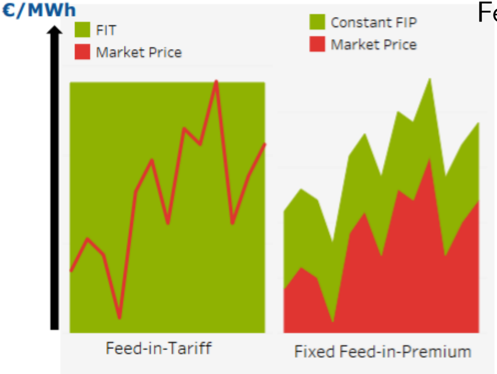

2. **Variable prices**: Feed-in-Premia (FiP)
   - Prices in wholesale energy markets + fixed premium
   - No direct effect on market power
   - Promote **arbitrage** across markets

For given capacities, what are the **market power impacts** of paying producers according to **fixed vs. variable prices**?

Iberian electricity market: an ideal laboratory

Changes in wind regulation:

- 02/2013: variable prices (R I) $\rightarrow$ fixed prices (R II)
- 04/2014: fixed prices (R II) $\rightarrow$ variable prices (R III)

Iberian electricity market: an ideal laboratory

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- 02/2013: variable prices (R I) $\rightarrow$ fixed prices (R II)
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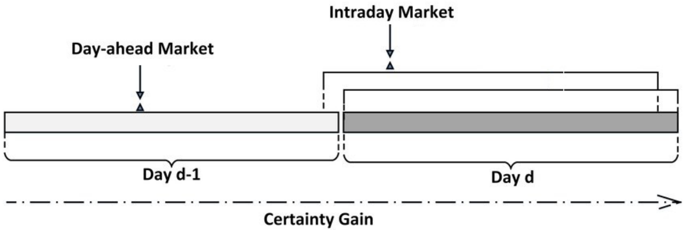
Market Rules:

- Sequential markets: day-ahead market + intraday markets



- Arbitrage across markets allowed, with limits
  - Forward premia consistent with market power due to witholding strategy

Data from the Iberian electricity market

- Sample: 2012-2015
- Detailed hourly bid and cost data at the plant level
  - Dominant firms and a group of smaller (fringe) firms
  - High wind penetration (covering 20-23% of demand)

	Regime I Market Prices		Regime II Fixed Prices		Regime III Market Prices	
	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)
Installed capacity wind	22.76		23.01		23.03	
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)
Installed capacity non-wind	99.82		100.16		100.08	

Market impacts of price exposure & existing studies

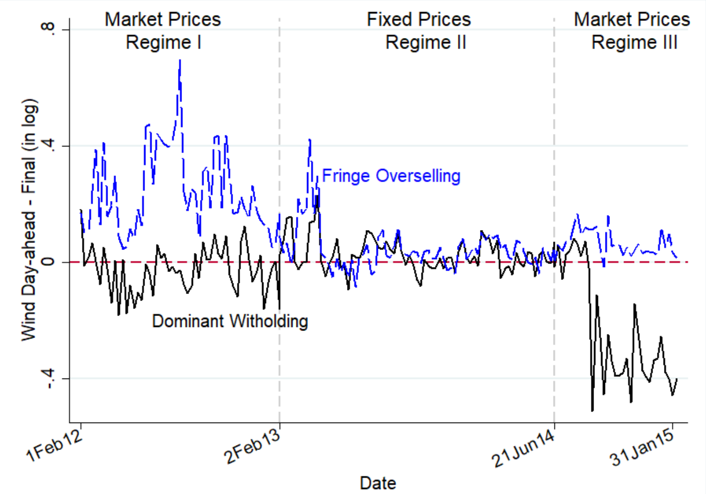
1. **Positive effects** of paying renewables at **fixed prices**:
   - Reduce risk premia and financing costs (Newbery, 2016)
   - Promote entry of smaller players
   - Mitigate market power in the wholesale market (This paper)
2. **Negative effects** of paying renewables at **fixed prices**:
   - Value of investments not internalized (Joskow, 2011)
   - Arbitrage is discouraged (Ito and Reguant, 2016; This paper)

Contribution: how these trade-off impact market prices and efficiency.

Key message: the impact of renewable policy requires an analysis of the interaction between conventional and renewable suppliers.

Raw data suggests that price exposure matter

Figure: Overselling and withholding by wind producers



Research questions & hypothesis

Under which pricing scheme is day-ahead market power lower and what are the channels?

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3. **Market power in the day-ahead market?**
   - Which of the two channels dominate, leading to less market power in the day-ahead market?

The results preview

1. **Under variable prices:**
   - Wind firms arbitrage price differences (arbitrage effect)
   - This reduces market power and price discrimination
2. **Under fixed prices:**
   - Dominant firms have less ability to exercise market power because part of their output is paid on fixed prices (forward-contract effect)
   - This reduces market power and price discrimination
3. **Fixed vs. variable prices:**
   - Which of the two effects dominate, leading to less market power in the day-ahead market?
   - The comparison depends on market structure: **who owns renewable energy**
   - In the context of the Iberian electricity market, we find:
     - Fixed prices led to less market power than variable prices

Roadmap

1. **Empirical Analysis**
   - Bidding incentives in the day-ahead market
   - Arbitrage across markets
   - Market power in the day-ahead market
2. **A Simple Model**
   - Wind receives market prices (price exposure)
   - Wind receives fixed prices (no price exposure)
   - Comparison
3. **Conclusions**

Empirical Analysis

[1.] The forward contract effect

Bidding 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:

$$p_1 = p_2 + \left| \frac{\partial DR_i}{\partial p} \right|^{-1} (q_i - I_t w_i),$$

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

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Empirical bidding equation:

$$b_{ijt} = \rho \hat{p}_{2t} + \beta \left| \frac{q_{it}}{DR'_{it}} \right| + \sum_{s=1}^{3} \theta^s \left| \frac{w_{it}}{DR'_{it}} \right| I_t^s + \alpha_{ij} + \gamma_t + \epsilon_{ijt},$$

where I_t^s is an indicator, $s =$RI, RII, RIII. ▸ Slopes Residual Demands

2SLS - Identification

1. Endogeneity in the mark-ups components: we instrument DR'_{it} using wind speed and precipitation (and each of them interacted with three dummies for the pricing scheme) as residual demand shifters.
   - Conditional on unit and time fixed effects, wind speed and precipitation affect firms marginal bids only through the markup parameters (Fabra and Reguant, 2014; Ito and Reguant, 2016).
2. Omitted variable bias: we add a set of flexible controls, such as time trends, and quadratic time trends, on the top of a set of fixed effects discussed earlier.

The forward contract effect

Table: The Forward Contract Effect

	2SLS			
	(1)	(2)	(3)	(4)
Market Prices (RI) × $\frac{w_{it}}{DR'_{it}}$	6.35	9.31	9.10	5.54
	(5.03)	(6.28)	(6.10)	(5.47)
Fixed Prices (RII) × $\frac{w_{it}}{DR'_{it}}$	-14.2***	-14.5***	-14.9***	-14.3***
	(3.03)	(2.88)	(3.02)	(3.24)
Market Prices (RIII) × $\frac{w_{it}}{DR'_{it}}$	1.72	0.049	0.60	5.69
	(4.10)	(3.42)	(3.21)	(5.24)
Expected spot price ($\hat{p}_{2t}$)	0.77***	0.78***	0.77***	0.38***
	(0.057)	(0.062)	(0.062)	(0.15)
Markup term ($\frac{q_{it}}{DR'_{it}}$)				4.81***
				(1.25)
Linear Trends	N	Y	Y	Y
Quad. Trends	N	N	Y	Y
Observations	19,805	19,805	19,805	19,805

The forward contract effect

Table: The Forward Contract Effect Accounting for Vertical Integration

	2SLS			
	(1)	(2)	(3)	(4)
Market Prices (RI) × $\frac{w_{it}}{DR'_{it}}$	11.9*	12.5*	12.4*	18.5**
	(6.45)	(6.59)	(6.41)	(8.79)
Fixed Prices (RII) × $\frac{w_{it}}{DR'_{it}}$	-14.1***	-12.7***	-13.1***	-7.48**
	(3.47)	(2.83)	(2.97)	(3.48)
Market Prices (RIII) × $\frac{w_{it}}{DR'_{it}}$	1.09	1.15	1.78	7.57*
	(3.91)	(3.74)	(3.43)	(4.18)
$\hat{p_{2t}}$	0.94***	0.96***	0.96***	1.18***
	(0.064)	(0.067)	(0.067)	(0.10)
$\frac{q_{it}}{DR'_{it}}$				3.36***
				(0.93)
Linear Trends	N	Y	Y	Y
Quad. Trends	N	N	Y	Y
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[2.] The arbitrage effect

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

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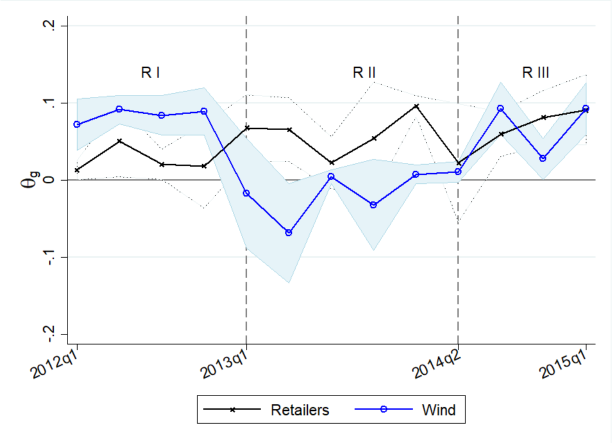
$$\Delta \ln q_{tg} = \alpha + \sum_{q=1}^{13} \theta_{gq} \Delta\hat{p}_t + \gamma D_t^{er} + \delta w_t^{er} + \rho \mathbf{X}_t + \eta_{tg}$$

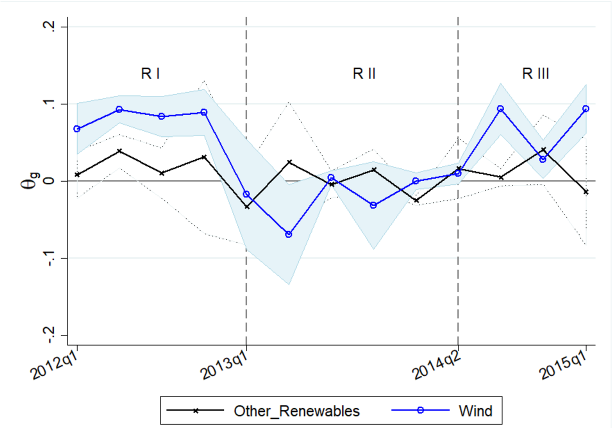
Response of overselling to predicted price premium

Figure: (1) using retailers as the control group



Response of overselling to predicted price premium

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



Notes: Other renewable units included are solar, small hydro and co-generation production units.

Arbitrage by fringe firms: Diff-in-Diff

Two subsamples:

- $d = 1$: Feb 2012-Feb 2013 (includes RI $\rightarrow$ RII)
- $d = 2$: Feb 2013-Feb 2014 (includes RII $\rightarrow$ RIII)

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

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

- $W = 1$ treated group (Wind)
- $I_t^d = 1$ after regulatory change (I_t^1: RII; I_t^2: RIII)
- Treatment effect captured by $\boldsymbol{\beta_1}$

Overselling by the fringe (DID estimates)

Table: DID estimates of overselling by the fringe

	Non-wind renewables	Suppliers	
	(1)	(2)	(3)
$\Delta\hat{p}\times$ Wind $\times$ Fixed Prices (RII)	-0.071***	-0.069***	
	(0.0068)	(0.014)	
$\Delta\hat{p}\times$ Wind $\times$ Market Prices (RIII)			0.059***
			(0.011)
Observations	41,080	41,080	34,194

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

[3.] Market power

Market power in the day-ahead market

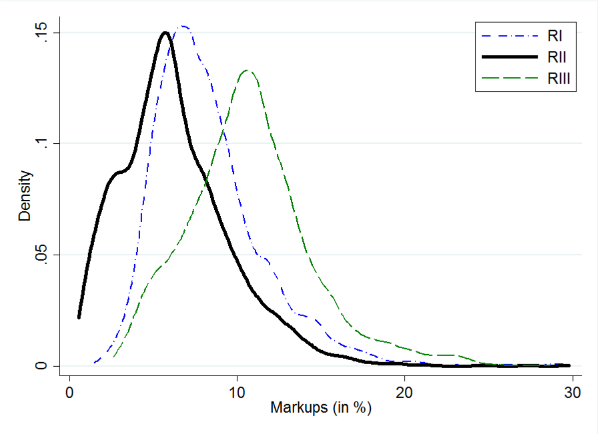
- We leverage on structural estimates to **compute mark-ups**:

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

for $I_t = 1$ fixed prices (RII); $I_t = 0$ market prices (RI and RIII).

Market power in the day-ahead market

Figure: Markup Distribution by Pricing Regime (All Firms)

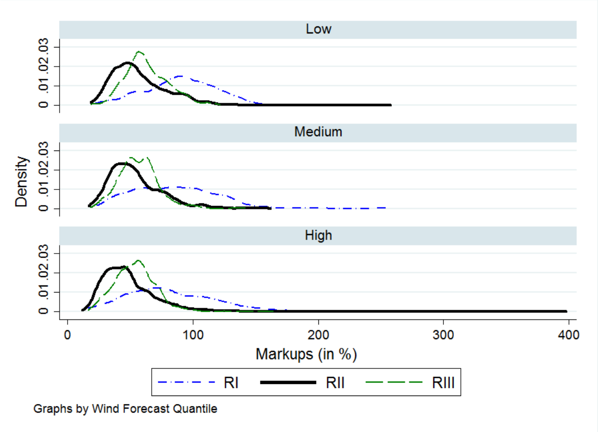


Notes: This figure plots the markup distributions of all firms by pricing regimes for hours with prices above 25 Euro/MWh.

Table
Markups by firm

Market power in the day-ahead market

Figure: Markup Distribution by Amount of Wind and Pricing Regime



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A Simple Model

Model Description

Markets and Demand:

- Sequential markets: day-ahead (p_{t-1}) and spot (p_t)
- Total demand $D(p_t)$
  - $D(p_{t-1})$ (day-ahead) + $[D(p_t) - D(p_{t-1})]$ (spot)
- (Some) consumers are myopic

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Technologies:

- Conventional: marginal costs c
- Wind: zero marginal costs; availability $w_i \leq k_i$

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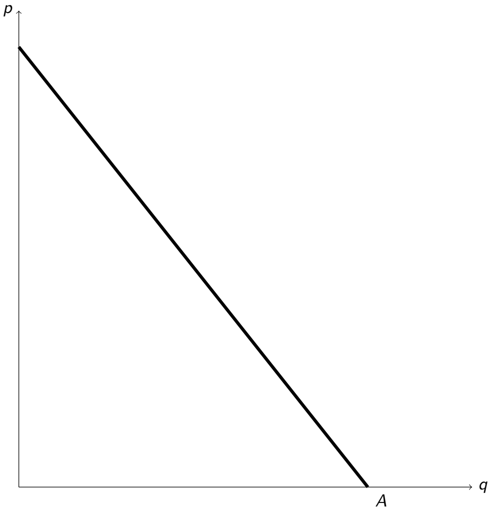
Firms and ownership:

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

Monopoly pricing in sequential markets



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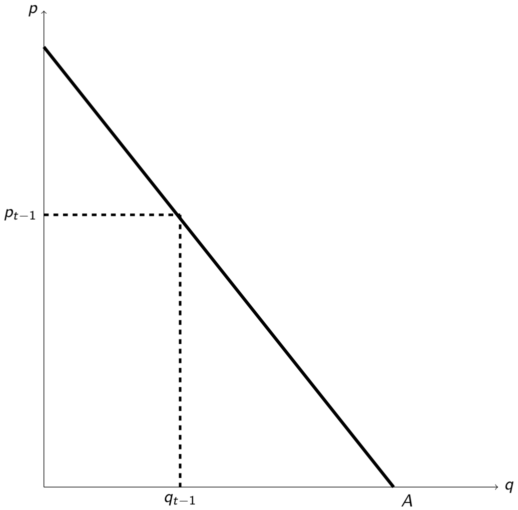

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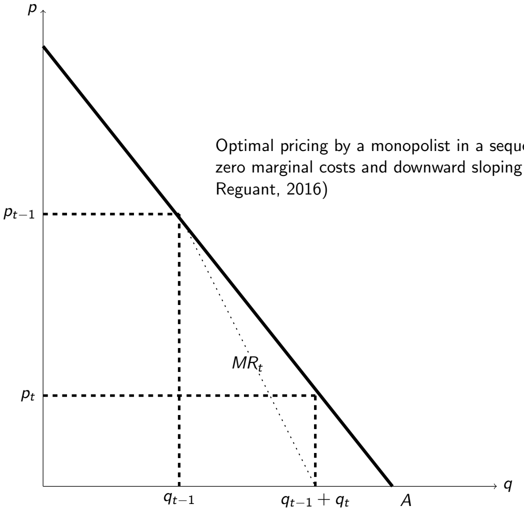

Optimal pricing by a monopolist in a sequential market facing zero marginal costs and downward sloping demand (Ito and Reguant, 2016)

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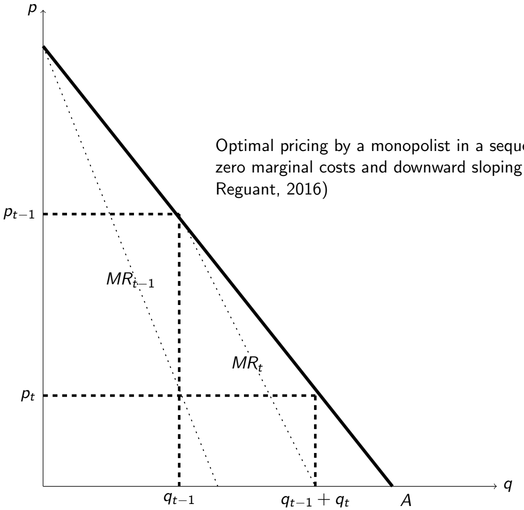

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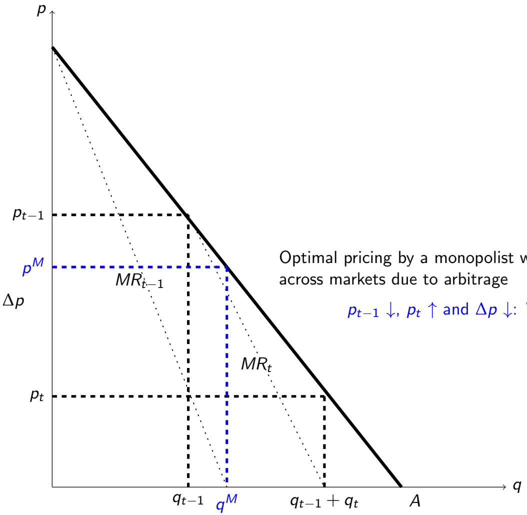
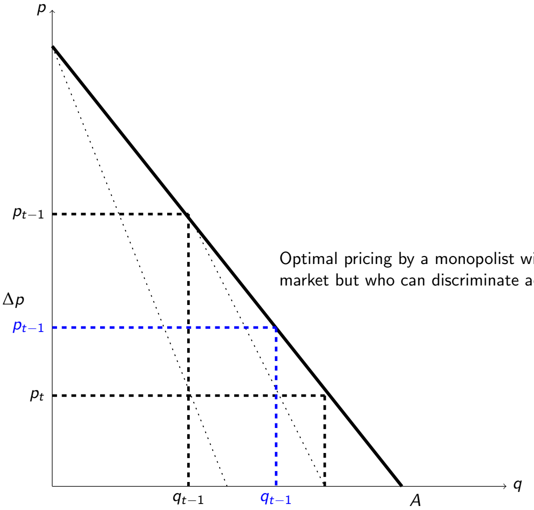
Sequential markets + full arbitrage - FiP



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

$p_{t-1} \downarrow$, $p_t \uparrow$ and $\Delta p \downarrow$: **Welfare** $\downarrow$; Consumer surplus?

Sequential markets + market power mitigation - FiT



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

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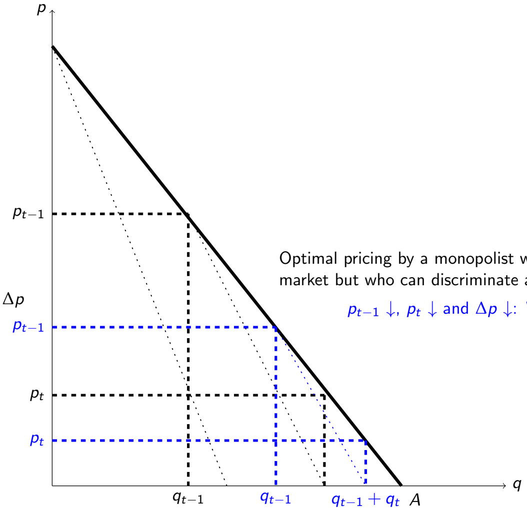

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Comparison across pricing rules

Comparing spot market prices:

- $p_2^M > p_2^B > p_2^F$

Comparing day-ahead prices:

[Arbitrage *vs.* forward-contract effects]

$$M : p_1 = p_2^M - \left|\frac{\partial D(p_1)}{\partial p_1}\right|^{-1} (D(p_1) - w_f - (k_f - w_f))$$

$$F : p_1 = p_2^F - \left|\frac{\partial D(p_1)}{\partial p_1}\right|^{-1} (D(p_1) - w_f - w_d)$$

- With linear demand, $p_1^F < p_1^M$ iff $w_d > (k_f - w_f)/2$.

Summary of the key results

	FiP	FiT
p_1	$\downarrow$	$\downarrow$
p_2	$\uparrow$	$\downarrow$
Δp	$\downarrow$	$\downarrow$
Channel	Arbitrage effect	Forward contract effect

Summary of the key results

	FiP	FiT
p_1	$\downarrow$	$\downarrow$
p_2	$\uparrow$	$\downarrow$
Δp	$\downarrow$	$\downarrow$
Channel	Arbitrage effect	Forward contract effect
Consumer Surplus	higher if $w_f >> w_d$	higher if $w_f << w_d$

Conclusions

1. Price exposure encourages fringe producers to be active market participants: **arbitrage** mitigates market power through their active participations
2. Reducing price exposure lowers the fringe producers' incentives to arbitrage but it **mitigates market power** of the dominant players.

This trade-off depends on market structure:
who owns renewable energy.

Policy relevant for:

- Design of renewables' auctions
- Design of other (sequential) markets:
  e.g., emissions markets in the presence of market power

Thank you!

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Comments? Questions?

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