The Energy Transition: Markets and Policies

Natalia Fabra

Universidad Carlos III and CEPR

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The Energy Transition

A challenge for the power sector

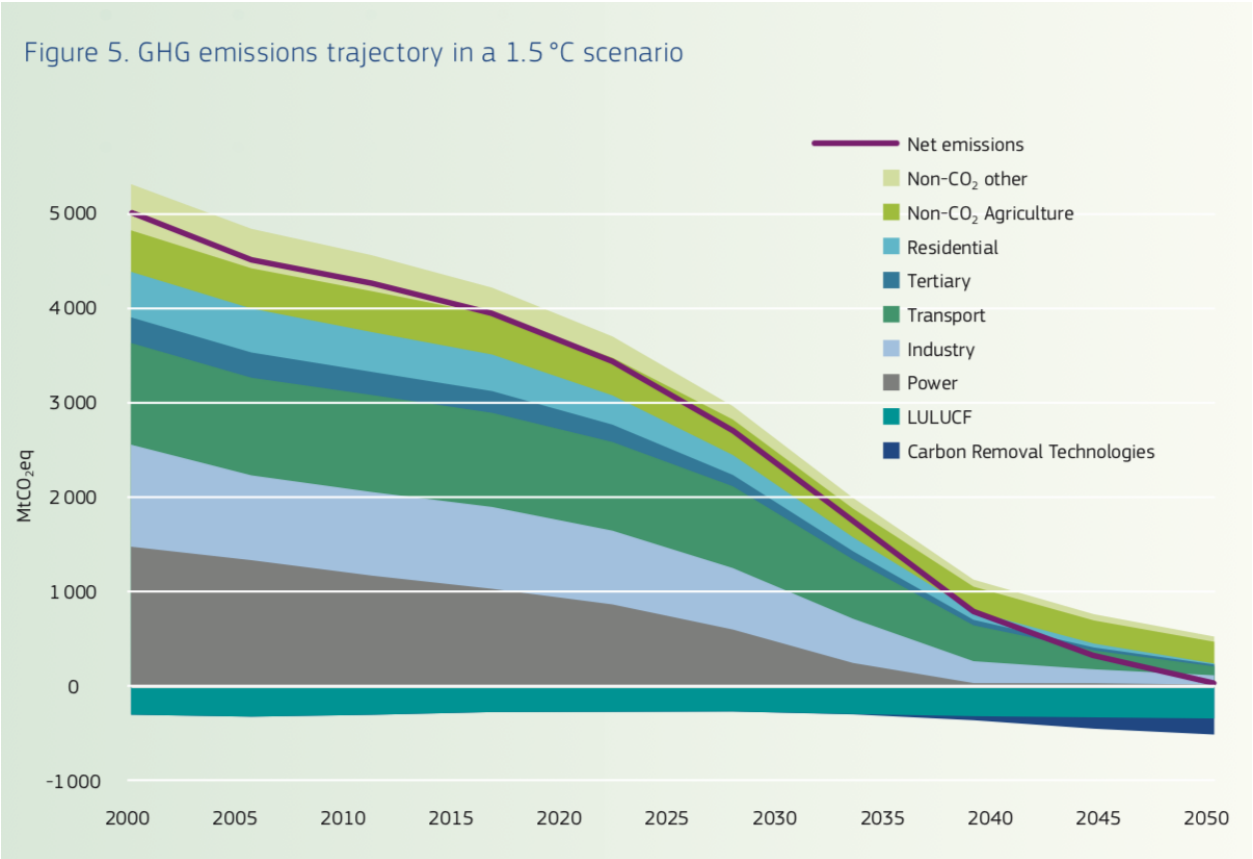

Figure: Emissions reductions in Europe to achieve Carbon Neutrality (Source: European Commission (2019): Going Climate Neutral by 2050)

The Energy Transition: How?

A pletora of research and policy questions

1. How will **renewables-dominated markets** work?
2. How will it depend on the **pricing scheme** faced by renewables?

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6. Will investment in **storage** facilities be enough?
7. Will **demand response** contribute to balancing the market?

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7. Will **demand response** contribute to balancing the market?
8. Is there a need to rethink electricity **market design**?
9. ....

The Energy Transition

An ongoing research agenda

How will renewables-dominated markets work?

- "Auctions with Unknown Capacities: Understanding Competition among Renewables", with G. Llobet

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How will it depend on the pricing scheme faced by renewables?

- "Price Exposure and Market Power: Learning from Changes in Renewables Regulation", with I. Wang

Renewables

An ongoing research agenda

How to promote investments in renewables?

- "Technology-Neutral *vs* Technology-Specific Procurement", with JP. Montero

Will investment in storage facilities be enough?

- "Storing Power: Market Structure Matters", with D. Andres-Cerezo

What to expect from demand response?

- "Real-Time Pricing for Everyone", with D. Rapson and M. Reguant
- "The Distributional Impacts of Real-Time Pricing", with M. Cahana and M. Reguant

Auctions with unknown capacities: Understanding competition among renewables

A new paradigm in electricity markets:

- The shift from fossil fuels to renewables: new paradigm
- Competition-wise, two key differences:
  - **Conventional plants**: known capacities, plausibly unknown (heterogeneous) marginal costs
  - **Renewables**: unknown capacities, known (zero) marginal costs

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Renewables fundamentally **change the nature of strategic interaction** among electricity producers

A Simple Model

Main Model Ingredients

Firms' and Demand:

- Ex-ante symmetric firms, with costs $c \geq 0$
- Available capacities k_i: common + idiosyncratic component
- Firms have private information about their idiosyncratic component
- Demand θ is price inelastic; price cap $P > c$
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Market Design:

- Uniform-price auction
- Renewables are paid at market prices (Feed-in-Premiums)
- Firms bid a price-quantity pair (b_i, q_i) with $q_i \leq k_i$

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Equilibrium concept: Bayesian Nash equilibrium

Symmetric equilibrium

Small installed capacities

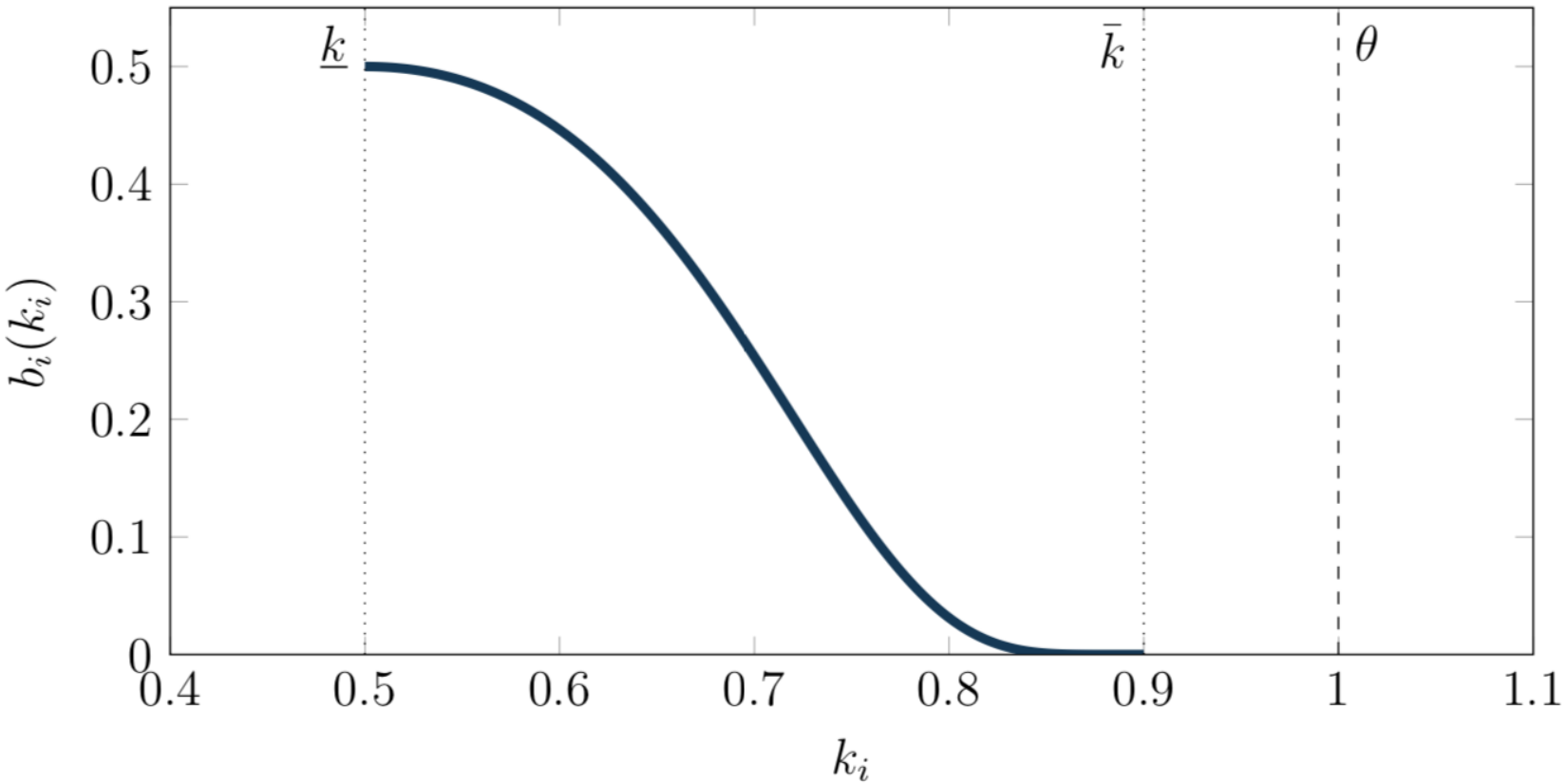

Figure: Equilibrium bids when $k_i \sim U[0.5, 0.9]$, $\theta = 1$, $c = 0$, and $P = 0.5$.

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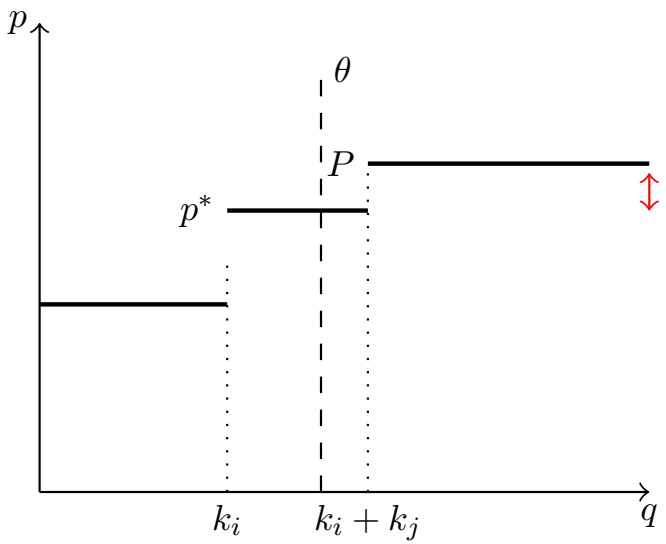
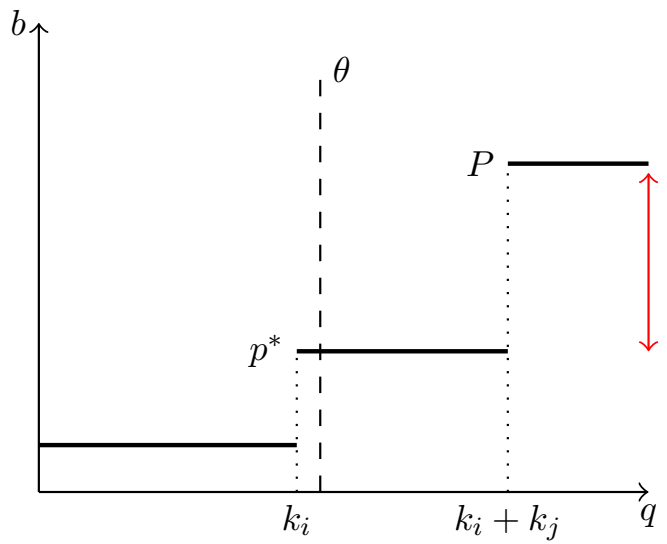
Implications for Market Performance

Price volatility across the day

- When realized capacities are larger relative to demand...
  - Supply functions shift downwards and outwards
  - Market prices fall



(a) Small price reduction



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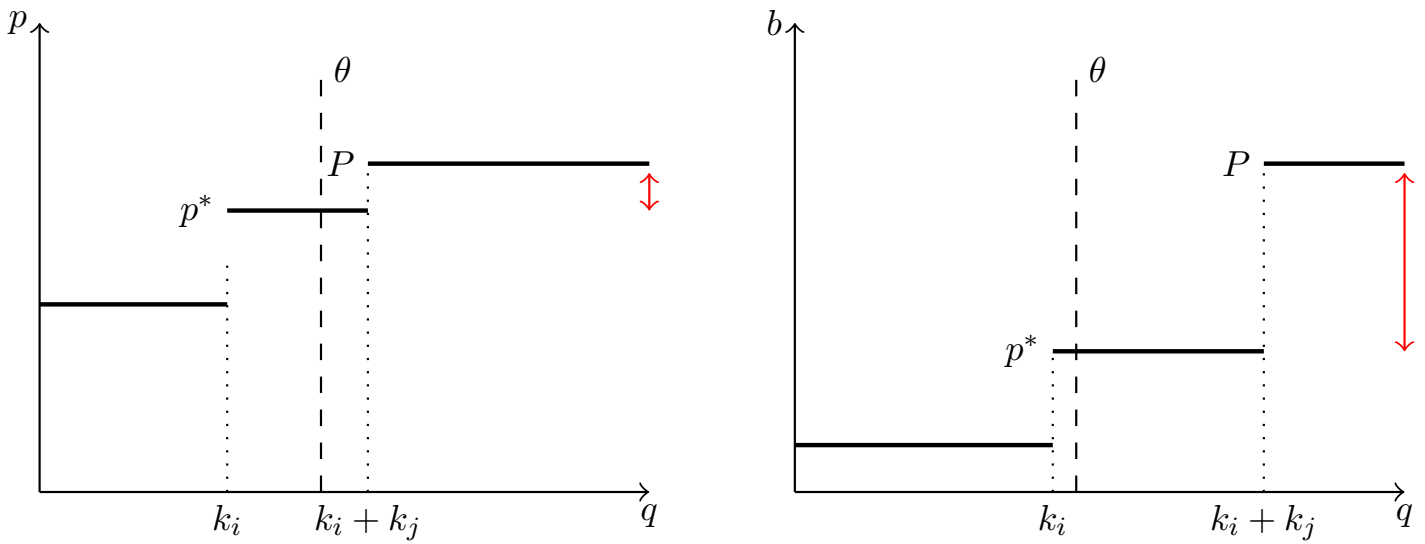

(a) Small price reduction (b) Large price reduction

- Market power mitigates the price-depressing effects of renewables
- But weaker market power than with conventional technologies

Implications for Market Performance

Lower prices as installed capacity increases

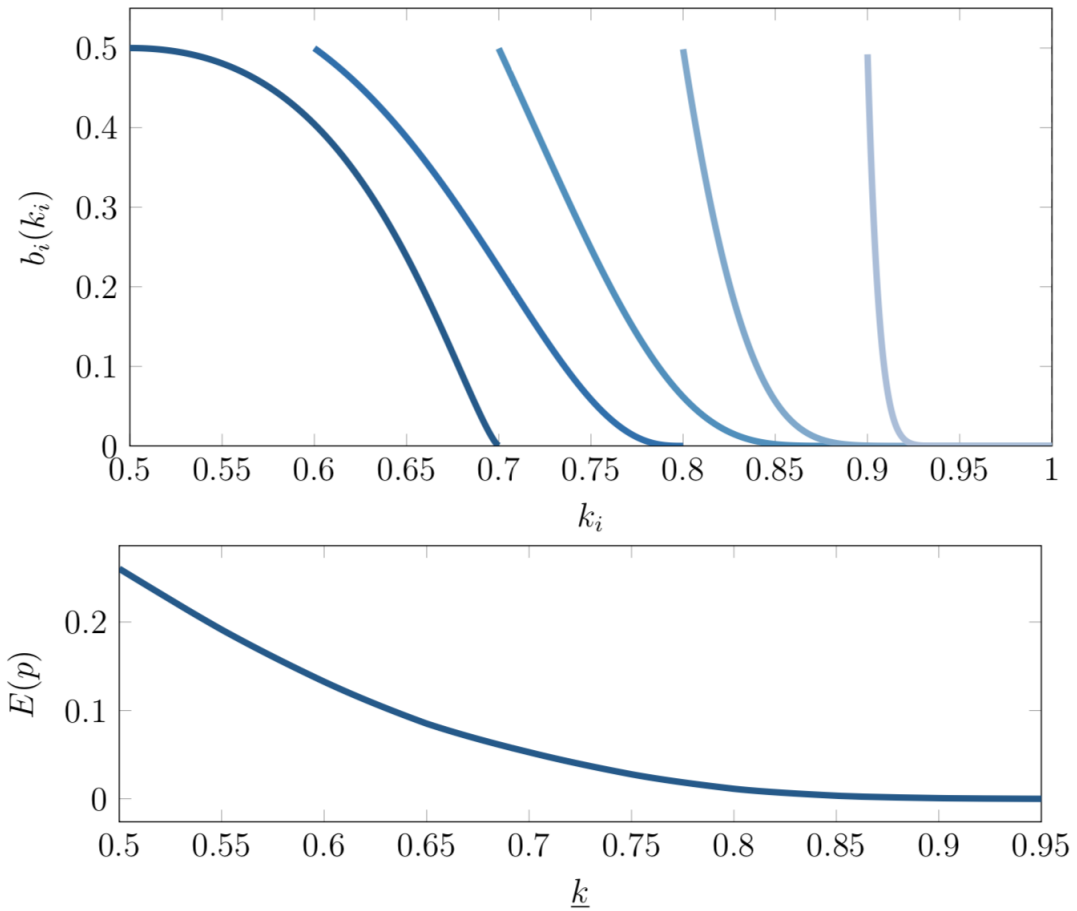

Figure: Equilibrium bids and expected prices as installed capacity increases; $\theta = 1$, $c = 0$, and $P = 0.5$

What have we learnt

Understanding competition among renewables

1. If market rules do not change: **market power and price dispersion** in renewables dominated markets.
2. Market power will result in:
   - **above marginal cost pricing**
   - **capacity withholding**
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Can we avoid these market distortions through market design?
How would the market perform with alternative pricing schemes?

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Regulatory options for promoting renewable investments:

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Which policies are better suited to promoting renewable investments at least cost?

Promoting Renewable Investments

Policy dimensions: [*preferred choices in bold*]

- Price instruments (FiTs) or quantity instruments (**auctions**)
- **Pay for energy** (MWh) or pay for capacity (MW)
- Expose producers to volatile energy prices or to **fixed prices**
- **Grid access** through **competitive** or non-competitive mechanisms
- Neutral approach or **technology-specific approach**

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Such choices have **strong implications for...**

- Location of new investments
- Financing costs
- Entry of new players $\rightarrow$ competition for investments
- Competition in the energy market
- Technology choices
- Payments by consumers

Technology-Neutral *vs* Technology-Specific Procurement

How to accelerate the energy transition at least cost?

1. Should the support be **technology-specific** or **technology-neutral**?
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3. What are the **trade-offs involved**?

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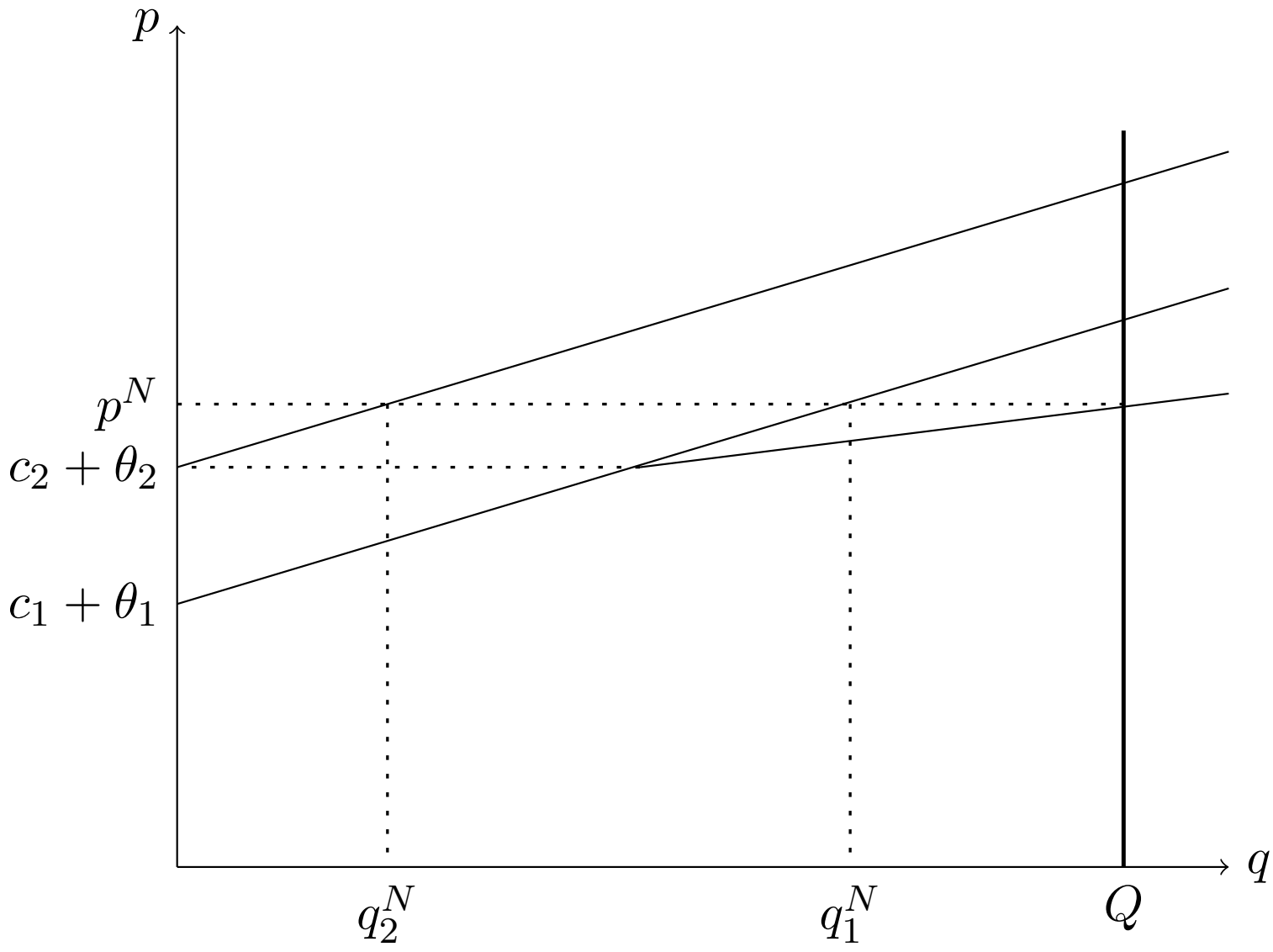
We identify a fundamental **rents-efficiency trade-off**:

- Technology-neutrality is good for **investment efficiency**
- But it leaves too **high rents** to suppliers

Technology-Neutral *vs* Technology-Specific Procurement



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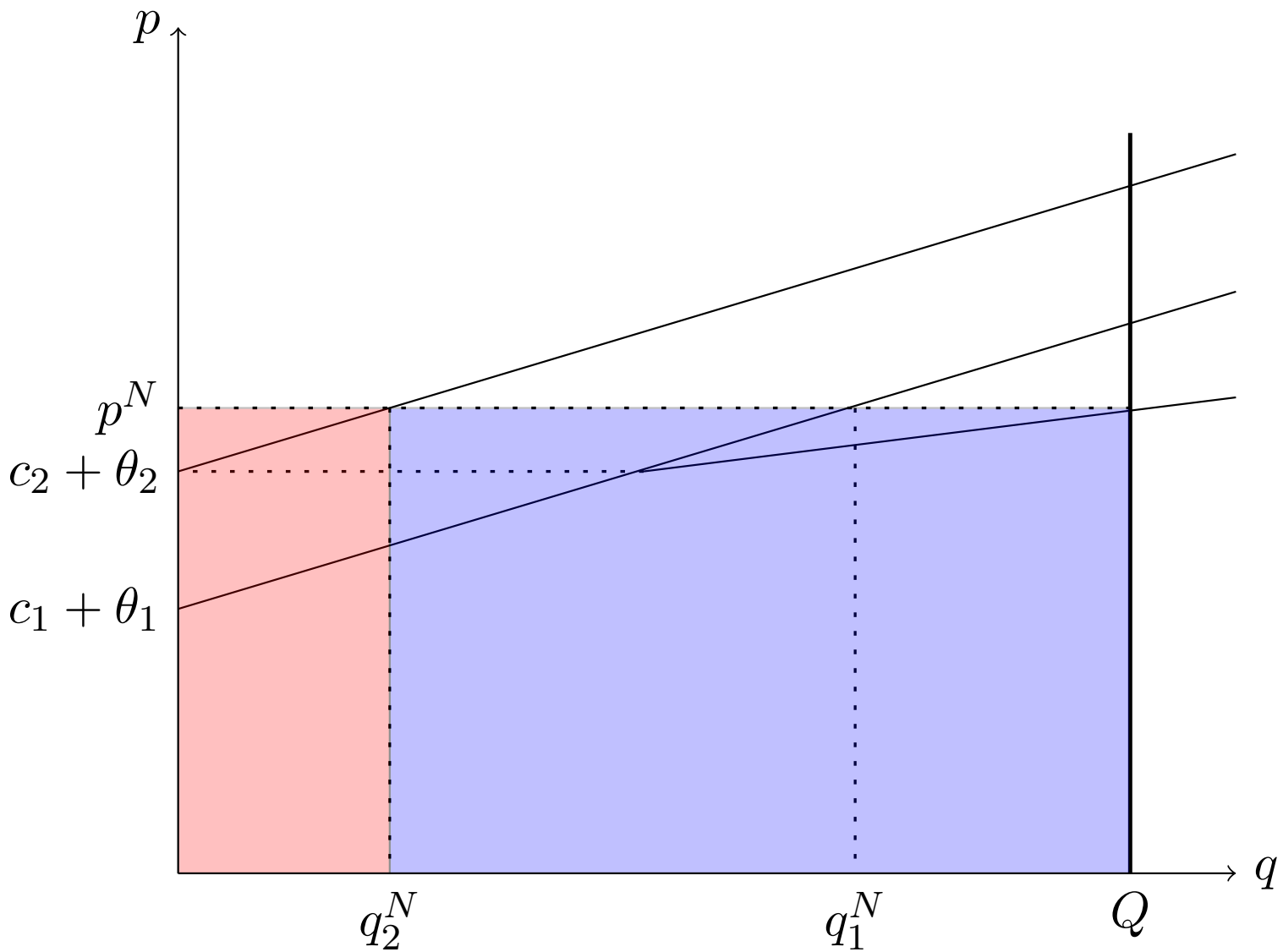

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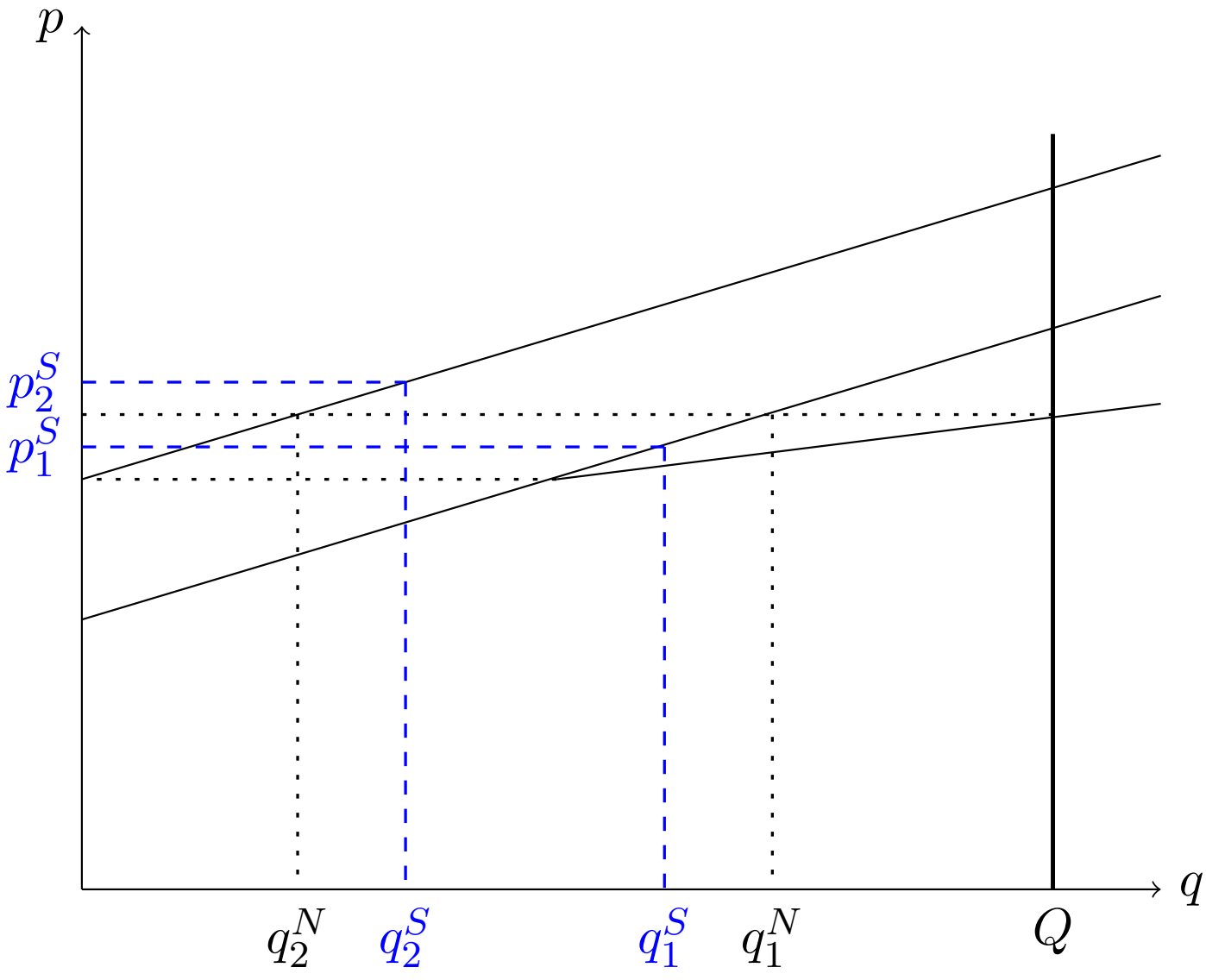

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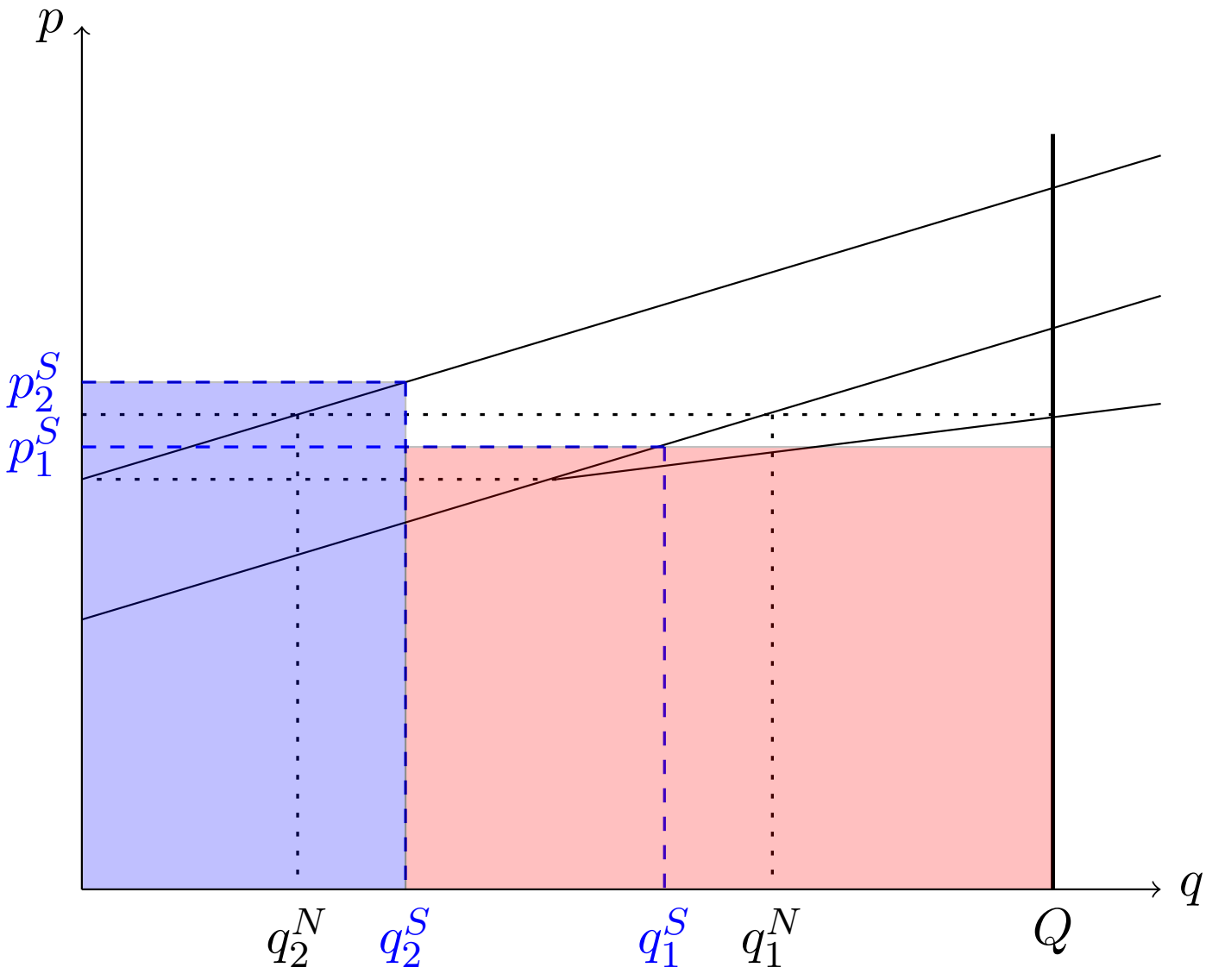

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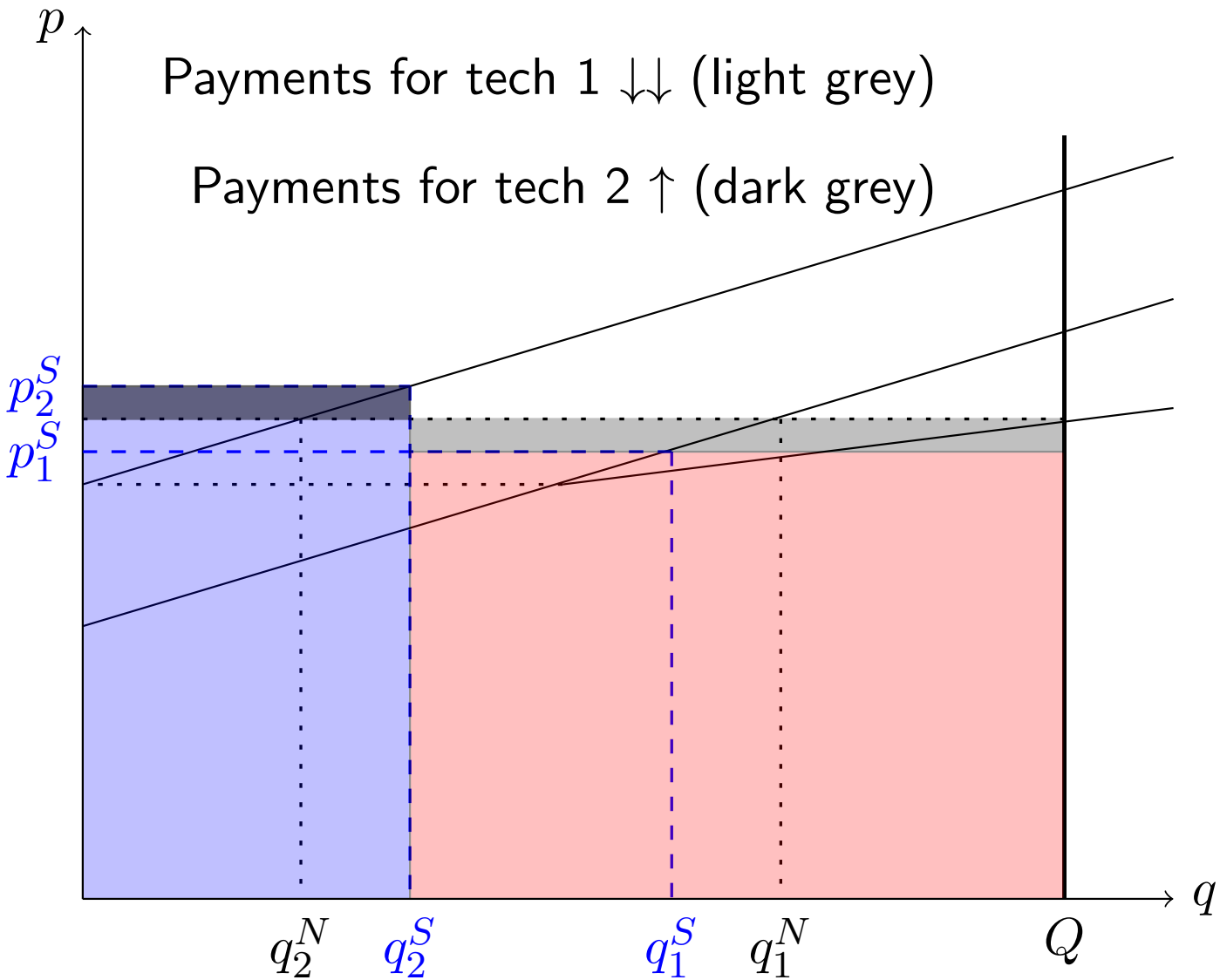

Paying for Renewables

How we pay for renewables has a broad impact on the overall market performance

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Most commonly used pricing schemes for renewables:

- **Feed-in-Premia** (FiP): mkt price + fixed premium
- **Feed-in-Tariffs** (FiT): fixed price per unit of output

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Hoes does renewable regulation affect market power, for given capacities?

Renewables regulation and market power

Ito and Reguant (AER, 2016) analyze bidding in sequential markets

- Dominant firms optimally set higher prices day-ahead
- Fringe firms arbitrage such price differences
- If not exposed to market prices (FiPs), fringe firms stop arbitraging

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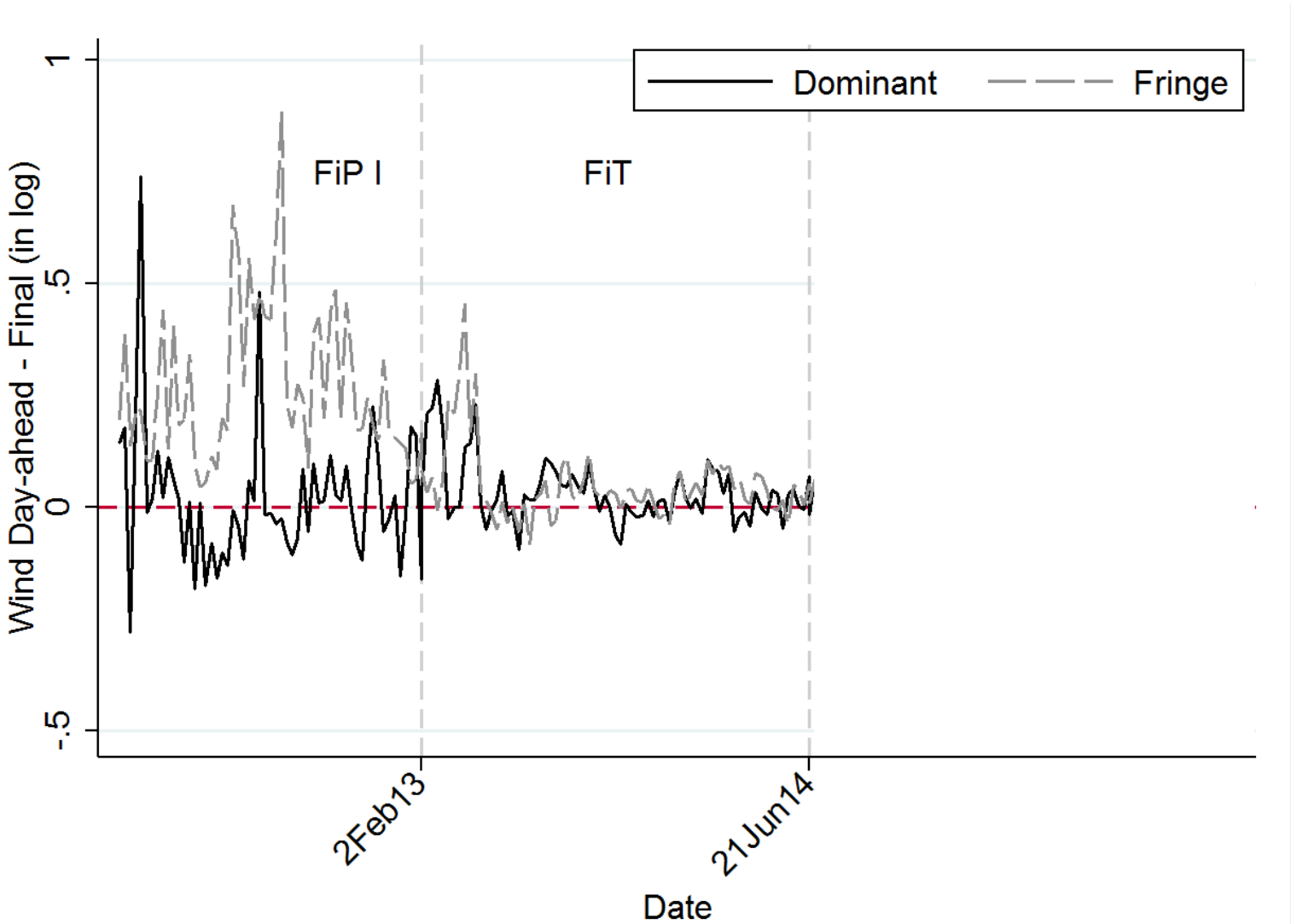
We show that if not exposed to market prices (**FiTs vs FiPs**)...

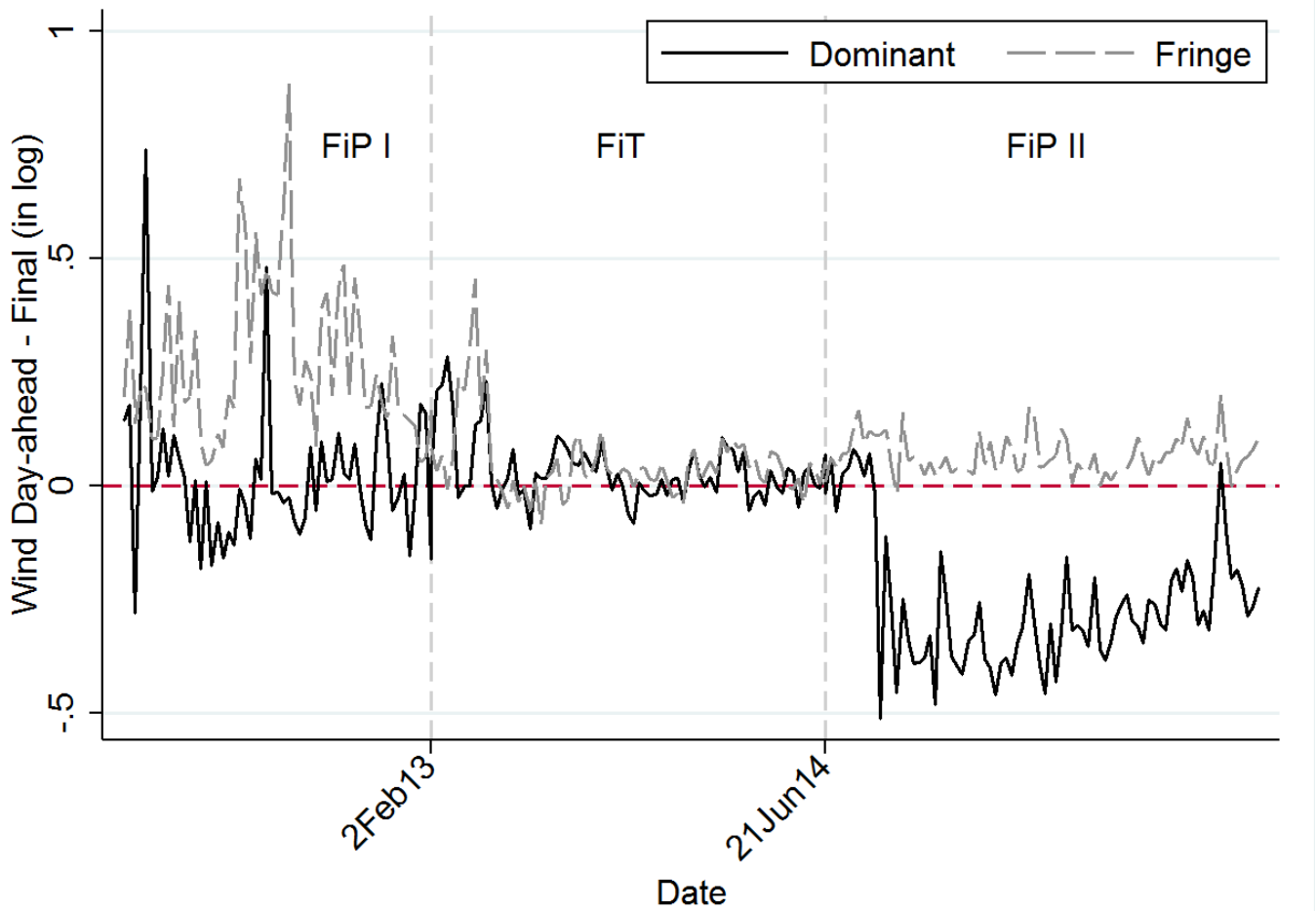
1. Dominant firms exercise less market power
2. This also reduces price differences across sequential markets
3. ...and gives rise to higher efficiency

▸ GO

Arbitrage and Withholding



Arbitrage and Withholding by Wind Producers



This figure shows day-ahead minus final commitments of wind producers.

▸ GO

Conclusions

The design of the energy transition will be critical for its success

- Market design and market structure will affect whether:
  - The necessary investments take place...
  - ...at least cost for society (technologies, locations, risk allocation...)
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These are exciting times for energy economists!

ENERGYECOLAB

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Thank You!

Questions? Comments?

More info at nfabra.uc3m.es

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Symmetric equilibrium

Small installed capacities

Proposition

Assume $\overline{k} < \theta$.

At the unique symmetric BNE, each firm $i = 1, 2$ *offers all its capacity,* $q^*(k_i) = k_i$, *at a price*

$$p^*(k_i) = c + (P - c) \exp\left(-\omega(k_i)\right),$$

where

$$\omega(k_i) = \int_{\underline{k}}^{k_i} \frac{(2k - \theta)g(k)}{\int_k^{\bar{k}} (\theta - k_j) g(k_j) dk_j} dk.$$

Symmetric equilibrium

Large installed capacities

Proposition

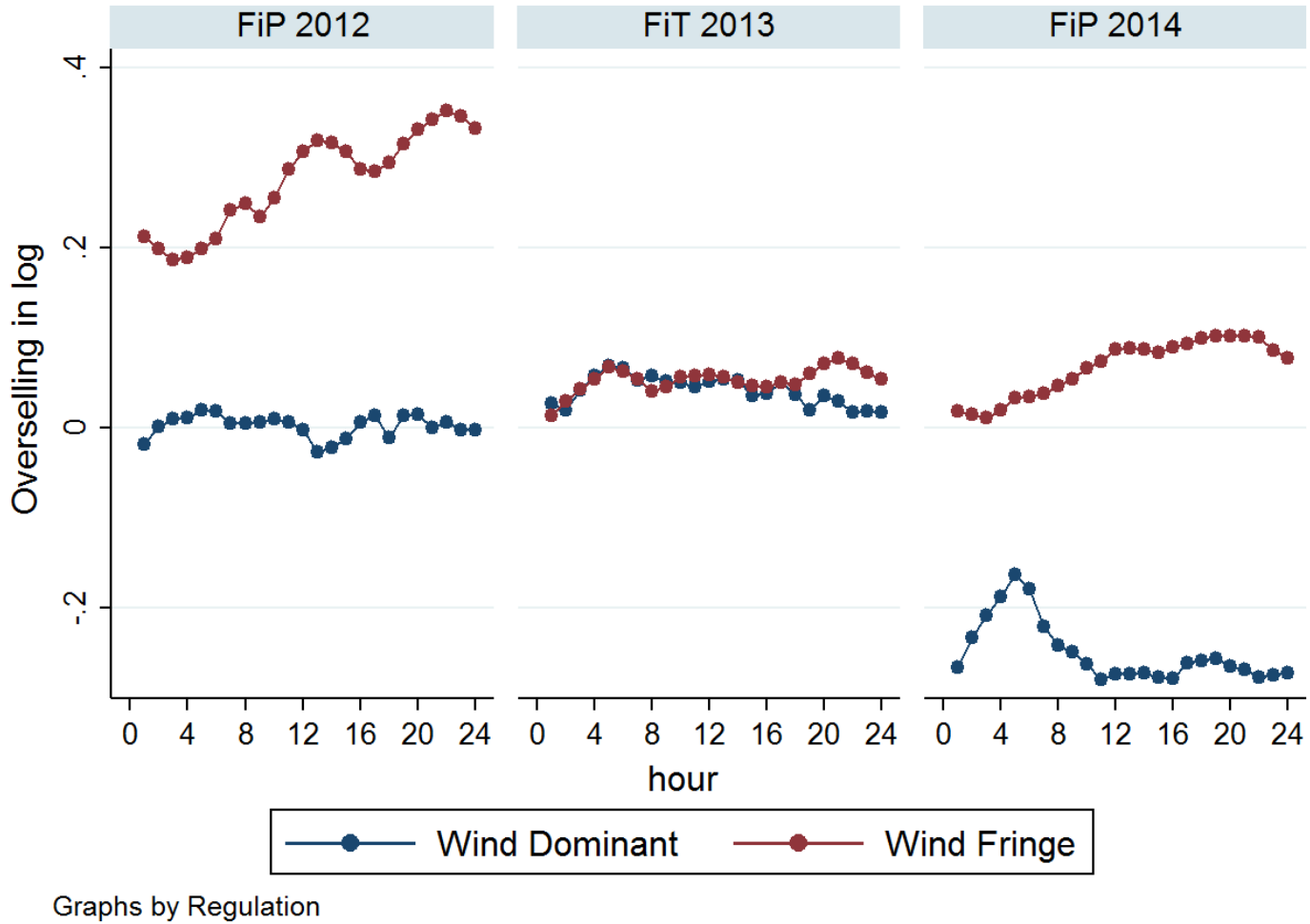
Assume $\overline{k} > \theta$.

(i) For $k_i \leq \theta$, *bidding is as in the small installed capacity case.*

(ii) For $k_i > \theta$, $b_i^*(k_i) = c$ *and firm* i *withholds output,* $q_i^*(k_i) = \theta$.

▸ Back

Overselling and withholding by wind producers



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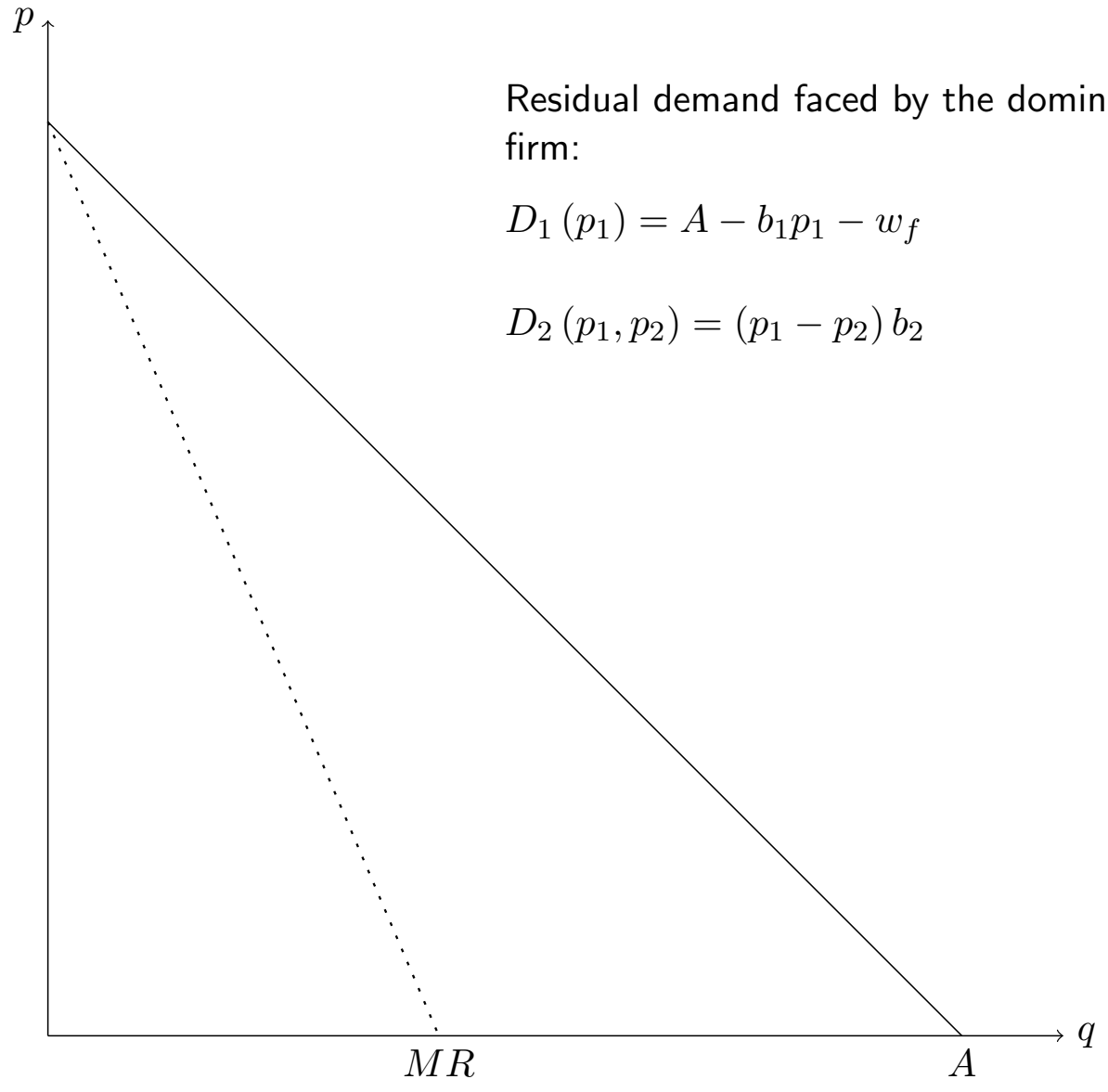
[1.] Model Intuition: Benchmark



Residual demand faced by the dominant firm:

$$D_1(p_1) = A - b_1 p_1 - w_f$$

$$D_2(p_1, p_2) = (p_1 - p_2)\, b_2$$

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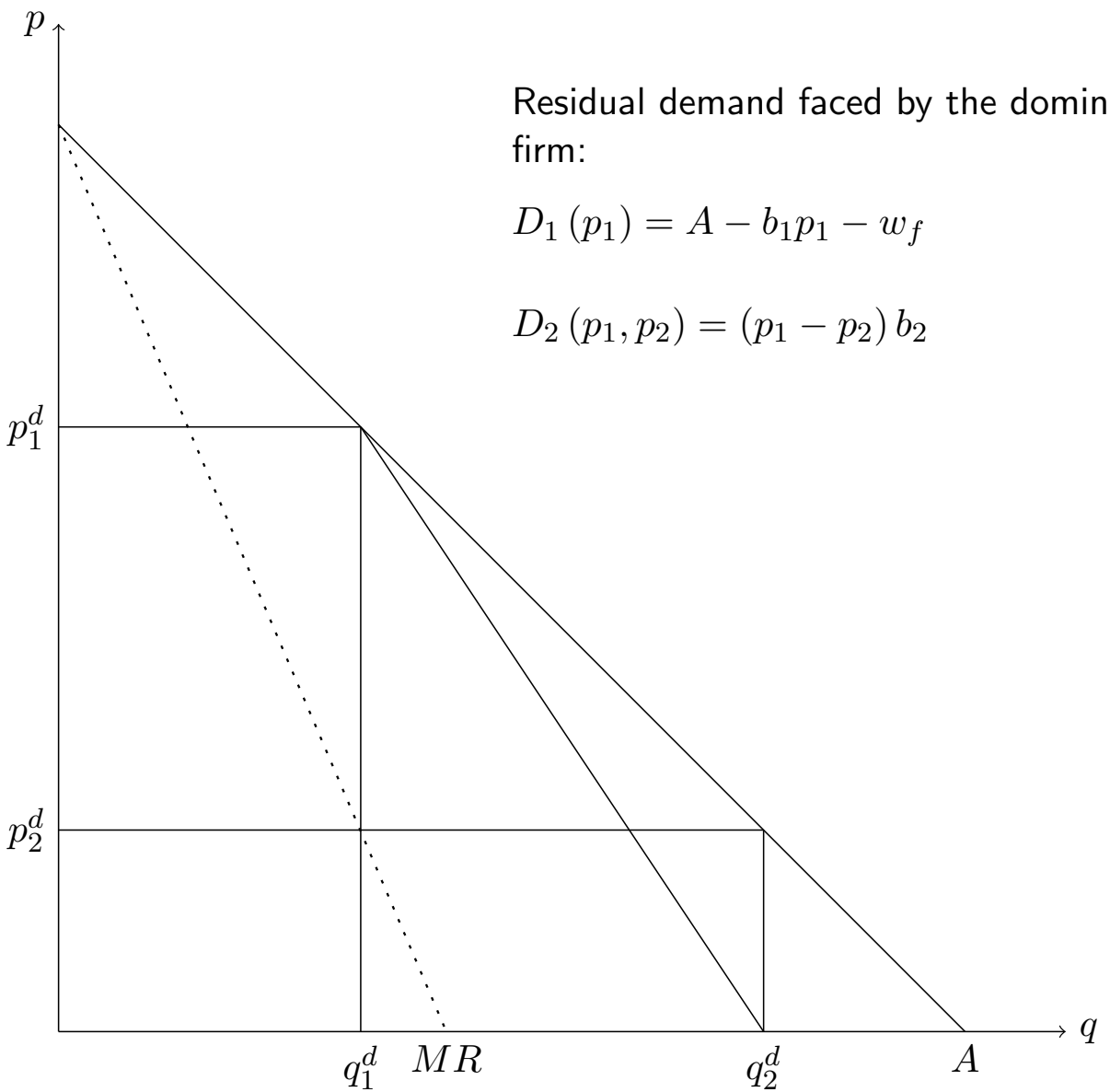

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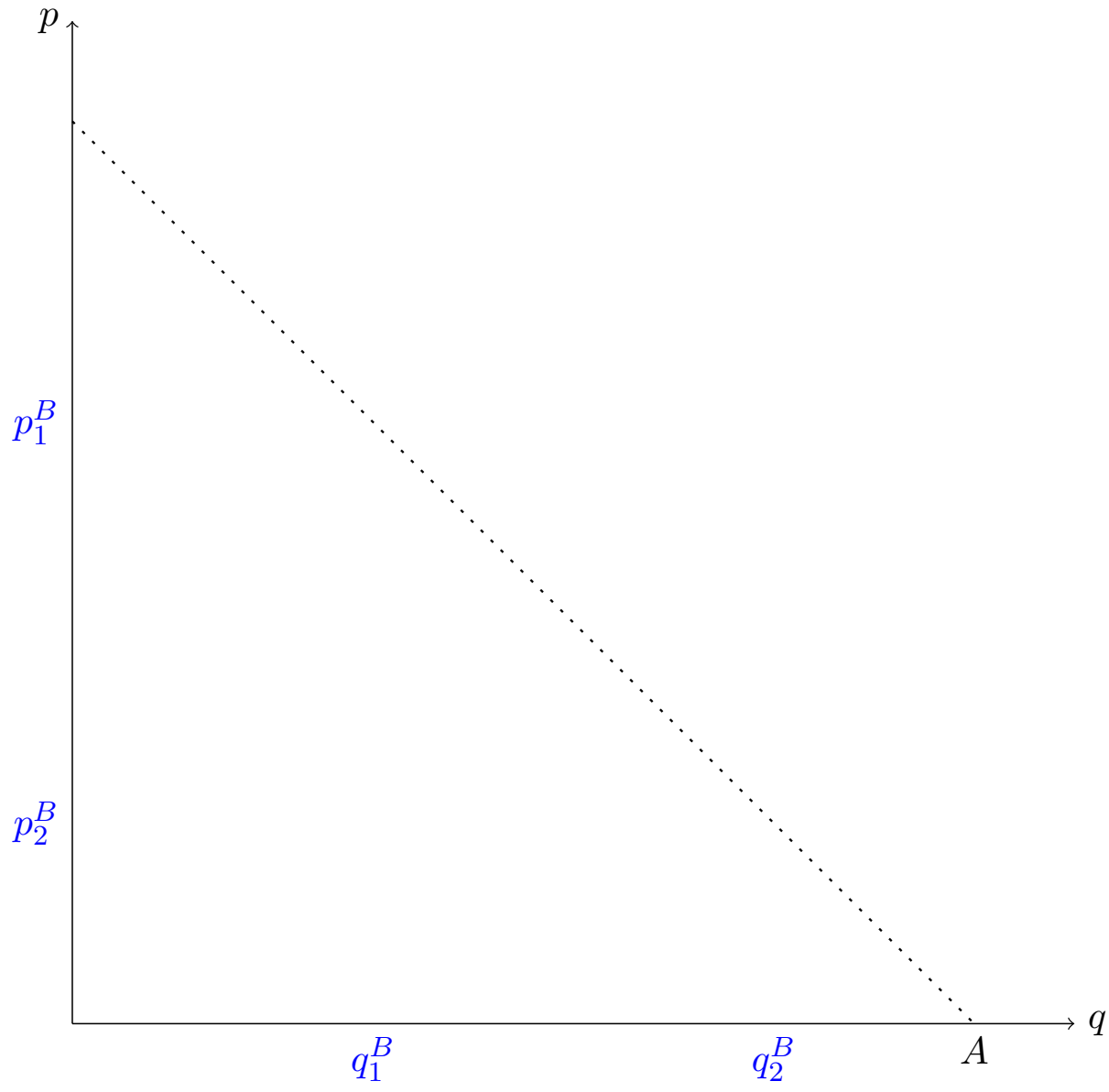
[2.] Feed-in-Premiums

1. Wind producers receive the market price plus a fixed premium
2. They are allowed to arbitrage their idle capacity

[2.] Model Intuition: Feed-in-Premium



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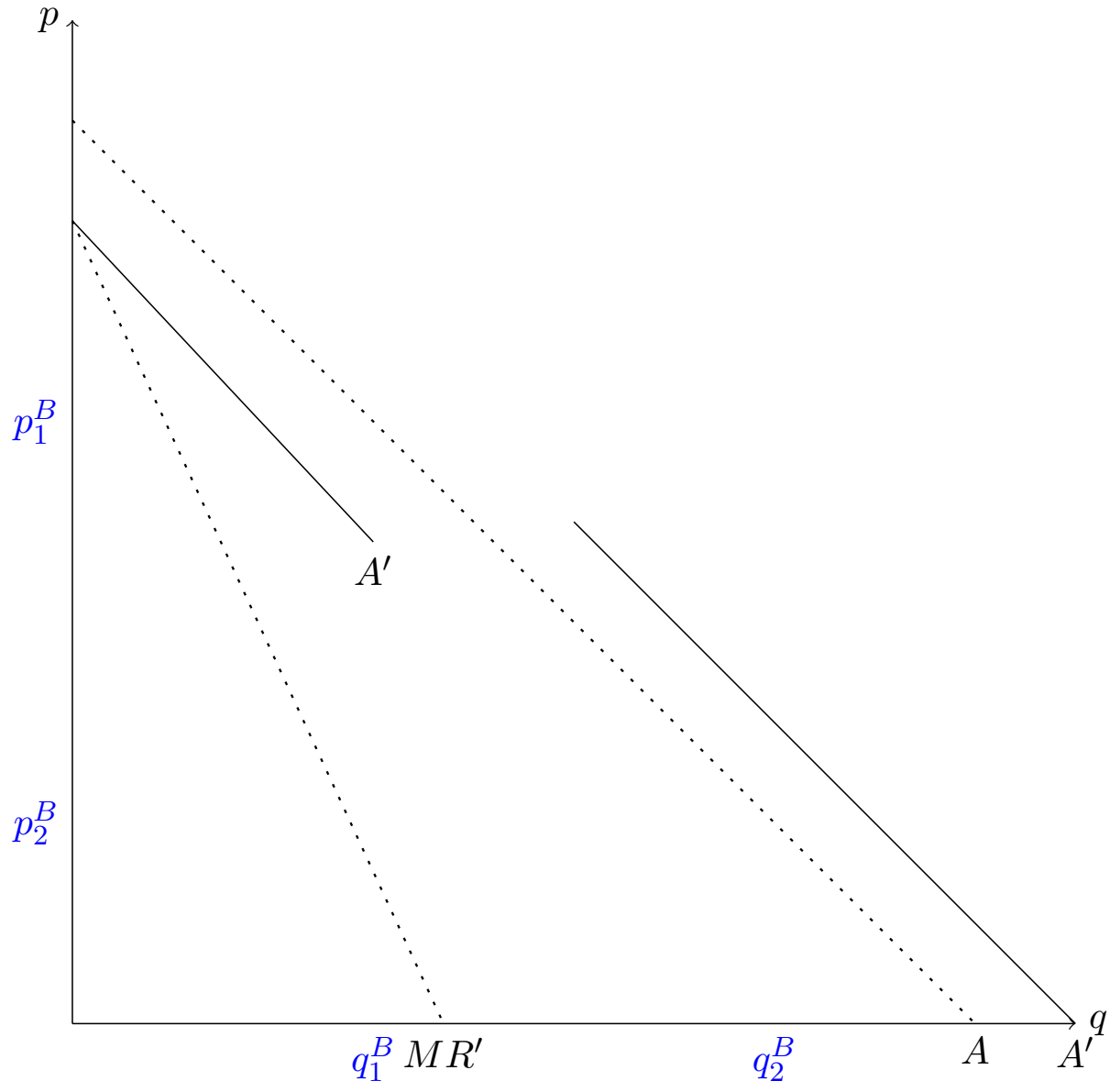

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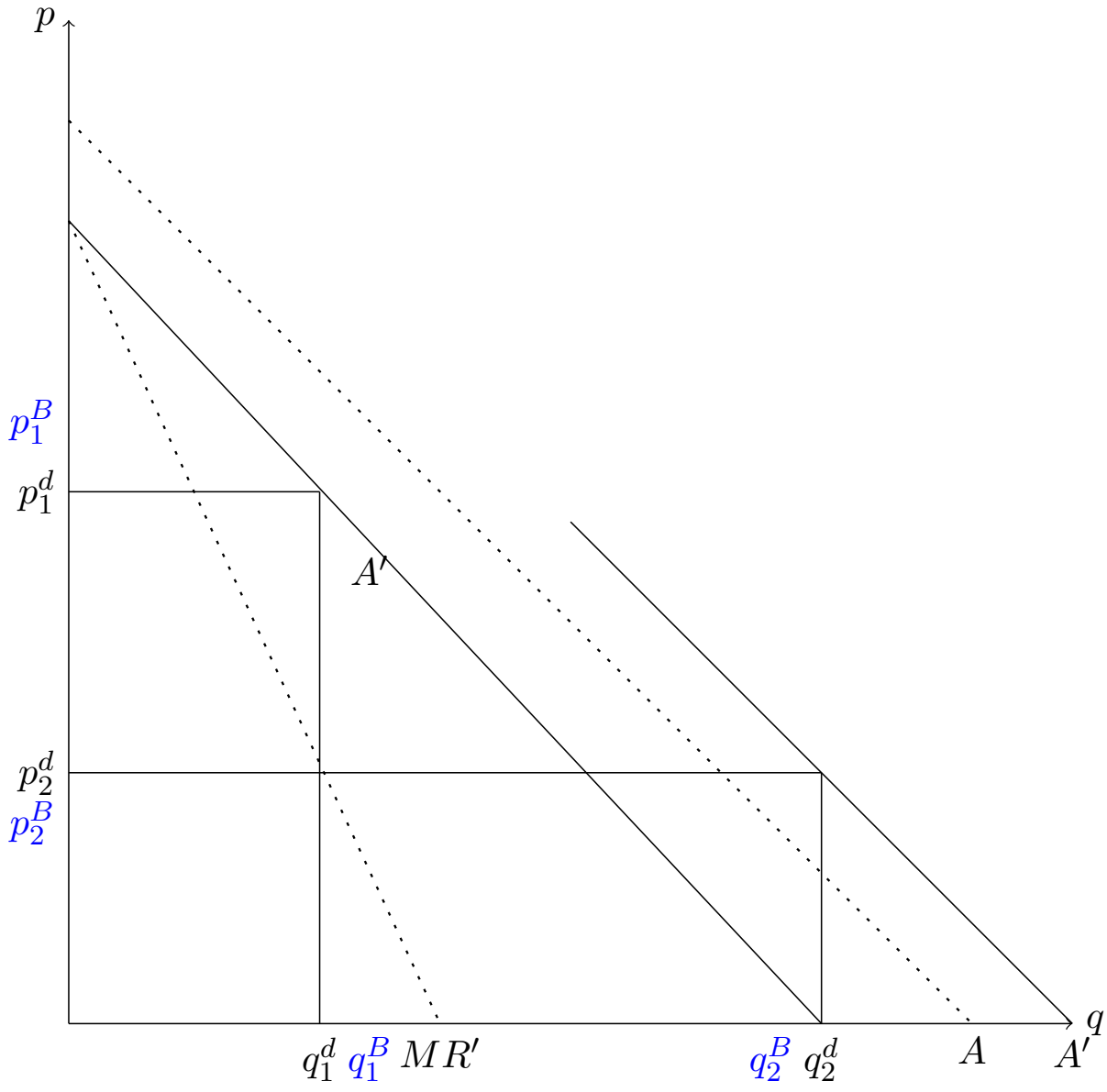

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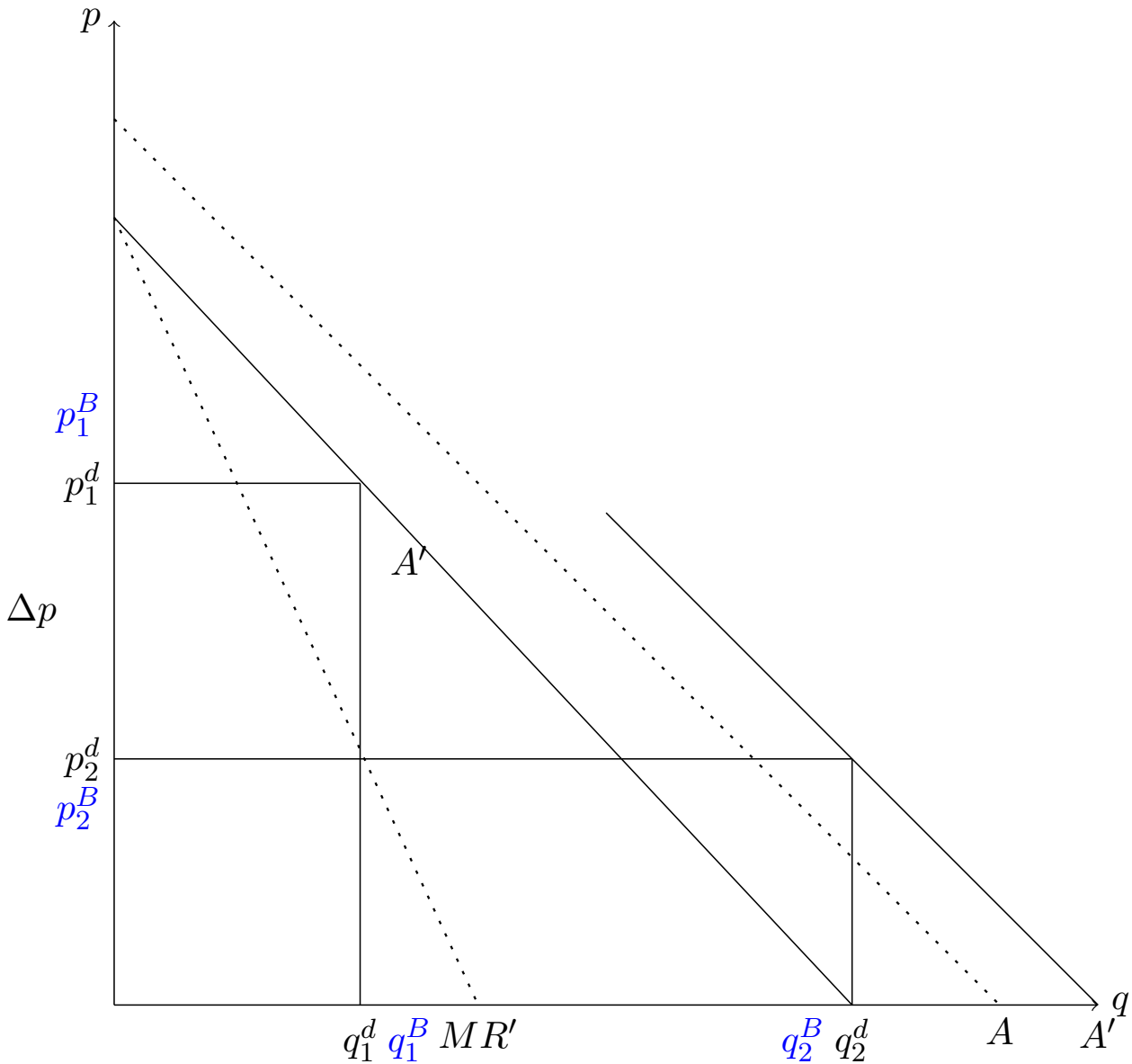

[3.] Feed-in-Tariffs

1. Wind producers receive fixed prices
2. They do not have incentives to arbitrage, even if allowed

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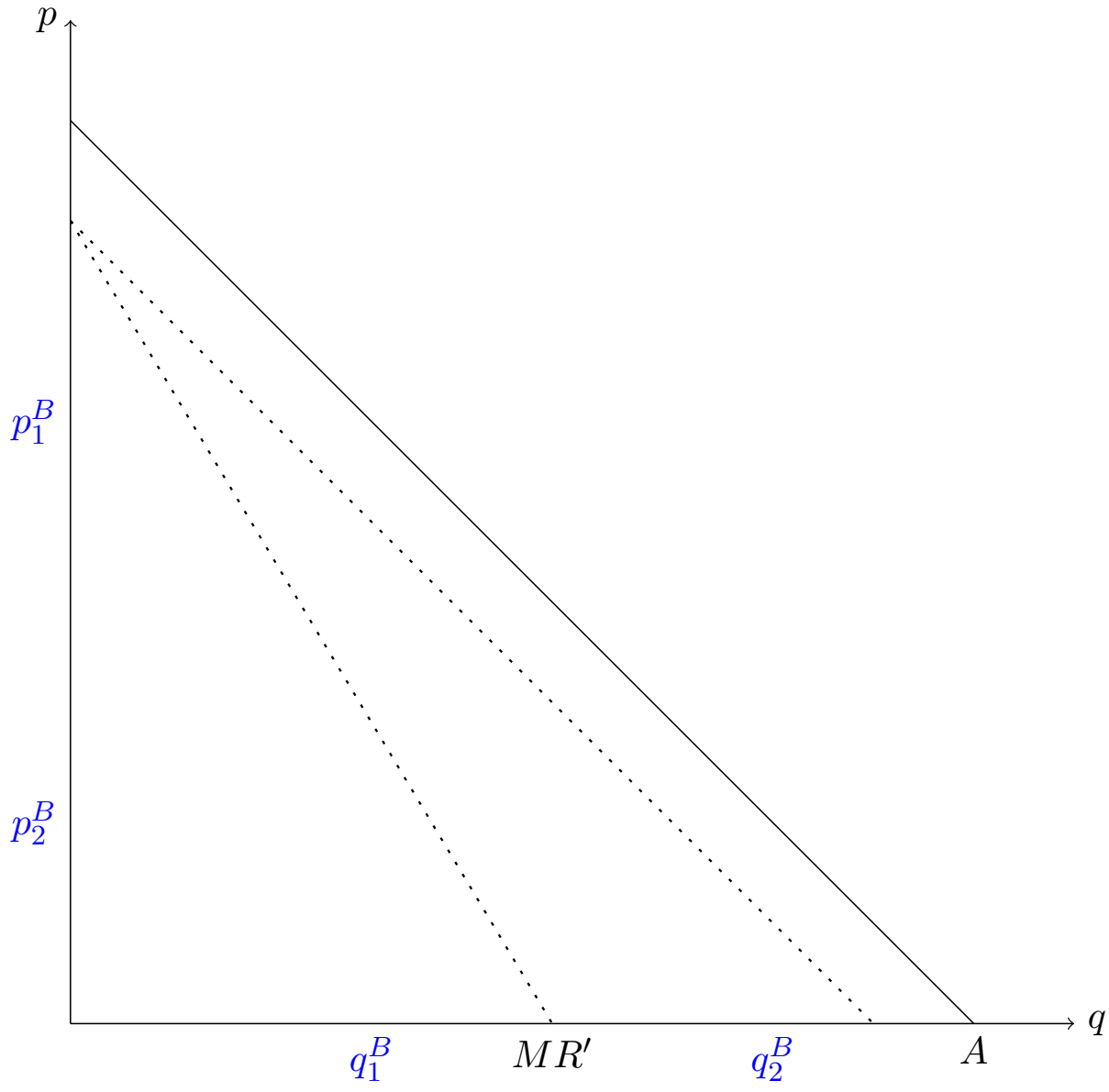

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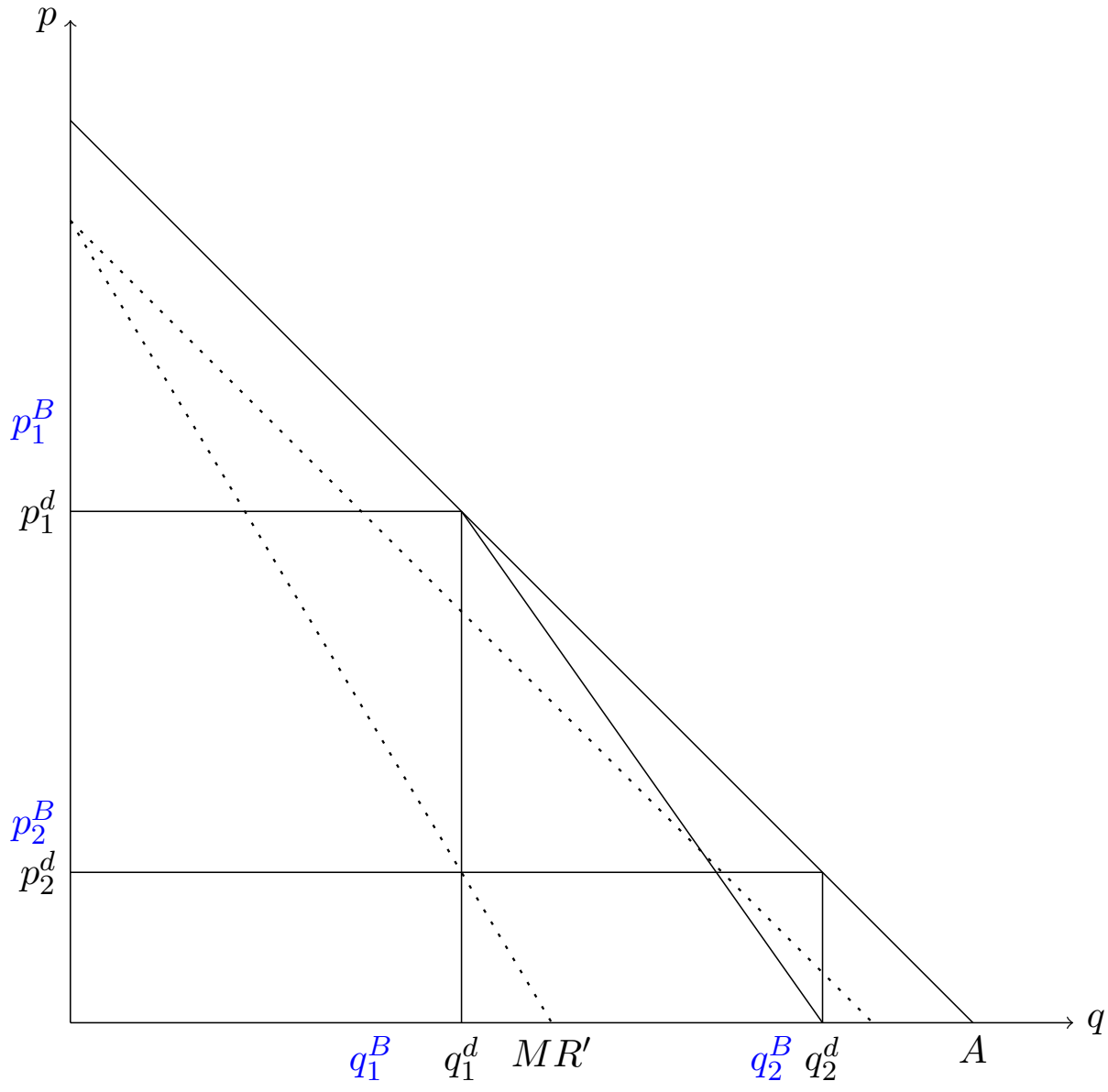

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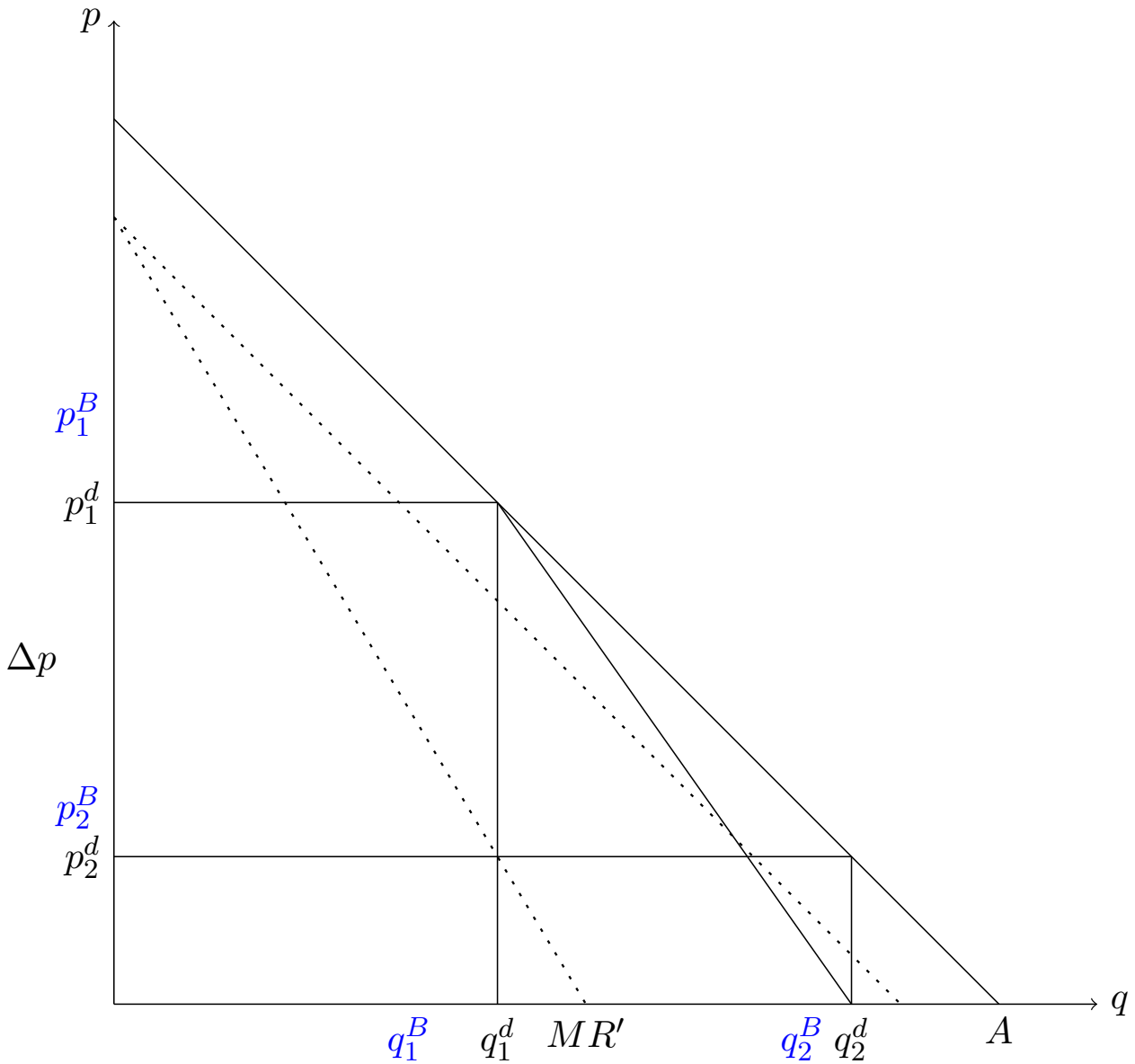

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