Pass-Through of Emissions Costs in Electricity Markets

Natalia Fabra
Universidad Carlos III de Madrid and CEPR

Mar Reguant
Stanford GBS and NBER

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Introduction

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  - Efficiency *vs.* distributional concerns.
- Pass-through, important measure to assess such concerns.

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- Pass-through: demand response, market power and cost internalization

Goal 2: Disentangle determinants of pass-through.

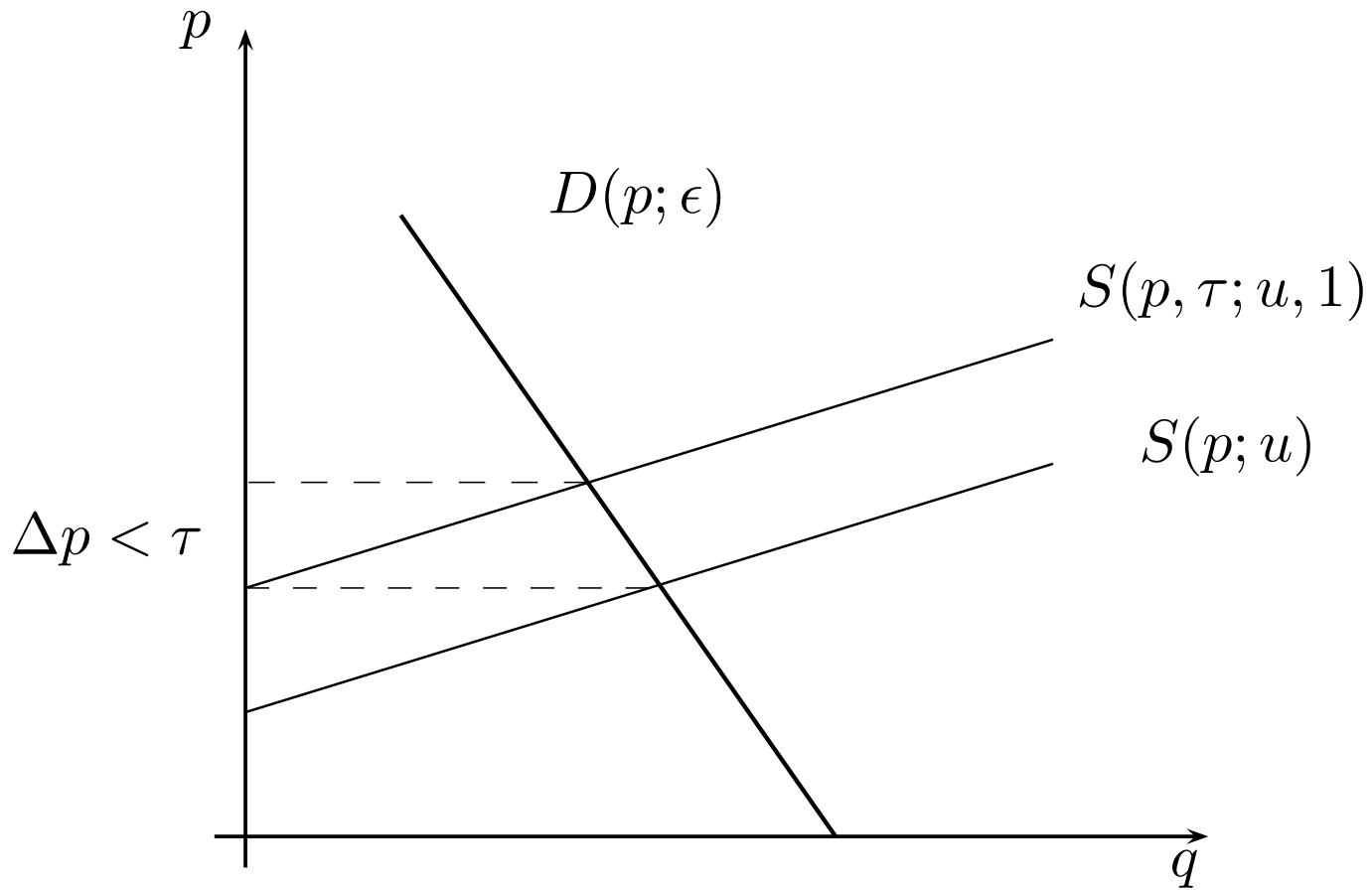
Pass-through, market power, and cost internalization

- German Federal Cartel Office sent a *warning letter* to RWE:

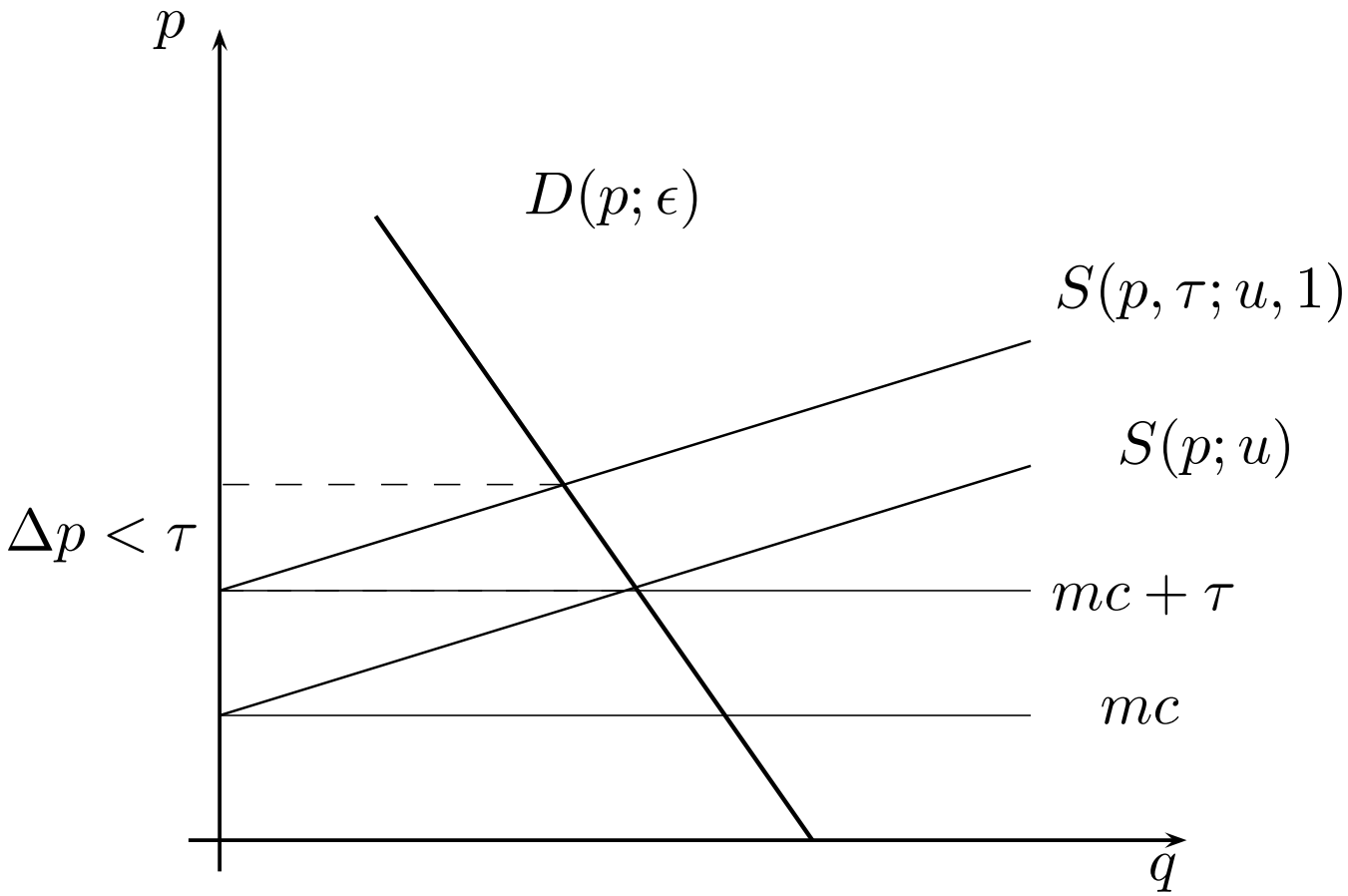
  The Bundeskartellamt does not object to up to a 25% **pass-through**... *any amount exceeding this figure would constitute an* **abuse of market dominance**.

  Opportunity costs *are in principle taken into account... However, this requires that the emission permits allocated free of charge are actually available for sale.*

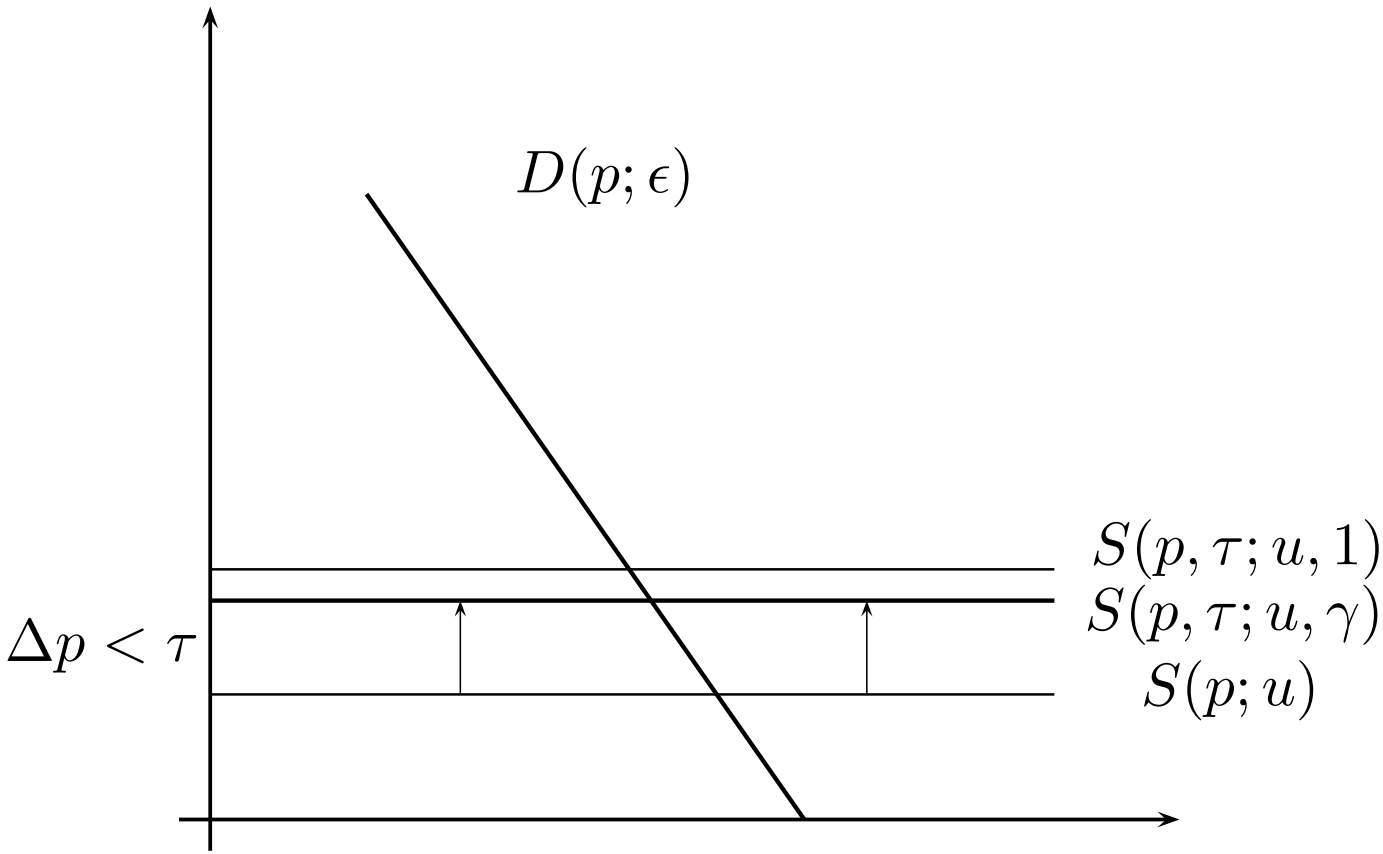
Incomplete pass-through and competitive behavior



Incomplete pass-through and market power



Incomplete pass-through and partial internalization



This paper

Quantify and disentangle determinants of pass-through.

- Reduced-form evidence
- Structural decomposition of the pass-through
  - emissions costs internalization
  - the role of demand response
  - the role of market power
  - technology substitution

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In the context of...

- EU's Emissions Trading Scheme (2005-2007)
- Spanish electricity market

Reduced form evidence on the Pass-through

- Identify pass-though rate from observed electricity price responses to CO_2 prices changes.
- Two pass-through measures:
  - **Cost pass-through**: effect of 1€ increase in the marginal cost of price-setting unit.
  - **Price pass-through**: effect of 1€ increase in the CO_2 price.

Pass-through regressions

Price pass-through regression:

$$p_{th} = \rho\tau_t + X_{th}\beta_0 + Z^S_{th}\beta_1 + Z^D_{th}\beta_2 + \omega_{th}\delta + \epsilon_{th}$$

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Cost pass-through regression:

$$p_{th} = \rho^c\tau_t e_{jt} + X_{th}\beta_0 + Z^S_{th}\beta_1 + Z^D_{th}\beta_2 + \omega_{th}\delta + \epsilon_{th}$$

- Marginal emissions costs instrumented with carbon price.

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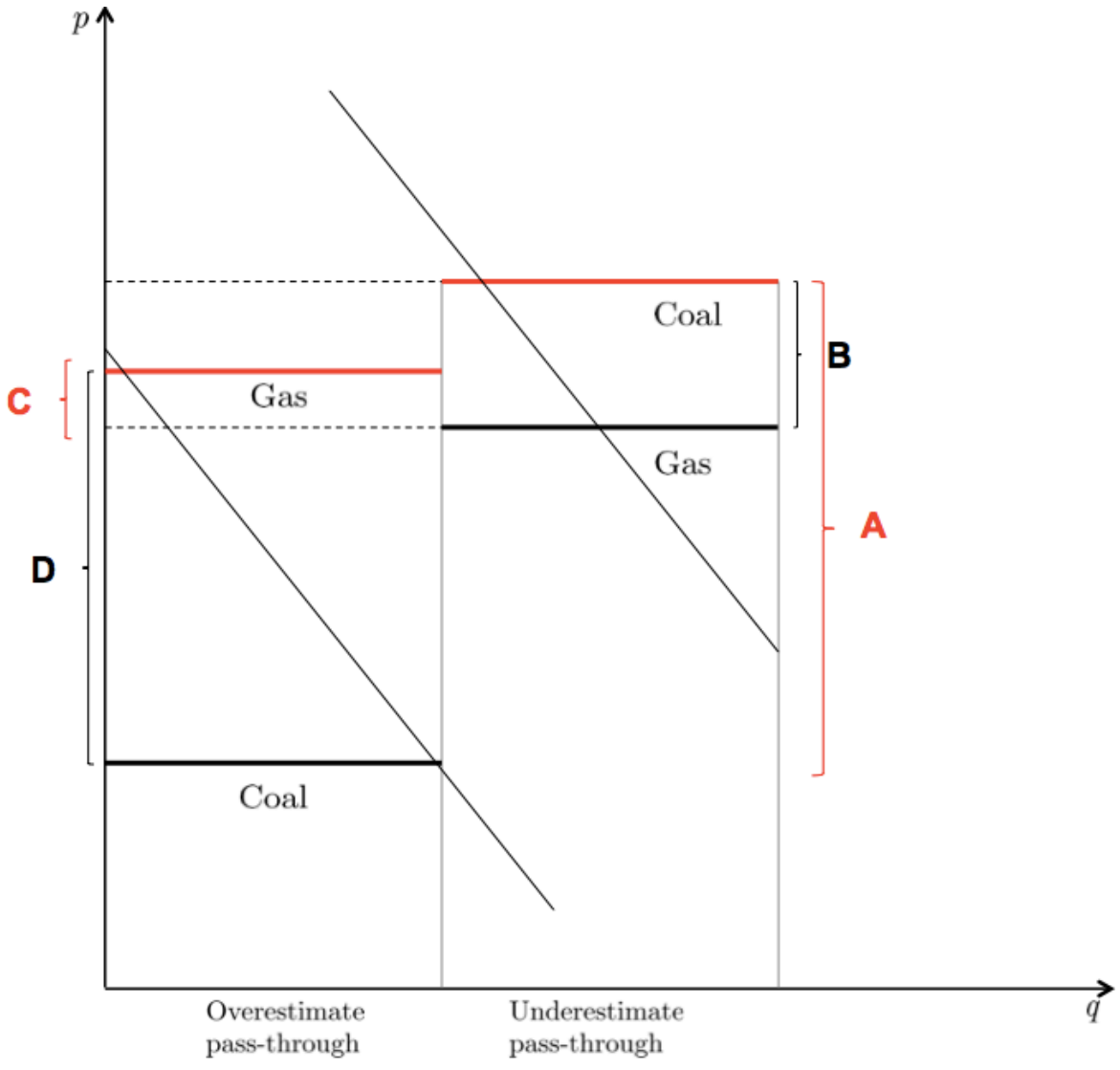
- Marginal emissions costs instrumented with carbon price.
- Regressions with dummy on whether gas or coal marginal.
  - Technology switching?

Technology switching



Reduced-form estimates: main results

- Estimated *price pass-through* is 41% to 57%.
- Estimated *cost pass-through* is 82%.
- When we condition on the technology of the marginal unit, *cost pass-through* is...
  - 63% when coal sets the price.
  - 93% when gas sets the price.
  - Suggestive evidence of coal substitution by gas.

Structural decomposition of the pass-through

- Firm i's profits:

$$\pi_i(p;\varepsilon,u) = p\left(D_i^R(p;\varepsilon,u_{-i}) - Q_i^D\right) - C(Q_i^S;u_i) - \tau e_i Q_i^S$$

where D_i^R: residual demand; Q_i^D: retail sales; Q_i^S: output.

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- Profit maximization:

$$p = c_i + \tau e_i + \left|\frac{\partial D_i^R}{\partial p}\right|^{-1}\left(Q_i^S - Q_i^D\right)$$

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- We estimate this equation when firm i sets market price:

$$b_{ijth} = \alpha_{ij} + \beta_i c_{jt} + \gamma_i \tau_t e_{ij} + \left|\frac{\partial \widehat{D^R}_{ith}}{\partial p_{th}}\right|^{-1} Q_{ith} + \epsilon_{ijth}$$

Do firms fully internalize the permit price?

Why would they not?

- Transaction costs in emissions markets?
- Expectations of future allocations based on current emissions?
- Behavioral biases?
- Financial market imperfections and liquidity constraints?

Do firms fully internalize the permit price?

	All	**Firm 1**	**Firm 2**	**Firm 3**	**Firm 4**
(1) No FE	1.059	1.034	1.063	1.237	1.099
	(0.065)	(0.065)	(0.051)	(0.055)	(0.077)
(2) Unit FE	1.000	0.961	0.874	1.078	1.044
	(0.023)	(0.025)	(0.040)	(0.034)	(0.083)
(3) Unit FE + season	0.981	0.949	0.855	1.033	1.023
	(0.019)	(0.026)	(0.034)	(0.021)	(0.077)
(4) Spec.3 + RD excluded	0.963	0.948	1.022	0.991	0.830
	(0.031)	(0.023)	(0.033)	(0.053)	(0.094)
(5) Spec.4 + Markup (IV)	0.966	0.967	1.029	0.732	0.871
	(0.042)	(0.041)	(0.037)	(0.074)	(0.092)
Obs.	16,190	5,244	3,211	5,689	2,046

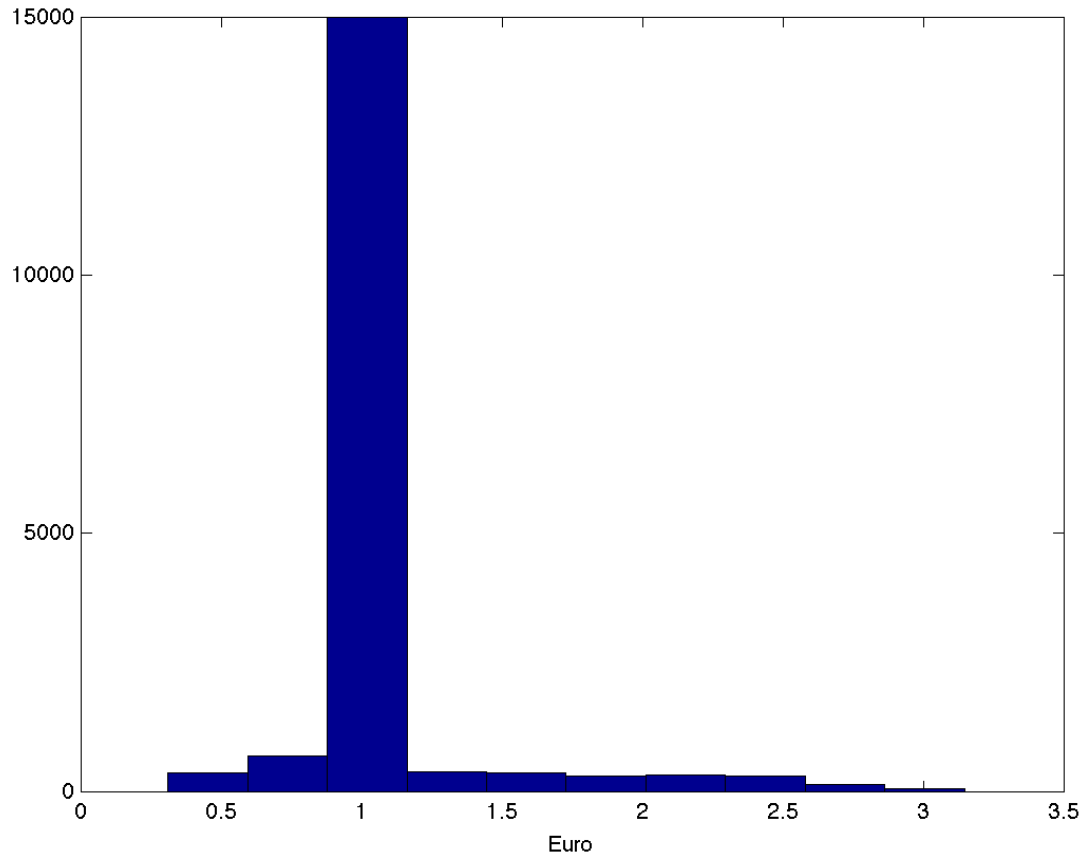
Simulating pass-through channels

- Compute marginal pass-through from bidding equations by perturbing the cost of CO_2 and re-computing optimal bids.

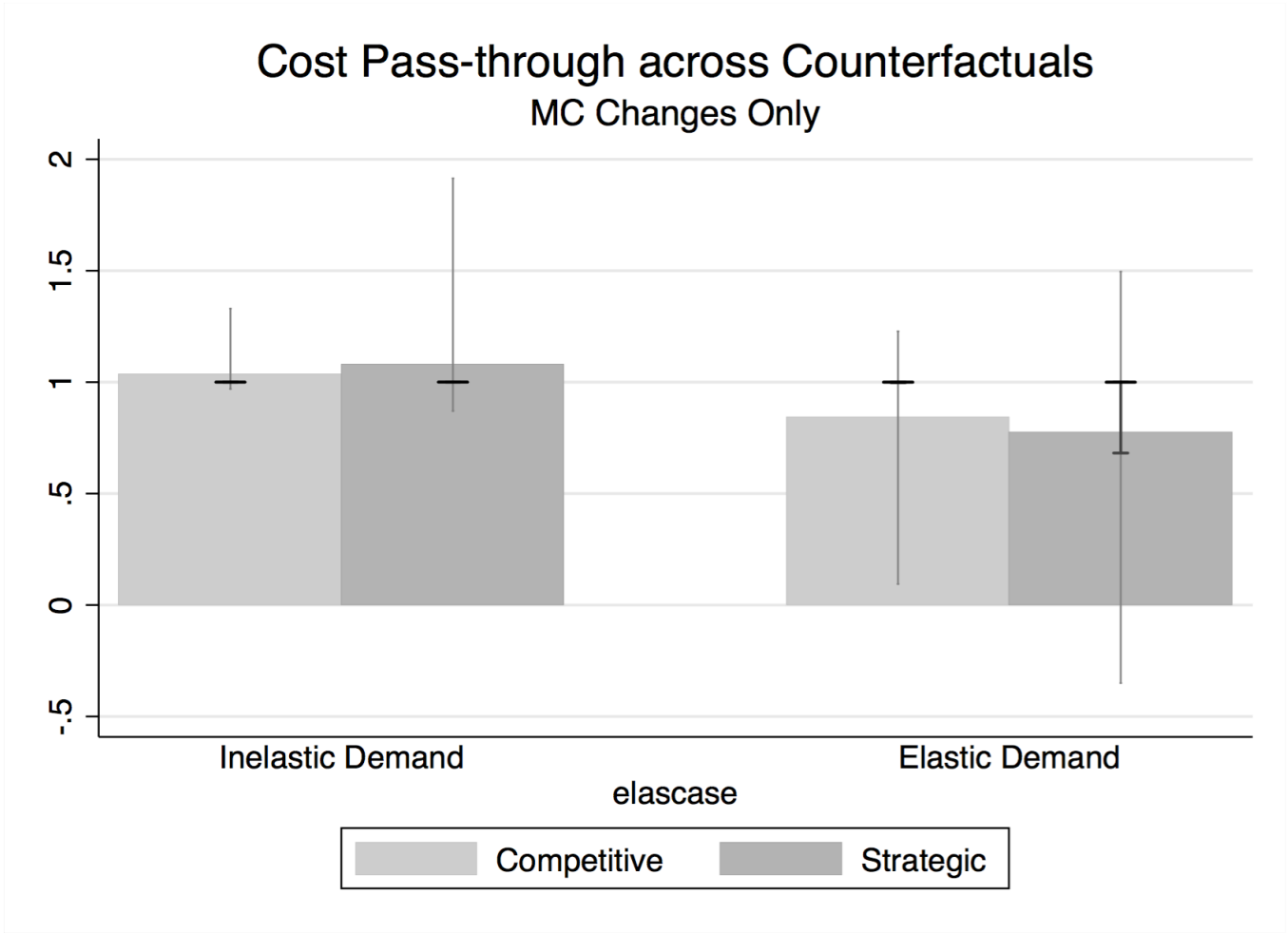
Table 1 : Simulated Bids and Pass-through Counterfactuals

I Inelastic Demand Only MC Change	II Demand Response Only MC Change
III. Inelastic Demand MC + Markup Change	IV. Demand Response MC + Markup Change

Inelastic demand and only MC change



Pass-through channels: results



Conclusions

- We explore the impact of emissions permits on firms' decisions and market outcomes: quantify and decompose the pass-through rate.

- Cost pass-through around 100% on average with inelastic demand, but heterogeneity due to technology switching.
- Demand elasticity decreases pass-through around 10-20% in the short-run.
- Electricity prices increase around 50% given technology mix.
- Results consistent with full internalization of emission costs.

- Windfalls from: free permits and price pass-through.

Thank You!

Cost pass-through: results

	(1)	(2)	(3)	(4)	(5)	(6)
$e_{jt}\tau_t$ $(\rho^{c,Coal})$	1.114	0.591	0.665	0.664	0.658	0.637
	(0.119)	(0.199)	(0.447)	(0.439)	(0.446)	(0.412)
$e_{jt}\tau_t$ $(\rho^{c,CCGT})$	1.998	1.025	0.780	0.862	0.881	0.933
	(0.067)	(0.126)	(0.276)	(0.272)	(0.277)	(0.254)
Obs.	27,530	27,530	16,902	16,902	16,902	16,902
Year-Month FE	N	Y	Y	Y	Y	Y
RD Excluded	N	N	Y	Y	Y	Y
MonthXTemp FE	N	N	N	Y	Y	Y
MonthXWind FE	N	N	N	N	Y	Y
Month-Hour FE	N	N	N	N	N	Y

Pass-through channels: the role of demand elasticity

Table 2 : Pass-through (PT) Results

		Cost Pass-through		Price pass-through	
		Inelastic	Elastic	Inelastic	Elastic
Competitive	Mean	1.034	0.842	0.706	0.561
	Median	1.000	1.000	0.716	0.580
	St.Dev.	(0.226)	(1.021)	(0.286)	(0.642)
Only MC Change	Mean	1.080	0.774	0.695	0.484
	Median	1.000	1.000	0.739	0.416
	St.Dev.	(0.335)	(0.747)	(0.275)	(0.466)
MC + Markup Change	Mean	1.099	0.778	0.697	0.479
	Median	1.000	1.000	0.715	0.415
	St.Dev.	(1.504)	(1.588)	(0.751)	(0.807)

Notes: Sample from January 2005 to March 2006. Period with Royal-Decree 3/2006 is excluded. Standard deviation of passthrough distribution in parenthesis. Interquantile range in brackets.Competitive counterfactual replaces original marginal bids of thermal plants with engineering cost estimates.