Pass-Through of Emissions Costs in Electricity Markets

Fabra and Reguant (2014), AER

Enviromental Reading Group session 8

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Research Question

- To what extent emissions costs are shifted to wholesale electricity prices?
- The mechanism(s)?

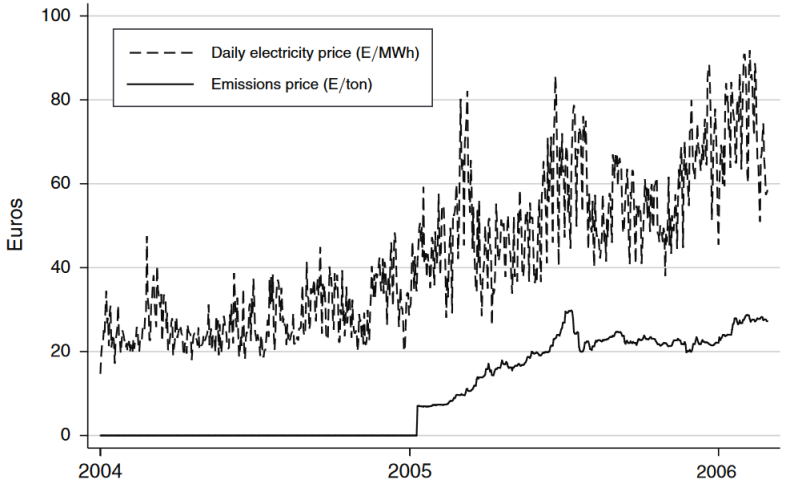
Context

- Spanish electricity spot market (Jan 2004 - Feb 2006).
- First stage of ETS (2005-2007): emission permits are distributed almostly for free.
- 4 integrated incumbents + small fringe firms.

Data

- Time: Jan 2004 - Feb 2006.
- Frequency: hourly, daily.
- day-ahead hourly spot prices (€/MWh).
- daily emissions price (€/ton).
- Hourly emission rate (ton/MWh).
- Daily fuel costs (€/MWh).
- Hourly bid information for each unit of each firm in the market (quantity, price).

Overview of Prices



Specification

$$p_{th} = \rho \tau_t e_{th} + \beta_0 \mathbf{X}_{th} + \beta_1 \mathbf{X}^D_{th} + \beta_2 \mathbf{X}^S_{th} + \beta_3 \mathbf{I}_{th} + \varepsilon_{th} \quad (1)$$

instrument: τ_t for $\tau_t e_{th}$.

Results

TABLE 1—COST PASS-THROUGH REGRESSION RESULTS

	(1)	(2)	(3)	(4)	(5)
Mg. emissions costs (ρ)	0.862	0.860	0.835	0.829	0.848
	(0.181)	(0.182)	(0.173)	(0.172)	(0.168)
Temperature	−0.231		−0.204		
	(0.060)		(0.057)		
Maximum temperature	0.137		0.112		
	(0.050)		(0.047)		
Wind speed	−2.086	−2.171	−2.089	−2.191	−2.238
	(0.354)	(0.361)	(0.333)	(0.337)	(0.329)
Wind speed squared	0.055	0.066	0.054	0.067	0.068
	(0.025)	(0.025)	(0.023)	(0.023)	(0.023)
Coal	57.477	45.548	57.496	45.469	
	(4.035)	(4.364)	(3.885)	(4.164)	
Gas	5.638	3.589	5.604	3.563	
	(0.407)	(0.405)	(0.391)	(0.387)	
Brent	−2.896	−1.685	−2.938	−1.778	
	(0.881)	(0.985)	(0.834)	(0.930)	
F-test	124.8	114.0	129.9	119.3	118.3
Month × temp, maxtemp	No	Yes	No	Yes	Yes
Month × hour FE	No	No	Yes	Yes	Yes
Hour × input	No	No	No	No	Yes

Peak vs. Off-peak

TABLE 2—COST PASS-THROUGH REGRESSION RESULTS: PEAK VERSUS OFF-PEAK

	(1)	(2)	(3)	(4)	(5)
Mg. emissions costs—peak	1.085	1.083	1.055	1.051	1.107
	(0.185)	(0.185)	(0.178)	(0.177)	(0.175)
Mg. emissions costs—off-peak	0.635	0.633	0.608	0.603	0.496
	(0.170)	(0.170)	(0.164)	(0.163)	(0.164)
Month × temp, maxtemp	No	Yes	No	Yes	Yes
Month × hour FE	No	No	Yes	Yes	Yes
Hour × input	No	No	No	No	Yes

FOC condition

$$\text{bid}_{it}(q_{it}) = \text{mc}_{it}(q_{it}) + \text{markup}_{it}(q_{it}) \tag{2}$$

$$\text{mc}_{it}(q_{it}) = \text{marginal emissions cost}_{it}(q_{it}) + \text{marginal input cost}_{it}(q_{it}) \tag{3}$$

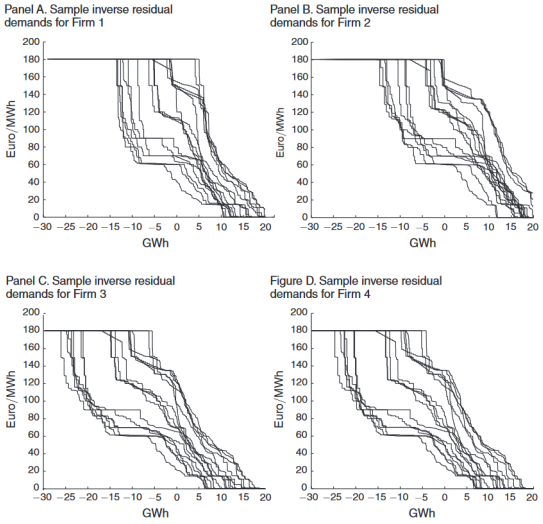
$$\text{markup}_{it}(q_{it}) = -\frac{\partial p_{it}(q_{it})}{\partial q_{it}} q_{it}^{N} \tag{4}$$

Markup Estimation

$$\text{markup}_{it}(q_{it}) = -\frac{\partial p_{it}(q_{it})}{\partial q_{it}} q_{it}^{N} \tag{5}$$

- Slope of residual demand curve: B-spline polynomial.
- Total production - physical and demand side contracts.

Inverse Demand



Results

Firm-level i, unit level j

$$b_{ijth} = \gamma e_j \tau_t + \beta c_{jt} + \theta \hat{m}_{ijth} + \varepsilon_{ijth} \tag{6}$$

H_0: $\gamma = 1$

Results

TABLE 3—TEST BASED ON STRUCTURAL EQUATIONS

	All	Firm 1	Firm 2	Firm 3	Firm 4
Panel A. Emissions cost (γ)					
(1) No FE	0.939	0.925	0.998	1.117	0.806
	(0.070)	(0.039)	(0.032)	(0.039)	(0.073)
(2) Unit FE	0.971	0.947	0.963	1.062	0.803
	(0.034)	(0.031)	(0.039)	(0.046)	(0.102)
(3) Unit FE + season	0.957	0.959	0.963	1.008	0.784
	(0.034)	(0.028)	(0.027)	(0.053)	(0.085)
(4) Spec.3 + markup (IV)	0.959	1.036	0.962	1.013	0.834
	(0.062)	(0.058)	(0.024)	(0.197)	(0.101)
Panel B. Input cost (β)					
(1) No FE	0.812	0.476	0.892	0.952	1.037
	(0.047)	(0.029)	(0.021)	(0.021)	(0.014)
(2) Unit FE	0.598	0.494	0.303	0.821	0.643
	(0.064)	(0.057)	(0.055)	(0.037)	(0.053)
(3) Unit FE + season	0.601	0.497	0.348	0.769	0.640
	(0.058)	(0.047)	(0.039)	(0.043)	(0.027)
(4) Spec.3 + markup (IV)	0.604	0.487	0.335	0.773	0.683
	(0.069)	(0.038)	(0.060)	(0.172)	(0.114)
Panel C. Markup (θ)					
(4) Spec.3 + markup (IV)	0.973	0.515	1.037	0.934	−1.086
	(0.398)	(0.227)	(0.177)	(2.411)	(6.117)
Observations	9,257	3,029	1,988	2,805	1,435

Mechanism

Strong pass-through:

- Demand inelasticity.
- Cost shocks across firms.
- Weak price rigidity.

Counterfactual Estimation

TABLE 4—PERCENT CHANGES IN QUANTITIES, MARKUPS, AND SLOPES

	Mean (percent)	Standard deviation (percent)	P25 (percent)	P50 (percent)	P75 (percent)
Panel A. Changes in quantity					
Aggregate Demand	−0.2	0.3	−0.2	0.0	0.0
Firm 1	−0.3	1.3	0.0	0.0	0.0
Firm 2	−0.2	0.8	0.0	0.0	0.0
Firm 3	−0.3	7.1	0.0	0.0	0.0
Firm 4	−0.3	1.2	0.0	0.0	0.0
Panel B. Changes in slope of inverse residual demand					
Firm 1	1.1	7.1	−2.0	0.8	4.1
Firm 2	0.3	7.0	−2.5	0.2	3.1
Firm 3	0.9	7.0	−2.0	0.6	3.7
Firm 4	0.8	6.8	−1.9	0.5	3.5
Panel C. Changes in markup					
Firm 1	−0.9	9.6	−4.5	−1.0	1.9
Firm 2	0.1	10.3	−3.3	−0.3	2.5
Firm 3	−0.7	12.3	−4.2	−0.8	1.9
Firm 4	−0.6	10.1	−3.9	−0.7	1.9

Price Rigidity

TABLE 6—FREQUENCY OF BID CHANGES

	Previous day unit-level	Previous week unit-level	Previous day firm-level
All days	0.375	0.710	0.795
Monday	0.490	0.705	0.907
Tuesday	0.304	0.691	0.774
Wednesday	0.276	0.682	0.719
Thursday	0.277	0.691	0.694
Friday	0.287	0.697	0.713
Saturday	0.605	0.739	0.932
Sunday	0.392	0.764	0.831

Wrap Up

- This paper presents complete pass-through in electricity spot market.
  1. highly frequent auction: easy to change price;
  2. low demand elasticity+high correlation of cost shocks among firms
- Policy implications:
  1. auctioning permits should have no inflationary effect on electricity prices.
  2. Windfall gain obtained by clean firms + distributional effects from market interventions.

Reference

Fabra, N., & Reguant, M. (2014). Pass-through of emissions costs in electricity markets. American Economic Review, 104(9), 2872-2899.