The effect of climate policy on productivity and cost pass-through in the German manufacturing sector

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Introduction

Growing literature about costs and benefits of climate policy on firms

$\rightarrow$ Emissions, employment, R&D, ...

$\rightarrow$ Cost pass-through in power sector

This paper:

- Effect of EU ETS on German **manufacturing firms** with respect to **productivity** and **profits**
- Compute marginal production costs and estimate **cost pass-through**

Allowance allocation in the EU ETS

Phases I and II: Mostly free allocation ($\approx 100\%$)

Phase III and IV:

- No free allocation to power plants of EU-15
- Manufacturing sector: Start with 80% in 2013, reduction to 30% by 2020
- Exceptions: Subsectors that are deemed at risk for carbon leakage continue to receive almost full free allocation

Exceptions are based on assumptions about firms' ability to pass on carbon costs to consumers

Methodology

1. Estimate translog production function for physical output on 4-digit level, using control function approach to address
   - simultaneity bias between inputs and unobserved productivity (Ackerberg, Caves & Frazier, 2015)
   - unobserved input quality (De Loecker et al., 2016)
2. Use parameter estimates to compute
   - elasticities
   - total factor productivity
   - markups and marginal costs
3. Identify causal effect of EU ETS on TFP and profits using DiD with matching
4. Estimate cost pass-through by regressing prices on marginal costs

Data

AFiD: “Administrative Firmendaten in Deutschland”

- Physical quantity and value of output (product level)
- Labor expenditure and investment (plant level)
- Expenditure on materials (firm level)

Merge with ETS membership status, free allocation, verified emissions, price deflators and energy prices

Descriptive statistics

Nr.	Industry description	Revenue (%)	All Firms	SP Firms	ETS Firms	Products
10	Food products	13.10	1,632	510	42	779
11	Beverages	2.40	211	50	4	137
13	Textiles	0.73	289	114	7	394
14	Wearing apparel	0.30	178	63	0	320
16	Wood and cork products	1.52	367	141	17	162
17	Paper and paper products	4.43	479	228	69	510
20	Chemicals and chemical prod.	16.08	804	235	82	1,430
22	Rubber and plastic products	5.83	953	350	13	504
23	Other nonmetallic mineral prod.	3.37	617	283	88	426
24	Basic metals	13.66	650	228	56	564
25	Fabricated metal products	7.71	1,598	781	3	902
26	Electronic and optical prod.	5.56	612	337	6	564
27	Electrical equipment	7.78	657	323	2	588
28	Machinery and equipment	16.68	1,590	905	9	1,544
32	Other manufacturing	0.86	174	121	1	232
	Overall	100	10,811	4,669	399	9,056

Average elasticities, TFP and markups

Nr.	Industry	Labour	Capital	Materials	RTS	TFP	Markup
10	Food products	0.24	0.05	0.70	0.98	-1.10	1.42
11	Beverages	0.31	0.09	0.56	0.96	1.02	1.71
13	Textiles	0.32	-0.04	0.49	0.78	0.68	1.24
14	Wearing apparel	0.37	-0.05	0.57	0.89	-1.18	1.55
16	Wood and wood products	0.43	0.10	0.61	1.14	-4.68	1.24
17	Paper and paper products	0.32	0.06	0.62	1.00	-3.70	1.31
20	Chemicals and chemical prod.	0.36	0.08	0.56	1.00	-6.13	1.30
22	Rubber and plastic products	0.41	0.10	0.59	1.09	-2.15	1.34
23	Other nonmetallic mineral prod.	0.43	0.05	0.50	0.98	-3.63	1.36
24	Basic metals	0.31	0.03	0.63	0.96	-7.03	1.36
25	Fabricated metal products	0.46	0.03	0.50	0.98	-4.03	1.35
26	Electronic and optical prod.	0.44	-0.01	0.49	0.92	-3.76	1.33
27	Electrical equipment	0.46	0.06	0.57	1.09	-5.61	1.36
28	Machinery and equipment n.e.c.	0.46	0.09	0.52	1.07	-7.72	1.31
32	Other manufacturing	0.46	0.25	0.51	1.22	-4.76	1.77

Difference-in-differences analysis

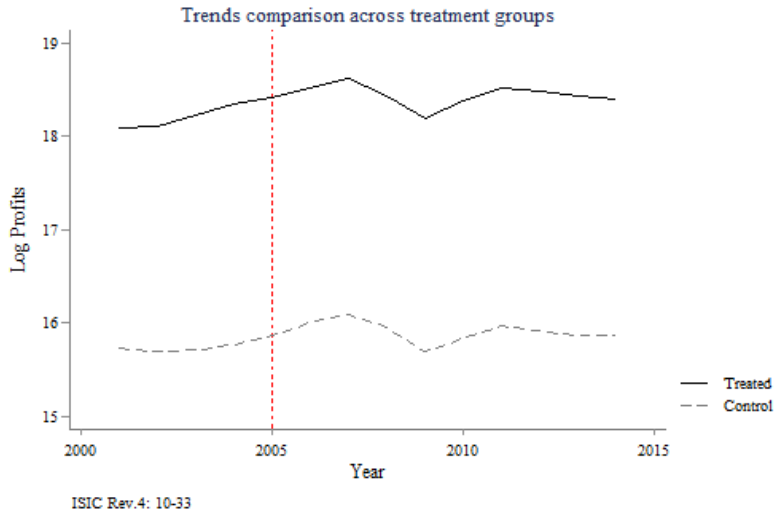
→ Match on pre-treatment characteristics

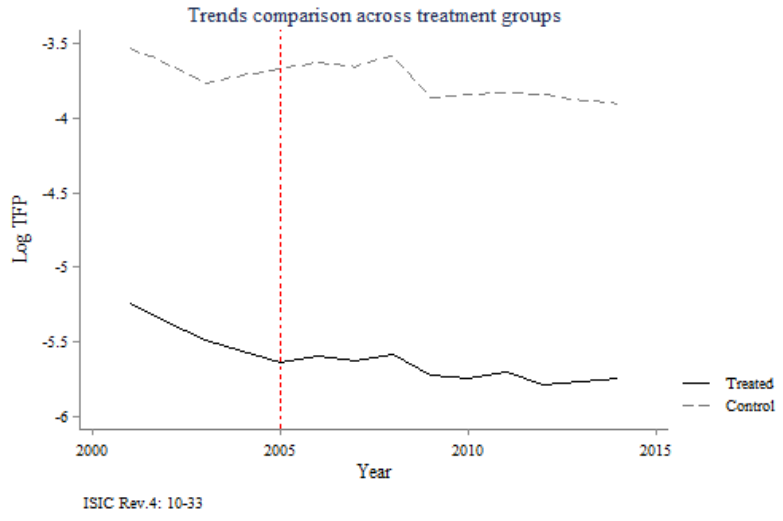
- Industry clasification
- Capital
- Employment
- Emission intensity
- Energy use

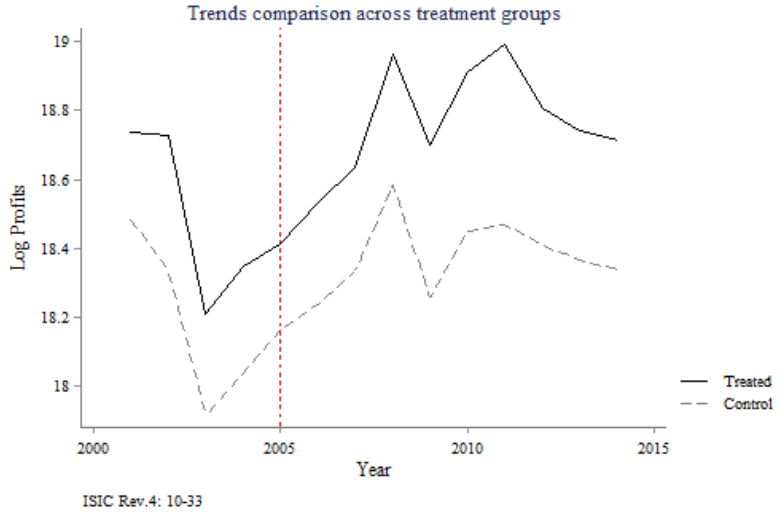
→ Regress TFP and profits on

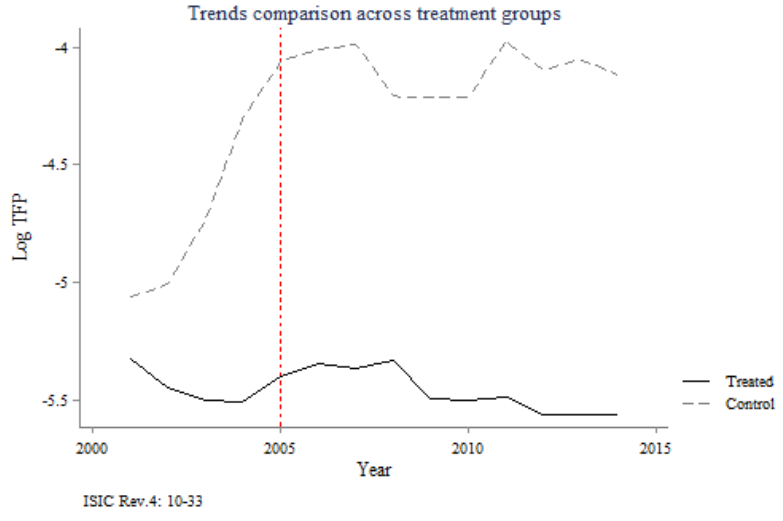
- Firm FE
- Year dummies
- DiD dummy denoting active ETS membership

Pre-treatment trends









Effect of the EU ETS on profits

DiD with matching

	Sector	10	17	20	23	24
ETS	0.054	0.246	0.022	0.057	-0.019	0.187***
	(0.037)	(0.162)	(0.074)	(0.117)	(0.078)	(0.060)
Matching	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
N	6,874	504	980	1,380	1,238	1,114

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors (in parentheses) clustered on the matched pair.

Effect of the EU ETS on TFP

DiD without matching

	Sector	10	17	20	23	24
ETS	-0.087	-0.138	-0.137	-0.037	-0.230	0.266**
	(0.0966)	(0.419)	(0.124)	(0.101)	(0.356)	(0.107)
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
N	466,073	97,480	13,885	73,049	19,660	23,208

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors (in parentheses) clustered on the firm level.

Estimating cost pass-through

Identity involving price, marginal cost and markup in levels:

$$P_{fjt} = \lambda_{fjt} + MU_{fjt}$$

$$= \overline{MU}_{fj} + \lambda_{fjt} + \left(MU_{fjt} - \overline{MU}_{fj}\right)$$

Regression equation:

$$P_{fjt} = c_{fj} + \alpha \cdot \lambda_{fjt} + \epsilon_{fjt}$$

$\alpha = 1$: Complete cost pass-through (=constant markup)

Problem: We don't know λ_{fjt}, only its estimate $\hat{\lambda}_{fjt}$.

$\Rightarrow$ OLS will lead to biased results due to measurement error

IV strategy

Use different instruments to identify different types of cost pass-through:

1. Lagged marginal costs
   Pass-through of **materials costs**
2. Energy costs, multiplied by fixed shares
   Pass-through of **energy costs**
3. Allowance prices
   Pass-through of **carbon costs** *(not successful so far)*

Materials cost pass-through

	Sector	10	17	20	23	24
mc	1.383***	1.352***	1.160***	1.302***	1.182***	1.088***
	(0.007)	(0.029)	(0.044)	(0.010)	(0.041)	(0.032)
N	272,109	59,060	8,053	46,237	10,814	14,570

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Instruments are lagged marginal costs. Standard errors (in parentheses) are clustered on the firm level.

Energy cost pass-through

	Sector		
mc	0.450***	0.338***	0.915
	(0.048)	(0.071)	(0.545)
N	400,835	278,857	268,028

Individual industries

	10			17			20		
mc	0.402***	0.098	0.729***	0.504***	0.412***	1.147***	1.300***	1.240***	0.618***
	(0.072)	(0.135)	(0.203)	(0.104)	(0.151)	(0.270)	(0.113)	(0.144)	(0.173)
N	85,690	55,200	54,422	11,935	9,131	8,375	64,553	41,605	39,972

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors (in parentheses) clustered on the firm level. Models 1 and 3 use energy prices as an instrument; model 2 uses a shift-share instrument.

Discussion

- No significant effect of EU ETS on TFP and profits
  - ⇒ Positive effect for some industries
  - ⇒ No adverse effects overall
- More than complete pass-through of materials costs
  - ⇒ Constant proportional markup
- Incomplete pass-through of energy costs
- Possible explanation: Geographic scale of cost shock
  - ⇒ (Muehlegger & Sweeney, 2020)
- German manufacturing firms received $>$80% of their emissions allocated for free, while passing on more than 40% to consumers
  - ⇒ Free allocation reduced to 30% by 2020, problem solved?
  - ⇒ Focus on exempt firms

Surplus slides

Theoretical model

$$Q_{fjt} = Q_{jt}(L_{fjt}, K_{fjt}, M_{fjt}) \cdot \Omega_{fjt}$$

Lagrangian for cost minimization by firm f to produce product j at time t, given Q_{fjt}:

$$\max_{L_{fjt}, K_{fjt}, M_{fjt}} \quad \mathscr{L} = P^L_{fjt} L_{fjt} + P^K_{fjt} K_{fjt} + P^M_{fjt} M_{fjt}$$

$$+ \lambda_{fjt} \left[Q_{fjt} - Q_{fjt}(L_{fjt}, K_{fjt}, M_{fjt}; \Omega_{fjt}) \right]$$

Derivation of markup

FONC w.r.t. Materials input M_{fjt}:

$$P^M_{fjt} = \lambda_{fjt} \frac{\partial Q_{fjt}}{\partial M_{fjt}}$$

Multiply by $\frac{M_{fjt}}{Q_{fjt}}$ and rearrange:

$$\frac{\partial Q_{fjt}}{\partial M_{fjt}} \frac{M_{fjt}}{Q_{fjt}} = \frac{1}{\lambda_{fjt}} \frac{P^M_{fjt} M_{fjt}}{Q_{fjt}}$$

Define markup as $\mu_{fjt} \equiv P_{fjt}/\lambda_{fjt}$ and substitute:

$$\mu_{fjt} = \left(\frac{\partial Q_{fjt}}{\partial M_{fjt}} \frac{M_{fjt}}{Q_{fjt}} \right) \left(\frac{P^M_{fjt} M_{fjt}}{P_{fjt} Q_{fjt}} \right)^{-1}$$

Production function

Translog function:

$$f_j(l_{fjt}, k_{fjt}, m_{fjt}; \beta) = \beta_l l_{fjt} + \beta_{ll} l_{fjt}^2 + \beta_k k_{fjt} + \beta_{kk} k_{fjt}^2 + \beta_m m_{fjt} + \beta_{mm} m_{fjt}^2$$

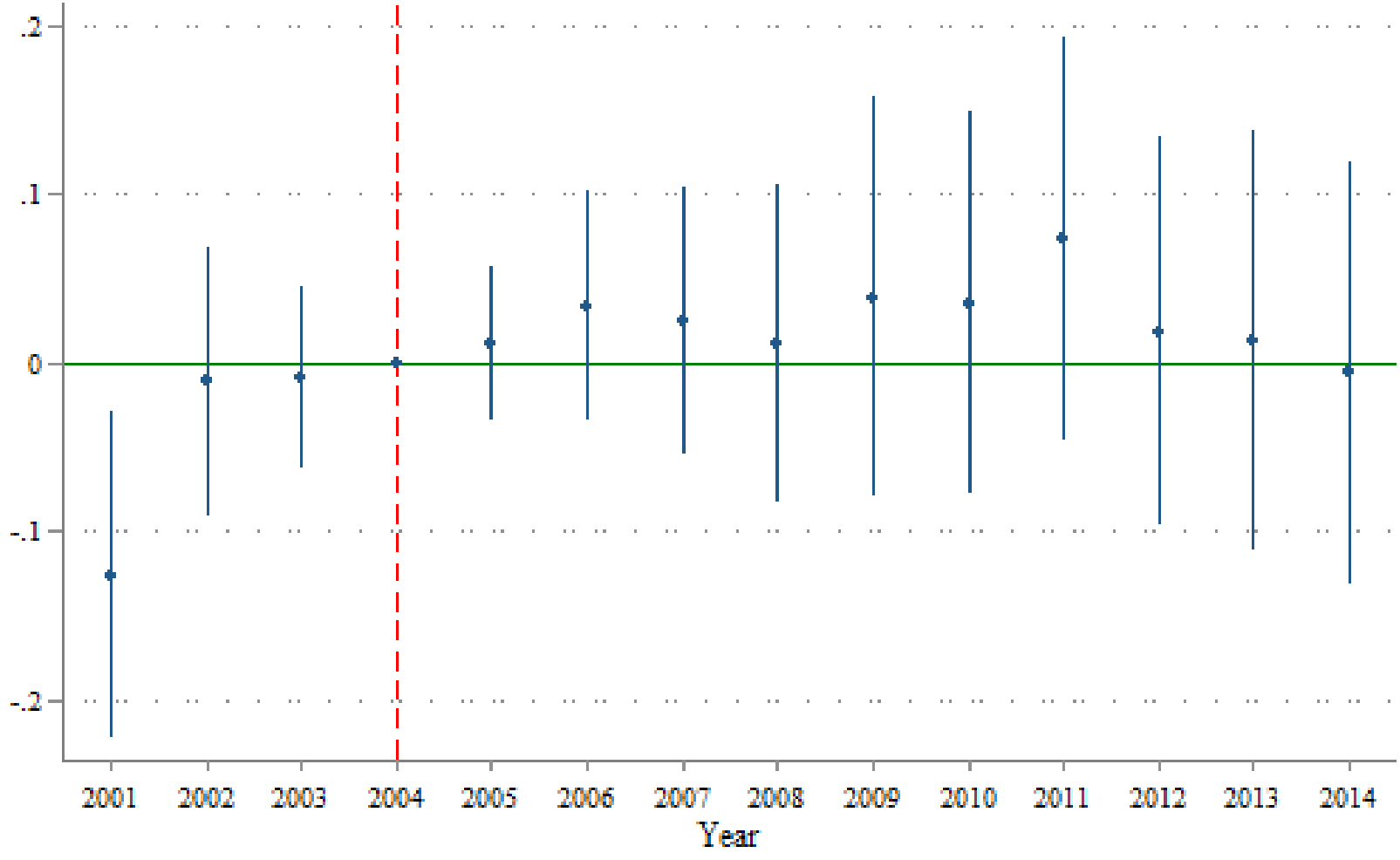
$$+ \beta_{lk} l_{fjt} k_{fjt} + \beta_{lm} l_{fjt} m_{fjt} + \beta_{mk} m_{fjt} k_{fjt}$$

Endogenous regressors: l_{fjt}, m_{fjt}

Exogenous regressors: k_{fjt}, dummies for ETS status and R&D expenditure, product and unit dummies, lagged nr. of products

Excluded instruments: Lags of labor and materials, lagged output price, lagged market share, additional lags of inputs

Event study graph: Profits



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Event study graph: TFP