

Carbon Pricing and Firm-Level CO₂ Abatement: Evidence from a Quarter of Century-Long Panel

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Carbon tax is a key climate policy tool to make firms internalize the costs of their emissions:

- Nordhaus (1993) ; Golosov et al. (2014); Rockström et al. (2017); Sterner et al. (2019);
- Starting early 1990s, several countries have introduced carbon pricing schemes;
- Very few empirical studies (e.g., Greenstone et. al (2016));
- Do they have any effect on emissions?

Objectives

Main goal: A comprehensive evaluation of how carbon pricing has affected manufacturing firms' emissions.

We examine

- the sectoral distribution of carbon emissions and taxes;
- how carbon pricing has shaped firms' emissions;

Favorable empirical settings

Sweden is a good testbed for empirical analyses:

- available long and granular registry data;
- significant time series and cross-sectional variation of tax rates
- gradual adjustment and account for huge within-sector differences in emission intensities

Not available tax records: we approximate based on legislative documents

Findings in a nutshell

Sectoral distribution: exploratory analyses

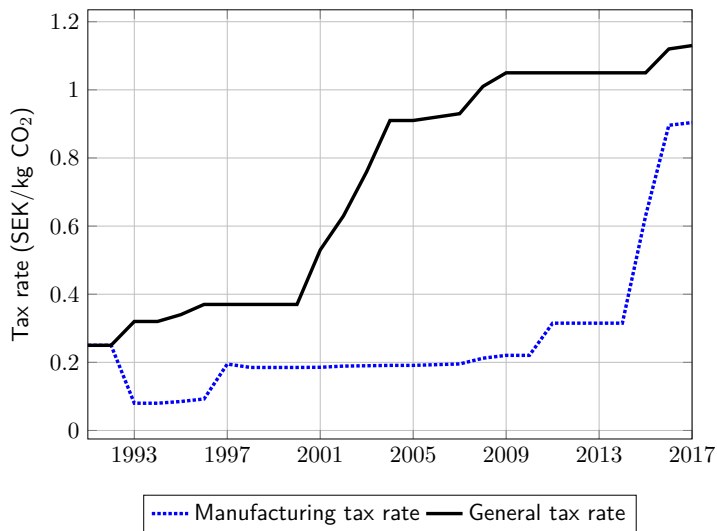
- Skewed distribution in carbon emissions and taxes;
- 75% of emissions belong to cement, refineries, steel, paper

Firms' normalized emissions: effects of carbon pricing

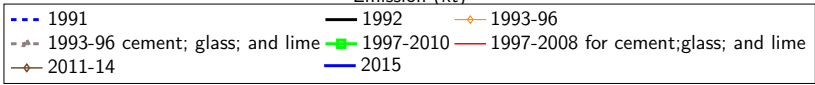
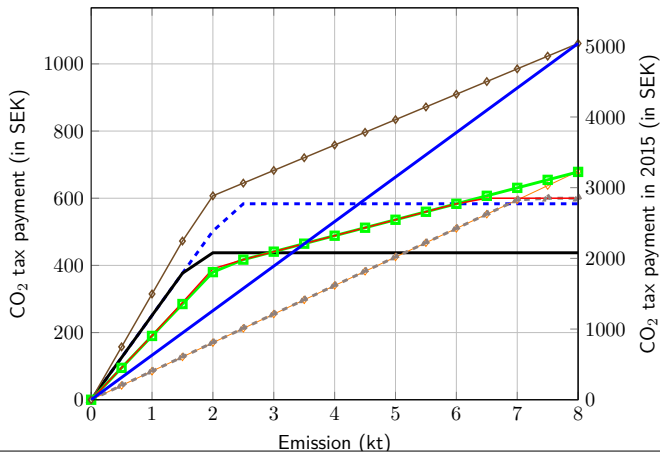
- Carbon pricing works;
- Firms respond to positive marginal carbon prices;
- Large emitters' response has been moderate;
- Considerable effect in lower-emitting sectors

On average, **4,000** manufacturing firms, **85%** taxable emissions are covered in the Swedish sample.

Nominal carbon tax rates



Exemptions - an example



Building blocks

- Normalized emission (emission intensity): measures the emissions necessary for a unit of output, a measure of 'cleanness'
- Normalization takes the size of a firm into account

Emission intensity approach

- **Sort** each four-digit industry (NACE codes) into ten deciles based on emission intensities (i.e. EI) in 1990;
- **Evaluate** EI, emissions, and tax payments of the deciles

Distribution of CO₂ emissions and sales

Figure 3: Distribution of CO₂ emissions from Swedish manufacturing (1990-2015)

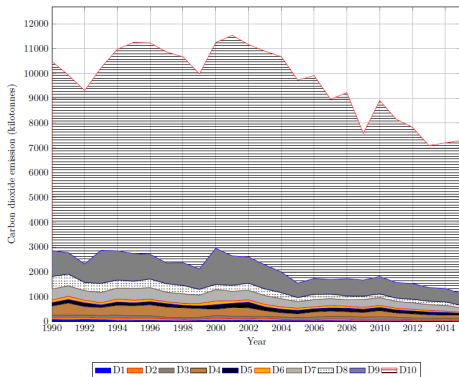
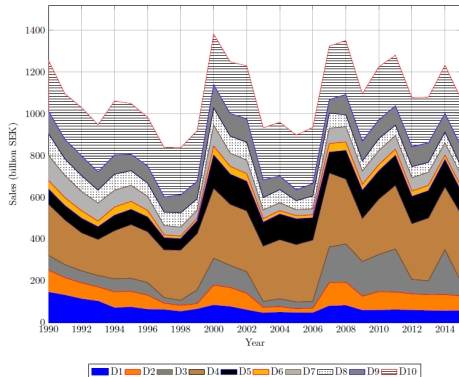


Figure 4: Distribution of sales in the Swedish manufacturing sector (1990-2015)



Building blocks

- Hypothesis: marginal price shapes firms' incentives;
- Emissions respond with delay: lag structure;

$$\ln \underbrace{\left(\frac{E_{i,t}}{Y_{i,t}} \right)}_{\text{Emission intensity}} = \omega + \sum_{s=0}^q \sigma_s \cdot \ln(1 + \tau_{i,t-s}) + \underbrace{\delta_i + \delta_t}_{\text{Fixed effects}} + \epsilon_{i,t}$$

$\tau_{i,t-s}$: marginal price of emissions

- Marginal carbon tax rate under carbon taxation
- Price of emission permits under EU ETS
- Transitional years under both systems: emissions-weighted average of prices

Table 6: Baseline regression results

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: $\log(\text{CO}_2/\text{Y})(i,t)$				
	All			D10	
$\log(1 + \text{marginal tax rate})(i,t)$	-2.758 (0.365)***	-2.244 (0.320)***	-1.967 (0.320)***	-1.859 (0.359)***	-1.962 (0.468)***
$\log(1 + \text{marginal tax rate})(i,t-1)$		-1.091 (0.275)***	-0.848 (0.236)***	-0.693 (0.251)***	-1.146 (0.364)***
$\log(1 + \text{marginal tax rate})(i,t-2)$			-0.595 (0.264)**	-0.366 (0.236)	-0.714 (0.331)**
$\log(1 + \text{marginal tax rate})(i,t-3)$				-0.485 (0.294)*	-0.800 (0.407)*
Sum σ	-2.758	-3.335	-3.410	-3.403	-4.622
F-test	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Firm fixed effects	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
OBS	32,345	28,387	24,355	20,296	2,026
Adjusted R^2	0.800	0.807	0.816	0.822	0.770

Table 6 tabulates our baseline regression results, i.e. the relationship between lagged marginal tax rates and emission intensities (CO_2/Y).

- The effect is stable over the introduction of EU ETS from 2005;
- The result is stronger for firms in industries with lower abatement costs and less movable assets

Effects on aggregate emissions

- Aggregate manufacturing emission reduction (1990-2015): 31%
- Decomposition (Grossman and Krueger (1993)): -18% (technique); -10% (composition);
- How much did carbon pricing contribute?

- We investigate how carbon pricing affects manufacturing firms' CO₂ emissions;
- Our analyses exploit a rich set of registry/microdata;
- Skewed distribution of emitted CO₂ and taxes;
- Positive marginal carbon emission price is a key in abatement incentives;

Thank you for your attention!