Carbon Taxation, Firm Performance, and Labor Demand

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Introduction

- Carbon pricing is a central climate policy instrument to reduce emissions.
- Many countries have introduced carbon taxes, often with exemptions for industry.
- Motivation: protect firms' competitiveness and employment in exposed sectors.
- However, there is limited empirical evidence on the actual impacts on firms and workers.

Research Questions

- I study a reform of the Swedish carbon tax in 2011–2018 in manufacturing.
- **Q1:** What is the effect of higher carbon taxation on firms' **emissions** and **economic performance**?
- **Q2:** What are the (heterogeneous) effects on **labour demand**?
  - How are effects distributed across workers by **education**, **age** and **gender**?
- Results inform both the **effectiveness** of the carbon tax and its **distributional impacts** in the labour market.

Related Literature

- **Carbon pricing and emissions:** Andersson (2019); Brännlund et al. (2014); Colmer et al. (2024); Dechezleprêtre et al. (2023); Jaraite and Di Maria (2016); Leroutier (2022); Marin et al. (2018); Martin et al. (2014); Martinsson et al. (2024).

→ Semi-elasticity for carbon taxation (% / €) for non-ETS sample.

Related Literature

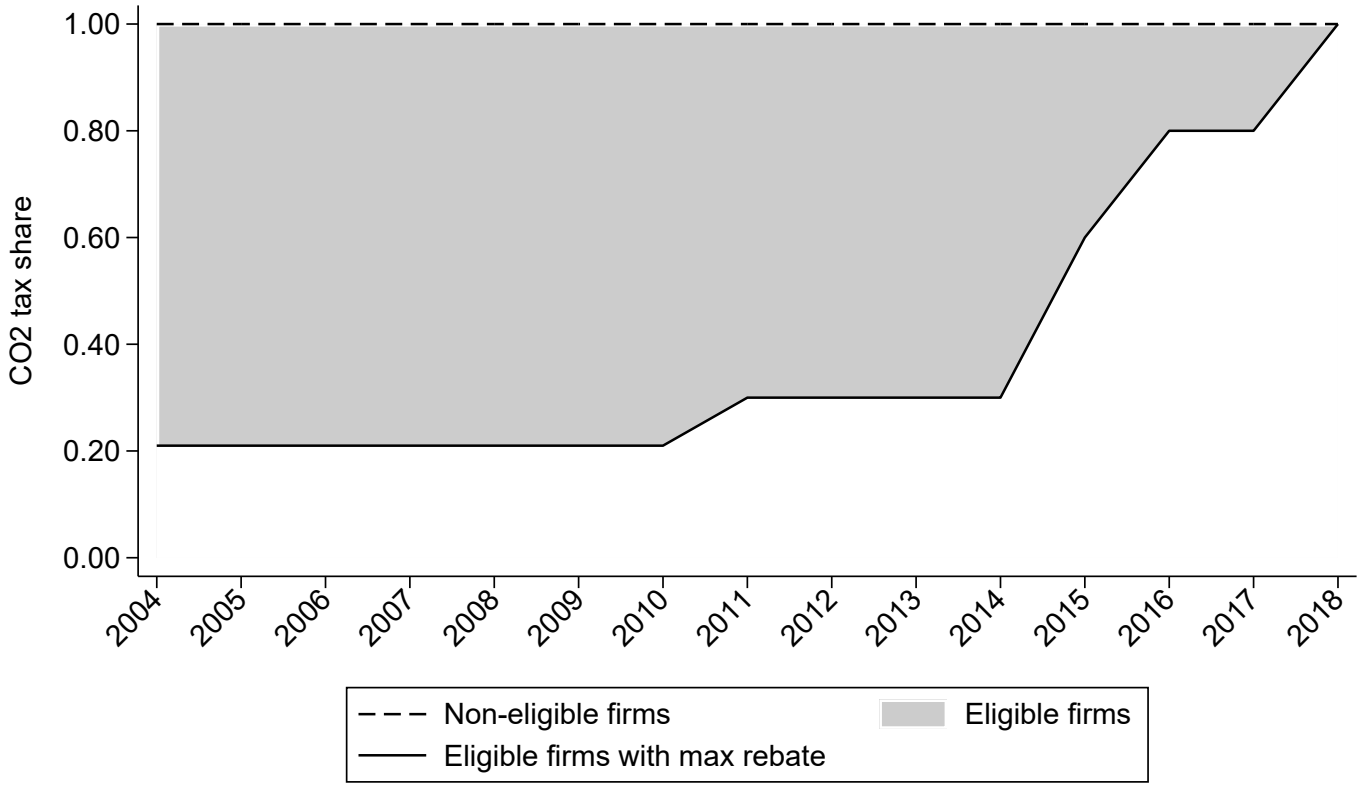
- **Carbon pricing and employment (firm-level):** Colmer et al. (2024); Dechezleprêtre et al. (2023); Marin et al. (2018); Martin et al. (2014).
- **Carbon pricing and employment (individual-level):** Yamazaki (2017, 2019); Yip (2018).

→ The first paper to study **heterogeneous effects of carbon pricing** on labor demand using firm- *and* worker-lever data.

Policy Background

- Sweden introduced a carbon tax in 1991.
- The tax is levied on fuel suppliers $\rightarrow$ higher fossil fuel prices for users.
- Before 2011, eligible manufacturing firms effectively paid about **21% of the general carbon tax rate**.
- A main **rebate scheme** was phased out in 2011–2018 (announced in 2009).
- From 2018, most manufacturing firms **outside the EU ETS** pay the full carbon tax rate.

Policy Background: Tax Rates Over Time



Potential CO_2 tax shares (SEK/ton) for eligible and non-eligible firms.

Tax Rebate Eligibility and Treatment

- Only firms fulfilling certain criteria could apply for carbon tax rebates.
- Some fuel uses were **not** eligible for rebates:
  - Fuel used in mobile engines (cars, trucks, etc.).
  - Fuel used outside the *main* manufacturing process.
  - Lack of information or administrative capacity.
- Manufacturing firms without rebates on fossil fuel use were not directly affected when rebates were phased out.

$\rightarrow$ **Treatment:** $D_j = 1$ for firms receiving carbon tax rebates before reform announcement (2008).

Data Overview

- Fuel data from *Energy Use in Manufacturing* (ISEN), 2004–2018.
- Compulsory for manufacturing firms with more than 9 employees.
- Register of excise duty refunds (carbon and energy taxes on fuels), 2008–2018.
- Linked to firms' accounts and individual registers (LISA).
- Exclude firms covered by the EU ETS and firms with zero emissions in 2004–2008.

→ Balanced panel of 1,078 manufacturing firms, 2004–2018.

Pre-reform Characteristics

	Pre-reform means		
	Treated (1)	Control (2)	Difference (1) - (2)
#Firms	849	615	
Revenue (mSEK)	329.25	185.12	144.13***
CO_2 emissions (ton)	642.03	133.48	508.54***
CO_2 intensity (ton/mSEK)	29.13	4.33	24.80**
Employment	130.09	87.78	42.31***
Share no high school	0.25	0.22	0.03***

Empirical Strategy: Event Study

Event-study model with binary treatment:

$$\log Y_{jt} = \sum_{k=2004, k\neq 2008}^{2018} \beta^k \times \mathbf{1}(t = k) \times D_j + \eta_j + \alpha_{It} + \epsilon_{jt}$$

- Firm j, year t.
- Outcomes Y_{jt}: CO_2, revenue, employment, etc.
- D_j: indicator for receiving a rebate in 2008.
- Firm fixed effects η_j, industry-year fixed effects α_{It}.

Empirical Strategy: Long Difference-in-Differences

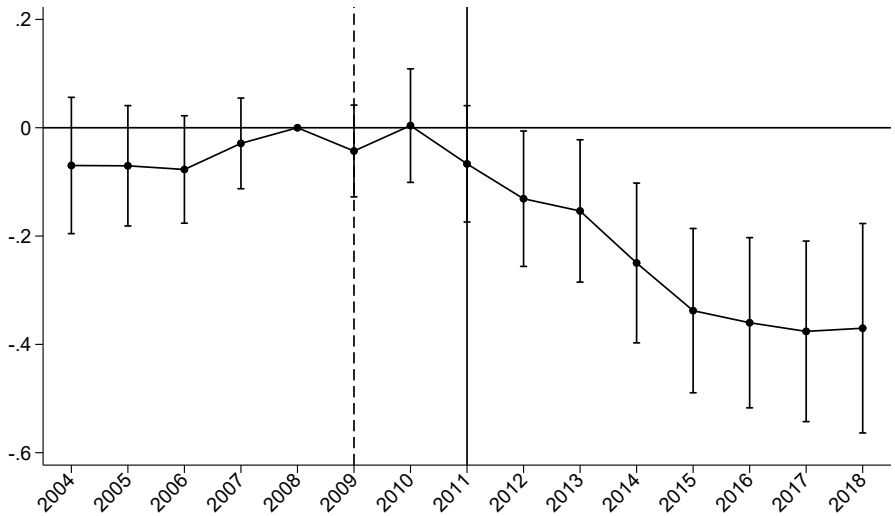
Long-difference DiD model with binary treatment:

$$\log Y_{jt} = \eta_j + \Gamma_l \times Post_t + \beta D_j \times Post_t + \epsilon_{jt}$$

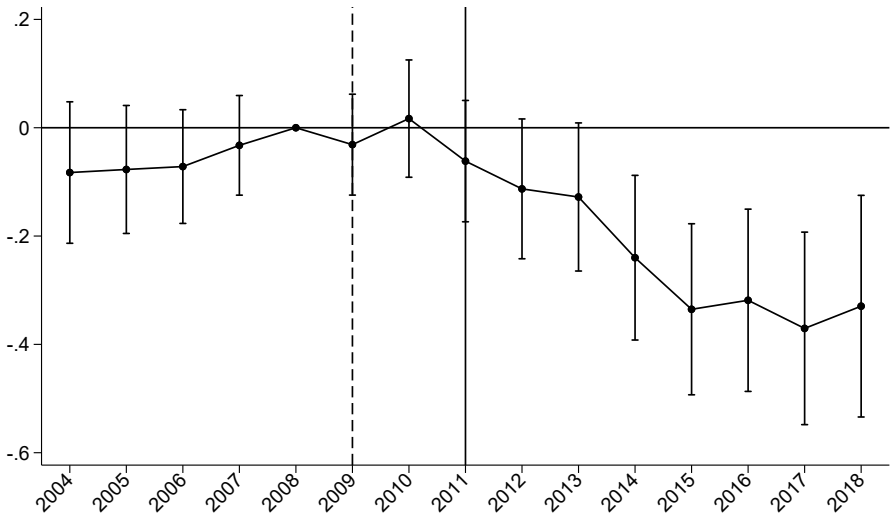
- $t \in \{2008, 2018\}$, with $Post_t = \mathbf{1}(t = 2018)$.
- Y_{jt}: CO_2, revenue, employment, etc.
- D_j: treatment indicator (rebate in 2008).
- Firm fixed effects η_j, industry-specific trends $\Gamma_l \times Post_t$.
- β captures long-run average treatment effects of the tax increase.

Results: Emissions and Emission Intensity

(a) log CO_2



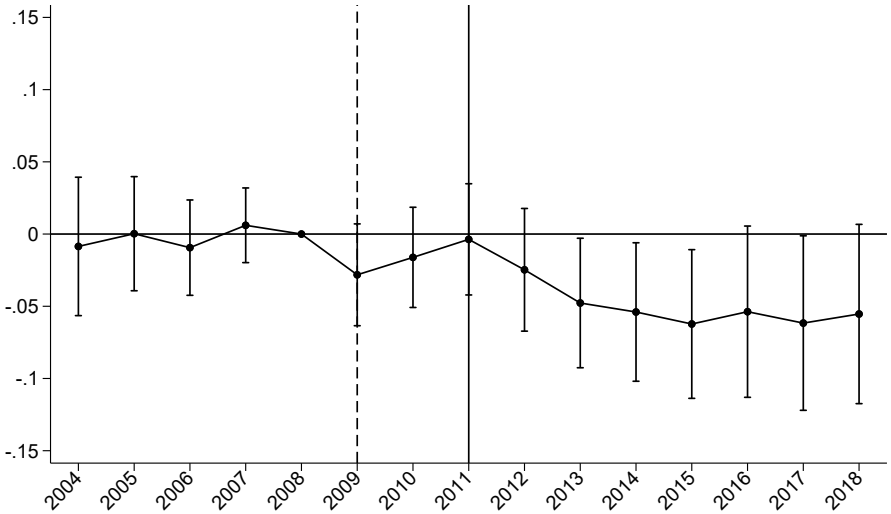
(b) log CO_2/VA



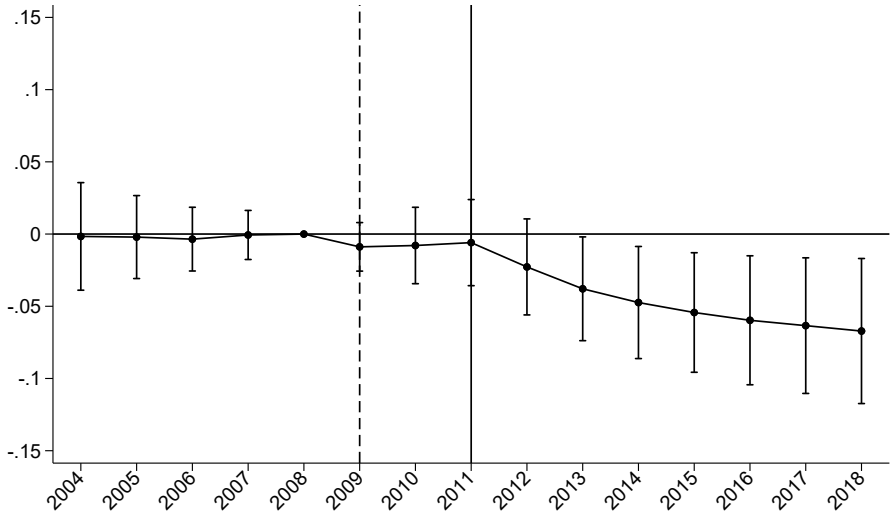
$\approx$ **30% reduction** in emissions and emission *intensity* among treated firms.

Results: Revenue and Employment

(a) log Revenue



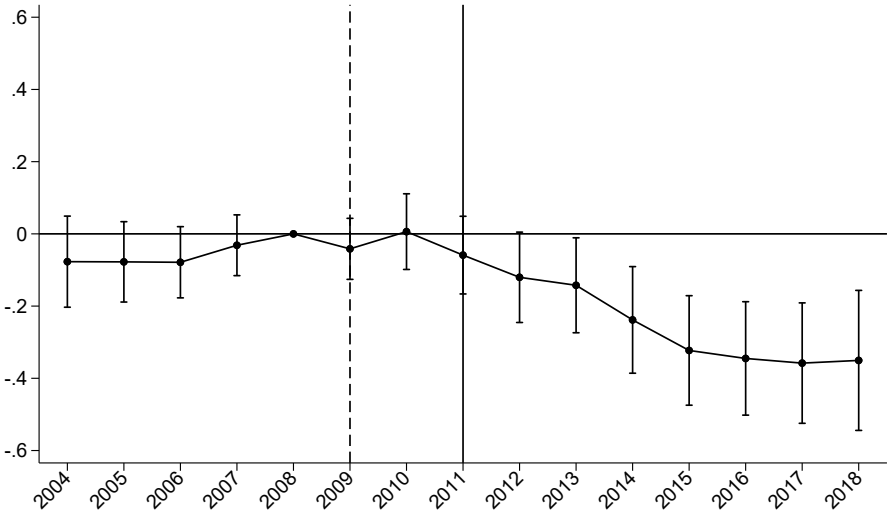
(b) log Employment



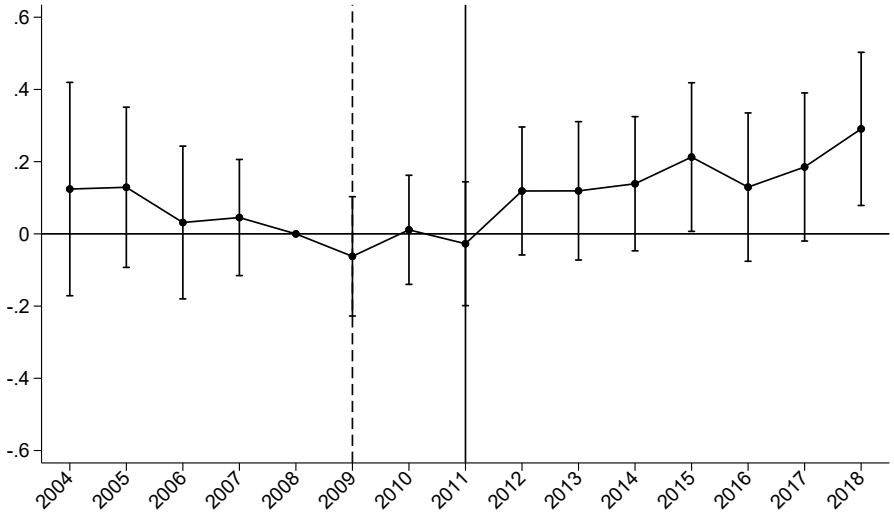
$\approx$ **6–7% reduction** in revenue and employment in treated firms.

Mechanism: Fuel Switching

(a) log Fossil fuels



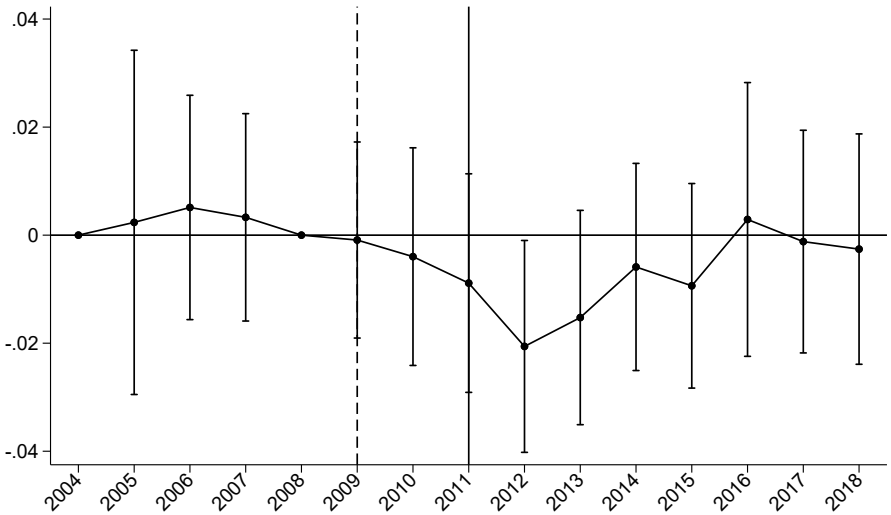
(b) log Biofuels



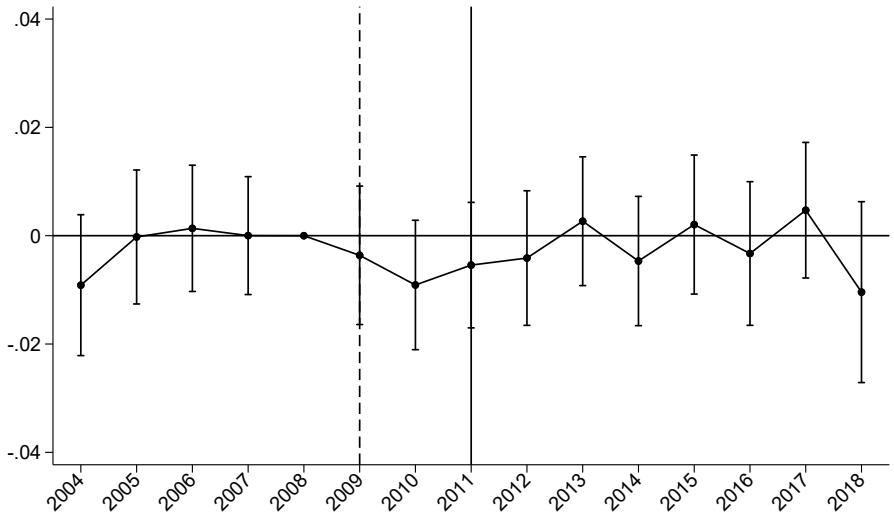
A substantial part of the emission reduction is driven by **substitution from fossil fuels to biofuels**.

Mechanism: Employment Adjustments

(a) Hiring rate



(b) Separation rate



Negative employment effect driven by **lower hiring**.

Heterogeneous Effects

			log(Employment)			
	log(CO_2)	log(Revenue)	All	No high school	High school	Above high school
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: All firms			
D × *Post*	**-0.361*****	-0.059*	**-0.070*****	**-0.137*****	-0.037	-0.047
	(0.100)	(0.032)	**(0.026)**	**(0.042)**	(0.028)	(0.041)
Observations	1,840	2,148	2,154	2,070	2,154	1,972

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	log(CO_2)	log(Revenue)	All	No high school	High school	Above high school
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	(0.100)	(0.032)	**(0.026)**	**(0.042)**	(0.028)	(0.041)
Observations	1,840	2,148	2,154	2,070	2,154	1,972
			Panel B: Emission-intensive firms			
D × *Post*	**-0.421*****	**-0.107****	**-0.133*****			
	(0.133)	**(0.048)**	**(0.043)**			
Observations	932	1,054	1,060			

Heterogeneous Effects

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	log(CO_2)	log(Revenue)	All	No high school	High school	Above high school
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Observations	1,840	2,148	2,154	2,070	2,154	1,972
			Panel B: Emission-intensive firms			
$D \times Post$	**-0.421*****	**-0.107****	**-0.133*****	**-0.224*****	-0.073	**-0.171****
	(0.133)	**(0.048)**	**(0.043)**	**(0.076)**	(0.050)	**(0.080)**
Observations	932	1,054	1,060	1,018	1,060	952

Heterogeneous Effects

	log Employment						
				Age			
	All	Men	Women	16–29	30–39	40–49	50–64
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A: No high school						
$D \times Post$	**-0.137*****	**-0.134*****	**-0.122****	-0.051	0.057	**-0.141****	**-0.146*****
	(0.042)	**(0.043)**	**(0.061)**	(0.084)	(0.080)	**(0.071)**	**(0.048)**
Observations	2,070	2,018	1,180	984	1,024	1,240	1,866

Additional Results and Robustness

- No detectable effect on individual wages.
- No strong evidence of increased firm exit.
- Results robust to:
  - controlling for differential trends in exporter status, workforce size and capital,
  - using balanced vs. unbalanced panels,
  - region-year FE.
- Effects correspond to semi-elasticities of -0.58%/€ (emissions) and -0.20%/€ (low-educated labor).

Thanks!

Appendix: Constructing Effective Carbon Tax Rates

- I observe the *amount* of refunded carbon and energy taxes.
- I compute firm-year specific effective carbon tax rates in SEK/ton using:
  - i) fuel consumption by fuel type,
  - ii) fuel-specific statutory (pre-rebate) tax rates,
  - iii) carbon tax refunds (implying net tax paid),
  - iv) fuel-specific emission factors (implying CO_2 emissions).

Appendix: Semi-elasticities

- $\Delta \text{CO}_2\text{TAX}_j$: Change in firm js tax rate 2008-2018
- Γ_I: Industry FE

$$\Delta \text{CO}_2\text{TAX}_j = \Gamma_I + \gamma D_j + \Delta v_j$$

$$\Delta \log Y_j = \Gamma_I + \phi \Delta \widehat{\text{CO}_2\text{TAX}}_j + \Delta \varepsilon_j$$

- $\widehat{\gamma}$: Conditional average increase in treated firms' carbon tax rates
- $\widehat{\phi}$: Relative effect on Y in terms of €/ton CO_2 increase

Appendix: Semi-elasticities

		Δ log Employment			
	Δ log CO_2	All	No high school	High school	Above high school
	(1)	(2)	(3)	(4)	(5)
$\Delta\widehat{CO_2 TAX}$	**-0.0058*****	**-0.0010*****	**-0.0020*****	-0.0005	-0.0008
	(0.0016)	(0.0004)	(0.0006)	(0.0004)	(0.0006)
$\widehat{\gamma}$	64.89	66.07	66.73	66.07	65.26
F-stat	766.80	1,080.79	1,045.16	1,080.79	948.33
Observations	920.00	1,077.00	1,035.00	1,077.00	986.00

- Emissions fall by **0,58%** per €/ton CO_2.
- Employment for workers without a high school degree falls by **0,20%**.