The Effects of Carbon Cost Compensation in Emissions Trading

Evidence from German Manufacturing

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Introduction

- Unilateral carbon pricing → fear of **carbon leakage**
- **Carbon cost compensation** to emission intensive industries to protect competitiveness & prevent carbon leakage
- All emissions trading schemes (ETS) covering industry provide compensation via **free allocation (FA)** (Sato et al. 2022)
- We study effects of compensation on manufacturing firms looking at effects of FA in EU ETS

Introduction

Carbon cost compensation in the EU ETS:

- EU ETS is 2nd largest emission trading system in the world
- FA as carbon cost compensation to protect competitiveness
  - Value of FA at carbon price of 60 EUR $>$ 40 bn. EUR per year (Elkerbout 2022)
  - Introduction of carbon border adjustment (CBAM) $\rightarrow$ phase-out of FA; full phase-out in 2034
- 2013: Change FA-rules from grandparenting to benchmarking $\rightarrow$ **We exploit this change to study effects of FA**

Research questions

1. **Effect of carbon cost compensation on firm-level outcomes?**
   - Effect on emissions, employment, output and investments

2. **Heterogeneity of effect by sector?**
   → which sectors should (not) receive compensation?

Related literature

- **Empirical evaluations of effects of carbon prices**
  - Colmer et al. (2024), Dechezleprêtre, Nachtigall and Venmans (2023), Löschel, Lutz and Managi (2019), and Martin, Preux and Wagner (2014)
- **Design of carbon cost compensation rules**
  - Böhringer, Fischer and Rivers (2023), Martin et al. (2014a,b), and Sato et al. (2015)
- **Empirical evaluations of carbon cost compensation**
  - Basaglia, Isaksen and Sato (2024), Locatelli et al. (2022), Ulmer (2022), and Zaklan (2023)

Contribution

- Empirical strategy using **within-sector firm-level variation** of FA
  $\rightarrow$ can analyse **heterogenous effects** of FA across sectors receiving compensation
  $\rightarrow$ implications for future design & reform of compensation rules
- Analysis includes years 2018-2019 when some firms were short in FA & carbon prices were relatively high

Institutional setting

EU-ETS

- **Emission intensive manufacturing**, power sector, domestic aviation
- Every year, firms surrender allowances for GHG emissions
- Allowances are either **auctioned or distributed for free**

Phases I (2005-2007) & II (2008-2012)

- **Grandparenting**: free allocation based on historical emissions
- (Nearly) full free allocation in phases I & II

Phase III (2013-2020)

- **Benchmark**: average emission intensity of sector's top 10%
- Default: 80% of benchmark as FA in 2013 declining to 30% in 2020
- Carbon leakage risk sectors: 100% of benchmark as free allocation

Free allocation after 2013: Benchmarking

How are FA determined?

$$FA_{ist} = Benchmark_s * Activity_i * RF_{it} * CLF_{st}$$

- $Benchmark_s$: emission intensity of 10% most efficient installations
- $Activity_i$: historic activity level of installation i
- RF_{it}: cross-sectoral correction factor ensuring that free allocations do not exceed the total amount available for free allocation
- CLF_{st}: Carbon leakage risk factor; 1 for leakage risk sectors CLR criteria; decreases from 0.8 in 2013 to 0.3 in 2020 for all other sectors

- Heterogeneous reduction of free allocations within sector
  $\Rightarrow$ larger reduction for plants further above benchmark

Data

- We merge firm-level data from the German manufacturing census (AFiD) and the EU Transaction Log (EUTL)

German manufacturing census (AFiD)

Data on production, sales, inputs and investments

EU Transaction Log (EUTL)

Data on emissions and free allowances

- Final sample of $\sim$ 300 manufacturing firms
- Years 2010-2019

Treatment definition

2013: change in FA-rules from grandparenting to benchmarking
$\rightarrow$ variation in free allocation at firm-level

$$D_{it}^{c} = \frac{(\overline{FA}_{i,pre} - FA_{it}) * P_t^{CO_2}}{\overline{Costs}_{i,pre}}$$

- D_{it}^{c}: Change in annual carbon compliance costs (as a share of total costs)
- Varying treatment intensity
- No estimator allowing varying treat. intensity & interactions of treatment with heterogeneity variables (Roth et al. 2023).

Treatment definition & DiD-estimator

Binary treatment variable:

$$D_{it} = \begin{cases} 1 & \text{if } D^c_{it} < -0.1\% \\ 0 & \text{if } D^c_{it} \in [-0.1\%, 0.1\%] \end{cases}$$

- Staggered treatment timing → use ETWFE-estimator (Wooldridge 2023, 2021)
- ETWFE:
  - Robust to heterogenous treatment effects in staggared settings
  - Allows for interactions of treatment with heterogeneity vars

Empirical specification

Extended Two-Way-Fixed-Effects

$$y_{it} = \eta + \alpha_i + \gamma_t + \mu_i + \gamma_t \times \mu_i + \pi\gamma_t \times LP_{i,t_0} + \sum_{r=2013}^{2019} \sum_{s=r}^{2019} \tau_{rs} D_{rs} + u_{it}$$

- α_i: firm fixed effects
- γ_t: year fixed effects
- μ_i: sector fixed effects
- $\mathrm{LP}_{i,t0}$: baseline labor productivity
- D_{rs}: treatment variable

Identifying assumptions

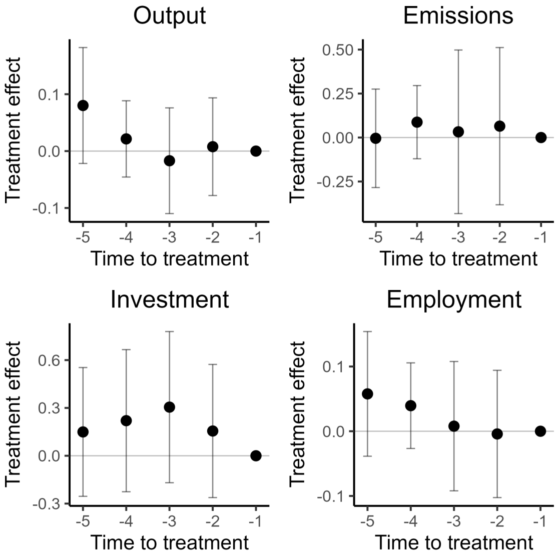
No anticipation
We ensure no anticipation by excluding year 2012 when FA for phase 3 was announced.

(Conditional) parallel trends
Conditional on base-period productivity LP_{i,t_0}, trend in outcome y_{it} does not depend on cohort status g_i.

$$E[y_{it}(\infty) - y_{i,2010}(\infty) \mid g_i, LP_{i,t_0}] = E[y_{it}(\infty) - y_{i,2010}(\infty) \mid LP_{i,t_0}]$$

for t = 2011, 2013, ..., 2019

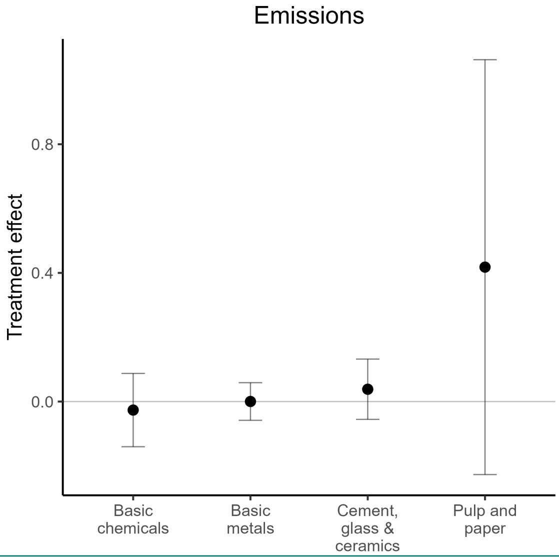
Parallel trends



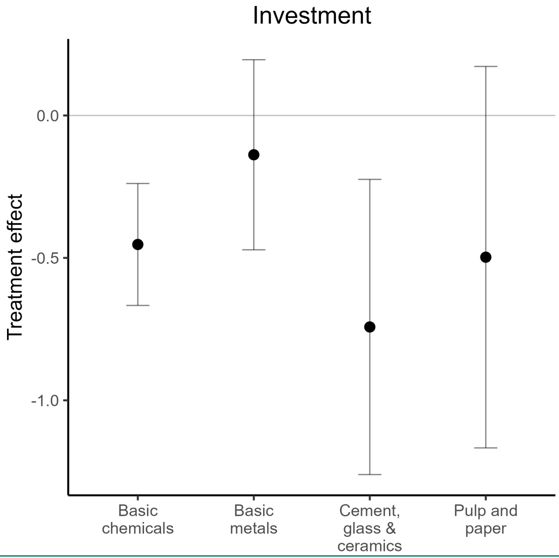
Average effects

	Output	Emissions	Investment	Employment
ETWFE	-0.03 (0.02)	-0.054 (0.113)	-0.16 (0.132)	-0.029 (0.03)
ETWFE + heterog. trends	-0.031 (0.02)	-0.057 (0.113)	-0.159 (0.131)	-0.029 (0.03)
ETWFE + heterog. trends + sec X year FEs	-0.024 (0.024)	-0.046 (0.112)	-0.107 (0.137)	-0.035 (0.029)
nr. of observations	1873	1859	1820	1866

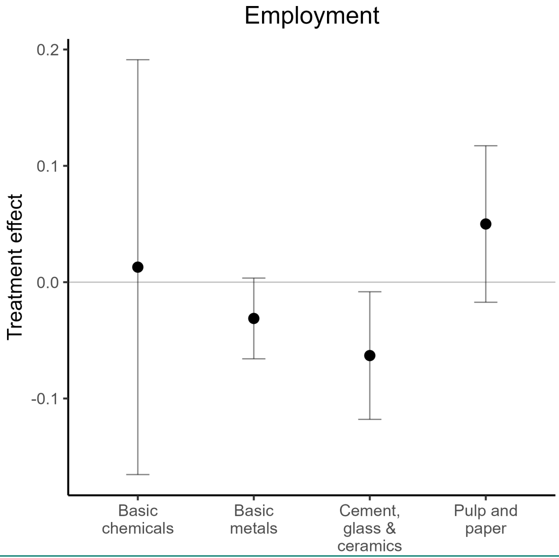
Heterogenous effects - Emissions



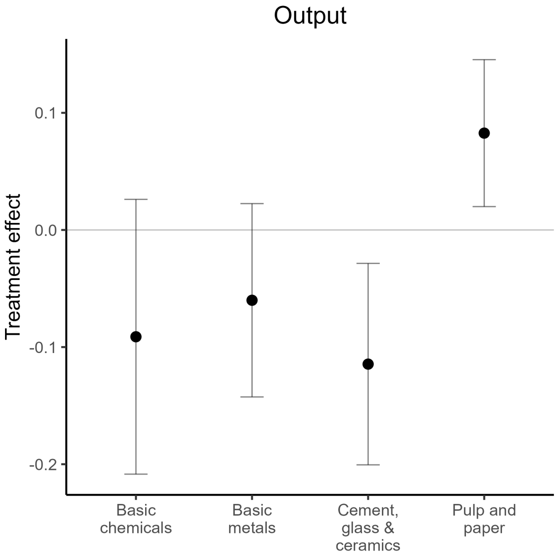
Heterogenous effects - Investment



Heterogenous effects - Employment



Heterogenous effects - Output



Conclusion

- In line w/ previous literature no significant effects on emissions, employment, investment and output.
- Heterogenous effects:
  - Negative effects on investment for basic chemicals and cement, glass & ceramics
  - Small negative effects on employment and output for cement, glass & ceramics
- Compensation in phase III of EU ETS for competitiveness protection was not necessary in most sectors
- If at all, compensation is necessary for some emission-intensive and trade-exposed basic material sectors

Thank you!

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References I

Basaglia, P., Isaksen, E. T. and Sato, M. (2024). *Carbon pricing, compensation, and competitiveness: Lessons from UK manufacturing*. en. Tech. rep. London: London School of Economics and Political Science.

Böhringer, C., Fischer, C. and Rivers, N. (July 2023). "Intensity-Based Rebating of Emission Pricing Revenues". In: *Journal of the Association of Environmental and Resource Economists* 10.4. Publisher: The University of Chicago Press, pp. 1059–1089. ISSN: 2333-5955. DOI: 10.1086/723645. Available at: https://www.journals.uchicago.edu/doi/10.1086/723645, accessed on August 22, 2024.

Colmer, J., Martin, R., Muûls, M. and Wagner, U. J. (May 2024). "Does Pricing Carbon Mitigate Climate Change? Firm-Level Evidence from the European Union Emissions Trading System". In: *The Review of Economic Studies*, rdae055. ISSN: 0034-6527. DOI: 10.1093/restud/rdae055. Available at: https://doi.org/10.1093/restud/rdae055, accessed on August 22, 2024.

Dechezleprêtre, A., Nachtigall, D. and Venmans, F. (March 2023). "The joint impact of the European Union emissions trading system on carbon emissions and economic performance". In: *Journal of Environmental Economics and Management* 118, p. 102758. ISSN: 0095-0696. DOI: 10.1016/j.jeem.2022.102758. Available at: https://www.sciencedirect.com/science/article/pii/S0095069622001115, accessed on April 29, 2024.

Elkerbout, M. (2022). "Can ETS free allocation be used as innovation aid to transform industry?" en. In.

Locatelli, A., Marin, G., Palma, A. and Dal Savio, G. (2022). "The impact of EU-ETS on trade: Evidence on Italian manufacturing firms". In: *Politica economica* 38.2. Publisher: Società editrice il Mulino, pp. 253–278.

Löschel, A., Lutz, B. J. and Managi, S. (May 2019). "The impacts of the EU ETS on efficiency and economic performance – An empirical analyses for German manufacturing firms". en. In: *Resource and Energy Economics*. Recent Advances in the Economic Analysis of Energy Demand - Insights for Industries and Households 56, pp. 71–95. ISSN: 0928-7655. DOI: 10.1016/j.reseneeco.2018.03.001. Available at: https://www.sciencedirect.com/science/article/pii/S0928765516303785, accessed on July 24, 2023.

References II

Martin, R., Muûls, M., Preux, L. B. de and Wagner, U. J. (August 2014a). "Industry Compensation under Relocation Risk: A Firm-Level Analysis of the EU Emissions Trading Scheme". en. In: *American Economic Review* 104.8, pp. 2482–2508. ISSN: 0002-8282. DOI: 10.1257/aer.104.8.2482. Available at: https://www.aeaweb.org/articles?id=10.1257/aer.104.8.2482, accessed on April 17, 2023.

— (September 2014b). "On the empirical content of carbon leakage criteria in the EU Emissions Trading Scheme". en. In: *Ecological Economics* 105, pp. 78–88. ISSN: 0921-8009. DOI: 10.1016/j.ecolecon.2014.05.010. Available at: https://www.sciencedirect.com/science/article/pii/S092180091400161X, accessed on April 17, 2023.

Martin, R., Preux, L. B. de and Wagner, U. J. (September 2014). "The impact of a carbon tax on manufacturing: Evidence from microdata". In: *Journal of Public Economics* 117, pp. 1–14. ISSN: 0047-2727. DOI: 10.1016/j.jpubeco.2014.04.016. Available at: https://www.sciencedirect.com/science/article/pii/S0047272714001078, accessed on January 31, 2024.

Roth, J., Sant'Anna, P. H. C., Bilinski, A. and Poe, J. (January 2023). *What's Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature*. en. Number: arXiv:2201.01194 arXiv:2201.01194 [econ, stat]. Available at: http://arxiv.org/abs/2201.01194, accessed on April 11, 2023.

Sato, M., Neuhoff, K., Graichen, V., Schumacher, K. and Matthes, F. (January 2015). "Sectors Under Scrutiny: Evaluation of Indicators to Assess the Risk of Carbon Leakage in the UK and Germany". en. In: *Environmental and Resource Economics* 60.1, pp. 99–124. ISSN: 1573-1502. DOI: 10.1007/s10640-014-9759-y. Available at: https://doi.org/10.1007/s10640-014-9759-y, accessed on April 13, 2023.

References III

Sato, M., Rafaty, R., Calel, R. and Grubb, M. (2022). "Allocation, allocation, allocation! The political economy of the development of the European Union Emissions Trading System". en. In: *WIREs Climate Change* 13.5. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/wcc.796, e796. ISSN: 1757-7799. DOI: 10.1002/wcc.796. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/wcc.796, accessed on April 12, 2023.

Ulmer, C. (January 2022). *Free Allowances and the Risk of Carbon Leakage at the Beginning of the Third Phase of the EU ETS*. en. SSRN Scholarly Paper. Rochester, NY. DOI: 10.2139/ssrn.3880946. Available at: https://papers.ssrn.com/abstract=3880946, accessed on April 17, 2023.

Wooldridge, J. M. (September 2023). "Simple approaches to nonlinear difference-in-differences with panel data". en. In: *The Econometrics Journal* 26.3, pp. C31–C66. ISSN: 1368-4221, 1368-423X. DOI: 10.1093/ectj/utad016. Available at: https://academic.oup.com/ectj/article/26/3/C31/7250479, accessed on December 1, 2023.

— (August 2021). *Two-Way Fixed Effects, the Two-Way Mundlak Regression, and Difference-in-Differences Estimators*. en. SSRN Scholarly Paper. Rochester, NY. DOI: 10.2139/ssrn.3906345. Available at: https://papers.ssrn.com/abstract=3906345, accessed on April 5, 2023.

Zaklan, A. (May 2023). "Coase and Cap-and-Trade: Evidence on the Independence Property from the European Carbon Market". en. In: *American Economic Journal: Economic Policy* 15.2, pp. 526–558. ISSN: 1945-7731. DOI: 10.1257/pol.20210028. Available at: https://www.aeaweb.org/articles?id=10.1257/pol.20210028, accessed on August 22, 2024.

Sectors at risk of carbon leakage

In phase 3 (2013-2020), a sector is defined to be at risk of carbon leakage according to the following criteria (Sato et al. 2015):

- combined criterion **(A)**
  - carbon costs are higher than 5 % of GVA
    AND
  - trade intensity (share of non-EU imports & exports relative to EU market size) is higher than 10 %
- single criteria
  - carbon costs are higher than 30 % of GVA **(B)**
    OR
  - non-EU trade intensity is above 30 % **(C)**

Sectors at risk of carbon leakage

Figure 1: Carbon and trade intensity of sectors

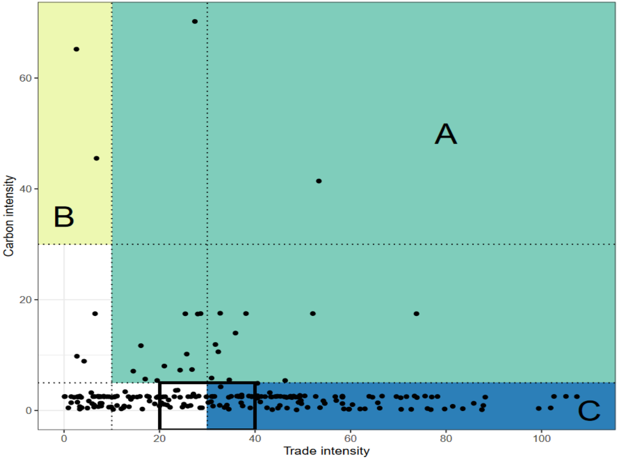

Figure from Ulmer (2022)