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Is Germany becoming the European Pollution Haven?

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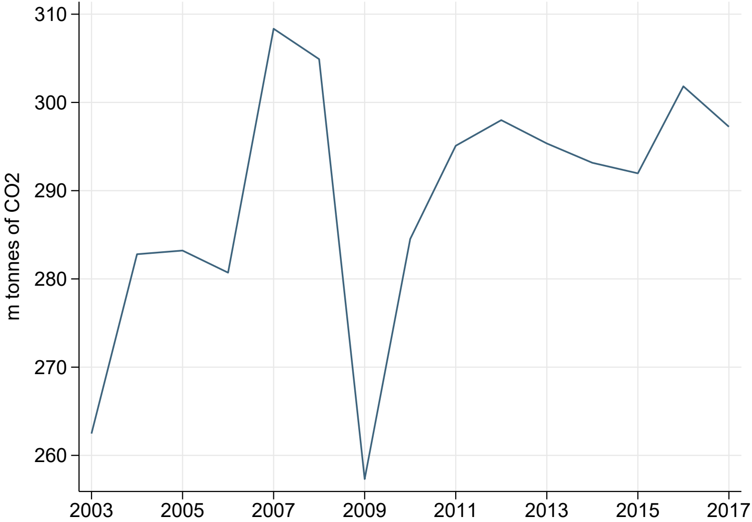
In German manufacturing, emissions have increased



Our contribution

Use a Melitz-style model to

- retrieve an aggregate measure of regulation (emissions trading, energy prices, and command and control instruments)
- understand how important EU climate regulation is for German emissions development

The Model: Shapiro and Walker (AER, 2018)

Melitz-style model with heterogeneous firms

- Production is Cobb-Douglas in emissions and inputs
- Firms can invest in pollution abatement (at the cost of producing less output)
- multi-country (Germany, rest of EU, rest of world)
- multi-sector (11 manufacturing sub-sectors)

The Quantitative Model

Assumptions:

- Preferences

$$U_d = \prod_s \left(\left[\sum_o \int_{\omega \epsilon \Omega_{o,s}} q_{od,s}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega \right]^{\frac{\sigma_s}{\sigma_s - 1}} \right)^{\beta_{d,s}}$$

- Firms
- Pollution
- Competitive Equilibrium

The Quantitative Model

Assumptions:

- Preferences
- Firms

$$\pi_{od,s}(\varphi) = p_{od,s}(\varphi)q_{od,s}(\varphi) - w_o l_{od,s}(\varphi)\tau_{od,s} - t_{o,s}z_{od,s}(\varphi)\tau_{od,s} - w_d f_{od,s}$$

▸ Pareto

- Pollution
- Competitive Equilibrium

The Quantitative Model

Assumptions:

- Preferences
- Firms
- Pollution

$$z_{od,s}(\varphi) = (1 - a(\varphi))^{\frac{1}{\alpha_s}} \varphi l_{od,s}(\varphi)$$

optimal abatement

- Competitive Equilibrium

The Quantitative Model

Assumptions:

- Preferences
- Firms
- Pollution
- Competitive Equilibrium
  - Labour demand must equal labour supply in each country
  - The expected profit that an entrepreneur obtains from drawing a productivity must equal the fixed cost of doing so (Free entry condition)

equilibrium conditions

Some things to note about how we use the model

- We aggregate the model to the sector-country level
- We rewrite the model in changes from a baseline (Dekle et al., 2008, "hat algebra") ▸ aggregate emissions ▸ equilibrium conditions in changes
- We define "shocks" to the model whose impact on emissions we measure
  1. German/EU regulation $\hat{t}$

$$\hat{t}_{o,s} = \frac{\hat{M}^e_{o,s}\hat{w}_o}{\hat{Z}_{o,s}}$$

  2. expenditure share shock $\hat{\beta}$
  3. competitiveness shocks: comprising all variables related to trade cost, productivity, and, for the rest of world, regulation ▸ competitiveness shocks

Putting the model to the data

What we use the model for:

- Calculate historical shocks by plugging in parameter values, production and trade values
- Decompose: How did the shocks affect carbon emissions in Germany?

Parameter estimation using the German Manufacturing Census

σ_s

- Demand elasticities (substitutability)
- Recovered via markups (κ_s), approximated with the ratio of revenues to variable cost: $\sigma_s = \frac{1-\alpha_s}{(1-\alpha_s)-\frac{1}{\kappa_s}}$

α_s

- Abatement elasticity
- Approximated with output elasticity of energy, corrected by sector-level fuel mixes
- Output elasticity of energy as energy cost share (Syverson, 2011)

θ_s

- Pareto shape parameter of firm productivity (φ) distribution
- Estimated using log sales rank of firms ▸ parameter values

Production and Trade Data

General:

- Study period: 2005 to 2019
- Level: 11 manufacturing sectors sector list
- Level: 3 world regions (DE, EU, ROW)

Trade data

- Eurostat data on German and EU trade

World output data

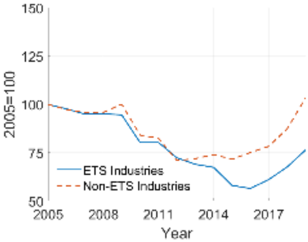
- UNIDO INDSTAT data comparison AFiD

Emissions, fuel mixes and energy prices comparison AFiD

- IEA data

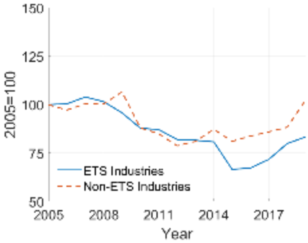
Historical regulation shock

The stringency of regulation in Germany



- ETS sectors: Paper, coke, chemicals, non-metallic mineral products, metals

The stringency of regulation in the rest of the EU

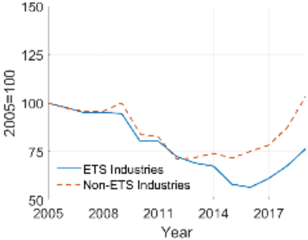


- Non-ETS sectors: Remaining sectors (food, textiles, furniture, cars, etc.)

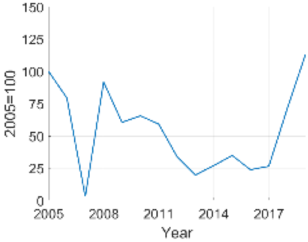
▸ Other historical shocks ▸ AFiD emissions

Historical regulation shock

The stringency of regulation for ETS and non-ETS sectors



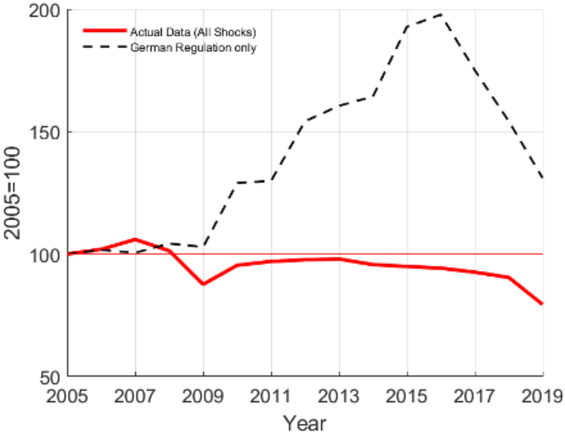
The price of carbon emissions in the ETS



Source: Statista (2022)

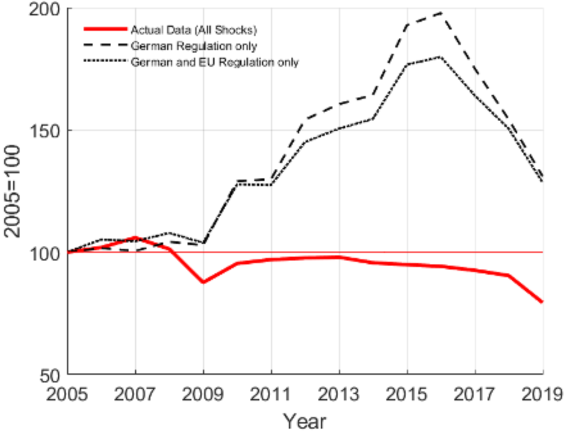
▸ Regressions: Explaining the regulation shock ▸ EU vs German regulation shock

Counterfactual emissions regulation shock only

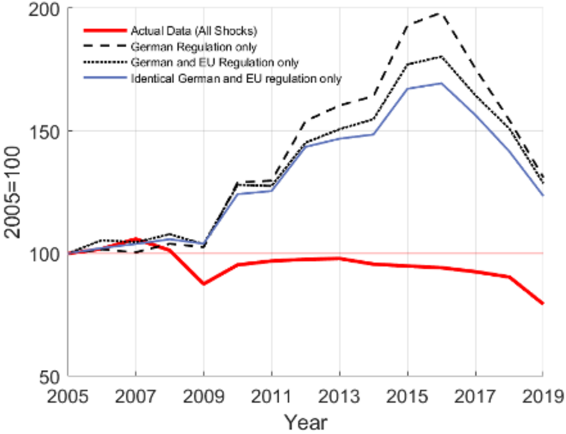


▸ full decomposition

Counterfactual emissions regulation shock only



Counterfactual emissions regulation shock only



Discussion

Germany as a European pollution haven:

- German industrial carbon emissions have increased because the implicit carbon price has decreased
- In fact, it has decreased more than in the EU
- This difference seems influential for the emissions development in German manufacturing...
- ...while competitiveness (and regulation) shifts in the rest of the world matter only little
  - We are talking a lot about the CBAM – while intra-EU carbon prices differences might be a lot more relevant!

Thank you very much!

Financial support from the Leibniz Association is gratefully acknowledged

Appendix

Firm entry and cutoff productivity

Productivity draw: *Firms draw a productivity from a Pareto distribution at the expense of a fixed cost* $f^e_{i,s}$

$$G(\varphi; b_{i,s}) = 1 - \frac{(b_{i,s})^{\theta_s}}{\varphi^{\theta_s}}$$

Cutoff productivity: *Firms are indifferent whether or not to produce as they make zero profits*

$$\varphi^*_{id,s} = \left(\frac{\sigma_s}{\sigma_s - 1} \frac{c_{i,s}\tau_{id,s}}{P_{d,s}} \left(\frac{\sigma_s w_d f_{id,s}}{E_{d,s}} \right)^{\frac{1}{\sigma_s - 1}} \right)^{\frac{1}{1-\alpha_s}}$$

main

Comparative statics

Proposition 1: *Pollution intensity of a firm is locally decreasing in productivity. Pollution intensity of a sector is locally decreasing in taxes, productivity and trade liberalization*

- From the FOC of the firm: $1 - a = (\frac{w_o}{\varphi t_{os}} \frac{\alpha_s}{1-\alpha_s})^{\alpha_s}$
- Trade liberalization redistributes market shares to more productive (and cleaner) firms

- To assess impact of non-marginal changes and take account of general equilibrium effects we need to use the quantitative model

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Equilibrium conditions

Labour market clearing: *In equilibrium, labour markets clear*

$$L_i = L_i^e + L_i^p + L_i^t + L_i^m + L_i^{nx}$$

Free entry: *In equilibrium, the fixed cost of drawing a productivity are equal to the expected profits of doing so*

$$w_i f_{i,s}^e = \left(1 - G\left[\varphi_{ii,s}^*\right]\right) E\left[\pi | \varphi > \varphi_{ii,s}^*\right]$$

▸ main

Aggregate emissions

Emissions in changes:

$$\hat{Z}_o = \frac{\sum_s \frac{\hat{M}^e_{o,s}\hat{w}_o}{\hat{t}_{o,s}} Z_{o,s}}{\sum_s Z_{o,s}}$$

▸ main

The equilibrium conditions in changes

Labour market clearing:

$$1 = \psi_o \left(\frac{\sum_s \hat{M}_{o,s} \hat{R}_{o,s} \frac{(\sigma_s - 1)(\theta_s - \alpha_s + 1)}{\sigma_s \theta_s} + \frac{1}{\hat{w}_o} \eta'_{os}}{\sum_s R_{o,s} \frac{(\sigma_s - 1)(\theta_s - \alpha_s + 1)}{\sigma_s \theta_s} + \eta_{o,s}} \right)$$

Free entry:

$$\hat{w}_o = \sum_d \frac{\zeta_{od,s} \left(\frac{\hat{w}_o}{\hat{b}_{o,s}} \right)^{-\theta_s} \left(\hat{\tau}_{od,s} \right)^{-\frac{\theta_s}{1-\alpha_s}} \left(\hat{f}_{od,s} \right)^{1 - \frac{\theta_s}{(\sigma_s - 1)(1-\alpha_s)}} \left(\hat{t}_{o,s} \right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}}}{\sum_i \lambda_{id,s} \hat{M}^e_{i,s} \left(\frac{\hat{w}_o}{\hat{b}_{o,s}} \right)^{-\theta_s} \left(\hat{\tau}_{od,s} \right)^{-\frac{\theta_s}{1-\alpha_s}} \left(\hat{f}_{od,s} \right)^{1 - \frac{\theta_s}{(\sigma_s - 1)(1-\alpha_s)}} \left(\hat{t}_{o,s} \right)^{-\frac{\alpha_s \theta_s}{1-\alpha_s}}} \hat{\beta}_{d,s} \frac{R'_d - NX'_d}{R_d - NX_d}$$

▸ main

Competitiveness shocks

Definition of competitiveness shocks:

$$\hat{\Gamma}^*_{od,s} \equiv (1/\hat{b}_{o,s})^{-\theta_s} (\hat{\tau}_{od,s})^{-\frac{\theta_s}{1-\alpha_s}} (\hat{f}_{od,s})^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}$$

Measurement of competitiveness shocks:

$$\hat{\Gamma}^*_{od,s} = (\hat{t}_{o,s})^{\frac{\alpha_s\theta_s}{1-\alpha_s}} \frac{\hat{\lambda}_{od,s}}{\hat{M}^e_{o,s}\hat{w}_o^{-\theta_s}} (\hat{P}_{d,s})^{\frac{\theta_s}{1-\alpha_s}} \left(\frac{\hat{\beta}_{d,s}}{\hat{w}_d} \frac{R'_d - \hat{NX}_d NX_d}{R_d - NX_d} \right)^{1-\frac{\theta_s}{(\sigma_s-1)(1-\alpha_s)}}$$

▸ main

Parameter values

Table 1: Estimated parameter values

NACE 2 Code	θ_s	σ_s	α_s
10 to 12	2.102	2.512	0.020
13 to 15	7.124	4.442	0.019
16	6.442	4.767	0.038
17 and 18	16.871	10.270	0.058
19	0.797	1.767	0.009
20 and 21	2.605	3.101	0.041
22	5.483	4.323	0.024
23	6.841	4.563	0.078
24	8.187	7.396	0.063
25 to 28, 33	7.063	6.194	0.010
29 to 32	5.147	6.133	0.008

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Intermediate steps for parameter values

Table 2: Intermediate results for the parameter estimation

NACE 2 Code	Coefficient estimate for θ_s	markups	energy output elasticity	emissions elasticity
	(1)	(2)	(3)	(4)
10 to 12	-1.391	1.695	0.020	0.974
13 to 15	-2.065	1.319	0.019	1.002
16	-1.708	1.325	0.041	0.873
17 and 18	-1.825	1.170	0.058	0.962
19	-1.038	2.347	0.011	1.001
20 and 21	-1.239	1.538	0.041	0.993
22	-1.652	1.339	0.024	1.012
23	-1.924	1.395	0.078	0.946
24	-1.277	1.235	0.063	0.993
25 to 28, 33	-1.363	1.206	0.010	1.011
29 to 32	-0.936	1.203	0.008	1.001

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Getting from markups to the elasticity of demand

$$w_o L^p_{o,s} = (1 - \alpha_s)\frac{\sigma_s - 1}{\sigma_s} R_{o,s}$$

Measurement of $w_o L^p_{o,s}$:

materials and labour expenditures, plus 0.2 times the capital stock

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Getting from the energy to the emissions output elasticity

The output elasticity of emissions:

$$\frac{\partial q}{\partial z}\frac{z}{q} = \frac{\partial q}{\partial e} \times \frac{\partial e}{\partial z}\frac{z}{q} = \frac{\frac{\partial q}{\partial e}}{\frac{\partial z}{\partial e}}\frac{e}{q}\frac{z}{q}\frac{q}{e} = \frac{\frac{\partial q}{\partial e}\frac{e}{q}}{\frac{\partial z}{\partial e}\frac{e}{z}}$$

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Sector list

Table 3: Analysed NACE 2 sectors

NACE 2 Code	Description
10 to 12	Food, tobacco and beverages
13 to 15	Textiles, wearing apparel, fur, leather and footwear
16	Wood products (no furniture)
17 and 18	Paper, paper products, printing and publishing
19	Coke and petroleum
20 and 21	Chemicals, chemical products and pharmaceuticals
22	Rubber and plastic products
23	Non-metallic mineral products
24	Basic metals
25 to 28, 33	Fabricated metals, electronic products, electric equipment, engineering and installation of machinery
29 to 32	Vehicles, vehicle components, other transport, manufacturing n.e.c.

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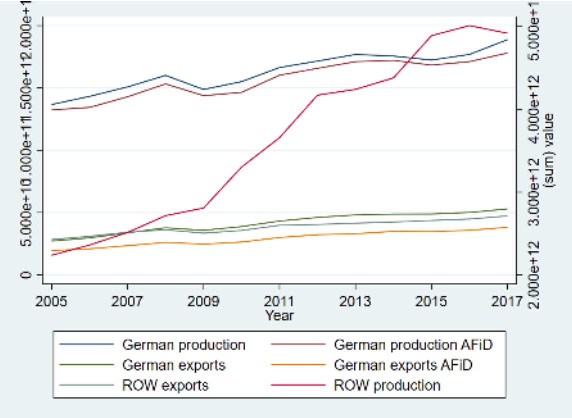
Trade and output data

What does this data look like: Example for food/beverages (sectors 10 and 11)



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Emissions data IEA versus AFiD

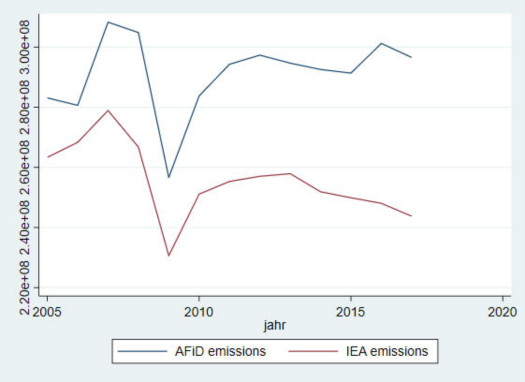


Figure 1: Aggregate emissions development in German manufacturing according to IEA and Manufacturing Census

▸ main

Emissions data IEA versus AFiD

Table 4: Percentage deviation between emissions from IEA and German manufacturing Census across sectors

NACE 2 Code	Average deviation	Median deviation
10 to 12	-0.033	-0.039
13 to 15	-0.055	-0.055
16	-0.032	-0.031
17 and 18	-0.011	-0.017
19	0.129	0.142
20 and 21	-0.060	-0.095
22	-0.038	-0.039
23	-0.074	-0.080
24	-0.318	-0.345
25 to 28, 33	-0.045	-0.037
29 to 32	-0.051	-0.055

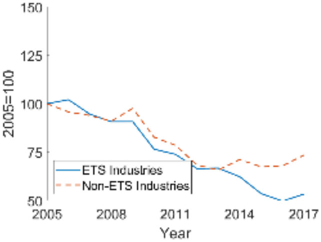
▸ main

Historical regulation shock

The stringency of regulation in Germany (IEA)

- ETS sectors: Paper, coke, chemicals, non-metallic mineral products, metals

The stringency of regulation in Germany (AFiD)



- Non-ETS sectors: Remaining sectors (food, textiles, furniture, cars, etc.)

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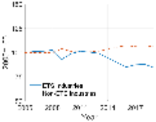
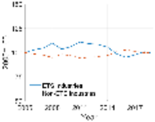
Historical expenditure share shocks

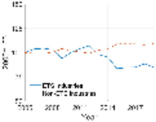
Germany:



ROW:



EU:



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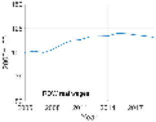
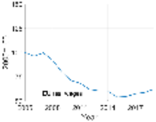
Results - Historical wages

Germany:

ROW:



EU:



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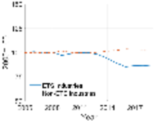
Germany:



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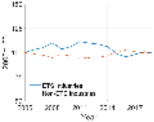
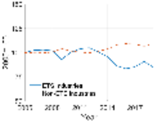


EU:



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Explaining the regulation shock

$$\hat{t}_{i,s,t} = \beta_f \hat{p}^{energy}_{i,s,t} + \beta_{ets} \hat{p}^{ets}_{i,s,t} + \mu_{i,t} + \epsilon_{i,s,t}$$

Table 5: Determinants for the development of implicit carbon prices

	$\hat{t}_{i,t,s}$ (1)	$\mu_{i,t}$ (2)
$\hat{p}^{energy}_{i,s,t}$	0.278***	
	(0.074)	
$\hat{p}^{ets}_{i,(s),t}$	-0.001	0.251***
	(0.015)	(0.022)
N	330	330
R^2	0.49	0.28

Notes: The regressions include observations from 2005–2019. Dependent variables are indexed and are 1 in 2005. The regression in (1) is run with country by year fixed effects. Standard errors are displayed in parentheses. *, ** and *** indicate significance at 10%, 5% and 1%, respectively.

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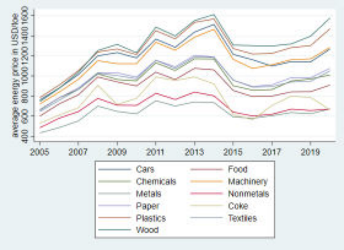
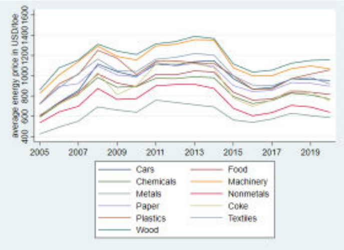
IEA energy prices

Germany:



EU:



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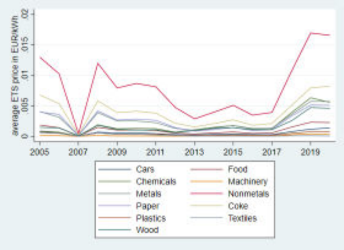
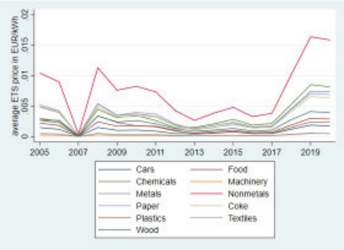
Effective carbon prices

Germany:



EU:



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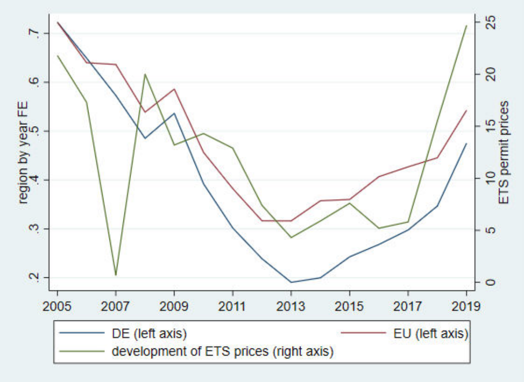
Explaining the regulation shock

The time-specific component of the regulation shock develops similarly in DE and the EU:



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Explaining the regulation shock II

Why would German and EU implicit carbon prices develop similarly?

- EU ETS
- Common command and control regulations such as LCP, E-PRTR

Why would German and EU implicit carbon prices develop differently?

- Different fuel prices
- Different implementation of regulation (e.g., NAPs under EU ETS)
- Additional regulation on the level of single countries (e.g., renewable energy surcharge, exemptions from paying it)

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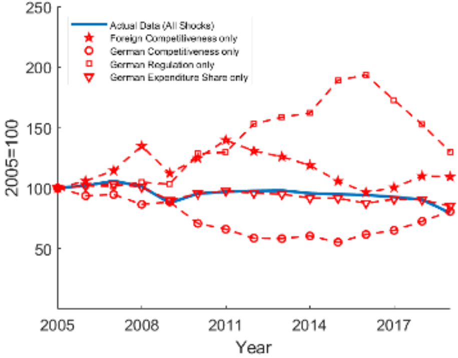
Decomposition: The relevance of different shocks

How would emissions have evolved in counterfactual scenarios, two world regions?



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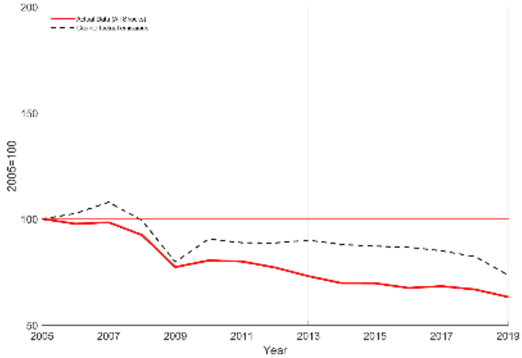
Counterfactual analysis: Equating carbon prices for Germany and the EU



For identical implicit carbon prices, German emissions would have increased

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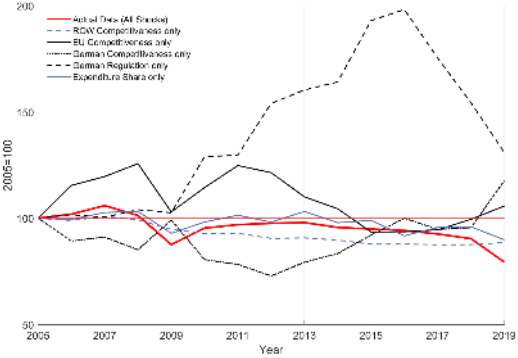
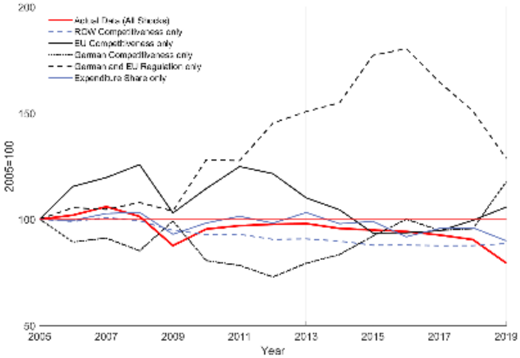
How would emissions have evolved in counterfactual scenarios?



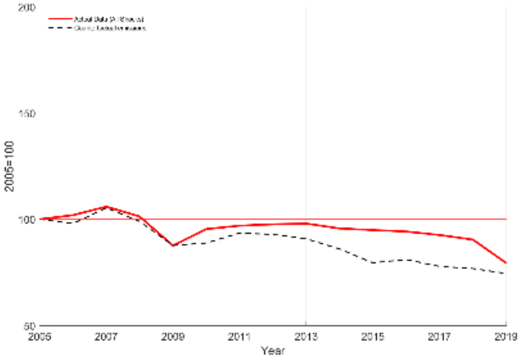
This is quite stylized: German emission prices in reality do not change independently from EU emission prices...

▸ Two world regions ▸ main

What about if we allow German and EU carbon prices to change simultaneously?



Counterfactual analysis: Equating carbon prices for Germany and the EU



For identical implicit carbon prices, the German metal sector would have grown less ‣ EU emissions