Emission Trading and Overlapping Environmental Support: Installation-level Evidence from the EU ETS

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Motivation

- EU Emissions Trading System (EU ETS) **creates carbon price**
  - Market for tradeable emission permits with progressively tightening cap on annual emissions of large emitters
  - Extensively studied (Fabra and Reguant, 2014; Calel and Dechezleprêtre, 2016; Calel, 2020; Abrell et al., 2022; Dechezleprêtre et al., 2023; Colmer et al., 2024)

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- Increasing number of environmental support policies at **national level**
  - Evidence on effects of some policies in isolation (Martin et al., 2014; Abrell and Kosch, 2022; Ferrara and Giua, 2022; Gerster and Lamp, 2024; Basaglia et al., 2024)

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- Interaction between EU ETS and overlapping national support understudied
  - Simulation-based evidence (Anke et al., 2020; Delarue and Van den Bergh, 2016; Bruninx et al., 2020)
  - This paper provides novel **empirical evidence**

Motivation

"In the first half of 2017, we decided to retrofit our hard coal-fired power plants Eemshaven and Amer 9 for co-firing with biomass. The Dutch state approved subsidies of up to €2.6 billion for the two plants."

RWE AG, annual report 2017

"The [Memorandum of Understanding] states the commitment of ArcelorMittal and the Government of Spain to transition towards a decarbonised steel industry. [...] The Government of Spain is exploring regulatory instruments to support the industry in the transition process, such as compensation programmes for electricity-intensive industries, tools to promote improved energy efficiency [...]."

ArcelorMittal, press release 13/07/2021

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  - renewable energy support for power producers: more than 260 billion EUR since 2012 (on average $\sim$ 30 EUR per tCO2)
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  - difference-in-differences exploiting variation in carbon price exposure
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  - high-exposed installations reduce emissions significantly after the shock ($\sim$ 40% for power producers, $\sim$ 4% for manufacturers)
- Estimate **interactions** of national environmental support with the EU ETS
  - triple difference exploiting variation in national environmental support
  - positive interaction: power producers in countries with high levels of renewable support reduce emissions significantly more (by $\sim$ 20 p.p.)
  - negative interaction: manufacturers in countries with high levels of cost compensation reduce emissions significantly less (by $\sim$ 6 p.p.)

Empirical Strategy

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- Unexpected regulatory tightening of the EU ETS in 2017 details

$$\text{Post}_t = \begin{cases} 1, & \text{if } t > 2016, \\ 0, & \text{else.} \end{cases} \tag{1}$$

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- Carbon price exposure depends on emission intensity details

$$\mathbb{1}^{\text{CPE}_i} = \begin{cases} 1, & \text{if emitter } i \text{ is high-exposed,} \\ 0, & \text{else.} \end{cases} \tag{2}$$

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- Variation in overlapping national support details

$$\mathbb{1}^{\alpha}_{cj} = \begin{cases} 1, & \text{if pre-shock support in country-industry } cj \text{ is high,} \\ 0, & \text{else.} \end{cases} \tag{3}$$

Empirical specification

- Difference-in-differences: the **effect of the carbon price shock**

$$\begin{aligned}\text{Emissions}_{it} = \beta_0 + X_{it} + \lambda_i + \tau_t + \epsilon_{it} \\ + \beta_1 \times \text{Post}_t \times \mathbb{1}^{\text{CPE}_i}\end{aligned} \tag{4}$$

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- Installation fixed effects λ_i and year fixed effects τ_t
  - Also account for time-varying heterogeneity at year-industry-activity (τ^1_{tja}), year-country (τ^2_{tc}), year-industry-activity-country (τ^3_{tjac})

Power producers and renwable energy support

Effect of the carbon price shock on power producers descriptives event study

	(1)	(2)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i}$	-0.516***	-0.674***
	(0.056)	(0.061)
Dependent variable	Emissions	Emissions
Fixed effects	λ_i, τ_t	λ_i, τ^2_{tc}
Energy price controls	Yes	Yes
Cluster variable	Installation	Installation
Clusters	832	831
Observations	9,114	9,102
Pseudo R^2	0.939	0.944
Estimator	Poisson QML	Poisson QML

Interactions with renewable energy support

descriptives | event study

	(1)	(2)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i}$	-0.364***	-0.517***
	(0.063)	(0.062)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i} \times \mathbb{1}^{\text{res}}_{cj}$	-0.393***	-0.341***
	(0.110)	(0.129)
Dependent variable	Emissions	Emissions
Fixed effects	λ_i, τ_t	λ_i, τ^2_{tc}
Energy price controls	Yes	Yes
Cluster variable	Installation	Installation
Clusters	832	831
Observations	9,114	9,102
Pseudo R^2	0.940	0.944
Estimator	Poisson QML	Poisson QML

Manufacturing and compensation for energy-intensive undertakings

The effect of the carbon price shock on manufacturing

descriptives | event study

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i}$	-0.032**	-0.032**	-0.035***	-0.035***
	(0.016)	(0.014)	(0.014)	(0.013)
Dependent variable	Emissions	Emissions	Emissions	Emissions
Fixed effects	λ_i, τ^1_{tja}	λ_i, τ^1_{tja}	λ_i, τ^3_{tjac}	λ_i, τ^3_{tjac}
Energy price controls	No	Yes	No	Yes
Cluster variable	Installation	Installation	Installation	Installation
Clusters	2,873	2,873	2,712	2,712
Observations	31,535	31,535	29,747	29,747
Pseudo R^2	0.988	0.988	0.990	0.990
Estimator	Poisson QML	Poisson QML	Poisson QML	Poisson QML

Compensation for energy-intensive undertakings

	(1)	(2)	(3)	(4)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i}$	-0.054**	-0.053***	-0.063***	-0.063***
	(0.021)	(0.019)	(0.020)	(0.018)
$\text{Post}_t \times \mathbb{1}^{\text{CPE}_i} \times \mathbb{1}^{\text{eiu}}_{cj}$	0.064**	0.060**	0.079***	0.079***
	(0.030)	(0.027)	(0.025)	(0.023)
Dependent variable	Emissions	Emissions	Emissions	Emissions
Fixed effects	λ_i, τ^1_{tja}	λ_i, τ^1_{tja}	λ_i, τ^3_{tjac}	λ_i, τ^3_{tjac}
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- **National environmental support** overlapping with the EU ETS is generous in aggregate and heterogneous across EU member states
- We find **significant interactions** between the EU ETS and national support
  - positive interaction with renewable energy support for power producers
  - negative interaction with cost compensation for energy-intensive industries
- Currently investigating **underlying mechanisms**
  - changes in output (e.g, partial cessations or capacity extensions)
  - retrofits of installations (e.g., biomass co-firing)
  - investments in new installations (e.g., electric arc furnaces)

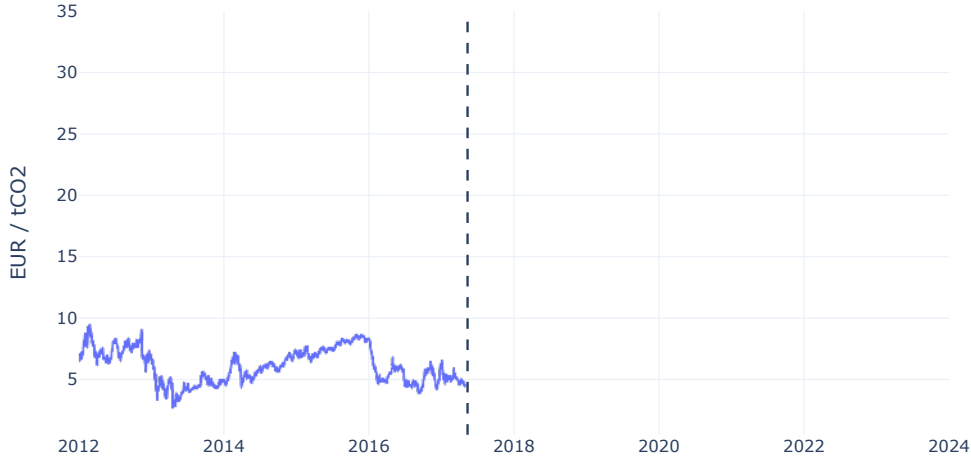
Thanks!

Draft available here.

Appendix

Regulatory tightening of the EU ETS

back



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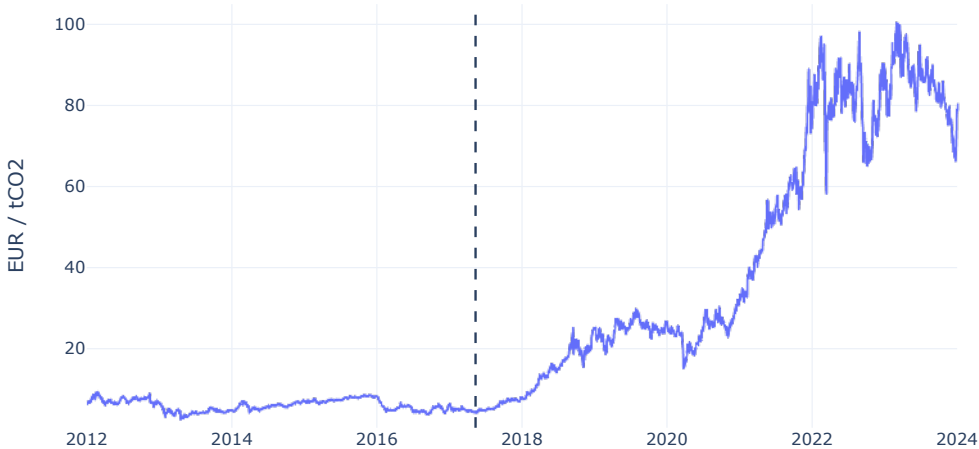
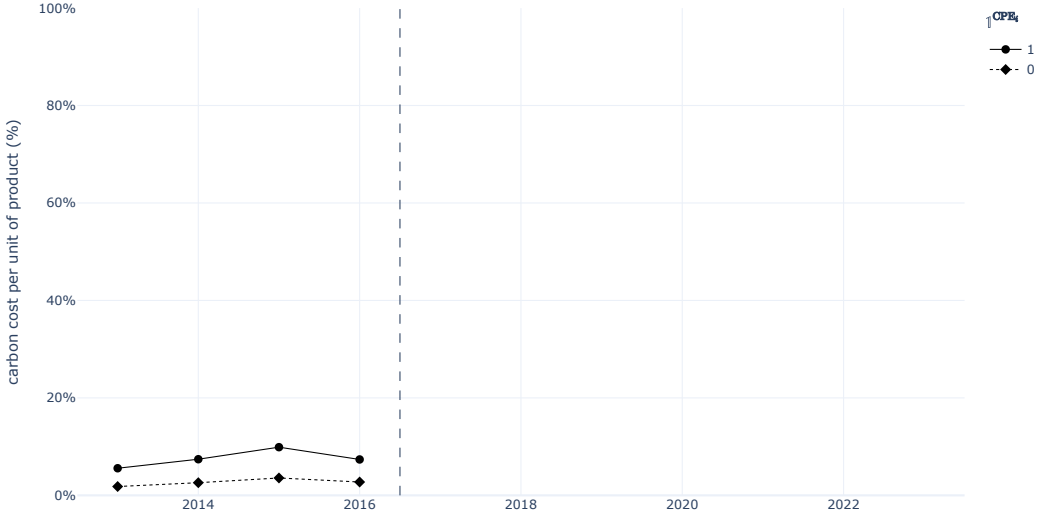
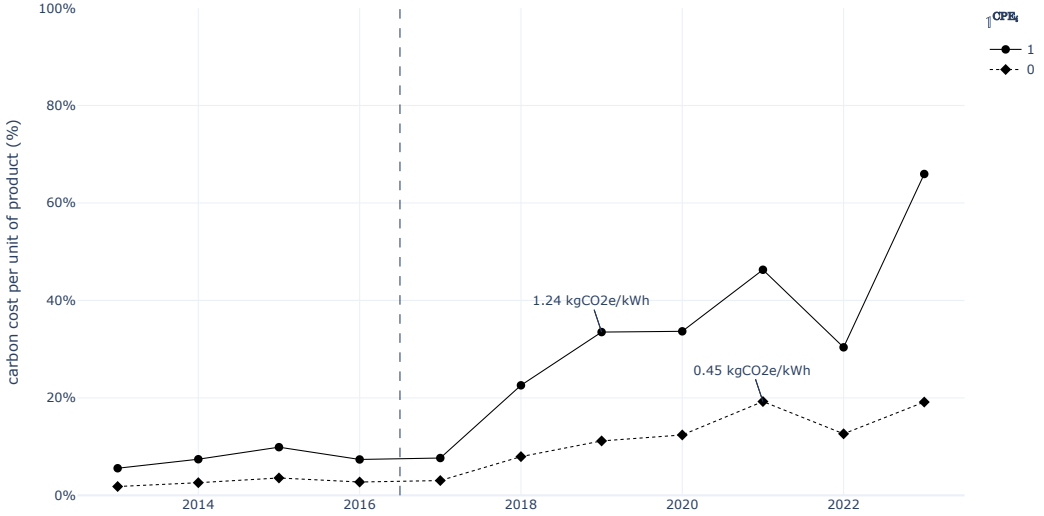


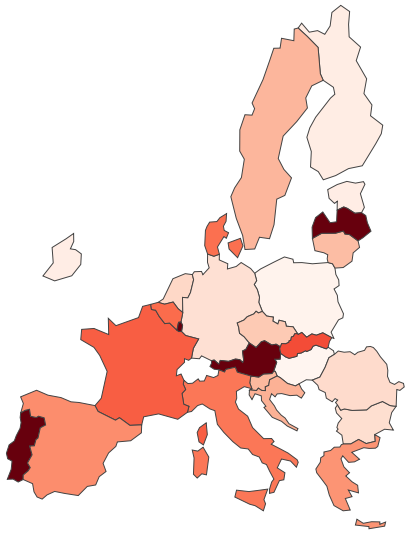
Carbon price exposure back

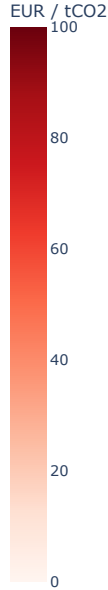


Carbon price exposure back

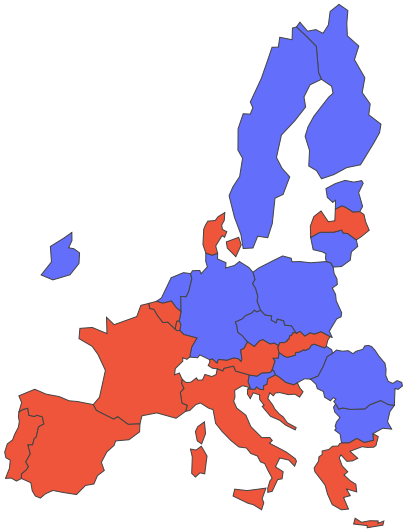


Renewable energy support back

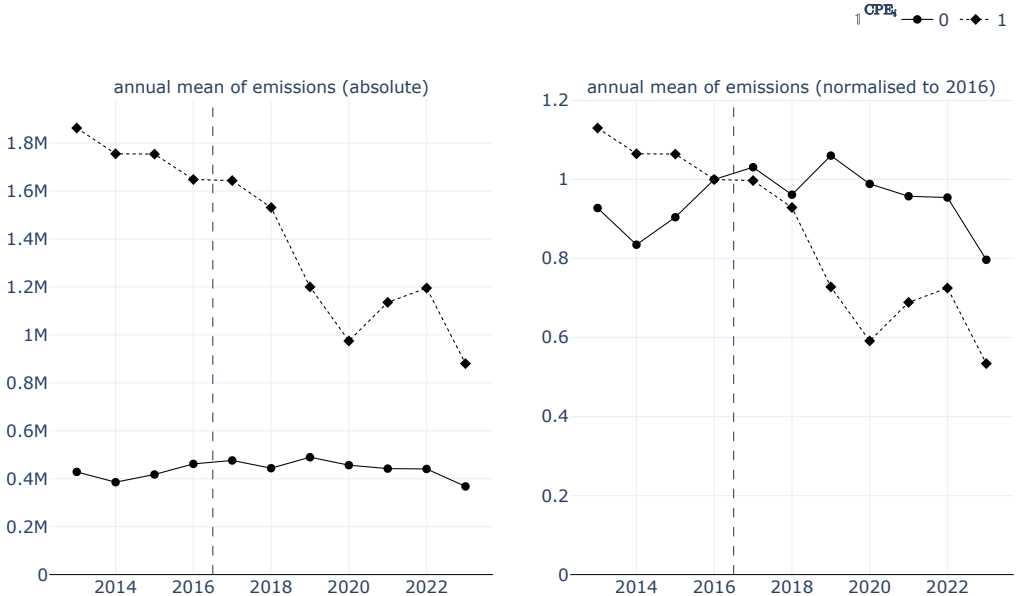




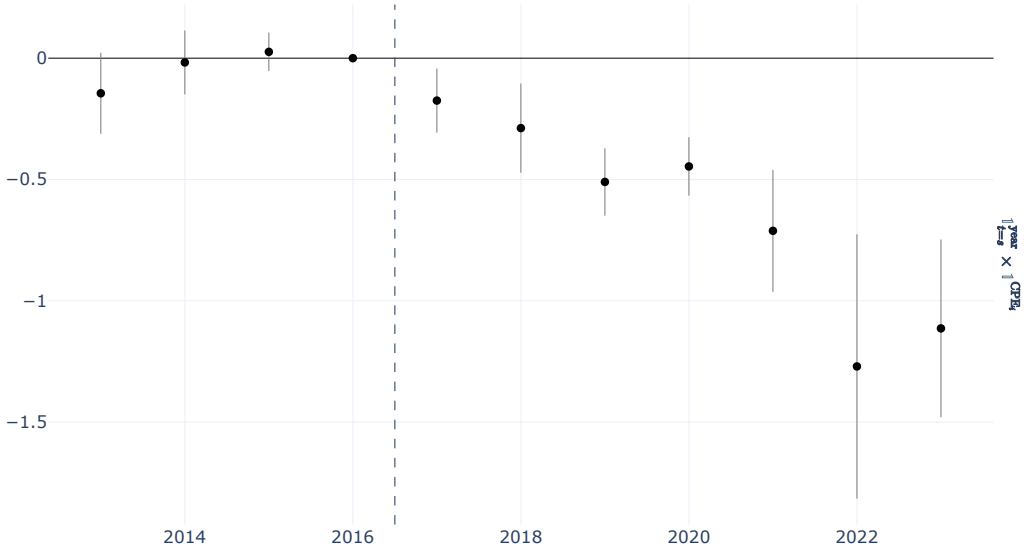
Renewable energy support back



Power baseline back

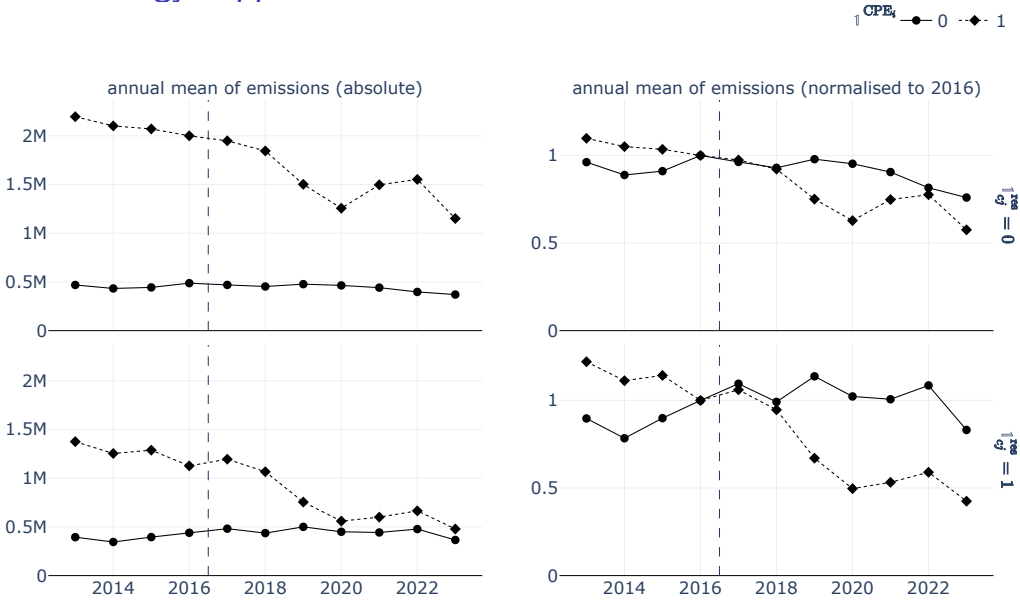


Power baseline back

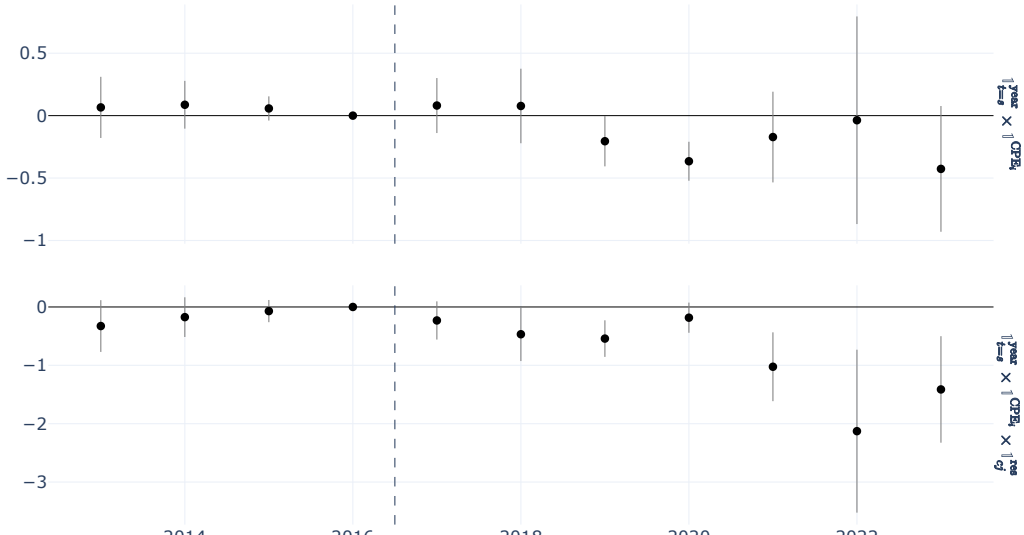


Renewable energy support

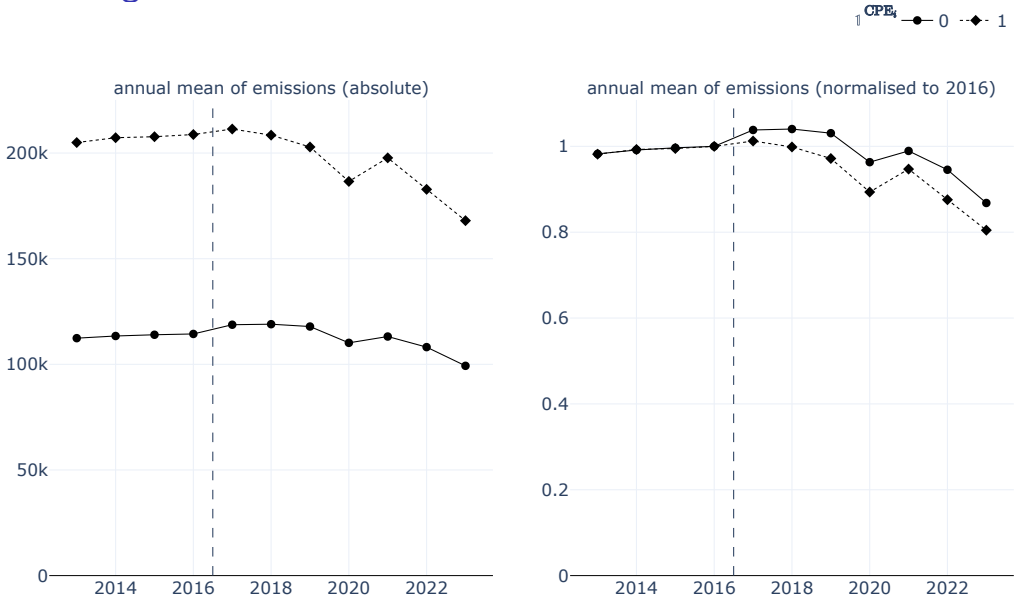
back



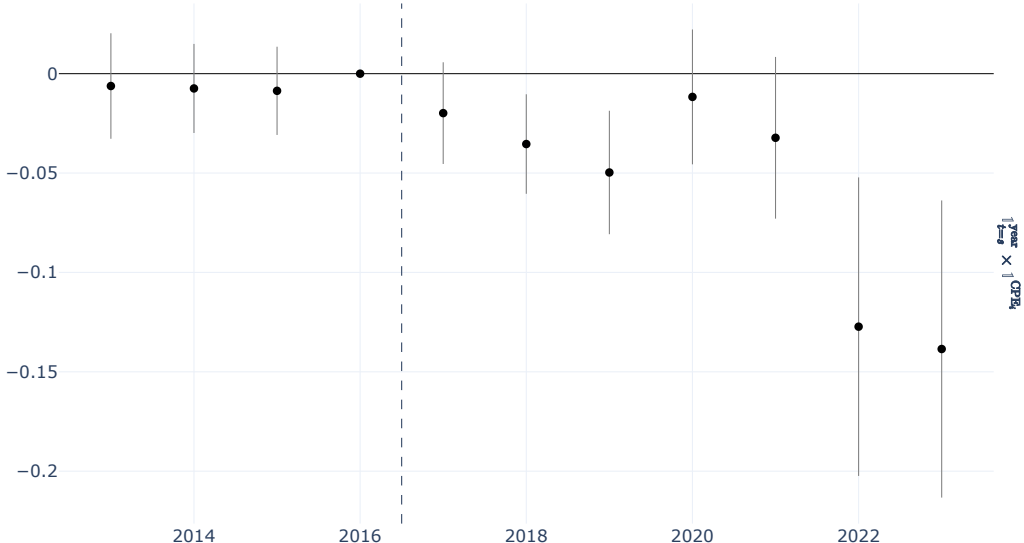
Renewable energy support back



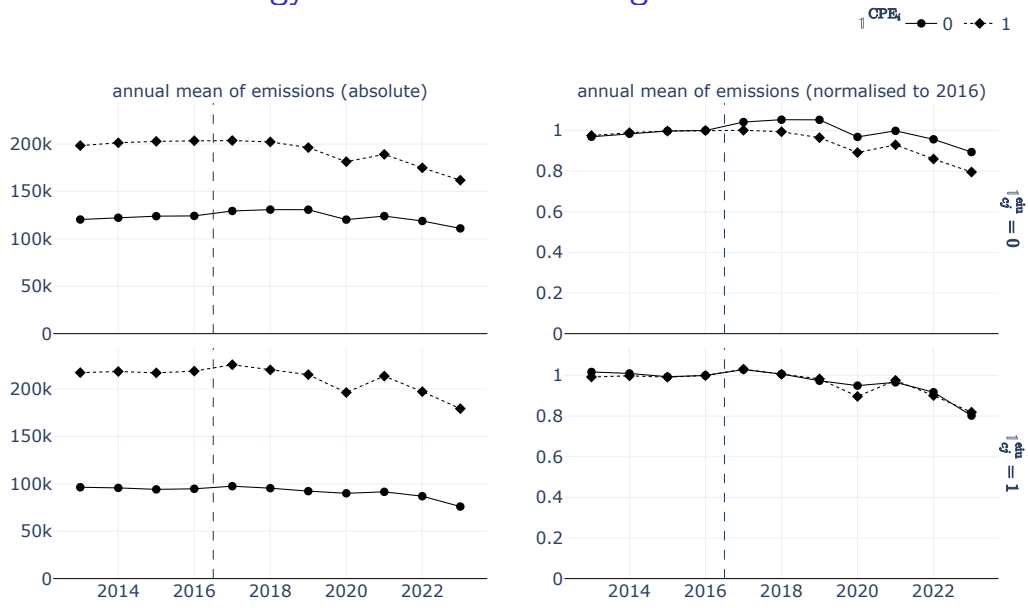
Manufacturing baseline back



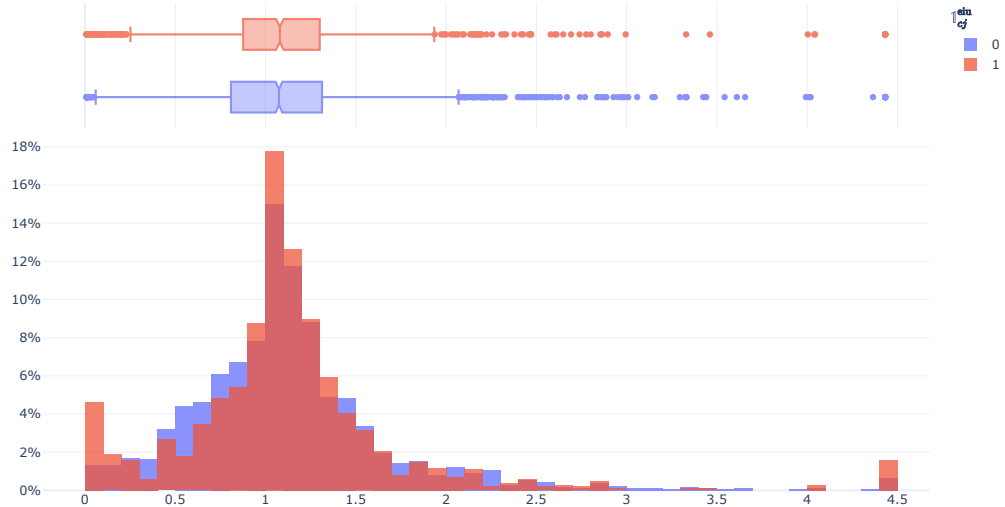
Manufacturing baseline back



Compensation for energy-intensive undertakings back



Carbon price exposure of manufacturing installations back



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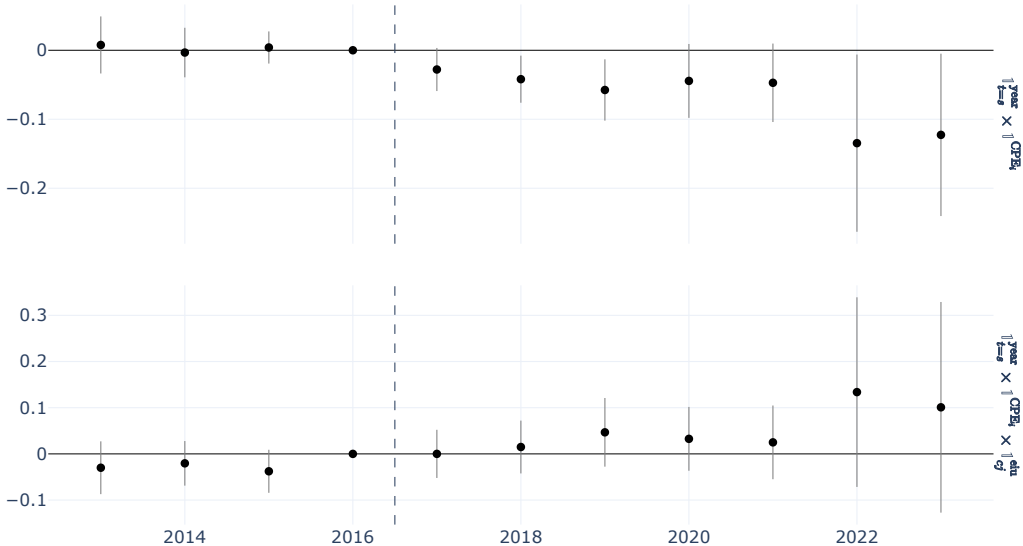

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