EUROPEAN CENTRAL BANK

EUROSYSTEM

Financing the low-carbon transition in Europe

Evidence from the EU ETS

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Margherita Giuzio

Olimpia Carradori, Sujit Kapadia, Dilyara Salakhova, Katia Vozian

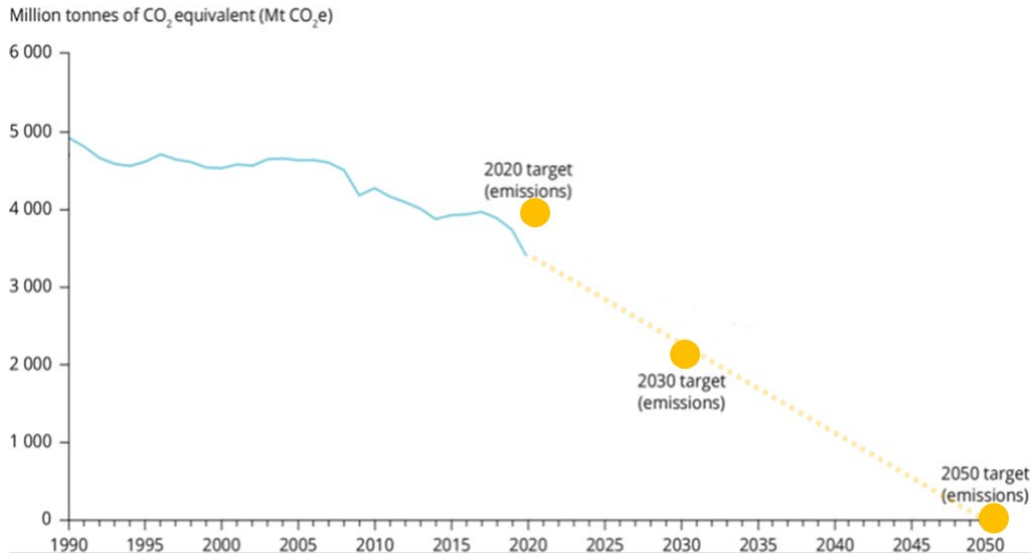
Motivation

1. The EU set the goal to reduce GHG emissions by **55% by 2030** and to reach **carbon neutrality by 2050**.

2. **Emissions Trading System** is the main driver of **emission reduction** in the EU.

3. **Financing** is central for **reducing emissions**. And debt is the primary source of firms’ external financing.

EU Greenhouse Gas historical emissions and targets



Source: European Environmental Agency and ECB adaptation

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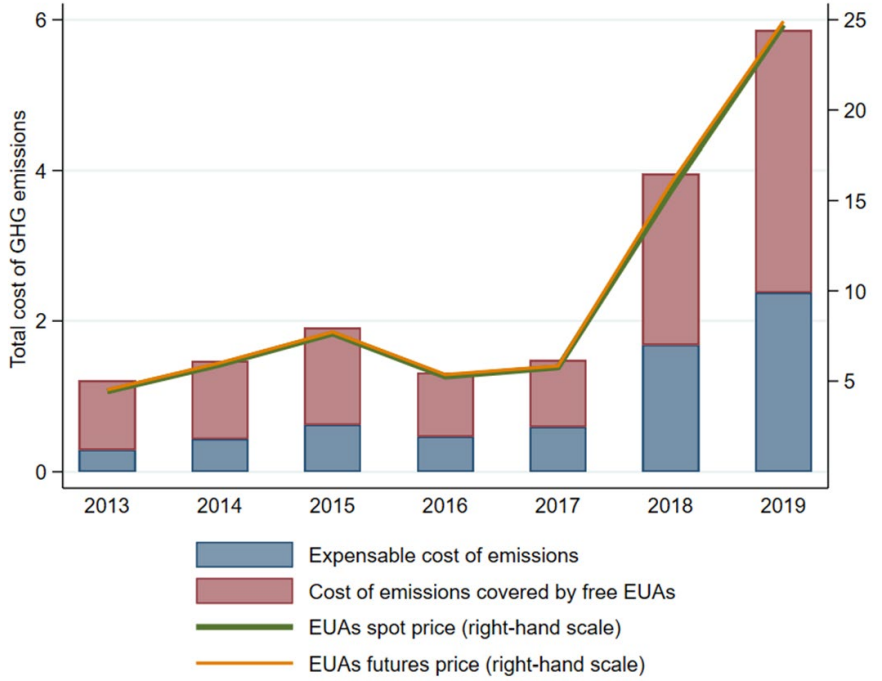
Cost of Greenhouse Gas emissions under the EU ETS Carbon Market



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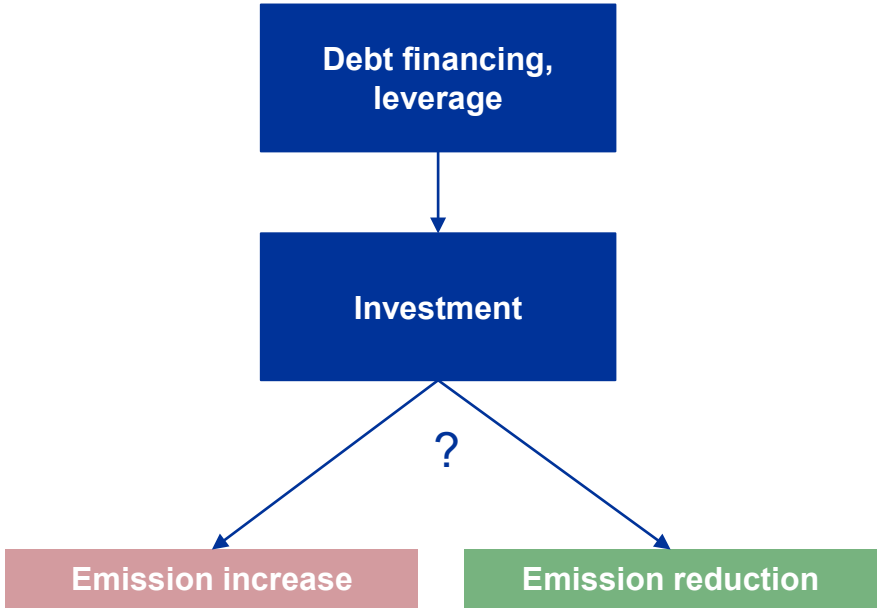


Research question and contribution

How does **debt finance** of corporate firms relate to their change in **ETS-emissions** in Europe?

Is there a significant relationship between firms’ capital structure, i.e., leverage, and ETS emissions?

Yes, high (an increase in) leverage is associated with low (a decrease in) ETS emissions, **but** only up to a certain level of leverage.

Do firms respond to a steep increase in allowances’ prices (EUAs) by reducing their emissions?
Do firms behave differently if they are highly indebted?

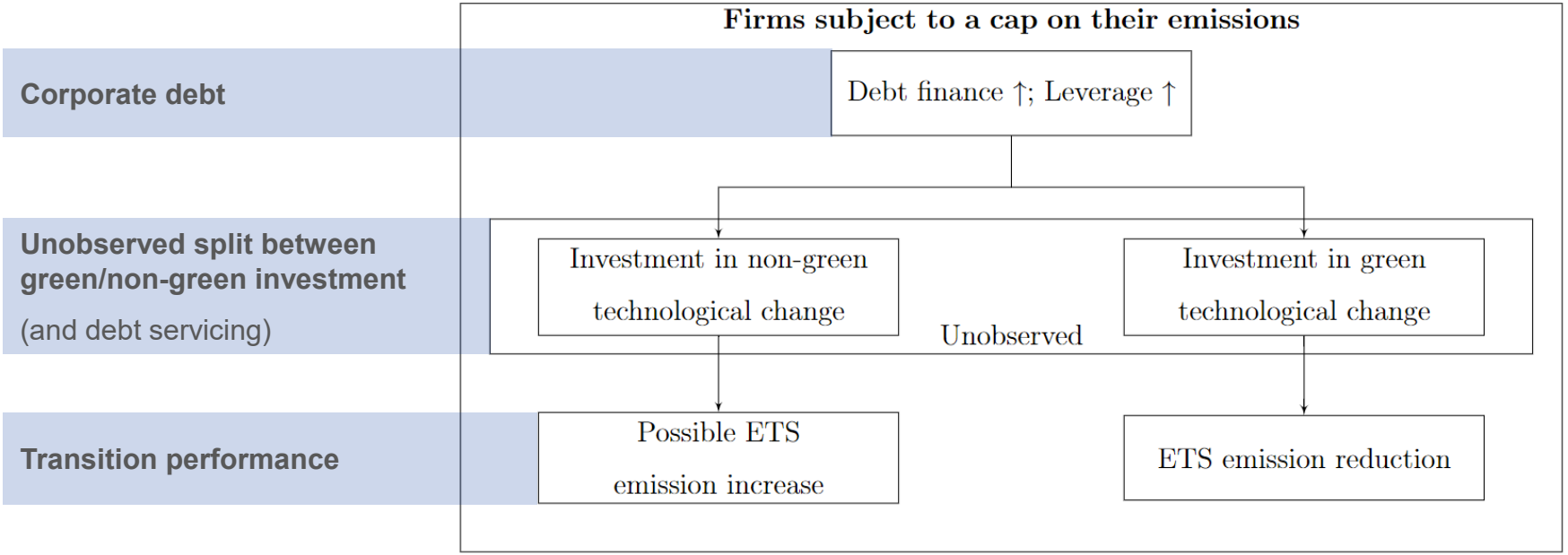
Yes, firms respond to higher EUA prices reducing their emissions, **unless** they are highly indebted and exposed to the rising price of EUAs.

Contribution: verified disclosed ETS emissions, debt financing and transition, non-listed firms, SMEs

1. Theoretical background and empirical strategy

Theoretical background and empirical predictions

Economic mechanism:
Corporate debt, **investment** and **low-carbon transition** of **firms** subject to a **cap** on their **emissions**

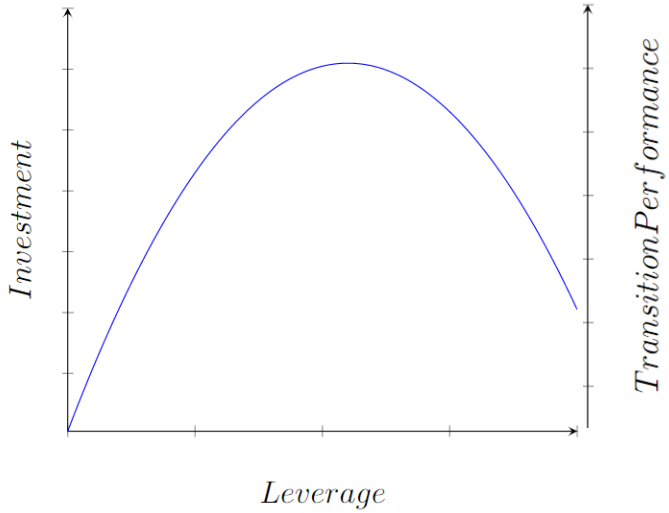


Theoretical background and empirical predictions

Theoretical background: **Corporate debt** and **investments** – two opposing forces

1 Corporate debt financing
↓
Tax advantages and reduced agency costs
↓
↑ **Investment**

2 Corporate indebtedness
↓
Higher interest expenses and difficulty to raise new external financing
↓
↓ **Investment**



H1 High (rising) leverage
↓
H2 ↑ (improving) **transition performance, but** only up to a certain level of leverage

H3 There is a group of firms that are too indebted for the low-carbon transition.

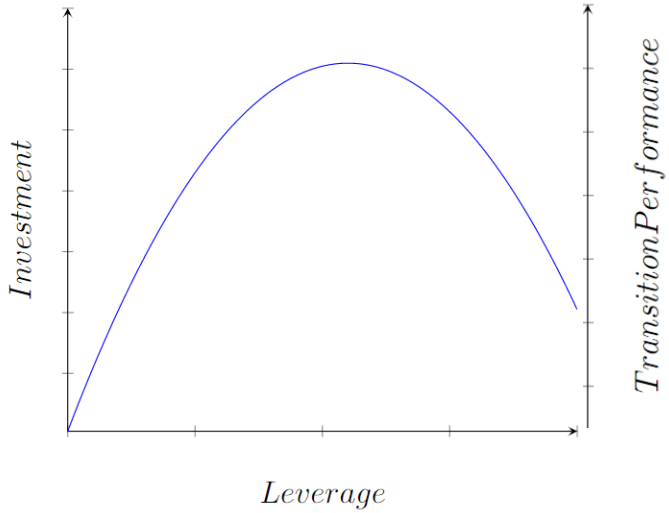
References: Modigliani and Miller, 1963; Ross, 1977; Grossman and Hart, 1982; Myers, 1977

Theoretical background and empirical predictions

Empirical prediction: Corporate debt and emissions

1 Corporate debt financing
↓
Tax advantages and reduced agency costs
↓
↑ **Investment**

2 Corporate indebtedness
↓
Higher interest expenses and difficulty to raise new external financing
↓
↓ **Investment**



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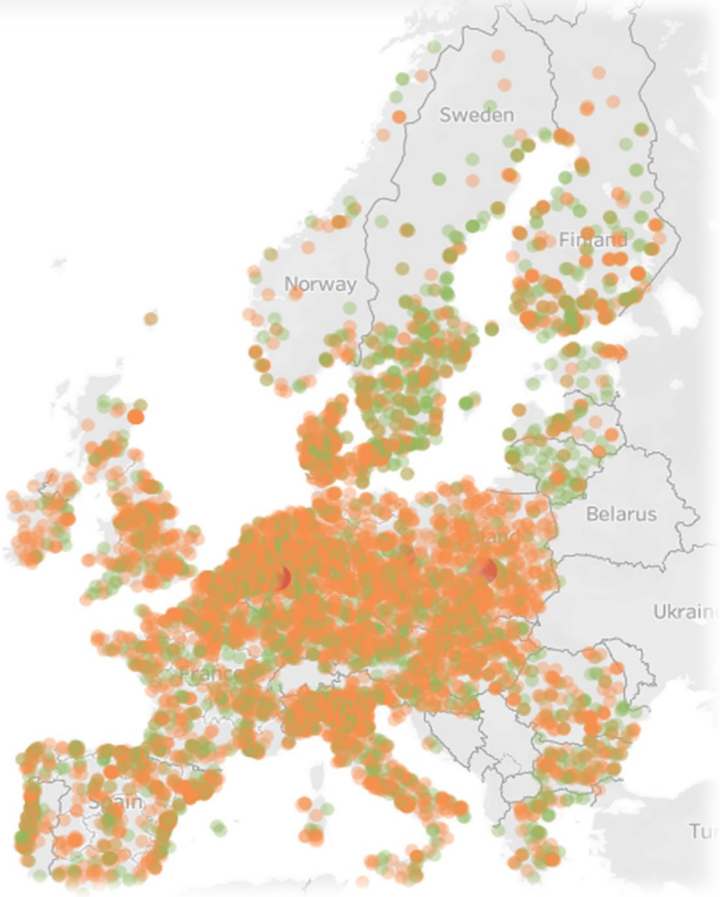
Novel dataset

- 3,724 NFCs (SMEs 40% + Large 60%) between 2013 - 2019
- **26% of EU emissions** (Fossil fuel intensive production in Europe based on oil, gas and coal)
- Sources: EUTL, Orbis, Bloomberg

Two **measures of transition performance**:

1. Change in emissions
2. Change in emission efficiency (i.e., revenues/emissions)

A reduction in emissions does not always lead to an increase in emission efficiency



EU ETS static installations in 2019

Empirical strategy

H1 Panel regressions with fixed effects estimation on levels

$$\text{Transition Performance}_{i,t} = \beta_1 leverage_{i,t-1} + \beta_2 leverage^2_{i,t-1} + \beta_n OtherDrivers + \rho SectorTimeFE_i + \sigma CountryFE_i + \epsilon_{i,t}$$

H2 Panel regressions with first differences estimation on changes with moderation

$$\Delta TransitionPerformance_{i,t} = \beta_1 \Delta leverage_{i,t-1} X IndebtednessThreshold_{i,t-1} + \beta_n \Delta OtherDrivers_{i,t} + \tau TimeFE_i + \epsilon_{i,t}$$

H3 Difference-in-differences analysis on firms' transition performance

$$\Delta Emissions_{i,t} = \alpha + \beta_1 treatment X postevent + \beta_2 treatment + \beta_3 postevent + \beta_4' \Delta OtherDrivers + \epsilon_{i,t}$$

Using both a 1 and a 3-years lag.

+ endogeneity and robustness tests

2. Baseline results

H1: leverage and transition performance

$$TransitionPerformance_{i,t} = \alpha + \beta_1 debttoassets_{i,t-1} + \beta_2 debttoassets^2_{i,t-1} + \beta_3' X_{i,t-1} + \epsilon_{i,t}$$

- There is a **non-linear** relationship between leverage and transition performance
- **Higher leverage** is associated with **higher (lower) transition performance** if the initial leverage is **below (above) ~50%**

$$threshold = \frac{-\beta_1}{2\beta_2}$$

Firm-level emissions change little over time, but they vary substantially across firms. Henceforth, we will focus on the results in columns (1) and (2).

VARIABLES	(1) ln(Emissions)	(2) ln(Rev./Em.)	(3) ln(Emissions)	(4) ln(Rev./Em.)
Debt-to-assets	-1.39***	2.60***	-0.053	1.15***
	(0.32)	(0.36)	(0.12)	(0.28)
(Debt-to-assets)^2	1.26***	-2.86***	0.10	-0.98***
	(0.48)	(0.50)	(0.20)	(0.37)
ln(Revenues)	0.31***		0.029***	
	(0.039)		(0.0081)	
ROA	-0.00041	0.016***	0.0019**	0.0060***
	(0.0021)	(0.0028)	(0.00081)	(0.0020)
Age	0.0018	0.0041***		
	(0.0011)	(0.0012)		
Installations	0.19***	-0.039**	0.13***	-0.038
	(0.023)	(0.016)	(0.023)	(0.037)
EUA balance cumul.	-0.073**	0.035*	-0.0080***	0.0087***
	(0.036)	(0.018)	(0.0022)	(0.0032)
Carbon tax flag	0.0049	0.096	0.023	0.17**
	(0.043)	(0.089)	(0.026)	(0.086)
Fossil fuel subsidies	6.81**	-12.0**	2.50*	-14.0***
	(2.72)	(5.02)	(1.51)	(4.46)
Constant	4.12***	7.64***	9.31***	7.91***
	(0.67)	(0.14)	(0.15)	(0.12)
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	N	N
Firm FE	N	N	Y	Y
Observations	20,903	20,903	20,663	20,663
R-squared	0.393	0.310	0.964	0.847

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Results are robust when we use a 3 rather than a 1-year lag.

H1: leverage and transition performance

$$TransitionPerformance_{i,t} = \alpha + \beta_1 debttoassets_{i,t-1} + \beta_2 debttoassets^2_{i,t-1} + \beta_3' X_{i,t-1} + \epsilon_{i,t}$$

Among other drivers of transition performance:

- ↑ revenues are associated with ↑ emissions
- ↑ profitability is associated with ↑ emission efficiency
- ↑ number of installations is associated with ↓ transition performance
- ↑ EUA balance is associated with ↑ transition performance
- ↑ fossil fuel subsidies are associated with ↓ transition performance

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Country FE	Y	Y	N	N
Firm FE	N	N	Y	Y
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Results are qualitatively unchanged when we use a 3 rather than a 1-year lag.

H2: Δleverage and Δtransition performance conditional on leverage level

$$\Delta TransitionPerformance_{i,t} = \alpha + \beta_1 \Delta debttoassets_{i,t-1} X threshold_{i,t-1} +$$

$$\beta_2 \Delta debttoassets_{i,t-1} + \beta_3 threshold_{i,t-1} + \beta_4' \Delta X_{i,t-1} + \epsilon_{i,t}$$

- When leverage is already **above 50%, a further increase** is associated with a **worse transition performance.**
- An increase in leverage is associated with an **improvement in emission efficiency** when leverage is **below 50%.**

VARIABLES	(1) fdln(Em.)	(2) fdln(Rev./Em.)	(3) fdln(Em.)	(4) fdln(Rev./Em.)
d(Leverage > 50%) X fd(Debt-to-assets)	0.17**	-0.21*		
	(0.085)	(0.12)		
d(Leverage ≤ 50%) X fd(Debt-to-assets)	-0.068	0.19***		
	(0.043)	(0.062)		
d(Leverage > 50%)	-0.018	0.0089		
	(0.016)	(0.018)		
d(Leverage ≥ 75%) X fd(Debt-to-assets)			0.26**	-0.13
			(0.13)	(0.23)
d(Leverage ≤ 25%) X fd(Debt-to-assets)			-0.11**	0.22***
			(0.054)	(0.082)
d(Leverage ≥ 75%)			-0.028	0.023
			(0.037)	(0.044)
Controls	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Observations	17,056	17,056	12,443	12,443
R-squared	0.022	0.006	0.027	0.007

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Economic magnitude

1 Leverage below 50%

Increase by 1-STD of leverage changes

↓

-5% emissions in the following year

+9% emission efficiency in the following year

By comparison: **-2%** avg. yearly reduction ETS emissions cap

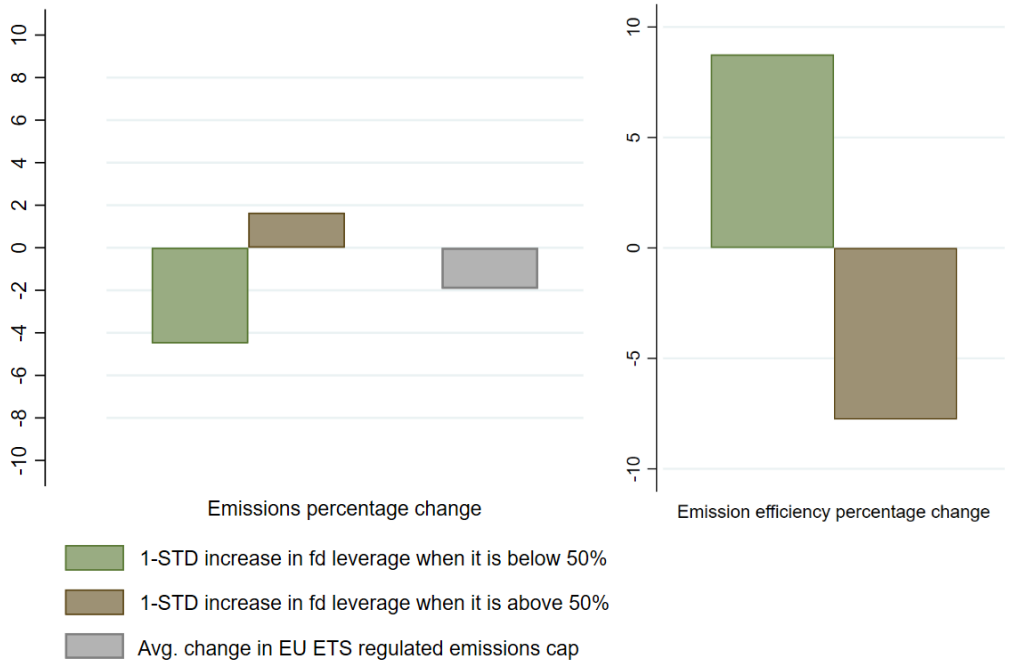
2 Leverage above 50%

Increase by 1-STD of leverage changes

↓

+2% emissions in the following year

-8% emission efficiency in the following year



3. Difference-in-differences result

H3: difference-in-differences design

EUAs price starts growing significantly in 2018:

- March 2018: introduction of the EU ETS Directive that sets the ground for phase 4 of the ETS.

H3 While the increased price of EUAs creates a pressure on firms' emission reduction efforts, **highly leveraged firms exposed to such rising price** are **unable to reduce their emissions**. Instead, **other firms successfully do so**.

Directive (EU) 2018/410 of the European Parliament and of the Council of 14-03-2018

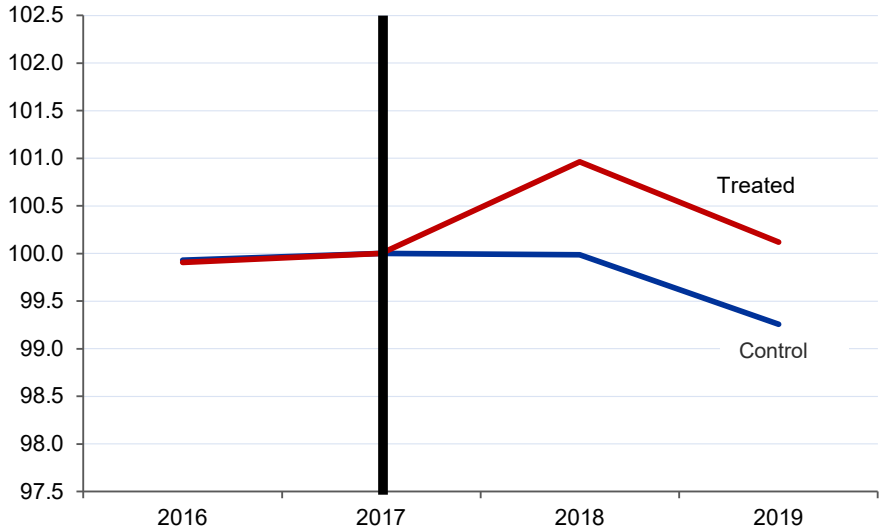
H3: difference-in-differences design

$$TransitionPerformance_{i,t} = \alpha + \beta_0 Treatment_i \times PostEvent_t + \Sigma_{j=1}^{N} \gamma_j Controls_{j,i,t} + FE_t + \epsilon_{i,t}$$

- *TransitionPerformance*: emission levels.
- *Treatment*: dummy equal to 1 for firms with a leverage above 50%, i.e. the firms has high debt, and if EUA balance is negative, i.e., the firm has emissions in excess of its EUAs **in the year prior the event (2017),** dummy equal to 0 for other firms.
- *PostEvent*: dummy equal to 0 in year before which the EUAs price has spiked (2016, 2017) and 1 in the years in and after the event (2018, 2019).

H3: difference-in-differences results

Firms that are subject to the introduction of the EU ETS Directive reduce their emissions on average, unless they are highly indebted and exposed to rising EUA prices given their negative EUA balance (treated).



On average emissions decreased over time in control firms, while they increased slightly in treated firms relative to 2017.

VARIABLES	(1) ln(Emissions)	(2) ln(Emissions)	(3) ln(Emissions)
D1(Treated) X Post	0.094*		
	(0.054)		
D2(Treated) X Post		0.082*	
		(0.047)	
D3(Treated) X Post			0.21**
			(0.10)
Controls	Y	Y	Y
Sector-year FE	Y	Y	Y
Country FE	Y	Y	Y
Firm FE	Y	Y	Y
Observations	10,464	6,904	4,912
R-squared	0.982	0.987	0.989

Difference-in-differences results for changes in emission following 2018.

4. Conclusion

Conclusion

How does debt finance of corporate firms relate to their change in ETS-emissions in Europe?

1. High leverage is associated with low emissions, but only up to a certain threshold of leverage.
2. An increase in leverage is associated with a decrease in emissions, but only up to a certain threshold of leverage.
3. On average, firms respond to higher EUA prices reducing their emissions, unless they are too indebted for the low-carbon transition

Policy relevance:

- Scope and role of EU ETS within the low-carbon transition
- Access to transition finance
- Debt as a driver of emission reduction and the importance of green debt for highly leveraged firms

Appendix

This paper's contribution

This paper: verified disclosed ETS emissions, debt financing and transition, non-listed firms, SMEs

Literature on green finance

The role of firms' financial structure, financing opportunities and constraints

- **Economies that are more equity-funded are greener** (De Haas and Popov, 2018)
- **Financial and managerial constraints are associated with worse transition performance** (De Haas et al., 2022; Xu and Kim, 2022; Barci et al., 2021)
- **Lower financial constraints are associated with more patents especially in industries related to clean energy and clean production** (Howell, 2017).

The role of debt in the low-carbon transition

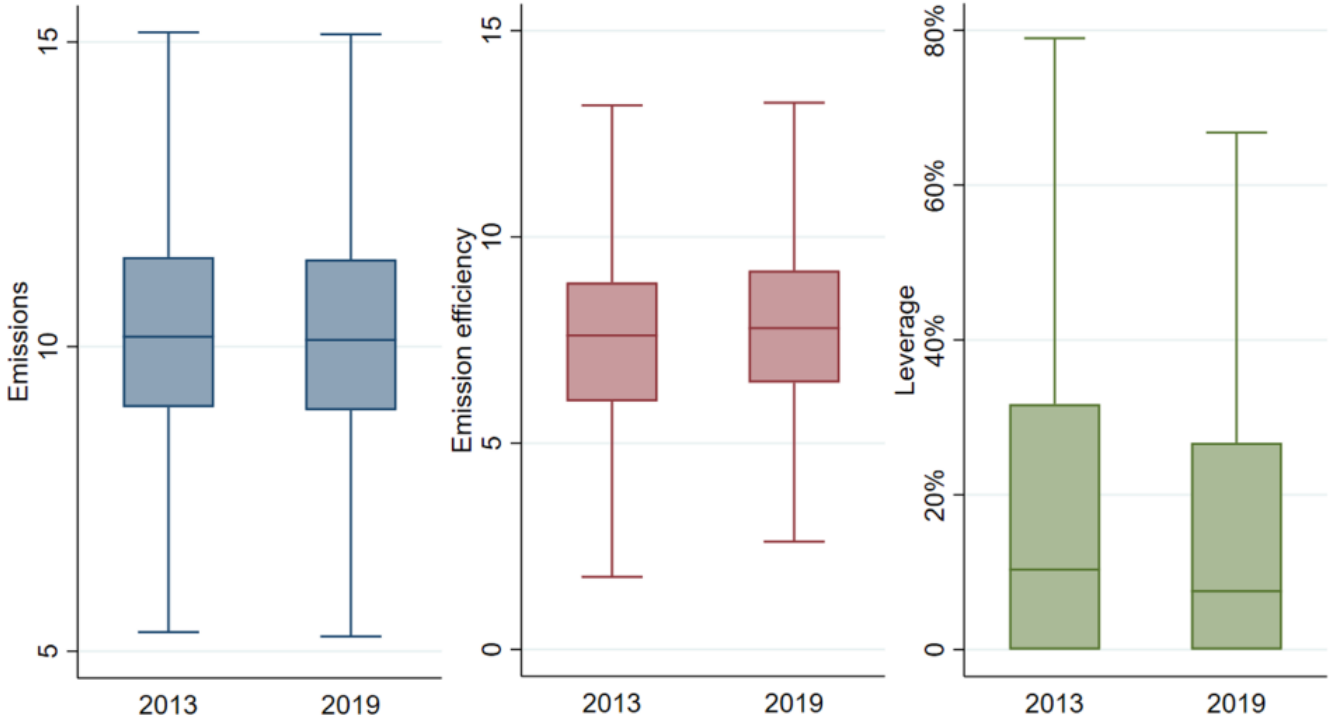
- **Debt finance and emissions**: mixed evidence (↓**Emissions:** Mésonnier, 2021; Ivanov et al., 2021; Kacperczyk and Peydró, 2021; Degryse et al., 2021; Maurin et al., 2021; ↑**Fossil fuels exposure**: Beyene et al., 2021)
- **Green bonds**: mixed evidence (↓**Emissions:** Flammer, 2021; Fatica and Panzica, 2021;↓ ↑ **Emissions:** Ehlers et al., 2020); **Green loans**: scarce evidence (↓ ↑ **Emissions:** Gilchrist et al., 2021)

EU ETS as a determinant of firms' transition performance

- **EU ETS had a negative effect on emissions** (Ellerman et al., 2020; Anderson and Di Maria, 2011; Petrick and Wagner, 2014; Ellerman and McGuinness, 2008; Wagner et al., 2013)
- **Carbon pricing is related to an uptick in green innovation** (Känzig, 2021; Martin et al., 2020; Martin et al., 2013; Calel and Dechezleprêtre, 2016; Borghesi et al., 2012).

Distribution of main variables of interest across time

- Stable emissions and rising emission efficiency across time.
- Decreasing debt-to-assets from 2013 to 2019.



Sample composition

Year	Obs.	Country	Obs.	Sector	Obs.
2013	2,761	France	2,850	B - Mining and quarrying	473
2014	3,153	Germany	1,732	C - Chemicals	2,014
2015	3,071	Poland	1,991	C - Food	1,634
2016	3,047	Spain	2,924	C - Metals	1,396
2017	3,020	Sweden	1,479	C - Non-metals	4,167
2018	3,022	Other	10,014	C - Paper	2,056
2019	2,916			C - Manufacturing other	2,756
				D - Electricity, gas, steam and air conditioning supply	5,735
				H - Transportation and storage	694
				Other	1645
Obs.	20,990	Obs.	20,990	Obs.	20,990
Firms	3,724	Firms	3,724	Firms	3,724

Additional analyses – Green debt

NFCs that have contracted green debt:

- Very limited number of firms active in the EU ETS, 18 in total, directly benefited from green debt.
- Only 37 firms might have benefited from it through their consolidated group structure.

	Green Bonds	Green Loans	Green Debt
NFCs in EU ETS with direct contraction of green debt	11	9	18
NFCs in EU ETS with possible indirect contraction of green debt	23	20	37
NFCs in Europe	162	636	739
NFCs in the World	506	1767	2238

Additional analyses – Listed vs. non-listed firms

Differential effect for the non-linear relationship between leverage and emissions performance:

Listed vs. non-listed firms

- The **non-linear** effect between leverage and transition performance is driven by **unlisted firms**.
- Approx. 96% of our EU ETS active firms are non-listed, the sample is also representative for the European economy.

VARIABLES	(1) Listed ln(Emissions)	(2) Non-listed ln(Emissions)	(3) Listed ln(Rev./Em.)	(4) Non-listed ln(Rev./Em.)
Debt-to-assets	0.71	-1.45***	1.23	2.61***
	(1.76)	(0.33)	(1.94)	(0.37)
$Debt-to-assets^2$	-2.72	1.39***	0.78	-2.92***
	(3.12)	(0.48)	(3.45)	(0.51)
Constant	3.94	4.20***	8.46***	7.65***
	(2.52)	(0.69)	(0.51)	(0.14)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Observations	813	20,060	813	20,060
R-squared	0.755	0.384	0.653	0.309

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Robustness test – firms that are not on carbon leakage list

Firms might use debt to finance emission reduction through regulatory arbitrage (e.g., they might shift production outside the EU ETS).

Currently available empirical research has not been able to find proof of carbon leakage associated with the EU ETS.

The non-linear relationship between leverage and emissions is significant for firms that are not deemed to be at risk of carbon-leakage.

VARIABLES	(1) On carbon leakage list ln(Emissions)	(2) Not on list ln(Emissions)	(3) On list ln(Rev./Em.)	(4) Not on list ln(Rev./Em.)
Debt-to-assets	-1.15***	-1.26***	1.92***	2.80***
	(0.38)	(0.41)	(0.41)	(0.49)
Debt-to-assets^2	0.98*	1.15*	-1.85***	-3.27***
	(0.56)	(0.60)	(0.57)	(0.66)
Constant	3.75***	4.48***	6.84***	8.03***
	(0.88)	(0.85)	(0.16)	(0.25)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Observations	9,083	11,795	9,083	11,795
R-squared	0.421	0.401	0.325	0.329

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 12: Difference-in-differences for firms that are not on the carbon leakage list

Notes: The table shows the result of the difference-in-differences regression. The analysis is performed on a sample covering the years 2016 to 2019. Column (1) shows results for the sub-sample of firms that are on the carbon leakage list, while column (2) shows results for the sub-sample of firms that are not on the carbon leakage list. Standard errors are indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

VARIABLES	(1) On carbon leakage list ln(Emissions)	(2) Not on list ln(Emissions)	(3) On carbon leakage list ln(Rev./Em.)	(4) Not on list ln(Rev./Em.)
D3(Treated) X Post	0.039	0.21**	-0.16**	-0.23
	(0.044)	(0.091)	(0.066)	(0.17)
Controls	Y	Y	Y	Y
Sector-year FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Observations	1,824	3,068	1,824	3,068
R-squared	0.991	0.988	0.983	0.882

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 16: Panel and first-differences regression for transition performance and leverage, from 2013 to 2019 using a 3-years lag

*Notes: In columns (1) and (2), the table shows the result of the panel regression relevant for H1. The relationship between transition performance and leverage is tested for the full data sample covering the period from 2013 to 2019. In columns (3) and (4), the table shows the result of the first-differences regression relevant for H2. The relationship between transition performance changes and leverage changes is tested for the full data sample covering the period from 2013 to 2019. Standard errors are indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10. All independent variables are lagged by one year (i.e., taken at time $t-3$, apart from $\ln(Revenues)$ which is taken at time t.*

VARIABLES	(1) ln(Emissions)	(2) ln(Rev./Em.)	(3) fdln(Emissions)	(4) fdln(Rev./Em.)
Debt-to-assets	-1.22***	2.16***		
	(0.33)	(0.36)		
(Debt-to-assets)^2	1.09**	-2.40***		
	(0.49)	(0.51)		
fdDebt-to-assets			0.023	0.30**
			(0.050)	(0.12)
d(Leverage>50%)			-0.032**	-0.040
			(0.015)	(0.033)
d(Leverage>50%) X fd(Debt-to-assets)			0.0017	-0.26
			(0.069)	(0.17)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y		
Country FE	Y	Y		
Time FE			Y	Y
Observations	19,103	19,103	15,831	15,831
R-squared	0.415	0.331	0.020	0.008

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 17: Regressions clustering errors at the corporate group level

Notes: The table shows the result of the panel regression relevant for H1 and H2 and the difference-in-differences regression relevant for H3. The treatment effect in the DiD model is equal to 1 for firms with leverage above 75% and negative EUA balance cumul., and 0 for firms with leverage below 25% and negative EUA balance cumul. Standard errors are clustered at the group level and indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10. D/A stands for debt-to-assets.

VARIABLES	(1) ln(Em.)	(2) ln(Rev./Em.)	(3) fdln(Em.)	(4) fdln(Rev./Em.)	(5) ln(Em.)	(6) ln(Rev./Em.)
D(Lev.<=25%) X fdD/A			-0.097*	0.21**		
			(0.055)	(0.084)		
D(Lev.>=75%)			-0.012	0.0071		
			(0.036)	(0.045)		
D(Lev.>=75%) X fdD/A			0.28**	-0.15		
			(0.14)	(0.23)		
D/A	-1.34***	2.60***				
	(0.34)	(0.43)				
$(D/A)^2$	1.13**	-2.86***				
	(0.50)	(0.54)				
D3(Treated) X Post					0.21**	-0.29*
					(0.10)	(0.16)
Controls	Y	Y	Y	Y	Y	Y
Time FE	N	N	Y	Y	N	N
Sector-time FE	Y	Y	N	N	Y	Y
Country FE	Y	Y	N	N	Y	Y
Firm FE	N	N	N	N	Y	Y
Observations	20,945	20,903	12,203	12,203	4,912	4,912
R-squared	0.391	0.310	0.023	0.007	0.989	0.902

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 18: Panel regression for transition performance and leverage, from 2013 to 2019 - Robustness test on sub-samples of firms excluding high-low emitters

Notes: The table shows the result of the panel regression relevant for H1. The relationship between transition performance and leverage is tested for the full data sample covering the period from 2013 to 2019. Standard errors are indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10. High emitters are firms with total verified emissions above 75% of the sample, while low emitters are firms with total verified emissions below 75% of the sample.

VARIABLES	(1) Excl. High Em. ln(Emissions)	(2) Excl. Low Em. ln(Emissions)	(3) Excl. High Em. ln(Rev./Em.)	(4) Excl. Low Em. ln(Rev./Em.)
Debt-to-assets	-0.79***	-1.15***	2.51***	2.62***
	(0.30)	(0.26)	(0.39)	(0.36)
$(\text{Debt-to-assets})^2$	0.47	1.45***	-2.65***	-3.10***
	(0.45)	(0.37)	(0.53)	(0.46)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Observations	16,010	15,377	16,031	15,377
R-squared	0.290	0.398	0.342	0.335

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 19: Panel regressions on sub-samples for large versus small and medium enterprises

Notes: The table shows the result of the fixed effects regression relevant for H1, pointing at the differential effect of leverage on transition performance for firms with different size. The relationship between transition performance and leverage is tested for the data sample covering the period from 2013 to 2019. Standard errors are indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

	(1)	(2)	(3)	(4)
	Large	SME	Large	SME
VARIABLES	ln(Emissions)	ln(Emissions)	ln(Rev./Em.)	ln(Rev./Em.)
Debt-to-assets	-0.90**	-1.54***	1.20***	3.62***
	(0.40)	(0.45)	(0.42)	(0.55)
$(\text{Debt-to-assets})^2$	0.92	1.13*	-1.61***	-3.76***
	(0.61)	(0.68)	(0.62)	(0.73)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Observations	12,688	8,121	12,688	8,121
R-squared	0.422	0.364	0.348	0.299

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Additional robustness test:

Table 20: Panel regressions on sub-samples for different sectors

Notes: The table shows the result of the fixed effect regression relevant for H1, pointing at the differential effect of leverage on transition performance in different sectors. The relationship between transition performance and leverage is tested for the data sample covering the period from 2013 to 2019. Standard errors are indicated in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

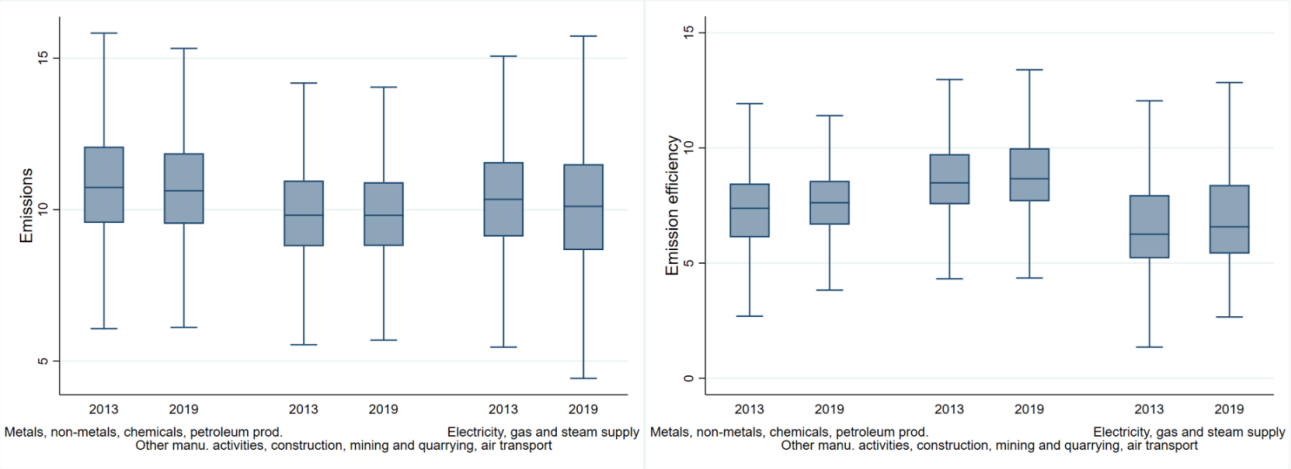
	(1)	(2)	(3)	(4)	(5)	(6)
		Metals	Other manu.		Metals	Other manu.
		Non-metals	Construction		Non-metals	Construction
		Chemicals	Mining		Chemicals	Mining
	Electr.	Petroleum prod.	Air transport	Electr.	Petroleum prod.	Air transport
VARIABLES	ln(Em.)	ln(Em.)	ln(Em.)	ln(Rev./Em.)	ln(Rev./Em.)	ln(Rev./Em.)
Debt-to-assets	-2.04***	-0.90**	-1.15**	2.96***	1.62***	2.51***
	(0.67)	(0.43)	(0.51)	(0.76)	(0.46)	(0.68)
Debt-to-assets^2	2.50**	1.11*	0.75	-3.76***	-1.77***	-2.96***
	(0.99)	(0.62)	(0.73)	(1.06)	(0.66)	(0.86)
Controls	Y	Y	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Observations	5,881	7,729	6,879	5,881	7,729	6,879
R-squared	0.449	0.484	0.398	0.294	0.293	0.264

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Transition performance across industries and time

Figure 9: Firm-level ETS emissions, emission efficiency across time and industry groups.

Notes: Emissions represent the natural logarithm of verified greenhouse gas emissions of firms, measured in CO2 equivalent tonnes. Emission efficiency is computed as the natural logarithm of the ratio of revenues on verified greenhouse gas emissions.



Leverage across industries and time

Figure 10: Firm-level leverage across time and industry groups.

Notes: Leverage is computed as debt-to-assets ratio.