



EUROPEAN CENTRAL BANK

EUROSYSTEM

Financing the low-carbon transition in Europe

Evidence from the EU ETS

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Disclaimer: The views expressed are those of the authors only and do not necessarily reflect the views of the European Central Bank or the Eurosystem.

Motivation

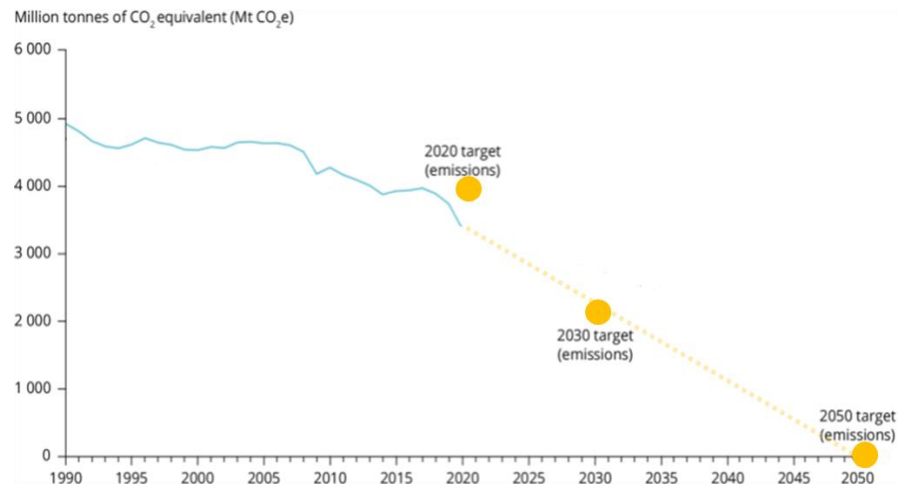
Financing the low-carbon transition in Europe – evidence from the EU ETS

1 **Financing** is central for **reducing emissions** (European Green Deal).

2 In the EU **debt finance** is the primary source of NFCs' **external financing**.

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

EU Greenhouse Gas historical emissions and targets



Source: European Environmental Agency and ECB adaptation

Research question

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 leverage is associated with low ETS emissions **but** only up to a certain level of leverage.

Is there a significant relationship between firms' increase in leverage and change in ETS emissions?

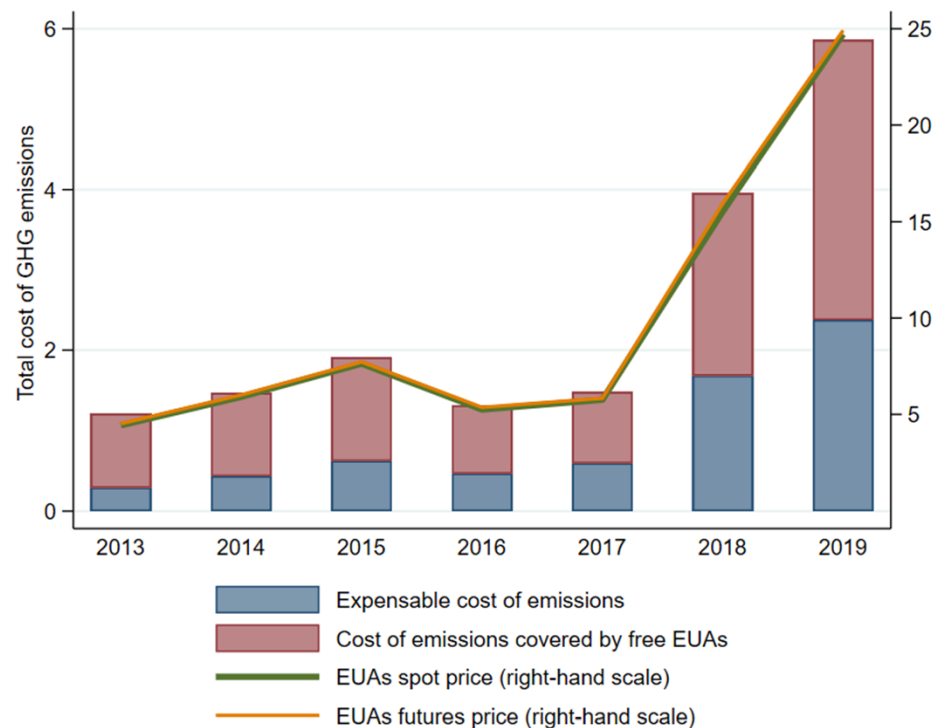
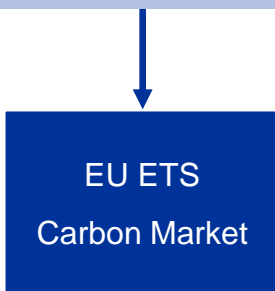


Yes, an increase in leverage is associated with a decrease in ETS emissions in the following years, **but** only up to a certain level of initial leverage.

EU ETS – Some fundamentals

Two alternatives for regulating pollutants:

1. Carbon tax [price control]
2. Cap-and-trade [quantity control]



This paper's contribution

Literature on green finance

Capital structure
and emissions
(macro and micro)

Determinants of
firms' green
investment

Green debt
and emissions
(micro)

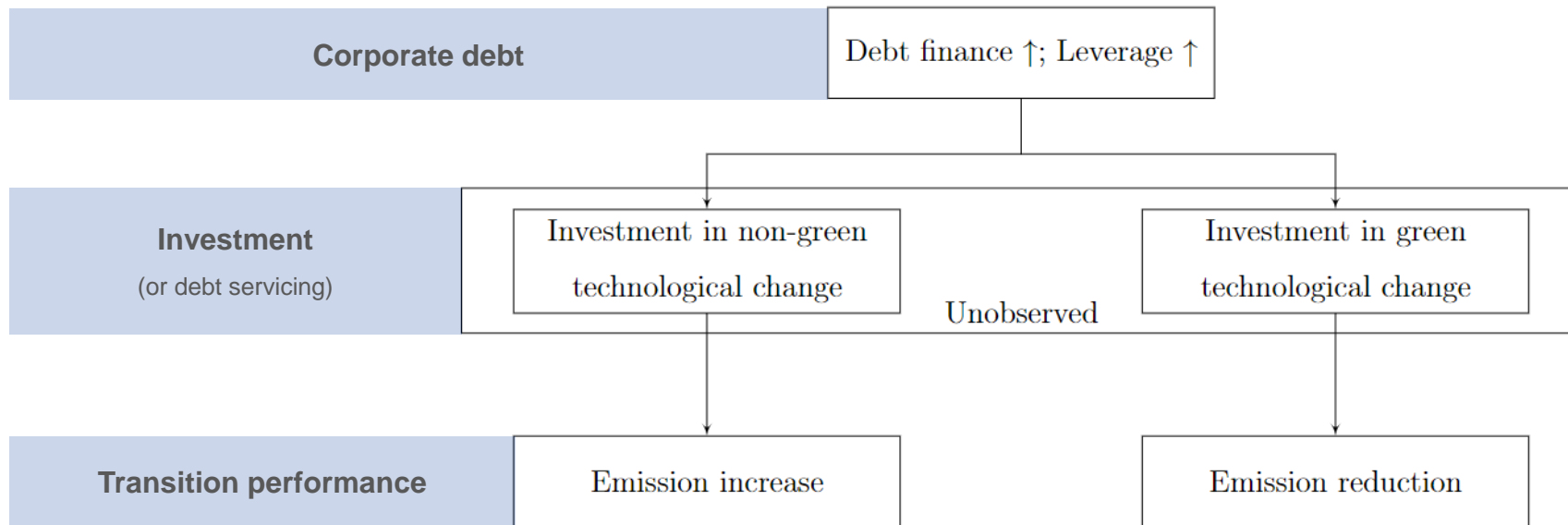
- **Debt finance and emissions:** mixed evidence
 ↓ **Emissions:** Mésonnier, 2021 Climate Policy, Ivanov et al., 2021 WP; Kacperczyk and Peydró, 2021 WP; WP Degryse et al., 2021 WP; Maurin et al., 2021 EIB report
 ↑ **Fossil fuels exposure:** Beyene et al., 2021 WP
- **Equity finance and emissions:** equity-based economies are greener
 ↓ **Emissions:** De Haas and Popov, 2019 WP
- **Credit constraints, green managerial constraints:**
 De Haas et al., 2022
- **Green bonds:** mixed evidence
 ↓ **Emissions:** Flammer, 2021 JFE; Fatica and Panzica, 2021 JRC;
 ↓ ↑ **Emissions:** Ehlers et al., 2020 BIS
- **Green loans:** scarce evidence
 ↓ ↑ **Emissions:** Gilchrist et al., 2021

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

1. Empirical approach

Theoretical background and empirical predictions

Economic mechanism: Corporate debt, investment and transition performance

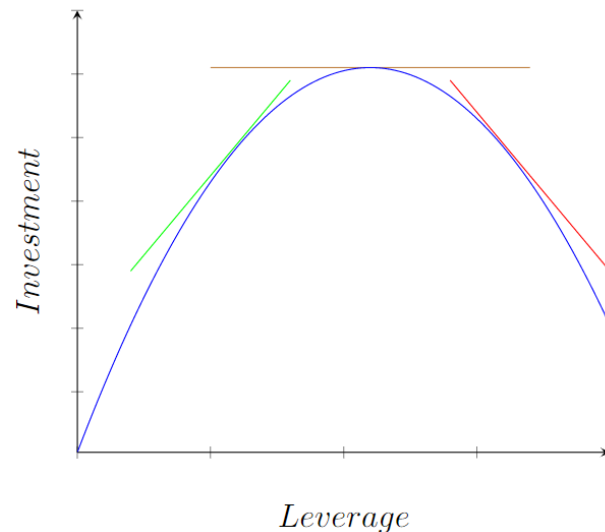


Theoretical background and empirical predictions

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**

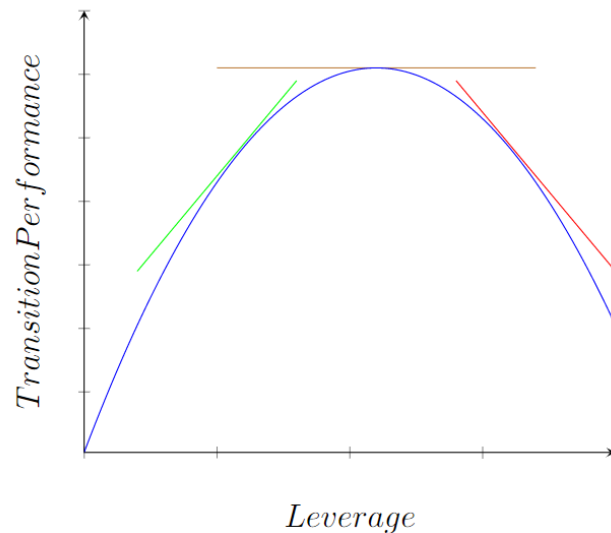


Theoretical background and empirical predictions

Empirical predictions: Corporate debt and transition performance – two hypotheses

H1 High corporate debt financing
↓
↑ **Transition performance**
Only up to a certain level of leverage

H2 Growth of debt financing
↓
↑ **Transition performance increase**
Only up to a certain level of pre-existing leverage



Empirical specification

H1 Panel regressions with fixed effects estimation on levels

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

H2 Panel regressions with first differences estimation on changes with interaction

$$\Delta \text{TransitionPerformance}_{i,t} = \beta_1 \Delta \text{leverage}_{i,t-1} \times \text{IndebtednessThreshold}_{i,t-1} + \beta_n \Delta \text{OtherDrivers}_{i,t} + \tau \text{TimeFE}_i + \epsilon_{i,t}$$

Panel regressions with first differences estimation on changes

$$\Delta \text{TransitionPerformance}_{i,t} = \beta_1 \Delta \text{leverage}_{i,t-1} + \beta_2 \Delta \text{leverage}_{i,t-1}^2 + \beta_n \Delta \text{OtherDrivers} + \tau \text{TimeFE}_i + \epsilon_{i,t}$$

+ Endogeneity and robustness

Measuring firms' transition performance

Two measures of transition performance (in line with De Jonghe et al. 2019):

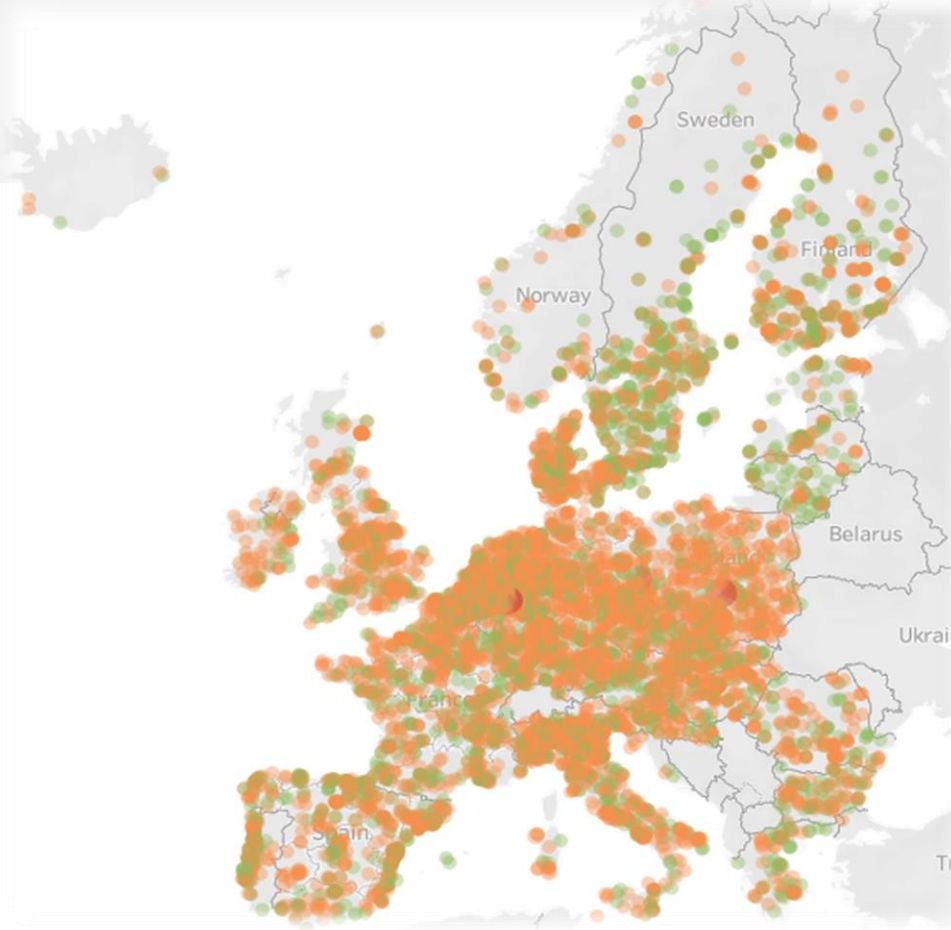
1. Change in emissions
2. Change in emission efficiency (i.e., revenues/emissions)

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

ETS-Emissions	2013	2019	Change in emissions	Change in emission efficiency
Shell Deutschland	3,997K	3,421K	- 576K	- 2K
Enel Produzione	34,556K	17,070K	- 17,485K	+ 0.1K
Saint Gobain Construction	34K	36K	+ 2K	+ 5K

A novel dataset

- 3,724 NFCs: (SMEs 40% + Large 60%)
- Geography: mostly EEA
- Period: 2013 - 2019
- Sources: EUTL, Orbis, Bloomberg
- **28% of EU emissions**
- Fossil fuel intensive production in Europe based on **oil, gas and coal**



EU ETS static installations in 2019

2. Results

H1: leverage and transition performance

$$\begin{aligned}
 TransitionPerformance_{i,t} = & \alpha + \beta_1 debttoassets_{i,t-1} + \beta_2 debttoassets_{i,t-1}^2 + \\
 & \beta_3 revenues_{i,t} + \beta_4 roa_{i,t-1} + \beta_5 age_{i,t-1} + \\
 & \beta_6 installations_{i,t-1} + \beta_7 euabalance_{i,t-1} + \\
 & \beta_8 Carbontaxflag_{i,t-1} + \beta_9 Fossilfuelsubsidies_{i,t-1} + \\
 & \rho SectorTimeFE_i + \sigma CountryFE_i + \epsilon_{i,t}
 \end{aligned}$$

- 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%**

VARIABLES	(1) ln(Emissions)	(2) ln(Rev./Em.)
Debt-to-assets	-1.37*** (0.32)	2.60*** (0.36)
<i>Debt - to - assets²</i>	1.24*** (0.48)	-2.86*** (0.50)
ln(Revenues)	0.31*** (0.039)	
ROA	-0.00020 (0.0020)	0.016*** (0.0028)
Age	0.0018 (0.0011)	0.0041*** (0.0012)
Installations	0.18*** (0.023)	-0.034** (0.016)
EUA Balance	-0.39** (0.17)	0.18** (0.081)
Carbon tax flag	-0.00098 (0.043)	0.099 (0.089)
Fossil fuel subsidies	7.90*** (2.68)	-12.6** (5.01)
Constant	4.20*** (0.67)	7.65*** (0.14)
Sector-Time FE	Y	Y
Country FE	Y	Y
Observations	20,903	20,903
R-squared	0.399	0.311

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.

H1: leverage and transition performance

$$\begin{aligned}
 TransitionPerformance_{i,t} = & \alpha + \beta_1 debttoassets_{i,t-1} + \beta_2 debttoassets_{i,t-1}^2 + \\
 & \beta_3 revenues_{i,t} + \beta_4 roa_{i,t-1} + \beta_5 age_{i,t-1} + \\
 & \beta_6 installations_{i,t-1} + \beta_7 euabalance_{i,t-1} + \\
 & \beta_8 Carbontaxflag_{i,t-1} + \beta_9 Fossilfuelsubsidies_{i,t-1} + \\
 & \rho SectorTimeFE_i + \sigma CountryFE_i + \epsilon_{i,t}
 \end{aligned}$$

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

VARIABLES	(1) ln(Emissions)	(2) ln(Rev./Em.)
Debt-to-assets	-1.37*** (0.32)	2.60*** (0.36)
Debt - to - assets ²	1.24*** (0.48)	-2.86*** (0.50)
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Fossil fuel subsidies	7.90*** (2.68)	-12.6** (5.01)
Constant	4.20*** (0.67)	7.65*** (0.14)
Sector-Time FE	Y	Y
Country FE	Y	Y
Observations	20,903	20,903
R-squared	0.399	0.311

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

H2: Δ leverage and Δ transition performance conditional on leverage level

$$\Delta TransitionPerformance_{i,t} = \alpha + \beta_1 \Delta debttoassets_{i,t-1} threshold_{i,t-1} + \beta_3 \Delta revenues_{i,t} + \beta_4 \Delta roa_{i,t-1} + \beta_5 \Delta installations_{i,t-1} + \beta_6 \Delta euabalance_{i,t-1} + \beta_7 \Delta Fossilfuelsubsidies_{i,t-1} + \tau TimeFE_i + \epsilon_{i,t}$$

- An increase in leverage is associated with an improvement in transition performance **when debt-to-assets ratio is below 50%**
- When debt-to-assets ratio is already above 50%, a **further increase in leverage** is associated with an **increase in emissions** and a reduction in emission efficiency, albeit not significant

VARIABLES	(1) fdln(Emissions)	(2) fdln(Rev./Em.)
Leverage <= 50% X fdDebt-to-assets	-0.086* (0.045)	0.20*** (0.064)
Leverage > 50% X fdDebt-to-assets	0.13** (0.062)	-0.032 (0.094)
fdln(Revenues)	0.031*** (0.0073)	
fdROA	0.0012** (0.00060)	-0.0019* (0.0010)
fdInstallations	0.093*** (0.022)	-0.050 (0.040)
fdEUA balance	-0.17*** (0.045)	0.096** (0.044)
fdFossil fuel subsidies	-1.03 (0.80)	0.22 (2.16)
Time FE	Y	Y
Observations	17,609	17,609
R-squared	0.031	0.006

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: When excluding firms with leverage close to 50%, i.e., when using an interaction term equal to 1 if leverage is above 75% and 0 when leverage is below 25%, results remain robust.

H2: Δ leverage and Δ transition performance over 1 year

$$\Delta TransitionPerformance_{i,t} = \alpha + \beta_1 \Delta debttoassets_{i,t-1} + \beta_2 \Delta debttoassets_{i,t-1}^2 + \beta_3 \Delta revenues_{i,t} + \beta_4 \Delta roa_{i,t-1} + \beta_5 \Delta installations_{i,t-1} + \beta_6 \Delta euabalance_{i,t-1} + \beta_7 \Delta Fossilfuelsubsidies_{i,t-1} + \tau TimeFE_i + \epsilon_{i,t}$$

- An increase in leverage is associated with an increase in emission efficiency.
- There is a potential non-linear relationship between leverage changes and transition performance changes, albeit not significant on the 1-year horizon.

VARIABLES	(1) fdln(Emissions)	(2) fdln(Rev./Em.)
fdDebt-to-assets	-0.14 (0.088)	0.25** (0.12)
fdDebt - to - assets ²	0.20 (0.14)	-0.21 (0.18)
fdln(Revenues)	0.031*** (0.0075)	
fdroa	0.0011* (0.00061)	-0.0018* (0.0011)
fdEUA balance	-0.16*** (0.043)	0.089** (0.044)
fdFossil fuel subsidies	-0.99 (0.82)	-1.02 (1.93)
fdInstallations	0.096*** (0.024)	-0.053 (0.041)
Time FE	Y	Y
Observations	17,056	17,056
R-squared	0.026	0.006

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

H2: Δ leverage and Δ transition performance over 3 years

$$\Delta TransitionPerformance_{i,t} = \alpha + \beta_1 \Delta debttoassets_{i,t-3} + \beta_2 \Delta debttoassets_{i,t-3}^2 + \beta_3 \Delta revenues_{i,t} + \beta_4 \Delta roa_{i,t-3} + \beta_5 \Delta installations_{i,t-3} + \beta_6 \Delta euabalance_{i,t-3} + \beta_7 \Delta Fossilfuelsubsidies_{i,t-3} + \tau TimeFE_i + \epsilon_{i,3}$$

- There is a **non-linear relationship** between leverage changes and emission efficiency changes after three years.
- A growth in leverage is associated with a growth in emission efficiency **as long as leverage is below ~ 50%**, and inverts afterwards

VARIABLES	(1) fdln(Emissions)	(2) fdln(Rev./Em.)
fdDebt-to-assets	-0.031 (0.097)	0.66** (0.26)
fdDebt - to - assets ²	0.11 (0.14)	-0.66** (0.33)
fdln(Revenues)	0.0069*** (0.0026)	
fdEUA balance	-0.033*** (0.0095)	0.016 (0.036)
fdroa	0.00058 (0.00042)	-0.000090 (0.0017)
fdInstallations	0.018*** (0.0058)	0.0027 (0.014)
Time FE	Y	Y
Observations	13,398	13,398
R-squared	0.008	0.008

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Endogeneity and Robustness test

Firms' preferences for green may drive emissions reductions.

Firm FE: Results qualitatively unchanged.

High or low emitters might drive the emissions reductions.

Robustness removing high / low –emitters: Results qualitatively unchanged.

VARIABLES	(1) ln(Emissions)	(2) ln(Rev./Em.)
Debt-to-assets	-0.10 (0.12)	1.25*** (0.28)
<i>Debt – to – assets</i> ²	0.17 (0.20)	-1.12*** (0.37)
Constant	9.31*** (0.18)	7.87*** (0.12)
Controls	Y	Y
Firm FE	Y	Y
Time FE	Y	Y
Observations	20,754	20,754
R-squared	0.962	0.845

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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*** (0.30)	-1.15*** (0.26)	2.51*** (0.39)	2.62*** (0.36)
<i>Debt – to – assets</i> ²	0.47 (0.45)	1.45*** (0.37)	-2.65*** (0.53)	-3.10*** (0.46)
Constant	5.99*** (0.42)	7.13*** (0.59)	7.59*** (0.12)	6.64*** (0.11)
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

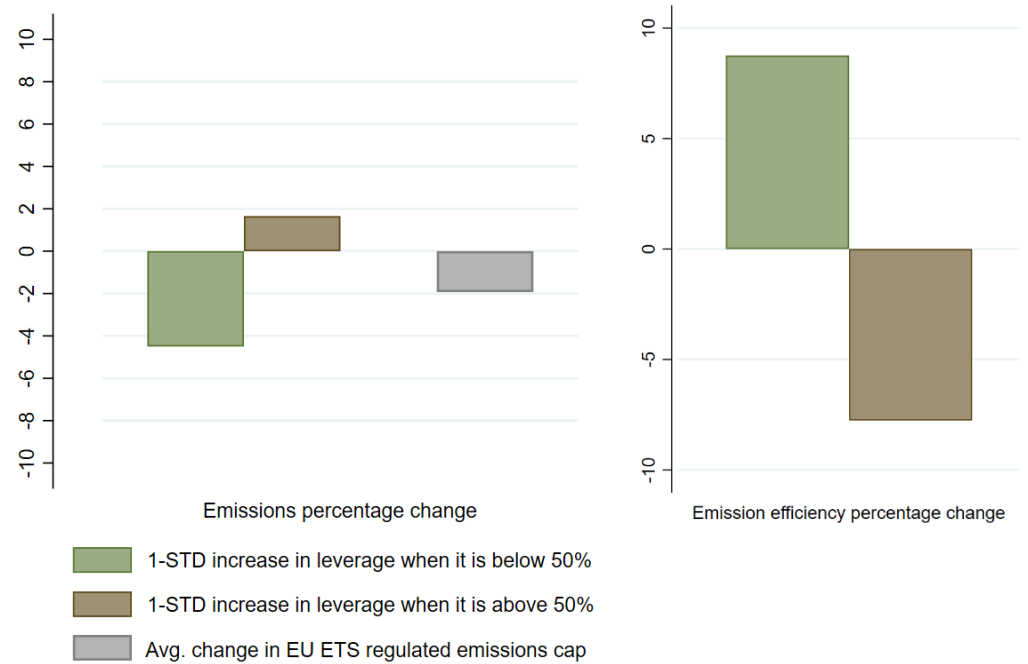
3. Economic magnitude

Economic magnitude

1 **Leverage below 50%**
 1-STD increase in debt-to-assets
 ↓
 -4.5% emissions in the following year
 +8.8% emission efficiency in the following year

 By comparison: **-1.9%** avg. yearly reduction ETS emissions cap

2 **Leverage above 50%**
 1-STD increase in debt-to-assets
 ↓
 +1.6% emissions in the following year
 -7.8% emission efficiency in the following year



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 initial leverage level.
3. Firm-specific environmental factors – such as balance of free allowances to emit – and country-specific environmental factors – such as fossil fuel subsidies – influence firms’ ability to reduce emissions.

Policy relevance:

- Scope and role of EU ETS within the low-carbon transition
- Disclosure of emissions (EU CSRD)
- Debt – and not only equity – as a driver of emission reduction, the role of green debt
- ECB monetary and non-monetary operations

Appendix

Additional robustness test

Results on H2 may be driven by firms with leverage ratio around 50%

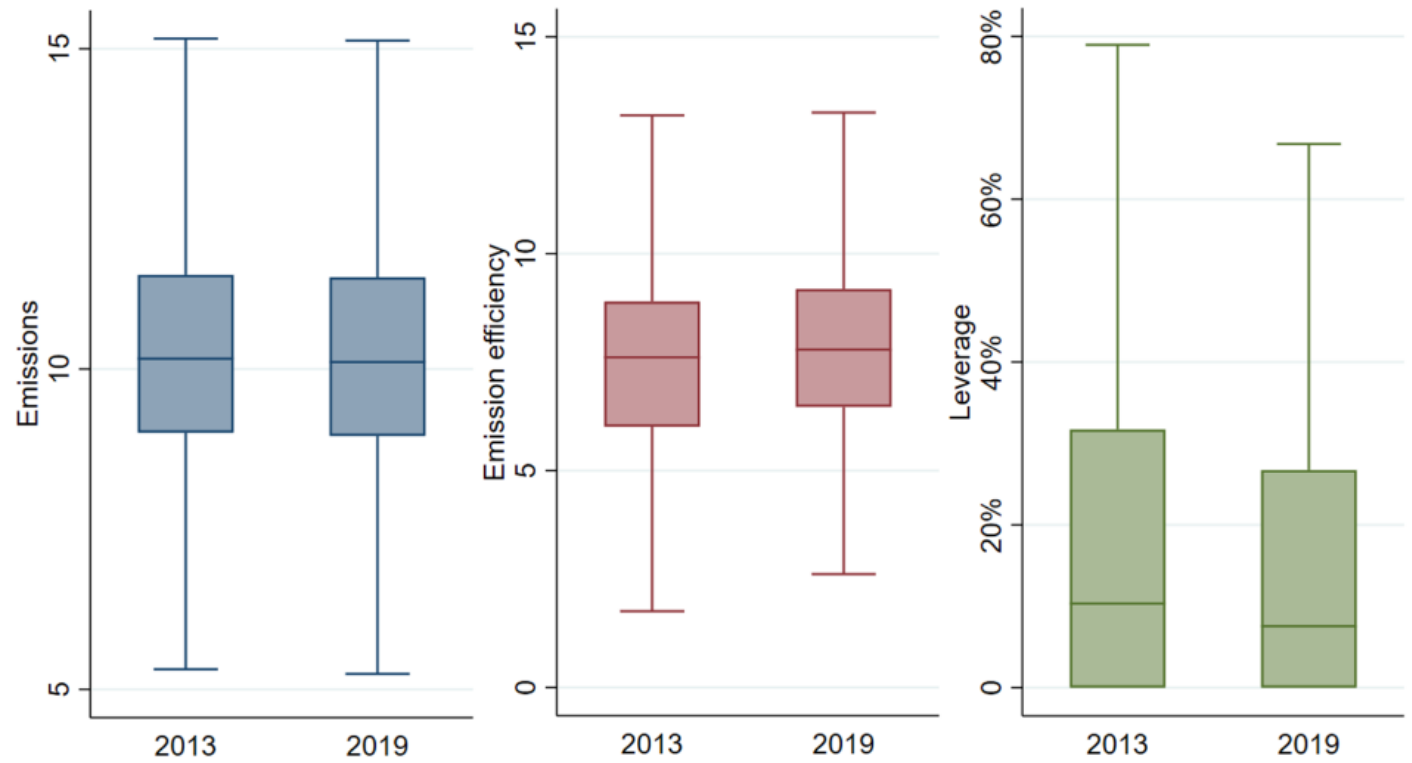
When excluding firms with leverage close to 50%, i.e., when using an interaction term equal to 1 if leverage is above 75% and 0 when leverage is below 25%, results remain robust.

VARIABLES	(1) fdln(Emissions)	(2) fdln(Rev./Em.)
Leverage \leq 25% X debt-to-assets	-0.11** (0.054)	0.22*** (0.082)
Leverage \geq 75% X debt-to-assets	0.19* (0.10)	0.053 (0.19)
fdln(Revenues)	0.022*** (0.0055)	
fdROA	0.0011* (0.00058)	-0.0025* (0.0013)
fdEUA balance	-0.15*** (0.052)	0.068 (0.057)
fdFossil fuel subsidies	-1.47 (1.09)	-0.66 (2.45)
fdInstallations	0.096*** (0.026)	-0.052 (0.047)
Time FE	Y	Y
Observations	12,443	12,443
R-squared	0.027	0.007

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Distribution of main variables of interest across time



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 – Differential effect: carbon price

- EUA price started increasing in 2018
- Results of the sub-sample analysis are aligned with hypothesis 1 across time: the non-linear relation has been observed for both measures of transition performance in 2017 and 2018 and for emissions efficiency only in 2019.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	2017 ln(Emissions)	2018 ln(Emissions)	2019 ln(Emissions)	2017 ln(Rev./Em.)	2018 ln(Rev./Em.)	2019 ln(Rev./Em.)
Debt-to-assets	-1.29*** (0.40)	-1.34*** (0.40)	-1.33*** (0.45)	2.41*** (0.49)	2.05*** (0.45)	1.82*** (0.48)
<i>Debt to assets</i> ²	1.11* (0.58)	1.39** (0.61)	1.20 (0.73)	-2.57*** (0.63)	-2.38*** (0.65)	-2.00*** (0.74)
Constant	4.30*** (0.92)	2.22* (1.17)	1.73 (1.29)	7.41*** (0.099)	7.57*** (0.080)	7.68*** (0.077)
Controls	Y	Y	Y	Y		
Sector-Time FE	Y	Y	Y	Y		
Country FE	Y	Y	Y	Y		
Observations	2,998	3,004	2,900	2,998	3,004	2,900
R-squared	0.419	0.442	0.443	0.323	0.373	0.367

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Additional analyses – Differential effect: industries

- Results are significant and aligned with hypothesis 1. They show that there is not a significant difference in the relationship between leverage and transition performance across the two samples of firms on/off the carbon leakage list.
- The hypothesis of a convex (concave) relationship between leverage and emissions (emission efficiency) is particularly driven by firms in the sectors of electricity, gas, steam and air conditioning supply (Nace 2-digits sector 35) and non-metals manufacturing (Nace 2-digits sector 23)

VARIABLES	(1)	(2)	(3)	(4)
	On carb. leakage list ln(Emissions)	Not on carb. leakage list ln(Emissions)	On carb. leakage list ln(Rev./Em.)	Not on carb. leakage list ln(Rev./Em.)
Debt-to-assets	-1.15*** (0.38)	-1.26*** (0.41)	1.92*** (0.41)	2.80*** (0.49)
<i>Debt – to – assets</i> ²	0.98* (0.56)	1.15* (0.60)	-1.85*** (0.57)	-3.27*** (0.66)
Constant	3.75*** (0.88)	4.48*** (0.85)	6.84*** (0.16)	8.03*** (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

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	35 ln(Emissions)	23 ln(Emissions)	20 ln(Emissions)	35 ln(Rev./Em.)	23 ln(Rev./Em.)	20 ln(Rev./Em.)
Debt-to-assets	-2.07*** (0.67)	-1.41** (0.64)	-0.56 (0.87)	3.02*** (0.76)	2.15*** (0.64)	1.19 (0.89)
<i>Debt – to – assets</i> ²	2.49** (0.98)	1.90** (0.90)	0.85 (1.38)	-3.80*** (1.06)	-2.76*** (0.94)	-1.02 (1.35)
Constant	3.33** (1.35)	-0.34 (1.94)	2.73 (2.06)	6.81*** (0.33)	6.63*** (0.16)	7.92*** (0.24)
Controls	Y	Y	Y	Y		
Sector-Time FE	Y	Y	Y	Y		
Country FE	Y	Y	Y	Y		
Observations	5,734	3,497	1,835	5,734	3,497	1,835
R-squared	0.456	0.516	0.428	0.295	0.131	0.183

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Additional analyses – Differential effect: size

- There is not a significant difference in the relationship between leverage levels and transition performance levels across the samples.
-

An increase in leverage is significantly associated with an increase in emission efficiency in the following year for SMEs.

VARIABLES	(1)	(2)	(3)	(4)
	Large ln(Emissions)	SME ln(Emissions)	Large ln(Rev./Em.)	SME ln(Rev./Em.)
Debt-to-assets	-0.90** (0.40)	-1.54*** (0.45)	1.20*** (0.42)	3.62*** (0.55)
<i>Debt – to – assets</i> ²	0.92 (0.61)	1.13* (0.68)	-1.61*** (0.62)	-3.76*** (0.73)
Constant	5.17*** (1.40)	6.14*** (0.53)	8.22*** (0.13)	7.36*** (0.25)
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

VARIABLES	(1)	(2)	(3)	(4)
	Large fdln(Emissions)	SME fdln(Emissions)	Large fdln(Rev./Em.)	SME fdln(Rev./Em.)
fdDebt-to-assets	-0.10 (0.094)	-0.19 (0.17)	0.20 (0.14)	0.37* (0.21)
<i>fdDebt – to – assets</i> ²	0.18 (0.16)	0.21 (0.24)	-0.25 (0.23)	-0.17 (0.30)
Controls	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Observations	10,486	6,570	10,486	6,570
R-squared	0.021	0.056	0.005	0.011

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Additional analyses – Differential effect: group dependency

- There is a significant convex relationship between leverage and emission levels for subsidiaries; while the relationship is convex, but not significant, for independent firms.
- An increase in leverage is significantly associated with an increase in transition performance for subsidiaries (columns (1) and (3)).

VARIABLES	(1)	(2)	(3)	(4)
	Subsidiaries ln(Emissions)	Independent ln(Emissions)	Subsidiaries ln(Rev./Em.)	Independent ln(Rev./Em.)
Debt-to-assets	-1.36*** (0.36)	-0.62 (0.69)	2.30*** (0.42)	3.44*** (0.75)
<i>Debt – to – assets</i> ²	1.20** (0.55)	0.74 (1.02)	-2.35*** (0.57)	-4.82*** (1.03)
Constant	4.79*** (0.84)	3.51*** (0.90)	7.75*** (0.14)	7.32*** (0.29)
Controls	Y	Y	Y	Y
Sector-Time FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Observations	15,745	5,082	15,745	5,082
R-squared	0.409	0.444	0.321	0.376

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1)	(2)	(3)	(4)
	Subsidiary fdln(Emissions)	Independent fdln(Emissions)	Subsidiary fdln(Rev./Em.)	Independent fdln(Rev./Em.)
fdDebt-to-assets	-0.16* (0.093)	-0.033 (0.23)	0.27** (0.13)	0.23 (0.28)
<i>fdDebt – to – assets</i> ²	0.21 (0.14)	0.090 (0.35)	-0.28 (0.21)	0.040 (0.33)
Controls	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Observations	12,957	4,099	12,957	4,099
R-squared	0.025	0.053	0.007	0.009

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Additional analyses – Differential effect: Country of firm

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

1. Country of firm

- The **non-linear** effect between leverage changes and transition performance changes is particularly significant in **Poland**, given the **high reliance** of Polish firms on **debt financing**.
- Approx. 10% of our EU ETS active firms are registered in Poland

VARIABLES	(1) France fdln(Em.)	(2) Germany fdln(Em.)	(3) Poland fdln(Em.)	(4) France fdln(Rev./Em.)	(5) Germany fdln(Rev./Em.)	(6) Poland fdln(Rev./Em.)
fdDebt-to-assets	0.21 (0.16)	-0.10 (0.17)	-0.48** (0.23)	1.96* (1.11)	0.71** (0.33)	0.81*** (0.29)
fdDebt - to - assets ²	-0.043 (0.22)	0.13 (0.22)	0.89** (0.44)	-2.64** (1.33)	-0.62 (0.43)	-1.88*** (0.60)
Controls	Y	Y	Y	Y		
Time FE	Y	Y	Y	Y		
Observations	1,745	1,054	1,276	1,745	1,054	1,276
R-squared	0.009	0.018	0.077	0.022	0.015	0.137

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: NFCs in Poland rely heavily on debt and were characterized by an aggregate debt-to-assets ratio of 56% in 2019, while this value was 34% in France in the same period and 46% in Germany.
(source: Quarterly Sector Accounts)

Additional analyses – Differential effect: listed vs. non-listed firms

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

2. Listed vs. non-listed firms

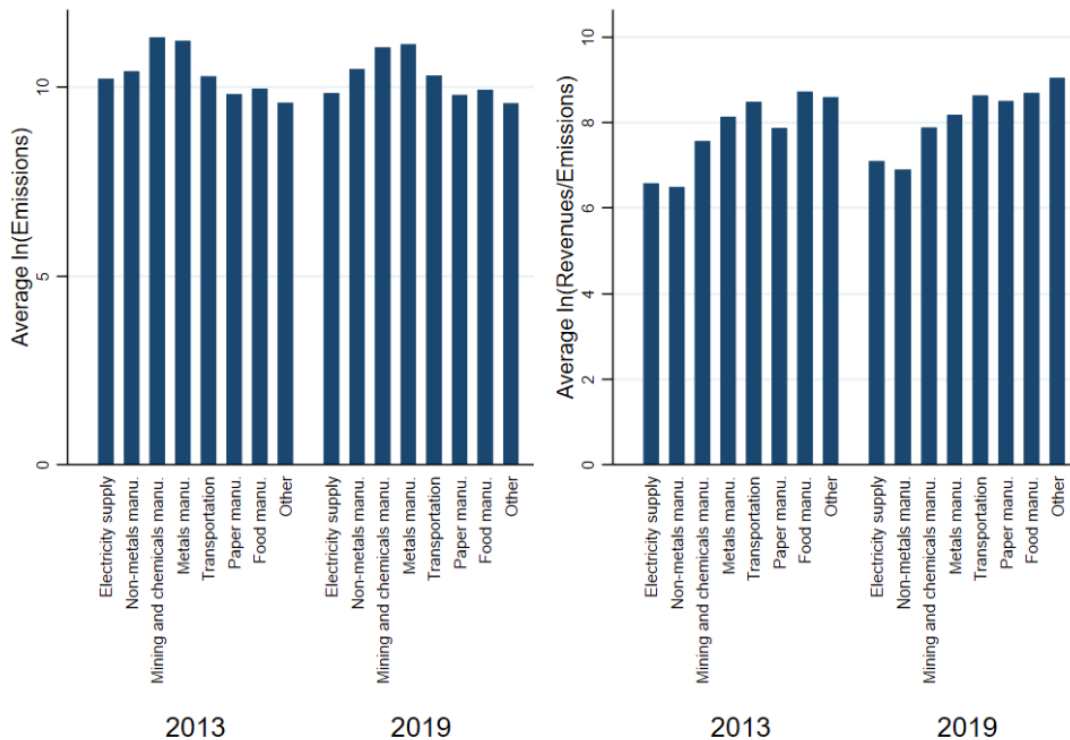
- The **non-linear** effect between leverage and transition performance is driven by **unlisted firms**.
- Approx. 96% of our EU ETS active firms are non-listed, the sample is also representative for the European economy.

VARIABLES	(1)	(2)	(3)	(4)
	Listed ln(Emissions)	Non-listed ln(Emissions)	Listed ln(Rev./Em.)	Non-listed ln(Rev./Em.)
Debt-to-assets	0.71 (1.76)	-1.45*** (0.33)	1.23 (1.94)	2.61*** (0.37)
<i>Debt – to – assets</i> ²	-2.72 (3.12)	1.39*** (0.48)	0.78 (3.45)	-2.92*** (0.51)
Constant	3.94 (2.52)	4.20*** (0.69)	8.46*** (0.51)	7.65*** (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

Measuring a firm's transition performance – across industries and time



Leverage across industries and time

