# Pollution permits and financing costs

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# Motivation

- Transition of energy-intensive economies from fossil fuels to green energy.
- A policy instrument widely implemented in line with the goal to reduce carbon emissions is cap-and-trade.
- Recent arguments call for raising the indirect costs of carbon emissions via less favorable financial terms
  - E.g., Increased loan spreads.
  - UniCredit, BNP Paribas, Barclays and Societe Generale have lent €7.9bn to the eight highest-emitting coal consumers (Financial Times 2020)

# Motivation

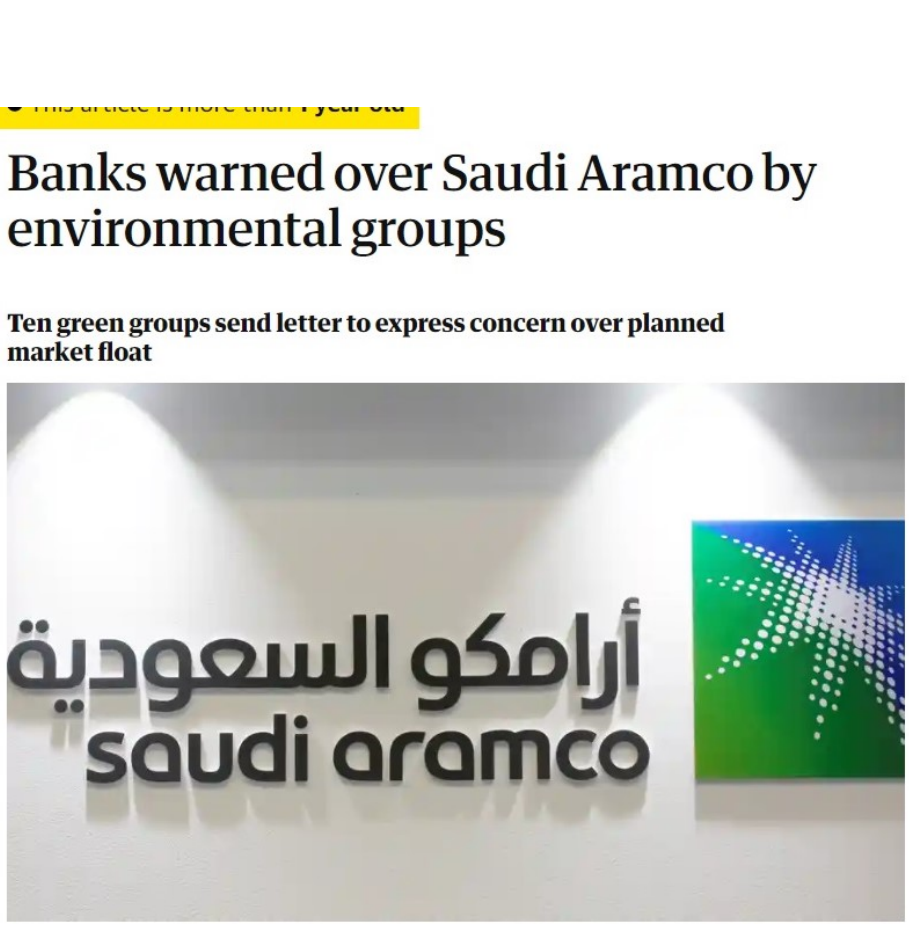


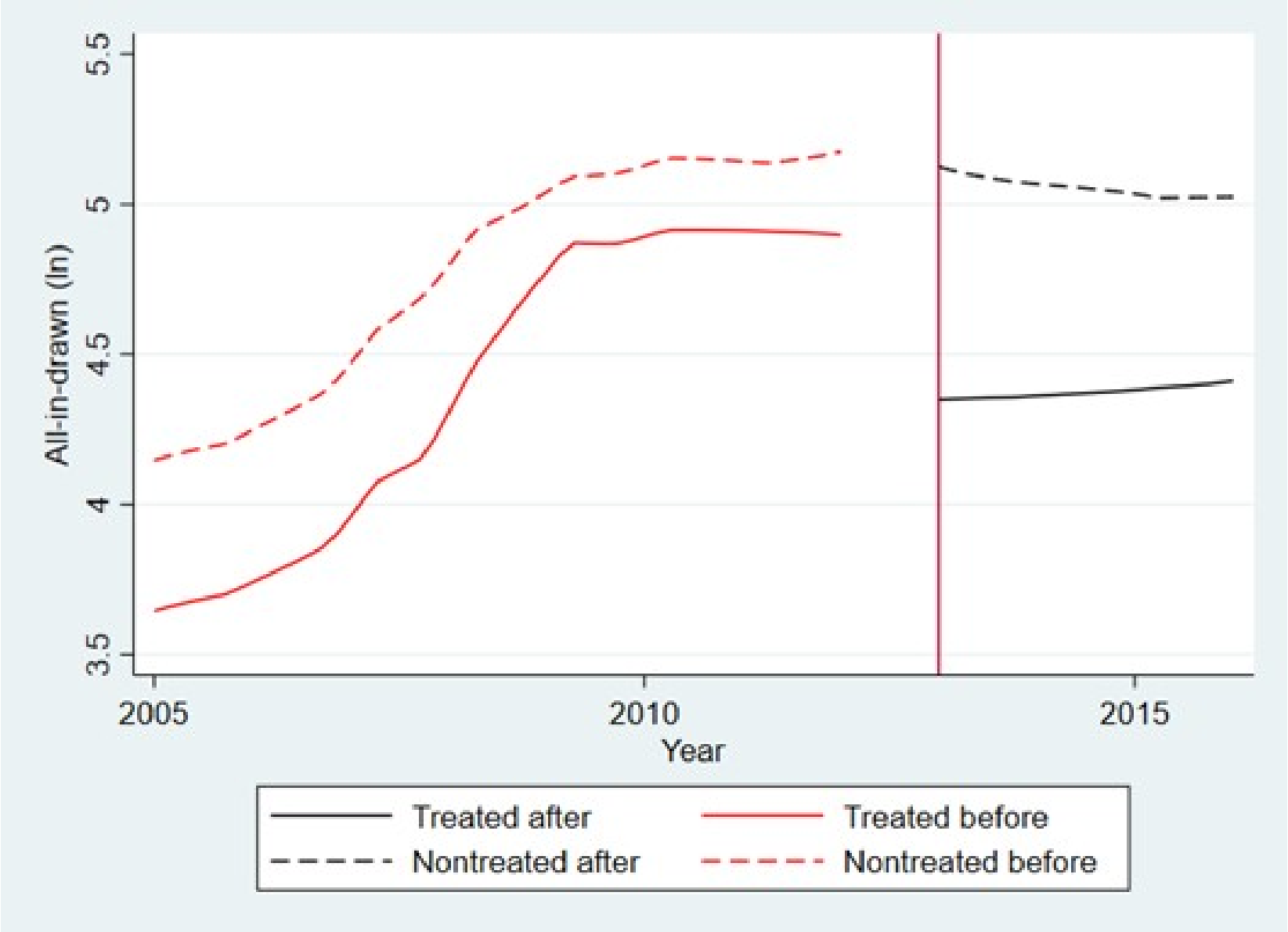


Figure: Banks' propping up coal polluters

# Motivation

- The European Union Emissions Trading System (EU ETS) was launched in 2005.
- In 2013 phase III begins and important structural changes occurred in the system.
  - emission allowances offered at a decreasing rate of 1.74%/year
  - participating firms received less free allowances
  - firms had to purchase the rest in the market
- This reform aims to increase the cost of carbon for polluters.
- The corresponding financial terms should internalize this risk after 2013.

# Anecdotal evidence about the loan spreads



# Preview of the results

- The treated firms have 25% lower loan spreads
  - corresponds to a €5.56 million reduction in interest expense for loans
  - results robust also to the bond market
- The effect is most negative when the EUA price is low, which is the case in 2013-2017.
- We identify another reason for allowances storage:
  - the effect is much smaller for treated firms that are net buyers of permits
  - they have not stored enough allowances

# Preview of the results

- Significant negative association between loan spreads and the treated firms' verified CO2 emissions.
- The declining CO2 emissions (as noted by e.g., Bayer and Aklin, 2020) would have been even lower if financing costs did not decline.
- Our estimates show a further 7.9% decline in CO2 emissions if there is no decrease in loan spreads.

# Related literature I

- No evidence of an adverse effect for phases I, II on competitiveness (e.g., Abrell, 2011; Commins et al., 2011; Joltreau and Sommerfeld, 2019; Martin et al. 2016).
- Phase I led regulators to increase local pollution in order to promote exports (Antoniou and Kyriakopoulou 2019).
- In phase II banking allowances induce the market to incorporate the future scarcity of allowances (Hintermann et al. 2016).
- De Jonghe et al. (2020) exploit the tightening EU ETS regulation in 2017 and show that high permit prices improve the emission efficiency of highly polluting firms.

# Related literature II

- De Haas and Popov (2019) summarize two main arguments:
  1. Banks are ineffective in limiting pollution as they finance few green investments (Minetti, 2011)
  2. New technologies are usually intangible assets without collateral value (Hall and Lerner, 2010)

- Credit constraints increase pollution emissions (Andersen 2017).

- Banks price in the risk that fossil fuel reserves will become unburnable only after 2015 (Delis et al. 2019).

- Ivanov et al. (2020), show that cap-and-trade policy affects borrowing among private firms
  - firms face shorter loan maturities,
  - less access to permanent forms of bank financing,
  - higher participation among shadow banks in their lending syndicates.

# Theoretical foundation

## The firm's problem

- Free allocated emission permits $\overline{e}_{it}$.
- The firm may purchase allowances $e_{it}$.
- Abatement: $a_{it} = x_{it} - \overline{e}_{it} - e_{it} - s_{it-1}$, where $x_{it}$ is production and $s_{it-1}$ are stored permits from $t-1$.
- Profits in each period:
  $\pi_{it} = r(x_{it}) - c(a_{it}) - [e_{it} + 1_{s_{it}>0} s_{it}] P_t - R_{it} k_{it} + \theta_{it} - A_{it}$
  - $R_{it}$ interest rate, $k_{it}$ capital, $A_{it}$ fixed payment
  - $\theta_{it} \sim [-\theta, \theta]$ with zero mean.
- Variable operational profits $\pi^v_{it} = r(x_{it}) - c(a_{it}) - e_{it} P_t$
- The firm maximizes expected profits.

# Theoretical foundation

## The bank's problem

- Expected profits of the bank that provides a loan $k_{it}$

$$B_t = \varphi\left(\pi_{it}^{v}\right) R_{it} k_{it} - \rho_{it} k_{it},$$

  - $\rho_{it}$ the central's bank interest rate,
  - $\varphi\left(\pi_{it}^{v}\right)$ subjective probability that the bank assigns upon success of the project, $\varphi^{'}\left(\pi_{it}^{v}\right) > 0$

- Participation constraint

$$B_t \geq 0 \Leftrightarrow R_{it} \geq \frac{\rho_{it}}{\varphi\left(\pi_{it}^{v}\right)}$$

# Theoretical foundation

## The permits market

- Market clearing condition

$$\sum_{i=1}^{I} \left( e_{it} + \overline{e}_{it} + 1_{s_{it}>0} s_{it} \right) = \overline{z}_t$$

$\overline{z}_t$ supply of allowances in period t.

- This equation determines permits price, $P_t$.
  - $\downarrow \overline{z}_t \Rightarrow \uparrow P_t$
  - $\uparrow e_{it}, s_{it} \Rightarrow \uparrow P_t$

# Theoretical foundation

## Timing and solution concept

- t=1: (period prior to 2013; pre-treatment)
  1. The competitive bank sets $R_{i1}$ to firm i.
  2. Firm i selects $x_{i1}$, $e_{i1}$ and $s_{i1}$.
- t=2: (period after 2013; post-treatment)
  1. The competitive bank sets $R_{i2}$ to firm i.
  2. Firm i selects $x_{i2}$ and $e_{i2}$.
- Solution concept: *Subgame Perfect Nash Equilibrium*

# Main theoretical results

### Remark (1)

When the number of free allocated allowances increases, loan spread decreases.

### Remark (2)

When the number of stored allowances increases, loan spread decreases.

### Remark (3)

When the permits price increases, loan spread increases.

### Remark (Main Hypothesis)

Loan spread is lower in period 2 than in period 1.

# Data

- We use data from the EU ETS
  - all 3 phases covered from 2005-2018.
- We hand-match account holders to listed firms in the Compustat Global and North America databases.
- We match the identified EU ETS listed firms to DealScan's syndicated loan database.
  - Loan-level variables from *DealScan*, borrower/lender characteristics from *Compustat*, borrower/lender country characteristics from the *World Development Indicators* database, borrower's country electricity price from *Eurostat*.

# Empirical identification

- To identify how the EU ETS program affects loan spreads we use:

$$Loan\ spread_{libt} = a_0 + a_1\, Treated_{it} + a_2 3rd\ phase\ dummy_t + \\ + a_3\, Treated_{it} \cdot 3rd\ phase\ dummy_t + L_{it} + F_{it} + B_{bt} + C_t + u_{lit}$$

- Loan spread is the log of the spread over LIBOR for syndicated loan $l$ from bank $b$ to firm $i$ in year $t$.
- Treated=1 if the borrower participates in the EU ETS.
- Vectors of the loan ($L$), firm ($F$), bank ($B$), and country ($C$) control variables.
- We focus on $a_3$, which shows the treatment effect of initiating phase III of the EU ETS program.

# Empirical identification

- Several tests verify that our analysis resembles the characteristics of a randomized quasi-natural experiment.
  1. Parallel trends and placebo tests.
  2. We slide the treatment period in 2012, 2011, and 2010, and show that the observed change in Loan spread coincides with the event. This also implies that there is no pretreatment trend in the event.
  3. We provide 2 falsification tests.
     - we include a different control group of firms (e.g., U.S. firms in nontreated sectors).
     - We use a different treated group of firms in the treated sectors from Asia or Switzerland.
  4. Including controls does not significantly affect $a_3$.

# Baseline results-Dependent variable log loan spread

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Treated | -0.016 | -0.014 | 0.026 | 0.022 | 0.027 | 0.055 | 0.024 |
| | (-0.12) | (-0.11) | (0.24) | (0.21) | (0.25) | (0.123) | (0.107) |
| Treated x 3rd phase dummy | -0.232*** | -0.238*** | -0.239*** | -0.251*** | -0.261*** | -0.279*** | -0.254*** |
| | (-2.78) | (-2.98) | (-3.30) | (-3.35) | (-3.58) | (0.079) | (0.076) |
| | (342.51) | (41.88) | (3.42) | (4.37) | (3.42) | (0.567) | (0.601) |
| Observations | 132,209 | 130,856 | 46,322 | 45,998 | 18,646 | 45,925 | 45,990 |
| No of firms | 4,389 | 4,336 | 1,232 | 1,227 | 1,045 | 1,224 | 1,227 |
| Borrower, Lender, Loan purpose, Loan type, Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry x year FE | No | No | No | No | No | Yes | No |
| Clustering | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower |
| Adj-$R^2$ | 0.90 | 0.90 | 0.91 | 0.91 | 0.91 | 0.92 | 0.91 |

# Robustness-Placebo tests

**Table 4. Placebo tests**

| | Shifting backwards the 3rd phase | | | | Treated group is Australian/Asian firms in the same EU ETS pollutant sectors | Treated group is Swiss firms in the same EU ETS pollutant sectors | Control group is U.S. firms in non-EU ETS sectors | Dependent variable is facility amount |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Treated | 0.010 | -0.016 | -0.069 | -0.072 | | | | -0.058 |
| | (0.09) | (-0.14) | (-0.61) | (0.112) | | | | (-0.41) |
| Treated × 3rd phase dummy(2012) | -0.199** | | | | | | | |
| | (-2.50) | | | | | | | |
| Treated × 3rd phase dummy(2011) | | -0.121* | | | | | | |
| | | (-1.68) | | | | | | |
| Treated × 3rd phase dummy(2010) | | | -0.029 | | | | | |
| | | | (-0.39) | | | | | |
| Treated × 3rd phase dummy(2009) | | | | | | | | |
| Treated × 3rd phase dummy | | | | -0.024 | -0.091 | -0.042 | -0.237*** | -0.049 |
| | | | | (0.073) | (-1.38) | (-0.19) | (-3.41) | (-0.69) |
| Loan spread | | | | | | | | -0.142*** |
| | | | | | | | | (-2.84) |
| Observations | 45,998 | 45,998 | 45,998 | 45,998 | 49,757 | 35,514 | 93,364 | 45,998 |
| No of firms | 1,227 | 1,227 | 1,227 | 1,227 | 1,648 | 1,027 | 2,424 | 1,227 |
| Borrower, Lender, Loan purpose, Loan type, Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Clustering | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower |
| Adj-$R^2$ | 0.91 | 0.91 | 0.91 | 0.91 | 0.90 | 0.91 | 0.88 | 0.82 |

# Controlling for foreign subsidiaries,permit prices & allowances characteristics

**Table 5. Foreign subsidiaries, EUA price, and EU ETS program characteristics**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Treated | -0.186 | 0.014 | -0.050 | 0.059 | 0.046 | -0.076 | -0.127 | -0.120 |
| | (-1.49) | (0.13) | (-0.48) | (0.49) | (0.39) | (-0.89) | (-1.233) | (-1.083 |
| 3rd phase dummy | | 0.109** | 0.085 | 0.085 | 0.096* | 0.122** | 0.076 | 0.081 |
| | | (2.16) | (1.62) | (1.62) | (1.90) | (2.51) | (1.496) | (1.410) |
| Treated × 3rd phase dummy | -0.238** | -0.247*** | -0.248*** | -0.269*** | -0.260*** | -0.285*** | -0.311*** | -0.309** |
| | (-2.14) | (-3.19) | (-3.11) | (-3.06) | (-2.99) | (-3.08) | (-3.203) | (-3.141 |
| EUA price | | 0.060*** | | | | 0.061*** | 0.058*** | 0.069 |
| | | (6.32) | | | | (6.05) | (5.041) | (1.146) |
| Costly allocated allowances | | | 0.112 | | | 0.192 | 0.223 | 0.217 |
| | | | (0.64) | | | (1.24) | (1.337) | (1.268) |
| Allocated allowances | | | | -0.036 | | -0.055 | -0.062 | -0.060 |
| | | | | (-0.79) | | (-0.90) | (-0.961) | (-0.909 |
| Bought / sold allowances | | | | | -0.022 | -0.023 | -0.024 | -0.021 |
| | | | | | (-0.60) | (-0.56) | (-0.632) | (-0.484 |
| **First-stage results** | | | | | | | | |
| Standard deviation of wind speed | | | | | | | | -1.155** |
| | | | | | | | | (-4.73) |
| Underidentification test (p-value) | | | | | | | | 0.000 |
| Weak identification test and critical value in parenthesis | | | | | | | | 22.37 |
| | | | | | | | | (16.38) |
| Observations | 27,239 | 45,367 | 45,998 | 45,998 | 42,672 | 42,041 | 40,726 | 40,726 |
| No of firms | 867 | 1,212 | 1,227 | 1,227 | 1,196 | 1,181 | 1,154 | 1,160 |
| Borrower, Lender, Loan purpose, Loan type FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Clustering | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower | Borrow |
| Adj-$R^2$ | 0.92 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | |

# The role of the price and allocation of permits

**Table 7. Heterogeneity due to the price of permits and EU ETS program characteristics**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Treated | -0.220 | -0.155 | -0.144 | -0.151 | -0.147 |
| | (-1.56) | (-1.21) | (-1.21) | (-1.19) | (-1.20) |
| 3rd phase dummy | 0.315*** | 0.051 | 0.040 | 0.041 | 0.144 |
| | (2.91) | (1.00) | (0.73) | (0.76) | (0.75) |
| Treated × 3rd phase dummy | -0.751*** | -1.423*** | -0.275*** | -0.253** | -2.473*** |
| | (-3.55) | (-3.01) | (-2.84) | (-2.55) | (-3.81) |
| EUA price | 0.058*** | 0.061*** | 0.063*** | 0.063*** | 0.055*** |
| | (4.22) | (5.35) | (5.67) | (5.64) | (4.12) |
| Treated × EUA price | 0.018 | | | | 0.015 |
| | (0.87) | | | | (0.69) |
| 3rd phase dummy × EUA price | -0.153** | | | | -0.053 |
| | (-2.49) | | | | (-0.47) |
| Treated × 3rd phase dummy × EUA price | 0.306*** | | | | 0.364** |
| | (2.71) | | | | (2.05) |
| Costly allocated allowances | 0.204 | 0.208 | 0.077 | 0.192 | 0.090 |
| | (1.10) | (1.13) | (0.39) | (1.08) | (0.45) |
| Treated × 3rd phase dummy × Costly allocated allowances | | | 0.197 | | 0.230 |
| | | | (1.26) | | (1.35) |
| Allocated allowances | -0.036 | -0.076 | 0.000 | -0.050 | -0.034 |
| | (-0.82) | (-1.21) | (0.00) | (-1.01) | (-0.42) |
| Treated × 3rd phase dummy × Allocated allowances | | | | 0.061 | 0.116* |
| | | | | (0.83) | (1.76) |
| Bought / sold allowances | | -0.144*** | | | -0.138*** |
| | | (-4.41) | | | (-3.96) |
| Treated × 3rd phase dummy × Bought / sold allowances | | 0.161** | | | 0.200*** |
| | | (2.49) | | | (2.76) |
| Observations | 43,748 | 40,422 | 43,748 | 43,748 | 40,422 |
| No of firms | 1,188 | 1,154 | 1,188 | 1,188 | 1,154 |
| Control variables | Yes | Yes | Yes | Yes | Yes |
| Borrower, Lender, Loan purpose, Loan type FE | Yes | Yes | Yes | Yes | Yes |
| Clustering | Borrower | Borrower | Borrower | Borrower | Borrower |
| Adj-$R^2$ | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |

# The role of green banking

| | (1) | (2) | (3) |
|---|---|---|---|
| Treated | 0.028 | 0.027 | 0.031 |
| | (0.27) | (0.25) | (0.29) |
| Treated × 3rd phase dummy | -0.259*** | -0.275*** | -0.276*** |
| | (-3.53) | (-3.64) | (-3.74) |
| Treated × UNEPFI banks | -0.005 | -0.007 | -0.006 |
| | (-0.58) | (-0.97) | (-0.42) |
| 3rd phase dummy × UNEPFI banks | -0.023** | -0.025** | -0.027 |
| | (-2.13) | (-2.30) | (-1.24) |
| Treated × 3rd phase dummy × UNEPFI banks | 0.032* | 0.038** | 0.026 |
| | (1.89) | (2.23) | (0.98) |
| Observations | 46,322 | 45,998 | 18,646 |
| No of firms | 1,232 | 1,227 | 1,045 |
| Borrower, Lender, Loan purpose, Loan type, Year FE | Yes | Yes | Yes |
| Clustering | Borrower | Borrower | Borrower |
| Adj-$R^2$ | 0.91 | 0.91 | 0.91 |

# Loan spreads and CO2 emissions

We estimate the empirical model:

$$\textit{Verified } CO_2 \textit{ emissions}_{it} = a_0 + a_1 \textit{Weighted average loan spread}_{it} + a_2 \textit{3rdphase dummy}_t + a_3 \textit{Weighted average loan spread}_{it} \cdot \textit{3rdphase dummy}_t + F_{it} + C_t + u_{it}$$

# Loan spreads and CO2 emissions

| | Panel A: $CO_2$ emissions at $t$ | | | Panel B: $CO_2$ emissions at $t$+1 | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Weighted average loan spread | -0.558*** | -0.710*** | -0.673*** | -0.479*** | -0.611*** | -0.615*** |
| | (-3.30) | (-3.93) | (-3.68) | (-2.63) | (-3.07) | (-3.06) |
| Weighted average loan spread × 3rd phase dummy | 0.276 | 0.330 | 0.289 | 0.243 | 0.293 | 0.290 |
| | (1.07) | (1.29) | (1.13) | (0.92) | (1.11) | (1.11) |
| Borrower's book leverage | | 2.106 | 2.214 | | 1.691 | 1.850 |
| | | (1.54) | (1.58) | | (1.21) | (1.30) |
| Borrower's asset tangibility | | -1.242 | -1.349 | | -2.060 | -2.158 |
| | | (-0.82) | (-0.87) | | (-1.21) | (-1.24) |
| Borrower's M/B | | -2.624 | -2.917 | | -3.371 | -3.813 |
| | | (-1.06) | (-1.18) | | (-1.44) | (-1.65) |
| Borrower's EBIT | | -1.428 | -0.970 | | 0.255 | 0.834 |
| | | (-0.56) | (-0.37) | | (0.10) | (0.33) |
| EUA price | | | -0.055 | | | 0.036 |
| | | | (-0.31) | | | (0.19) |
| Constant | 14.740*** | 14.660*** | 14.615*** | 14.408*** | 14.677*** | 14.528*** |
| | (21.77) | (12.10) | (11.04) | (20.04) | (11.99) | (10.90) |
| Observations | 503 | 469 | 459 | 487 | 454 | 445 |
| No of firms | 222 | 206 | 200 | 219 | 204 | 199 |
| Industry, Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Clustering | Borrower | Borrower | Borrower | Borrower | Borrower | Borrower |
| Adj-$R^2$ | 0.46 | 0.48 | 0.47 | 0.44 | 0.46 | 0.45 |

# Concluding remarks

- We examine the effects of permit trading on firm financing costs, as well as how these effects shape firm incentives to pollute.
- Once firms anticipate regulatory stringency, market forces work proactively, which reduces corporate loan spreads.
- We identify a fall in loan spreads among treated firms (those participating in the EU ETS) of approximately 25%.
- Had the response in loan spread been neutralized, CO2 emissions would have fallen by 8%.
- Our results also provide an empirical corroboration for any forms of stability reserves in allowance markets.