Pollution permits and financing costs

Fabio Antoniou
Athens University of Economics and Business

Manthos D. Delis
Montpellier Business School

Steven Ongena
University of Zurich, Swiss Finance Institute, KU Leuven, NTNU and CEPR

Chris Tsoumas♣

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Coordinates of the authors. Antoniou is with the Department of Economics, Athens University of Economics and Business (fantoniou@aueb.gr) and Humboldt University Berlin. Delis is with the Montpellier Business School (m.delis@montpellier-bs.com). Ongena is with the University of Zurich, Swiss Finance Institute, KU Leuven, NTNU, and CEPR (steven.ongena@bf.uzh.ch).

♣ Christos has unfortunately passed away. His contribution in developing this project has been substantial and inspiring. We hereby honor his memory. May he rest in peace.

Pollution permits and financing costs

Abstract

Effective environmental policy should consider how the financiers of polluting firms behave. In our theoretical model describing the periods before and after policy implementation, loan spreads for firms participating in cap-and-trade programs are a function of the costs of compliance, the specific features of the permits markets, and the firms' strategic actions. Our empirical analysis exploits the dichotomy created by phase III of the EU Emission Trading System, designed to increase and pass the cost of CO_2 emissions to the polluters. In contrast with possible program intentions, but in line with our theoretical predictions, we find that —starting in 2013— loan spreads fall by almost 25%. We show that this decrease is almost entirely driven by the low permit prices in that period and the firms' proactiveness to store permits, and cannot be explained by the decline in energy prices in that period or other alternative explanations. This dynamic partly undermines the envisioned reductions in CO_2 emissions.

Keywords: Pollution permits; Loan spreads; Bond spreads; EU Emission Trading System; CO_2 emissions

JEL classification: G21; G12; Q5

1. Introduction

A prevalent issue in the current global agenda is the fight against climate change and the transition of energy-intensive economies from fossil fuels to green energy. According to the World Wide Fund for Nature (WWF, 2020), the momentum around dealing with climate change is now “positive”. Polluting firms must have less incentive for releasing CO_2 emissions, so that prices reflect the social costs of carbon. A policy instrument widely implemented in line with the goal to reduce carbon emissions is cap-and-trade, whereby a regulator sets a target by issuing a binding number of permits (also called “allowances”), which individual firms can then trade. Cap-and-trade programs are gaining support in most countries around the globe (ICAP, 2021), as they combine accurate target levels and cost efficiency. On top of that, the revenues can finance green projects.

Importantly, recent arguments call for raising the indirect costs of carbon emissions via less favorable financial terms, especially less favorable lending terms. This indirect channel works through increased loan or bond spreads for polluting firms and sectors. However, most anecdotal evidence suggests that, at least until recently, this has not been the case; banks continue to finance heavily polluting activities (e.g., Banking on Climate Change Report, 2020; Financial Times, 2020; Guardian, 2021).

In line with the discussion on direct and indirect polluting costs, our study asks whether and how tradable pollution permits, along with the specific features and the firms’ responses to the introduction of such markets, affect lending terms. The answers to these questions are important to understand how financiers affect the transition to greener technology, and whether environmental policy design gives financiers the right incentives to promote this transition.

The most well-known fully operational cap-and-trade system is the European Union Emissions Trading System (EU ETS) launched in 2005.[1] In 2013, along with the initiation of phase III, important structural changes occurred in the system. Emission allowances were offered at a decreasing rate of 1.74% per year, and participating firms received a lower proportion of allowances for free; firms had to purchase the rest in the market or via auctions, with few exemptions (European Commission, 2015). This reform aims to increase the cost of carbon for polluters so that they decrease their carbon footprint. Given that the system and the regulatory framework became tighter, implying higher costs for polluting firms, we expect that the corresponding financial terms (reflected in the loan spreads) internalize this risk after 2013.

However, anecdotal evidence of loan spreads around phase III of the EU ETS shows a different picture. Figure 1 plots regression lines for loan spreads of syndicated loans (DealScan) in the treated group (firms participating in the EU ETS) and the control group (nonparticipating firms) before and after the initiation of phase III in 2013. The figure shows parallel trends in loan spreads for the treated and control groups before the program. This is consistent with the flexibility of the syndicated loan market, as lending terms for a loan facility can easily readjust via special covenants, etc. (e.g., Roberts and Sufi, 2009). Moreover, any proactive measures that prepare firms for future tighter regulation, such as the purchase and storage of allowances, does not affect the actual risk of the projects, because firms can pledge these allowances as collateral and easily liquidate them. The rising trends in both lines up to 2013 are mainly due to the higher financing costs induced by the global financial crisis and the European debt crisis. From 2013 onward, loan spreads fall for the treated firms but remain approximately at their 2012 level for nontreated firms. A more detailed focus on the EU ETS market at that time shows that there has been a huge surplus of approximately

[1] In section 2.1 we provide details for the EU ETS.

1.8 billion allowances which led the permits price to a record low of 2.81 euros, partly because the firms' carried allowances from the previous phase (Ellerman et al. 2016). At the same time the European Commission suggested to withdraw 900 million allowances from the market to sustain higher prices, but this proposal was indeed rejected. The latter appears to be equivalent in terms of outcome to a permits price floor, absent at that time in the EU ETS, contrary to the corresponding market in California. According to Jeff Swartz of the International Emissions Trading Association "It [the ETS] may well become an example of what not to do," (Economist, 2013).

[Insert Figure 1 about here]

To analyze this stylized fact and identify the channels that lead to this counterintuitive observation, we first introduce a two-period theoretical model, where its details are fully developed in the appendix. In brief, our theoretical model involves a lender (bank) that lends to a polluting firm in each period. The bank's loan spread depends positively on the probability of the project success, which in turn is adversely affected by the cost of regulatory compliance. We do illustrate, among other things, that the firm has an incentive in the first period to act proactively to deal with potential tighter future regulation, which implies a higher loan spread in the second period. Our model predicts that such actions entail a double dividend. In particular, the firms store permits, hold offsets, or undertake actions with a similar effect to facilitate future regulatory compliance. Notably, these allowances do not affect the actual risk of the funded projects, as the loans are short-lived, and collateral is easily liquidated at any point in the spot market. However, in the second period, stored permits lower the demand for costly allowances in that period and therefore reduce the cost of compliance. This, in turn, lowers lender risk, thereby inducing lower loan spreads in the second period.

In addition, we obtain a collective outcome once we aggregate individual decisions. The oversupply of permits in the second period reduces permit prices, which also drives down compliance costs. Risk is lower, and the loan spread follows. Both the proactiveness in holding allocated allowances (in the first period) and the lower permit prices (in the second period) induce reductions in loan spreads (in the second period), which in turn partly mitigates the effect of tighter regulation.

We empirically examine the results of our theoretical model using a novel hand-matched dataset that brings together data on syndicated loans to European firms (DealScan), firm-year characteristics (Compustat), pollution permits to specific firms (EU ETS), and the Carbon Emission Allowances-EUA price (EEX market). For our preferred specification, we have 45,998 observations, corresponding to 1,227 borrowing firms, from 2005 to 2018.

Our identification strategy examines the behavior of loan spreads before and after the implementation of phase III of the EU ETS program in 2013 for treated firms (those participating in the program) and nontreated firms (those that do not participate). Phase III of the EU ETS program is the most important for lenders because it introduces costly permits for most polluters (until then, the lion's share of permits was freely allocated to specific firms). Our empirical model resembles a quasi-natural experiment (and not a fully randomized experiment) in that the EU ETS selects the participating sectors. However, we show that, given that the selection involves sectors (not specific firms) and that it is fairly easy to adjust loan spreads for syndicated loans (e.g., Nikolaev, 2018; Roberts and Sufi, 2009), all our validation tests show that our setting resembles the outcome of a randomized experiment.

We find that the interaction term between the treatment-control groups and the pre-post 2013 dummy variable has a negative and significant coefficient. Our preferred specification shows that the treated firms have 25% lower loan spreads, which is equivalent to a reduction of 25.4 basis points. To provide a perspective for the reduction in total loan cost, 25.4 basis points corresponds to a €5.56 million reduction in interest expense for loans of average size and maturity.

Besides showing the aforementioned parallel trends even on a year-on-year basis pretreatment, we conduct many tests on the validity of our quasi-experimental approach. Specifically, we slide the treatment period backward (to 2012, 2011, and 2010), use different treatment and control groups (placebo tests), use different dependent variables (most notably the loan amount), and exclude the heaviest polluters (the power sector).

Moreover, our baseline inferences are robust to several respecifications. An important first test is to show that our results fully survive (both economically and statistically) when using firms without operations outside the EU-ETS and thus are not explained by any strategic decision to shift polluting activities abroad. Moreover, using different control variables (especially controlling for significant changes in energy prices during that period) and fixed effects (including year, quarter, and month fixed effects that account for changes in the EUA price or energy prices), different standard errors clustering, differentiating between credit lines and term loans, accounting for possible endogeneity of the EUA price affecting our main inferences, and multiple other tests. For example, in an involved robustness test, we also collect data on corporate bond yields (from SDC Platinum) and show that bond spreads decrease for treated firms from 2013 onward. Thus, bond markets also align their incentives with banks, yielding an overall picture of more competitive financing costs for polluting firms after phase III of the EU ETS policy. In a nutshell, these robustness tests validate our main identification approach and show that our results are not subject to selection problems or any other alternative explanations.

We then identify the main channels for the reduction in loan spreads due to the EU ETS policy. We find that the effect is most negative when the EUA price is at particularly low levels (below 10 euro), which is the case in 2013-2017 (Figure 2). We also identify the firms' proactiveness, especially via allowances storage, as a factor that mitigates the effect of the permits market on loan spreads. In line with a key prediction of our theoretical framework, the decline in loan spreads is much smaller for treated firms that are net buyers of permits in the current year, which are the firms that have not been sufficiently proactive and thus are more exposed to the effects of the program. In contrast, the decline in loan spreads is considerably stronger for firms that are net sellers, implying that they have stored enough permits and, concomitant with the low EUA price during 2013-2017, are considerably less exposed to any policy risk.

In fact, for sufficiently high EUA prices (above 20 euro) and allowances net selling, the positive effect of the program on loan spreads is completely buffered (and thus fully explained). Effectively, and along with our robustness tests, this rules out alternative explanations for our baseline findings, e.g., attributed to financial constraints or frictions (Bartram et al., 2021; De Haas et al., 2021), liability protection (Akey and Appel 2021), or foreign operations (Ben-David et al., 2020) which appear to be orthogonal to our analysis. Indeed, anecdotal evidence in Figure 3 suggests that many firms are proactive net buyers of permits just prior to phase III of EU ETS.

[Insert Figures 2 & 3 about here]

Our analysis, placing financing costs at the heart of the effect of environmental policy, has real implications for the polluting activities of firms. By identifying lower financing costs among polluting firms after the implementation of phase III of the EU ETS program, we essentially show that for the treated firms, decreases in financing costs compensate for increased costs from the program. At the end of our analysis, we document a significant negative association between loan spreads and the treated firms' verified CO_2 emissions, which together with our main findings suggests that the declining CO_2 emissions (as noted by e.g., Bayer and Aklin, 2020) would have in fact been even lower if financing costs did not decline. Our estimates show a further 7.9% decline in CO_2 emissions if there is no decrease in loan spreads.

Related literature. The most related study to ours is Ivanov et al. (2020), that uses the California cap-and-trade bill to show that cap-and-trade policy affects borrowing among private firms. Specifically, treated firms face lower access to permanent forms of bank financing, higher interest rates, and higher participation of shadow banks in their lending syndicates. Especially the result on higher lending rates, despite seemingly at odds with our finding, is in fact complementary. We focus on the EU ETS where we explore the specific characteristics of the market at hand and argue that the market design accounting for firms' incentives is important to obtain the desired outcome. We do show that if permits prices are very low (in our case below 20 euro, whereas in the California case there is a lower cap) and there is abundance of permits in the absence of a price floor (in California this was not the case), not only the policy is not priced in, but it produces opposite results. Moreover, in our paper, we identify an economic mechanism, whereby firms' proactive behavior anticipating a tighter framework in regulatory programs can lower firms' funding costs, which can then backfire against the initial regulatory intentions. This is a finding with novel policy implications, related to the potential ineffectiveness of cap-and-trade policies when they are not complemented by restrictions on permit supply and a price floor. Further, our analysis uniquely places the whole of the financial sector (both loans and bonds markets) into this framework.

Our paper contributes to two additional strands of literature. The literature dealing with ex-post evaluation of the efficacy of the EU ETS in terms of pollution reduction or its effects on EU firms' competitiveness is not satiated and it is "still very much a work in progress" (Martin et al., 2016). The EU ETS program results in significant emission reduction (e.g., Bayer and Aklin, 2020; Ellerman et al., 2016; Martin, et al., 2016;). Several studies examine the effect of the EU ETS on competitiveness and find no evidence of an adverse effect for the first two phases when allowances are allocated for free (e.g., Abrell, 2011; Bushnell, et al., 2013; Commins et al., 2011; Joltreau and Sommerfeld, 2019; Martin et al. 2016,).

Martin et al. (2014) focus on the compensation rules proposed under phase III of the EU ETS, where carbon-intensive and trade-exposed industries receive free allowances; they argue that this policy is inefficient. Antoniou and Kyriakopoulou (2019) show that introducing the EU ETS (phase I) led regulators to increase local pollution in order to promote exports. Hintermann (2010) focuses on the drivers of the allowance prices in phase I and argues that, although prices are not initially related to marginal abatement costs, this inefficiency is corrected later. Hintermann et al. (2016) find that the EU ETS market matures in phase II and that banking allowances induces the market to incorporate the future scarcity of allowances, which our analysis also accommodates for. On top of the well-known motives for accumulating and storing permits (e.g., Considine and Larson, 2004), we unveil a strategic incentive to withhold permits. De Jonghe et al. (2020) exploit the tightening EU ETS regulation in 2017 and show that high permit prices in emission-trading schemes improve the emission efficiency of highly polluting firms. Aside from the EU ETS, Ben-David et al. (2020) document that large public firms headquartered in countries with strict environmental policies perform their polluting activities in countries with weaker policies.

The second strand relates to the emerging literature on green finance. De Haas and Popov (2019) review this literature and summarize two main arguments on the role of green banking.[2] First, banks are relatively ineffective in limiting pollution because they are conservative in financing green investments, especially due to the underlying erosion of existing collateral (Minetti, 2011) and the fact that new technologies are usually intangible assets without collateral value (Hall and Lerner, 2010). Andersen (2017) focuses on external borrowing and shows that credit constraints significantly increase pollution emissions. Second, the right incentives might have only been in place since the 2015 Paris agreement or due to regulatory initiatives to relax

[2] De Haas and Popov (2019) show that pollution is lower in countries with more equity-funded investments.

credit constraints. In a recent study Bartram et al. (2021) explore the impact of the California cap-and-trade program and illustrate that financially constrained firms shift emissions from California to other states where they have similar underutilized plants. De Haas et al. (2021) attest that both financial frictions and managerial constraints slow down firm investment in less polluting technologies. Akey and Apel (2021) highlight the moral hazard problem associated with the parent's firm limited liability protection for some subsidiaries. Our results complement these findings and provide a new channel through which the firms can strategically deal with future tighter regulation instead of avoiding it, which in turn ensures more favorable financial loan terms for their companies.

Using syndicated loans data, Delis et al. (2019) show that banks price in the risk that fossil fuel reserves will become unburnable only after 2015, and not to the extent that the extra cost of credit covers potential losses. Similarly, Degryse et al. (2021) use syndicated loans and show that firms' are rewarded for being green in the form of cheaper loans--however, only when borrowing from a green consortium of lenders, and only after the ratification of the Paris Agreement in 2015. Levine et al. (2018) show that credit constraints must relax to observe a decline in emitted toxic air pollutants. In a similar vein, Götz (2018) concludes that firms facing fewer financial constraints implement more environmentally friendly activities and thus reduce pollution. Very recently, green finance initiatives ask for depositor discipline among banks financing polluting activities (e.g., Financial Times, 2020; Guardian, 2021; Homanen, 2018).

Organization of the study. Section 2 provides details about the EU ETS and illustrates the theoretical model, along with its key results. In section 3 we discuss the data. In section 4, we discuss the empirical identification and our results. Section 5 concludes the paper and offers policy implications. In appendix A1 we present more details on the three phases of EU ETS program, in appendix A2 we provide a model for our theoretical findings, and in appendix A3 we include additional empirical results.

2. Theoretical framework

We first introduce a brief description and history of the European Union Emission Trading System (EU ETS) in its first three phases. Then we refer to our theoretical foundation adapted to the EU ETS framework, which acts as a reference point for our empirical analysis. The analysis is based on a theoretical model developed in the appendix A2.

2.1. The EU ETS program

The EU ETS is a cap-and-trade system introduced in the EU countries in 2005 as an instrument to curb greenhouse gas (GHG) emissions, mainly CO_2 emissions. It constitutes the world's largest GHG trading system, covering many sectors in 31 countries (the EU 27 plus Iceland, Lichtenstein, Norway, and the United Kingdom) with more than 11,000 firms. The program sets a cap in order to reach the target for emissions, and it establishes trading permits to achieve this target in the most cost-effective way. The system has three phases up to 2020. Phase I covers 2005-2007, phase II covers 2008-2012, and phase III 2013-2020.

Phase I was a pilot phase to ensure that the EU ETS functioned effectively ahead of 2008 so as to comply with the commitments under the Kyoto Protocol. In phase II, firms could also use emission-reduction units generated under the Joint Implementation (JI) and the Clean Development Mechanism (CDM) to fulfill their obligations under the EU ETS. On top of that, a firm could bank (store) these allowances for the next phase. Indeed, by the end of phase II, there was a surplus of approximately 2 billion allowances (EC, 2015). However, the price of permits did not fall to zero in 2012 as it did in 2007, because firms stored allowances for the future.

Phase III has brought important changes in the market. A notable change has been the gradual decrease of emission caps, reducing the number of allowances available to businesses covered by the EU ETS by 1.74% per year. Only a proportion of these allowances was grandfathered to producers. The manufacturing industry received 80% of its allowances for free in 2013, but this proportion decreased gradually year-on-year, down to 30% in 2020 (other than for sectors deemed exposed to carbon leakage). Since 2013, power generators (with very few exceptions) must purchase all their allowances. Thus, phase III implies higher costs for producers, as they have to abate the extra emissions or resort to new allowances either from the market or through auctions. Currently, phase IV involves tighter caps to satisfy the 2030 targets for CO_2 emission reductions.[3] Appendix A1 provides further detail about the EU ETS, also reflecting our choices in the theoretical and empirical models.

2.2. Theoretical foundation

The firm's problem. We note that the firms analyzed here correspond to the treated firms in our empirical analysis, where treated firms are polluting firms that participate in the EU ETS. The firm is endowed with a number of free allocated (grandfathered) emission allowances/permits set by the regulator. Yet, the firm must abate its excess emissions through private abatement technology which allows adherence to the binding level of grandfathered emissions; alternatively, it may purchase extra allowances from the tradable permits market at a given price, or use other offsets and stored allowances. Notably, free allocated allowances and purchased or stored allowances are

[3] A detailed analysis of the EU ETS is in European Commission (2015), ICAP (2021), and references therein.

perfect substitutes. In order to operate, a firm needs access to bank loans at an interest rate set by the bank.

The bank's problem. A competitive bank provides a loan to the firm at a unit interest rate. The projects that the bank finances are uncertain, and the probability of success depends on the firm's expected profits, which, in turn, are adversely affected by the level of regulation. Thus, tighter regulation reduces the probability of success.

The permits market. The market-clearing condition equalizes the aggregate demand for permits from all sectors to the total supply, i.e., cap, set by the regulator which is exogenous in our analysis. Naturally, we expect that a reduction (increase) in the supply of allowances, leads to a higher (lower) price. Similarly, if the demand for allowances from firms increases (decreases), prices surge (fall).

Timing of the game. We study a two-period game where each period has two stages. In the *first* stage the competitive bank sets the interest rate to the firm. In the *second* stage the firm selects its production, number of permits, and the number of stored permits (if any).

In terms of the empirical model in section 4, the first period corresponds to the period prior to 2013 (when phase III started), and the second refers to the period after 2013 when our treatment took place.

Main results

Our main results are derived in appendix A2. We study the effect on bank loan spreads implied by interest rates, as we change the number of costly allocated allowances, the number of stockpiled allowances, and the permits price. Central to our analysis (main hypothesis) is determining how loan spreads change between time periods that correspond to the transition from phase II to phase III.

Regarding the effect of costly allocated allowances, we obtain the following.

Result 1: *When the number of free allocated allowances increases, loan spread decreases.*

Free allocated and purchased allowances are perfect substitutes in terms of abatement reduction. The negative relation that we establish in Result 1 comes from the fact that when more free allowances are allocated, *ceteris paribus*, the firm must acquire from the market fewer rights to emit. Thus, a higher number of free allocated allowances reduces the firm's compliance costs, which in turn implies a higher probability of project success. The bank faces a less risky project and requires a lower loan spread. Conversely, following a similar rationale, it follows that the higher the number of costly allocated allowances, the higher the loan spread.

Next, we focus on the effect of the number of stored allowances on the loan spread.

Result 2: *When the number of stored allowances increases, loan spread decreases.*

Stored allowances economically are equivalent to free allowances in the period in which the firm utilizes them. A higher number of stored allowances decreases the necessity for new allowances because these two are perfect substitutes. As a result, the firm's costs of compliance are lower, implying a higher probability of success, which leads to a lower loan spread.

We now focus on the effect of the permits price over the loan spreads. The permits price is an indirect measure of the regulatory policy tightness.

Result 3: *When the permits price increases, loan spread increases.*

An increase in the price of permits increases the firm's costs if the firm is a permits buyer. This decreases the firm's expected profits, and thus the loan becomes riskier for the bank, which charges a higher loan spread.

The main focus (and main hypothesis) of this paper is the change in loan spreads between periods (phases II and III of the EU ETS).

Main Hypothesis: *Ceteris paribus the loan spread is lower in period 2 than in period 1.*

To understand this result, we focus on a strategic incentive present in the first period of the game and at the same time exploit Result 2. The firm stores a strictly positive quantity of permits in the first period exactly because these allowances can reduce the second-period interest rate (see Result 2). Remarkably, this holds true even if we abstract from any additional motives such as arbitrage or cost smoothing attributed to intertemporal differences in the prices of allowances. This strategic incentive is absent in Ivanov et al. (2020) since the Californian market was launched in 2013, whereas in the EU ETS, the year 2013 has been a year of reform, the details of which were known prior to the implementation and thus the firms could prepare accordingly by carrying permits from phase II to phase III.

This analysis captures a direct effect at the firm level. Thus far, we have abstracted from any general equilibrium effects in the permits market, i.e., price is treated as an exogenous variable. Yet, we can argue descriptively the additional general equilibrium effects through the permits market, focusing on Result 3 that describes how permits price changes affect the loan spread. Given that in equilibrium there is positive storage of permits, we end up with an oversupply of permits in the allowances market in the second period. Once this effect is aggregated for every sector of the economy and every country, it leads to a permits price drop. This, in turn, implies an even lower loan spread.

In terms of the EU ETS, it seems that both things occurred. First, firms prepared in the period prior to 2013 for the expected tighter environmental policy of phase III which also involved auctioning more allowances and less grandfathering. Second, when phase III commenced, firms faced a laxer framework reflected into lower permit prices exactly because they prepared for it. As previously presented, in the beginning of phase III the market faced a surplus of 1.8 billion allowances. The second effect reinforced the first, and these two together outweighed the opposite pressure on loan spreads created by tighter policy. Thus, the net effect resulted in lower loan spreads in phase III.

Figures 2 and 3 illustrate our claims. Figure 3 shows that purchases of allowances increase (compared to sales) while approaching phase III. There is also evidence of a decoupling between surrendered and allocated allowances during phase III. The evolution of the permit prices in Figure 2 is also consistent with our general equilibrium analysis. In particular, the permits price is lower in the post-treatment period (remains below 10 euro until 2018). Both stored allowances and lower permit prices lead to the theoretical prediction that the loan spread in the post-treatment period should be lower.

Related caveats

A natural query that might arise from the main result regards how the transition between phases affects emissions. This is generally difficult to identify because many effects are simultaneously at play. On one side, regulation in the second period (phase III of the EU ETS) is tighter, which leads to lower emissions. On the flip side, lower interest rates may lead firms to request bigger loans and expand their activity. For simplicity and to preserve the essence of our main results, this is not included in the current model. However, it is natural to expect that once the firm expands its activity, it tends to increase production and the related level of emissions. Thus, the aggregate effect on emissions is ambiguous. We provide a counterfactual in section 5 that accounts for the negative effect that the drop in interest rate has on the reduction of CO_2 emissions.

3. Data

We use data from the European Union Emissions Trading System (EU ETS).[4] This database comprises, among other things, the number of allocated allowances, surrendered allowances, verified CO_2-equivalent emissions, and CO_2 emission allowance transactions.[5] The data covers all three phases of the program at a yearly frequency for 2005-2018. It includes 15,757 stationary installations and aircraft operators participating in the program, belonging to 10,907 account holders. More important, EU ETS provides details for each account holder (i.e., the name, address, city, and country of the holder that owns each installation) and is responsible for providing the data to the regulatory authority.

Using this information, along with information for the account holder's ultimate parent company from the Dun & Bradstreet online database, we hand-match account holders to listed firms in the Compustat Global and North America databases. We identify the Compustat's gvkey for 4,427 installations / aircraft operators owned by 2,221 account holders that ultimately belong to 1,042 unique listed firms.

In the next step, we calculate at the firm-year level *Allocated allowances* and *Verified* CO_2 *equivalent emissions* as the sum of the respective variables for all installations belonging to that listed firm in a given year. We perform a similar calculation for the allowance transactions by first adding the number of acquired allowances from all transactions of each installation in a given year and then subtracting the total number of transferred allowances of the same installation in that year. We next sum this variable across all installation(s) at the firm-year level and denote it as *Bought / sold allowances.* This variable captures a firm's net position as a buyer (+) or a seller (-) of allowances in the CO_2 emission allowances EEX market that year. We also construct *Costly*

[4] This data are freely available from the European Union Transaction Log (EUTL) database at https://ec.europa.eu/clima/ets.
[5] Transaction-level data are available for 2005-2016 and are in the EUTL database by the European Energy Exchange (EEX) market for each installation, with information for the acquiring and transferring installation per transaction.

allocated allowances, which equals 1 for an EU ETS program-participating firm in a sector with costly allocated allowances and 0 otherwise (i.e., for firms belonging to the free allocation allowances sectors).[6]

Subsequently, we match the identified EU ETS listed firms to DealScan's syndicated loan database. We consider only syndicated loans to borrowers in the EU ETS countries for 2005-2018. This matching results in 412 distinct firms that borrow syndicated loans, corresponding to 25,176 loan facilities for 298 unique, listed, ultimate owners participating in the EU ETS program.[7] Accordingly, the dummy variable *Treated* equals 1 for loan facilities matched with listed EU ETS firms, and 0 otherwise. In the appendix section A3, we include details of the control group. We show in placebo tests that changing the control group does not affect our inferences. Because our focus is on phase III of the EU ETS program, we also define *3rd phase dummy*, which equals 1 for 2013-2018 and 0 otherwise.

We use an array of loan-level variables from DealScan, borrower and lender characteristics from Compustat, borrower and lender country characteristics from the World Development Indicators database, as well as the borrower's country electricity price from Eurostat on a biannual basis (alternatively using the crude oil price does not affect our inferences). Table 1 provides details about the variables in the analysis, along with their sources. Depending on data availability for control variables, the number of observations (loan facilities) ranges from 132,209 to 18,646 in our

[6] Sectors with free (as opposed to costly) allocated allowances in phase III of the EU ETS program are those exposed to a significant risk of carbon leakage. The information is from the commission's December 29, 2009, decision, available at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:001:0010:0018:EN:PDF. These sectors are defined at the NACE-4 level. We map the NACE-4 codes to SIC codes using sector descriptions and the full list of SIC codes available at http://www.ehso.com/siccodes.php. Whenever there is a discrepancy in sector definitions between the two lists, we drop the relevant sector from the list.

[7] To ease selection bias concerns, we consider whether the 412 firms identified in DealScan have similar characteristics with the 1,042 firms in Compustat. Comparing the firm-year variables in the two groups, we find statistically insignificant differences for all variables, especially for the emissions and permits-related variables (none of the differences are statistically significant at the 5% level; only the difference in the tangibility ratio is statistically significant at the 10% level, being larger in the DealScan sample).

baseline results. Table 2 reports basic summary statistics for the sample in our preferred specification (45,998 observations). Appendix A3 provides details for the number of observations by borrower country and the number of treated and nontreated observations by year; it also reports the number of treated observations and that of distinct treated firms in our preferred specification. Importantly, we discuss the sample means for the treated and control groups and show that they are economically comparable across the vast majority of variables. Statistically significant differences across *Borrower's size* and *Borrower's M/B* are fully controlled in all our specifications, while further tightening our sample to match similar firms across these dimensions produces economically stronger coefficients on our main variables (at the expense of degrees of freedom).

[Insert Tables 1 & 2 around here]

4. Empirical identification and results

4.1. Identification method

Our benchmark model to identify how the EU ETS program affects loan spreads is the following:

$$Loan\ spread_{libt} = a_0 + a_1 Treated_{it} + a_2 3rd\ phase\ dummy_t + a_3 Treated_{it} \times 3rd\ phase\ dummy_t + L_{lt} + F_{it} + B_{bt} + C_t + u_{lit}. \quad (1)$$

In equation (1), *Loan spread* is the log of the spread over LIBOR (plus any facility fee) for syndicated loan *l* from bank *b* to firm *i* in year *t*. *Treated* is a binary variable equal to 1 if the borrower participates in the EU ETS program (0 if the borrower does not participate). This variable distinguishes the treatment from the control group. The actual treatment takes place in the beginning of 2013; thus, *3rd phase dummy* equals 1 for 2013 to 2018 and 0 for 2005 to 2012.[8] Equation (1) also includes vectors of the loan (*L*), firm (*F*), bank (*B*), and country (*C*) control variables.[9] Finally, *u* is the stochastic disturbance.

Our focus is on a_3, which shows the treatment effect of initiating phase III of the EU ETS program. A negative and statistically significant a_3 shows that banks charge lower spreads to treated firms from 2013 onward, compared to treated firms before 2013 and nontreated firms (both before and after 2013).[10]

Our analysis represents a quasi-natural experiment, in the sense that all observed and unobserved factors related to loan spreads similarly affect the treatment and control groups. The reason we use the term *quasi-natural experiment* is that theoretically our analysis has some elements of nonrandom treatment assignment: we rely on "conditionally exogenous" variation (e.g., Glaeser and Guay, 2017).[11] We have conditionally exogenous variation because the EU ETS classifies (selects) firms into treatment and control groups based on sector. However, this is a "weak assignment" because the EU ETS does not select individual firms; it selects the sectors to which these firms belong (more discussion in Appendix A1). Naturally, the assignment of firms into sectors is predetermined. Thus, our experiment also has characteristics of a randomized experiment, and we actually show that these characteristics are particularly strong in our data set.

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[8] There are few firms which join the program after 2013. For these firms *Treated* = 1 in the year they join. Thus, we maintain the *t* subscript on *Treated* and note that the inclusion of year fixed effects does not drop the main term on *Treated*. In contrast, *3rd phase dummy* drops out (we leave it visible in equation (1) for symmetry).

[9] We also distinguish between borrower-country characteristics and lender-country characteristics, given that a large number of lead banks and firms are from different countries.

[10] Agarwal et al. (2015) uses a similar empirical design; that study explores the effects of the CREDIT card act during the distinct implementation phases of the act. In a similar vein, Fabrizio et al. (2007) exploit the different phases of the transition from cost-of-service regulation to a market-oriented environment for U.S. electric-generating plants.

[11] "Conditionally exogenous" variation is the result of an intentional process that classifies firms into treatment and control groups based on some nonrandom variation (e.g., regulation that classifies firms into treatment and control groups based on state borders). The researcher uses this variation to estimate causal effects under the assumption that assignment is exogenous with respect to the outcome of interest, conditional on the empirical model's controls. In contrast to plausibly exogenous variation, random variation is the result of intentionally classifying firms into treatment control groups based on randomly generated variation (e.g., a researcher rolling a die to classify test subjects).

Specifically, we conduct three tests to verify that our analysis resembles the characteristics of a randomized natural experiment. First, we show several validation tests, including parallel trends and placebo tests (e.g., Lechner, 2010). Figure 1 shows parallel trends pretreatment, and in Figure 4 we enhance this figure by using nonparametric local regression lines, so as to observe in more detail the time evolution of *Loan spread* of the two groups, especially in the pretreatment period.[12] We use the sample size of our most baseline regression (to be reported in Table 3). There is a small decrease in the gap between treated and nontreated firms in 2009, but the trends remain almost parallel. Parallel trends clearly break in 2013: *Loan spread* falls for the treated firms but remains approximately at its 2012 level for the nontreated firms.

[Insert Figure 4 about here]

Second, we provide results for two falsification (placebo) tests. In a standard test, 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. Theoretically, this should also be the case as the syndicated loan market is particularly flexible in readjusting the lending terms via covenants (even for the same loan package).[13] This flexibility in reshaping debt contracts, along with the fact that firms can pledge stored allowances as collateral and easily liquidate them, explain why banks do not increase loan spreads for treated firms before 2013; they can actually price the risk associated with EU ETS in 2013 onward if they have to. Moreover, we include a different control group of firms that are not in the EU ETS program (e.g.,

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[12] Treated firms consistently have lower loan spreads during our sample period. The reason is mainly their larger size (along with the larger loans and larger syndicates). Once we control for size or even by using firm fixed effects, this first-differencing result disappears.

[13] Roberts and Sufi (2009) precisely study this issue. Nikolaev (2018) presents the two main theoretical mechanisms behind the scope for renegotiating private debt contracts that increase the demand for monitoring: a) the presence of ex-ante exogenous uncertainty due to large number of future contingencies, which are difficult to incorporate in the initial contract; and b) the fact that the outcome is also shaped by the agents' actions. Nikolaev (2018) finds that 37% of firm-year observations have at least one renegotiation. The relevant figure for renegotiations in European countries is 18.25%, but the option to renegotiate is indeed strongly present (Godlewski, 2020).

U.S. firms in nontreated sectors) and show that our results are almost intact. Similarly, we use a different treated group of firms in the treated sectors from Asia or Switzerland that are not in the EU ETS program; our results collapse.

Third, and related, we recognize that the key way to show that our quasi-natural experiment resembles a randomized experiment is that including controls does not significantly affect a_3 (e.g., Angrist and Pischke, 2009). Indeed, this is the case in our empirical analysis, especially when adding important controls such as the EUA price, the number of allocated allowances, whether a firm faces allowance costs, etc. Thus, even controlling for the key features of the EU ETS does not affect a_3, implying that any relevant selection problems do not affect loan spreads of the treatment group relative to loan spreads of the control group. All in all, we argue that this holds mainly because the EU ETS scheme is designed for (pollutant) sectors, not firms, and because loan spreads very easily adjust when events are anticipated (such as phase III of the program).[14, 15]

A separate potential problem with any such model is serial correlation in the errors. Given the large number of cross-sectional units (firms) in our sample, firm-level clustering alleviates this problem (Esarey and Menger, 2019). Further, besides using several controls, we saturate equation (1) with four types of fixed effects. First, we use year fixed effects, which implies that *3rd phase dummy* drops from equation (1). The year fixed effects control for time-varying effects common to all banks and firms. Importantly, these effects control for the effect of crises years and other regulatory initiatives (especially bank regulations) on loan spreads. Along these lines, important

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[14] Below we show results from an additional matching test, as in Stiebale (2016), following the empirical approach and relevant discussion in Calel and Dechezleprêtre (2016).

[15] Other potential caveats of quasi-experiments include the stable unit value treatment assumption (SUTVA) and the perfect compliance assumption (Glaeser and Guay, 2017). Violation of the first assumption relates to the possibility that the status of the treated group affects the loan pricing of control group counterparts and vice-versa. Violation of the second assumption relates to the possibility that firms are treated in the pretreatment period, whereas only the treated firms are treated in the post-treatment period. In our setting it is highly unlikely that these hold, as our tests also show.

controls are borrower country and lender country average country-year spreads, which capture trends and developments in the country-year economic environments. We also use bank and firm fixed effects, which control for time-invariant bank and firm characteristics. The firm fixed effects in particular render the gap in the loan spread between the treated and control groups statistically insignificant (as shown on the main term *Treated* in our estimated specifications). On top of that they account also for other intrinsic differences such as differences in the transaction costs of the firms participating in the permit markets that can potentially affect their storage behavior (Stavins, 1995). At the loan level, we use loan type and loan purpose fixed effects. The loan-type fixed effects, in particular, control for the important difference between term loans and credit lines.[16]

4.2. Baseline results and robustness

Table 3 reports our baseline results. In line with Figure 1, the estimate on *Treated* × *3rd phase dummy* (a_3) is negative and statistically significant at the 1% level. Column 1 only includes our key variables; in columns 2 to 5, we sequentially add groups of controls (loan controls, borrower controls, macro controls, and lender controls). In line with our discussion in section 4.1, the fact that adding controls yields a remarkably stable a_3 (in terms of statistical and economic significance) is a good indication of the validity of our identification approach; it also shows that our findings are not subject to a bad controls problem (e.g., Angrist and Pischke, 2009).[17] The year fixed effects control for annual changes in potentially confounding effects such as the EUA price,

[16] The key difference is that term loans usually do not include fees, and they feature weak covenants, longer maturities, and low amortization, which require high capital requirements for banks. Therefore, to compensate for pipeline risk, we expect banks to charge a premium on these loans. As such, banks many times sell these loans to institutional investors (in fact, term loans are structured to appeal to institutional investors). Even though we control for loan types in our baseline results, we also split our sample between term loans and credit lines in robustness tests.

[17] This is more so, as adding controls yields a significant drop in observations, suggesting the results are very similar for significantly smaller samples.

energy prices, etc. (we further inquire into this below). Adding instead quarter or month fixed effects does not affect our inferences. Moreover, the firm fixed effects render the main term *Treated* statistically insignificant, thus placing the treatment and control groups at a level playing field (opposite to the illustration on Figures 1 and 3). Also, the coefficients on the control variables are consistent with expectations and the extant literature (e.g., Delis et al., 2019; Hasan et al., 2014). Especially the firm controls are important to insulate our results from the effect of financial constraints (e.g., Bartram et al., 2021).[18]

[Insert Table 3 about here]

Using the results from specification 4, we find that after 2013 the treated firms borrow at a 25% lower spread on average compared to the untreated firms.[19] This effect is economically large. The mean spread in our sample is 101.5 basis points (inverse log of 4.62), implying that a 25% decrease yields a decrease in spread of 25.4 points. For a loan of average size (560,870,164) and maturity (3.9 years), a 25.4 basis point decrease implies a reduction in interest expense of 5.56 million per loan (560.9×3.9×0.254%).

In our first set of robustness tests, we examine the validity of our empirical model through three key processes discussed in the literature (besides showing parallel trends in Figure 1). First, we perform a falsification test using a treatment group that sequentially includes years 2012, 2011, and 2010 (results in the first three columns of Table 4). When using 2012 as the cutoff point (column 1), we add the 2012 observations in the treatment group as false treated along with the actual treated observations from 2013 onward; a_3 is statistically significant at the 5% level, but the

[18] To this end, adding more firm controls such as the firms' Tobin's q, credit ratings, long-term and short-term debt, dividend ratios, tangibility ratios etc., does not affect our inferences (it only leads to smaller samples).
[19] We calculate this effect, as well as all effects throughout the results where the estimated equation includes a log-transformed dependent variable and a dummy explanatory variable, using the formula $100x(exp(a_3 - V(a_3)/2) - 1)$ (Halvorsen and Palmquist, 1980; Kennedy, 1981).

economic effect is considerably lower compared to the baseline models. When using 2011 (column 2), we add observations from two more years (2011 and 2012) and a_3 further loses statistical significance at the 10% level, because more false treated observations are added. When using 2010 as the cutoff point (column 3), we add observations from three more years in the treatment group (2012, 2011, and 2010), and a_3 is statistically insignificant. These results clearly show that the period from 2013 onward drives our baseline findings and that adding false treated observations from pre-2013 gradually makes the statistical significance disappear.

In columns 4 and 5 of Table 4, we use different treated firms that belong to the same pollutant sector but are not affected by the 2013 EU ETS program (thus they count as false-treated). In column 4 we use Australian and Asian firms, and in column 5 we use Swiss firms. The control group includes EU firms that are not affected by the EU ETS program. Intuitively, we find that a_3 in both specifications is statistically insignificant.

Perhaps the most important of these tests is that our baseline results remain unaffected when using a different control group (i.e., a control group other than the unaffected EU firms receiving syndicated loans). In column 6 of Table 4, instead of the European firms, our control group is the equivalent U.S. firms. Our findings show that a_3 remains negative and statistically significant. Importantly, a_3 shows a 24% reduction in the loan spread, which is very close to the 25% decrease in the equivalent specification of Table 3.

[Insert Table 4 about here]

Another falsification test concerns using different dependent variables that should not be affected by the treatment. This is also a test on whether our baseline results suffer from a bad controls problem (adding controls that might themselves be affected by the treatment). The variable more likely affected by the EU ETS policy is loan amount, especially if firms alter their investments to decrease emissions or require extra financial capital to deal with increased costs from regulation. In column 7, we report the results using *Facility amount* as the dependent variable. We find that a_3 is indeed statistically insignificant.[20] Finally, many empirical corporate finance studies exclude financial and real estate firms from their samples. However, as we show in the Appendix, there are firms in these industries that participate in the program. Typically, these are financial firms that belong to a polluting global owner. Excluding them does not affect our inferences (results in column 7). None of the rest of our empirical tests are affected by their inclusion.

We next show that our baseline results are robust to using only the observations for firms without subsidiaries outside the EU and for controlling for potentially important confounding factors/ features of the EU ETS program: the electricity price, which fell significantly post-2013; permit prices, which were particularly low (below 10 euro) during 2013 to 2017; and the allowances characteristics. However, it is important to note that using year fixed effects in Table 3 controls for these effects. Further, adding quarter or even month fixed effects does not affect our baseline findings in Table 3.

Using only firms without foreign subsidiaries is an important robustness test, as it insulates our results from firms strategically choosing the location of their production to avoid the introduction of costly permits in 2013.[21] We report the results in the first column of Table 5 and find that the coefficient estimate on the interaction term is consistent with the respective in Table 3. Thus, our baseline result is not explained by the strategic choice of firms to shift polluting production outside the EU-ETS countries.

[20] This is also the case for other loan controls used as controls (results are available on request).
[21] Ben-David et al. (2020) show the importance of this strategic firm behavior using microdata about multinational firms' CO2 emissions across countries.

Another concern is that the level terms of permit prices and their characteristics (i.e., their number, whether they are costly, and the number of stored allowances) might affect a_3, especially in light of the significant developments highlighted in Figures 2 and 3. In our baseline regressions, these effects are absorbed by the year fixed effects (information on allowances is available annually), which we drop here to examine changes in our baseline results.[22]

In column 2 of Table 5, we include the EUA (permits) price, which carries a statistically significant coefficient (at the 1% level) without substantially affecting the coefficient on *Treated × 3rd phase dummy*. Our inferences are very similar when including *Costly allocated allowances* (column 3), *Allocated allowances* (column 4), and *Bought / sold allowances* (column 5).[23] All these variables enter with a statistically insignificant coefficient, which shows that their unconditional (to the treatment) effect is insignificant. In column 6 of Table 5 we include all variables from specifications 1 to 4 in the regression, and this yields the same inferences. We show below that these variables are important when we include their effect conditional on the treatment (in triple interaction terms).

In column 7 we add as control variable the electricity price, which carries a positive and statistically significant coefficient. This is intuitive because higher electricity prices increase production costs for both the treated and control groups. Energy (both electricity and oil prices) decreased significantly in 2014 and 2015 and this analysis is a buffer against the alternative explanation that our results on the treatment variable are due to these developments in energy prices. However, including the electricity price (or the crude oil price in untabulated results) does not affect our main inferences or the estimates on the other permits-related variables. Further,

[22] In appendix A3, Table A1, we replicate Table 3 without year fixed effects and show that our results remain very similar. In the last column of that table, we also add lender × year fixed effects, which just decrease the degrees of freedom without affecting our main interaction term or adding considerably to the adjusted R-squared.
[23] The *Bought / sold allowances* variable is available up to 2016, which explains the smaller sample.

including the electricity price (crude oil price) in an interaction term with the treatment dummy (along with the main variable) gives a negative and statistically significant coefficient (as expected due to the decline in energy prices post-treatment. However, our main interaction term remains negative and statistically significant at the 1% level (results available on request).

Controlling for the EUA price in the regressions of Table 5 limits the possibility that the effect of the introduction of costly permits in 2013 is simply driven by the EUA price. We delve deeper into any potential direct effect of the EUA price on the coefficient a_3, also considering that research on the determinants of the low EUA price in the period 2011-2017 is ongoing (e.g., Chung et al., 2018). Specifically, in the last column of Table 5, we consider whether the EUA price is endogenous to unobserved time-varying characteristics of the permits market (or other characteristics of the European economy outside those we control for), and the omission of these characteristics also affects a_3.

We do so by instrumenting the EUA price and using its predicted value in equation (1) (2SLS model). As instrument, we consider climate variables (e.g., country-month means or standard deviation of temperature, wind speed, and precipitation). We resort to the country-month standard deviation of wind speed obtained from the Copernicus database (the equivalent country-month mean also works but the standard deviation is stronger). The relevance condition suggests that stronger winds (producing higher standard deviation of wind speed) increase wind power and lower the EUA price. Our first stage results, reported in the lower part of column 8 of Table 5, show that this is indeed the case with the instrument passing both the underidentification and the weak identification tests. For the exclusion condition, our assumption is that there is no direct effect of wind on loan pricing (rather this effect will be via the energy prices reflected in the EUA price).[24]

[24] Further controlling for oil or coal prices in the 2SLS model does not affect the results.

This is plausible because it is unlikely that loan prices are different in windy or less windy months. Importantly, the second-stage results show an estimate of a_3=-0.309, which is almost the same with the estimate of -0.311 in column 7 (estimation via OLS).

[Insert Table 5 about here]

Another potential criticism of our baseline findings is that our results are an artifact of specific characteristics of the syndicated loan market and do not extend to financing from other markets. Our theoretical framework models banks, but the underlying idea easily extends to bond financing. The premise is that corporate bond buyers would also observe the lower risk post-treatment and determine corporate bond yields for treated and nontreated firms accordingly. To test this hypothesis, we conduct an extensive robustness test using bonds data from SDC platinum. We define all variables in the last panel of Table 1.

Table 6 reports the results using a specification similar with that in Table 3 and bond spreads as the dependent variable. The results are remarkably close to those in Table 3, showing an approximately 30% decline in corporate bond spreads for the treated firms in the post-treatment period (vis-à-vis the control group). This finding is consistent across the specifications of Table 6 that include different controls and different fixed effects.[25]

[Insert Table 6 about here]

Another important robustness test in empirical models involving natural or quasi-natural experiments is the type of standard-error clustering. In our setting, serial correlation might be the result of (i) lending by the same lead bank, (ii) loans originated in the same year, and (iii) lending to the same industry. In appendix A3, Table A2, we cluster standard errors by bank and firm; bank,

[25] Of course, this sample is smaller and does not allow the inclusion of firm fixed effects. Further, the nature of the market is such that we cannot include lender fixed effects. Given the inferior sample, we do not explore the bond market further and leave any related issues (such as loan-bond substitutability) for future research (potentially involving more detailed and not widely available data).

firm, and year; and bank, firm, year, and industry. We find that a_3 remains statistically significant at the 1% level across all three specifications. We further examine results when using observations only for lead arrangers. These sensitivity tests guarantee that our findings are not due to relevant within cluster correlation. The results in appendix A3, Table A3 show that our results remain statistically significant at the 1% level.

Firms in the power sector are the heaviest polluters and do not receive free allowances from 2013 onward. Therefore, these firms have the highest environmental risk, and we expect that the decrease in loan spreads post-2013 is stronger when we exclude these firms. Table A4 in appendix A3 reports the results, showing indeed economically stronger results on a_3 (30% decrease or higher across the different specifications). This result suggests that what we capture is the decline in loan spreads under the mechanisms underlying our main hypothesis. More specifically, subtracting the power sector from our sample directly reflects the application of Result 1 of our theoretical model.

We conduct several additional tests, the results of which are in appendix A3, Tables A5 to A7.[26] Several studies of the syndicated loans market show the importance of loan fees (e.g., Berg et al., 2016). Using the all-in-undrawn as our dependent variable (which in addition to the facility fee contains the commitment fees on the unused amount of loan commitments) yields statistically insignificant effects (Table A5). In Table A6, we distinguish between credit lines (column 1) and

[26] In addition to these tests, we also use propensity-score matching. We follow Stiebale (2016) and Calel and Dechezleprêtre (2016), and conduct the matching using the sample of our preferred specification (i.e., that in column 4 of Table 3). For the matching, we use as a control variable the average over the second phase (2008-2012) all-in-drawn spread, taking into account that the matched treated and control loan facility should belong to the same industry, and the facility should be of the same loan type and loan purpose. In the matching procedure, we employ common support, calipers, and nearest neighbors, yielding a matched sample of 35,168 loan facilities, of which 3,445 are treated firms' loan facilities matched to 31,723 nontreated firms' facilities. The test of the balancing property for the matched sample with respect to the average over the second phase (2008-2012) all-in-drawn spread is marginally significant at the 10% level (t-statistic equals 1.66), thus revealing that the matched sample is satisfactorily balanced. The all-in-drawn spread for the post-treatment period (i.e., the third phase) is the outcome variable. The result shows that the all-in-drawn spread for the treated loan facilities is about 18% lower (coef./t-stat: -0.186/-8.38) than that of the matched control loan facilities, which is quite close to our baseline results and thus provides reassurance that selection bias does not contaminate our findings.

term loans (column 2). Despite using loan-type fixed effects in our baseline models, we expect that the economic impact of our results is stronger for term loans that have higher pipeline risk and (usually) no fees. Indeed, we document a significantly more potent negative coefficient for *Treated* × *3rd phase dummy* for term loans (column 2). Last, we use weighted least squares (as opposed to OLS) to account for differences in the number of loans by country-year. The weights are the number of observations in a borrower's country-year (see appendix A3). The results, reported in Table A7 are, if anything, stronger than our baseline.

Overall, our key findings in this section suggest that phase III of the EU ETS environmental regulation in 2013 lowers the cost of credit for treated firms. This effect is important considering that the program aims to increase costs and associated environmental risk for polluting firms as an incentive to move to greener production. In contrast, the treatment decreases credit costs, providing incentives against pro-environmental actions. In the next section, we examine the mechanisms that transmit this effect.

4.3. The role of the price and allocation of permits

As per our theoretical considerations, an important differentiating characteristic in our setting is that from 2005 onward there is a market for permits. The distinguishing feature of this market is that the EU ETS regulates the number of allowances, which naturally affects both the quantity and the price of permits. In the previous section, we show that our benchmark model is stable when controlling for the price of permits and the key quantity characteristics of these permits. In this section, we examine whether these market characteristics influence the negative effect that the 2013 treatment has on the cost of credit. This also pinpoints the precise channels through which we test the main hypothesis in the previous section.

We first examine the triple interaction term *Treated* × *3rd phase dummy* × *EUA price* and report the results in column 1 of Table 7. Consistent with Result 3 in our theoretical model, we expect that in periods with higher permit prices, projects become riskier and costlier for treated firms that purchase allowances. We indeed find that the triple term carries a positive and statistically significant coefficient, but the double term *Treated* × *3rd phase dummy* retains its negative and significant coefficient.[27]

[Insert Table 7 about here]

This specification has interesting economic implications, obtained from calculating the EUA price for which the negative effect of the treatment is zero. We carry out this calculation using the marginal effect ∂*Loan spread* / ∂*Treated*, setting it equal to zero and solving for the EUA price. We find that this price approximately equals 3 or, taking its antilog, 20.1. Notably, this EUA price is quite high and observed only before 2010 or after 2018.

This finding provides a nice picture for understanding bank behavior in the context of interest rates for polluting firms in the post-treatment period. Specifically, when EUA price decreases, the environmental risk among firms that see a reduction in actual and expected costs associated with the permits-related environmental regulation decreases. Banks also observe this lower risk and offer better loan spreads in loans originated post-enforcement. In other words, banks observe that the expectations formed in the pretreatment period regarding increased regulatory costs do not materialize in the post-treatment period and decrease the loan spreads.

In addition to the mechanism working through the EUA price, a key implication of our theoretical model is that the firms with a large number of stored allowances or, alternatively, any

[27] Working in the same way as in column 8 of Table 5, we also consider the EU price as endogenous. Using 2SLS and multiple instruments (both the mean and the standard deviation of wind speed), our results are consistent with the OLS results in Table 7.

other offsets or any prior investment that have a similar impact, face lower spreads (see Result 2). We do not directly observe the number of stored allowances, or more general proactive actions taken by the firms, but we do observe the extent to which firms are net buyers or net sellers of allowances (*Bought / sold allowances*). This is indeed helpful for our purposes because stored allowances or any proactive actions (investments) that result into lower future demand for permits shall imply less bought or more sold allowances. In terms of our theoretical modeling, these variables are substitutes. Using a triple interaction model with *Bought / sold allowances* in specification 2 of Table 7, we indeed find that this is a key driver of our main results. Specifically, the triple term has a positive and statistically significant coefficient (at the 1% level), showing that the treatment effect is less negative for firms that are large net permit buyers. Essentially, this result shows that the more permits a firm buys from 2013 onward compared to the permits it sells (the most potent the indication that a firm is not proactive in storing permits), the higher its exposure to the related risk (then priced by banks). In contrast, firms selling more than buying have been sufficiently proactive and are less risky.

In specifications 3 and 4 of Table 7, we include triple-interaction terms with *Costly allocated allowances* and *Allocated allowances*, respectively. Both terms are statistically insignificant at conventional levels. Especially for *Costly allocated allowances*, this shows that the very low price of permits in the post-treatment period essentially places firms with costly allocated allowances in the same shoes as firms obtaining free allowances. Interestingly, any potential fears about the possibility of the firms to move operations outside the Union, as a result of phase III tighter regulation, known as carbon leakage, shall be mitigated. As we also argue in section 3 (see footnote 7), firms that are deemed likely to "carbon leak" outside the EU countries are compensated with a higher number of free allowances. However, we do not observe any effect, as the coefficient of the triple interaction term of *Costly allocated allowances* is statistically insignificant. This is consistent with Ecorys (2013) who refers to the first two phases of the EU ETS.

In specification 5, we include all triple-interaction terms in the same model to infer which identified mechanisms carry the most weight and examine whether these heterogenous effects completely buffer the effect identified through the coefficient on *Treated* × *3rd phase dummy*. In line with our theoretical results 2 and 3, we indeed find that *EUA price* and *Bought / sold allowances* are significant in banks' decision to lower loan spreads in the post-treatment period. Next, we take the derivative of the specification with respect to *Treated* and plug in the 3rd quartile values for the *EUA price* and *Bought / sold allowances* while keeping *Costly allocated allowances* and *Allocated allowances* at their means.[28] We find a marginal effect on the treatment equal to -0.076, which taking the antilog equals -0.93 basis points. This effect, which is equivalent to zero, implies that our baseline negative effect identified in previous tables is *fully* explained in the results of Table 7 by the low EUA price and firms proactiveness, e.g., storage behavior.

We conduct several robustness tests on the results in this section. First, our results are robust to all the additional tests in section 5.1 (results available on request). Second, a potential question with our estimates is whether banks observe *Bought / sold allowances* contemporaneously or with a lag. This also reflects on potential reverse causality problems arising if, for example, a higher cost of credit due to limited holdings of allowances results in firms buying fewer allowances in that year. As a remedy for this problem, we report in Table 8 the results from lagging the allowances-related variables (*Allocated allowances* and *Bought / sold allowances*). In column 1, we include the first-year lags. The results are equivalent to those in Table 7, with the triple-interaction term reflecting, if anything, a bit stronger heterogeneous effects. As a placebo test against capturing

[28] The 3rd quartile values are 2.79 and 7.36 for the *EUA price* and *Bought / sold allowances*, respectively.

long-term dynamics, in column 2 we include the two-year lags; the results (both on the double and the triple terms) lose their statistical and economic significance. This is intuitive because banks are unlikely to price loans based on *Bought / sold allowances* from two years ago (that is, banks mostly rely on information from more recent periods).

[Insert Table 8 about here]

We report the results from a last robustness test in Table A8 of appendix A2. This table replicates Table 7 but includes the allowances-related variables scaled by total assets. We include these results as a means to buffer criticism that our allowances variables capture scale effects (despite controlling for *Borrower's size*). The results are very similar to the baseline.

4.4. The role of green banking

The effects uncovered in the previous two sections are in line with a lively debate on the role of banking in climate change (e.g., Banking on Climate Change Report, 2020; Financial Times, 2020; Delis et al., 2019; Degryse et al., 2021). In particular, the UNEP Finance Initiative mobilizes private sector financing for sustainable development. Several banks worldwide embrace this initiative, aligning their business models with sustainable development goals and the Paris Climate Agreement. Therefore, it is reasonable to expect that syndicated loans with UNEPFI banks as lead arrangers to treated firms are not priced significantly lower in the post-treatment period.

From a statistical viewpoint, the role of UNEPFI banks points to a difference-in-difference-in-differences approach, with the UNEPFI banks dummy being the third difference component. We report the results including the triple difference (along with all the double differences and the main terms) in column 1 of Table 9. The results confirm our expectations, with the triple term *Treated* × *3rd phase dummy* × *UNEPFI banks* carrying a positive coefficient. However, both its statistical and economic significance are not substantial. Specifically, *Treated × 3rd phase dummy* in specification 2 shows that the treatment effect on *Loan spread* is a negative 27%. The equivalent coefficient on the triple term is only a positive 3%, which shows that the treatment effect on *Loan spread* even for the UNEPFI-bank loans is substantially negative (subtracting 3% from the 27%).[29] Moreover, the statistical significance disappears when we control for bank-year characteristics in specification 3. Thus, even UNEPFI banks follow the general trend in lowering spreads for treated firms from 2013 onward (albeit to a slightly lesser extent).[30]

[Insert Table 9 about here]

4.5. Loan spreads and CO_2 emissions

Our key finding so far is that the European permits scheme, the third phase of which began in 2013, decreased the cost of credit. The key reasons are that most of the affected firms have been proactive, and this keeps the price of permits at particularly low levels in phase III up to 2018. In addition, other environmentally friendly policies have been introduced, such as the promotion of renewable energy (e.g., feed-in tariffs or premia). This led to lower demand for CO_2 allowances, which, in turn, further relaxed the stringent framework. The intuitive outcome of these dynamics is that the reduction in the cost of credit offsets the additional costs polluting firms face, thus maintaining polluting incentives. Lower loan spreads lead to an expansion of the firms' activities and as emissions are by-products of production they also tend to increase.[31]

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[29] This results from $100\text{x}(\exp(a_3 - \text{V}(a_3)/2) - 1) = 100\text{x}(\exp(0.038 - 0.017/2) - 1) = 3\%$.
[30] Our results here are robust to the full battery of sensitivity tests discussed in previous sections.
[31] Note that we explore short-run correlation between loan spreads and *Verified CO2 emissions*. In the long-run other channels may be at play such as promotion of investments in more efficient abatement technologies that can result into lower emissions (e.g., De Haas et al., 2021).

The EU transaction Log database has information for the verified CO_2 emissions of the treated firms. In this section, we verify that the relation between loan spreads and CO_2 emissions is indeed negative. We estimate the empirical model:

$$Verified\ CO2\ emissions_{it} = a_0 + a_1 Weighted\ average\ loan\ spread_{it} + a_2 3rd\ phase\ dummy_t + a_3 Weighted\ average\ loan\ spread_{it} \times 3rd\ phase\ dummy_t + F_{it} + C_t + u_{lit}. \quad (2)$$

We define all variables in Table 1 and estimate this specification for the treated firms only, because we do not have reliable data on verified emissions for the nontreated firms. Given that the dependent variable (*Verified CO_2 emissions*) is identified by firm-year, we construct weighted-average loan spreads by firm-year, where the weights are the facility amounts.

We report summary statistics in Table 10 and estimation results in Table 11. In the first three specifications, we look at the contemporaneous CO_2 emissions; in the latter three, we look at the next year's CO_2 emissions. The results on the main term, *Weighted average loan spread*, across all six specifications confirm our suggestion that a higher cost of credit, even for the within-sample of treated firms, implies lower CO_2 emissions.[32]

[Insert Tables 10 and 11 about here]

Further, the interaction term is positive but statistically insignificant at conventional levels. The derivative of specification 6 with respect to *Weighted average loan spread* equals -0.615 when 3^{rd} phase dummy = 0 (i.e., before 2013), and it equals -0.316 when 3^{rd} phase dummy = 1 (from 2013 onward). Thus, a 1% increase in *Weighted average loan spread* associates with a 0.316% decrease from 2013 onward.

[32] As in previous specifications, we can make direct inferences on this term because the interacting variable phase III dummy is a binary variable.

Taken together with our baseline results, our findings in Table 11 imply that CO_2 emissions of treated firms in the post-2013 period are higher than if there is no decrease in the cost of credit. Figure 5 plots the annual mean of verified CO_2 emissions for the firm-year observations in Table 11. Consistent with previous literature (e.g., Bayer and Aklin, 2020) the figure shows a gradual decrease in verified CO_2 emissions. Our analysis suggests that this decrease is considerably lower if the loan spread does not decrease after 2013. Given the 25% reduction in loan spread (documented in our baseline results) and the 0.316% increase in CO_2 emissions following a 1% decline in loan spread (documented in Table 11), CO_2 emissions would decrease by another 7.9% (25% × 0.316%) had there not been a negative effect of the EU ETS policy on loan spreads.

[Insert Figure 5 about here]

5. Concluding remarks

Cap-and-trade systems are gaining support as a means to tackling climate change. Recent trends (e.g., ICAP 2021) and theoretical findings promote the linkage of local systems to thicker setups (e.g., Doda et al., 2019; Landry, 2021), suggestions that are based, *inter alia*, on the manifested advantage of accuracy in achieving the target in a cost-efficient manner. Yet, in order to expand the use of such cap-and-trade programs, there is a need to understand better their features and the dependent outcomes. Our study contributes to the extant academic and policy debate by providing new insights on how environmental policy affects financing costs. Specifically, we examine the effects of permit trading on firm financing costs, as well as how these effects shape firm incentives to pollute.

We theoretically show that loan spreads depend positively on permit prices and on the number of costly allocated allowances. However, our theoretical and empirical results suggest that once firms anticipate regulatory stringency, market forces work proactively, which reduces corporate loan (and corporate bond) spreads. The effect is economically significant, as we identify a fall in loan spreads among treated firms (those participating in the EU ETS) of approximately 25% (compared to the control group of nonparticipating firms and the pretreatment period). The latter undermines the effectiveness of policy toward emissions reduction. In the context of the EU ETS, our results are in line with Bayer and Aklin (2020), who show that CO_2 emissions decrease over time despite the prevalence of low permit prices. However, we show that had the response in loan spread been neutralized, CO_2 emissions would have fallen further by almost 8%.

Our findings uncover a strategic role for commitment through proactive actions such as permits storage, so that future interest rates are distorted downward. Without disputing the proclaimed advantages of permits storage, such as cost-smoothing over time, the strategic incentive presented here can be detrimental in terms of pollution. A potential policy implication could be to allow for permits that are swappable at the end of a period for cash plus some rate in the form of a repo, so that firms are disincentivized from flooding the market with extra allowances in the subsequent period. More generally, regulators should carefully account for firms' strategic incentives to manipulate future regulation and loan spreads.

Our results also provide an empirical corroboration for any forms of stability reserves in allowance markets, such as the EU ETS market stability reserve introduced in 2019 (see ICAP, 2021) where the regulator might withdraw permits in case of excessive surplus of allowances or, in the opposite case, add allowances in order to temper price increases. The latter is a timely issue as the EUA price is expected to average 55.88 euros a ton in 2021 and 69.87 euros in 2022 after soaring global gas prices led some electricity generators to switch to more polluting coal-fire power, ramping up demand for carbon permits (Reuters, 2021). Our rationale relies on the fact that a surplus (deficit) of allowances, along with a permits price reduction (increase), also reduces (increases) loan spreads, which leads to even higher (lower) emissions. Permits withdrawal deters banks from relaxing their interest rates, or conversely adding permits into the system might lead banks to sustain their interest rates and alleviate the regulatory pressure of the firms. Put differently, setting limits on permit prices by controlling the number of allowances in the market can be beneficial if the aim is to keep emissions within a politically acceptable rate of variation. This complements Borenstein et al. (2019), who attest that ex-ante uncertainty in business-as-usual emissions resulting from other nonmarket policies most likely lead to extreme prices (i.e., to the price floor or ceiling). Therefore, the exact level of the boundaries is instrumental for financing costs and firms' associated response to emissions or their investments in general.

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Table 1. Variable definitions and sources

Variable	Definition and source
Panel A. EU ETS data	
Treated	Dummy variable equal to 1 for a syndicated loan facility granted to a borrowing firm in the DealScan's syndicated loan database if the firm also participates in the EU ETS program (2005-2020) and 0 otherwise. Source European Union Transaction Log data.
3rd phase dummy	Dummy variable equal to 1 for the years 2013-2018 and 0 otherwise.
Allocated allowances	Natural logarithm of the number of allowances allocated each year by the regulator to firms participating in the EU ETS program (rescaled in million allowances). It takes the value 0 for the non-EU ETS firms. Source European Union Transaction Log data and authors' calculations.
Bought / sold allowances	Natural logarithm of the number of allowances (plus the minimum value plus 1) that an EU ETS firm bought (+) or sold (-) in the European Energy Exchange (EEX) market each year (re-scaled in million allowances). It takes the value 0 for the non-EU ETS firms. Source European Union Transaction Log data and authors' calculations. Data available up to 2016.
EUA price	Natural logarithm of the price (in €) of the EU allowances (permits) in the EEX market. Available daily for the period March 9, 2005 until December 31, 2018. We first calculate the monthly average EUA price and then match it with the syndicated loans dataset (using the month the loan is originated). Source Datastream and authors' calculations.
Costly allocated allowances	Dummy variable equal to 1 for an EU ETS program participating firm that belongs to the sectors with costly allowances and 0 otherwise (i.e., 0 for the EU ETS firms belonging to the free allocation allowances sectors or to the non-EU ETS firms). Source https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:001:0010:0018:EN:PDF .
Panel B. Loan-level data	
Loan spread	Natural logarithm of the all-in-spread-drawn (in basis points), defined as the sum of the spread over LIBOR plus any facility fee. Source DealScan and authors calculations.
All-in-undrawn	Natural logarithm of the all-in-undrawn. Source Dealscan and authors calculations.
Facility amount	Natural logarithm of the syndicated loan facility amount (in €). Source DealScan and authors calculations.
Maturity	Natural logarithm of the number of months for which a syndicated loan is granted. Source DealScan and authors calculations..
Number of lenders	Natural logarithm of the number of banks participating in a syndicating loan. Source DealScan and authors calculations..
Collateral	Dummy variable equal to 1 for collateralized loans and 0 otherwise. Source DealScan.
Performance dummy	Dummy equal to 1 if the loan has performance pricing provisions and 0 otherwise. Source DealScan.
Loan purpose	A series of dummy variables indicating loan purpose (e.g., corporate purpose, debt repay, etc.). Source DealScan.
Loan type	A series of dummy variables indicating loan type (e.g., bridge loan, revolver/line >= 1 Yr., term loan, etc.). Source DealScan.
Borrower's country loan spread	Natural logarithm of the borrower's country-year mean of all-in-spread-drawn. Source DealScan and authors calculations.
Lender's country loan spread	Natural logarithm of the lender's country-year mean of all-in-spread- drawn. Source DealScan and authors calculations.
Relationship lending amount	The ratio of the amount of prior loan facilities between the lender and the borrower in the 5-year period before the loan facility's origination year to the total amount of loans received by the borrower during the same period. Source DealScan and authors calculations.
UNEPFI banks	Dummy variable equal to 1 for the banks in the syndicated loan market that have signed the UN's Principles for Responsible Banking, and 0 otherwise. Source https://www.unepfi.org/banking/bankingprinciples/signatories/.

Panel C. Firm-year data	
Borrower's size	Natural logarithm of the borrowing firm's total assets (in €). Source Compustat.
Borrower's M/B	Borrowing firm's market to book ratio. Source Compustat.
Borrower's EBIT	Borrowing firm's earnings before interest and taxes (EBIT) to total assets. Source Compustat.
Borrower's book leverage	Borrowing firm's book value of debt to total assets. Source Compustat.
Borrower's asset tangibility	Borrowing firm's property, plant and equipment book value to total assets. Source Compustat.
Above median Bought / sold dummy	Dummy variable equal to 1 for a firm-year's Bought / sold allowances above median and 0 otherwise. Source European Union Transaction Log data and authors' calculations. Data available up to 2016.
Verified CO_2 emissions at *t*	Natural logarithm of verified emissions (measured in CO_2 equiv.) by firm-year at the year of the syndicated loan origination. Source European Union Transaction Log data.
Verified CO_2 emissions at *t*+1	Natural logarithm of verified emissions (measured in CO_2 equiv.) by firm-year one year after the syndicated loan origination. Source European Union Transaction Log data.
Weighted average loan spread	Natural logarithm of weighted by the facility amount average of all-in-spread-drawn of syndicated loans by firm-year. Source DealScan and authors' calculations.
Loan cost	Natural logarithm of the (average) cost of the syndicated loan(s) provided to a borrowing firm in a given year, calculated as (weighted average all-in-drawn /100) × (average facility amount / 1,000,000) × Maturity (in years). Source DealScan and authors' calculations.
Panel D. Bank-year data	
Lender's book leverage	Lender's book value of debt to total assets. Source Compustat.
Lender's non-performing assets	Lender's non-performing assets to total assets. Source Compustat.
Lender's size	Natural logarithm of the lender's total assets (in €). Source Compustat.
Lender's EBIT	Lender's earnings before interest and taxes (EBIT) to total assets. Source Compustat.
Panel E. Country-level data	
Borrower's country elect. price	Borrower's country industrial electricity price (€ per kilowatt-hour), including taxes and levies, biannual data. Source Eurostat.
Borrower's country GPD growth	Borrower's country real GPD growth rate (annual %). Source WDI.
Lender's country GPD growth	Lender's country real GPD growth rate (annual %). Source WDI.
Borrower's country crises	Dummy variable that takes the value 1 for the years the borrower's country experiences a systemic banking crisis and 0 otherwise. Source Laeven and Valencia (2020).
Lender's country crises	Dummy variable that takes the value 1 for the years the borrower's country experiences a systemic banking crisis and 0 otherwise. Source Laeven and Valencia (2020).
Standard deviation of wind speed	The monthly standard deviation of the daily mean wind speed in the borrower's country. Source Copernicus.
Panel F. Bonds data	
Spread	Natural logarithm of the spread (in basis points). Source SDC and authors' calculations.
Total amount	Natural logarithm of the total issuance amount (in €). Source SDC and authors' calculations.
Maturity	Natural logarithm of the number of months for which a bond is issued. Source SDC and authors' calculations.
Moody's rating	Natural logarithm of Moody's credit rating, transformed into a numeric scale from 1 (Aaa rating) to 21 (C rating). Source SDC and authors' calculations.
Borrower's country-year mean of spread	Natural logarithm of issuer's country-year mean of spread. Source SDC and authors' calculations.

Table 2. Summary statistics

The table reports basic summary statistics using the syndicated loans sample. Definitions for all variables are in Table 1. The sample period is 2005-2018.

Variable	Obs.	Mean	St. Dev.	Min.	Max.
Treated	45,998	0.295	0.456	0	1
3rd phase dummy	45,998	0.314	0.464	0	1
Allocated allowances	45,998	0.297	0.816	0	4.874
Bought / sold allowances	42,683	7.341	0.311	0	7.949
EUA price	45,375	1.920	1.521	-4.373	3.300
Costly allocated allowances	45,998	0.130	0.336	0	1
Loan spread	45,998	4.620	0.983	0.916	7.244
All-in-undrawn	9,638	2.903	0.990	1.098	5.521
Facility amount	45,998	20.145	1.580	0	24.313
Maturity	45,998	3.945	0.561	0.693	6.198
Number of lenders	45,998	2.736	0.678	0.693	4.263
Collateral	45,998	0.264	0.441	0	1
Performance dummy	45,998	0.128	0.334	0	1
Borrower’s country loan spread	45,998	5.358	0.332	2.785	6.091
Lender’s country loan spread	45,998	5.370	0.287	3.367	6.332
Relationship lending amount	45,998	0.028	0.063	0	1
UNEPFI banks	45,998	0.586	0.493	0	1
Borrower’s size	45,998	9.172	1.780	2.795	14.847
Borrower’s M/B	45,998	0.048	0.192	0	5.402
Borrower’s EBIT	45,998	0.071	0.050	-0.371	0.516
Lender’s book leverage	28,135	0.944	0.031	0.151	1.000
Lender’s non-performing assets	18,754	0.011	0.013	0.000	0.208
Lender’s size	28,135	13.555	1.126	5.892	14.916
Lender’s EBIT	28,047	0.046	0.025	-0.054	0.243
Borrower’s country electricity price	44,686	0.122	0.038	0.047	0.266
Borrower’s country GPD growth	45,998	1.795	2.168	-9.132	25.163
Lender’s country GDP GPD growth	45,998	1.879	2.093	-9.132	25.163
Borrower’s country crises	45,998	0.208	0.406	0	1
Lender’s country crises	45,998	0.192	0.394	0	1
Standard deviation of wind speed	45,722	0.485	0.220	0.219	1.183

Table 3. Baseline results

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	-0.016	-0.014	0.026	0.022	0.027
	(-0.12)	(-0.11)	(0.24)	(0.21)	(0.25)
Treated × 3rd phase dummy	-0.232***	-0.238***	-0.239***	-0.251***	-0.261***
	(-2.78)	(-2.98)	(-3.30)	(-3.35)	(-3.58)
Facility amount		-0.034***	-0.027**	-0.027**	-0.029***
		(-6.41)	(-2.57)	(-2.51)	(-2.98)
Maturity		0.131***	0.112***	0.115***	0.102***
		(7.31)	(3.69)	(3.91)	(2.99)
Number of lenders		-0.071***	-0.029	-0.031	-0.040
		(-3.84)	(-1.03)	(-1.08)	(-1.44)
Collateral		0.143***	0.170***	0.167***	0.174***
		(4.36)	(3.47)	(3.45)	(3.58)
Performance dummy		-0.003	0.074*	0.083**	0.074*
		(-0.09)	(1.73)	(2.00)	(1.93)
Borrower’s country loan spread			0.542***	0.494***	0.506***
			(7.87)	(7.44)	(7.09)
Lender’s country loan spread			0.148***	0.117***	0.071*
			(3.94)	(3.44)	(1.86)
Borrower’s size			-0.101**	-0.107***	-0.131***
			(-2.42)	(-2.61)	(-3.28)
Borrower’s M/B			0.052	0.068	0.105
			(0.65)	(0.87)	(1.21)
Borrower’s EBIT			-1.488***	-1.499***	-1.708***
			(-3.76)	(-3.77)	(-4.44)
Borrower’s country GPD growth				-0.020**	-0.018*
				(-2.26)	(-1.83)
Lender’s country GPD growth				0.000	0.003
				(0.02)	(1.07)
Borrower’s country crises				0.093*	0.097*
				(1.88)	(1.85)
Lender’s country crises				0.013	0.009
				(1.33)	(0.81)
Lender’s book leverage					0.868**
					(2.28)
Lender’s non-performing assets					0.861**
					(2.08)
Lender’s size					-0.009
					(-0.47)
Lender’s EBIT					0.033
					(0.11)
Constant	5.087***	5.316***	2.111***	2.584***	2.399***
	(342.51)	(41.88)	(3.42)	(4.37)	(3.42)
Observations	132,209	130,856	46,322	45,998	18,646
No of firms	4,389	4,336	1,232	1,227	1,045
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes	Yes	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.90	0.90	0.91	0.91	0.91

Table 4. Placebo tests

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread* in specifications (1) to (6) and *Facility amount* in specification (7). Definitions for all variables are in Table 1. In specifications (1) to (3), we shift backwards the 3rd phase dummy variable in year 2012, 2011 or 2010 (instead of 2013), thus including in the treated group one, two, or three more years. In specifications (4) and (5), the treated group includes the Australian/Asian or Swiss firms, respectively, that belong in the same pollutant EU ETS sectors. In specification (6), the control group includes the U.S. firms that belong in the non- EU ETS sectors. In specification (7), the dependent variable is *Facility amount*, whereas *Loan spread* is a control variable. Estimation method is OLS with fixed effects (reported in the lower part of the table) and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	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	Drop financial and real estate firms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated	0.010 (0.09)	-0.016 (-0.14)	-0.069 (-0.61)				-0.058 (-0.41)	0.053 (0.48)
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				-0.091 (-1.38)	-0.203 (-0.67)	-0.237*** (-3.41)	-0.049 (-0.69)	-0.219*** (-2.88)
Loan spread							-0.142*** (-2.84)	
Facility amount	-0.027** (-2.53)	-0.027** (-2.45)	-0.027** (-2.46)	-0.007 (-0.77)	-0.046*** (-4.52)	-0.024*** (-4.21)		-0.018* (-1.66)
Maturity	0.113*** (3.82)	0.111*** (3.71)	0.107*** (3.58)	0.149*** (6.27)	0.113*** (4.43)	-0.033 (-1.31)	0.281*** (5.87)	0.100*** (3.23)
Number of lenders	-0.032 (-1.11)	-0.033 (-1.13)	-0.034 (-1.16)	-0.043 (-1.45)	-0.001 (-0.03)	-0.030** (-2.00)	0.404*** (8.30)	-0.025 (-0.82)
Collateral	0.163*** (3.34)	0.165*** (3.39)	0.162*** (3.32)	0.019 (0.22)	0.150*** (3.02)	0.158*** (7.75)	0.055 (0.73)	0.160*** (3.13)
Performance dummy	0.093** (2.25)	0.101** (2.39)	0.103** (2.42)	0.086* (1.66)	0.077 (1.42)	-0.009 (-0.68)	-0.007 (-0.10)	0.086** (1.99)
Borrower's country loan spread	0.499*** (7.47)	0.506*** (7.53)	0.508*** (7.49)	0.372*** (5.76)	0.286*** (2.91)	0.522*** (4.50)	-0.027 (-0.24)	0.533*** (7.43)
Lender's country loan spread	0.115*** (3.39)	0.117*** (3.49)	0.119*** (3.55)	0.171* (1.78)	0.140*** (3.67)	0.168*** (4.67)	0.055 (1.10)	0.131*** (3.69)
Borrower's size	-0.107*** (-2.58)	-0.107** (-2.56)	-0.109** (-2.55)	-0.037 (-0.87)	-0.045 (-0.91)	-0.067*** (-3.36)	0.376*** (6.32)	-0.147*** (-3.26)
Borrower's M/B	0.073 (0.91)	0.077 (0.91)	0.081 (0.92)	-0.066*** (-3.11)	0.078 (0.73)	-0.032 (-0.88)	0.146 (1.07)	0.018 (0.51)

Borrower’s EBIT	-1.483***	-1.458***	-1.448***	-0.832***	-1.431***	-1.415***	0.346	-2.035***
	(-3.73)	(-3.65)	(-3.62)	(-2.59)	(-3.48)	(-7.20)	(0.64)	(-4.44)
Borrower’s country GPD growth	-0.021**	-0.020**	-0.021**	-0.014	-0.004	-0.027***	0.010	-0.021**
	(-2.43)	(-2.36)	(-2.46)	(-1.17)	(-0.26)	(-2.64)	(0.62)	(0.008)
Lender’s country GPD growth	0.000	0.000	0.000	-0.000	0.000	0.004**	-0.000	-0.001
	(0.22)	(0.22)	(0.18)	(-0.00)	(0.00)	(1.97)	(-0.02)	(-0.35)
Borrower’s country crises	0.085*	0.071	0.066	0.168***	0.232***	0.009	0.005	0.069
	(1.67)	(1.34)	(1.25)	(3.02)	(3.83)	(0.14)	(0.06)	(1.34)
Lender’s country crises	0.010	0.008	0.009	0.019	0.009	0.009	0.029*	0.008
	(1.07)	(0.79)	(0.93)	(1.35)	(0.80)	(1.04)	(1.74)	(0.80)
Constant	2.591***	2.536***	2.557***	1.963***	3.348***	2.516***	14.950***	2.590***
	(4.38)	(4.29)	(4.26)	(2.65)	(4.70)	(3.27)	(17.98)	(4.04)
Observations	45,998	45,998	45,998	49,757	35,514	93,364	45,998	40,398
No of firms	1,227	1,227	1,227	1,648	1,027	2,424	1,227	992
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	0.90	0.91	0.88	0.82	0.91

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

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method for the first seven specifications is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. Specification 8 is estimated with 2SLS, where the EUA price is instrumented with the standard deviation of wind speed in the borrowers' country during the month of the loan facility. The first stage results are in the lower part of the table. We do not include year fixed effects, because these are collinear with the EUA price and the EU ETS program characteristics, which we aim to explicitly control for in these specifications. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(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)
Facility amount	-0.015	-0.025**	-0.030***	-0.030***	-0.027**	-0.023*	-0.023*	-0.023*
	(-1.39)	(-2.20)	(-2.66)	(-2.65)	(-2.23)	(-1.86)	(-1.840)	(-1.815)
Maturity	0.108***	0.105***	0.099***	0.098***	0.096***	0.100***	0.096***	0.098***
	(3.53)	(3.37)	(3.03)	(3.05)	(2.83)	(3.18)	(2.973)	(2.877)
Number of lenders	-0.042	-0.025	-0.016	-0.017	-0.010	-0.016	-0.004	-0.006
	(-1.09)	(-0.87)	(-0.51)	(-0.52)	(-0.31)	(-0.51)	(-0.145)	(-0.176)
Collateral	0.182***	0.171***	0.148***	0.152***	0.169***	0.190***	0.165***	0.167***
	(3.05)	(3.44)	(2.93)	(3.02)	(3.18)	(3.62)	(3.154)	(3.166)
Performance dummy	0.101*	0.067	0.081*	0.080*	0.084*	0.075*	0.076*	0.074*
	(1.78)	(1.63)	(1.91)	(1.89)	(1.84)	(1.74)	(1.789)	(1.650)
Borrower's country loan spread	0.426***	0.639***	0.644***	0.636***	0.608***	0.591***	0.585***	0.583***
	(5.19)	(10.81)	(10.05)	(10.34)	(9.45)	(10.38)	(10.410)	(10.299)
Lender's country-year loan spread	0.084*	0.910***	0.974***	0.978***	1.012***	0.958***	0.901***	0.894***
	(1.95)	(13.88)	(14.35)	(14.62)	(14.38)	(13.97)	(12.938)	(11.311)
Borrower's size	-0.079	-0.109***	-0.118***	-0.115***	-0.110**	-0.093**	-0.098**	-0.092
	(-1.57)	(-2.79)	(-2.89)	(-2.75)	(-2.50)	(-2.09)	(-2.054)	(-1.594)
Borrower's M/B	0.020	0.080	0.071	0.073	0.249	0.269	0.432	0.439
	(0.44)	(0.98)	(0.91)	(0.93)	(1.08)	(1.13)	(1.051)	(1.063)
Borrower's EBIT	-0.791*	-1.541***	-1.534***	-1.525***	-1.657***	-1.655***	-1.817***	-1.811***
	(-1.72)	(-4.02)	(-4.02)	(-4.00)	(-4.04)	(-3.99)	(-4.148)	(-4.116)

Borrower's country electricity price							1.509*	1.512*
							(1.711)	(1.721)
Borrower's country GPD growth	-0.024	-0.021***	-0.021**	-0.021**	-0.020**	-0.021***	-0.021***	-0.022***
	(-1.34)	(-2.76)	(-2.56)	(-2.56)	(-2.41)	(-2.72)	(-2.811)	(-2.744)
Lender's country GPD growth	0.000	0.008**	0.006	0.006	0.006	0.009**	0.007*	0.008*
	(0.17)	(2.21)	(1.48)	(1.46)	(1.47)	(2.26)	(1.955)	(1.952)
Borrower's country crises	0.138*	0.147***	0.148***	0.147***	0.158***	0.152***	0.134***	0.131***
	(1.87)	(3.31)	(3.28)	(3.22)	(3.49)	(3.46)	(2.903)	(2.796)
Lender's country crises	0.010	0.012	-0.004	-0.004	-0.004	0.014	0.018	0.022
	(0.80)	(0.77)	(-0.23)	(-0.23)	(-0.22)	(0.89)	(1.058)	(0.878)
Constant	2.714***	-2.542***	-2.585***	-2.598***	-2.604***	-2.568***	-2.329***	
	(4.17)	(-4.64)	(-4.76)	(-4.78)	(-4.10)	(-4.04)	(-3.541)	
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	Borrower
Adj-R^2	0.92	0.90	0.90	0.90	0.90	0.91	0.91	

Table 6. Results using the bonds sample

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the bonds sample. The dependent variable is *Spread* in all specifications. Definitions for all variables are provided in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	0.029	0.027	0.070	-0.118	-0.008
	(0.34)	(0.33)	(0.88)	(-0.87)	(-0.06)
3rd phase dummy		-0.106	-0.102	-0.065	-0.011
		(-1.34)	(-1.32)	(-0.81)	(-0.13)
Treated × 3rd phase dummy	-0.318***	-0.308***	-0.303***	-0.276**	-0.296***
	(-3.16)	(-3.07)	(-3.11)	(-2.51)	(-2.69)
Total amount	0.021	0.020	-0.030	0.017	-0.035
	(0.71)	(0.64)	(-0.96)	(0.52)	(-1.13)
Maturity	0.308***	0.297***	0.283***	0.262***	0.255***
	(6.15)	(6.03)	(5.72)	(4.93)	(4.84)
Moody's rating	0.972***	0.979***	0.928***	0.971***	0.950***
	(10.58)	(10.86)	(11.01)	(9.31)	(9.65)
Borrower's country-year mean of spread	0.498***	0.563***	0.543***	0.562***	0.493***
	(4.88)	(4.59)	(4.39)	(4.87)	(4.75)
Borrower's size	-0.006	-0.007	0.010	-0.011	-0.015
	(-0.17)	(-0.19)	(0.30)	(-0.33)	(-0.48)
Borrower's M/B ratio	0.124*	0.148**	0.098**	0.157**	0.138*
	(1.90)	(2.53)	(1.99)	(2.04)	(1.70)
Borrower's EBIT ratio	-2.415***	-2.382**	-2.113**	-2.324**	-2.139**
	(-2.67)	(-2.56)	(-2.31)	(-2.49)	(-2.58)
Borrower's country electricity price					5.083
					(1.58)
Borrower's country real GPD growth rate	-0.026	-0.045***	-0.049***	-0.039**	-0.046**
	(-1.00)	(-2.66)	(-2.82)	(-2.14)	(-2.49)
Borrower's country crises dummy	-0.028	0.281***	0.278***	0.306***	0.285***
	(-0.29)	(3.19)	(3.07)	(3.48)	(2.96)
EUA price				0.024	0.065*
				(0.75)	(1.80)
Costly allocated allowances				0.071	0.024
				(0.46)	(0.15)
Allocated allowances				0.083*	0.090**
				(1.67)	(1.97)
Bought / sold allowances				-0.087	-0.082
				(-1.38)	(-1.59)
Constant	-0.697	-0.969	-0.604	-0.177	-0.004
	(-1.12)	(-1.36)	(-0.84)	(-0.18)	(-0.00)
Observations	1,635	1,635	1,633	1,408	1,367
No of firms	292	292	291	275	271
Borrower' country, Sector FE	Yes	Yes	Yes	Yes	Yes
Market FE	No	No	No	No	Yes
Year FE	Yes	No	No	No	No
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.63	0.62	0.64	0.64	0.67

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

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread* and all specifications include the control variables of Table 6. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. We do not include year fixed effects, because these are collinear with the EUA price and the EU ETS program characteristics, which we aim to explicitly analyze in these specifications. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(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

Table 8. Lagging the EU ETS program characteristics

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread* and all specifications include the control variables of Table 5. Definitions for all variables are in Table 1. In specification (1) *Allocated allowances* and *Bought / sold allowances* are lagged one year, while in specification (2) they are lagged two years. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. We do not include year fixed effects because these are collinear with the EU ETS program characteristics we aim to explicitly analyze in these specifications. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Treated	-0.182	-0.234*
	(-1.45)	(-1.72)
3rd phase dummy	0.162	0.149
	(0.84)	(0.77)
Treated × 3rd phase dummy	-2.119***	-0.079
	(-2.84)	(-0.18)
EUA price	0.055***	0.054***
	(4.10)	(4.01)
Treated × EUA price	0.024	0.033
	(1.10)	(1.49)
3rd phase dummy × EUA price	-0.060	-0.054
	(-0.52)	(-0.47)
Treated × 3rd phase dummy × EUA price	0.348**	0.249
	(2.04)	(1.64)
Costly allocated allowances	0.002	0.048
	(0.01)	(0.23)
Treated × 3rd phase dummy × Costly allocated allowances	0.293**	0.234*
	(2.19)	(1.78)
Allocated allowances lagged	0.059*	0.094***
	(1.96)	(2.59)
Treated × 3rd phase dummy ×Allocated allowances lagged	0.080	-0.002
	(1.23)	(-0.04)
Bought / sold allowances lagged	-0.134***	-0.175***
	(-4.05)	(-5.13)
Treated × 3rd phase dummy × Bought / sold allowances lagged	0.161**	-0.088**
	(2.10)	(-2.15)
Observations	40,756	41,043
No of firms	1,156	1,157
Control variables	Yes	Yes
Borrower, Lender, Loan purpose, Loan type FE	Yes	Yes
Clustering	Borrower	Borrower
Adj-R^2	0.91	0.91

Table 9. The role of 'green' banks (UNEPFI banks)

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. *UNEPFI banks* is a dummy variable that takes the value of 1 for the banks in the syndicated loan market that have signed the UN's Principles for Responsible Banking and 0 otherwise. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(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)
Facility amount	-0.027**	-0.027**	-0.029***
	(-2.57)	(-2.51)	(-2.99)
Maturity	0.112***	0.115***	0.102***
	(3.69)	(3.91)	(2.99)
Number of lenders	-0.029	-0.031	-0.040
	(-1.03)	(-1.09)	(-1.44)
Collateral	0.170***	0.168***	0.174***
	(3.47)	(3.45)	(3.58)
Performance dummy	0.074*	0.083**	0.074*
	(1.73)	(2.00)	(1.93)
Borrower's country loan spread	0.541***	0.493***	0.506***
	(7.87)	(7.44)	(7.09)
Lender's country loan spread	0.149***	0.118***	0.077**
	(3.96)	(3.45)	(1.99)
Borrower's size	-0.101**	-0.107***	-0.131***
	(-2.43)	(-2.62)	(-3.27)
Borrower's M/B	0.053	0.069	0.105
	(0.66)	(0.88)	(1.21)
Borrower's EBIT	-1.488***	-1.499***	-1.707***
	(-3.76)	(-3.77)	(-4.44)
Borrower's country GPD growth		-0.020**	-0.018*
		(-2.27)	(-1.83)
Lender's country GPD growth		0.000	0.003
		(0.09)	(1.15)
Borrower's country crises		0.093*	0.097*
		(1.89)	(1.84)
Lender's country crises		0.014	0.011
		(1.46)	(0.96)
Lender's book leverage			0.866**
			(2.33)
Lender's non-performing assets			0.940**
			(2.27)
Lender's size			-0.015
			(-0.78)
Lender's EBIT			-0.044
			(-0.15)
Constant	2.116***	2.590***	2.460***
	(3.44)	(4.39)	(3.54)

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

Table 10. Summary statistics for the analysis of pollution

The table reports basic summary statistics. Only treated firms (those participating in the EU ETS program), collapsed by firm-year are included in the sample. The sample period is 2005-2018. The variables are defined in Table 1.

Variable	Obs.	Mean	St. Dev.	Min.	Max.
3rd phase dummy	503	0.312	0.464	0	1
Verified CO_2 emissions at *t*	503	12.691	2.861	3.045	18.722
Verified CO_2 emissions at *t*+1	479	12.729	2.883	1.609	18.727
Weighted average loan spread	503	4.389	1.011	2.398	7.004
EUA price	493	2.045	1.293	-4.373	3.291
Borrower's book leverage	499	0.604	0.142	0.243	0.963
Borrower's asset tangibility	499	0.334	0.184	0.002	0.904
Borrower's M/B	469	0.031	0.047	0.000	0.559
Borrower's EBIT	499	0.066	0.044	-0.224	0.213

Table 11. Weighted average loan spread and CO_2 emissions

The table reports coefficient estimates and t-statistics (in parentheses). Only treated firms (those participating in the EU ETS program), collapsed by firm-year are included in the sample. The dependent variable in all specifications is *Verified CO_2 emissions*, either at *t* in Panel A or at *t*+1 in Panel B. Definitions for all variables are provided in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	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

Figure 1. Loan spread for the treatment and control groups

The figure reports regressions between the all-in-spread-drawn (in basis points) and years for the treated group (which comprises firms participating in the EU ETS program) and the control group (which comprises firms that do not participate in the EU ETS program) before and after the implementation of phase III of the program in 2013. The regression lines show parallel trends in the loan spreads of the treatment and control group before the treatment and a significant decline in the loan spreads only for the treated group in 2013.

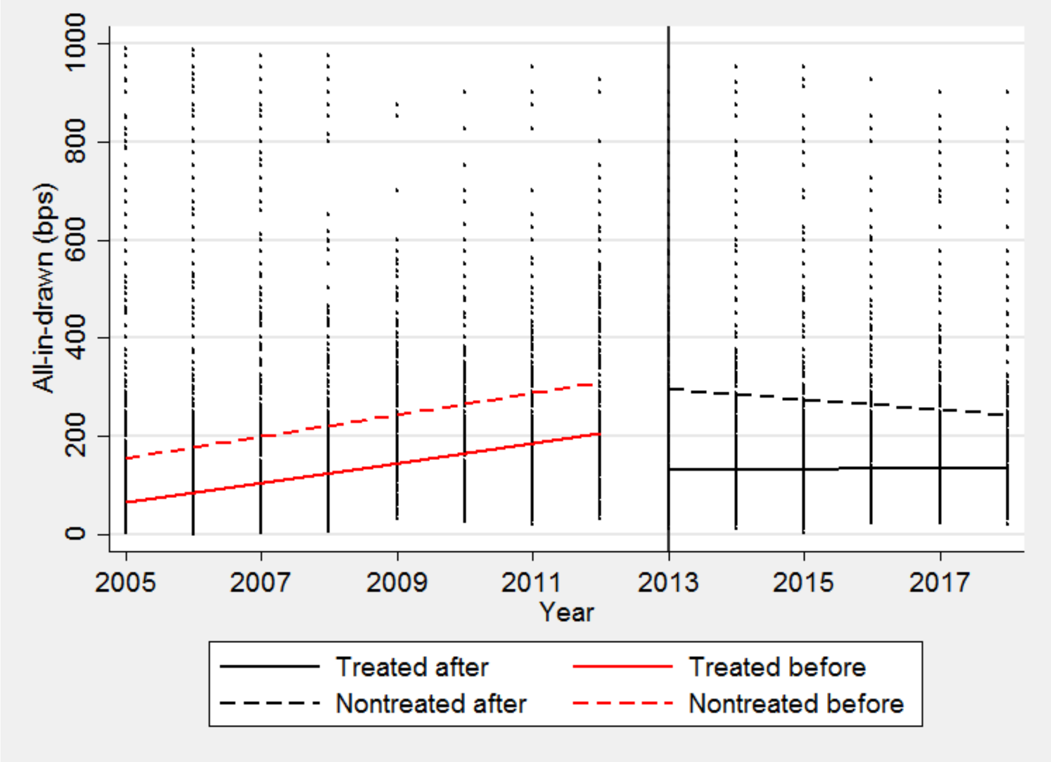


Figure 2. EUA price over the sample period

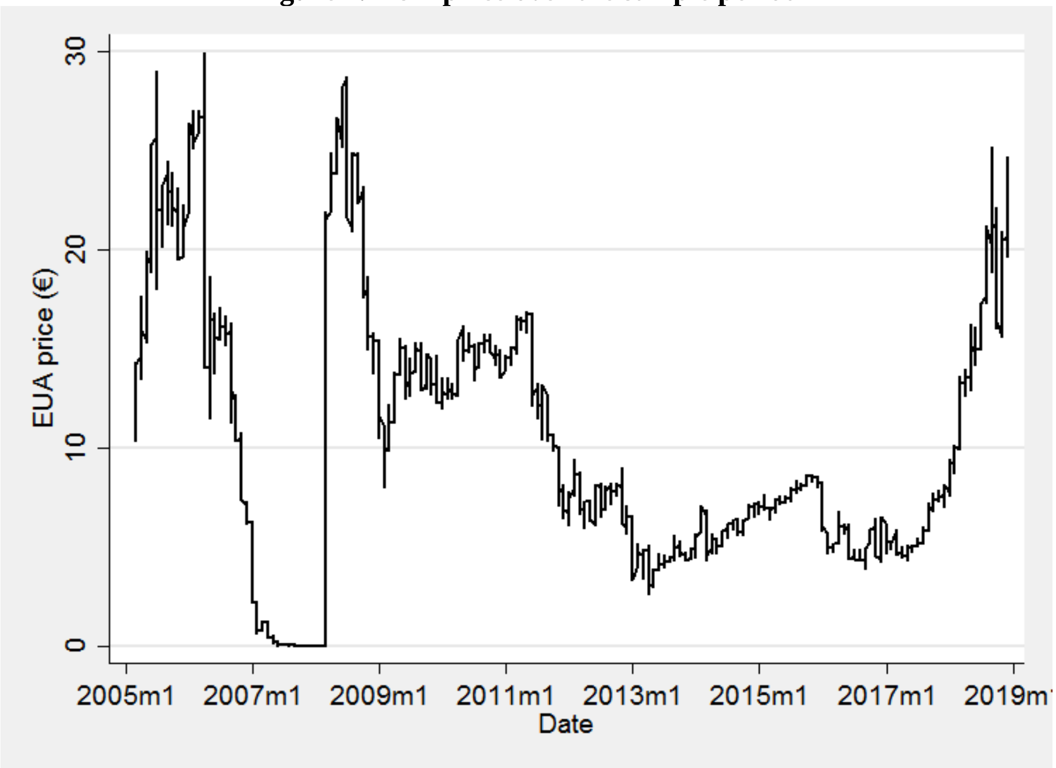


Figure 3. Number of allowances over the sample period

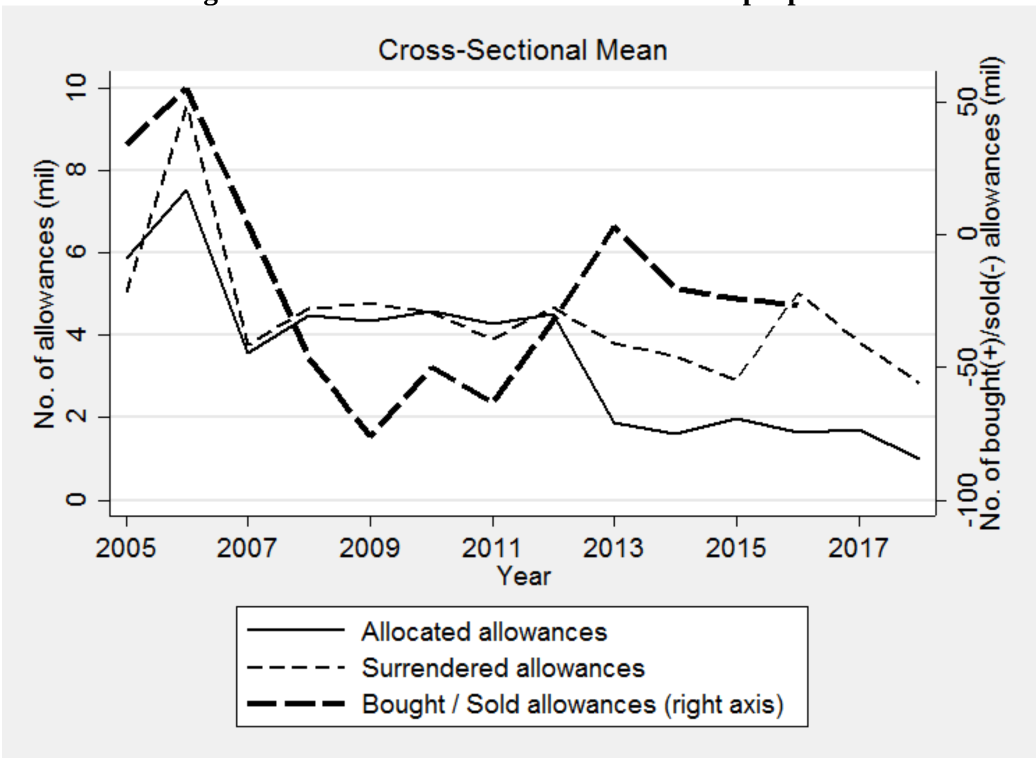


Figure 4. Loan spread for treated and control groups: Nonparametric lines

The figure reports local polynomial regressions between the all-in-spread-drawn (in basis points) and years for the treated group (which comprises firms participating in the EU ETS program) and the control group (which comprises firms that do not participate in the EU ETS program) before and after the implementation of phase III of the program in 2013. We use the sample of column 4, Table 3. The regression lines show almost parallel trends in the loan spreads of the treatment and control group before the treatment and a significant decline in the loan spreads only for the treated group in 2013.

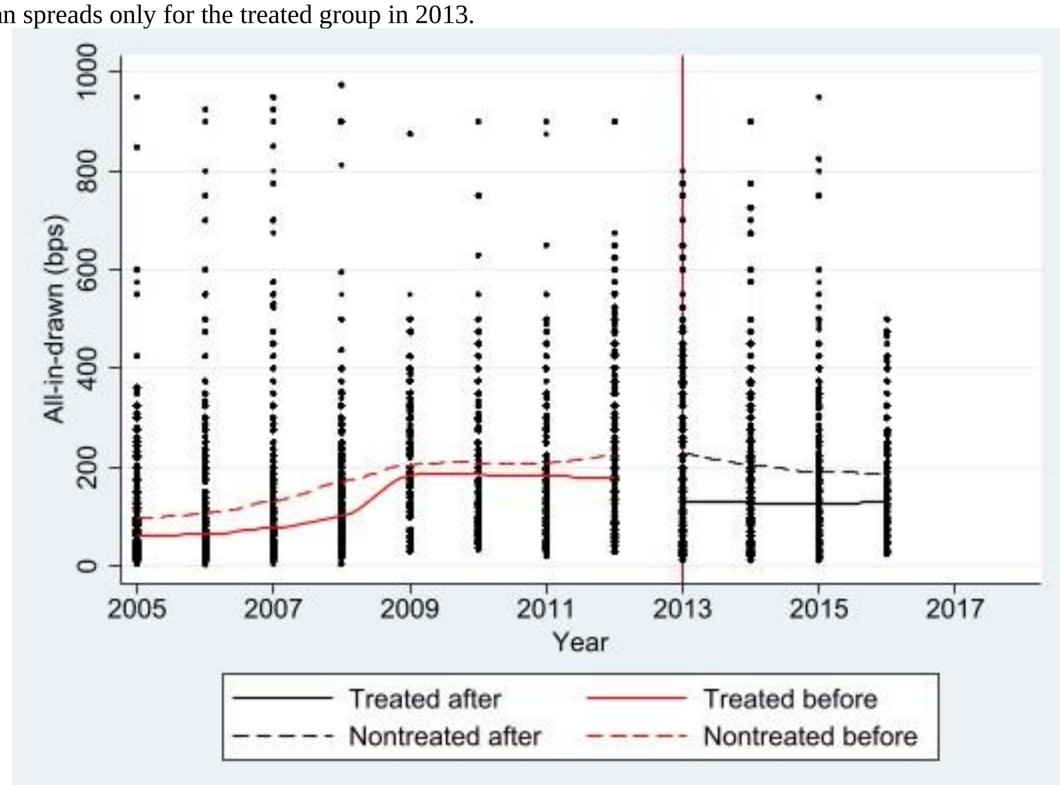
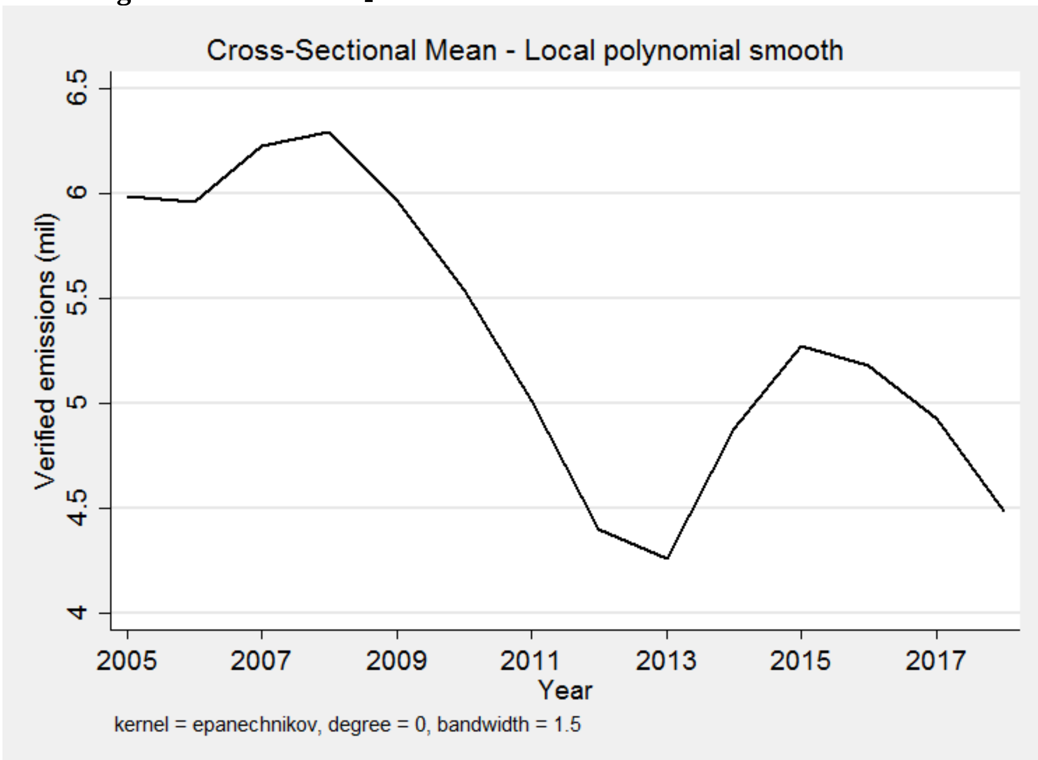


Figure 5. Verified CO_2 emissions at *t* - Cross sectional mean over time



Appendix

A1. Details on the three phases of EU ETS

Phase I of EU ETS included power stations and other combustion installations with more than 20MW thermal rated input, industry (various thresholds) including oil refineries, coke ovens, iron and steel plants, cement, glass, lime, bricks, ceramics, pulp, paper, and board. The cap was based on the aggregation of the national allocation plans of each Member State. According to Article 27 of the Directive 2003/87/EC (still in act) small installations, emitting less than 25,000 tons of CO2 equivalent, can be excluded from the EU ETS by the Member States, provided that are subject to measures that will achieve an equivalent contribution to emission reductions.[33] The firms could also use emission reduction units generated under Joint Implementation (JI) and the Clean Development Mechanism (CDM) to fulfil their obligations under the EU ETS.

In phase II, the number of allowances were reduced by 6.5% compared to 2005, out of which about 90% of allowances were allocated for free following benchmarking. A tiny fraction (about 3%) was auctioned in 8 Member States. Still most categories of emission reduction units from CDM/JI were allowed up to a certain percentage limit, which was determined in each country's national allocation plan. On top of that, a firm could bank (store) these allowances during this period and carry them to the next phase. Indeed, by the end of phase II, a surplus of approximately 2 billion allowances was accumulated (EC, 2015). Moreover, the aviation sector was included into the EU ETS on 1 January 2012.

The most important changes were introduced in phase III. According to Directive 2009/29/EC, the allocation of free emission allowances is not decided in a decentralized fashion,

[33] All Directives and Acts regarding the EU ETS can be found on https://eur-lex.europa.eu/homepage.html?locale=en.

but it is determined centrally, envisaging a harmonized allocation scheme that reduces competitive distortions among producers of similar products across Member States. Few more sectors, such as carbon capture and storage installations, production of petrochemicals, ammonia, nonferrous and ferrous metals, gypsum, aluminum, as well as nitric, adipic, and glyoxylic acid were included.

Two main features of the scheme deserve further qualification, namely benchmarking and free allocation of allowances to sectors that are exposed to carbon leakage. Benchmarking is based on average emission intensity over the years 2007-2008 and allowances are set at the average of the 10% most efficient installations in the sector or subsector. The level of free allocated allowances are defined as $\bar{e}_{ijt}$, where *i* stands for the installation, *j* for the benchmarked product and *t* for the year. The formula is

$$\bar{e}_{ijt} = benchmark_j \times historical\ activity\ level_{ij} \times reduction_{it} \times correction_t,$$

where *historical activity level* stands for the median activity level of past years, *reduction* takes the value 1 if the installation faces the risk of carbon leakage (or 0.8 and decreases over time for other industrial installations), and *correction* aligns the total free allocation to benchmarked installations with the overall cap on emissions (for further details, see Martin et al., 2014). The less efficient installations, however, must resort to the market to purchase any extra allowances.

Carbon leakage risk is assessed against the criteria of emissions intensity and trade exposure or their combination. In particular, direct and indirect cost increase must be larger than 30%, or non-EU trade intensity larger than 30%, or direct and indirect cost increase larger than 5%, and trade intensity larger than 10%. According to Decision 2010/2/EU (pursuant to Directive 2003/87/EC), the list of sectors facing significant risk of carbon leakage are assessed at a 4-digit level (NACE-4 level). Direct costs are linked to an estimated emissions price 30 € per ton of CO_2 equivalent, whereas the indirect costs to the usage intensity and the price of electricity.

A2. Theoretical Model

A2.1. Model details

Setup

The firm's problem. We focus on the behavior of a single firm, as the role of competition for our research question is orthogonal to our analysis. Indirectly, multiple firms that are active in different markets are present.

We consider a typical firm *i* that is active in sector *i* = 1,…., I in periods *t* = 1, 2. Firm *i* produces a quantity x_{it} that yields revenues $r(x_{it})$, where it holds $r'(x_{it}) > 0$ and $r''(x_{it}) < 0$. That is, revenues are an increasing and concave function with respect to production. One unit of production implies a unit of emissions.

The firm is endowed with a number of free allocated (grandfathered) emission allowances/permits $\bar{e}_{it}$ set by the regulator. Yet, the firm must abate its excess emissions through private abatement technology α_{it}, which allows adherence to the binding level of grandfathered emissions; alternatively, it may purchase extra allowances, e_{it}, from the tradable permits market at a given price P_t. Therefore, abatement equals:

$$\alpha_{it} = x_{it} - \bar{e}_{it} - e_{it} - s_{it-1}. \quad \text{(A1)}$$

The term s_{it-1} stands for the number of stored allowances, or any alternative offset, from period *t-1* that can be used in period *t*. Put simply, equation (A1) mandates that firms must abate the emissions exceeding the free allocated and purchased allowances. Notably, free allocated allowances and purchased or stored allowances are perfect substitutes. Following standard literature (e.g., Barrett 1994), we introduce an abatement cost function $c(\alpha_{it})$, which is increasing and convex (i.e., $c'(\alpha_{it}) > 0$ and $c''(\alpha_{it}) > 0$). In order to operate, firm *i* in period *t* needs access to bank loans that amount to k_{it} at unit cost R_{it} (interest rate). Profits in each period for firm *i* are:

$\pi_{it} = r(x_{it}) - c(\alpha_{it}) - (e_{it} + \mathbf{1}_{s_{it}>0} s_{it})P_t - R_{it}k_{it} - A_{it} + \theta_{it},$

where $\mathbf{1}_{s_{it}>0}$is an indicator function that equals 1 when $s_{it} > 0$, A_{it} denotes fixed payments per period, and θ_{it} is a stochastic term that follows a distribution $\theta_{it} \sim [-\theta, \theta]$ with zero mean, where θ is a positive scalar. The bounds are set such that the firm can end up with negative profits upon certain realizations of θ_{it}, whenever abatement costs bite. The sum of discounted profits is $\pi_i = \pi_{i1} + \pi_{i2}$, where the discount factor is set equal to one for simplicity. We define separately as variable operational profits the following expression:

$\pi_{it}^{v} = r(x_{it}) - c(\alpha_{it}) - e_{it}P_t + \theta_{it},$

where the fixed components that do not vary with economic activity, i.e., $R_{it}k_{it}$ and A_{it} are absent, as well as the expenses for purchasing permits for future utilization, as they do not affect actual variable profits (they can be liquidated at any point in time). Variable profits are instrumental for the analysis as they vary over time, and they critically affect aggregate profits and the associated risk of default.

The firm maximizes expected profits denoted by the operator *E* so that:

$$\begin{Bmatrix} In\ t = 1:\ argmax_{x_{i1}, e_{i1}, \alpha_{i1}, s_{i1}} E\pi_i \quad s.t.\ \ (A1) \\ In\ t = 2:\ argmax_{x_{i2}, e_{i2}, \alpha_{i2}} E\pi_{i2} \quad s.t.\ \ (A1) \end{Bmatrix} \tag{A1}$$

We can simplify the maximization problems in (A2) by replacing the corresponding binding abatement constraint $(A1)$ into the profit functions. Then, the firm's choice variables are (i) production, (ii) allowance purchases in each period, and (iii) the number of stored allowances (when applicable).

The bank's problem. A competitive bank provides a loan k_{it} to firm *i* in period *t* at unit rate R_{it}. The fixed interest rate of the central bank equals ρ_t. The bank's expected profits are:

$B_t = \varphi(E\pi_{it}^{v})R_{it}k_{it} - \rho_t k_{it}.$

Note that $E\pi_{it}^{v}$ denotes the expected variable operational profits where the stochastic term θ_{it} disappears as it has zero mean. The term $\varphi(E\pi_{it}^{v}) \in (0,1)$, where $\varphi'(E\pi_{it}^{v}) > 0$, stands for the subjective probability that the bank assigns upon success of the project; that is, the corresponding period's expected profits are positive.[34] Thus, tighter regulation reduces the probability of success. Following Andersen (2017) we assume that lenders are risk neutral and have a reservation rate of return normalized to 0. The bank's participation constraint in each period for an arbitrary loan amount $k_{it} > 0$ is the following:

$$B_t \geq 0 <=> R_{it} \geq \frac{\rho_t}{\varphi(E\pi_{it}^{v})}\,. \tag{A3}$$

The permits market. Resembling all the active tradable allowance systems around the globe, and more specifically the EU ETS, we allow firms in every sector *i* to participate in the permits market. The market-clearing condition in period *t* is described by the following equation:

$$\sum_{i=1}^{I}(e_{it} + \bar{e}_{it} + \mathbf{1}_{s_{it}>0} s_{it}) = \bar{z}_t, \tag{A4}$$

where $\bar{z}_t$, exogenous in our setup, is the aggregate cap set by the regulator in period *t*, or equivalently the supply of allowances in that period. When the market clears, as described in (A4), we obtain the corresponding equilibrium permits price P_t. Note that the individual firms are price takers, as this market is thick and involves a large number of firms across different sectors (e.g., Requate, 2006). Naturally, we expect that a decrease in $\bar{z}_t$, which is a reduction (increase) in the supply of allowances, leads to a higher (lower) price. Similarly, if the demand for allowances from firms, $\sum_{i=1}^{I} e_{it}$ or $\sum_{i=1}^{I} s_{i1} > 0$, increases (decreases), prices surge (fall).

[34] We employ the notion of (expected) variable operational profits, $E\pi_{it}^{v}$, to focus on first order effects. The subjective probability of success, $\varphi(E\pi_{it}^{v})$, depends on the effect of regulation over the direct activities of the firm and not so much on the effect over the interest rate set by the bank. Put simply, a project should not fail because the bank sets excessively high interest rates as a result of a tighter policy. The response of the interest rate on policy changes and the associated effect over the probability of the project success is a second order effect that follows the main change, and thus we opt to rule it out for expositional purposes.

Timing of the game. We study a two-period game where each period has two stages:

- *Period 1 (t=1)*

  a. The competitive bank sets R_{i1} to firm i.

  b. Firm i selects x_{i1}, e_{i1}, and s_{i1}.

- *Period 2 (t=2)*

  a. The competitive bank sets R_{i2} to firm i.

  b. Firm i selects x_{i2} and e_{i2} .

The problem is resolved backward, and the solution concept is the subgame perfect Nash equilibrium. This is so despite the presence of uncertainty, as there is no asymmetry of information between participants. Uncertainty is revealed to participants ex-post. It is also important to stress that in each period the regulator determines the number of free allocated allowances to all sectors. Yet, this decision is exogenous to our analysis.

In terms of the empirical model in section 4, period 1 (t = 1) corresponds to the period prior to 2013 (when phase III started), and period 2 (t = 2) refers to the period after 2013 when our treatment took place.

Main results

We study the effect on bank loan spreads implied by interest rates, as we change the number of costly allocated allowances, the number of stockpiled allowances, and the permits price.[35] Central to our analysis (main hypothesis) is determining how loan spreads change between time periods that correspond to the transition from phase II to phase III.

Regarding the effect of costly allocated allowances, we obtain the following.

Result 1: *When the number of free allocated allowances increases, loan spread decreases.*

[35] Note that the interest rate implies the loan spread, as the latter equals $R_{it} - \rho_t$, where ρ_t is fixed.

This result follows $\frac{dR_{i2}}{d\bar{e}_{i2}}$, which we derive in the set of equations (A7) in appendix A2.2. This equation captures the sign of the change of free allocated allowances over the interest rate. From equation (A1), free allocated and purchased allowances are perfect substitutes in terms of abatement reduction. The negative relation that we establish in Result 1 comes from the fact that when more free allowances are allocated, *ceteris paribus*, the firm must acquire from the market fewer rights to emit; the optimal level of abatement does not change, because the permits price, which is fixed, determine it. Thus, a higher number of free allocated allowances reduces the firm's compliance costs, which in turn implies a higher probability of project success, $\varphi'(E\pi_{it}^{v}) > 0$. The bank faces a less risky project and requires a lower loan spread. Conversely, following a similar rationale, it follows that the higher the number of costly allocated allowances, the higher the loan spread.

Next, we focus on the effect of the number of stored allowances on the loan spread. From the second-period perspective, stored allowances chosen endogenously in the first period are exogenous. Note that the number of stored allowances is just one instrument the firm can use to comply with tighter future regulation and alleviate the cost of regulation. Any prior investment in abatement technologies or action that leads to a lower future demand for allowances has a similar effect. A concrete example is the use of credits from the Joint Implementation and the Clean Development Mechanism, which offset the emission allowances required (see Ellerman et al., 2016).

Result 2: *When the number of stored allowances increases, loan spread decreases.*

The derivative $\frac{dR_{i2}}{ds_{i1}}$ described in the set of equations (A7) in appendix A2.2. leads to this conclusion. Note that this derivative is equal to $\frac{dR_{i2}}{d\bar{e}_{i2}}$ because the mechanics are exactly the same. Stored allowances economically are equivalent to free allowances in the period in which the firm utilizes them. A higher number of stored allowances decreases the necessity for new allowances because these two are perfect substitutes. As a result, the firm's costs of compliance are lower, implying a higher probability of success, which leads to a lower loan spread.

We now focus on the effect of the permits price, P_t, over the loan spreads. The permits price is an indirect measure of the regulatory policy tightness. It is determined through the market clearing condition (A4) in every period, but as the firms are price takers P_t is treated as an exogenous parameter into their decision problem.

Result 3: *When the permits price increases, loan spread increases.*

We verify the effect that permits price has on interest rate by the sign of the derivative $\frac{dR_{i2}}{dP_2}$ illustrated also in the set of equations (A7) in appendix A2.2. An increase in the (second period) price of permits increases the firm's costs if the firm is a permits buyer. This decreases the firm's expected profits, and thus the loan becomes riskier for the bank, which charges a higher loan spread.

The main focus (and main hypothesis) of this paper is the change in loan spreads between periods (phases II and III of the EU ETS).

Main Hypothesis: *Ceteris paribus the loan spread is lower in period 2 than in period 1.*

To understand this result, we focus on the strategic incentive present in the first period of the game and at the same time exploit Result 2. It suffices to show that $s_{i1} > 0$. Following equations (A8) and (A9) in appendix A2.2., which evaluate the first-order condition for profit maximization with respect to the number of stored allowances intended for future use at $s_{i1} = 0$, we observe that this is indeed verified, all else being equal. The firm holds a strictly positive quantity exactly because these allowances can reduce the second-period interest rate (see Result 2). Remarkably, this is a sufficient condition if we abstract from any additional motives such as arbitrage or cost smoothing attributed to intertemporal differences in the prices of allowances. Hence, we obtain $s_{i1} > 0$ when we artificially set the prices of allowances equal between periods to remove any incentives for arbitrage that could trigger permits storage.

A2.2. Solution and comparative statics

Solving backwards we start from *t* = 2b. Substituting equation (A1) into the profit function the optimization problem described in equation (A2) is simplified and first order conditions of the optimization problem are now:

$$\begin{Bmatrix} \frac{\partial \pi_{i2}}{\partial x_{i2}} = r'(x_{i2}) - c'(x_{i2} - \bar{e}_{i2} - e_{i2} - s_{i1}) = 0 \\ \frac{\partial \pi_{i2}}{\partial e_{i2}} = c'(x_{i2} - \bar{e}_{i2} - e_{i2} - s_{i1}) - P_2 = 0. \end{Bmatrix} \quad \text{(A5)}$$

In order to obtain a maximum, the problem must be concave and thus the second order conditions must be satisfied. This holds when the Hessian matrix $\boldsymbol{H_2}$ is negative definite.

Moving to *t* = 2a the bank's participation constraint as described by equation (A3) must be binding. Therefore, the second period interest rate equals

$$R_{i2} = \frac{\rho_2}{\varphi(E\pi_{i2}^{v})}. \quad \text{(A6)}$$

Applying the implicit function theorem in (A6) and exploiting the Envelope Theorem from the first order conditions for profit maximization presented in (A5) we obtain:

$$\begin{Bmatrix} \frac{dR_{i2}}{d\bar{e}_{i2}} = -\frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(E\pi_{i2}^{v})^2}\frac{\partial E\pi_{i2}^{v}}{\partial \bar{e}_{i2}} = -\frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(E\pi_{i2}^{v})^2}P_2 < 0 \\ \frac{dR_{i2}}{ds_{i1}} = -\frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(E\pi_{i2}^{v})^2}\frac{\partial E\pi_{i2}^{v}}{\partial s_{i1}} = -\frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(\pi_{i2}^{v})^2}P_2 < 0 \\ \frac{dR_{i2}}{dP_2} = -\frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(E\pi_{i2}^{v})^2}\frac{\partial E\pi_{i2}^{v}}{\partial P_2} = \frac{\varphi'(E\pi_{i2}^{v})\rho_2}{\varphi(E\pi_{i2}^{v})^2}e_{i2} > 0 \end{Bmatrix} \quad \text{(A7)}$$

The last step is to show explicitly that there exists an incentive for the firm, *ceteris paribus*, to purchase allowances and store them in the first period and use them in the second period. To this end, we examine stage *t* = 1b and focus on the decision of the firm regarding s_{i1}. This is the variable that links the two periods, while the rest of the analysis remains intact also in the first period. The first order condition for the aggregate profits' maximization described in equation (A2) with respect to s_{i1} is:

$$\frac{\partial \pi_i}{\partial s_{i1}} = -P_1 + c'(x_{i2} - \bar{e}_{i2} - e_{i2} - s_{i1}) - \frac{dR_{i2}}{ds_{i1}} k_{it} \geq 0. \quad \text{(A8)}$$

Note that from the first order condition $\frac{\partial \pi_{i2}}{\partial e_{i2}} = 0$ in (A5) we obtain $P_2 = c'(x_{i2} - \bar{e}_{i2} - e_{i2} - s_{i1})$.

Now (A8) reduces to $\frac{\partial \pi_i}{\partial s_{i1}} = P_2 - P_1 - \frac{dR_{i2}}{ds_{i1}} k_{it} \geq 0$. From (A7) we know that $\frac{dR_{i2}}{ds_{i1}} < 0$. To highlight the presence of a strategic incentive to store allowances, we remove any other possible motivation for storage such as arbitrage or intertemporal cost smoothing. To this end and given that the permit prices are exogenous in our analysis, we arbitrarily set $P_1 = P_2$. We evaluate $\frac{\partial \pi_i}{\partial s_{i1}}$ at $s_{i1} = 0$. When the latter holds, and using (A7), the derivative is:

$$\frac{\partial \pi_i}{\partial s_{i1}}\Big|_{s_{i1}=0} = -\frac{dR_{i2}}{ds_{i1}} k_{it} > 0. \quad \text{(A9)}$$

A3. Sample details and additional robustness tests

	Observations by country			Observations by year			
	Country	Obs.	Percent	Year	Nontreated obs.	Treated obs.	Total obs.
1	Austria	298	0.65	2005	5,669	2,174	7,843
2	Belgium	842	1.83	2006	3,898	1,270	5,168
3	Bulgaria	70	0.15	2007	3,063	1,562	4,625
4	Croatia	17	0.04	2008	2,377	602	2,979
5	Cyprus	93	0.2	2009	1,185	529	1,714
6	Czech	48	0.1	2010	1,687	1,184	2,871
7	Denmark	549	1.2	2011	2,685	1,125	3,810
8	Finland	559	1.22	2012	1,538	988	2,526
9	France	7,474	16.27	2013	1,636	1,131	2,767
10	Germany	7,578	16.5	2014	2,509	1,016	3,525
11	Greece	145	0.32	2015	2,370	921	3,291
12	Hungary	299	0.65	2016	1,220	344	1,564
13	Iceland	276	0.6	2017	1,733	446	2,179
14	Ireland	432	0.94	2018	860	276	1,136
15	Italy	2,562	5.58				
16	Luxembourg	889	1.94				
17	Malta	19	0.04				
18	Netherlands	3,605	7.85				
19	Norway	867	1.89				
20	Poland	511	1.11				
21	Portugal	352	0.77				
22	Slovakia	22	0.05				
23	Slovenia	67	0.15				
24	Spain	7,439	16.2				
25	Sweden	865	1.88				
26	United	10,120	22.00				
	Total	**45,998**	**100**	**Total**	**32,430**	**13,568**	**45,998**

Number of distinct treated firms effectively in the sample

Sample version		Treated obs.	No of distinct treated firms
Column IV in Table 3	Whole EU ETS program (2005-2018)	13,568	237
	3rd phase only (2013-2018)	4,134	101

Our baseline sample includes firms in the treated and control groups that come from all sectors. Using the Global Industry Classification, the control (treatment) group includes 4,461

(3,503) observations from the energy and materials, 10,837 (3,151) from industrial and consumer discretionary, 2,886 (2,777) from consumer staples and health care, 3,637 (322) from financials and IT, 5,814 (2,696) from communication services and utilities, and 799 (5) from real estate. As shown in the last specification of Table 4, removing the finance and real estate sectors from the sample yields equivalent results. This is the case for all the results in the paper. Given that some financial firms are subsidiaries of polluting holding companies and participate in the program, we keep all sectors in the baseline results.

The countries used in our sample are symmetric for both treatment and controls groups. The treatment and control groups are also comparable across several dimensions. Importantly, using t-tests on means, we find that the mean spread in the borrowers' countries equals 5.41 (5.39) for the control (treatment group), with the difference being statistically insignificant. The statistics across several other dimensions are also directly comparable. Average *Facility amount* equals 19.82 (20.87) for the control (treated) group, *Maturity* equals 3.96 (3.93), *Borrower's EBIT* equals 0.073 (0.069), and the debt to assets ratio equals 0.94 for both groups. There are some statistically significant differences in *Borrower's size* (8.80 for the control group vs. 10.05 for the treatment group) and to a lesser extent in *Borrower's M/B* (0.39 vs. 0.30), but we control for these variables in all our empirical tests. Further tightening the sample to fully match on observables yields even more statistically significant results, but this comes at the expense of loss in degrees of freedom.

Table A1. Replicates Table 3 without year FE or adding lender fixed effects

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Treated	-0.003 (-0.02)	-0.003 (-0.02)	0.039 (0.35)	0.033 (0.28)	0.031 (0.27)	-0.023 (-0.18)
3rd phase dummy	0.081** (2.43)	0.082** (2.54)	-0.005 (-0.11)	0.086 (1.63)	0.049 (0.92)	
Treated × 3rd phase dummy	-0.243*** (-2.60)	-0.234*** (-2.60)	-0.225*** (-3.00)	-0.249*** (-3.13)	-0.265*** (-3.40)	-0.238*** (-3.18)
Facility amount		-0.039*** (-6.02)	-0.031*** (-2.71)	-0.030*** (-2.64)	-0.034*** (-3.23)	-0.029*** (-2.75)
Maturity		0.034 (1.51)	0.088*** (2.62)	0.100*** (3.04)	0.087** (2.37)	0.119*** (3.67)
Number of lenders		-0.089*** (-3.72)	-0.020 (-0.62)	-0.017 (-0.54)	-0.026 (-0.85)	-0.040 (-1.33)
Collateral		0.156*** (3.81)	0.156*** (3.14)	0.150*** (2.99)	0.152*** (3.02)	0.173*** (3.60)
Performance dummy		-0.011 (-0.24)	0.068 (1.55)	0.080* (1.88)	0.078* (1.95)	0.076* (1.71)
Borrower's country loan spread			0.705*** (10.26)	0.643*** (10.10)	0.637*** (9.42)	
Lender's country loan spread			1.054*** (16.36)	0.973*** (14.45)	1.015*** (13.27)	
Borrower's size			-0.123*** (-2.99)	-0.118*** (-2.87)	-0.127*** (-3.14)	-0.105** (-2.25)
Borrower's M/B			0.059 (0.73)	0.071 (0.91)	0.110 (1.28)	-0.005 (-0.05)
Borrower's EBIT			-1.576*** (-4.16)	-1.531*** (-4.01)	-1.782*** (-4.72)	-1.684*** (-3.87)
Borrower's country GPD growth				-0.021** (-2.55)	-0.020** (-2.20)	
Lender's country GPD growth				0.006 (1.47)	0.001 (0.18)	
Borrower's country crises				0.149*** (3.29)	0.149*** (3.18)	
Lender's country crises				-0.004 (-0.26)	-0.010 (-0.46)	
Lender's book leverage					-2.211*** (-4.00)	
Lender's non-performing assets					2.020*** (3.97)	
Lender's size					0.041* (1.68)	
Lender's EBIT					-1.697*** (-4.66)	
Constant	5.061*** (226.23)	5.817*** (36.67)	-3.212*** (-5.99)	-2.597*** (-4.76)	-1.019 (-1.36)	5.898*** (12.46)
Observations	132,209	130,856	46,322	45,998	18,646	45,268
No of firms	4,389	4,336	1,232	1,227	1,045	1,226
Borrower, Lender, Loan purpose, Loan type FE	Yes	Yes	Yes	Yes	Yes	Yes
Adding lender × year fixed effects	No	No	No	No	No	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.85	0.85	0.90	0.90	0.89	0.91

Table A2. Different clustering of standard errors

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
Treated	0.022 (0.21)	0.022 (0.24)	0.022 (0.26)
Treated × 3rd phase dummy	-0.251*** (-3.40)	-0.251*** (-4.18)	-0.250*** (-6.43)
Facility amount	-0.027** (-2.51)	-0.027** (-2.89)	-0.027** (-2.36)
Maturity	0.115*** (3.97)	0.115*** (4.02)	0.116** (2.95)
Number of lenders	-0.031 (-1.08)	-0.031 (-1.21)	-0.030 (-1.17)
Collateral	0.167*** (3.51)	0.167*** (3.30)	0.169*** (4.19)
Performance dummy	0.083** (2.03)	0.083** (2.23)	0.083** (2.25)
Borrower's country loan spread	0.494*** (7.53)	0.494*** (7.12)	0.494*** (5.47)
Lender's country loan spread	0.117*** (3.19)	0.117*** (3.39)	0.116** (2.48)
Borrower's size	-0.107*** (-2.66)	-0.107** (-2.99)	-0.108** (-2.60)
Borrower's M/B	0.068 (0.88)	0.068 (0.89)	0.068 (0.84)
Borrower's EBIT	-1.499*** (-3.83)	-1.499*** (-3.33)	-1.537** (-2.62)
Borrower's country GPD growth	-0.020** (-2.29)	-0.020** (-2.66)	-0.020** (-2.32)
Lender's country GPD growth	0.000 (0.02)	0.000 (0.02)	-0.000 (-0.14)
Borrower's country crises	0.093* (1.91)	0.093 (1.49)	0.094 (1.55)
Lender's country crises	0.013 (1.35)	0.013 (1.16)	0.012 (0.77)
Constant	2.584*** (4.36)	2.584*** (5.37)	2.598*** (3.62)
Observations	45,998	45,998	45,925
No of firms	1,227	1,227	1,224
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes
Clustering	Borrower, lender	Borrower, lender, year	Borrower, lender, industry, year
Adj-R^2	0.91	0.91	0.91

Table A3. Replicates Table 3 - Lead arrangers only

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	-0.078	-0.079	-0.032	-0.034	-0.022
	(-0.56)	(-0.61)	(-0.30)	(-0.31)	(-0.19)
Treated × 3rd phase dummy	-0.232***	-0.228***	-0.219***	-0.230***	-0.229***
	(-2.79)	(-2.87)	(-3.00)	(-3.06)	(-3.08)
Facility amount		-0.033***	-0.025***	-0.024**	-0.025***
		(-6.08)	(-2.67)	(-2.56)	(-2.80)
Maturity		0.127***	0.111***	0.113***	0.104***
		(6.61)	(3.37)	(3.58)	(2.96)
Number of lenders		-0.096***	-0.055**	-0.057**	-0.060**
		(-5.39)	(-2.01)	(-2.06)	(-2.09)
Collateral		0.127***	0.131**	0.129**	0.146***
		(3.67)	(2.57)	(2.56)	(2.87)
Performance dummy		0.019	0.092**	0.103***	0.092**
		(0.53)	(2.28)	(2.71)	(2.49)
Borrower's country loan spread			0.506***	0.460***	0.473***
			(6.95)	(6.59)	(6.15)
Lender's country loan spread			0.168***	0.128***	0.099**
			(4.24)	(3.65)	(2.40)
Borrower's size			-0.080*	-0.087**	-0.119***
			(-1.94)	(-2.13)	(-2.89)
Borrower's M/B			0.084	0.111	0.131
			(0.79)	(1.06)	(1.11)
Borrower's EBIT			-1.578***	-1.562***	-1.765***
			(-3.97)	(-3.95)	(-4.28)
Borrower's country GPD growth				-0.027***	-0.026**
				(-3.10)	(-2.31)
Lender's country GPD growth				-0.001	0.003
				(-0.59)	(1.15)
Borrower's country crises				0.073	0.084
				(1.41)	(1.51)
Lender's country crises				0.013	0.017
				(1.07)	(1.19)
Lender's book leverage					2.135***
					(3.67)
Lender's non-performing assets					0.728
					(1.55)
Lender's size					0.019
					(0.81)
Lender's EBIT					0.316
					(0.82)
Constant	5.128***	5.415***	2.064***	2.585***	0.759
	(294.79)	(40.39)	(3.21)	(4.22)	(0.89)
Observations	88,365	87,451	32,820	32,701	14,398
No of firms	4,192	4,139	1,196	1,191	985
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes	Yes	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.90	0.90	0.91	0.91	0.90

Table A4. Replicates Table 3 – Excluding firms in the power sector

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	0.105	0.102	0.106	0.107	0.099
	(0.88)	(0.93)	(0.95)	(0.94)	(0.90)
Treated × 3rd phase dummy	-0.302***	-0.302***	-0.300***	-0.315***	-0.310***
	(-3.01)	(-3.12)	(-3.26)	(-3.32)	(-3.47)
Facility amount		-0.039***	-0.045***	-0.046***	-0.042***
		(-7.83)	(-4.45)	(-4.54)	(-3.70)
Maturity		0.130***	0.110***	0.117***	0.108***
		(7.88)	(3.86)	(4.09)	(3.49)
Number of lenders		-0.065***	-0.009	-0.013	-0.018
		(-3.41)	(-0.30)	(-0.41)	(-0.62)
Collateral		0.154***	0.203***	0.199***	0.196***
		(4.54)	(3.77)	(3.73)	(3.64)
Performance dummy		-0.022	0.045	0.061	0.060
		(-0.58)	(0.92)	(1.27)	(1.35)
Borrower's country loan spread			0.459***	0.406***	0.409***
			(5.29)	(5.15)	(5.04)
Lender's country loan spread			0.169***	0.137***	0.081*
			(4.21)	(3.83)	(1.85)
Borrower's size			-0.092*	-0.098**	-0.125***
			(-1.95)	(-2.12)	(-2.81)
Borrower's M/B			0.061	0.076	0.104
			(0.77)	(0.98)	(1.16)
Borrower's EBIT			-1.746***	-1.778***	-1.947***
			(-3.53)	(-3.58)	(-3.99)
Borrower's country GPD growth				-0.019*	-0.018*
				(-1.95)	(-1.67)
Lender's country GPD growth				0.001	0.003
				(0.49)	(1.21)
Borrower's country crises				0.107*	0.109*
				(1.86)	(1.76)
Lender's country crises				0.015	0.011
				(1.48)	(0.84)
Lender's book leverage					0.825*
					(1.92)
Lender's non-performing assets					0.873*
					(1.91)
Lender's size					0.004
					(0.20)
Lender's EBIT					0.164
					(0.48)
Constant	5.116***	5.415***	2.696***	3.205***	2.864***
	(511.92)	(45.38)	(3.86)	(4.81)	(3.69)
Observations	124,467	123,167	39,065	38,824	15,823
No of firms	4,207	4,156	1,058	1,055	901
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes	Yes	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.90	0.90	0.91	0.91	0.91

Table A5. Replicates Table 3 – Dependent variable is All-in-undrawn

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *All-in-undrawn*. Definitions for all variables are in Table 1. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	-0.062	-0.078	-0.048	-0.087	-0.112
	(-0.12)	(-0.15)	(-0.10)	(-0.20)	(-0.28)
Treated × 3rd phase dummy	-0.093	-0.070	0.144	0.188	0.112
	(-0.35)	(-0.26)	(0.78)	(1.02)	(0.65)
Facility amount		-0.026	0.011	0.005	-0.012
		(-1.07)	(0.34)	(0.15)	(-0.41)
Maturity		-0.137*	-0.148	-0.154*	-0.083
		(-1.67)	(-1.62)	(-1.67)	(-0.99)
Number of lenders		-0.013	0.005	0.015	0.035
		(-0.18)	(0.06)	(0.20)	(0.52)
Collateral		0.236*	-0.047	-0.060	-0.012
		(1.80)	(-0.28)	(-0.37)	(-0.07)
Performance dummy		0.088	0.212**	0.209**	0.243***
		(1.05)	(2.39)	(2.44)	(2.98)
Borrower's country loan spread			0.569***	0.535***	0.531***
			(3.38)	(3.61)	(3.38)
Lender's country loan spread			0.026	0.012	-0.006
			(0.80)	(0.33)	(-0.11)
Borrower's size			0.003	-0.048	-0.034
			(0.03)	(-0.59)	(-0.39)
Borrower's M/B			0.300	0.427*	0.484**
			(1.14)	(1.66)	(2.30)
Borrower's EBIT			-2.674***	-2.736***	-2.669***
			(-2.74)	(-2.95)	(-3.18)
Borrower's country GPD growth				-0.087***	-0.058**
				(-2.77)	(-2.00)
Lender's country GPD growth				0.000	-0.000
				(0.17)	(-0.09)
Borrower's country crises				-0.022	-0.022
				(-0.13)	(-0.14)
Lender's country crises				0.027	0.015
				(1.53)	(0.70)
Lender's book leverage					0.729
					(1.25)
Lender's non-performing assets					0.366
					(0.60)
Lender's size					-0.030
					(-1.12)
Lender's EBIT					-0.159
					(-0.42)
Constant	3.239***	4.252***	0.218	1.260	0.974
	(27.05)	(7.61)	(0.16)	(1.07)	(0.64)
Observations	17,719	17,629	9,481	9,471	3,961
No of firms	996	986	438	438	372
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes	Yes	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.94	0.95	0.95	0.95	0.95

Table A6. Replicates Column (4) in Table 3 – Credit lines vs. Term loans

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. In specifications (1) and (2) only loan types characterized as credit lines or term loans, respectively, are included in the sample. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Treated	-0.041	0.283**
	(-0.37)	(2.06)
Treated × 3rd phase dummy	-0.181**	-0.545***
	(-2.32)	(-2.92)
Facility amount	-0.050**	-0.031**
	(-2.25)	(-2.52)
Maturity	-0.116*	0.232***
	(-1.95)	(5.23)
Number of lenders	0.036	-0.030
	(0.88)	(-0.81)
Collateral	0.147**	0.176***
	(2.02)	(2.97)
Performance dummy	0.122**	-0.028
	(2.28)	(-0.44)
Borrower's country loan spread	0.414***	0.562***
	(6.07)	(4.76)
Lender's country loan spread	0.089***	0.133***
	(2.60)	(3.13)
Borrower's size	-0.058	-0.086
	(-1.22)	(-1.37)
Borrower's M/B	0.060	0.006
	(1.24)	(0.14)
Borrower's EBIT	-1.380***	-1.192
	(-3.27)	(-1.17)
Borrower's country GPD growth	-0.027***	-0.003
	(-2.60)	(-0.36)
Lender's country GPD growth	0.002	0.002
	(0.76)	(0.96)
Borrower's country crises	0.088	0.113
	(1.64)	(1.18)
Lender's country crises	0.013	0.021*
	(1.30)	(1.70)
Constant	3.696***	1.767**
	(5.04)	(2.22)
Observations	23,108	18,180
No of firms	891	731
Borrower, Lender, Loan purpose, Year FE	Yes	Yes
Clustering	Borrower	Borrower
Adj-R^2	0.92	0.92

Table A7. Replicates Table 3 – Weighted least squares

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*. Definitions for all variables are in Table 1. Estimation method is weighted least squares, using as weights the number of observations in a borrower's country-year, with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, type of clustering, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	0.192*	0.199**	0.188*	0.195*	0.199**
	(1.67)	(2.00)	(1.72)	(1.80)	(1.97)
Treated × 3rd phase dummy	-0.297***	-0.319***	-0.320***	-0.337***	-0.345***
	(-3.29)	(-3.77)	(-4.29)	(-4.35)	(-4.82)
Facility amount		-0.033***	-0.016	-0.016	-0.022*
		(-4.23)	(-1.07)	(-1.04)	(-1.68)
Maturity		0.181***	0.124***	0.125***	0.105***
		(9.04)	(4.15)	(4.28)	(3.20)
Number of lenders		-0.080***	-0.027	-0.031	-0.044
		(-4.07)	(-0.86)	(-0.99)	(-1.37)
Collateral		0.158***	0.211***	0.208***	0.211***
		(4.54)	(4.34)	(4.34)	(4.55)
Performance dummy		-0.037	0.051	0.055	0.041
		(-0.87)	(1.10)	(1.19)	(1.00)
Borrower's country loan spread			0.813***	0.700***	0.618***
			(6.76)	(5.41)	(4.89)
Lender's country loan spread			0.109***	0.088***	0.075**
			(3.40)	(2.94)	(2.02)
Borrower's size			-0.117***	-0.119***	-0.127***
			(-2.76)	(-2.78)	(-3.04)
Borrower's M/B			-0.095	-0.103	-0.004
			(-0.42)	(-0.47)	(-0.02)
Borrower's EBIT			-2.007***	-2.039***	-2.123***
			(-4.12)	(-4.20)	(-4.69)
Borrower's country GPD growth				-0.014	-0.011
				(-0.68)	(-0.55)
Lender's country GPD growth				-0.000	0.003
				(-0.25)	(1.17)
Borrower's country crises				0.106*	0.120*
				(1.68)	(1.87)
Lender's country crises				0.010	0.007
				(0.95)	(0.57)
Lender's book leverage					0.822**
					(2.44)
Lender's non-performing assets					0.659
					(1.48)
Lender's size					-0.016
					(-0.93)
Lender's EBIT					0.008
					(0.02)
Constant	5.001***	4.999***	0.620	1.362	1.574*
	(420.32)	(30.00)	(0.80)	(1.58)	(1.74)
Observations	132,209	130,856	46,322	45,998	18,646
No of firms	4,389	4,336	1,232	1,227	1,045
Borrower, Lender, Loan purpose, Loan type, Year FE	Yes	Yes	Yes	Yes	Yes
Clustering	Borrower	Borrower	Borrower	Borrower	Borrower
Adj-R^2	0.92	0.92	0.93	0.93	0.92

Table A8. Replicates Table 7 – Use allowances-related variables per € of total assets

The table reports coefficient estimates and t-statistics (in parentheses) from estimations using the syndicated loans sample. The dependent variable is *Loan spread*, and all specifications include the control variables of Table 6. Definitions for all variables are in Table 1. In this table, *Allocated allowances per € of total assets* and *Bought / sold allowances per € of total assets* are calculated as allocated allowances and bought / sold allowances divided by total assets, respectively. Estimation method is OLS with the fixed effects reported in the lower part of the table and robust standard errors clustered by borrower. We do not include year fixed effects because these are collinear with the EUA price and the EU ETS program characteristics, which we aim to explicitly analyze in these specifications. The sample period is 2005-2018. The lower part of the table also reports the number of observations, number of firms, and the adjusted R-squared. The ***, **, and * marks denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Treated	-0.241	-0.093	-0.180	-0.020	0.010
	(-1.25)	(-0.45)	(-1.05)	(-0.10)	(0.05)
3rd phase dummy	0.318***	0.055	0.040	0.044	0.142
	(2.94)	(1.07)	(0.73)	(0.82)	(0.73)
Treated × phase dummy	-0.738***	-3.512***	-0.273***	-0.457**	-4.944***
	(-3.49)	(-3.35)	(-2.80)	(-2.31)	(-4.90)
EUA price	0.058***	0.061***	0.063***	0.063***	0.055***
	(4.22)	(5.46)	(5.70)	(5.69)	(4.12)
Treated × EUA price	0.020				0.014
	(0.96)				(0.68)
3rd phase dummy × EUA price	-0.153**				-0.052
	(-2.50)				(-0.45)
Treated × 3rd phase dummy × EUA price	0.310***				0.356**
	(2.76)				(2.01)
Costly allocated allowances	0.189	0.168	0.071	0.171	0.076
	(0.99)	(0.89)	(0.37)	(1.03)	(0.46)
Treated × 3rd phase dummy × Costly allocated allowances			0.209		0.246
			(1.49)		(1.58)
Allocated allowances per € of total assets	0.000	-0.011	0.005	-0.016	-0.018
	(0.03)	(-0.58)	(0.29)	(-0.83)	(-0.77)
Treated × 3rd phase dummy × Allocated allowances per € of total assets				0.026	0.037*
				(1.46)	(1.89)
Bought / sold allowances per € of total assets		-0.178***			-0.195***
		(-3.22)			(-4.00)
Treated × 3rd phase dummy × Bought / sold allowances per € of total assets		0.176***			0.195***
		(3.14)			(3.96)
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