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Effect of climate-related risk on the costs of bank loans: Evidence from syndicated loan markets in emerging economies☆

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ABSTRACT

Based on a novel dataset that combined syndicated loans originated in the emerging market economies with greenhouse gas emission intensity data of borrowers, this study examines whether and to what extent banks in these emerging markets have factored in climate transition risk in their lending decisions. On loan pricing, our results suggest that banks in these emerging markets have started to price-in climate transition risk for loans to emissions-intensive sector since the Paris Agreement. This could reflect their increased awareness of a climate-transition risk towards such firms. The extent of the transition risk premium is also found to be dependent on the environmental attitude of banks. Specifically, green banks are found to charge a higher loan spread than other banks, when lending to the same brown firm after the Paris Agreement. Apart from pricing a transition risk premium in the loan spread, we find evidence that banks may also consider imposing more stringent non-pricing contractual terms, such as shortening loan tenor and imposing collateral requirement, on brown firms especially when the associated credit risk impacts on these firms are more uncertain.

1. Introduction

Climate change has been receiving increasing attention in recent years. Indeed, it has become a core part of the agenda of public and private sectors globally. Policymakers worldwide have shown strong commitment to tackling climate change. Most notably, the United Nations Framework Convention on Climate Change (UNFCCC) reached an agreement to adopt a legally binding international treaty on climate change at the 21st Conference of the Parties in Paris on 12 December 2015 (i.e. the Paris Agreement). The objective is to limit global warming to well below two degrees Celsius, preferably to 1.5 degrees.[1] To achieve this long-term temperature goal, participating countries agreed on the need to reach a global peak of greenhouse gas (GHG) emissions as soon as possible, and

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[1] To reach the target of limiting global temperature increase to 1.5 degrees Celsius, it is estimated by IPCC that net human-caused carbon dioxide equivalent emissions must fall by 45% by 2030 and reach net zero by 2050.

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concurrently working towards emissions reductions. The ambitious task of transitioning towards a low-carbon economy will likely have large financial implications for a wide range of industries, as their future business operations could be significantly affected by changes in climate policy and climate-related technology. The transition towards a low-carbon economy could also have strong implications for banks. For example, carbon pricing may be adopted by governments to incentivise corporates to reduce GHG emissions. The future cash flows and valuation of banks' corporate borrowers, particularly for those from the largest-emitting sectors could therefore fall significantly, which could in turn affect the credit risks for banks' loan portfolios (Grippa et al. (2019), BCBS (2021a), Capasso et al. (2020)).

In view of the potential adverse impact arising from transitioning to a low-carbon economy, regulators and other key stakeholders have increasingly emphasised the urgency to manage and pre-emptively mitigate climate-related financial risks in the financial system. Wider policy debates have now emerged over what policy toolkits[2] should be implemented by central banks to ensure that the banking system can weather the coming climate transition more smoothly. In particular, the proposal to integrate climate related financial risks into the prudential capital requirement has recently attracted increased attention from central banks (Berenguer et al., 2020). One of the important questions, which could help contribute to this discussion, is whether and to what extent banks have taken the associated climate-related risks (particularly the transition risk[3]) into their lending considerations. If there is evidence to suggest that climate-related risks are largely ignored or overlooked in banks' current business practices, this may justify bank regulators to promptly consider more proactive and stringent strategies to strengthen banks' capacity to withstand the threat of potential abrupt climate transition in future.

In addition, this question is highly relevant to policymakers in the emerging market economies (EM). From the financial stability perspective, given the emerging market economies host a number of the largest greenhouse gas (GHG) emission countries in the world, the potential adverse impact of climate transition risks on these banks could be significant as bank funding is usually considered to be key funding sources for corporates in these economies. On the other hand, from the perspective of promoting sustainable finance, a better understanding of this issue may help inform policymakers about potential action to foster more green financing by the banking sector. However, empirical evidence remains rather limited potentially due to the fact that granular information containing both firms' carbon emission data and their loan terms with banks are generally scarce. While there are a few recent studies (Kleimeier and Viehs, 2018; Degryse et al., 2022; Delis et al., 2021; Ehlers et al., 2022) that address similar questions, they focus mainly on the U.S. or global markets. By contrast, studies on emerging markets remain scant, if any. Therefore, to shed light on the loan pricing of transition risk in the emerging markets, this study compiles a novel dataset by combining multiple data sources to construct a sample of syndicated loans originated in the emerging markets, with the corresponding financial and environmental characteristics of the borrowers and lenders being matched. The data construction will be discussed in detail in the next section.

There are several advantages in using syndicated loan data in this analysis. Firstly, as a large portion of syndicated loan borrowers are listed firms, it enables us to match their GHG emission data from *S&P Trucost database* which covers mainly listed firms as well. Secondly, as the size of syndicated loans is relatively large by nature, lead arranging banks in a loan syndicate should have stronger incentives to scrutinise all the relevant risks of the borrower (including climate-related risks) compared with those smaller bilateral loans.[4] Thirdly, the rich micro-level information available from syndicated loan data, including loan-level characteristics, and the identity of borrowers and lenders, allows us to strengthen the empirical identification of climate transition risk in loan-pricing after controlling for all other key determinants.

In this analysis, we aim to shed light on the aforementioned issue by answering the following questions. Firstly, we seek to investigate whether banks would charge a higher loan spread on firms with higher GHG emissions in the syndicated loan markets in emerging markets.[5] Previous studies (Kleimeier and Viehs (2018), Degryse et al. (2022), Delis et al. (2021), Ehlers et al. (2022), etc) have investigated whether different environmental characteristics of a borrower, such as climate disclosure actions, fossil fuel reserve holdings and current GHG emission profiles, could affect the cost of borrowing in syndicated loan market.[6] While these studies have

[2] Some of the proposed policy actions include mandatory requirement for financial institutions to disclose information on material climate-related financial exposures and risks, climate-risk stress testing, targeted asset purchases in quantitative easing programmes, integrating climate related financial risks into the prudential capital requirement, adjusting the pricing or even eligibility of highly emitting counterparties in accessing credit operations by central banks, etc. (Feridun and Güngör (2020), NGFS (2020), NGFS (2021)).

[3] Transition risk is a financial risk which can result from the process of adjustment towards a low-carbon economy prompted by, for example, changes in climate policy, technological changes or a change in market sentiment. Throughout the paper, transition risk and climate transition risk are used interchangeably.

[4] As lead banks are liable to participant banks for the pricing of all relevant risks and effective screening and monitoring of borrowing firms, lead banks have strong incentives to price loans accurately (Delis et al., 2021).

[5] In principle, highly emitting firms would be more exposed to the transition risk, in which their future cash flows, and hence their debt repayment ability could be adversely affected in the event of a disorderly transition towards a low-carbon economy. If such a risk is considered by banks at the time of loan origination, a higher loan spread should be charged to compensate banks for the additional credit costs stemming from the transition risk.

[6] Kleimeier and Viehs (2018) examine whether firms made voluntarily disclosure to Carbon Disclosure Project (CDP) can receive lower costs of credit. Degryse et al. (2022) extend the investigating in finding whether banks being member of environmental friendly programme would price differently on firms that made voluntarily climate disclosure to CDP, relative to those firms that did not. Delis et al. (2021) find that banks generally did not price climate policy exposure regarding borrowers' stranded fossil fuel reserves before 2015, but starting to price-in this factor afterward. Based on a sample of global project finance syndicated loans, Ehlers et al. (2022) find that firms with higher emission intensity are charged with higher loan spreads, also only after the Paris Agreement.

found supporting evidence that firms with weaker environmental performance are usually charged with higher loan spreads after the Paris Agreement, it is less certain whether their results are also applicable to the EM loan markets given their samples are predominately concentrated in loans syndicated in advanced economies.[7] More importantly, recent studies have found notable geographical variations in the carbon premium of the equity markets around the world. Bolton and Kacperczyk (2020b) finds that a large and significant carbon premium in stock returns arose only after the Paris Agreement, and this change in premium is found to mainly be contributed in Asia (and, albeit based on a smaller sample, also in Africa, Australia, and South America) rather than change in Europe and the United States. As such, it is possible that such geographical differences in the transition risk loan premium may also be present across syndicated loan markets in advanced and emerging economies. Our study therefore would help fill this gap in the literature by broadening our understanding on the impacts of transition risk on loan pricing for the syndicated loan markets from an emerging market perspective.

Secondly, we will examine how far banks' attitude towards green initiatives matters in determining the extent of transition risk in loan pricing. This question is particularly relevant for policymakers in EM given there is a rising share of green banks headquartered in emerging economies over the past few years (see Section II). Intuitively, a more environmentally concerned bank (i.e. "green" bank) should make a greater effort to internalise the potential negative impact on its operations arising from climate-related risk by charging a higher loan spread to a brown borrower relative to non-green banks. Compared with the previous question, existing results in literatures are somewhat mixed. For instance, Degryse et al. (2022) finds evidence that green banks would charge a lower (higher) spread than other non-green banks would do on firms with (without) emissions disclosures, while Delis et al. (2021) also finds similar conclusion that green banks would penalise fossil fuel firms more than other banks. However, on the other hand, Ehlers et al. (2022) do not find evidence that green banks would charge an additional carbon risk premium relative to other banks based on a sample of global project finance syndicated loans. In view of the mixed results, and also given these studies are less focused on the emerging markets, it is difficult to ascertain to what extent the transition risk premium would be determined by the green attitude of banks in the emerging markets. Therefore, we aim to broaden our understanding on this issue, particularly from an emerging market perspective.

Finally, apart from pricing in the transition risks of borrowers in the loan spread, we also investigate whether other non-pricing contractual features in the syndicated loans may be imposed or adjusted by banks as other ways to mitigate the potential credit risk arising from borrowers' transition risks. As suggested in previous literature (Strahan, 1999; Goss and Roberts, 2011; Fard et al., 2020, etc), non-pricing loan features may be used by banks as an alternative or complementary means to mitigate banks' risk exposure when lending to firms that are more subject to climate transition risks. We therefore investigate whether banks would adjust these non-pricing contractual features with regard to borrowers' GHG emission profile in the syndicated loan markets from emerging market economies. To our best knowledge, this is the first paper that examines the effect of climate transition risk on non-pricing loan contractual terms in the EM syndicated loan markets.

Overall, our analysis suggests that banks in emerging economies have started to price-in climate transition risk in the loan spread for loans to emissions-intensive sectors since the Paris Agreement. This could reflect banks' increased awareness of climate-related risks to those corporate borrowers that are more subject to the transition risk arising from direct GHG emissions (i.e. Scope 1 emissions). The extent of the transition risk premium is also found to be dependent on the environmental attitude of banks. Specifically, green banks are found to charge a higher loan spread than other banks, when lending to the same brown firm in the post-Paris Agreement period. Apart from charging a transition risk loan premium, there is also evidence to support that banks may consider imposing more stringent non-pricing contractual terms in the loan contract to mitigate the transition risk of borrowers, especially when the associated financial impacts of transition risks on these borrowers are subject to high uncertainty. In particular, our findings suggest that banks would tend to shorten loan tenor and/or impose collateral requirement on brown firms from non-emissions-intensive sectors, as their transition risks are generally more determined by their indirect emissions (i.e. Scope 2) and thus the resulting credit risk impacts are likely to be subject to high uncertainty. Taken together, these findings provide supportive evidence that banks in these emerging markets have started to incorporate climate risk consideration into their existing risk management framework.

The remainder of this paper is structured as follows. Section II describes the data sources employed in this study. Section III discusses the empirical specification settings and associated results for the research questions. Section IV reports results for examining changes in non-pricing contractual terms. Section V concludes.

2. Data

To shed light on the loan pricing on climate transition risk with a particular focus in the emerging markets, we construct a sample of syndicated loans from syndicated loan market in emerging economies, which is then merged with several data sources to match the relevant financial and environmental characteristics for the corresponding borrowers and lenders of these loans. The main data sources used in constructing the estimation sample are briefly described as follows:

2.1. Syndicated loan data

Our analysis covers a sample of syndicated loans over the period 2010 to March 2021. The loan-level information was obtained from Thomson Reuters LPC DealScan Database (via the Refinitiv Loan Connector platform). Following the literature, we measure loan

[7] Based on information on Refinitiv Loanconnector platform, between 2010 and 2020, around 85% of reported loans with benchmark rates and interest spread information were syndicated in "USA/Canada" and "Western Europe" market.

spread by the "All-in-drawn spread" in basis points and thus consider only those loans with information on the loan spreads. Given that our focus is on the emerging market syndicated loans market, we further restrict our loan sample to those syndicated in major emerging market markets[8] (i.e. where the majority of funds were sourced to finance the loan), but also keep a broader set of loan reference rates.[9] Godlewski and Weill (2008) documented that syndicated loans have undergone a major expansion and represented an important source of external finance in emerging markets even before the global financial crisis. To control for the potential heterogeneity in the intercept level of the loan spread over currencies and over different benchmark rates, we added fixed effects on the currencies and types of benchmark rate in all regressions. We further collect loan characteristics such as the borrower (and its parent) names and industries, syndicate structures, loan active date, size, maturity, pricing details, financial covenants, tranche types and purposes and whether the loan is secured as loan controls. In particular, by linking the names of the bank-type lead arrangers[10] in each loans' syndicate structure to the corresponding financial institutions, it enables us to capture the impacts of variations in lenders' financial characteristics and also banks' environmental attitude in loan pricing decisions.

2.2. Borrowers' and lenders' financial data

The balance sheet data of loan borrowers and lenders were obtained from S&P Capital IQ to control for the impacts of borrowers' and lenders' financial strength on loan pricing whenever available. S&P Capital IQ additionally provides details on the industry classification, organisation structure, state ownership shares and geographical locations for both borrowers and lenders.[11] We further restrict our sample by excluding loans in which the borrower is a financial institution, or if the lead arranger group consists only of lenders which are not commercial and investment banks based on the information from S&P Capital IQ (i.e., policy banks and non-bank type financial institutions are excluded in our sample).

2.3. Firms' GHG emissions data

We gauge firms' exposure to the transition risk by their GHG emissions. The GHG emissions data of corporates are obtained from *S&P Trucost.* It provides annual corporate Carbon Dioxide and other Greenhouse gas (CO_2e) emissions data between 2005 to 2019 for more than 17,000 companies globally (covering more than 90% of global market capitalisations according to the S&P Global). Consistent with the standards set out by the GHG Protocol,[12] three types of GHG emissions data of a corporate are available from *S&P Trucost* - namely Scope 1, 2 and 3 emissions. Generally speaking, Scope 1 emissions cover all emissions generated during fuel combustion activities from a firm (or its controlled affiliates) while Scope 2 emissions cover indirect generation relating to the purchase of energy. Scope 3 emissions include all other indirect emissions that occur in a company's value chain (See Fig. 1 on the definitions of scopes of emissions according to GHG Protocol).

In practice, Scope 1 and 2 emissions data are more widely applied in the assessment of firms' GHG emissions performance, given their clearer and more standardised measurement provided. Such property of consistency allows us to treat the estimated data by Trucost as reasonably comparable to other reported data for corporates' Scope 1 and 2 emissions.[13] Thus, and in line with existing literature, our study focuses primarily on non-financial corporates' Scope 1 and 2 emissions only, and disregards scope 3 emissions.

It is also noteworthy that the absolute amount of GHG emissions is highly correlated with a firm's size. To ensure the comparability of GHG emissions performance across firms, we divide their emissions by their total revenue, which is equivalent to firms' GHG emission intensity. In addition, measuring a firm's GHG emissions relative to its revenue also helps capture the severity of the potential financial impact from a tightening of carbon emission regulations, such as an imposition of a higher carbon tax. For instance, among two firms which have the same amount of total GHG emissions, the firm with a higher GHG emission intensity will find the financial impact of a carbon tax more material compared to the other firm with a lower GHG emission intensity.

It is also noteworthy that the level of emission intensity generally varies across sectors. Fig. 2 presents the average emission intensity of firms across economic sectors by the Global Industry Classification Standards (GICS). As shown, mainly reflecting the nature

[8] We follow the BIS and IMF in defining emerging market economies and include the list of countries of syndication as shown in left panel of Table A2.

[9] These include Bank Bill Swap Bid Rate, Euro Interbank Offered Rate, Hong Kong Interbank Offered Rate, London interbank offered rates, Singapore Interbank Offered Rate and Singapore Swap Offer Rate, Taiwan Interbank offered rates, Tokyo Interbank offered rates and Yen LIBOR. Loans for other reference rates are not included due to a small number of observations remaining after data matching with other data sources.

[10] The lead arrangers are usually responsible for ex ante due diligence and ex post monitoring on the borrower. They usually retain substantial stake in the syndicate (Sufi (2007)).

[11] Specifically, we first match the names of borrowers and lead arranger from DealScan with S&P Capital IQ using the SPCIQ Identifier Converter Excel Template. As a borrower and a lead arranger could negotiate and reach the loan deals through their solely owned subsidiaries or branches, we typically look up the corporate's organisation tree until a parent corporate is identified, which usually the firm would be either a publicly-listed firm or have financial data reported. Second, we match S&P Trucost with S&P Capital IQ conveniently given the availability of International Securities Identification Number (ISIN) for most of the firms under the Trucost Platform. Finally, we merge the three sources, whenever available, to construct the firm-loan-bank relationship data.

[12] The GHG Protocol is considered to be the most widely recognised international accounting tool for the measurement of GHG emissions.

[13] Bolton and Kacperczyk (2020a, 2020c), Dai et al. (2021), Jondeau et al. (2021) and Ehlers et al. (2022) similarly employed the Trucost data to study the pricing of carbon risk. Box 2 in BCBS (2021a, 2021b) also documented that bank respondents confirmed that they look at scope 1 and 2 emissions relatively more than scope 3 emissions.

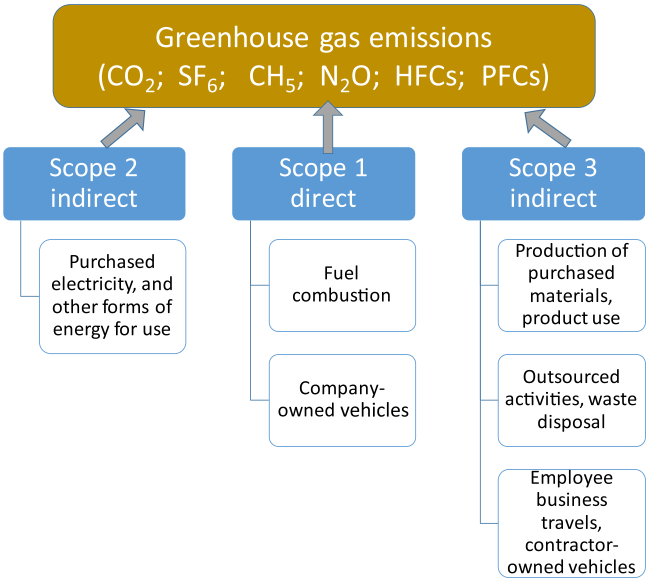


Fig. 1. Overview of greenhouse gas emissions as defined in the Greenhouse Gas Protocol.
Note: Definition of different scopes of greenhouse gases emissions as stated in *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* by World Resources Institute and World Business Council for Sustainable Development (2004).

of their business activities, "utilities", "materials", and "energy" sectors are the largest emitting sectors (denoted as emissions-intensive sectors hereafter). This observation leads us to investigate whether there could be a difference in the loan pricing of transition risk between borrowers from the emissions-intensive sectors and those from other sectors, as the transition for the former may be much higher than the latter.

2.4. Proxy for banks' environmental attitude

Lastly, we use bank membership in the United Nations Environment Programme Finance Initiatives (UNEP FI) as a proxy for a bank's attitude towards green. Following the practice of Delis et al. (2021) and Degryse et al. (2022), we consider a bank (at the group parent level)'s membership signature in UNEP FI revealing its attitude towards climate change issues. UNEP FI is a partnership between the UN and the financial sector to encourage private sector funding in financing sustainable development. Signatory banks signal the public and their investors that they are committed to working towards integrating environmental considerations into their operations and business decisions. If a lead arranger has already been a member of the UNEP FI at the time of loan originations, we consider the lead arranger to be a green bank (i.e. $GreenBank_{b,\ t}$=1).

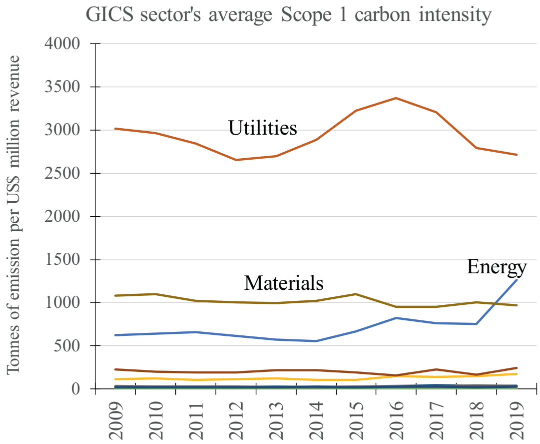
Despite this public commitment, the signature action could also be in part motivated by the reputational benefits from enhanced corporate images[14] and, therefore, not necessarily reflecting that banks have committed tangible efforts to promote greenness. As such, we propose another more restrictive "green" classification for a lead arranger by requiring additional green effort from banks. Specifically, the narrow green bank measure ($GreenBank_{b,\ t}''$) takes the value of 1 only if the lead arranger has already been a member of UNEP FI and, at the same time, it or the ultimate parent holding firm, have been self-disclosing CO_2e emission information of the organisation. As shown in upper panel of Fig. 3, about 22% of the lead arrangers in our sample had already joined the UNEP FI before 2010, while the share had increased to around 40% by the end of 2020, in part reflecting increased global awareness in climate-related risks. The increase is also found among the group of banks headquartered in emerging markets, with the ratio rising from 5% only in 2010 to 19% in 2020 as shown in the lower panel of Fig. 3. As a result, based on those that have become members within the sample period, we can exploit the "within bank variation" in memberships alongside the lead arranger fixed effect.

2.5. Overview of the final sample

By combining all relevant data from different sources described above and removing those loans with missing data, our final sample covers 2222 loans for estimations which span over 655 unique borrowing firms and 166 unique banking corporations. In Table 1, we provide a descriptive statistic table of the final sample of loans. In panel A, we report the summary statistics of the variables at the loan-level, the middle panel is the data for borrowers and the lower panel for lead arrangers. The all-in-spread-drawn to firms is, on average, 186 basis points (bps) over the reference rates, with a standard deviation of 102 bps. The median number of lead arrangers in the

[14] Cao et al. (2015) finds that a US company with a higher reputation score obtains a lower cost of equity capital after controlling for other factors.

Panel A: GICS sector's average Scope 1 CO_2e emission intensity



Panel B: GICS sector's average Scope 1 plus Scope 2 CO_2e emission intensity

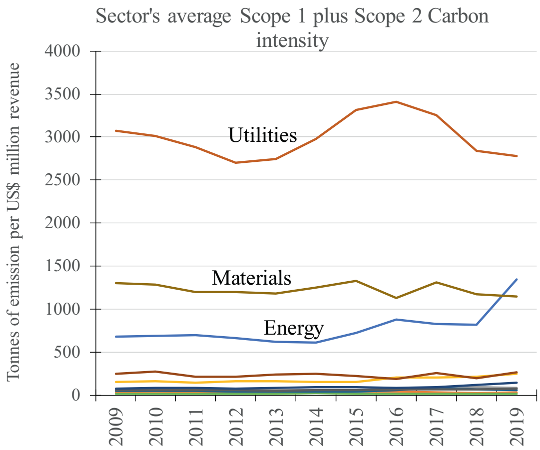


Fig. 2. Average CO_2e emission intensity among GICS sectors.
Source: Authors' calculations based on data from S&P Trucost.
Note: Panel A and B present the average firm emission intensity (in tons of CO_2e equivalent to revenues in US$ millions) by GICS economic sectors.

syndicate is 4, which is consistent with the characteristics of the global syndicated loan market outside the United States (see, for instance, Ferreira and Matos (2012), Europe Economics (2019), Tanjung et al. (2012)).[15] The average size and tenor of the loans are 19.0 in logarithm of US dollar equivalent (that is, US$178.5 million), and 50.9 months respectively. Loans are roughly evenly distributed before and after the Paris Agreement, with the mean value of post-Paris Agreement dummy equal to 0.53. For the borrower's CO_2e emission intensity, the average emission intensity for scope 1 and scope 2 are 629.6 and 83.6 (both in tonnes per US$ millions) respectively. Regarding the geographical distribution of the borrowers, the majority of the 655 borrowers are also headquartered in emerging market, with firms from China having the strongest presence (around 20%) in the sample. Borrowers from Taiwan, Hong Kong, India, South Korea and ASEAN economies also constituted sizable shares in the sample as shown in the right panel of Table A2. Only less than 10% of the borrowers are from the U.S or other advanced economies (such as the Western Europe, Japan and Australia, etc). As such, our sample should be representative of the corporate lending situation in emerging market.

[15] Consistent with the characteristics of the Europe market, the number of lead arrangers in loans originated in emerging market is also higher than those observed in the U.S. market. One of the reason is that foreign banks (i.e. banks from US or Europe) also actively participate in the local syndicated loan market, and they usually pair up with local banks which possess soft information on borrowers from the same places to arrange the loan package. Tanjung et al. (2012) studied the trend in syndicated loan market in the Asia pacific region and found that most of the loans have at least two lead arrangers. This is significantly different from the U.S. market as found by Ivashina (2009) that 98% of US syndicated loans were led by one arranger only.

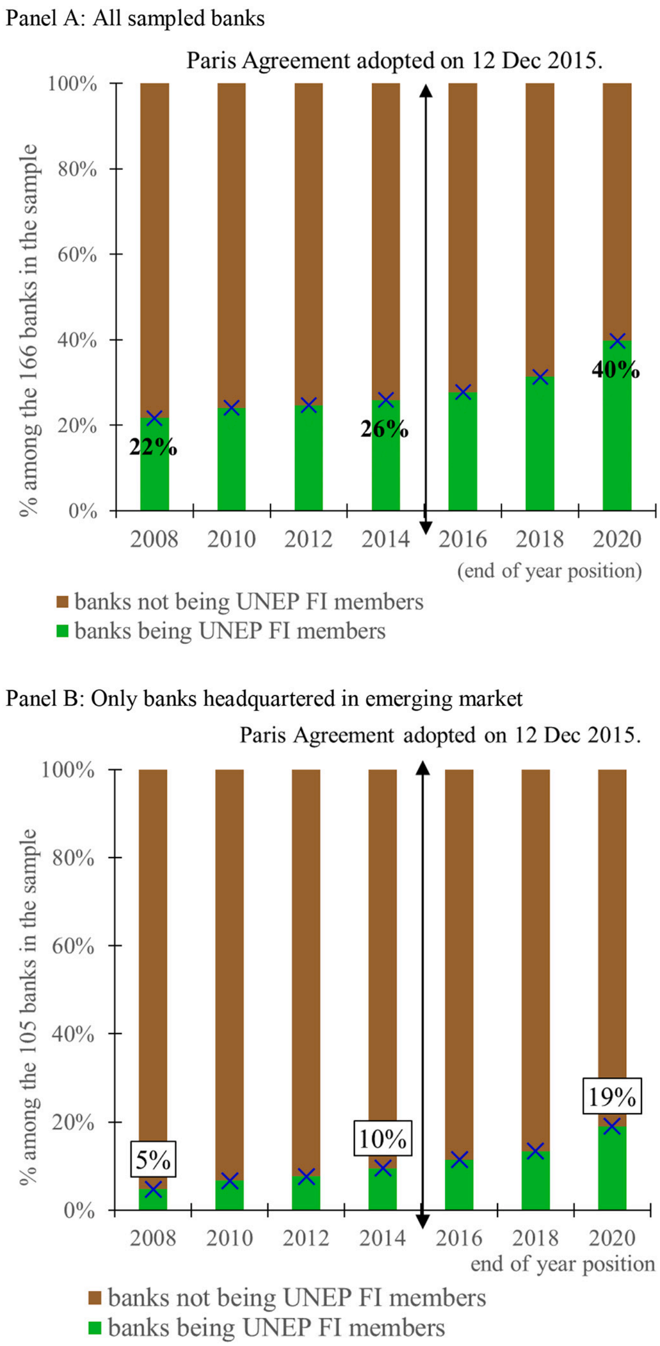


Fig. 3. Share of the sampled banks which are members of the UNEP FI.
Source: Dealscan, UNEP FI and authors' calculations.

Table 1
Summary statistics.

Panel A (loan-level / loan-lead arranger level)								
Variable names	N	mean	sd	min	p25	p50	p75	max
LoanSpread	2222	185.68	102.14	10	110	160	240	750
LoanTenor	2222	50.90	26.32	11	36	48	60	186
Ln(LoanAmount)	2222	18.95	1.22	12.77	18.20	19.05	19.74	22.51
Covenant	2222	0.16	0.37	0	0	0	0	1
Collateral	2222	0.24	0.43	0	0	0	0	1
Concentration	2222	4.01	2.22	1	2	5	8	14
Paris	2222	0.53	0.50	0	0	1	1	1
GreenBank	11,256	0.37	0.48	0	0	0	1	1
Panel B (unique borrower-year level)								
Variable names	N	mean	sd	min	p25	p50	p75	max
ROA (Borrower)	1329	4.10	3.10	−1.38	1.93	3.60	5.73	11.24
Debt-to-asset (Borrower)	1329	32.53	13.49	8.78	23.03	31.85	41.04	62.38
Ln(Assets) (Borrower)	1329	22.69	1.48	18.48	21.62	22.73	23.67	27.56
State-owned dummy (Borrower)	1329	0.09	0.29	0	0	0	0	1
Scope 1 emission intensity	1329	629.61	2215.7	0.00	14.32	41.48	246.68	28,702
Scope 2 emission intensity	1329	83.58	232.0	0.00	14.72	36.09	64.65	5294
Scope 1&2 emission intensity	1329	713.19	2240.7	0.02	44.15	98.59	366.46	28,703
Panel C (unique lead arranger-year level)								
Variable names	N	mean	sd	min	p25	p50	p75	max
ROA (Lender)	1095	0.73	0.43	0.00	0.36	0.73	1.04	1.47
Ln(Assets) (Lender)	1095	26.36	1.46	24.19	25.00	26.44	27.57	28.62
CapitalRatio (Lender)	1095	12.07	2.57	8.21	9.90	11.88	13.73	17.00

Note: Panel A reports summary statistics for the full sample at the loan-level, except for GreenBank is reported at the loan-lead arranger level. Panel B reports the relevant statistics at unique borrower-year level for loan-level regression, while panel C reports related statistics at unique lead arranger-year level for the loan-lead arranger level regression.

3. Empirical specifications and results

3.1. Do banks charge a higher lending rate on brown firms than their non-brown industry peers?

To answer this research question, we compare the loan spread charged on a highly emitting firm with an otherwise identical firm in the same industry but with a lower CO_2e emission intensity, after controlling for all relevant loan-level, borrower and lender characteristics. Specifically, we run the following firm-loan level regression model (1):

$$LoanSpread_{i,t} = \alpha + FE_{i,t} + \beta_1 HighCO2_{i,t-1} + \delta' Z_{i,t} + \gamma' X_{i,t-1} + \varepsilon_{i,t} \tag{1}$$

The dependent variable $loanSpread_{i,\ t}$ denotes the lending spread over reference rates in basis points for loan *i* issued in year *t*. $HighCO2_{i,\ t-1}$ is a dummy variable defined as one if the borrower of loan i's CO_2e scope 1 emission intensity is higher than its respective industry-average level at year *t-1*. By construction, $HighCO2_{i,\ t-1}$ captures the average impact for a borrower being brown relative to its same-industry-peers at year *t-1* on the pricing of loan at year *t*. Details about the CO_2e emission intensity and the industry-average level are provided in Section II. $FE_{i,\ t}$ is a vector of fixed effects which includes borrower's country-, borrower's industry-, year-, country of loan syndication-, loan reference rates-, loan currency- and loan type-fixed effects to control for unobserved differences in the cost of bank loans across various dimensions. $Z_{i,\ t}$ and $X_{i,\ t-1}$ are vectors of loan-level, and one-year lagged borrower-level characteristics control variables, respectively. Loan-level and lender-control variables include logarithm of loan size, loan maturity, number of lead arrangers in the syndicate, dummies for the existence of financial covenants or being secured by collateral, the average profitability, Tier-1 capital ratio and size of the lead arranger consortium. The borrower firm control variables are intended for controlling for the impacts from other borrower features being considered during loan pricing.[16] These include a borrower's return-on-assets (ROA), debt-to-asset ratio, logarithm of firm's total assets, and an dummy variable for identifying whether the borrower is under state controls. $\varepsilon_{i,\ t}$ denotes the idiosyncratic error term.

The coefficient of interest here is β_1, which is the difference in average loan spreads between loans to brown firms and that of

[16] Ideally, one would include credit ratings of borrowers as one of the control variables as it provides a holistic summary of the firms' financial strength. However, as credit ratings are generally limited in our sampled borrowers, this precludes us from including this variable in our analysis as it will substantially reduce the number of observation. Therefore, we control for borrowers' financial strength by their balance sheet characteristics, namely leverage, profitability and size, instead.

similar loans to non-brown firms (i.e. the control group) in the same industry and country, and originated in the same year. A statistically significant and positive β_1 would imply that banks tend to charge a higher loan spread on brown firms on average relative to non-brown industry-peers to compensate for the associated climate transition risk, all else being held constant.

Given the Paris Agreement is regarded as one key international commitment for both developed and developing countries to set emissions-reduction pledges to slow temperature rises globally, the increased global awareness of climate-related risks since then may lead banks in emerging markets to factor in the transition risk of borrowers in the loan pricing.[17] To test whether banks have started to price in the transition risk after the Paris Agreement, we therefore consider a modified regression model (2) by adding a Post-Paris Agreement dummy and an interaction term of $HighCO2_{i,\ t-1}$ with the Post-Paris Agreement dummy in Eq. (1):

$$LoanSpread_{i,t} = \alpha + FE_{i,t} + \beta_1 HighCO2_{i,t-1} + \beta_2 HighCO2_{i,t-1} \times Paris_t + \mu Paris_t + \delta' Z_{i,t} + \gamma' X_{i,t-1} + \varepsilon_{i,t} \tag{2}$$

where $Paris_t$ takes the value one if loans are issued in and after 2016. The coefficient β_2 in essence tests whether there is a significant change in the average loan spread charged among the group of highly emitting firms after the Paris Agreement relative to that during pre-Paris Agreement period.

All regressions are estimated using the ordinary least square method. Given the existence of multiple-ways of fixed effects in the specifications, we adopt the linear estimator proposed by Correia (2016) which is a feasible and computationally efficient estimator for large and complex datasets. Clustered-robust standard errors are reported, unless otherwise specified.

Results for the loan-level regression Eq. (1) are presented in columns (1) to (3) of Table 2, while results for Eq. (2) are shown in columns (4) to (6). As shown in Table 2, the control variables are mostly statistically significant across specifications and are consistent with their underlying economic intuitions respectively, suggesting they are important determinants of the loan spreads in our sample. However, there appears to be no significant difference in the loan pricing between brown firms and non-brown firms in the same industry over the whole sample period, as indicated in column (1). The same result held true even if we re-estimate Eq. (1) by splitting the sample into two subgroups – namely the emissions-intensive sectors (i.e. firms in the Utilities, Materials and Energy sectors) in column (2) and other sectors in column (3). This finding appears to suggest that for the whole sampling period from 2010 to 2021, the climate transition risk was not priced on average for loans originated in the syndicated loan market among emerging economies.[18]

When the interaction term is added to differentiate loans originated before and after the Paris Agreement, we find some evidence that banks would charge a higher loan spread on brown firms relative to their non-brown peers.[19] In column (4), we find that the coefficient of $HighCO2_{i,\ t-1} \times Paris_t$, which is denoted as $\widehat{\beta_2}$, is positive and statistically significant at the 5% level, indicating a positive change in larger loan pricing driven by brown borrowers' poorer environmental performance after the Paris Agreement. The higher loan spread charged is consistent with the view that reaching the Paris Agreement in Dec 2015 had updated creditors' expectations on the stringency of the environmental policy into the future. The cross-sectional difference in loan spreads between brown firms and their non-brown counterparts in the post-Paris Agreement period is jointly determined by $\widehat{\beta_1} + \widehat{\beta_2}$. The statistically significant result in this linear combination test also suggests that the positive transition risk premium has been included in loan pricing in emerging market economies, which is consistent with the findings in Bolton and Kacperczyk (2020b), Delis et al. (2021) and Ehlers et al. (2022), etc.[20]

We then investigate further whether the change in loan pricings among emerging market economies could be found from all firms or only firms from any of the two sectors groups. By splitting the sample into emissions-intensive sectors group and other sectors group in columns (5) and (6), we find that the statistically significant results are only present for borrowers from the emissions-intensive sectors in the post-Paris Agreement period (i.e. column (5)). This suggests that the statistically significant result in column (4) was

[17] Several studies have highlighted the importance of the Paris Agreement on relevant issues. Voysey et al. (2016) outlined several risks and opportunity implications of the Paris Agreement for the international financial sector. Kruse et al. (2020) argued that the outcome of the Paris agreement is surprisingly better than anticipated in having a more ambitious 1.5 °C target included in the agreement. In view of its importance, they adopted the event as an exogenous political shock to study stock market reactions. Ardia et al. (2020) also noted a spike in their constructed Media Climate Change Concerns index when the Paris Agreement was sealed, potentially reflecting the special attention put on this historical event and its implications as well. Indeed, recent studies find evidence of the existence of a carbon premium only after the signing of the Paris Agreement. Besides those already mentioned, Capasso et al. (2020) find that the positive relationship between corporates' distance-to-default risk and carbon footprint becomes stronger after the Paris Agreement.

[18] The insignificant finding does not necessarily imply an inconsistency with the findings in Chava (2014) and other related works, where they find that the environmental performance of a borrower will affect the pricing term of a syndicated loan even before the Paris Agreement. We offer two plausible explanations here. First, the dataset used in existing literature for the syndicated loan market is largely reflecting results for loans originated in the US. This could differ from the syndicated loan markets in emerging economies which we focused on. Second, while the climate transition risk of a corporate in principle could be one important environmental constraint faced by borrowers, banks may simply look at the holistic ratings of the borrowers' environmental profiles, rather than focusing solely on the dimension of transition risk.

[19] In Table A3, we test whether the results are sensitive to alternative measures of firms' carbon emission intensity. Specifically, we alternatively define brown firms based on the sum of Scope 1 and 2 emission intensity. The results remained quantitatively similar. This can be attributed to the fact that given the business nature of the emissions-intensive sectors group, Scope 1 emission intensity of those corporates in the group usually dominates their Scope 2 emission intensity.

[20] In Table A5, we also try an alternative specification to test the impact of replacing the brown firm dummy variable with the emission intensity deviation from the industry average level (i.e. a continuous variable) for the loan-level regression. The results in Table A5 show that the coefficient of the combination effect is positive and statistical significant at the 5% level. This suggests that firms with higher intensity levels above the industry average would be charged a higher premium following the Paris Agreement, which is consistent with the regression result in column (5) of Table 2.

Table 2
Estimation results for Eqs. (1) and (2) with the loan level observations.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable (LoanSpread)	All sectors	Emissions-intensive sectors	Other sectors	All sectors	Emissions-intensive sectors	Other sectors
HighCO2 (β_1)	5.526	9.614	6.424	−4.173	−8.346	6.010
	(3.943)	(8.130)	(4.421)	(6.125)	(10.05)	(6.817)
HighCO2 X Paris (β_2)				19.16**	46.11***	0.751
				(8.092)	(15.85)	(8.619)
Joint test: $H_0 : \beta_1 + \beta_2 = 0$				14.99***	37.76***	6.761
p-value				*0.00592*	*0.00218*	*0.227*
LoanTenor	0.222**	0.492***	0.173*	0.226**	0.502***	0.173*
	(0.0883)	(0.139)	(0.0974)	(0.0882)	(0.129)	(0.0975)
Ln(LoanAmount)	−4.967**	0.102	−6.458**	−5.147**	−2.021	−6.451**
	(2.233)	(3.800)	(2.503)	(2.195)	(3.739)	(2.496)
ROA (Borrower)	−0.998	−0.00927	−2.383***	−1.075	−0.0149	−2.385***
	(0.853)	(1.394)	(0.908)	(0.863)	(1.375)	(0.909)
Debt-to-asset (Borrower)	0.997***	1.217***	1.004***	1.018***	1.336***	1.005***
	(0.184)	(0.304)	(0.200)	(0.185)	(0.302)	(0.201)
Ln(Assets) (Borrower)	−8.859***	−5.525	−8.627***	−9.152***	−6.915	−8.642***
	(2.065)	(4.205)	(2.336)	(2.045)	(4.271)	(2.354)
Avg. ROA (Lender)	12.20	0.503	17.31	12.93	−1.793	17.35
	(10.67)	(18.29)	(11.13)	(10.56)	(18.58)	(11.16)
Avg. ln(Assets) (Lender)	−9.962***	−9.292*	−11.48***	−9.796***	−8.827	−11.48***
	(2.695)	(5.513)	(3.216)	(2.657)	(5.410)	(3.217)
Avg. CapitalRatio (Lender)	4.177*	3.534	5.020*	4.160*	4.745	5.013*
	(2.276)	(3.875)	(2.812)	(2.245)	(3.705)	(2.826)
Concentration	−7.086***	−13.00**	−4.240	−6.762**	−12.56**	−4.225
	(2.665)	(5.301)	(2.957)	(2.687)	(5.299)	(2.965)
Covenant	−7.946	−29.65***	−0.511	−8.298	−28.80***	−0.530
	(5.504)	(8.913)	(6.286)	(5.547)	(8.891)	(6.328)
State-owned dummy	−23.80***	−23.44	−16.50	−23.18**	−19.91	−16.54
	(9.106)	(14.31)	(11.30)	(9.125)	(14.46)	(11.26)
Observations	2222	653	1564	2222	653	1564
R-squared	0.550	0.643	0.584	0.552	0.650	0.584
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Borrower country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

mainly attributable to a change in loan pricing on borrowers from the emissions-intensive sectors. As shown in column (5), we also find a positive and statistically significant coefficient on the interaction term (i.e. $\widehat{\beta_2} = 46.1$), suggesting that brown firms from the emissions-intensive sectors are, on average, charged higher by around 46 bps for their loans in the post-Paris Agreement period relative to the pre-Paris Agreement period. The tests for the cross-sectional difference for the emissions-intensive sectors group are again reported in the table. The results in column (5) suggests that banks on average charge a 38 bps loan spread higher on brown borrowers relative to their non-brown peers in emissions-intensive sectors group after the signing of the Paris Agreement.[21] Importantly, this result is not only statistically significant but also economically meaningful. Given that the average loan spread over the reference rate in our sample is 186 bps,[22] this implies these brown firms are, on average, being charged around 20% more than their non-brown peers after the Paris Agreement, ceteris paribus.

By contrast, among loans borrowed by firms from the other sectors group, we do not find any statistically significant coefficients for both β_1 and β_2 in column (6). A plausible explanation is that, on average, firms in these lower emissions industries generally have relatively low Scope 1 (direct) emission intensity (see Panel A in Fig. 2), so the associated climate transition risk may not be significant enough to trigger concern among arranging banks. As a result, banks may be less inclined to consider their Scope 1 emission profile as

[21] One may argue that the difference can be merely driven by correlation with other factors such as rating. However, Ehlers et al. (2022) finds that there is virtually no correlation between firms' carbon emission intensity with corporate ratings in their sample.

[22] The average lending spreads, charged on loans for firms in the three emissions-intensive industries after the Paris Agreement, is quantitatively similar (190 bps).

an important factor in the loan pricing decision for firms in these sectors. Instead, the loan spreads charged on these firms will largely be determined by their financial characteristics and the specific loan features as captured in the control variables. Nonetheless, as will be discussed in the later section, we do find evidence that banks may adjust non-pricing loan features to mitigate the potential transition risk impacts arising from borrowers' Scope 2 (indirect) emissions intensity.

To ensure the above empirical findings are not driven by different groups of borrowers with different characteristics across the two periods (i.e. pre-Paris Agreement and post-Paris Agreement), a robustness check was conducted, in which we restrict our sample to those borrowers that have borrowed a loan at least once in both periods.[23] The estimation results based on the fixed sample are reported in columns (1) to (3) of Table 3. As can be seen, the estimation results remain quantitatively similar, suggesting our baseline results are robust. Importantly, we continue to find evidence that banks would on average charge a higher lending spread to brown firms by around 38.5 basis points as compared to that of non-brown firms from the emissions-intensive sectors in the post-Paris Agreement period.

Another follow-up question is whether the transition risk premium found above is driven by those loans syndicated in international financial centres only. As existing results in the literature suggest that banks in advanced economies (particularly the U.S. syndicated loans market given the sheer number of syndicated loans reported) do factor in transition risk in their loan pricing, one may argue that our results could be driven by loans originated in international financial centres (i.e. Hong Kong SAR and Singapore) given their strong presences of banks headquartered in advanced economies. To examine this, we re-run Eq. (2) by removing the loans syndicated in "Hong Kong SAR" and "Singapore" to test whether the transition risk premium would still be found in the narrower sample. Columns (4) to (6) of Table 3 report results for the three sectors grouping in a similar manner as those in Table 2. We continue to find quantitatively similar results as seen in Table 2, reaffirming that the transition risk premium charged on brown firms from emissions-intensive sectors after the Paris Agreement may be a general phenomenon in the EM syndicated loan markets.

Taken together, our empirical results find supportive evidence that banks in these markets have started to consider climate transition risk in their loan pricing after the Paris Agreement, at least in their syndicated loans. The existence of the transition risk premium is found mainly in those loans extended to firms from emissions-intensive sectors group, potentially reflecting banks' increased awareness of climate-related risk to those corporates that are more subject to the transition risk.

3.2. Does the environmental attitude of banks play a role in determining the extent of climate transition risk in loan pricing?

Given the findings above, an important related question is whether the green attitude of banks matters in determining the extent of a transition risk premium charged on brown firms. As mentioned previously, there have been no conclusive evidence in the existing literatures on this issue. Therefore, we aim to broaden our understanding on this issue, particularly from the EM perspective, by providing evidence based on our sample of syndicated loans originated in emerging market economies.

As discussed in section II, given there is no consensus on which indicator can perfectly measure a bank's green status, we therefore employ two measures to classify whether a bank is green or not in this analysis. For a broad measure, we consider a bank is green if it has already been a member of the UNEP FI before the loan was originated. For a narrow measure, conditional on the bank already being a member of the UNEP FI, we further require that particular bank (or its ultimate parent holding company) to have already disclosed its own GHG emissions information. The latter condition attempts to narrow down those green banks that have committed tangible measures and costs in implementing climate-related practices in their operations.

To empirically separate the effect of banks' environmental attitudes from other banks' financial characteristics, we further decompose loan-level observations into loan-lead arranger level observations following Degryse et al. (2022) and Delis et al. (2021).[24] This decomposition allows us to define a time-varying bank-level dummy variable (i.e. $GreenBank_{b,t}$) to capture the bank's green attitude to estimate its standalone and interaction effects on loan spreads, and also to include the lead arranger fixed effects whenever possible. Specifically, we consider the following firm-loan-lead arranger level regression model (3):

$$\begin{aligned} LoanSpread_{i,b,t} =& \alpha + FE_{i,b,t} + \beta_1 HighCO2_{i,t-1} + \beta_2 GreenBank_{b,t} + \beta_3 HighCO2_{i,t-1} \times Paris_t + \beta_4 HighCO2_{i,t-1} \times GreenBank_{b,t} \\ &+ \beta_5 GreenBank_{b,t} \times Paris_t + \beta_6 HighCO2_{i,t-1} \times GreenBank_{b,t} \times Paris_t + \mu Paris_t + \delta' Z_{i,t} + \gamma' X_{i,t-1} + \theta' Y_{b,t-1} + \varepsilon_{i,t} \end{aligned} \quad (3)$$

where $GreenBank_{b,\,t}$ takes the value of one if the lead arranger *b* is classified as green bank at loan origination year *t* and zero otherwise. As discussed, two measures of green bank proxies (broad and narrow measures) are considered in this analysis which are denoted as $GreenBank_{b,\,t}$ and $GreenBank_{b,\,t}''$ respectively. Other specification details are largely similar to the loan-level regressions (1) and (2), except that the fixed effect term $FE_{i,\,b,\,t}$ additionally includes borrower and lead arranger fixed effects[25] while $Y_{b,\,t-1}$ includes each lead arranger *b*'s profitability, Tier-1 capital ratio and size variables, to replace the corresponding average variables for the whole lending consortium in the loan. Here our variables of interest is the coefficient on the triple interaction term $HighCO2_{i,\,t-1} \times GreenBank_{b,\,t} \times$

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[23] The fixed sample analysis enables us to include time invariant borrower fixed effects to control for unobserved characteristics of borrowers. As borrowing country- and borrower industry- fixed effects are being absorbed by including the borrower fixed effects, the former two fixed effects are therefore omitted in Table 3.

[24] Ferreira and Matos (2012) and Liu and Pogach (2016) also include bank characteristics as control variables when loan spread is used as the dependent variable.

[25] As a result, state-ownership dummy, borrowing country- and borrower industry- fixed effects are being absorbed by including the borrower fixed effects.

Table 3
Estimation results for Eq. (2) with the loan level observations for a fixed sample (columns (1) to (3)) and for sample without international financial centers (columns (4) to (6)).

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable (LoanSpread)	All sectors	Emissions-intensive sectors	Other sectors	All sectors	Emissions-intensive sectors	Other sectors
Jurisdiction of syndication	Fixed sample			Excluding Hong Kong SAR and Singapore		
HighCO2 (β_1)	4.085	15.49	2.458	−7.832	−11.03	1.238
	(8.329)	(14.38)	(10.53)	(7.127)	(12.26)	(8.352)
HighCO2 X Paris (β_2)	12.78	13.77	8.670	31.57**	56.17***	3.494
	(8.588)	(17.23)	(8.776)	(14.91)	(18.76)	(10.44)
Joint test: $H_0: \beta_1 + \beta_2 = 0$	16.87**	29.27**	11.13	23.74*	45.14***	4.733
p-value	*0.0259*	*0.0328*	*0.255*	*0.0565*	*0.00163*	*0.557*
LoanTenor	0.446***	0.547**	0.162	0.202**	0.477***	0.165
	(0.142)	(0.264)	(0.173)	(0.0948)	(0.124)	(0.112)
Ln(LoanAmount)	−4.459**	−4.246	−4.604*	−1.066	−0.719	−3.975
	(2.243)	(5.989)	(2.355)	(2.934)	(3.688)	(3.526)
ROA (Borrower)	−1.307	0.580	−0.923	−3.201***	−0.963	−4.386***
	(1.112)	(2.161)	(1.547)	(0.926)	(1.774)	(0.945)
Debt-to-asset (Borrower)	0.674	1.160	0.195	0.948***	1.496***	0.631***
	(0.476)	(0.780)	(0.515)	(0.245)	(0.385)	(0.224)
Ln(Assets) (Borrower)	−12.80	−4.002	−15.86*	−8.371**	−3.380	−6.370**
	(8.469)	(15.66)	(8.499)	(3.215)	(4.211)	(3.138)
Avg. ROA (Lender)	38.70***	8.659	48.45***	13.32	9.042	25.62*
	(12.73)	(18.04)	(14.74)	(14.82)	(21.70)	(13.88)
Avg. ln(Assets) (Lender)	−3.805	−1.191	−6.913*	−7.361*	−3.220	−8.562**
	(3.140)	(4.872)	(4.067)	(4.164)	(7.323)	(3.972)
Avg. CapitalRatio (Lender)	0.210	−3.280	0.165	4.581	4.667	4.100
	(2.102)	(3.999)	(2.682)	(2.788)	(4.302)	(3.177)
Concentration	−4.126	−0.867	−4.119	−9.655**	−14.05*	−8.615**
	(4.106)	(8.761)	(4.599)	(4.734)	(7.816)	(4.087)
Covenant	−17.73**	−23.33**	−17.46*	−10.97**	−24.93***	−5.976
	(8.349)	(10.49)	(9.159)	(5.517)	(7.634)	(8.056)
State-owned dummy	NA	NA	NA	−24.46*	−18.09	3.510
				(12.97)	(15.68)	(32.93)
Observations	1279	345	930	1412	537	869
R-squared	0.817	0.832	0.831	0.585	0.678	0.608
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	NA	NA	NA	Yes	Yes	Yes
Borrower country fixed effect	NA	NA	NA	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes
Borrower fixed effect	Yes	Yes	Yes	NA	NA	NA

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors. As we have included the borrower fixed effect in Columns (1) to (3), borrower country, borrower industry group fixed effects, and also dummy for state-ownership would be absorbed.

$Paris_t$, which captures whether the loan spread on a brown firm by a green bank will exhibit a larger change relative to the same loan by a non-green bank after the Paris Agreement.

The left panel of Table 4 reports the results of Eq. (3) for all sectors, emissions-intensive sectors group and the other sectors group respectively, using the broad green bank proxy $GreenBank_{b,\ t}$, while the right panel of Table 3 reports the results using the narrow green bank proxy $GreenBank_{b,\ t}''$.

First of all, our previous findings continue to hold after decomposing the loan-level observations into loan-lead arranger level observations. That is, banks on average charge a higher loan spread on brown firms from the emissions-intensive sectors after the Paris Agreement, as indicated by the positive and significant coefficient on the $HighCO2_{i,\ t-1} \times Paris_t$ in columns (1), (2), (4) and (5). Likewise, similar to the results in Table 2, the significant results for loans in all sectors appear to be largely driven by lending to borrowers from emissions-intensive sectors as the coefficient on interaction term is found to be not statistically significant when other sectors is considered (i.e. columns (3) and (6)). Given evidence for the additional transition risk premium on brown firms after the Paris Agreement is mainly present for borrowers from the emissions-intensive sectors, we will therefore turn our focus on these borrowers when discussing the potential impacts of the green status of a bank on the extent of transition risk premium in the loan pricing.

There are evidences to suggest that the green status of banks does matter in determining the extent of transition risk premium in the loan pricing. In particular, we consistently find positive and statistically significant coefficients on the triple interaction term $HighCO2_{i,}$

$_{t-1} \times GreenBank_{b,\,t} \times Paris_t$ in columns (2) and (5). The positive $\widehat{\beta_6}$, along with the positive coefficients on the double interaction term $HighCO2_{i,\,t-1} \times Paris_t$, indicate that there is a larger rise in the loan spread on brown firms on average after the Paris Agreement, but the change in the spread is larger if the brown firm borrows from a green bank compared with those borrowing from a non-green bank, after controlling for other key loan determinants. Based on the sample of syndicated loans in emerging markets, our findings support the view that green banks are more concerned about the associated transition risk in their loan portfolios after the Paris Agreement, thus leading them to charge an even larger rise in the loan spreads for highly emitting borrowers than would otherwise be the case for the non-green banks.

While the positive triple interaction term (i.e. $\widehat{\beta_6}$) points to a larger rise in the loan spread charged by a green bank towards a brown firm after the Paris Agreement, the cross-sectional difference in the level of loan spread between those charged by green banks and those by non-green banks during the post-Paris Agreement period is jointly determined by the sum of $\widehat{\beta_2} + \widehat{\beta_4} + \widehat{\beta_5} + \widehat{\beta_6}$.[26] The statistical tests for the cross-sectional difference in loan spread based on the two green bank proxies are separately reported in the lower panel of Table 4. Based on the broad green bank proxy, the loan spread is around 14.3 bps higher if the loan to a brown firm is arranged by a green firm, but the result is statistically significant only at the 10% level (column (2)). The difference in loan spread is found to be slightly larger and statistically significant at the 5% level if the narrow green bank proxy is employed for the classification of green banks (column (5)).[27] Such difference may indicate that the definition of green bank may also matter in informing the discussion. For instance, looking at whether green banks are concurrently implementing and adhering to climate-related practices in their internal operations and business decisions can better refine the green bank definition. The magnitude of 15.3 bps is also economically significant, as it implies that green banks will require an additional 8% transition risk premium (as divided by the average lending spread of 186 bps for the sampled loans) in lending to the brown firm, compared with non-green banks. These results together favour the view that the green attitude of banks plays a key role in determining the extent of transition risk premium.[28]

4. Non-pricing contractual terms

In the previous section, we have focused primarily on whether banks would factor in the climate transition risk of borrowers in the loan spread. Apart from charging a transition risk premium in the lending rate, banks could also impose more stringent non-price contractual terms as alternative ways to mitigate the associated credit risk of borrowers arising from transition risks. As indicated in previous literature (Strahan, 1999; Goss and Roberts, 2011; Fard et al., 2020, etc), these non-pricing loan features may include shortening loan tenor and/or requiring collaterals, which essentially reduce the extent of credit risk exposures faced by banks. In particular, Fard et al. (2020) based on a sample of international syndicated loans finds that banks would tend to shorten loan tenor and impose collateral requirements when lending to borrowers that face more stringent environmental regulations at the country-level.

To examine this, we augment our regressions to investigate whether and to what extent banks may impose more stringent non-pricing contractual terms on brown firms than their non-brown peers in the same industry. In particular, we would focus on two key non-pricing contractual terms, namely loan tenor and collateral requirement. Following the literature, we hypothesise that if banks are concerned about the potential credit risks arising from the climate transition risk, they should tend to shorten the loan tenor and/or to require the borrower to pledge collateral in the loan contract.

4.1. Loan tenor

We first start our analysis on loan tenor. We modify Eq. (2) by replacing $LoanSpread_{i,\,b,\,t}$ with ln*(LoanTenor)* as the dependent variable and add *ln(LoanSpread)* as control variable. We also restrict our sample to those loans with tenor of at least one year or longer to ensure the results are not distorted by loans with specific purposes such as those short-term refinancing loans or commercial bridge loans.[29] The estimated results are presented in Table 5.

There are several interesting results that worth highlighting. First, for loans to emissions-intensive sector, while we find negative coefficients on $HighCO2_{i,\,t-1} \times Paris_t$ when Scope 1 and Scope 1 & 2 emission intensity are considered respectively in columns (1) and (3), they are both found to be statistically insignificant. Furthermore, the cross-section difference in loan tenor between brown and non-brown firms in the post-Paris Agreement, as determined by the linear combination test of $\widehat{\beta_1} + \widehat{\beta_2}$, is also found to be statistically insignificant. As such, there appears no strong evidence to suggest that banks would shorten loan tenors for brown firms from the emissions-intensive sectors in the post-Paris Agreement period to mitigate the associated credit risk impact arising from the transition

[26] Based on Eq. (3), the cross-sectional difference in the loan spread between a brown firm borrowing from green bank and a brown firm borrowing from a non-green bank in the post-Paris Agreement is determined by $Y[GreenBank = 1, HighCO2 = 1, Paris = 1] - Y[GreenBank = 0, HighCO2 = 1, Paris = 1] = \beta_2 + \beta_4 + \beta_5 + \beta_6$.

[27] In Table A6 of the Appendix, we employ two other different clustering groups of standard errors for testing the linear combination effects. In both cases, we can also reject the hypothesis that the linear combination test is zero at either the 10% or 5% statistically significance level.

[28] We also conduct the split sample exercise without loans syndicated in IFCs in similar manner as done in Eq. (2) for Eq. (3). The green bank premium largely continues to hold at the 10% statistical significance level, as shown by positive results of the linear combination test in both Columns (5) and (6). This suggests the additional green bank premium found in our sample is not driven by loans syndicated in IFCs. Results are available upon request.

[29] Results are qualitatively similar without such data restriction. Results are available upon request.

Table 4
Estimation results for Eq. (3) with the loan-lead arranger level observations.

	(1)	(2)	(3)	(4)	(5)	(6)
Green bank proxy	UNEPFI			UNEPFI + disclosure action		
VARIABLES (LoanSpread)	All sectors	Emissions-intensive sectors	Other sectors	All sectors	Emissions-intensive sectors	Other sectors
HighCO2 (β_1)	2.979	7.489	0.909	2.823	7.350	0.729
	(2.899)	(5.406)	(3.312)	(2.892)	(5.416)	(3.311)
GreenBank (β_2)	1.596	5.102	0.939	3.853	5.735	2.107
	(3.785)	(6.823)	(3.842)	(3.176)	(6.036)	(3.367)
HighCO2 X Paris (β_3)	6.969**	14.97**	4.780	7.221**	15.84**	5.006
	(3.159)	(7.399)	(3.485)	(3.138)	(7.454)	(3.454)
HighCO2 X GreenBank (β_4)	−8.634***	−6.927	−8.871***	−8.397***	−6.919	−8.416**
	(2.585)	(4.398)	(3.308)	(2.566)	(4.365)	(3.358)
GreenBank X Paris (β_5)	−2.213	2.724	−2.468	−1.269	4.979	−1.531
	(2.739)	(4.787)	(2.915)	(2.761)	(4.726)	(2.993)
HighCO2 X GreenBank X Paris (β_6)	11.26***	13.42*	6.414	10.78***	11.53*	5.765
	(3.831)	(7.126)	(4.465)	(3.847)	(6.911)	(4.537)
Joint test:						
$H_0: \beta_2 + \beta_4 + \beta_5 + \beta_6 = 0$	2.004	14.32*	−3.985	4.967	15.32**	−2.076
p-value	*0.631*	*0.0505*	*0.364*	*0.179*	*0.0221*	*0.613*
LoanTenor	0.505***	0.748***	0.312***	0.505***	0.750***	0.312***
	(0.0643)	(0.0929)	(0.0808)	(0.0643)	(0.0927)	(0.0808)
Ln(LoanAmount)	−3.320***	−3.240**	−3.254***	−3.316***	−3.242**	−3.253***
	(0.737)	(1.593)	(0.771)	(0.737)	(1.591)	(0.771)
ROA (Borrower)	−0.644*	0.413	−0.654*	−0.643*	0.412	−0.655*
	(0.354)	(0.807)	(0.391)	(0.354)	(0.805)	(0.390)
Debt-to-asset (Borrower)	0.631***	1.632***	0.0554	0.630***	1.630***	0.0543
	(0.113)	(0.269)	(0.136)	(0.113)	(0.270)	(0.135)
Ln(Assets) (Borrower)	−20.61***	−13.77**	−24.50***	−20.66***	−13.90**	−24.53***
	(3.093)	(5.388)	(3.490)	(3.091)	(5.391)	(3.491)
ROA (Lender)	11.30***	9.549*	8.084***	11.39***	9.703*	8.134***
	(2.640)	(5.040)	(3.032)	(2.650)	(5.044)	(3.048)
Ln(Assets) (Lender)	−0.570	−10.12*	1.922	0.107	−9.610	2.491
	(3.204)	(6.120)	(3.800)	(3.216)	(6.165)	(3.839)
CapitalRatio (Lender)	−1.679***	−2.688***	−1.159**	−1.690***	−2.706***	−1.180**
	(0.469)	(0.810)	(0.542)	(0.467)	(0.809)	(0.538)
Concentration	−0.586	−1.024	−0.395	−0.593	−0.993	−0.420
	(2.006)	(3.047)	(2.670)	(2.005)	(3.045)	(2.668)
Covenant	−15.64***	−21.00***	−12.04***	−15.67***	−21.07***	−12.04***
	(2.424)	(3.474)	(2.830)	(2.427)	(3.480)	(2.831)
Observation	11,256	3172	8054	11,256	3172	8054
R-Squared	0.876	0.874	0.893	0.876	0.874	0.893
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes
Tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes
Lender fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Borrower fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by lender#year standard errors.

risk.

By contrast, for borrowers in other sectors (i.e. non-emissions-intensive sectors), we find a statistically significant and negative coefficient on $HighCO2_{i,\,t-1} \times Paris_t$when Scope 1 & 2 emission intensity is considered in column (4), suggesting that banks tend to mitigate the associated transition risk for brown firms from other sectors by reducing the loan tenor by a larger extent in the post-Paris Agreement than before. It should be noted that such significant result is only apparent when borrowers' Scope 2 emission intensity is also considered. Therefore, results in columns (1) to (4) together suggest that banks' decision on shortening loan tenor is found to be responsive to Scope 2 emission intensity of borrowers from other sectors, which generally accounts for a significant share of total emissions for these firms.[30]

[30] On average, Scope 2 emissions account for more than 50% of total Scope 1 and 2 emissions for firms from other sectors, while that for firms in emissions-intensive sectors account for merely less than 10% of their total emissions.

Based on the result in column (4), the reported linear combination test of $\widehat{\beta_1} + \widehat{\beta_2}$ suggests that banks would tend to shorten the loan tenor for brown firms from other sectors relative to their non-brown peers in the post-Paris Agreement period by −4.3%, which is equivalent to a reduction of 2.2 months given the sample average of loan tenor in other sectors group is 50.6 months. We further conduct several robustness checks to ensure our results are not sensitive to the choice of loan tenor restriction. Specifically, we re-estimate by alternatively considering 2 years and 3 years as the restriction thresholds respectively. The coefficients on $HighCO2_{i,t-1} \times Paris_t$ for the 2-year threshold (i.e. column (5)) and 3-year threshold (i.e. column (6)) as well as their corresponding linear combination tests of $\widehat{\beta_1} + \widehat{\beta_2}$ are also found to be negative and statistically significant respectively.

A plausible interpretation of this finding is that banks may consider to impose more stringent non-pricing terms in the loan contract (in this case shortening the loan tenor) as an alternative risk mitigation tool when they find it more challenging to price in the transition risk of brown firms in the loan spread. As compared with firms' Scope 1 direct emissions, the associated credit risk impact stemming from Scope 2 emissions is relatively more difficult to ascertain by banks as it will hinge on the future dynamics of energy prices as well as the energy efficiency of energy suppliers, which are highly uncertain at the time of loan origination. Also, as argued in Ehlers et al. (2022), firms may have strong incentives to move or outsource their Scope 2 emissions to jurisdictions where carbon reduction policies are not in place or less likely to be implemented in order to reduce costs, thereby further complicating the assessment of transition risk impact on these firms. As Scope 2 emissions generally account for the major source of transition risk exposure to borrowers from the non-emissions-intensive sectors, this partly explains why banks may be more inclined to shorten the loan tenor as an alternative risk mitigation tool for brown firms from these sectors.

4.2. Collateral requirement

To support our conjecture in the above sub-section, we further investigate whether banks are also more likely to impose collaterals requirements on brown firms from the other sectors. In principle, banks should similarly be keen to impose collateral requirement on these brown firms to mitigate the risk concern if the credit risk impacts of transition risk on brown borrowers are prone to uncertainty. Again following the empirical setting in Fard et al. (2020), we modify Eq. (2) by replacing the dependent variable *LoanSpread* with a dummy variable, *Collateral,* which indicates whether a collateral requirement is imposed in the loan contract. Given that the *Collateral* is a zero-one dummy variable, we employ a pooled probit regression model to estimate the modified Eq. (2). To alleviate the issues of potential complete or quasi-complete separations in the probit regression from including multiple levels of fixed effects, we replace country of syndication and borrower country fixed effects by market of syndication and borrower market fixed effects.[31] We also regroup the benchmark rates and loan currency fixed effects for estimation.[32] In columns (1) to (4) of Table 6, we present the results for pooled probit regression for loans to borrowers from emissions-intensive sectors and other sectors respectively.

In line with our conjecture and also consistent with the findings for the loan tenor, we find a positive and statistically significant coefficient on $HighCO2_{i,t-1} \times Paris_t$ for loans to borrowers from other sectors. Again, the results are statistically significant when firms' Scope 1 & 2 emission intensity is considered (column (4)). This indicates that, other things being constant, banks are more likely to impose collateral requirements in the loan contract to a brown firm from other sectors as compared to its non-brown industry peers in the post-Paris Agreement period.[33] This finding is consistent with our conjecture that banks would tend to impose more stringent non-pricing contractual terms as an alternative risk mitigation tool if it is more challenging to determine the extent of financial impacts from borrowers' transition risk at the time of loan origination. Importantly, the effect is found to be more significant after the Paris Agreement, further supporting the notion of rising climate awareness in banks after the Paris Agreement. Specifically, conditional on the borrower being a brown firm, the likelihood of being imposed a collateral requirement in the post-Paris Agreement period is estimated to be 15 percentage points higher than that in the pre-Paris Agreement period.

Taken together, our findings in this section provide suggestive evidence that while banks are not found to charge a transition risk premium on brown borrowers from the other sectors, in part reflecting the uncertainty surrounding the extent of transition risk for these firms, banks may alternatively consider imposing more stringent non-pricing contractual terms in the syndicated loans (for instance, by shortening the loan tenor and/or imposing collateral requirement) as alternative ways to reduce their transition risk exposures.

5. Conclusion

Based on a unique sample of syndicated loans originated in emerging markets economies, our analysis suggests that banks in these economies do factor in climate transition risks into their lending decision. On loan pricing, our results suggest that banks have started to price in transition risk arising from firms' Scope 1 (direct) emissions for loans to emissions-intensive sectors since the Paris

[31] In LPC Dealscan database, markets are segmented as “Asia Pacific”, “Middle East”, “Africa”, “Western Europe”, “Eastern Europe/Russia”, “USA/ Canada” and “Latin America and Caribbean”.

[32] Specifically, for base rate fixed effects, we group every loan with non-LIBOR based reference rate into one group. For currency fixed effects, we group every loan not denominated in US dollar into a group. In Table A7, additional results based on a probit specification with only the year of syndication fixed effect are reported. The results are quantitatively similar to those reported in Table 6 below. This suggests that the results found in Table 6 are robust to different sets of fixed effects.

[33] The average marginal effect of being a brown firm in the post-Paris Agreement shows that the probability of requiring collateral condition for a brown firm is 11.8 percentage points higher than a non-brown firm from the other sectors.

Table 5
Estimation results for Eq. (2) with the loan level observations using ln(LoanTenor) as dependent variables.

	Tenor longer than 1 year	Tenor longer than 1 year	Tenor longer than 1 year	Tenor longer than 1 year	Tenor longer than 2 year	Tenor longer than 3 year
	Scope 1 intensity	Scope 1 intensity	Scope 1&2 intensity	Scope 1&2 intensity	Scope 1 & 2 intensity	Scope 1 & 2 intensity
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable (Ln (LoanTenor))	Emissions-intensive sectors	Other sectors	Emissions-intensive sectors	Other sectors	Other sectors	Other sectors
HighCO2 (β_1)	0.0108	0.0281	0.00449	0.0357	0.0370	0.0348
	(0.0520)	(0.0338)	(0.0540)	(0.0323)	(0.0285)	(0.0266)
HighCO2 X Paris (β_2)	−0.0652	−0.0425	−0.00683	−0.0787**	−0.0833**	−0.0699**
	(0.0934)	(0.0419)	(0.0917)	(0.0395)	(0.0364)	(0.0343)
Joint test: $H_0 : \beta_1 + \beta_2 = 0$	−0.0544	−0.0144	−0.00234	−0.0430*	−0.0463**	−0.0352*
p-value	*0.475*	*0.561*	*0.974*	*0.0759*	*0.0322*	*0.0871*
Ln(LoanSpread)	0.140**	−0.0135	0.134*	−0.0122	−0.0261	−0.0292
	(0.0680)	(0.0286)	(0.0688)	(0.0284)	(0.0230)	(0.0216)
Ln(LoanAmount)	0.0227	0.0402***	0.0199	0.0407***	0.0367***	0.0310***
	(0.0196)	(0.0127)	(0.0195)	(0.0126)	(0.0110)	(0.00966)
ROA (Borrower)	−0.00624	−0.00150	−0.00573	−0.00131	−0.00186	−0.00196
	(0.00973)	(0.00478)	(0.00959)	(0.00469)	(0.00404)	(0.00350)
Debt-to-asset (Borrower)	−0.0072***	−0.000404	−0.0070***	−0.00042	−0.00040	4.55e-05
	(0.00222)	(0.000825)	(0.00218)	(0.000840)	(0.000849)	(0.000732)
Ln(Assets) (Borrower)	0.0293	−0.0160*	0.0258	−0.0167*	−0.0107	−0.00636
	(0.0235)	(0.00967)	(0.0235)	(0.00951)	(0.00905)	(0.00846)
Avg. ROA (Lender)	0.226**	−0.0333	0.224**	−0.0321	0.0358	−0.00549
	(0.0933)	(0.0520)	(0.0924)	(0.0519)	(0.0432)	(0.0424)
Avg. ln(Assets) (Lender)	0.0354	0.0183	0.0356	0.0182	0.0244*	0.0253*
	(0.0240)	(0.0158)	(0.0244)	(0.0159)	(0.0125)	(0.0128)
Avg. CapitalRatio (Lender)	−0.0513***	−0.00982	−0.0501***	−0.0101	−0.00618	−0.00564
	(0.0177)	(0.00800)	(0.0177)	(0.00806)	(0.00850)	(0.00787)
Concentration	0.0316	−0.00819	0.0316	−0.00721	−0.0150	−0.0155
	(0.0287)	(0.0177)	(0.0289)	(0.0175)	(0.0157)	(0.0136)
Covenant	−0.0659	−0.113**	−0.0672	−0.114**	−0.0265	−0.00388
	(0.0561)	(0.0546)	(0.0557)	(0.0538)	(0.0320)	(0.0344)
State-owned dummy	−0.0656	0.0342	−0.0601	0.0280	0.00204	0.00400
	(0.0564)	(0.0508)	(0.0563)	(0.0503)	(0.0427)	(0.0404)
Observations	609	1494	609	1494	1445	1374
R-squared	0.424	0.353	0.423	0.354	0.403	0.441
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Borrower country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

Agreement. This could reflect banks' increased awareness of climate changes to those borrowers that are more subject to transition risk arising from direct GHG emissions. The extent of the transition risk premium is also found to be dependent on the environmental attitude of banks. Specifically, green banks are found to charge a higher loan spread than other banks, when lending to the same brown firm after the Paris Agreement. Apart from charging a transition risk premium in the loan spread, we also find evidence that banks may also consider imposing more stringent non-pricing contractual terms on brown firms, especially when the financial impacts of climate transition risks on these borrowers are more prone to uncertainty. Specifically, banks would tend to shorten loan maturity and are more likely to impose collateral requirement on brown firms from other non-emissions-intensive sectors, in part reflecting that their transition risk exposures are dominated by their Scope 2 (indirect) emissions and thus the resulting credit risk impacts are subject to high uncertainty.

These findings together provide some important policy implications. Firstly, our analysis contributes to the policy debate on whether imposing climate-related regulatory requirements on banks, on top of the existing regulatory framework, could help them manage climate-related risks. Our findings show that banks in these emerging economies have started to factor in climate-related risks

Table 6
Estimation results for probit model with the loan level observations using dummy(collateral) as dependent variables.

	Scope 1 intensity		Scope 1 & 2 intensity	
Probit regression	(1)	(2)	(3)	(4)
Dependent variable: Collateral	Emissions-intensive sectors	Other sectors	Emissions-intensive sectors	Other sectors
HighCO2 (β_1)	0.346	0.0582	0.389	−0.132
	(0.255)	(0.119)	(0.256)	(0.0911)
HighCO2 X Paris (β_2)	0.166	−0.124	0.191	0.581***
	(0.325)	(0.214)	(0.324)	(0.195)
Average marginal effect for a change in Paris conditional on being brown firms:	0.0375	−0.0316	0.0437	0.150***
p-value	*0.614*	*0.565*	*0.560*	*0.00229*
Ln(LoanSpread)	0.533**	0.419**	0.529**	0.416**
	(0.208)	(0.168)	(0.208)	(0.183)
LoanTenor	0.00323	−0.00358*	0.00282	−0.00339
	(0.00275)	(0.00208)	(0.00285)	(0.00217)
Ln(LoanAmount)	−0.102*	0.0494	−0.106*	0.0534
	(0.0615)	(0.0373)	(0.0612)	(0.0394)
ROA (Borrower)	−0.0213	−0.0334	−0.0201	−0.0387*
	(0.0321)	(0.0235)	(0.0321)	(0.0233)
Debt-to-asset (Borrower)	0.00424	0.00706	0.00472	0.00757
	(0.00594)	(0.00493)	(0.00564)	(0.00501)
Ln(Assets) (Borrower)	−0.195***	−0.0962***	−0.197***	−0.106***
	(0.0641)	(0.0358)	(0.0658)	(0.0341)
Avg. ROA (Lender)	−0.0406	−0.375	−0.0546	−0.350
	(0.404)	(0.244)	(0.404)	(0.239)
Avg. ln(Assets) (Lender)	−0.243**	−0.174***	−0.250***	−0.171***
	(0.0989)	(0.0498)	(0.0933)	(0.0496)
Avg. CapitalRatio (Lender)	0.0188	−0.0622**	0.0144	−0.0584**
	(0.0572)	(0.0263)	(0.0575)	(0.0250)
Concentration	−0.193*	−0.123**	−0.177*	−0.119**
	(0.101)	(0.0484)	(0.0961)	(0.0493)
Dummy(Covenant)	0.477	0.399*	0.452	0.407**
	(0.308)	(0.209)	(0.306)	(0.203)
State-owned dummy	−0.0112	−0.175	−0.00386	−0.258
	(0.352)	(0.248)	(0.352)	(0.287)
Observations	654	1574	654	1574
Pseudo R-squared	0.280	0.212	0.284	0.223
Base rate (regrouped) dummy	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Sector fixed effect	Yes	Yes	Yes	Yes
Regions of borrower fixed effects	Yes	Yes	Yes	Yes
Currency (regrouped) fixed effects	Yes	Yes	Yes	Yes
Regions of syndication fixed effect	Yes	Yes	Yes	Yes
tranche type dummy	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors. Fixed effects are regrouped here to alleviate the drop of observations driven by complete or quasi-complete separation issues in probit estimation. For details of the regrouping, please refer to footnotes 34 and 35.

in their lending consideration (both in the pricing and non-pricing components of loan contracts) since the Paris Agreement, potentially reflecting that climate risks have been considered in the credit risk management of banks. The findings support the view that climate-related risks can be captured under the existing regulatory framework. This may suggest that the benefits of additional regulatory requirements on climate-related risks should be assessed carefully. Relatedly, there is an argument that climate-related capital requirement, if designed inappropriately, could unduly influence banks' lending behaviour which may potentially lead to unintended consequences for financial stability (Bailey (2021)). As such, evaluating the trade-offs between additional climate-related capital requirements and the potential unintended consequences is highly warranted.

Secondly, despite the fact that banks in emerging markets have started to incorporate climate risk into their existing risk management framework, managing climate risks will remain a key challenge for banks due to the different nature from the traditional risk types[34] and data gaps. Banks should therefore keep abreast of the latest developments in climate risk management practices to adjust their own risk management approach. Therefore, policymakers in emerging economies should proactively engage with the banking industry and help facilitate banks to incorporate climate risk management practices into their operations. In addition, it is important

[34] Compared to the traditional risk types, climate risks are more susceptible to non-linearity and fat-tailed distributions.

for policymakers to promote GHG emission disclosure by firms and urge them to follow common environmental reporting standards, such as those recommended by the TFCD. Looking ahead, a broader coverage and higher quality of firms' environmental disclosure data would be highly desirable for banks to better assess the associated climate risk in their overall loan exposures.

CRediT authorship contribution statement

Kelvin Ho: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Andrew Wong:** Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

Appendix A. Appendix

Table A1
Variable definitions and sources.

Variable	Description	Source
loan-level variables		
LoanSpread	All-in-spread-drawn, defined as loan spread over reference rates in basis points.	Dealscan
LoanAmount	The loan amount in US dollar with natural logarithm transformation.	Dealscan
LoanTenor	The maturity of the loan in months.	Dealscan
Collateral	Dummy equal to 1 if the loan is secured with collaterals.	Dealscan
Covenant	Dummy equal to 1 if the financial covenant is present in the loan contract.	Dealscan
Concentration	The number of lead arranger in the loan syndicate.	Dealscan
Loan type	In line with Degryse et al. (2022), three broad categories are considered: 1. credit line; 2. term loans; 3. Other loan types.	Dealscan
Country of syndication	The location of the loan syndication.	Dealscan
Paris	Dummy taking value of 1 if the loan active day is after 1 January 2016.	Dealscan
borrower-level variables		
Ln(Assets) (Borrower)	Logarithm of total assets in US dollar, one-year lagged.	S&P Capital IQ
ROA (Borrower)	The return on asset, one-year lagged.	S&P Capital IQ
Debt-to-asset (Borrower)	The ratio of total debt to total asset, one-year lagged.	S&P Capital IQ
State ownership dummy	This variable is for capturing the risk mitigating effect for lending to borrower which are backed by the state government. Specifically, dummy takes the value of 1 if the borrower/ultimate parent of the borrower is controlled by state/ having significant ownership shares (i.e. 20%) by the state government/SOEs.	S&P Capital IQ
CO_2e scope 1 emission intensity	Borrower's tonnes of scope 1 CO_2e emissions per US$ million, one-year lagged.	S&P Trucost
CO_2e scope 2 emission intensity	Borrower's tonnes of scope 2 CO_2e emissions per US$ million, one-year lagged.	S&P Trucost
Global industry average level of emission intensity	The global industry (GICS sub-industry) group average scope 1 (scope2) emission intensity level for each calendar year. The data is available at S&P Trucost *E*-board platform.	S&P Trucost
HighCO2	Dummy variable taking value of 1 if the borrower's CO_2e scope 1 (Scope1&2) intensity is higher than its respective industry-average level at year t-1.	S&P Trucost and authors' calculation.
lead arranger-level variables		
ROA (Lender)	The return on asset, one-year lagged.	S&P Capital IQ
CapitalRatio (Lender)	T1 Capital ratio, one-year lagged (or the latest quarterly available data before the loan origination date up to one-year lagged period, whichever is available).	S&P Capital IQ
Ln(Assets) (Lender)	Logarithm of total assets in US dollar, one-year lagged.	S&P Capital IQ
GreenBank	Green lender proxy. This is a dummy taking value of 1 if the lead arranger has become a member of UNEP FI as of the loan origination date.	Website of UNEP FI
GreenBank"	A more restrictive green lender proxy. This is a dummy taking value of 1 if as of the loan origination date, i.) the lead arranger has become a member of UNEP FI and ii.) the lead arranger (or its parent holding company) is also regularly self-disclosing GHG footprint.	Website of UNEP FI & S&P Trucost

Table A2
Country of loan syndication and country of unique borrowers.

Country of syndication	No. of tranche	Country of borrowers	No. of unique borrower
Hong Kong	695	China	143
Taiwan	600	Taiwan	139
India	126	Hong Kong	92

(*continued on next page*)

Table A2 (*continued*)

Country of syndication	No. of tranche	Country of borrowers	No. of unique borrower
Singapore	111	India	32
Indonesia	104	South Korea	31
China	91	Singapore	19
South Korea	68	Malaysia	17
Brazil	49	Indonesia	17
Mexico	47	United States	14
Vietnam	40	Brazil	13
Russian Federation	40	Thailand	12
Philippines	34	Russia	12
South Africa	33	Mexico	12
Malaysia	29	Philippines	11
Turkey	27	South Africa	10
Chile	26	Other AEs	43
Thailand	23	Other EMEs	38
Colombia	16	Total	655
Argentina	15		
Others*	48		
Total	2222		

Note: Others* include "Czech, UAE, Israel, Peru, Romania, Poland and Egypt.

Table A3
Estimation results for Eqs. (1) and (2) with the loan level observations (Scope 1 and 2 emissions).

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable (LoanSpread)	All sectors	Emissions-intensive sectors	other sectors	All sectors	Emissions-intensive sectors	other sectors
HighCO2 (β_1)	2.396	6.459	2.659	−10.34*	−9.140	−2.393
	(4.356)	(8.121)	(4.776)	(5.850)	(10.19)	(6.404)
HighCO2 X Paris (β_2)				24.50***	39.46***	8.691
				(8.015)	(14.86)	(8.206)
Joint test: $H_0 : \beta_1 + \beta_2 = 0$				14.16**	30.32***	6.298
p-value				*0.0103*	*0.00842*	*0.285*
LoanTenor	0.223**	0.488***	0.175*	0.230**	0.481***	0.182*
	(0.0891)	(0.141)	(0.0979)	(0.0886)	(0.137)	(0.0981)
Ln(LoanAmount)	−5.010**	0.122	−6.476**	−5.358**	−1.810	−6.486***
	(2.225)	(3.805)	(2.494)	(2.197)	(3.788)	(2.486)
ROA (Borrower)	−1.003	−0.0614	−2.365***	−1.125	−0.0951	−2.405***
	(0.842)	(1.403)	(0.887)	(0.849)	(1.386)	(0.899)
Debt-to-asset (Borrower)	1.004***	1.214***	1.018***	1.036***	1.318***	1.024***
	(0.185)	(0.306)	(0.206)	(0.183)	(0.302)	(0.205)
Ln(Assets) (Borrower)	−8.789***	−5.216	−8.700***	−8.825***	−6.302	−8.688***
	(2.054)	(4.197)	(2.314)	(2.027)	(4.260)	(2.310)
Avg. ROA (Lender)	11.40	0.726	16.11	11.65	0.334	15.99
	(10.56)	(18.33)	(10.98)	(10.44)	(18.70)	(10.97)
Avg. ln(Assets) (Lender)	−10.14***	−9.404*	−11.73***	−10.05***	−9.364*	−11.72***
	(2.696)	(5.528)	(3.204)	(2.669)	(5.480)	(3.202)
Avg. CapitalRatio (Lender)	4.206*	3.552	5.033*	4.370*	4.482	5.032*
	(2.297)	(3.873)	(2.839)	(2.296)	(3.757)	(2.834)
Concentration	−7.139***	−12.66**	−4.434	−7.145***	−11.67**	−4.498
	(2.657)	(5.277)	(2.873)	(2.654)	(5.259)	(2.889)
Covenant	−7.985	−29.62***	−0.653	−8.325	−29.36***	−0.890
	(5.627)	(8.872)	(6.514)	(5.742)	(9.026)	(6.498)
State-owned dummy	−24.17***	−23.54	−17.74	−22.48**	−19.86	−17.26
	(9.171)	(14.44)	(11.70)	(9.167)	(14.62)	(11.54)
Observations	2222	653	1564	2222	653	1564
R-squared	0.550	0.642	0.584	0.553	0.647	0.584
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Borrower country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country of synd. Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes
Tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

Table A4
Estimation results for Eqs. (1) and (2) with continuous GHG emission intensity deviation as interaction term (all sectors and emissions-intensive sectors group only).

	(1)	(2)	(3)	(4)
Dependent variable (LoanSpread)	All sectors	All sectors	Emissions-intensive sectors	Emissions-intensive sectors
Firm's CO_2e emission deviation from industry benchmark (β_1)	7.202**	3.623	6.241**	3.198
	(2.850)	(4.149)	(3.054)	(4.222)
Firm's CO_2e emission deviation from industry benchmark X Paris (β_2)		7.069		6.723
		(5.704)		(5.911)
Joint test: $H_0 : \beta_1 + \beta_2 = 0$		10.69***		9.922**
p-value		*0.00731*		*0.0217*
LoanTenor	0.224**	0.225**	0.494***	0.490***
	(0.0871)	(0.0873)	(0.136)	(0.134)
Ln(LoanAmount)	−4.972**	−5.018**	0.438	0.189
	(2.224)	(2.216)	(3.741)	(3.749)
ROA (Borrower)	−1.018	−0.987	−0.0570	0.126
	(0.835)	(0.833)	(1.375)	(1.391)
Debt-to-asset (Borrower)	1.003***	1.016***	1.245***	1.318***
	(0.185)	(0.187)	(0.306)	(0.310)
Ln(Assets) (Borrower)	−9.021***	−9.066***	−5.876	−6.072
	(2.025)	(2.011)	(3.949)	(3.944)
Avg. ROA (Lender)	11.41	11.57	−1.225	−0.873
	(10.39)	(10.39)	(18.17)	(18.25)
Avg. ln(Assets) (Lender)	−9.921***	−10.02***	−8.917	−9.255*
	(2.700)	(2.689)	(5.439)	(5.411)
Avg. CapitalRatio (Lender)	4.177*	4.175*	3.774	3.971
	(2.284)	(2.282)	(3.763)	(3.709)
Concentration	−7.508***	−7.430***	−13.99***	−13.57**
	(2.643)	(2.640)	(5.354)	(5.349)
Covenant	−8.426	−8.910	−29.47***	−30.89***
	(5.530)	(5.538)	(9.143)	(9.241)
State-owned dummy	−24.41***	−23.95***	−23.94*	−23.29
	(9.099)	(9.128)	(13.94)	(14.08)
Observations	2222	2222	653	653
R-squared	0.553	0.553	0.646	0.647
Base rate dummy	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Borrower country fixed effect	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes
Tranche type dummy	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

Table A5
Estimation results for Eq. (3) with the loan-lead arranger level observations (Scope 1 and 2 emissions).

	(1)	(2)	(3)	(4)	(5)	(6)
GreenBank proxy	UNEPFI			UNEPFI + Trucost dislcosure		
Dependent variable (LoanSpread)	All sectors	Emissions-intensive sectors	Other sectors	All sectors	Emissions-intensive sectors	Other sectors
HighCO2 (β_1)	6.625**	20.70***	2.266	6.377**	20.68***	1.908
	(2.891)	(4.968)	(3.562)	(2.881)	(4.960)	(3.557)
GreenBank (β_2)	0.935	6.217	−0.535	3.262	7.399	0.614
	(3.842)	(6.624)	(4.033)	(3.247)	(5.979)	(3.608)
HighCO2 X Paris (β_3)	0.517	4.456	−1.423	0.861	5.297	−1.122
	(3.661)	(7.339)	(4.207)	(3.647)	(7.401)	(4.187)
HighCO2 X GreenBank (β_4)	−6.333**	−7.128	−4.312	−5.864**	−7.326*	−3.505
	(2.465)	(4.371)	(2.998)	(2.465)	(4.366)	(3.038)
GreenBank X Paris (β_5)	−0.0955	1.220	0.558	0.994	3.407	1.648
	(2.810)	(4.826)	(3.159)	(2.838)	(4.746)	(3.223)
HighCO2 X GreenBank X Paris (β_6)	5.033	15.69**	−1.580	4.275	13.88**	−2.494
	(3.649)	(7.166)	(4.229)	(3.691)	(6.897)	(4.317)
LoanTenor	0.504***	0.731***	0.303***	0.504***	0.733***	0.302***
	(0.0643)	(0.0925)	(0.0805)	(0.0643)	(0.0923)	(0.0805)

(*continued on next page*)

Table A5 (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)
GreenBank proxy	UNEPFI			UNEPFI + Trucost dislcosure		
Dependent variable (LoanSpread)	All sectors	Emissions-intensive sectors	Other sectors	All sectors	Emissions-intensive sectors	Other sectors
Ln(LoanAmount)	−3.417***	−3.375**	−3.291***	−3.414***	−3.369**	−3.283***
	(0.740)	(1.593)	(0.770)	(0.740)	(1.591)	(0.770)
ROA (Borrower)	−0.520	0.236	−0.593	−0.524	0.240	−0.603
	(0.358)	(0.802)	(0.403)	(0.358)	(0.801)	(0.402)
Debt-to-asset (Borrower)	0.647***	1.754***	0.0655	0.646***	1.752***	0.0636
	(0.113)	(0.265)	(0.135)	(0.113)	(0.265)	(0.135)
Ln(Assets) (Borrower)	−20.43***	−20.60***	−24.05***	−20.50***	−20.71***	−24.10***
	(3.114)	(5.601)	(3.532)	(3.112)	(5.597)	(3.532)
ROA (Lender)	11.00***	9.316*	8.144***	11.11***	9.509*	8.246***
	(2.678)	(4.936)	(3.067)	(2.685)	(4.941)	(3.079)
ln(Assets) (Lender)	−0.889	−9.836	1.841	−0.186	−9.441	2.480
	(3.221)	(6.108)	(3.831)	(3.228)	(6.158)	(3.854)
CapitalRatio (Lender)	−1.645***	−2.459***	−1.146**	−1.656***	−2.482***	−1.172**
	(0.470)	(0.809)	(0.545)	(0.468)	(0.809)	(0.541)
Concentration	−0.496	−0.798	−0.481	−0.514	−0.765	−0.521
	(2.034)	(3.041)	(2.687)	(2.033)	(3.040)	(2.687)
Covenant	−15.29***	−22.72***	−11.75***	−15.31***	−22.80***	−11.74***
	(2.479)	(3.394)	(2.862)	(2.481)	(3.400)	(2.860)
Observation	11,256	3172	8054	11,256	3172	8054
R-Squared	0.876	0.874	0.893	0.876	0.874	0.893
Base rate dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes	Yes	Yes
Tranche type dummy	Yes	Yes	Yes	Yes	Yes	Yes
Lender fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Borrower fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

Table A6

Estimation results for Eq. (3) using different clustering group for calculating standard errors (emissions-intensive sectors only).

Clustering group(s)	borrower#year level		country of syndication#year level AND borrower sector#year level	
	(1)	(2)	(3)	(4)
GreenBank proxy	UNEPFI	UNEPFI + disclosure action	UNEPFI	UNEPFI + disclosure action
Dependent variable (LoanSpread)	Emissions-intensive sectors	Emissions-intensive sectors	Emissions-intensive sectors	Emissions-intensive sectors
HighCO2 (β_1)	7.489	7.350	7.489	7.350
	(11.68)	(11.61)	(10.96)	(10.82)
GreenBank (β_2)	5.102	5.735	5.102	5.735
	(5.215)	(4.497)	(5.966)	(4.797)
HighCO2 X Paris (β_3)	14.97	15.84	14.97	15.84
	(15.36)	(15.27)	(17.24)	(17.25)
HighCO2 X GreenBank (β_4)	−6.927	−6.919	−6.927	−6.919
	(4.534)	(4.586)	(4.458)	(4.129)
GreenBank X Paris (β_5)	2.724	4.979	2.724	4.979
	(6.110)	(6.238)	(5.892)	(6.015)
HighCO2 X GreenBank X Paris (β_6)	13.42	11.53	13.42**	11.53*
	(8.371)	(8.581)	(5.965)	(6.335)
Joint test: $H_0: \beta_2 + \beta_4 + \beta_5 + \beta_6 = 0$	14.32**	15.32**	14.32**	15.32***
p-value	*0.0380*	*0.0191*	*0.0345*	*0.00915*
Observation	3172	3172	3172	3172
R-Squared	0.874	0.874	0.874	0.874
Base rate dummy	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Country of syndication fixed effect	Yes	Yes	Yes	Yes
Currency fixed effect	Yes	Yes	Yes	Yes
Collateral dummy	Yes	Yes	Yes	Yes

(*continued on next page*)

Table A6 (*continued*)

Clustering group(s)	borrower#year level		country of syndication#year level AND borrower sector#year level	
	(1)	(2)	(3)	(4)
GreenBank proxy	UNEPFI	UNEPFI + disclosure action	UNEPFI	UNEPFI + disclosure action
Dependent variable (LoanSpread)	Emissions-intensive sectors	Emissions-intensive sectors	Emissions-intensive sectors	Emissions-intensive sectors
Tranche type dummy	Yes	Yes	Yes	Yes
Lender fixed effect	Yes	Yes	Yes	Yes
Borrower fixed effect	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered standard errors generated from different choices of clustering group, as stated in the first row.

Table A7
probit estimation on *Collateral* with only year of loan syndication fixed effects.

	Scope 1 intensity		Scope 1 & 2 intensity	
Probit regression	(1)	(2)	(3)	(4)
Dependent variable: Collateral	Emissions-intensive sectors	Other sectors	Emissions-intensive sectors	Other sectors
HighCO2 (β_1)	0.339	0.0295	0.348	0.0269
	(0.249)	(0.124)	(0.256)	(0.134)
HighCO2 X Paris (β_2)	0.173	−0.165	0.211	0.415**
	(0.307)	(0.191)	(0.320)	(0.204)
Average marginal effect for a change in Paris conditional on being brown firms:	0.0426	−0.0464	0.0524	0.121**
p-value	*0.578*	*0.391*	*0.517*	*0.0369*
Ln(LoanSpread)	0.414***	0.280**	0.416***	0.289**
	(0.147)	(0.135)	(0.148)	(0.143)
LoanTenor	0.00391	0.000561	0.00361	0.000741
	(0.00242)	(0.00188)	(0.00245)	(0.00188)
Ln(LoanAmount)	−0.0655	0.0233	−0.0691	0.0230
	(0.0620)	(0.0337)	(0.0618)	(0.0354)
ROA (Borrower)	0.00433	−0.0310	0.00549	−0.0364
	(0.0261)	(0.0239)	(0.0262)	(0.0245)
Debt-to-asset (Borrower)	0.00356	0.00900*	0.00406	0.00957*
	(0.00459)	(0.00544)	(0.00427)	(0.00557)
Ln(Assets) (Borrower)	−0.121**	−0.0774**	−0.120**	−0.0828***
	(0.0527)	(0.0302)	(0.0536)	(0.0303)
Avg.ROA (Lender)	−0.250	−0.347	−0.272	−0.285
	(0.377)	(0.212)	(0.372)	(0.204)
Avg. ln(Assets) (Lender)	−0.278***	−0.186***	−0.287***	−0.176***
	(0.0844)	(0.0470)	(0.0792)	(0.0479)
Avg. CapitalRatio (Lender)	−0.00918	−0.0460	−0.0112	−0.0426
	(0.0647)	(0.0302)	(0.0644)	(0.0298)
Concentration	−0.241***	−0.107**	−0.222***	−0.0995*
	(0.0908)	(0.0525)	(0.0853)	(0.0544)
Covenant	0.303	0.335*	0.275	0.352*
	(0.298)	(0.185)	(0.296)	(0.180)
State-owned dummy	−0.161	−0.288	−0.146	−0.358
	(0.266)	(0.236)	(0.269)	(0.260)
Observations	662	1574	662	1574
Pseudo R-squared	0.220	0.129	0.223	0.140
Year fixed effect	Yes	Yes	Yes	Yes

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. Figures in the parentheses are the clustered by country of syndication#year standard errors.

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