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The pricing of carbon risk in syndicated loans: which risks are priced and why?[1]

Torsten Ehlers, Frank Packer and Kathrin de Greiff [2]

Abstract

Do banks price the risks of climate policy change? Combining syndicated loan data with carbon intensity data (CO_2 emissions relative to revenue) of borrowers across a wide range of industries, we find a significant "carbon premium" since the Paris Agreement. The loan risk premium related to CO_2 emission intensity is apparent across industries and broader than that due simply to "stranded assets" in fossil fuel or other carbon-intensive industries. The price of risk, however, appears to be relatively low given the material risks faced by borrowers. Only carbon emissions directly caused by the firm (scope 1) are priced, and not the overall carbon footprint including indirect emissions. "Green" banks do not appear to price carbon risk differently from other banks.

Keywords: environmental policy, climate policy risk, transition risk, loan pricing.

JEL classification: G2, Q01, Q5.

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1. Introduction

Both the physical risks from climate events, and even more, the transition risks from a tightening of environmental regulations, can lead to potentially large revaluations of financial assets if not anticipated (Carney (2015), Dietz et al (2016)). The more informed investors and creditors are of the financial risks of climate change, the more they will reallocate from investments with high climate-related financial risks to more environmentally beneficial investments with lower risks. The pricing of climate-related financial risks, therefore, is an important factor in climate change mitigation.

We concentrate on carbon emissions as a source of financial risk for firms, often referred to in the literature as "carbon risk" (eg Bolton and Kacperczyk (2021), Goergen et al (2020), Andersson et al (2016)). In December 2015, 195 states and the European Union agreed in Paris to adopt a goal of limiting global warming to well below 2 degree Celsius, preferably to 1.5 degrees, above pre-industrial levels and pursue efforts consistent with that goal. Achieving this goal implies a very rapid reduction of CO_2 emissions (Rogelj et al (2016), IPCC (2015)). Very carbon intensive firms therefore face relatively high financial risks if, and when, governments take measures to comply with their commitments to reduce carbon emissions.

One instance of carbon risk that has received early attention in the literature is the case of stranded assets in the fossil fuel industry (Ansar et al (2013)). Stranded assets are physical assets whose value declines substantially due to the effects of climate change or climate change policies. The carbon reduction requirements in the Paris Agreement and related policies imply that some fossil fuel firms might not be able to fully utilize their existing fossil fuel reserves (McGlade and Ekins (2015)), leading to a decline in the financial value of those reserves. Under given climate policy scenarios, the carbon risk from stranded assets in the fossil fuel industry can be directly measured, making it a natural approach for studying climate-related financial risks.

Carbon risk, however, goes beyond stranded assets. Firms with relatively high emissions are at a greater risk of suffering financial penalties if environmental policies tighten. Direct penalties can result, for instance, from the extra costs of carbon taxes on firm emissions. These can apply to firms in all industries with a carbon footprint and are not limited to fossil fuel producers.

Our main contribution to the literature is to consider pricing of carbon risk in the context of syndicated bank loans. Lead banks in a loan syndicate have a strong incentive (and the means) to consider all relevant risk when pricing a loan – in particular when it is of large value and long maturity as is typical in the syndicated loan market. We document that for a significant share of firms in our sample, carbon risk is financially material. Hence, banks should be expected to price such risks.

We use carbon intensity – carbon emissions relative to revenue – as a proxy for carbon risk. We argue that carbon intensity can capture the severity of the potential financial impact of a tightening of carbon emission policies, such as an imposition of a carbon tax. Ultimately, costs related to carbon emissions are balanced against revenue, and firms with greater carbon emissions relative to revenue will find transition costs (such as carbon taxes) to be more burdensome.

The analysis of carbon risk across a broad set of industries is enabled by the increasing availability of carbon emissions data for a broad range of firms. We use carbon emissions data from S&P Trucost that covers listed firms in all major advanced and emerging economies. The availability of such data allows us to distinguish between inter- and intra-industry differences in carbon emissions. Also, the firm-level physical measures of carbon emissions enable us to analyze emissions directly attributable to the firm (scope 1), and those more broadly measured to include indirect emission from consumed energy (scope 2) and production inputs of the firm ("upstream" scope 3).

To preview our results, we find that the pricing of carbon risk in the syndicated loan market changed significantly after the Paris Agreement. The difference in risk premia due to CO_2 emission intensity is apparent across industry sectors. It is not driven by any specific industry sectors and therefore reflects a phenomenon broader than simply "stranded assets" in fossil fuel or other carbon-intensive industries. These results are robust to including loan fees, and the premium is not prevalent in the years before the Paris Agreement. We argue that the Paris Agreement increased the awareness of banks to carbon risk, analogous to survey evidence for institutional investors (Krueger et al (2020)).

While our results suggest that banks have started to internalize possible risks from the transition to a low-carbon economy across a broad range of industries, we find that they have done so only for the narrowly defined scope 1 carbon emissions (ie those directly caused by the firm). Our results suggest that carbon emissions indirectly caused by production inputs were not priced at the margin, implying that the overall carbon footprint is less of a concern to banks than direct emissions caused by the firms' activities. This seeming indifference of banks to higher scope emissions of borrowers parallels one finding of Bolton and Kacperczyk (2021), who show that the likelihood of divestment by institutional investors significantly increases with the degree and intensity of scope 1 emissions of the target firm, but not with emissions of other broader scopes. This suggests potential for "green-washing": scope 1 emissions of a firm can be reduced by simply outsourcing carbon intensive activities (Ben-David et al (2021)), without reducing the firm's broader carbon footprint.

Apart from the narrow scope of carbon risk that we find to be priced in syndicated bank loans, the price of risk also appears to be relatively low. On average, our regression results imply a carbon risk premium since 2016 of about 3-4 basis points (ie a 0.03-0.04% loan rate premium). For the high emitters (the 90th percentile in our sample), the premium increases to 7 basis points. High carbon emitters are firms with a carbon intensity of >1000 tonnes of CO_2 per $ million of revenue in our sample. Ceteris paribus, the introduction of a carbon price of $100 per tonne of CO_2 would imply that these firms would have to spend at least 10% of total revenues on carbon taxes alone.[3] Carbon risk would hence be highly material for such firms and the potential financial impact is unlikely to be fully internalized by a 7 basis points premium.

We further investigate whether syndicated loans arranged by "green banks" (as lead arrangers) price climate change risks more than other banks. We look at both banks that signal they are green (as members of the United Nations Environmental Programme Finance Initiative (UNEP FI) or parties to the Equator Principles (EP)) and

[3] The carbon price on the European Union's Emission Trading System (EU ETS), currently the largest such scheme in the world, was around €50 (around $60) per CO2 tonne at the beginning of May 2021. The EU ETS is a so-called "cap and trade" system, where companies have to purchase emission rights if they exceed a given (and periodically decreasing) emission allowance. As we discuss below, an *average* carbon price of $100 (ie an average across all emissions and not only those exceeding a given threshold) is plausible considering estimates of optimal carbon prices from the literature.

"de facto" green banks that lend less to carbon-intensive sectors. We cannot find any evidence that green banks put a higher price on carbon risk, though there is some evidence that green banks belonging to the UNEP FI or adopting the EP screen out companies with high carbon exposure – analogous to the evidence for asset managers in Bolton and Kacperczyk (2021).

Academic research to date on the pricing of climate change risk, including on carbon risk, has tended to focus on the pricing of climate-related risks in equity markets. Existing research indicates a transition risk premium in equity and option markets which seems to be more pronounced in times of high public climate change awareness (Ilhan et al (2021), Bolton and Kacperczyk (2021), Goergen et al (2020), Ramelli et al (2018), among others).[4]

By contrast, the literature on the pricing of climate-related risks in bank loan markets is more limited. Ongena et al (2018) examine syndicated loan data for fossil fuel firms to assess whether banks price the risk of stranded assets. Their study reveals that only post-2015 (after the establishment of the Paris Agreement) did banks begin pricing the risk of stranded fossil fuel reserves. In contrast, our paper's set-up allows us to test whether it is oil and gas alone that is driving the results for carbon emissions. At the same time, our finding that scope 1 emissions are priced while other scopes are not, provides an important insight into the (lack of) efficiency with which syndicated loan markets are pricing transition risks. Kleimeier and Viehs (2018) also exploit syndicated loan data to investigate whether firms voluntarily disclosing their carbon emissions to CDP (formerly Carbon Disclosure Project) are able to lower their costs of credit. They find that firms that voluntarily disclose CO_2 emissions face lower costs of credit compared to non-disclosing firms.

The rest of the paper will proceed as follows. In the next section, we introduce the data available to us for the empirical investigation, including bank and borrower-level syndicated loan data, and firm-level carbon intensity data. In the third section, we discuss the materiality of carbon risk, while the fourth section presents the econometric model and the baseline results with a particular focus on inter vs. intra-industry effects. The fifth investigates the extent to which the pricing impact differs across different measures of carbon emissions, while part six discusses the extent to which the greenness of the banks providing the finance affects the pricing of carbon risk. After some robustness checks in part seven, part eight concludes.

2. Data

We merge annual carbon emissions data for corporate borrowers with syndicated loans data for the period 2005-2018. The combined data set covers 567 different firms in total from 2005 to 2018 from 31 countries. Table 1 provides a description of our key variables.

Compared to the existing research on the pricing of climate risks in the syndicated loan market, we have access to carbon emissions data for a significantly broader set of listed firms. We obtain data on firm's carbon emissions from Trucost, a data vendor that is part of S&P Global. The database provides carbon emissions,

4 Physical climate change risks, however, do not seem to be priced in correctly (Hong et al (2019), Murfin and Spiegel (2020), among others).

including scope 1-3 carbon emissions, on an annual basis since 2006 for around 12,000 firms in 2018. Those are virtually all listed firms in advanced and the major emerging economies. The data are taken by Trucost either from companies' reports to CDP, corporate Annual Reports, Corporate Social Responsibility reports, corporate websites and companies' feedback via the Trucost Environmental Register. Importantly, Trucost estimates missing data using an input-output model, recommended by the greenhouse gas (GHG) protocol to estimate the impact of

Description of key variables

Table 1

Variable	Description	Source
A. *Dependent variables*		
Margin (bp)	Numerical value of tranche margin measured in basis points	Dealogic
All-in-Pricing (bp)	Numerical value of tranche margin plus any kind of fees measured in basis points	Dealogic
Fees (bp)	The difference of All-in-Pricing and Margin.	Dealogic
B. *Explanatory variables: Interest rates and loan characteristics*		
Term Spread	Spread between a governments bond of equivalent maturity to the syndicated loan over the reference rate of the syndicated loan in the currency of denomination of the syndicated loan	Central banks, Bloomberg
Log(Loan Value)	Log of the loan facility amount ($ millions).	Dealogic
Maturity	Loan duration in years.	Dealogic
Leveraged	Dummy equal to one if it is a leveraged loan	Dealogic
Subordinated	Dummy equal to one if it is a subordinated loan	Dealogic
C. *Explanatory variables: Borrower characteristics*		
Borrower Rating	Borrower S&P rating at signing in a numerical form ranging from 20 for AAA to 0 for a C rating.	Dealogic
Log(Revenues)	Log of borrowers annual revenues ($ millions).	Trucost
Carbon Intensity	Carbon Intensity Scope 1 measured as annual scope 1 carbon emissions over annual revenues (CO_2 tonnes/$ millions) in a given fiscal year of a borrowing firm.	Trucost
Carbon Intensity Scope 1 + 2	Sum of Carbon Intensity Scope 1 and 2.	Trucost
Carbon Intensity Scope 1 – 3	Sum of Carbon Intensity Scope 1, 2 and 3. Scope 3 covers upstream activities (production inputs) only.	Trucost
D. *Explanatory variables: Bank characteristics, country climate policy stringency and oil prices*		
Green Bank (EP)	Dummy equal to one from the year onwards in which the bank signed the Equator Principles (EP).	Principle's webpage
Green Bank (UNEP-FI)	Dummy equal to one from the year onwards in which the lender signed the green principles of the United Nations Environment Programme Finance Initiative (UNEP-FI).	Principle's webpage
Climate Change Performance Index (CCPI)	The CCPI assesses each country's performance in four categories: GHG Emissions, Renewable Energy, Energy Use and Climate Policy, as well as extent the respective country acts adequately to achieve the Paris climate targets.	Germanwatch
Oil Price	Average of three major spot prices (Brent, West Texas Intermediate, and the Dubai Fateh) in $/barrel.	IMF

investments.[5] Trucost compares the estimates with the emissions that firms report and adds "missing" emissions if necessary.[6] For our sample period, scope 3 emissions are only available for upstream activities, ie those related to production inputs and supplies. Emissions are measured annually over the course of a firms' fiscal year.

Still there might be a remaining concern with the fact that all firms voluntarily disclose carbon emissions, and the selection issues that might arise. Firms potentially do not disclose carbon emissions because they are reluctant to acknowledge high carbon intensity or else due to the simple absence of correct carbon intensity measures. As for the latter case, Trucost data includes estimates that actually allow us to include such firms in our analysis. We later examine evidence whether carbon emissions that are estimated by Trucost rather than disclosed by the firm itself bias our results in any way. We further address firm specific differences by controlling for firm characteristics.

We obtain global loan-level syndicated loan data from Dealogic. Our main dependent variable is the margin, which equals the spread of the loan facility. For our regressions, to reduce the effect of outliers, we winsorize the sample for margins below the 1% percentile and above the 99% percentile. Berg, Saunders, and Steffen (2016) show the importance of fees in the overall pricing of loans. Thus, in robustness checks we use a measure of all-in pricing that includes all types of fees charged by the lender, including commitment fees (paid on unused amount of loan commitments), utilization fees (paid on the drawn amount once a threshold has been exceeded), and fixed upfront fees. We control for the rating of the borrower, the maturity of the loan facility, the size of the loan amount, the size of the borrower and whether or not the loan is leveraged. We restrict the sample to loans with maturities of at least 1 year, as we assume that short-term loans are unlikely to be subject to carbon risk. We further exclude observations with financial companies as borrowers, as emissions data are unlikely to properly reflect the climate-related risk exposures of these companies. We concentrate on loans identified as having the purpose to finance new investments or projects. We therefore exclude loans made for refinancing or buyout purposes.

Our final sample covers a maximum of 1469 observations across a wide range of industries (Table 2). About 350 out of the 567 borrowing firms take out more than one syndicated loan. The average maturity of the loans in the sample is slightly more than 4 years, with a total aggregate value of loans of around \$1.4 trillion. According to our numeric transformation – that corresponds to AAA=20, AA+=19, and so on down to C=0 – the mean rating is equivalent to BBB (12). That said, in our regressions we use rating dummies throughout, so that the scaling of this transformation is not an issue in the analysis. For numerical precision of the coefficient estimates, we divide the carbon intensity by 1000 (ie CO_2 tonnes/\$ thousand revenue) for our regression analyses in sections 4-7.

5 Trucost's so-called environmentally extended input-output model combines industry-specific environmental impact data with quantitative macroeconomic data on the flow of goods and services between different sectors in the economy to estimate carbon emissions of firms.

6 Thus, Trucost's methodology is applied consistently across voluntary carbon emission disclosers and non-disclosers, ie, if Trucost views the voluntary disclosures as insufficient, they will add to the carbon emissions estimates. For this reason, the availability of CO_2 emission data is complete across listed firms of major exchanges and it is not necessary to estimate selection models for disclosure as do Ilhan et al (2021).

Summary statistics

Table 2

Industry Group	Carbon Intensity[1] Mean	Carbon Intensity[1] Std	Loan Margin[2] Mean	Loan Margin[2] Std	Borrower Rating[3] Mean	Loan Maturity[4] Mean	Loan Value[5] Total	Obs No
Automobile	12	3	170	106	11	4	83	35
Capital goods	54	169	117	94	13	4	176	180
Commercial services	295	538	152	78	11	4	31	43
Consumer durables and apparel	34	41	159	129	11	4	48	63
Consumer services	37	64	238	121	9	4	40	64
Energy	484	473	163	107	11	4	236	176
Food & Staples Retailing	16	9	160	189	11	4	22	26
Food, Beverage & Tobacco	56	53	114	87	12	4	70	67
Health Care	20	40	137	79	11	4	42	40
Household & Personal Products	165	288	177	204	12	4	7	9
Materials	628	1,057	137	87	12	4	101	131
Media	5	3	180	102	10	4	32	33
Pharma & Life Sciences	14	8	68	73	16	4	96	32
Real Estate	20	40	173	119	11	4	69	149
Retailing	15	9	140	102	11	4	61	71
Semiconductors	31	29	150	113	11	5	20	27
Software & Services	5	6	131	70	12	4	68	58
Technology Hardware	14	13	144	123	11	4	46	57
Telecommunication	5	3	180	147	11	4	86	46
Transportation	639	473	163	136	13	5	22	26
Utilities	4,226	4,606	131	107	12	4	95	136
All	544	1,877	149	111	12	4	1,449	1,469

[1] In tonnes of CO_2 per $ million revenue. [2] In basis points. [3] Rating translated into numeric values. 20 for AAA, 19 for AA+ etc. [4] In years. [5] In $ billions.

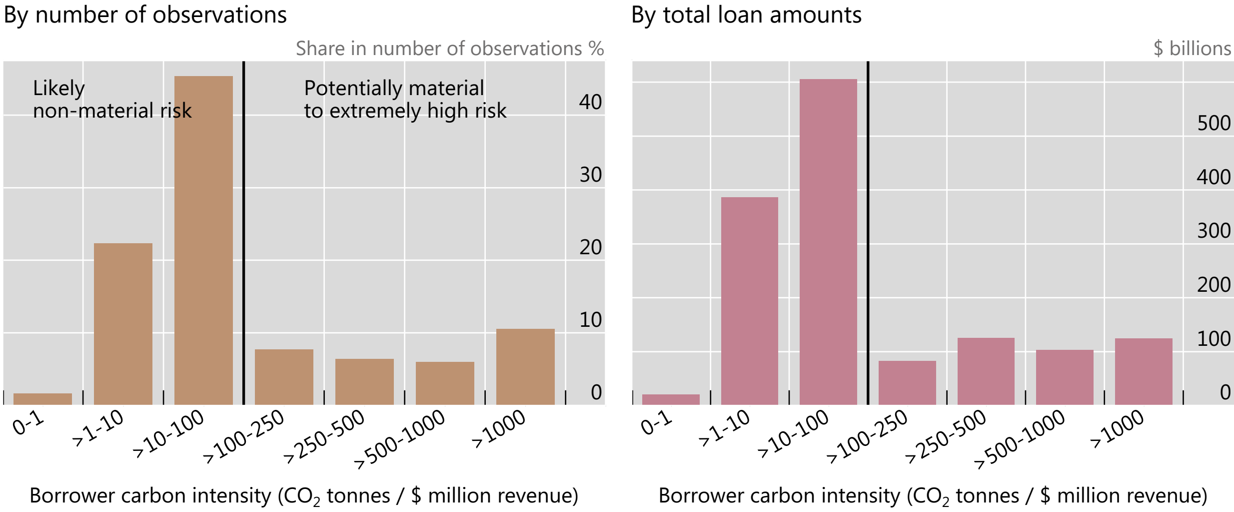
Sources: Dealogic; S&P Trucost; authors' calculations.

3. Materiality of carbon risk

Before turning to the pricing of carbon emission risks, it is pertinent to establish whether those risks are material enough for creditors to consider. An increasing number of firms do consider environmental factors, most importantly carbon emissions, as a material risk and disclose them accordingly in their Annual Reports (FSB (2019)). The recommendations of the FSB Task Force for Climate Related Financial Disclosures as well as mandatory disclosure requirements in major jurisdictions (eg for listed and larger unlisted firms in the UK) are testament to the fact that both market participants and regulators are increasingly demanding more information from firms on climate-related financial risk exposures (CDSB (2016)). Ilhan et al. (2020) find that institutional investors have a strong preference for firms that disclose (scope 1) emissions, suggesting that carbon risks are perceived as financially material.

To illustrate the potentially severe financial impact of the materialization of carbon emission-related risks, we do a simple thought experiment. Using the Trucost data on carbon intensities (CO_2 emissions (scope 1) in tonnes per $ million revenue), we can determine the impact of a hypothetical but realistic carbon tax[7] on firms' revenue margins. The left-hand panel of Graph 1 shows the distribution of average carbon intensities over the sample period for all firms in our sample, while the right-hand panel shows the distribution by loan value. Prominent estimates for the optimal price of carbon provide reference points for a potential carbon tax. At the lower range of optimal carbon pricing estimates are those by Nordhaus (Royal Swedish Academy of Sciences (2018)) which do not consider the need to limit global temperature increases to come close to Paris Agreement targets. According to these calculations, the economically optimal price of carbon for 2020, is around \$35/CO_2 tonnes, rising to around \$50 in 2025 and \$65 in 2030. However, using Nordhaus' model and parameters, the required carbon prices to limit temperature increases to 2.5 degree Celsius relative to the 1900 average range far above \$100 (\$186 in 2020) rising to \$350 in 2030. For intermediate estimates, the Stern-Stiglitz report (High-Level Commission on Carbon Prices 2017) suggested prices of \$40-\$80 in 2020 and \$50-\$100 in 2030 to achieve the Paris Agreement goal of limiting temperature increases relative to the 1900 average to below 2 degree Celsius.

Distribution of carbon intensity[1] Graph 1



[1] Based on scope 1 carbon emissions.

Source: S&P Trucost; Dealogic; authors' calculations.

For a significant share of the sample firms, carbon emission risks appear to be material, even severe. With a price of \$100/CO_2 tonnes, a firm with a carbon intensity of 100 CO_2 tonnes per \$ million of revenue (more than 30% of firms and loan value exceed this carbon intensity) results in a 1% loss of revenue margin – an amount that is potentially material when it comes to assessing credit risks and hence determining loan margins. For 10% of the firms (9% of loan value) in our sample, the carbon

[7] Apart from carbon taxes, there is a multitude of policies that could lead to a materialization of environmentally-related financial risks (Nordhaus (2007)). Cap-and-trade systems, for instance, which are already in effect for carbon-intensive industries operating in the European Union, may impose costs only if carbon emissions cross a given threshold. The range of optimal prices of carbon is nevertheless a useful reference point, as they imply that any policy to achieve the Paris Climate goals would effectively have to impose an average cost of carbon equal to the optimal price. Further, from the viewpoint of a creditor bank, carbon taxes are arguably an instrument that has a high probability of being implemented on a broad scale in practice (Weitzman (2014)).

intensity exceeds 1000 CO_2 tonnes/$ millions of revenue. Even with carbon prices in the lower range of the above widely known estimates (eg $40/$CO_2$ tonnes), the implied losses in revenue margin (>4%) would have a significant impact on the financial health of those firms.

4. Regression analysis

Banks have an incentive to price any material risks which affect the ability of the borrower to repay. While banks can sell off syndicated loans, often to non-bank financial institutions, the originating lead-bank has a reputation at stake in the performance of syndicated loans even if it retains only a limited share. In this paper, we concentrate on the risks arising from carbon emissions. Borrowers with higher carbon emissions are more likely to face higher costs, or even hard emission constraints, if corresponding regulations tighten. For more traditional credit risks, banks and third party providers, such as rating agencies, have built extensive databases and models – not least to comply with banking regulations. Financial risks related to climate change, however, have only recently come into focus for banks, as well as regulators and supervisors. In recent years, several data providers for emission and other environmental data have emerged, including S&P Trucost, CDP, and Thomson Reuters among many others.

We start our analysis of the nature of emission-related risk pricing with an initial hypothesis that banks have started to price financial risks related to carbon emissions as the awareness of these risks and the likelihood of their materialization has increased.[8] We argue that the Paris Agreement struck in December 2015 was particularly relevant in this context, as it provided a strong and clear signal of potential tightening of carbon emission regulations. Not only did it contribute to heightening the awareness of the risks of carbon emission, it also specified quantifiable reduction targets for carbon emissions, thus providing banks with a clearer picture of the possible future path of emissions regulations.

Of course, the willingness and ability of policy makers to implement regulations to reach the emission targets specified in the Paris Agreement are subject to uncertainty. Policy makers can potentially retreat from their commitments, or entirely drop out as was briefly the case with the US.[9] Nevertheless, the clarity of the emission targets – in combination with an unusually well and strongly communicated intention of the respective governments whether or not they commit to the targets – has increased the awareness and facilitated the assessment of risks related to a tightening of carbon emission regulations.

8 The argument that awareness of climate risks affects pricing is similar to Choi et al (2020), who find that attention to climate change increases when local temperature is abnormally high. This causes stocks of carbon-intensive firms underperform firms with low carbon emissions in abnormally warm weather.

9 Though President Trump declared the intention to withdraw in June 2017, notice period requirements meant that it did not take effect until November 4, 2020. President Biden subsequently re-joined in February 2021.

4.1. Econometric model

The main variable of interest is the margins of syndicated loans, which proxies for the credit risks priced by banks. Our key hypothesis is that banks have started to price the financial risks related to carbon emissions once the Paris Agreement was struck. Our baseline panel data regression is as follows:

$$margin_{l,f,b,t} = \alpha\ Carbon\ Intensity_{f,t_{year-1}} + \beta Carbon\ Intensity_{f,t_{year-1}} \times D_{post\ Paris} + \gamma X_{l,f,t} + \delta D_{b,c,t} + \varepsilon_{l,f,b,t}$$

where we test whether $\beta > 0$ and $\alpha = 0$. The dummy $D_{post\ Paris}$ is a time dummy taking the value one after 2015, given that the Paris Agreement was announced in mid-December 2015. X represents a vector of dependent firm/loan variables, while D represents a vector of dummy variables capturing industry, bank and time effects. The subscript l denotes the individual loan, f the borrowing firm, b the bank syndicate and t denotes the origination date of the loan. Carbon intensity in the baseline regression is scope 1 emissions measured in tonnes of annual CO_2 emissions per $ thousand of annual revenue (not $ million as in Graph 1) for a given borrowing firm f. Scope 1 carbon intensity is the value at the end of the previous fiscal year, as lead banks originating the loan are assumed to have information about annual carbon emission from the past year only.

4.2. Baseline results

After presenting specifications that contain various borrower and loan-level controls, we introduce carbon intensity. We start with a specification that does not contain the interaction term of carbon intensity and the Paris Agreement to see whether banks have priced carbon-emissions related climate risks independent of the Paris Agreement (Table 3, column (3)). For the full sample period (2006-2018) we do not find an effect of carbon emission intensity on the loan margins of a given borrower. It appears that loan margins for the entire sample period are driven mainly by credit ratings of the borrower, the term spread, as well as other loan characteristics including maturity, whether a loan is leveraged and the loan amount (columns (1) and (2)). Borrower-country fixed effects as well as fixed-effects for the bank lending syndicate[10] absorb an additional large share of variation in the data.

Clearly, the determination of loan spreads by the lead bank will largely be based on borrower and loan characteristics. It is important, however, to note that the ratings in our sample do not exhibit any meaningful correlation with carbon intensity. The correlation between numeric ratings and carbon emission intensity is virtually zero (-0.049). If carbon intensity is indicative of material climate-related credit risks, they are hardly reflected in ratings in our data sample.

[10] There are hardly any bank syndicates that appear in more than one year in exactly the same composition in our sample. Hence we do not include bank syndicate x time fixed-effects. Including borrower x time fixed effects is not possible, since our main explanatory variable – carbon emission intensity – also varies over borrowers and time.

Baseline regressions[1]

Table 3

Dependent variable: loan margin in basis points; p-values in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Term Spread (bp)	0.488***	0.500***	0.499***	0.497***	0.518***	0.374***	0.587***	0.586***
Maturity (years)		-14.25***	-14.19***	-14.08***	-13.89***	-11.33***	-15.34***	-14.19***
Maturity-squared		0.457***	0.455***	0.443***	0.436***	0.401***	0.463***	0.462***
Rating: B or worse	221.7***	178.1***	177.7***	176.1***				
Rating: B+ to BB+	136.0***	103.4***	103.1***	102.7***				
Rating: BBB- to BBB	76.69***	61.96***	62.11***	61.27***				
Rating: BBB+ to A-	46.42***	34.44***	35.22***	34.90***				
Rating: A or better (Omitted – Base)								
D(Leveraged Loan)		26.60**	26.94**	26.45**	25.53**	18.05	23.32***	29.39**
D(Subordinated Loan)		261.1***	261.2***	261.8***	247.6***	254.1***	159.7**	237.8***
Log(Loan Value)		-10.80**	-10.87**	-11.08**	-7.342*	-7.230**	-4.909	-6.493*
Log(Revenue)		-2.590	-2.674	-2.975	-2.694	0.436	-4.153	-3.325
D(post Paris)				4.593	1.747	-7.308	0.139	
				(0.624)	(0.845)	(0.861)	(0.989)	
Oil Price								-0.603***
								(0.000)
Carbon Intensity			**-0.822**	**-1.367**	**-1.969**	**-7.166****	**-1.217**	**5.380**
			(0.407)	**(0.169)**	**(0.154)**	**(0.048)**	**(0.382)**	**(0.161)**
Carbon Intensity x D(post Paris)				**6.700****	**6.705****	**8.356***	**5.712***	**6.003***
				(0.023)	**(0.040)**	**(0.077)**	**(0.079)**	**(0.053)**
Observations	1,107	1,098	1,098	1,098	1,098	845	1,038	1,098
Adjusted R-squared	0.645	0.694	0.694	0.695	0.717	0.664	0.729	0.728
Borrower Country FE	Y	Y	Y	Y	Y	N	Y	Y
Bank Syndicate FE	Y	Y	Y	Y	Y	Y	Y	Y
Crisis FE	N	Y	Y	Y	Y	Y	Y	Y
Rating Dummies	N	N	N	N	Y	Y	Y	Y
CCPI x D(post Paris)[2]	N	N	N	N	N	Y	N	N
Additional Borrower Controls[3]	N	N	N	N	N	N	Y	N
Oil Price Interactions[4]	N	N	N	N	N	N	N	Y

[1] Standard errors double-clustered by borrowing firm and bank syndicate. [2] Climate Change Performance Index by Germanwatch interacted with the post Paris dummy as an additional control variable. See Table 1 for a description. [3] Additional borrower controls include operating margins, book-to-market and leverage. See main text for details. [4] In addition to the composite oil price in US dollars in the previous month included on its own, the same variable is interacted with i) the post-2015 dummy and ii) carbon intensity as additional control variables. See Table 1 and main text for more details. ***=p-value<1%, **=p-value<5%, *=p-value<10%.

When we add the interaction term of carbon intensity and the Paris Agreement dummy, its coefficient is positive at high levels of statistical significance (column (4)). This is robust to using rating dummies for single notches (AAA, AA+, AA, AA- etc) instead of ratings groups (column (5)). Our results support the findings in Ongena et al (2018), but are based on a broader sample that not only focusses on fossil fuel producers and their risks from stranded assets. Also, the nature of the risks from carbon emissions we emphasize is not necessarily the same as those related to stranded assets. Risks from carbon emissions are broader and therefore apply in principle to all industries.

While most of our specifications include borrower country fixed effects these do not allow for country hypotheses which are time-varying. As one additional exercise in specification (6) we include as a control variable an index for regulatory regime called the Climate Change Performance Index (CCPI) interacted with the post Paris dummy. This index measures how strict climate policies are in a given country. The main loan pricing results remain intact and the coefficient on the CCPI index itself is not significant.[11] That said, ceteris paribus, estimations with simple borrower country fixed effects (eg specification (5)) have a higher adjusted R-squared which suggests that in addition to differences across regulatory regime, there are other unspecified country factors that affect loan pricing.[12]

In column (7) we include additional borrower control variables from Refinitiv. These include operating margins (average over the past 3 years), the market-to-book ratio as well as the leverage of the borrower. None of the coefficients is significant, suggesting that they do not add much information beyond borrower ratings and the loan-level controls. For the regressions that follow, we leave them out.

To address the possibility that the significance for post Paris interaction terms might have been driven by declining oil prices that would have disproportionately affected high carbon emitters, in column (8) we include a specification that also controls for a composite oil price (see Table 1) in the month before loan origination as well as an interaction term of the composite oil price with firm carbon intensity (and an interaction term of the oil price with the post Paris dummy to account for a potentially different effect after the Paris Agreement). We also examined (unreported) specifications where the three month average of the oil price before loan origination was taken, and simpler specifications where we control only for oil prices and a post Paris interaction term. The main results did not change when controlling for oil prices in any of these specifications.[13]

Further, to check whether the borrowers for which carbon emissions data are estimated rather than disclosed change our main results, in an unreported regression, we added a triple interaction of carbon intensity, the post Paris dummy and a dummy that is one if its emission data is partially of fully estimated by Trucost to the column (4) specification. The triple interaction was not significant and the coefficient on the carbon intensity and post Paris interaction term remained significant and was of a similar magnitude.

[11] We use the index of the previous calendar year, as for instance the 2016 index builds on 2015 data. Also, we do not use index data before 2008, as the calculation method of the index was different before the 2008 report. Hence, we loose one year of observations when using the CCPI. We also explore other country-level climate indices, including the Climate Risk Index (also by Germanwatch) that measures physical risks for a given country, and the ND-GAIN index (by the University of Notre Dame), which combines the exposure to physical risk and mitigation measures taken by countries. None of these indices can explain a significant variation of the post-2015 loan margins. There is the caveat, however, that our setup and data is not well placed to look at country variation. Most borrowers in our sample are multinational companies that operate in many countries.

[12] We also test whether the carbon risk premium for US borrowers changed after the Trump administration announced the withdrawal of the US from the Paris agreement in June 2017. We cannot find any evidence, though we caution that our sample may not be long enough to yield dependable results.

[13] Further evidence is provided later in Table 4, where, if risk-based pricing had been driven by the impact of declining oil prices beyond that captured in credit ratings, we would have found the sensitivity of loan margins to carbon emissions to be greater in those sectors most exposed to oil prices, ie, oil & gas & coal or utilities. However, the findings of Table 4 do not show that carbon risk premia are significantly greater in those sectors.

4.3. Carbon risk premia are not driven by any single industry

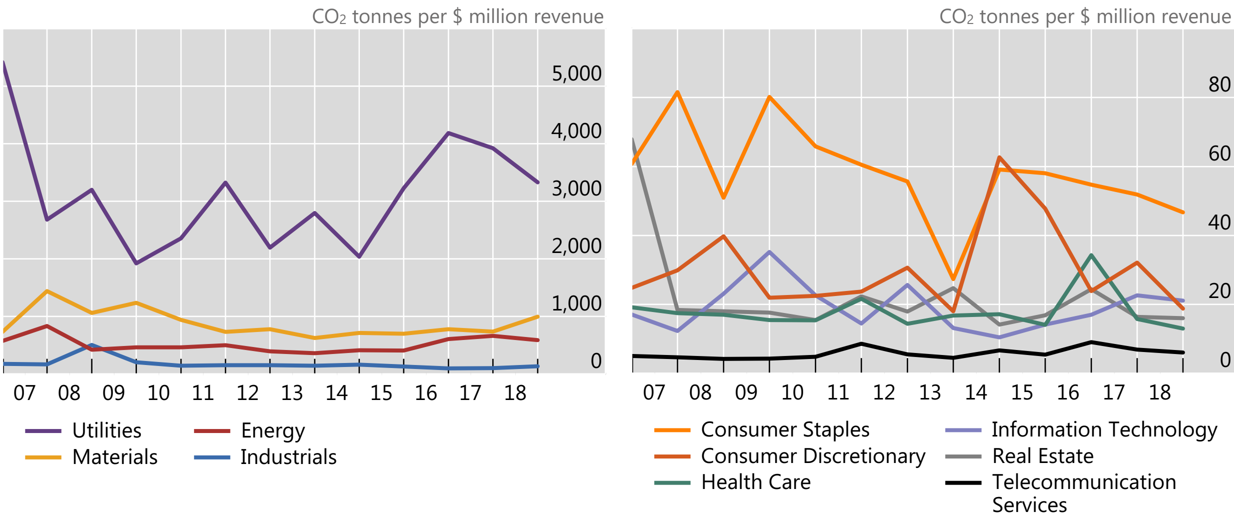
Even if banks price the potential materialization of carbon risk based on actual carbon emissions, they may still attach relatively higher prices to certain industry sectors. Mitigation policies could be mainly targeted at the most carbon-intensive sectors to achieve a large amount of reductions more quickly. Graph 2 illustrates that average carbon emissions (weighted by loan amounts) across Global Industry Classification Standards (GICS) sectors have remained relatively stable over time in our sample. Hence, sectoral differences have been highly persistent.

Our results suggest, however, that the sensitivity of loan margins with respect to carbon intensities is driven by the carbon intensity of the cross-section of firms across industries and not by the firms in any specific sector. We start with the inclusion of dummies for borrowers in oil, gas and coal-related sectors in the post 2015 (ie post Paris) period (Table 4, column (1)) based on granular GICS sub-industries. Again, in relation to previous findings in Ongena et al (2018), we take this as evidence for a more general pricing of carbon emission risks, which is not limited to sectors subject to stranded assets. We successively add dummies for other carbon-intensive sectors and find the same qualitative result. Utilities exclude water utilities, which are not typically associated with high carbon emissions. Analogously, Transport excludes GICS sub-industries related to railroad transportation. Column (5) includes separate interaction terms for each of these high-carbon sectors, with very similar results.

We view the above findings as evidence that banks price carbon risk based on actual carbon emission intensities and not only for industries subject to stranded assets.

Carbon intensity by sector[1] Graph 2

High carbon sectors Lower carbon sectors



[1] Value weighted by US dollar value of total loan origination in a given year. Sectors are determined by the GICS classification of the borrowing firm.

Source: Dealogic; Trucost; authors' calculations.

Carbon pricing is not solely driven by high-carbon industry sectors[1]

Table 4

Dependent variable: loan margin in basis point (bp), p-values in brackets.

	(1)	(2)	(3)	(4)	(5)
Carbon Intensity	-1.969	-1.972	-1.972	-1.971	-1.954
	(0.155)	(0.154)	(0.151)	(0.153)	(0.157)
Carbon Intensity	**6.776****	**7.046****	**8.411*****	**7.724*****	**7.117****
x D(post Paris)	**(0.049)**	**(0.027)**	**(0.0033)**	**(0.0099)**	**(0.025)**
D(Oil & Gas & Coal) x	-2.229				-5.633
D(post Paris)	(0.947)				(0.874)
D(Oil & Gas & Coal, Utilities) x		-2.850			
D(post Paris)		(0.911)			
D(Oil & Gas & Coal, Utilities,			-14.79		
Materials) x D(post Paris)			(0.502)		
D(Oil & Gas & Coal, Utilities,				-8.670	
Materials, Transport) x				(0.677)	
D(post Paris)					
D(Utilities) x D(post Paris)					-27.76
					(0.150)
D(Materials) x D(post Paris)					-5.470
					(0.779)
D(Transport) x D(post Paris)					57.03
					(0.297)
Observations	1,098	1,098	1,098	1,098	1,098
Adjusted R-squared	0.717	0.717	0.718	0.718	0.718
Loan-level & Borrower Controls[2]	Y	Y	Y	Y	Y
Borrower Country FE	Y	Y	Y	Y	Y
Bank Syndicate FE	Y	Y	Y	Y	Y
Crisis FE	Y	Y	Y	Y	Y
Rating Dummies	Y	Y	Y	Y	Y
Borrower Sector FE	Y	Y	Y	Y	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. FE indicates fixed effects. Crisis FE is a dummy equal to one for all loans made in 2008 or 2009. [2] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

Further evidence is provided in Table 5, where we include separate interaction terms for the sectors based on the Global Industry Classification Standards (GICS) in column (1) and all GICS industry groups in our sample in column (2). With one exception for the industry group Software & Services, where firms tend to have negligible scope 1 emissions and hence a significantly lower premium, industry groups do not seem to command a carbon premium that is different from that implied by the carbon intensity.

Intuition for our result is provided by the considerable variation of carbon intensity within sectors shown in Table 6. Pricing carbon risk based on industry averages rather than on actual firm-level emission intensities would omit the fact that there are very significant differences across firms. The findings are consistent with policy measures to achieve the Paris Climate goals that are not targeted at specific industries but rather at reducing overall carbon emissions to limit global temperature increases.

Carbon pricing is not solely driven by any industry sectors[1]

Table 5

Dependent variable: loan margin in basis point (bp), p-values in brackets.

GICS Sectors	(1)	GICS Industry Groups	(2)
Carbon Intensity x D(post Paris)	**7.106** **(0.041)**	**Carbon Intensity x D(post Paris)**	**9.239** **(0.033)**
D(Consumer Staples) x D(post Paris)	36.56 (0.400)	D(Capital Goods) x D(post Paris)	0.0435 (0.99)
D(Energy) x D(post Paris)	-4.624 (0.912)	D(Professional Services) x D(post Paris)	-32.25 (0.249)
D(Health Care) x D(post Paris)	-30.00 (0.255)	D(Consumer Durables & Apparel) x D(post Paris)	22.30 (0.715)
D(Industrials) x D(post Paris)	1.328 (0.954)	D(Energy) x D(post Paris)	-7.070 (0.854)
D(Information Technology) x D(post Paris)	5.841 (0.817)	D(Food & Staples Retailing) x D(post Paris)	4.046 (0.909)
D(Materials) x D(post Paris)	-26.26 (0.386)	D(Food, Beverage & Tobacco) x D(post Paris)	-13.54 (0.731)
D(Real Estate) x D(post Paris)	-7.547 (0.769)	D(Health Care) x D(post Paris)	-46.95 (0.104)
D(Utilities) x D(post Paris)	-1.372 (0.966)	D(Household & Personal Products) x D(post Paris)	145.3 (0.186)
		D(Materials) x D(post Paris)	-29.63 (0.252)
		D(Pharma & Life Sciences) x D(post Paris)	21.69 (0.393)
		Real Estate x D(post Paris)	-7.931 (0.772)
		D(Retailing) x D(post Paris)	-15.76 (0.580)
		D(Semiconductors) x D(post Paris)	12.69 (0.658)
		D(Software & Services) x D(post Paris)	-51.54* (0.084)
		D(Technology Hardware) x D(post Paris)	70.45 (0.350)
		D(Transportation) x D(post Paris)	30.31 (0.415)
Observations	1,098	Observations	1,098
Adjusted R-squared	0.719	Adjusted R-squared	0.726
Loan-level & Borrower Controls[2]	Y	Loan-level & Borrower Controls	Y
Borrower Country FE	Y	Borrower Country FE	Y
Bank Syndicate FE	Y	Bank Syndicate FE	Y
Crisis FE	Y	Crisis FE	Y
Rating Dummies	Y	Rating Dummies	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. FE indicates fixed effects. Crisis FE is a dummy equal to one for all loans made in 2008 or 2009. [2] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

The Consumer Discretionary GICS sector is the base in column (1) and hence omitted. The base for column (2) is the GICS Automobiles & Components industry group and hence omitted.

Financial firms, however, including banks and other private investors (CFA Institute (2017)) as well as public investors (Elsenhuber and Skenderasi (2020)), often use a so-called "best-in-class" approach when minimising carbon or ESG exposures more generally. This approach focusses on the best (or excludes the worst) performers within a given industry. In following a "best-in-class" strategy, banks may demand a higher premium for the highest polluters within a given sector. However, the results in Table 7 do not support this conjecture, again pointing to the pricing of carbon risk based on actual carbon intensities.

Mean and standard deviation of borrowers' carbon intensity by sector[1] — Table 6

Sector	Consumer Discretionary	Consumer Staples	Energy	Health Care	Industrials	Information Technology	Materials	Real Estate	Tele-communication Services	Utilities
Mean	29	113	466	20	203	23	863	20	6	3121
Std	96	253	585	20	720	55	2130	58	6	7491

[1] GICS sector of the borrowing firm. All numbers value weighted by US dollar value of total loan origination.

Source: Trucost; Dealogic; authors' calculations.

4.4. Economic significance

An important question from the policy perspective is what do the coefficients from the baseline regressions suggest about the economic magnitudes of the effects? More broadly, does the current level of premia that have been observed in syndicated loan markets since 2016 suggest that climate risks are being correctly priced, ie providing a deterrent to carbon emission producing activity that is in line with global efforts to mitigate climate change?

To start with the more narrow question, our baseline specification, model (5) of Table 3, has a coefficient of 6.7 on the regressor Carbon Intensity x D(post Paris). Since the average scope 1 carbon intensity within the sample after 2015 is 0.5 CO_2 tonnes per $ thousand, this yields an average premium of around 3-4 basis points. For relatively high emitters, at the 90^{th} percentile (1 CO_2 tonnes per $ thousand) the implied premium is around 7 basis points. For firms with emissions 1 standard deviation above the mean in our sample (2.5 CO_2 tonnes per $ thousand), the implied premium is around 17 basis points.[14]

Back of the envelope calculations suggest that the price of carbon risk in syndicated loan markets since 2016 is low relative to the material risks outlined in part 3. The top 10% of carbon emitters in our sample have a carbon intensity of >1 tonnes of CO_2 per $ thousand of revenue (or 1000 tonnes of CO_2 per $ million of revenue as in Graph 1). Ceteris paribus, the introduction of a carbon price of $100 per tonne of CO_2 – well within the range of estimates of optimal carbon taxes discussed in part 3 – would imply that at least 10% of the total revenues of those firms would have to be spent on carbon taxes alone, and likely much more.[15] In our sample, the

[14] These estimates are similar to Ongena et al (2018) who find an average 2 basis point premium for their climate policy exposure measure, and a 16 basis point premium for a one standard deviation higher policy measure.

[15] The average carbon intensity of the top 1% of the emitters is 10900 tonnes CO_2 per $ million, which implies a more than 100% hit to total revenues at a carbon price $100 per tonne of CO_2. Even at a conservative price of $40 per tonne of CO_2, it would imply a more than 40% hit to total revenues,

10% highest emitters have an average operating margin (earnings over revenues, before fixed costs, interest payments or taxes) over the last three years of around 13.4%. For such firms, carbon risk would be highly material and the potential financial impact is unlikely to be fully internalized by the implied 7 basis points premium.

Carbon pricing is not different for high emitters within industry sectors[1] — Table 7

Dependent variable: loan margin in basis point (bp), p-values in brackets.

	(1)	(2)	(3)
Carbon Intensity	-2.066	-2.039	-2.071
	(0.144)	(0.147)	(0.145)
Carbon Intensity x D(post2015)	**7.540*** **	**5.053***	**6.199*** **
	(0.00273)	**(0.0789)**	**(0.0359)**
D(above avg carbon intensity within sector) x D(post Paris)	-3.232		
	(0.801)		
D(75th percentile carbon intensity within sector) x D(post Paris)		18.99	
		(0.252)	
D(90th percentile carbon intensity within sector) x D(post Paris)			18.21
			(0.300)
Observations	1,098	1,098	1,098
Adjusted R-squared	0.705	0.706	0.706
Loan-level & Borrower Controls[2]	Y	Y	Y
Borrower Country FE	Y	Y	Y
Bank Syndicate FE	Y	Y	Y
Crisis FE	Y	Y	Y
Rating Dummies	Y	Y	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. FE indicates fixed effects. Crisis FE is a dummy equal to one for all loans made in 2008 or 2009. [2] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

Thought experiments based on the rating composition of the high emission issuers in our sample are just as uncompromising. The 10% highest emitters have an average rating of BBB, and the conservative assumption of a 10% decline in operating profit margin due to a carbon tax would lead most of these companies into margins of around 3%. But in our sample, average margins of around 3% are only observed for single B or lower-rated entities. According to the ICE BofA US high yield indices, BBB and B-rated credits in the markets were priced in mid-2018 at option-adjusted spreads at 163 and 386 basis points, respectively. Hence, a plausible change in creditworthiness resulting from the prospective tax burden corresponds to the a difference of the option-adjusted spreads of around 220 basis points – more than thirty times higher than the estimated 7 basis points carbon premium for high emitters.

which dwarfs the average operating margins of the top 1% emitters of 18.7% in our sample. The eventual financial impact would ultimately depend on the ability of firms to adjust their production or their pricing power, ie the ability of the firms to roll over their additional costs onto their customers. But the scale of the challenge would be immense.

5. The pricing of different carbon intensities

The literature thus far has mostly focused on scope 1 emissions – emissions from owned or controlled sources of a firm (Capasso et al (2020) and Kleimeier and Viehs (2019)). However, potential financial risks from carbon emissions are not limited to a companies' controlled resources. If a company uses carbon intensive inputs in its production process, a tightening in carbon regulations and a resulting increase in input prices have a direct effect on the profitability of the firm. Analogously, increased costs for downstream activities such as carbon intensive transportation and distribution would also lower margins.

The Greenhouse Gas (GHG) Protocol, the carbon accounting standard that more than 90% of reporting firms in our sample apply, defines two additional scopes of emissions (GHG Protocol (2017)): Scope 2 emissions – indirect emissions from electricity consumption; and scope 3 emissions, which cover further indirect emissions along the value chain such as from production of purchased materials, transport-related activities and outsourced activities.[16]

Do banks also price the risks from scope 2 and 3 emissions? Our results suggest that banks primarily focus on scope 1 emissions. Table 8 presents the results for our baseline specification, comparing different carbon scopes. In columns (2) and (3) we successively add higher scopes with the effect that the carbon intensity terms become a lot less significant. In column (4) we include separate interaction terms for each carbon scope. Scope 2 emissions do show up as significant and positive post Paris (ie after 2015). However, the point estimates are an order of magnitude smaller than for scope 1 emissions and average scope 2 emissions are only about one-tenth of scope 1 emissions in our sample. Further, the coefficient estimate of the scope 1 carbon intensity and post Paris interaction term changes only marginally from that reported in the baseline model in column (1).

Overall, we take this as evidence that banks' view on carbon risk is still relatively narrow. Policy measures aimed at reducing overall carbon emissions affect the entire value chain of a company. A focus on risks from direct emissions, as captured in scope 1, may seem rational at first. Highly electric energy-intensive production, as captured in scope 2, could be moved and outsourced to jurisdictions where carbon reduction policies are not in place and less likely to be implemented. A growing literature has documented such effects (eg Ben-David et al (2021)). Scope 3 emissions would look though such "carbon emission exporting", but the GHG protocol standards allow considerable discretion for reporting firms to define the perimeter for calculating scope 3 emissions. Carbon emission exporting, however, cannot lower the underlying risks and could well turn out to be inefficient, as policy makers become more capable of implementing effective carbon emission reduction measures.

[16] While our data from Trucost fully covers borrowing firms' scope 2 emissions, it only covers "upstream" scope 3 emissions from production inputs and not the entirety of scope 3 emissions as usually defined.

6. Do “green” banks price carbon risk differently?

A natural question about our main result is whether the pricing of carbon risk post 2015 after the Paris Agreement is driven by “greener” banks. We consider a bank as “green” if it openly recognizes the challenges posed by environmental and social issues and introduces needed actions into all aspects of its operations. Practically, we

Pricing of carbon intensity – scopes 1-3[1]

Table 8

Dependent variable: loan margin in basis point (bp), p-values in brackets.

	(1)	(2)	(3)	(4)
Carbon Intensity Scope 1	-1.969			-1.232
	(0.154)			(0.350)
Carbon Intensity Scope1 x D(post Paris)	**6.705****			**6.118***
	(0.0399)			**(0.0677)**
Carbon Intensity Scope 1+2		-1.819		
		(0.191)		
Carbon Intensity Scope 1+2 x D(post Paris)		5.548		
		(0.130)		
Carbon Intensity Scope 1-3			-1.855	
			(0.200)	
Carbon Intensity Scope 1-3 x D(post Paris)			5.545	
			(0.101)	
Carbon Intensity Scope2				-0.0979**
				(0.0270)
Carbon Intensity Scope 2 x D(post Paris)				0.189**
				(0.0398)
Carbon Intensity Scope3				-0.0161
				(0.299)
Carbon Intensity Scope 3 x D(post Paris)				0.0226
				(0.404)
Observations	1,098	1,098	1,098	1,098
Adjusted R-squared	0.717	0.717	0.717	0.721
Loan-level & Borrower Controls[2]	Y	Y	Y	Y
Borrower Country FE	Y	Y	Y	Y
Bank Syndicate FE	Y	Y	Y	Y
Crisis FE	Y	Y	Y	Y
Rating Dummies	Y	Y	Y	Y

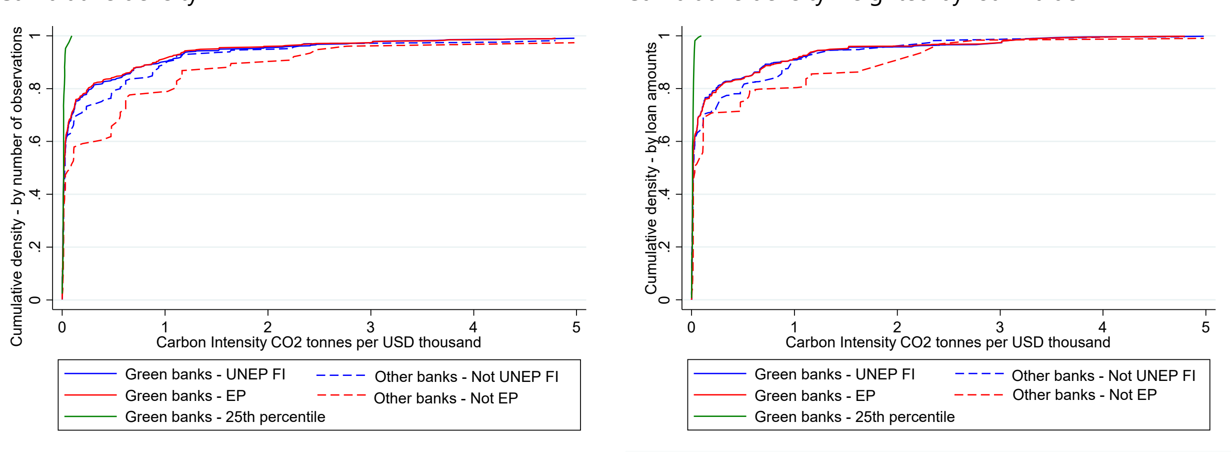
[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. [2] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

classify banks as green banks if they signed the Equator Principles or the United Nations Environment Programme – Finance Initiative (UNEP FI). The Equator Principles are a risk management framework of environmental and social risk in project finance which defines roles and responsibilities of lenders and borrowers in determining, assessing, and managing these risks. The Principles have been adopted by 92 commercial financial institutions. The UNEP Finance Initiative is a global partnership between UNEP and the financial sector. The initiative aims to understand the effect of environmental and social considerations on financial performance. Over 200 members (banks, insurers, and fund managers) have joined the initiative.[17]

For purposes of comparison, we also group the loans from lead banks with loans that have relatively low average carbon intensities (those lead banks in the lowest 25% percentile range of the carbon intensity distribution as far as their syndicated loans go). We label these as "de facto" green banks.

Within our sample, banks identified as green by either the United Nation (UNEP FI) or the Equator Principles (EP) do tend to have a greater proportion of loans with lower carbon intensity, both absolutely, or weighted by loan value, than other banks (Graph 3). Clearly, the proportions of the loan books occupied by lower carbon vs. high loan emitters are related to the UN or EP bank designations. That said, Graph 3 shows that the so-labelled green banks are far away from the de facto green banks.

Carbon Intensity Scope 1 distribution for green banks — Graph 3



Source: S&P Trucost; authors' calculations.

In Table 9 we test if loans originated by "green" lead banks—either identified as such by the United Nations or those officially adhering to the Equator Principles, or simply "de facto" green banks—exhibit a higher price of carbon risk– for instance, due to a higher awareness of climate-related risks of the lead banks. As some syndicated loans have more than one lead bank, we identify a syndicated loan as a loan from a green bank, if at least one lead bank fulfils the corresponding green criterion. Columns (1) and (2) show the results using the two institutional classifications of green banks, which all imply that the pricing of carbon risk is not significantly different across "green" vs. other lead banks. If anything, green banks seem to be attaching a lower price of carbon risk (though the coefficients are not statistically significant at conventional levels). Neither do the lead banks of syndicated loans of particularly low average carbon-intensity – less than the 25th percentile of lead banks in the sample – exhibit a significant difference in their carbon pricing (column (3)). Further, lead banks that are exceptionally tolerant in their lending toof high carbon emitters

[17] The list of participating banks for the Equator principles is available at (http://equator-principles.com/members-reporting/ Accessed April 2020) and that for UNEP FI at (http://www.unepfi.org/members/banking/ Accessed April 2020))

(greater than the 75th percentile) also show no significance differences in pricing (column (4)).

Since pricing of carbon emissions risks does not differ when the loans are arranged by lead banks identified as green, this is consistent with a competitive loan market in which climate change transition risks are priced by all banks. Thus, the risks of loans related to carbon emissions are priced similarly regardless of the banks' internal policies and relative exposure. Adjustment of the labelled or de facto green lead banks' quantities of loans outstanding is not associated with an observed differential price impact.

"Green" banks and carbon risk pricing[1]

Table 9

Dependent variable: loan margin in basis point (bp), p-values in brackets.

	(1)	(2)	(3)	(4)
Carbon Intensity x D(post Paris)	12.94	33.99	7.223**	8.104***
	(0.346)	(0.183)	(0.0276)	(0.0045)
D(UNEP FI member) x Carbon Intensity x D(post Paris)	**-7.363**			
	(0.603)			
D(Equator Principles signee) x Carbon Intensity x D(post Paris)		**-28.82**		
		(0.258)		
D(25th percentile carbon intensity of loan portfolio) x Carbon Intensity x D(post Paris)			**-15.61**	
			(0.336)	
D(75th percentile carbon intensity of loan portfolio) x Carbon Intensity x D(post Paris)				**-12.54**
				(0.577)
Observations	1,098	1,098	1,098	1,098
Adjusted R-squared	0.708	0.708	0.708	0.708
Loan-level & Borrower Controls[2]	Y	Y	Y	Y
Borrower Country FE	Y	Y	Y	Y
Bank Syndicate FE	Y	Y	Y	Y
Rating Dummies	Y	Y	Y	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. [2] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

7. Robustness checks

The fact that carbon risk is priced after 2015 is very robust and survives various controls and specifications is discussed above. In Table 10 we test whether carbon risk was priced even earlier. The evidence is strongest for a pricing of risks post-2015, as the Chow test statistic for a structural break after 2015 has the lowest p-value (p=0.040), though a break a year earlier, starting from 2015, cannot be ruled out (p=0.052). One interpretation may be that the awareness with respect to environmental risks started to build in 2015, culminating in the Paris Agreement in December. We do not take this as evidence against the robustness of the pricing of carbon risk post-2015, however.

Our key dependent variable is loan margins. Margins, however, do not necessarily cover all borrowing costs, as banks normally charge additional fees. We therefore run our baseline regressions with an "all in pricing" margin measure that includes both the margin and all fees that banks are charging on an ongoing basis. In particular, this includes utilization fees, which banks charge when a large part of the loan is disbursed to compensate for regulatory capital costs, as well as facility fees, which are paid by the borrower for a standing credit line with the syndicate. The results are summarized in Table 11. The results are almost identical (columns (1) and (2)) to those of the regressions with margins as the dependent variable (Table 3, columns (4) and (5)). Fees themselves (Table 11, columns (3) and (4)) do not seem to have any relation with the carbon intensity of the borrower.

Year by year regressions[1]

Table 10

Dependent variable: loan margin in basis point (bp), p-values in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)
Carbon Intensity x D(post 2010)	-0.287 (0.929)					
Carbon Intensity x D(post 2011)		2.897 (0.359)				
Carbon Intensity x D(post 2012)			3.015 (0.345)			
Carbon Intensity x D(post 2013)				4.876 (0.146)		
Carbon Intensity x D(post 2014)					6.243* (0.0521)	
Carbon Intensity x D(post Paris)						**6.705**** **(0.0399)**
Chow test[2] p-value	0.929	0.359	0.345	0.146	0.052*	**0.040****
Chow test[2] F-stat	0.008	0.846	0.896	2.124	3.817	**4.277**
Observations	1,098	1,098	1,098	1,098	1,098	1,098
Loan-level Controls	Y	Y	Y	Y	Y	Y
Loan-level & Borrower Controls[3]	Y	Y	Y	Y	Y	Y
Bank Syndicate FE	Y	Y	Y	Y	Y	Y
Rating Dummies	Y	Y	Y	Y	Y	Y
Cluster by Firm & Bank Syndicate	Y	Y	Y	Y	Y	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%. [2] Joint test of estimated coefficients for the time dummy D(post Year)=0 and equality of estimated coefficients on Carbon Intensity and the interaction term Carbon Intensity x D(post Year). [3] For simplicity, Loan-level & Borrower Controls include all controls from the baseline model in Table 3 column (5) and not shown here.

8. Conclusions

The evidence from our analysis for the pricing of carbon risk in the syndicated loan market is mixed. We do find a risk premium charged to borrowing firms with higher carbon intensities since the Paris Agreement, and the premium is not driven by firms in particular industries. But the level of the premium appears small relative to the material risks. Further, only those emissions narrowly attributable to the firm's own resources (scope 1) are priced, rather than the broader carbon footprint of the firm including indirect emissions related to energy consumption (scope 2) and production inputs ("upstream" scope 3). Though self-identified and de facto "green banks" may be lending less to high carbon emitters than other banks, they do not appear to be charging a higher carbon premium.

The above results point towards clear normative policy implications. Regulators and supervisors of financial institutions should design incentives to ensure regulated participants fully internalize the environmental impact of their activities, in particular on *higher-level* carbon emissions. One way of doing this is to implement incentives and penalties to key off ratings based on higher-level carbon emissions (see Ehlers et al (2020) for a stylized example of such a scheme). While regulators and supervisors of financial institutions are already taking measures to raise awareness of climate risks among banks (BCBS (2020)), they should redouble their efforts to ensure

All-in pricing and fees[1]

Table 11

	(1) All in Pricing	(2) All in Pricing	(3) Fees	(4) Fees
Term Spread (bp)	0.529***	0.530***	0.0103	0.0107
Maturity (years)	-15.64***	-15.39***	-1.545**	-1.574**
Maturity-squared	0.483***	0.474***	0.0355*	0.0358*
D(Leveraged Loan)	21.47*	22.37*	-4.015	-3.921
D(Subordinated Loan)	244.3***	247.8***	-3.598	-3.322
Log(Loan Value)	-7.732*	-7.774*	0.0571	0.105
Log(Revenue)	-2.370	-2.666	0.00758	-0.131
D(post Paris)	-1.501		-2.955	
Carbon Intensity	**-2.223**	**-2.124**	**-0.225**	**-0.210**
	(0.149)	**(0.176)**	**(0.343)**	**(0.374)**
Carbon Intensity x D(post Paris)	**6.829** (0.0463)**	**7.203** (0.0456)**	**0.0389 (0.947)**	**0.0153 (0.980)**
Observations	1,099	1,099	1,095	1,095
Adjusted R-squared	0.731	0.733	0.548	0.550
Borrower Country FE	Y	Y	Y	Y
Bank Syndicate FE	Y	Y	Y	Y
Crisis FE	Y	Y	Y	Y
Rating Dummies	Y	Y	Y	Y
Sector FE x D(post Paris)	N	Y	N	Y

[1] Standard errors double-clustered by borrowing firm and bank consortium. ***=p-value<1%, **=p-value<5%, *=p-value<10%.

those institutions are prepared for and internalizing the potential for the higher levels of carbon taxes implied by the Paris emission reduction goals (NGFS (2020)). An issue that has received relatively little attention in policy discussions is the decisive scope of emissions. Transition risks can affect firms not only through their direct emissions but also through reliance on carbon-intensive inputs. Ensuring greater disclosure and availability of such measures through, for example, the application of environmental standards based on broader scopes, would be highly desirable.

Central banks, both as a provider of services to the banking system and through their implementation of monetary policy decisions, can also contribute to a pricing of carbon risk that is commensurate with the corresponding risks. As a start, central banks could send a strong signal by taking into account such risks in their monetary operations, such as credit provision, collateral policies or asset purchases (NGFS (2021)). For example, central banks could adjust the eligibility of collateral that define the range of securities that can be used for credit operations, to reflect the climate risk profile of the issuers of said collateral. Similarly, the haircuts at which such collateral is accepted could be calibrated to reflect the carbon risk of the issuer.

While climate change mitigation through carbon emission reduction is a key global environmental goal, there are others. Efforts to ensure that the pricing of outcomes related to water security, biodiversity or climate adaptation are in line with the internalization of policy objectives will also be an important item for the "green" policy agenda going forward (Dasgupta (2021), Sustainable Finance Platform (2020)).

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