INTERNATIONAL MONETARY FUND

Carbon Risk in Loan Pricing:

Commitment Channels and Real Effects

Yao Dong, Martina Hengge, Fabián Valencia, and Richard Varghese

WP/25/250

2025
DEC

WORKING PAPER

 WP/25/250

IMF Working Paper
Strategy, Policy, and Review Department

Carbon Risk in Loan Pricing: Commitment Channels and Real Effects
Prepared by Yao Dong, Martina Hengge, Fabián Valencia, and Richard Varghese*

Authorized for distribution by Eugenio Cerutti
December 2025

ABSTRACT: We study how carbon risk affects the pricing of U.S. corporate loans and how firms' and lenders' commitments influence both loan terms and business decisions. Combining syndicated loan data with firm-level carbon emissions, we document a carbon risk premium: financial institutions charge higher loan risk spreads to borrowers with a higher carbon intensity. This premium varies with the environmental commitments of borrowers and lenders. Borrowers signaling commitments—emission targets, emission disclosures, or green loans—receive discounts that decline with increasing carbon intensity, while committed lenders charge higher interest rates to carbon-intensive borrowers. Beyond affecting the carbon premium, commitments influence real economic outcomes by increasing corporate investment and R&D expenditures, and by reducing precautionary liquidity holdings. We also show that the carbon premium in U.S. loan markets intensifies during periods of monetary tightening in line with the risk-taking channel of monetary policy. Notably, the carbon premium is time varying and has declined in recent years.

JEL Classification Numbers:	E52, G21, G30, Q54
Keywords:	carbon premium; interest rate; lending; corporate investment; monetary policy

Author's E-Mail Addresses:	yao.dong@kcl.ac.uk; mhengge@imf.org; fvalencia@imf.org; rvarghese@imf.org

*We would like to thank David Aikman, Carlo Altavilla, Rhys Bidder, Eugenio Cerutti, Romain Duval, Antonio Garcia Pascual, Ugo Panizza, and participants at IMF and KCL seminars for their suggestions and comments.

WORKING PAPERS

Carbon Risk in Loan Pricing:

Commitment Channels and Real Effects

Prepared by Yao Dong, Martina Hengge, Fabián Valencia, and Richard Varghese[1]

[1] We would like to thank David Aikman, Carlo Altavilla, Rhys Bidder, Eugenio Cerutti, Romain Duval, Antonio Garcia Pascual, Ugo Panizza, and participants at IMF and KCL seminars for their suggestions and comments.

1 Introduction

Loan risk spreads are a critical determinant of firms' financing costs, shaping which investments are pursued and how capital is allocated across the economy. While a large literature has examined the drivers of U.S. loan risk spreads, it has so far overlooked the role of corporate carbon emissions and the environmental commitments of borrowers and lenders.[1] Yet, there is little evidence on whether financial institutions lending to U.S. clients consider them significant enough to incorporate them into loan pricing decisions. Understanding if and how carbon risk enters loan pricing—and how commitments shape both loan pricing and corporate decisions—offers important insights into credit markets and investment decisions.

We combine granular data on U.S. syndicated loans with information on borrower carbon emissions, borrower and lender environmental commitments, and borrower balance sheet characteristics to address three questions. First, do financial institutions incorporate carbon risk into U.S. loan pricing? Second, do borrower and lender environmental commitments affect how this risk is priced? Third, do these commitments have real effects through corporate investment and financial behavior?

Our analysis begins by documenting a carbon premium in U.S. loan pricing. Firms with higher carbon intensity—those at the 90th percentile of carbon intensity, measured as scope 1 and 2 emissions per $1 million of revenue—face loan risk spreads that are 1-5 basis points (bps) higher. The estimated premium is economically significant and consistent with evidence from European and global lending markets (Altavilla et al., 2024; Ehlers et al., 2022). Notably, this premium is comparable in magnitude to the credit risk premium which is around 3 bps for a borrower at the 90th percentile of default probability, suggesting that lenders treat carbon risk as a material factor in loan pricing.

We also find that environmental commitments by both borrowers and lenders influence the carbon premium. On the borrower side, firms with commitments—such as emission reduction targets, voluntary carbon disclosures, or participation in green or sustainability-linked loans—pay lower loan spreads. This commitment discount, however, shrinks as carbon intensity increases. For example, an emission reduction target lowers spreads by approximately 19 basis points for high emitters (at the 90th percentile of carbon intensity), but the benefit diminishes as emission intensity rises further. This result suggests that borrower commitments can partially offset the carbon risk premium. On the lender side, financial institutions committed to the Science Based Targets initiative charge higher spreads to carbon-

[1] Previous studies have examined the effects of lead arranger share (Ivashina, 2009), non-bank lenders (Lim et al., 2014), peer information (Bao, 2022), relationship lending (Bharath et al., 2011), and borrower environmental impacts (Erten and Ongena, 2024) on loan pricing in the U.S loan market.

intensive borrowers than other lenders. This finding indicates that committed lenders place greater emphasis on carbon risk and enforce stricter pricing.

We next study the real effects of borrowers' environmental commitments. Such commitments may influence corporate investment and financial choices, potentially reinforced by the lower spreads associated with them. We find that borrowers with commitments undertake higher capital expenditure and R&D spending, consistent with investments in lower-carbon technologies. These effects, however, weaken as carbon intensity rises, echoing our results on loan pricing. For example, among high-emitters (at the 90th percentile of carbon intensity), adopting an emission reduction target is associated with a 6% increase in capital expenditure. This suggests that committed borrowers leverage cheaper financing to support investment and innovation. We also find that committed borrowers hold less cash, consistent with a reduced need for precautionary liquidity buffers and greater financial flexibility compared with non-committed borrowers.

We also examine how macroeconomic policies interact with carbon risk pricing. Consistent with evidence from Europe, we find that monetary policy tightening amplifies the carbon premium, in line with the risk-taking channel of monetary policy (Altavilla et al., 2024). Borrower commitments again help offset this effect, although the mitigating role of commitments weakens for firms with higher emissions.

Finally, rolling window regressions reveal that the carbon premium is time varying. It rose steadily until 2019, but has since declined and disappeared in the most recent 2018–23 window. Our analysis shows that this decline partly reflects expansionary pandemic-era policies and, more recently, the Inflation Reduction Act's support for investments into low-carbon technologies.

Related Literature

This paper contributes to several strands of literature. First, we add to the growing work on how financial institutions price carbon risk by providing the first comprehensive evidence for the U.S. syndicated loan market, complementing prior findings from Europe and global samples (Altavilla et al., 2024; Ehlers et al., 2022; Kleimeier and Viehs, 2021). Existing studies document a positive relationship between borrower emissions and loan spreads in Europe (Altavilla et al., 2024) and globally (Bruno and Lombini, 2023; Kleimeier and Viehs, 2021). We also contribute to the emerging literature on the interaction between carbon risk pricing and monetary policy, showing that monetary policy shocks influence the carbon premium in the U.S (Altavilla et al., 2024). Moreover, we extend this literature by documenting that the carbon premium is time varying, rising steadily until 2019 but disappearing in the most recent period.[2] Carbon risk has also been studied across other financial market segments, including corporate bonds (Seltzer et al., 2025), credit default swaps (CDS) (Zhang and Zhao, 2022), and equities (Bolton and Kacperczyk, 2021, 2023; Hengge et al., 2023).

Second, our analysis provides valuable insights into the role of environmental commitments by showing that both borrower and lender commitments influence loan pricing in the U.S., with effects that vary with carbon intensity. Existing studies have shown that emission reduction targets mitigate the carbon premium in loan pricing (Altavilla et al., 2024) and that board involvement is associated with lower loan spreads (Kleimeier and Viehs, 2021). We show that a range of borrower commitments—emission reduction targets, voluntary emissions disclosure, and green or sustainability-linked loans—matter. We also provide evidence that financial institutions' commitments through the Science Based Targets initiative have implications for loan spreads, consistent with evidence for Europe (Altavilla et al., 2024). Similarly, Delis et al. (2024) highlight that green banks charge higher interest rates to fossil fuel companies. However, the evidence is not uniform. For instance, Ehlers et al. (2022) find limited differences between green and non-green banks in loan pricing. Evidence from equity markets suggests similar benefits from carbon disclosure (Bolton and Kacperczyk, 2025; Matsumura et al., 2014).

Third, our paper makes novel contributions to the nascent literature on firm-level behavior and environmental commitments. We bridge the gap between carbon pricing, environmental commitments, and real economic outcomes by providing evidence that commitments impact corporate behavior through investment, innovation, and liquidity channels, possibly supported by lower loan spreads. Existing studies have shown that high-emission firms borrowing from lenders with climate commitment subsequently face reduced access to credit and respond by cutting debt, leverage, size, and investment while increasing cash holdings, yet without improving environmental performance (Kacperczyk and Peydró, 2024). Regarding borrower commitments, Hoang et al. (2025) find that green loan announcements are associated with positive cumulative abnormal stock returns, and that over the subsequent years, borrowers experience increases in operating income-to-asset ratios and reductions in carbon intensity.

The remainder of the paper is structured as follows. Section 2 describes the data and presents summary statistics. Section 3 examines whether financial institutions price carbon risk in the U.S. syndicated loan market. It also investigates whether environmental com-

[2] In related work on broader environmental risks and loan pricing, Chava (2014) find that lenders charge significantly higher interest rates to firms with poor environmental performance and lower institutional ownership. Similarly, Erten and Ongena (2024) find that banks charge higher rates to firms with greater environmental damage, particularly when banks are weakly capitalized or when firms are located in ("greener") states with greater public awareness of climate change.

mitments made by borrowers and lenders affect the pricing of carbon risk, and whether the commitment channel influences corporate behavior. Section 4 analyzes the effects of monetary policy shocks on the pricing of carbon risk. Section 5 explores the evolution of the carbon premium and the factors that account for its changes over time. Finally, Section 6 concludes.

2 Data

Our analysis integrates data from multiple sources. It combines data on syndicated loans issued to U.S.-based borrowers with firm-level carbon emissions over the period 2010Q1–2023Q4. We supplement this dataset with firm-level balance sheet information and probabilities of default to control for borrower characteristics. Finally, we augment the dataset with monetary policy shocks to explore whether the policy environment impacts the pricing of carbon risk. This section provides an overview of the data sources, variables, and summary statistics we use in the empirical analysis.

2.1 Data Sources and Variables

Given the importance of the syndicated loan market as a source of financing for U.S. firms, this market provides an ideal setting to examine how lenders price carbon risk. We extract syndicated loan data from Refinitiv LoanConnector DealScan (formerly LPC DealScan), a widely used source in loan pricing research. The dataset offers detailed information on lenders, borrowers, and loan terms. Specifically, it includes data on the all-in-spread-drawn (AISD)—our primary variable of interest—as well as the amount and non-pricing terms such as collateral status, covenants, maturity, and the market segment. The AISD measures the amount the borrower pays over LIBOR for each dollar drawn, expressed in basis points (bps), incorporating both the loan spread and any annual or facility fees charged by the lending syndicate.

Each observation in the DealScan dataset corresponds to a unique lender–borrower–tranche combination.[3] As loan pricing in syndicated loans is largely determined by lead arrangers, we aggregate the data at the lead arranger–loan tranche level for most of our analyses, consistent with prior literature (see, for example, Aghamolla et al., 2024; Degryse et al., 2023).[4]

[3] DealScan reports loan data at two levels: "Deal" (equivalent to "Package" in the legacy version), which refers to the initial or amended loan contract, and "Tranche" (formerly "Facility"), which identifies the specific tranche within a loan deal.

[4] Syndicated loans involve multiple lenders, including one or more lead arrangers responsible for screening

This unit of observation allows us to isolate the pricing decision of each lead arranger for a given tranche, which is essential for analyzing how financial institutions incorporate carbon risk into loan pricing.[5] To refine the DealScan dataset, we remove incomplete or duplicate entries, exclude loans with inconsistencies in borrower identity or loan terms, and filter out non-lender roles within syndicates.

We obtain firm-level carbon emissions data from Urgentem, which reports both absolute emissions (in tCO_2e) and emission intensity (in tCO_2e per $1 million of revenue) for scope 1, scope 2, and scope 3 emissions. Following the Greenhouse Gas Protocol (WBCSD, 2004), scope 1 refers to direct emissions from a firm's operations, scope 2 captures indirect emissions from purchased energy, and scope 3 encompasses all other indirect emissions across the upstream and downstream value chain. Our analysis focuses on scope 1 and 2 carbon emissions which fall within a firm's direct control. Moreover, we rely on carbon emission intensity, which facilitates a better cross-firm comparison, and in our view is more informative about a firm's operational efficiency and profitability in relation to transition risks. Since emission data are available annually and our analysis is conducted at the quarterly level, we repeat each annual value across the four quarters. In addition, Urgentem reports two variables that allow us to capture firms' climate commitments. First, the dataset provides information on firms' emission reduction targets including the target start year. Second, it indicates whether emissions data are disclosed by the firm and publicly available. These variables enable us to examine whether and how borrowers' environmental commitments affect the pricing of carbon risk.

We then merge borrower-level data from Dealscan with firm-level emissions data from Urgentem in three steps. First, we perform direct matching using Legal Entity Identifiers (LEIs). Second, we apply indirect matching using ISINs along with established linking tables, including the ISIN-to-LEI relationship file provided by the Global Legal Entity Identifier Foundation (GLEIF) and the Association of National Numbering Agencies (ANNA), the Dealscan–Worldscope linking table from Beyhaghi et al. (2021), and the Dealscan–Compustat linking table from Chava and Roberts (2008). Finally, we link remaining unmatched firms through fuzzy name matching, followed by manual verification. This matching produces 2,746 unique firms in our dataset.

---

and monitoring borrowers. Lead arrangers play a central role in pricing decisions, while participant lenders typically rely on information provided by the arrangers (Ivashina, 2009; Sufi, 2007).

[5] In this setup, a syndicated loan tranche with n lead arrangers is duplicated n times in the dataset, one for each lead arranger, thereby capturing each arranger's pricing decision. Following Bharath et al. (2011), we classify a lender as a lead arranger if it is explicitly designated as "Lead Arranger" in DealScan or assigned any of the following roles: administrative agent, agent, bookrunner, (mandated) arranger, (mandated) lead arranger, or syndication agent. In our sample, loan tranches are arranged by an average of 3.7 lead arrangers, broadly in line with Degryse et al. (2023).

To control for borrower characteristics, we incorporate firm-level balance sheet data on leverage, firms size, and profitability from Compustat and time-varying probabilities of default (PD) from the National University of Singapore Credit Research Initiative (NUS-CRI).[6] Compustat also includes data on capital expenditure which allows us to investigate the effects of borrower commitments to environmental objectives on corporate investment. We merge information from these data sources with our combined DealScan-Urgentem dataset using ISINs. Additionally, to closely link borrower commitments and investment purpose, we obtain environmental expenditure—capital spending related to environmental protection and the reduction of adverse environmental impacts—from Refinitiv. Since environmental expenditure is available only at an annual frequency, we merge this data with annual Compustat company balance sheet information using ISINs.

Next, to capture heterogeneity in lenders' environmental commitments, we augment our dataset with an indicator of 'green' lenders based on an established classification in the literature. Following Altavilla et al. (2024) and Kacperczyk and Peydró (2024), we classify a lender as green if it has committed to or set a target for emissions reduction through the Science Based Targets initiative (SBTi).[7] We merge SBTi data into our sample using fuzzy name matching.

Finally, to assess how monetary policy conditions shape the pricing of carbon risk in the syndicated loan market, we incorporate monetary policy shocks from Jarociński and Karadi (2020). We aggregate the monthly monetary policy shocks to the quarterly frequency by summing the shocks within each quarter. For ease of interpretation, we normalize the quarterly shocks by subtracting the mean and dividing by the standard deviation.

For detailed definitions of our main variables, see Table A.1.

2.2 Summary Statistics

Table 1 presents summary statistics for our main variables across loan tranches, borrowers, and lenders. Panel A reports tranche characteristics. The average AISD is 223 bps, with a standard deviation of 137 bps. The average loan tranche amount is around $1 billion with an average maturity of 4.5 years. Our sample summary statistics are broadly consistent with prior studies such as Degryse et al. (2023) and Delis et al. (2024).

[6]NUS-CRI provides a forward-looking, point-in-time probability of default measure, updated daily, and covering over 80,000 exchange-listed firms globally. The PD model is estimated using a comprehensive set of macrofinancial and firm-specific covariates. See Credit Research Initiative, National University of Singapore.

[7]The SBTi is a corporate climate action platform jointly established by the CDP, UN Global Compact, WWF, and WRI. As of 2025, over 11,000 companies, including 164 financial institutions, have set targets under the SBTi framework.

Panel B summarizes borrower characteristics. The average borrower in our sample has a carbon intensity—defined as scope 1 and 2 emissions per $1 million of revenue—of 0.25 thousand tCO_2e. This is slightly higher than the 0.18 thousand tCO_2e per million euros reported by Altavilla et al. (2024) for Euro area borrowers, suggesting regional differences in carbon intensity. Finally, firms exhibit an average PD of approximately 0.37%, with substantial variation. Summary statistics for additional firm-level controls from Compustat—such as leverage (total debt/total assets), size (log(total assets)), and profitability (return on assets)—are broadly consistent with those reported in the literature (see, for example, Kacperczyk and Peydró, 2024).

Panel C reports lender characteristics. Green lenders—identified based on SBTi target status—account for only 2% of financial institutions in our sample.

Table 1: Summary Statistics

This table presents the summary statistics for tranche characteristics, borrower characteristics, and lender characteristics.

Variable	**Mean**	**Std.Dev.**	**p25**	**Median**	**p75**
Panel A. Tranche characteristics					
All-in-spread-drawn (bps)	223.26	137.17	125.00	175.00	275.00
Maturity (years)	4.50	1.77	3.96	5.00	5.00
Amount ($ million)	1047.67	1786.48	250.00	500.00	1200.00
Log(amount)	6.23	1.27	5.52	6.21	7.09
Covenant (0/1)	0.42	0.49	0.00	0.00	1.00
Collateral (0/1)	0.40	0.49	0.00	0.00	1.00
Leveraged (0/1)	0.50	0.50	0.00	1.00	1.00
Term loan (0/1)	0.42	0.49	0.00	0.00	1.00
Green/sustainability-linked loan (0/1)	0.01	0.12	0.00	0.00	0.00
Panel B. Borrower characteristics					
Carbon intensity (thousand tCO2e/$1 million of revenue)	0.25	0.80	0.02	0.04	0.10
Emission reduction target (0/1)	0.18	0.39	0.00	0.00	0.00
PD (probability)	0.37	2.78	0.00	0.02	0.13
Leverage (total debt/total assets)	0.31	0.22	0.13	0.29	0.45
Total assets ($ million)	10515.04	41650.10	744.77	2128.00	6958.10
Log(total assets)	7.80	1.59	6.61	7.66	8.85
Return on assets (net income/total assets)	0.01	0.07	0.00	0.01	0.02
Panel C. Lender characteristics					
SBTi member (0/1)	0.02	0.14	0.00	0.00	0.00

Table 2 details carbon intensity by industry, sorted by the mean carbon intensity, highlighting substantial heterogeneity. High-emission industries, such as Utilities (with a mean intensity of 1.96), Mining (0.76), and Oil and Gas (0.49), exhibit significantly higher carbon intensities compared with low-emission industries, such as Financial Services (0.01), Broadcasting (0.01), and Media (0.02). This industry-level heterogeneity highlights substantially varying degrees of transition risk exposure across borrowing firms.

To further examine long-term patterns, we classify the 30 industries into three broad groups—high-, medium-, and low-carbon—based on their mean carbon intensity over the sample period. Figure 1 plots the time series of average carbon intensity for each group. Emission levels across the three groups show little fluctuation over time, with only limited changes in cross-industry group differences. This suggests that carbon intensity in the U.S. has not declined meaningfully over the sample period.

Figure 1: Carbon Intensity by Sector and Year

This figure plots the average scope 1 and 2 carbon intensity (in thousand tCO_2e per $1 million of revenue) across three industry groups from 2010 to 2023. The x-axis represents calendar years; the y-axis shows borrower-level average carbon intensity. The solid line corresponds to low-carbon industries (e.g., Financial Services, Healthcare), the dashed line to medium-carbon industries (e.g., Technology, Real Estate), and the dotted line to high-carbon industries (e.g., Oil and Gas, Utilities, Transportation).

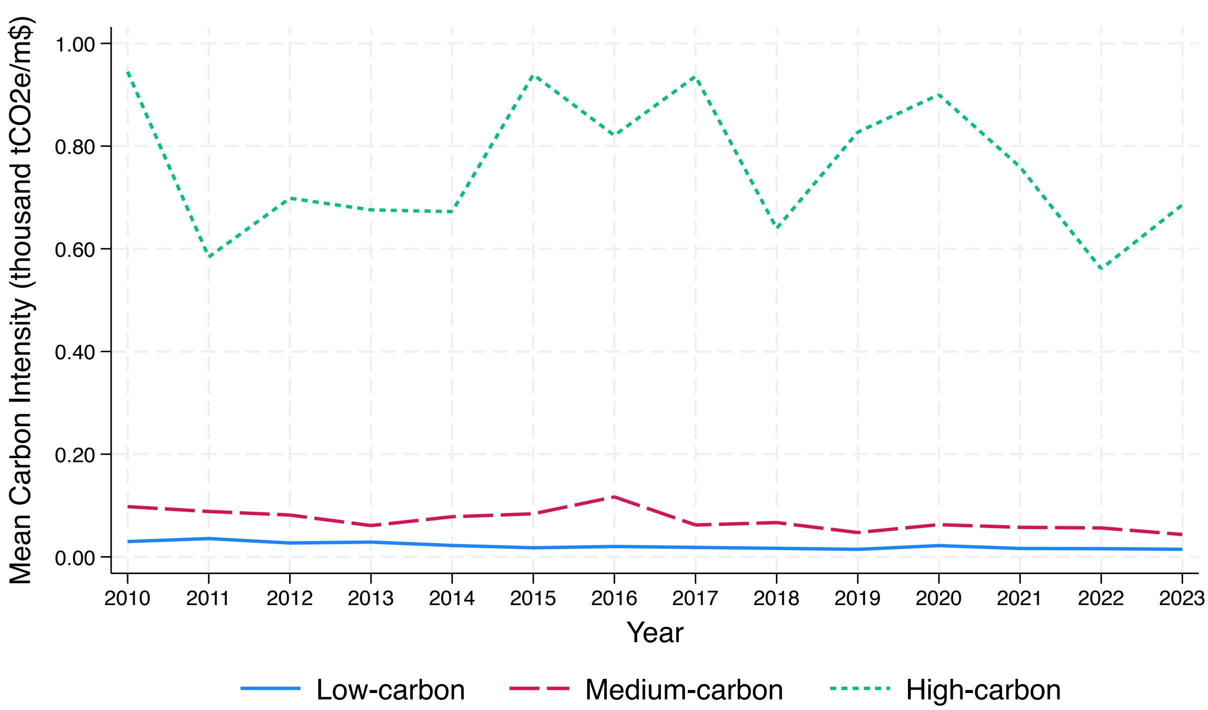


Table 2: Scope 1 and 2 Carbon Intensity by Industry

This table presents scope 1 and 2 carbon intensity (in thousand tCO2e per $1 million of revenue) across industries. Industries are based on major industry groups from DealScan.

Industry	Mean	Std.Dev.	p25	Median	p75
Utilities	1.96	2.21	0.29	1.05	3.29
Mining	0.76	1.15	0.30	0.46	0.62
Oil and Gas	0.49	0.37	0.25	0.46	0.70
Paper & Packaging	0.40	0.16	0.30	0.41	0.49
Transportation	0.40	0.41	0.03	0.29	0.74
Shipping	0.39	0.44	0.06	0.26	0.61
Construction	0.35	1.08	0.02	0.02	0.08
Chemicals, Plastics & Rubber	0.31	0.45	0.06	0.18	0.43
Wholesale	0.16	0.46	0.02	0.04	0.11
Hotel & Gaming	0.13	0.14	0.05	0.09	0.11
Beverage, Food, and Tobacco Processing	0.10	0.10	0.06	0.07	0.11
Automotive	0.10	0.58	0.02	0.04	0.05
General Manufacturing	0.09	0.22	0.02	0.03	0.05
Restaurants	0.08	0.06	0.05	0.08	0.09
REITS	0.08	0.07	0.07	0.07	0.08
Agriculture	0.07	0.10	0.02	0.03	0.11
Government	0.07	0.00	0.07	0.07	0.07
Real Estate	0.05	0.03	0.03	0.06	0.07
Technology	0.04	0.20	0.01	0.02	0.03
Leisure and Entertainment	0.04	0.03	0.01	0.03	0.07
Telecommunications	0.04	0.05	0.02	0.03	0.05
Aerospace and Defense	0.03	0.03	0.02	0.03	0.04
Retail & Supermarkets	0.03	0.03	0.02	0.03	0.04
Business Services	0.03	0.05	0.01	0.02	0.02
Healthcare	0.03	0.03	0.01	0.02	0.04
Textiles and Apparel	0.02	0.04	0.01	0.02	0.02
Services	0.02	0.01	0.01	0.02	0.03
Media	0.02	0.02	0.01	0.01	0.02
Broadcasting	0.01	0.01	0.01	0.01	0.02
Financial Services	0.01	0.03	0.00	0.00	0.01

3 Do Financial Institutions Price Carbon Risk in the U.S. Syndicated Loan Market?

This section addresses three questions. First, do financial institutions in the U.S. syndicated loan market price carbon risk, as reflected in a carbon premium in loan pricing? Second, do borrower and lender environmental commitments affect this premium? Third, does the carbon premium affect the real economy through its impact on corporate investment, R&D spending, and liquidity holdings?

3.1 Carbon Intensity and Loan Pricing

To examine whether a carbon premium exists in the U.S. syndicated loan market, we estimate the following loan pricing model:

$$Y_{libt} = \beta_0 + \beta_1 Carbon_{bt(y)} + \beta_2 Borrower_{bt} + \beta_3 Loan_l + \alpha_{it} + \phi_{Industry} + \lambda_{Location} + \varepsilon_{libt}, \quad (1)$$

where Y_{libt} denotes the all-in spread drawn for loan tranche l arranged by lender i for borrower b in quarter t. The key independent variable of interest, $Carbon_{bt(y)}$, represents the carbon intensity of borrower b in year y. We test whether lenders price carbon risks by charging a carbon premium to carbon-intensive borrowers, i.e. whether $\beta_1 > 0$.

To control for other loan pricing determinants, we include a set of borrower-level and loan-level controls. Appendix A (Table A.1) reports detailed definitions of these controls. $Borrower_{bt}$ are borrower-level controls including either the probability of default (PD) in quarter t or alternatively a set of balance sheet variables—borrower leverage, size, and profitability—lagged by one quarter. These controls are standard in the syndicated loan literature, as riskier, more leveraged, smaller, and less profitable firms are generally associated with higher borrowing costs (see, for example, Altavilla et al., 2024; Ivashina, 2009). In our baseline specification we opt for the PD to capture the credit risk of the borrower over time and to maximize the number of observations in our regression sample. Loan-level controls, $Loan_l$, include loan maturity, loan tranche amount, covenant, secured, leveraged, term loan, and loan purpose.[8] These variables help control for loan terms that directly influence loan pricing.

[8] Loan purpose control is a set of dummies based on the loan primary purpose on Dealscan which we classify into six categories following the literature (see, for example, Aghamolla et al., 2024; Bae and Goyal, 2009; Lin et al., 2013). Specifically, we classify loans into the following categories: corporate operating purposes; debt repayment; mergers and acquisitions; recapitalization; working capital financing; and residual purposes.

Additionally, we include a variety of fixed effects. Following Degryse et al. (2023) and Erten and Ongena (2024), our baseline specification includes lender-time fixed effects α_{it}, which allows us to compare loan spreads charged by the same lender in the same quarter across borrowers with different levels of carbon intensity. This is essential for isolating the pricing effect of carbon intensity from both unobserved time-varying shocks and lender-specific characteristics that affect credit supply. To control for time-invariant heterogeneity across (borrower) industries and regions, we include industry fixed effects $\phi_{Industry}$ and location fixed effects $\lambda_{Location}$. Industries are defined according to the *Major Industry Group* classification in DealScan, which comprises 30 distinct categories. Location fixed effects are defined using the nine U.S. census divisions, as per the U.S. Census Bureau. Thus our estimates capture the within-lender-quarter variation in the all-in spread drawn driven by borrowers' carbon intensity.

Finally, we cluster the standard errors at the lender level, following Bruno and Lombini (2023) and Erten and Ongena (2024) to account for potential correlations in loan pricing decisions made by the same lead arranger, as the same lead arranger may be involved in multiple loan tranches across time.

Table 3 reports the results of the estimation of the variants of Equation (1) over the entire sample period from 2010Q1 to 2023Q4. We begin with a parsimonious specification in column 1 which controls for time-invariant borrower characteristics through industry and location fixed effects. Column 2 replaces industry and location fixed effects with borrower fixed effects. To account for time-varying borrower credit risk, in column 3, we instead include observable balance sheet controls for leverage, size, and profitability. We find that lenders charge higher spreads to smaller and more leveraged borrowers. However, due to the limited availability of borrowers' balance sheet variables, this specification results in a sizable reduction in observations. Thus, in column 4 and in line with the literature (see, for example, Altavilla et al., 2024), we proxy for time-varying borrower risk through PDs that directly capture credit risk and are more widely available. The results indicate that the lenders charge a positive credit risk premium. We opt for this last specification, described in Equation (1), for all subsequent loan pricing regressions.

The estimates of β_1—our key coefficient of interest—are positive and statistically significant across all four specifications: financial institutions in the U.S. syndicated loan market charge higher credit spreads to firms with higher carbon emissions. In other words, our results provide evidence of a carbon premium in loan pricing. The results also confirm that financial institutions price in greater credit risk, as measured by the PD, and riskier loans structures as shown by the loan-level regressors.[9]

[9] Coefficients on loan-level controls are not reported in Table 3 but are available upon request. Loan

Table 3: Carbon Risk and Loan Spread

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), the probability of default (*PD*), leverage, the logarithm of total assets, and return on assets. Loan controls include tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose. Variables are defined in Table A.1. Column 1 does not include borrower controls. Column 2 includes borrower fixed effects. Column 3 includes borrower balance sheet variables. Column 4 includes the probability of default. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	2.01**	2.15*	8.90***	3.30***
	[0.994]	[1.165]	[1.927]	[0.927]
PD				481.19***
				[61.796]
Leverage			76.76***	
			[6.619]	
Total assets			-14.45***	
			[1.449]	
Return on assets			-149.19	
			[102.656]	
Observations	33,689	33,378	13,626	29,130
R-squared	0.613	0.800	0.637	0.610
Loan controls	Yes	Yes	Yes	Yes
Lender-time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	No	Yes	Yes
Location FE	Yes	No	Yes	Yes
Borrower FE	No	Yes	No	No

The magnitude of the estimated effect is economically meaningful: our estimates indicate that the premium on borrowers with high emissions (at the 90th percentile of carbon intensity) ranges between 1–5 bps with 2 bps in the baseline specification in column 4. These magnitudes are comparable to the credit risk premium observed for high-PD borrowers (at the 90th percentile of PD), which is about 3 bps. This finding suggests that lenders in the U.S. syndicated loan market treat carbon risk as a factor of comparable significance to traditional credit risk in their loan pricing decisions. This also suggests that carbon risk is not adequately captured by standard credit risk models used to estimate PDs, likely due to their short-term focus and limited capacity to account for tail risks (see also, Altavilla et al., 2024), or that the loss given default may be larger for carbon intensive firms than for other firms, perhaps because of irreversibility or illiquidity of assets.

The estimated carbon premium of 1–5 bps is consistent with those documented in the literature. Altavilla et al. (2024), report a carbon premium ranging from 2–4 bps for borrowers at the 90th percentile of carbon intensity in the Euro area. Ehlers et al. (2022), based on an annual, global sample, find a premium of approximately 7 bps.[10] Taken together, our results suggest that lenders do internalize carbon risk in loan pricing.

Robustness Checks

We confirm the robustness of the carbon premium in U.S. syndicated loans through a series of additional tests. First, we show that our results are robust to using different measures of carbon intensity. We re-estimate the baseline regression using scope 1 carbon intensity instead of combined scope 1 and 2 emissions. The estimate of β_1 remains positive and statistically significant, with a slightly larger effect of a borrower's carbon intensity on the AISD (Table A.3, column 1). This may reflect the fact that scope 1 emissions are both more directly observable and more closely linked to the borrower's activities, making them more influential in lenders' loan pricing decisions.

Second, we exclude borrowers in the following industries: Financial Services, Real Estate, REITs, and Government. Borrowers in these sectors may not be primary emitters, and their

amount is negatively associated with spreads, while covenants are associated with lower spreads. Term loans have higher spreads compared to revolvers. We find that leveraged loans are consistently associated with significantly higher spreads, consistent with findings in Ehlers et al. (2022) and Zhou et al. (2025). Collateral is also associated with higher spreads in most specifications, supporting the idea that it is more often required from riskier borrowers (Booth and Booth, 2006). The coefficient on loan maturity is positive and significant in most specifications, consistent with Bae and Goyal (2009) and Degryse et al. (2023).

[10]The slightly larger carbon premium in Ehlers et al. (2022) reflects two key differences in the empirical design. First, their baseline analysis focuses exclusively on scope 1 emissions, whereas ours includes both scope 1 and scope 2 emissions. As we show in Table A.3, column 1, we also find a higher premium when we restrict our analysis to scope 1 emissions. Second, the distribution of carbon intensity in their sample is more skewed: firms at the 90th percentile exhibit a carbon intensity above 1 thousand tCO2e per $1 million of revenue, compared with 0.52 thousand tCO2e in our sample.

carbon emissions are not as directly linked to core operational activities as those of non-financial firms. Our results are unchanged (Table A.3, column 2).

Third, following Ehlers et al. (2022), we replace our dependent variable—all-in spread drawn—with the loan margin as an alternative measure of loan pricing. The loan margin captures the interest rate spread but abstracts from additional fees. Our results are comparable to our baseline (Table A.3, column 3).

Fourth, we show that our results are robust to alternative choices of standard error clustering and fixed effects. Table A.4, column 1 clusters standard errors at the lender-time level, following Altavilla et al. (2024), to account for correlation in loan pricing decisions made by the same lender within a given quarter. Column 2 clusters at the lender-borrower level to capture persistent relationships between lenders and borrowers, following Reghezza et al. (2022). Column 3 introduces industry-time fixed effects as a tighter control for time-varying demand shocks across sectors. Finally, column 4 includes separate lender and time fixed effects, separability absorbing unobserved heterogeneity across lenders and quarters.

The estimate of β_1 remains positive and statistically significant across all additional tests confirming the robustness of the carbon premium in U.S. syndicated loans.

3.2 Impact of Environmental Commitments on the Carbon Premium

It is plausible that environmental commitments made by borrowers and lenders influence how carbon risk is priced in loan contracts. For instance, firms that publicly commit to reducing their carbon footprint may be perceived as less exposed to transition risk, and consequently, may face lower borrowing costs. Similarly, financial institutions that have committed to carbon-related objectives may incorporate environmental considerations into their credit decisions more systematically, thereby affecting loan pricing. These borrower and lender commitments can serve as signals of long-term risk management and alignment with regulatory or market expectations, potentially affecting the risk premium demanded by lenders. As such, commitments may play a meaningful role in shaping the pricing of carbon risk in the U.S. syndicated loan market.

To explore these channels, we analyze whether environmental commitments made by borrowers and lenders impact the carbon premium estimated in Section 3.1. We implement this by extending the baseline model by interacting borrower carbon intensity, $Carbon_{bt(y)}$, with variables that capture borrower and lender commitments:

$$\begin{aligned} Y_{libt} = \beta_0 + \beta_1 Carbon_{bt(y)} + \beta_2 Z_{bt,it,l,t} + \beta_3 Carbon_{bt(y)} \times Z_{bt,it,l} + \beta_4 PD_{bt} + \beta_5 Loan_l \\ + \alpha_{it} + \phi_{Industry} + \lambda_{Location} + \varepsilon_{libt}, \end{aligned} \tag{2}$$

where $Z_{bt,it,l,t}$ denotes the variable of interest related to borrower and lender commitments, which may vary across borrower-time (bt), lender-time (it), or loan (l) dimensions. Specifically, to explore the role of borrower commitment, we interact $Carbon_{bt(y)}$ with alternatively: (i) a dummy for whether the borrower has a carbon emission reduction target in quarter t; (ii) a dummy for whether a borrower publicly discloses its carbon emissions; and (iii) a dummy for whether the tranche is classified as a green or sustainability-linked loan. To capture lender commitment, we interact $Carbon_{bt(y)}$ with a dummy variable for whether the lead arranger is a green lender as defined by SBTi membership.

Across all specifications, β_1 captures the carbon premium associated with borrower carbon intensity, β_2 measures the differential in loan spreads related to the specific borrower/lender commitment, and β_3 captures whether this differential varies with carbon intensity. The results in Table 4 show that the carbon premium remains positive and statistically significant when we control for borrower or lender commitment.

First, we examine the role of borrower commitment through an emission reduction target. Table 4, column 1, shows that lenders charge lower spreads for borrowers with an emission reduction target, consistent with the interpretation that these commitments mitigate perceived carbon risk, and in line with the findings in Altavilla et al. (2024) who focus on the role of an emission reduction target in Europe. However, we find that β_3 is negative and statistically significant, indicating that the 'commitment discount' for a target declines with a borrower's carbon intensity. Interestingly, this finding contrasts those in Altavilla et al. (2024) who find that the mitigating effect of an emission reduction target on loan spreads is particularly strong for highly-polluting borrowers. This may suggest that in the U.S, and unlike in Europe, financial institutions are less supportive of firms' investments when meeting the target may involve costly reductions in emissions given the divergence between actual emissions and the target. Quantitatively, we find that for high-emitting borrowers (at the 90th percentile of carbon intensity), the estimated discount associated with a target is approximately 19 bps. However, this discount diminishes as emissions increase (Figure 2).

Second, we test whether there is a discount for borrowers who publicly disclose their emissions. We define disclosed emissions as observations classified as disclosure category 1 or 2, which refer to public, complete scope 1 and 2 emissions that are either assured or unassured. These data are made available through company sustainability reports, annual

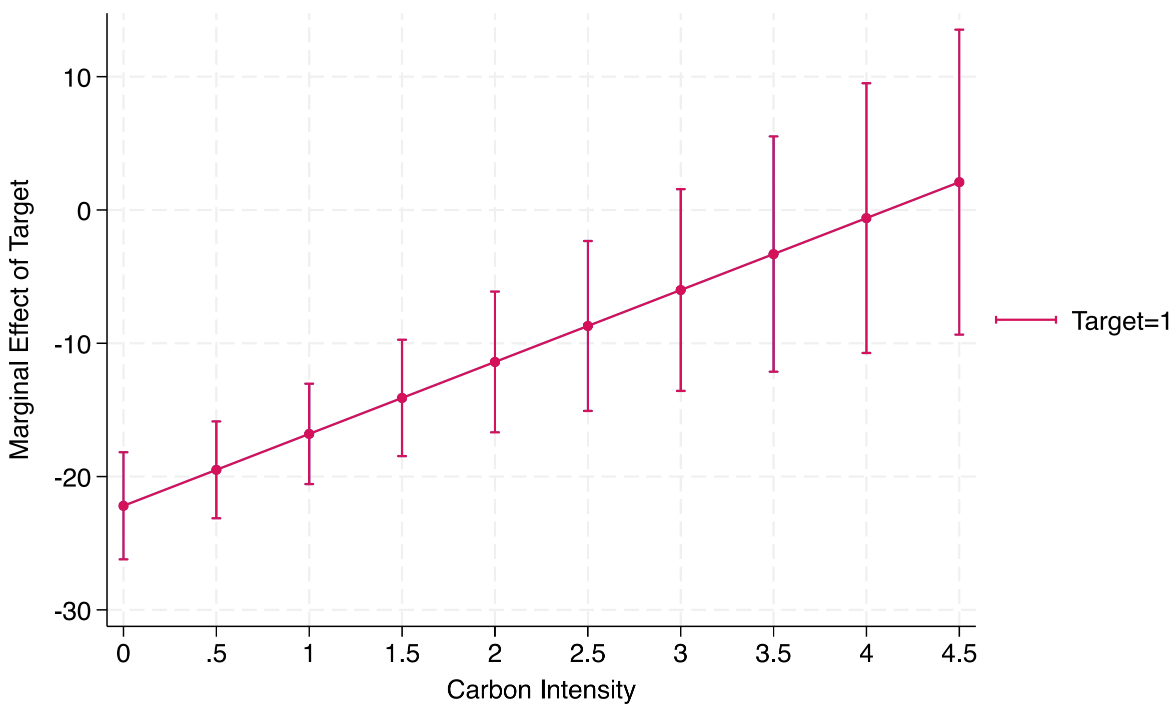
Table 4: Commitment and Carbon Premium

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), a dummy equal to 1 for borrowers with an emission reduction target (*Target*), a dummy equal to 1 if emission data are disclosed (*Disclosed*), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 for lenders who committed to or have targets under the Science-Based Targets initiative (*SBTi member*). All specifications control for the probability of default (PD) and include loan controls (tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose). Variables are defined in Table A.1. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	2.39**	2.52**	3.13***	3.24***
	[1.049]	[0.993]	[0.950]	[0.942]
Target	-22.19***			
	[2.443]			
Target × Carbon	5.40***			
	[1.703]			
Disclosed		-15.70***		
		[2.471]		
Disclosed × Carbon		3.82**		
		[1.841]		
Green loan			-11.13**	
			[4.418]	
Green loan × Carbon			7.94**	
			[3.379]	
SBTi member × Carbon				7.94***
				[2.129]
Observations	29,130	29,130	29,130	29,130
R-squared	0.613	0.611	0.610	0.610
PD	Yes	Yes	Yes	Yes
Loan controls	Yes	Yes	Yes	Yes
Lender-time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Location FE	Yes	Yes	Yes	Yes

Figure 2: Target and Carbon Premium

This figure plots the marginal effect of an emission reduction target on loan spreads across different levels of borrower carbon intensity, evaluated for firms that had disclosed such targets at the time of loan origination. Estimates are based on results reported in Table 4, column 1.



reports, or other publicly available sources. Table 4, column 2, shows that there is a discount for borrowers who disclose their emissions. This result is broadly consistent with Bolton and Kacperczyk (2025), who find that voluntary carbon disclosure is associated with lower stock returns relative to non-disclosing firms and with Matsumura et al. (2014) who show that disclosure helps mitigate the negative impact of carbon emissions on firm value. The interaction term β_3 is again positive and significant, suggesting that the benefit of disclosure fades as a borrower's carbon intensity increases. The estimated discount for high-emitting borrowers (at the 90th percentile) is 14 bps.

Third, we explore the impact of green and sustainability-linked loans as another channel of borrower commitment. Following Fuchs et al. (2024), we construct a dummy variable, *Green loan*, which equals one if the loan tranche is classified as either a "Green Loan" or a "Sustainability-Linked Loan" in the DealScan market segment variable. While both loan types signal environmental commitment, they differ in structure. Green loans directly finance specific, green projects whereas sustainability-linked loans are characterized by pricing terms, such as interest rates, being linked to a borrower's environmental, social, and governance (ESG) performance. The estimates in Table 4, column 3, show that companies that borrow through green or sustainability-linked loans face lower loan spreads. For high-emitting borrowers (at the 90th percentile), the estimated discount from borrowing through a green or sustainability-linked loan is 7 bps. This result is broadly consistent with Kim et al. (2022) who find that globally green loans are associated with lower spreads relative to conventional loans, whereas the effect for sustainability-linked loans is statistically insignificant. Again, we find that the discount associated with green borrowing declines with carbon intensity.

We next turn to lender commitments. Specifically, we test whether loan spreads differ between green and non-green lenders. Green lenders are defined as financial institutions that made commitments or have a decarbonization target under the SBTi. In this estimation, β_2 captures the differential in spreads associated with a green lender vs. a non-green lender, though this coefficient is absorbed by lender-time fixed effects. β_3 captures whether this differential varies with carbon intensity. Table 4, column 4, shows that carbon-intensive borrowers face higher loan spreads when borrowing from SBTi signatories. The carbon premium increases by 4 bps for high-emitting borrowers (at the 90th percentile) borrowing from SBTi signatories. This estimate is broadly consistent with Altavilla et al. (2024) who find an additional 2 bps carbon premium charged by SBTi signatories for lending in Europe.[11]

[11] While previous studies have widely used UNEP FI membership to identify green lenders (see, for example, Degryse et al., 2023; Ehlers et al., 2022), SBTi signatories—who explicitly commit to decarbonizing their investment portfolios—may serve as a more appropriate proxy for green lenders in the context of climate-related financial risks. We do not find a statistically significant impact of UNEP FI membership on spreads.

3.3 Impact of Environmental Commitments on Corporate Behavior

Beyond their impact on the carbon premium in loan pricing, environmental commitments may affect real economic outcomes through corporate behavior. When such commitments signal credible long-term strategies, they can shape firm-level decisions, including real investment choices and innovation activity. Firms committed to carbon-related goals, for instance, may increase capital expenditures, supported by the lower loan spreads documented earlier, which reduce financing costs for firms that set emission reduction targets or disclose emissions. Likewise, these commitments may spur greater investment in R&D, particularly in low-carbon technologies, again facilitated by improved financing conditions. The mitigating effect of such commitments on the carbon premium may also influence corporate financial decisions. Lower spreads, for instance, can reduce the need for precautionary liquidity hoarding, thereby lowering cash holdings and signaling enhanced financial flexibility. Finally, green lenders may allocate capital toward firms pursuing environmental strategies, reinforcing these behavioral shifts.

We test whether commitments to carbon-related objectives influence firm behavior across three dimensions: borrowers' capital expenditure (investment decisions), R&D expenses (innovation decisions) and liquid asset holdings (financial decisions).[12] To do so, we merge firm-level carbon emissions data from Urgentem with balance sheet information from Compustat, which provides both the outcome variables for corporate behavior and a set of firm-level controls, and restrict the sample to firms that borrow in the syndicated loan market during our sample period (equivalent to the sample in Table 3, column 1). We then estimate the following firm-level specification:

$$Y_{bt} = \beta_0 + \beta_1 Carbon_{bt(y)} + \beta_2 Z_{bt} + \beta_3 Carbon_{bt(y)} \times Z_{bt} + \beta_4 Borrower_{bt} + \phi_b + \lambda_t + \varepsilon_{bt}, \quad (3)$$

where Y_{bt} denotes the outcome variable for borrower b in quarter t which is alternatively the natural logarithm of capital expenditure, R&D expenses, or cash and short-term investments. We include borrower fixed effects ϕ_b to control for unobserved time-invariant borrower characteristics and time fixed effects λ_t. In addition, we control for borrower-level controls ($Borrower_{bt}$), namely lagged leverage, total assets, and return on assets to capture borrower fundamentals that may affect firm behavior.[13] As defined in Section 3.2, Z_{bt}

[12] We report summary statistics of the real effects outcomes in Table A.2.

[13] We opt for firm balance sheet controls rather than PDs as the latter may not be directly relevant to firm investment, innovation, and liquidity hoarding. In Sections 3.1 and 3.2, we opted for PDs as they are directly relevant to lenders' loan pricing.

denotes the different borrower and lender commitments. Borrower commitments include a dummy for a carbon emission reduction target, a dummy for disclosed emissions, and a dummy for whether the borrower has a tranche classified as a green or sustainability-linked loan. To assess the impact of lender-side commitments on borrower behavior, we introduce a dummy variable, *Post SBTi lead*, which equals one if the borrower previously engaged with a lead arranger that subsequently committed or validated a target under the SBTi (see, for example, Kacperczyk and Peydró, 2024). Standard errors are clustered at the borrower level.

Our main coefficients of interest, β_2 and β_3, respectively capture the direct effect of commitment on capital expenditure and the differential impact of carbon intensity on corporate behavior for borrowers with a commitment, relative to those without one.

The results from the capital expenditure regressions are reported in Table 5. Column 1 shows that carbon intensity does not significantly affect investment decisions for borrowers without an emission reduction target. This finding is intuitive, as firms lacking such commitments may have limited incentives to adjust their investment decisions in response to their carbon intensity. In contrast, we find that capital expenditure is higher for borrowers that have committed to an emission reduction target. The positive effect of commitment on capital expenditure declines with firms' carbon intensity, mirroring our earlier findings on the carbon premium in loan pricing. This result provides suggestive evidence that committed firms may increase their investment in less carbon-intensive production technologies. It also supports the interpretation that borrowers committed to an emission reduction target take advantage of lower interest rate spreads to finance their investment. Quantitatively, our estimates suggest that for a high-emitting borrower (at the 90th percentile), committing to an emission reduction target is associated with a 6% increase in capital expenditure.[14]

Columns 2 and 3 report the the results based on other forms of borrower commitment (disclosure of emissions in column 2 and green and sustainability-linked loans in column 3). These results further corroborate our hypothesis that borrower commitment translates to higher investment which declines with carbon intensity. However, the main coefficient on *Green loan* is not statistically significant. We also examine the impact of lender commitment in column 4. While the coefficient on *Post SBTi lead* is not significant, the interaction term is negative and statistically significant. This result shows that relationships with green

[14] The 90th percentile of carbon intensity is 0.28 in the firm-level dataset used in this regression. The higher 90th percentile of carbon intensity in the lead arranger–tranche dataset reflects the fact that carbon-intensive firms, which are typically capital-intensive (e.g., energy, utilities, heavy industry), require larger investments and therefore borrow more frequently in the syndicated loan market. In the lead arranger–tranche dataset, these firms therefore appear more frequently, which effectively gives them a higher weight and shifts the distribution to the right.

Table 5: Impact of Environmental Commitments on Capital Expenditure

This table reports a set of regressions where the dependent variable is the logarithm of quarterly capital expenditure ($ million). The explanatory variables are: scope 1 and 2 carbon intensity (in thousand $tCO2e/\$1$ million of revenue) ($Carbon$), a dummy equal to 1 for borrowers with an emission reduction target ($Target$), a dummy equal to 1 if emission data are disclosed ($Disclosed$), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 if the borrower previously engaged with a lead arranger that subsequently committed or validated a target under the SBTi (*PostSBTi lead*). All specifications include borrower controls (leverage, total assets, and return on assets, each lagged by one quarter). Variables are defined in Table A.1. Standard errors are clustered at the borrower level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	0.02	0.09**	0.02	0.02
	[0.032]	[0.045]	[0.029]	[0.027]
Target	0.08*			
	[0.047]			
Target × Carbon	-0.07***			
	[0.019]			
Disclosed		0.07*		
		[0.035]		
Disclosed × Carbon		-0.10***		
		[0.031]		
Green loan			0.20	
			[0.187]	
Green loan × Carbon			-2.55***	
			[0.505]	
Post SBTi lead				-0.10
				[0.089]
Post SBTi lead × Carbon				-0.09*
				[0.051]
Observations	19,574	19,574	19,574	19,574
R-squared	0.907	0.908	0.907	0.908
Borrower Controls	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

lenders do not affect all firms uniformly. Carbon-intensive borrowers reduce investment if a prior lead arranger becomes green, pointing to tighter financing constraints.

Overall, our findings support the interpretation that the presence of a carbon premium in loan pricing, by itself, does not induce changes in investment strategies. Instead, the carbon premium influences corporate investment decisions primarily through borrower or lender commitments.

Next, we analyze firms' R&D spending to assess whether commitments influence R&D expenses to support transition into low-carbon technologies. As reported in Table 6, the results are broadly consistent with those for capital expenditure. We find that R&D expenses increase for borrowers that have environmental commitments as indicated by a positive and statistically significant β_2 in all but one specification. Unlike in the capital expenditure regressions, the coefficient on carbon intensity is positive and significant (except in column 3), indicating that more carbon-intensive firms undertake higher R&D spending.

Motivated by the liquidity hoarding hypothesis, we examine the impact of carbon pricing on cash and short-term investments. Financial inflexibility typically leads firms to hold more liquid assets (e.g., see Bolton et al., 2019). As shown in Table 7, column 1, the coefficient on $Target$ is negative and statistically significant, suggesting that the pricing benefits associated with borrower commitments increase company financial flexibility, thereby reducing incentives to hoard liquidity for safety. We find similar results for green and sustainability-linked loans (column 3) and relationships with lenders who commit to SBTi (column 4). Disclosure of carbon emissions does not appear to impact liquidity hoarding (column 2). Overall, these findings indicate that commitments to environmental objectives may reduce borrowers' needs to hold excess liquid assets, potentially reflecting the benefits of loan spread discounts for committed borrowers.

Finally, we also explore the impact of commitment on environmental expenditure. The results, reported in Table A.5, are broadly consistent with those for capital expenditure and R&D expense. While these results further suggest that borrowers internalize their environmental commitments, one caveat to note is that these regressions are based on a limited sample.

4 Does Monetary Policy Affect the Pricing of Carbon Risk?

To understand how carbon risk is priced in loan contracts, it is important to account not only for firm- and lender-level characteristics but also for the broader policy environment in

Table 6: Impact of Environmental Commitments on R&D Expense

This table reports a set of regressions where the dependent variable is the logarithm of R&D expense ($ million). The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), a dummy equal to 1 for borrowers with an emission reduction target (*Target*), a dummy equal to 1 if emission data are disclosed (*Disclosed*), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 if the borrower previously engaged with a lead arranger that subsequently committed or validated a target under the SBTi (*PostSBTi lead*). All specifications include borrower controls (leverage, total assets, and return on assets, each lagged by one quarter). Variables are defined in Table A.1. Standard errors are clustered at the borrower level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	0.03***	0.18**	0.02	0.02***
	[0.005]	[0.086]	[0.010]	[0.005]
Target	0.07**			
	[0.033]			
Target × Carbon	-0.26***			
	[0.042]			
Disclosed		0.10***		
		[0.025]		
Disclosed × Carbon		-0.17*		
		[0.087]		
Green loan			0.12	
			[0.113]	
Green loan × Carbon			-0.66	
			[0.627]	
Post SBTi lead				0.13*
				[0.065]
Post SBTi lead × Carbon				-0.26***
				[0.035]
Observations	22,709	22,709	22,709	22,709
R-squared	0.980	0.980	0.980	0.980
Borrower controls	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Table 7: Impact of Environmental Commitments on Cash and Short-Term Investments

This table reports a set of regressions where the dependent variable is the logarithm of cash and short-term investments ($ million). The explanatory variables are: scope 1 and 2 carbon intensity (in thousand $tCO2e$/$1 million of revenue) (*Carbon*), a dummy equal to 1 for borrowers with an emission reduction target (*Target*), a dummy equal to 1 if emission data are disclosed (*Disclosed*), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 if the borrower previously engaged with a lead arranger that subsequently committed or validated a target under the SBTi (*PostSBTi lead*). All specifications include borrower controls (leverage, total assets, and return on assets, each lagged by one quarter). Variables are defined in Table A.1. Standard errors are clustered at the borrower level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	0.00	0.01	0.01	0.01
	[0.027]	[0.039]	[0.028]	[0.028]
Target	-0.10**			
	[0.042]			
Target × Carbon	0.06			
	[0.051]			
Disclosed		-0.05		
		[0.032]		
Disclosed × Carbon		0.01		
		[0.033]		
Green loan			-0.28**	
			[0.143]	
Green loan × Carbon			-0.00	
			[0.044]	
Post SBTi lead				-0.21***
				[0.078]
Post SBTi lead × Carbon				0.04
				[0.102]
Observations	45,483	45,483	45,483	45,483
R-squared	0.880	0.880	0.880	0.880
Borrower controls	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

which lending takes place, since this environment can shape the incentives and constraints of both financial institutions and borrowers. In this section, we examine how macroeconomic policy conditions affect the pricing of carbon risk. Specifically, we test whether the risk taking channel of monetary policy also applies to carbon risk, as shown by Altavilla et al. (2024) for lending in the Euro area.

To investigate this questions, we extend our empirical framework to assess how monetary policy impacts the pricing of carbon risk. We interact borrower carbon intensity, borrower commitments, and lender commitment with the monetary policy shock (e.g., Altavilla et al., 2024; Huang et al., 2025).

The extended regression takes the following general form:

$$\begin{aligned} Y_{libt} = \beta_0 &+ \beta_1 Carbon_{bt(y)} + \beta_2 Z_{bt,it,l} + \beta_3 Carbon_{bt(y)} \times Z_{bt,it,l} \\ &+ MPS_t \times (\beta_4 Carbon_{bt(y)} + \beta_5 Z_{bt,it,l} + \beta_6 Carbon_{bt(y)} \times Z_{bt,it,l}) \\ &+ \beta_7 Borrower_{bt} + \beta_8 Loan_l + \alpha_{it} + \phi_{Industry} + \lambda_{Location} + \varepsilon_{libt}, \end{aligned} \tag{4}$$

where MPS_t represents either monetary policy shocks from Jarociński and Karadi (2020). As above, the term $Z_{bt,it,l}$ captures borrower commitments and lender commitment, which vary across borrower–time (bt), lender–time (it), or loan-level (l) dimensions.

Table 8 presents the results, which show that our baseline findings remain robust. In column 1, the coefficient on the interaction term $MPS \times Carbon$, denoted β_4, is positive and statistically significant, indicating that the carbon premium increases when monetary policy tightens: restrictive monetary policy leads lenders to tighten credit conditions more for carbon-intensive firms. This finding is consistent with Altavilla et al. (2024) who show that tighter monetary policy is associated with an increase in the carbon premium in the Euro area reflecting the risk-taking channel of monetary policy. In terms of magnitude, a one standard deviation monetary policy shock is associated with a 1.6 bps additional increase in loan spreads for borrowers at the 90th percentile of carbon intensity.[15]

Next, in column 2, we introduce an interaction term between the MPS and $Target$. The coefficients on $Carbon$ and $MPS \times Carbon$ remain positive and statistically significant, confirming that the carbon premium increases under monetary policy tightening even when controlling for borrower commitments. The coefficient on $MPS \times Target$ is negative and significant: when monetary policy tightens, loan spreads increase by less for borrowers which committed to targets. This finding is consistent with Altavilla et al. (2024) who show that even under restrictive monetary policy, lenders differentiate between firms with and

[15] Our results remain robust even when replacing industry fixed effects with industry–time fixed effects, which provide tighter control for loan demand. This specification accounts for the possibility that some industries—particularly those with higher emissions—may be more sensitive to monetary policy shocks.

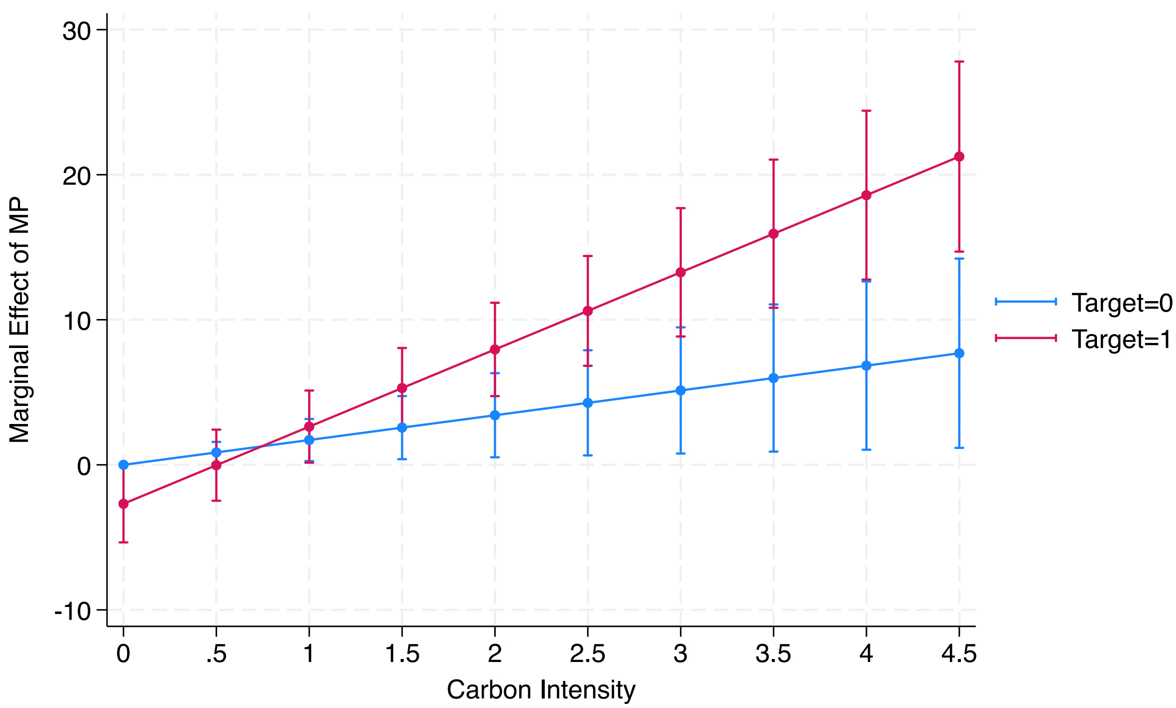
Table 8: Monetary Policy Shock and Carbon Premium

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), a standardized monetary policy shock (MPS), a dummy equal to 1 for borrowers with an emission reduction target ($Target$), a dummy equal to 1 if emission data are disclosed (*Disclosed*), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 for lenders who committed to or have targets under the Science-Based Targets initiative (*SBTi member*). All specifications control for the probability of default (PD) and include loan controls (tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose). Variables are defined in Table A.1. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Carbon	3.64***	2.64**	2.92***	3.56***	3.56***
	[0.944]	[1.036]	[1.015]	[0.968]	[0.966]
MPS × Carbon	3.16***	1.71*	3.18***	3.04***	3.24***
	[0.513]	[0.881]	[0.821]	[0.514]	[0.510]
Target		-22.08***			
		[2.431]			
Target × Carbon		5.55***			
		[1.732]			
MPS × Target		-2.69*			
		[1.619]			
MPS × Target × Carbon		3.61**			
		[1.393]			
Disclosed			-15.54***		
			[2.432]		
Disclosed × Carbon			3.73**		
			[1.890]		
MPS × Disclosed			-4.10***		
			[1.419]		
MPS × Disclosed × Carbon			0.62		
			[1.229]		
Green loan				-7.43	
				[4.832]	
Green loan × Carbon				1.73	
				[5.008]	
MPS × Green Loan				-12.42***	
				[2.073]	
MPS × Green Loan × Carbon				24.63*	
				[13.254]	
SBTi member × Carbon					8.55***
					[2.304]
MPS × SBTi member × Carbon					-12.23***
					[4.048]
Observations	29,130	29,130	29,130	29,130	29,130
R-squared	0.610	0.613	0.612	0.611	0.610
PD	Yes	Yes	Yes	Yes	Yes
Loan controls	Yes	Yes	Yes	Yes	Yes
Lender-time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Location FE	Yes	Yes	Yes	Yes	Yes

Figure 3: Monetary Policy Shock and Carbon Premium

This figure plots the marginal effect of monetary policy shock on loan spreads across different levels of borrower carbon intensity, evaluated for firms that had committed to emission reduction targets at the time of loan origination. Estimates are based on results reported in Column (2) of Table 8.



without emissions reduction targets in the Euro area. However, the positive and statistically significant coefficient on the triple interaction term, $MPS \times Target \times Carbon$, indicates that this mitigating effect diminishes with carbon intensity, as illustrated in Figure 3.

Columns 3 and 4 explore alternative borrower commitments through voluntary carbon emissions disclosure and the issuance of green or sustainability-linked loans. In column 3, the coefficient on $MPS \times Disclosed$ is negative and significant, pointing to a comparable mitigating effect for firms that voluntarily disclose emissions. However, the coefficient on the triple interaction term is not statistically significant, suggesting that the mitigating effect does not vary systematically with carbon intensity. Similarly, in column 4, the coefficient on $MPS \times Green\ loan$ is negative and significant, further validating the idea that borrower commitments mitigate the effect of monetary policy shocks on the carbon premium. The coefficient on the triple interaction term is positive and marginally significant, indicating that this mitigating effect weakens with carbon intensity.

Finally, we turn to lender heterogeneity in column 5. We are not able to observe the coefficient on $MPS \times SBTi$ as it gets absorbed by lender-time fixed effects in our specification. The coefficient on the triple interaction, $MPS \times Target \times SBTi$, is negative and significant. Following monetary tightening, the increase in loan spreads for carbon-intensive firms is smaller when borrowing from SBTi members. This result reflects that SBTi members demand significantly higher loan spreads when monetary policy tightens, thereby reducing the relative differentiation across borrowers by carbon intensity. Consequently, even firms at the 90th percentile of carbon intensity face elevated borrowing costs when obtaining loans from SBTi members under tighter monetary conditions.[16]

5 Has the Pricing of Carbon Risk Shifted Over Time?

This section examines the evolution of the carbon premium over time. We estimate a series of rolling regressions based on Equation 1 (Table 3, column 4), using six-year windows. The first window begins in 2010, with each subsequent window advancing by one year. The pricing of carbon risk is captured by the coefficient on carbon intensity.

Figure 4 presents the results. For the six-year rolling windows from 2010–2015 to 2014–2019, the estimated carbon premium is positive and statistically significant, with the coefficient increasing over time. This upward trend suggests that lenders increasingly priced in borrower carbon emissions during this period. In subsequent periods, the carbon premium

[16]We arrive at this conclusion based on an estimation with separate lender and time fixed effects, which allows us to estimate the impact of the interaction between a monetary policy shock and SBTi membership on the AISD.

Figure 4: Time-varying Carbon Premium

This figure plots the estimated coefficients on borrower carbon intensity (i.e., the carbon premium) from six-year rolling window regressions. The first dot covers the period from 2010 to 2015, with each subsequent dot moving forward by one year. Each marker represents the estimated coefficient, with vertical lines denoting 95% confidence intervals. Circle markers indicate statistical significance at the 5% level, square markers at the 10% level, and triangle markers indicate estimates that are not statistically significant.

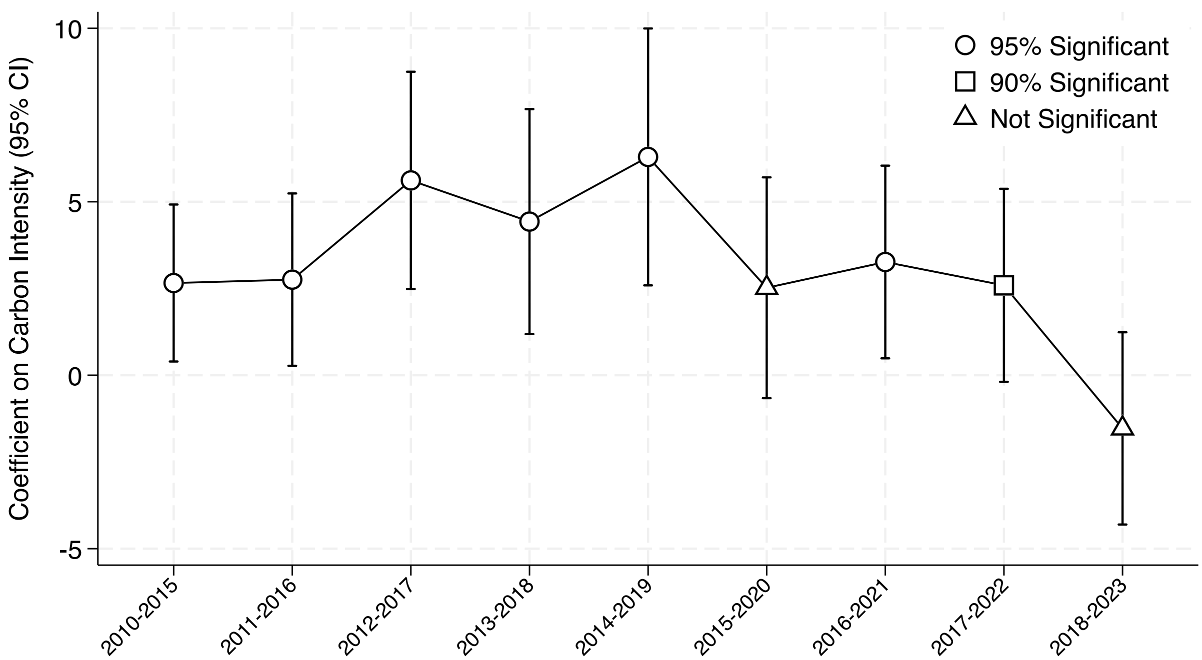


Table 9: Explanations behind the Decline in the Carbon Premium

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), a dummy equal to 1 for loans originated after the U.S. withdrawal of Paris Agreement in June 2017 and before U.S. rejoining in March 2021 (*Paris withdrawal*), a dummy equal to 1 for loans originated during COVID-19 from March 2020 to March 2022 (*Covid*), a dummy equal to 1 for loans originated after the introduction of Inflation Reduction Act in July 2022 (*Post IRA*). All specifications control for the probability of default (PD) and include loan controls (tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose). Variables are defined in Table A.1. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	3.04***	3.74***	3.33***	3.51***
	[0.896]	[0.965]	[0.925]	[0.919]
Paris withdrawal × Carbon	1.47			1.64
	[2.083]			[2.046]
Post COVID × Carbon		-4.76***		-5.08***
		[1.834]		[1.902]
Post IRA × Carbon			-8.69*	-9.02*
			[4.821]	[4.808]
Observations	29,130	29,130	29,130	29,130
R-squared	0.610	0.610	0.610	0.610
PD	Yes	Yes	Yes	Yes
Loan controls	Yes	Yes	Yes	Yes
Lender-time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Location FE	Yes	Yes	Yes	Yes

gradually declines both in magnitude and statistical significance. In the final window, spanning 2018–2023, the coefficient turns negative although remains insignificant. These patterns indicate a reversal in the earlier trend, suggesting that the impact of carbon risk on loan pricing has diminished in recent years.

To explore potential explanations for the decline in the carbon premium, we re-estimate Equation 1 and introducing interaction terms between carbon intensity and dummies identifying three major climate-related events that may have contributed to the shift: (i) the U.S. withdrawal from the Paris Agreement in June 2017; (ii) the onset of COVID-19 in March 2020; (iii) and the introduction of the Inflation Reduction Act (IRA) in July 2022. The results in Table 9 suggest that both COVID-19 and the IRA contributed to a weakening of the carbon premium. The post–COVID-19 decline likely reflects the effects of pandemic-related policies, including expansionary monetary and fiscal measures, regulatory forbearance, and corporate support, all of which improved financing conditions, including for carbon-intensive industries. In contrast, the IRA introduced additional provisions, such as tax credits, grants, and loan guarantees, that encouraged investment in clean energy, electric vehicles, and low-carbon infrastructure.

These findings are consistent with the recent literature. Bauer et al. (2023) document rapid, positive stock market reactions to the passage of IRA, particularly in sectors that were expected to benefit such as utilities, construction, and transportation. Many of these industries are carbon intensive and face elevated transition risks.

6 Conclusion

Loan spreads play a central role in shaping firms' financing costs, investment decisions, and ultimately the allocation of capital across the economy. Understanding the factors that influence loan pricing is therefore critical, not only for borrowers and lenders but also for assessing broader implications for financial stability. Analyzing how financial markets price carbon risks helps better understand the behavior of loan risk spreads and the challenges to financial stability posed by carbon risk exposures.

Our paper presents new evidence on the role of carbon risk in U.S. syndicated loan markets. We document the existence of a carbon premium, examine how borrower and lender characteristics shape its magnitude, and analyze how it interacts with monetary policy. We also show that it is time varying, diminishing in recent years.

We find robust evidence that lenders charge higher loan spreads to borrowers with higher carbon intensity. Additionally, borrower commitments and lender characteristics significantly influence this relationship. Borrowers with carbon disclosures or emission reduction targets, and those borrowing through green or sustainability-linked loans, receive lower risk spreads. However, these discounts decline with the borrower's carbon intensity. On the lender side, we find that SBTi members appear to charge higher spreads to more carbon-intensive borrowers.

The pricing of carbon risk has tangible real effects on firms' behavior. Borrower commitment is generally associated with higher investment and R&D spending, although these effects are weaker for more carbon-intensive firms. Additionally, committed borrowers hold lower liquidity. Relationships with lenders which commit to environmental objectives also lead to lower investment for carbon-intensive firms. Furthermore, we find that tightening monetary policy shocks amplify the carbon premium, consistent with the risk-taking channel of monetary policy. Employing a set of rolling window regressions, we observe a recent disappearance of the carbon premium, potentially reflecting policy responses to the COVID-19 pandemic and the Inflation Reduction Act.

References

Aghamolla, Cyrus et al. (2024). “Merchants of Death: The Effect of Credit Supply Shocks on Hospital Outcomes”. *American Economic Review* 114.11, pp. 3623–3668.

Altavilla, Carlo et al. (2024). *Climate Risk, Bank Lending and Monetary Policy.* ECB Working Paper No. 2024/2969. European Central Bank.

Bae, Kee-Hong and Vidhan K Goyal (2009). “Creditor Rights, Enforcement, and Bank Loans”. *The Journal of Finance* 64.2, pp. 823–860.

Bao, Yangming (2022). “Peer Information in Loan Pricing”. *Journal of Corporate Finance* 76, p. 102248.

Bauer, Michael, Eric Offner, and Glenn D Rudebusch (2023). *The Effect of US Climate Policy on Financial Markets: An Event Study of the Inflation Reduction Act.* CESifo Working Paper No. 10739. CESifo.

Beyhaghi, Mehdi et al. (2021). “International Lending: The Role of Lender’s Home Country”. *Journal of Money, Credit and Banking* 53.6, pp. 1373–1416.

Bharath, Sreedhar T et al. (2011). “Lending Relationships and Loan Contract Terms”. *The Review of Financial Studies* 24.4, pp. 1141–1203.

Bolton, Patrick and Marcin Kacperczyk (2021). “Do Investors Care About Carbon Risk?” *Journal of Financial Economics* 142.2, pp. 517–549.

— (2023). “Global Pricing of Carbon-Transition Risk”. *The Journal of Finance* 78.6, pp. 3677–3754.

— (2025). “Carbon Disclosure and the Cost of Capital”. *Available at SSRN 3755613.*

Bolton, Patrick, Neng Wang, and Jinqiang Yang (2019). “Investment Under Uncertainty with Financial Constraints”. *Journal of Economic Theory* 184, p. 104912.

Booth, James R and Lena Chua Booth (2006). “Loan Collateral Decisions and Corporate Borrowing Costs”. *Journal of Money, Credit and Banking*, pp. 67–90.

Bruno, Brunella and Sara Lombini (2023). “Climate Transition Risk and Bank Lending”. *Journal of Financial Research* 46, S59–S106.

Chava, Sudheer (2014). “Environmental Externalities and Cost of Capital”. *Management Science* 60.9, pp. 2223–2247.

Chava, Sudheer and Michael R Roberts (2008). "How Does Financing Impact Investment? The Role of Debt Covenants". *The Journal of Finance* 63.5, pp. 2085–2121.

Degryse, Hans et al. (2023). "When Green Meets Green". *Journal of Corporate Finance* 78, p. 102355.

Delis, Manthos D et al. (2024). "Being Stranded with Fossil Fuel Reserves? Climate Policy Risk and the Pricing of Bank Loans". *Financial Markets, Institutions & Instruments* 33.3, pp. 239–265.

Ehlers, Torsten, Frank Packer, and Kathrin De Greiff (2022). "The Pricing of Carbon Risk in Syndicated Loans: Which Risks are Priced and Why?" *Journal of Banking & Finance* 136, p. 106180.

Erten, Irem and Steven Ongena (2024). "Do Banks Price Environmental Risk? Only When Local Beliefs are Binding!" *Available at SSRN 4932511*.

Fuchs, Larissa et al. (2024). "Climate Stress Tests, Bank Lending, and the Transition to the Carbon-Neutral Economy". *Available at SSRN 4427729*.

Hengge, Martina, Ugo Panizza, and Richard Varghese (2023). *Carbon Policy and Stock Returns: Signals From Financial Markets*. IMF Working Paper No. 2023/013. International Monetary Fund.

Hoang, Bao Trung et al. (2025). "Green Loans and Firm Performance: Evidence on Signalling and Impact Investing Effects". *European Financial Management*.

Huang, Sijia et al. (2025). "Impact and Transmission Mechanism of China's Climate Policy Uncertainty on Bank Risk-taking". *Energy Economics*, p. 108214.

Ivashina, Victoria (2009). "Asymmetric Information Effects on Loan Spreads". *Journal of Financial Economics* 92.2, pp. 300–319.

Jarociński, Marek and Peter Karadi (2020). "Deconstructing Monetary Policy Surprises—The Role of Information Shocks". *American Economic Journal: Macroeconomics* 12.2, pp. 1–43.

Kacperczyk, Marcin and José-Luis Peydró (2024). *Carbon Emissions and the Bank-lending Channel*. ECGI Finance Working Paper No. 991/2024. European Corporate Governance Institute.

Kim, Sehoon et al. (2022). *ESG Lending*. ECGI Finance Working Paper No. 817/2022. European Corporate Governance Institute.

Kleimeier, Stefanie and Michael Viehs (2021). "Pricing Carbon Risk: Investor Preferences or Risk Mitigation?" *Economics Letters* 205, p. 109936.

Kumar, Praveen and Vijay Yerramilli (2023). "Firm Size, Capital Investment, and Debt Financing over Industry Business Cycles". *Journal of Financial and Quantitative Analysis*, pp. 1–27.

Lim, Jongha, Bernadette A Minton, and Michael S Weisbach (2014). "Syndicated Loan Spreads and the Composition of the Syndicate". *Journal of Financial Economics* 111.1, pp. 45–69.

Lin, Chen et al. (2013). "Directors' and Officers' Liability Insurance and Loan Spreads". *Journal of Financial Economics* 110.1, pp. 37–60.

Matsumura, Ella Mae, Rachna Prakash, and Sandra C Vera-Muñoz (2014). "Firm-Value Effects of Carbon Emissions and Carbon Disclosures". *The Accounting Review* 89.2, pp. 695–724.

Reghezza, Alessio et al. (2022). "Do Banks Fuel Climate Change?" *Journal of Financial Stability* 62, p. 101049.

Seltzer, Lee H, Laura Starks, and Qifei Zhu (2025). *Climate Regulatory Risk and Corporate Nonds*. Federal Reserve Bank of New York Staff Reports No. 1014. Federal Reserve Bank of New York.

Sufi, Amir (2007). "Information Asymmetry and Financing Arrangements: Evidence from Syndicated Loans". *The Journal of Finance* 62.2, pp. 629–668.

WBCSD, WRI (2004). *GHG Protocol Corporate Accounting and Reporting Standard*.

Zhang, Zehua and Ran Zhao (2022). "Carbon Emission and Credit Default Swaps". *Finance Research Letters* 50, p. 103286.

Zhou, Xiao Yan et al. (2025). "An Empirical Analysis of Climate and Environmental Policy Risk, the Cost of Debt and Financial Institutions' Risk Preferences". *Energy Economics* 144, p. 108323.

Appendices

A Additional Tables

Table A.1: Variable Definitions and Data Sources (Continued on Next Page)

Variable	Definition	Source
Panel A. Tranche characteristics		
All-in-spread-drawn	Amount the borrower pays in basis points over LIBOR for each dollar drawn down, which adds the spread of the loan with any annual or facility fee paid to the bank group.	DealScan
Maturity	Maturity of the loan tranche in years.	DealScan
Amount	Logarithm of the tranche amount ($ million).	DealScan
Covenant	Dummy variable equal to 1 if the loan tranche has covenants.	DealScan
Collateral	Dummy variable equal to 1 if the loan tranche is secured.	DealScan
Leveraged	Dummy variable equal to 1 if the tranche is a leveraged loan.	DealScan
Term loan	Dummy variable equal to 1 if it is a term loan.	DealScan
Loan purpose	Dummies for different loan purpose indicators.	DealScan
Green loan	Dummy variable equal to 1 if it is a green loan or sustainability-linked loan.	DealScan
Panel B. Borrower characteristics		
Carbon	Scope 1 and 2 carbon intensity measured as annual scope 1 and 2 carbon emissions over annual revenues (thousand tCO2e/1$ million revenue).	Urgentem
Target	Dummy variable equal to 1 if the borrower has an emission reduction target.	Urgentem
PD	Probability of default.	NUS-CRI
Leverage	Total debt divided by total assets.	Compustat
Size	Logarithm of total assets ($ million).	Compustat
Profitability	Return on assets measured as net income divided by total assets.	Compustat

Table A.1: Variable Definitions and Data Sources (Continued)

Variable	Definition	Source
Panel B. Borrower characteristics (continued)		
CAPEX	Logarithm of quarterly capital expenditure ($ million). Quarterly capital expenditure equals reported "CAPXY" in the first fiscal quarter, and the difference between current and lagged "CAPXY" in subsequent quarters (Kumar and Yerramilli, 2023).	Compustat
R&D expense	Logarithm of expenditure on research and development ($ million).	Compustat
Cash	Logarithm of cash and short-term investments ($ million).	Compustat
Environmental expenditure	Logarithm of annual environmental investment and expenditures ($ million). These include spending on environmental protection or measures to control environmental impacts.	Refinitiv
Panel C. Lender characteristics		
SBTi member	Dummy variable equal to 1 if the lead arranger makes commitment or has climate mitigation target under the SBTi.	SBTi

Table A.2: Summary Statistics of Real Effect Outcomes (Firm–Quarter Level)

This table reports summary statistics for the real effect outcomes in the firm-level dataset. All variables are measured at the firm–quarter level. CAPEX, R&D expense, and Cash are reported in $ million, and we use their logarithms in the regressions.

Variable	Mean	Std.Dev.	p25	Median	p75
CAPEX ($ million)	54.81	234.84	1.81	7.90	31.60
Log(CAPEX)	2.35	1.70	1.03	2.19	3.48
R&D expense ($ million)	74.21	535.09	0.00	4.45	26.46
Log(R&D expense)	1.90	1.95	0.00	1.69	3.31
Cash ($ million)	1342.85	11426.60	43.02	145.43	453.34
Log(Cash)	4.97	1.89	3.78	4.99	6.12

Table A.3: Carbon Risk and Loan Pricing: Robustness Checks

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 carbon intensity (in thousand tCO2e/$1 million of revenue) ($Carbon(S1)$), scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) ($Carbon$), and the probability of default (PD). Loan controls include tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose. Variables are defined in Table A.1. Column 1 uses scope 1 carbon intensity instead of combined scope 1 and 2 carbon intensity as the key independent variable. Column 2 excludes borrowers in the following industries: Financial Services, Real Estate, REITs, and Government; Column 3 uses the loan margin as an alternative measure of loan pricing. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
Carbon (S1)	3.85***		
	[0.997]		
Carbon		3.50***	3.03***
		[0.982]	[0.893]
PD	481.41***	478.34***	478.92***
	[61.818]	[62.150]	[61.419]
Observations	29,130	25,082	29,086
R-squared	0.610	0.610	0.618
Loan Controls	Yes	Yes	Yes
Lender-Time FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Location FE	Yes	Yes	Yes

Table A.4: Carbon Risk and Loan Pricing: Additional Robustness Checks

This table reports a set of regressions where the dependent variable is the all-in-spread-drawn of the loan tranche. The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), and the probability of default (*PD*). Loan controls include tranche size, maturity, collateral, covenant status, leveraged status, and loan purpose. Variables are defined in Table A.1. Column 1 clusters standard errors at the lender-time level and column 2 at the lender-borrower level. Column 3 includes industry-time fixed effects and column 4 includes separate lender and time fixed effects. Standard errors are clustered at the lender level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	3.30***	3.30***	3.01***	3.97***
	[1.035]	[1.068]	[1.012]	[0.871]
PD	481.19***	481.19***	568.16***	525.56***
	[63.263]	[59.713]	[71.421]	[56.141]
Observations	29,130	29,130	29,071	30,227
R-squared	0.610	0.610	0.718	0.537
Loan controls	Yes	Yes	Yes	Yes
Lender FE	No	No	No	Yes
Time FE	No	No	No	Yes
Lender-time FE	Yes	Yes	Yes	No
Industry FE	Yes	Yes	No	Yes
Industry-time FE	No	No	Yes	No
Location FE	Yes	Yes	Yes	Yes

Table A.5: Impact of Environmental Commitments on Environmental Expenditure

This table reports a set of regressions where the dependent variable is the logarithm of annual environmental expenditure ($ million). The explanatory variables are: scope 1 and 2 carbon intensity (in thousand tCO2e/$1 million of revenue) (*Carbon*), a dummy equal to 1 for borrowers with an emission reduction target (*Target*), a dummy equal to 1 if emission data are disclosed (*Disclosed*), a dummy equal to 1 for green and sustainability-linked loan tranches (*Green loan*), and a dummy equal to 1 if the borrower previously engaged with a lead arranger that subsequently committed or validated a target under the SBTi (*PostSBTi lead*). All specifications include borrower controls (leverage, total assets, and return on assets, each lagged by one quarter). Variables are defined in Table A.1. Standard errors are clustered at the borrower level and reported in brackets. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Carbon	0.28*	0.27	0.10	0.17
	[0.170]	[0.168]	[0.091]	[0.103]
Target	0.32*			
	[0.186]			
Target × Carbon	-0.24**			
	[0.105]			
Disclosed		0.11		
		[0.182]		
Disclosed × Carbon		-0.17*		
		[0.102]		
Green loan			0.94**	
			[0.387]	
Green loan × Carbon			-1.03***	
			[0.126]	
Post SBTi lead				0.07
				[0.243]
Post SBTi lead × Carbon				-0.39***
				[0.127]
Observations	448	448	448	448
R-squared	0.900	0.897	0.908	0.905
Borrower controls	Yes	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

PUBLICATIONS

Carbon Risk in Loan Pricing: Commitment Channels and Real Effects

Working Paper No. WP/2025/250