# Climate Risk, Green Confusion and Bank Lending

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# Motivation

- Banks might play a key role in directing funds toward green projects, and incentivizing firms to engage in sustainability practices
- In 2022, ECB sets deadline for banks to meet all supervisory expectations regarding climate risks by end of 2024
- Expectation number 8.5: "Institutions loan pricing frameworks are expected to reflect their credit risk appetite and business strategy with regard to climate-related and environmental risks." (ECB, 2020)

Multiple reasons to price climate risks:

- Green halo: Banks want to appear virtuous and show that they care about climate (Sangiorgi and Schopohl, 2021)
- Lower firms' probability of default, as these debtors have already started their climate transition (Harrison et al., 2020)

# This paper

How do European banks incorporate transition climate risk into corporate loan pricing and what factors limit them to actively price climate considerations?

**Objective:**

- Estimate through time (2021-2024) the impact of being a green firm (low carbon emissions intensity) on the pricing of corporate loans in Europe (interest rate)

**Data:**

- Leverages new granular data from 2024 EBA Fit-for-55 climate data collection: banks report how they perceive climate intensities of top debtors

# Contribution to the literature

Banks have begun to respond to climate risks based on syndicated loans to large publicly listed firms using one climate data provider (Javadi and Masum, 2021; Kacperczyk and Peydró, 2022; Altavilla et al., 2024),

- **Contribution 1:** Novel evidence of a growing greenium since 2022 with a sample containing unlisted firms and non sysndicated loans and using the same information set as banks: (16-40bps)

There is uncertainty about the reliability of green data, strong divergences between data providers(Berg et al., 2022; Avramov et al., 2022)

- **Contribution 2**: Green confusion impacts also loan pricing
- **Contribution 3**: Data availability is not enough, banks also need to know how to access it and use it: banks identified as having too much missing and aberrant data in their reportings are not able to price climate risks

# Institutional framework

Climate regulation and engagement is rapidly increasing in Europe, and all these decisions have impact on climate risk pricing according to literature

- 2015 Paris Agreement (Ho and Wong, 2023; Ehlers et al., 2022)
- 2020 ECB Guide on climate risk management (Aiello, 2024)
- 2020 State-guaranteed loans(Ehlers et al., 2022)
- 2021 First sectoral data collection and regulatory climate stress test (ACPR) (Fuchs et al., 2024)
- 2022 First granular data collection and ECB bottom-up stress test
- 2022 Thematic review ECB (Aiello, 2024)
- 2022 Monetary policy tightening (Altavilla et al., 2024)
- 2023 First ECB top-down stress test
- 2024 EBA Fit-for-55 data collection and top-down stress test
- 2024 EBA guidelines on ESG risk management

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# Literature review

- **Event Studies**
  - Ehlers et al. (2022): **+7 bps** (90th percentile carbon intensity)
  - Degryse et al. (2023): **-60 bps** (for green-committed banks)
  - Ho et al. (2023): **+46 bps** (high-emission sectors)
  - Delis et al. (2024): **+25.3 bps** (1 std fossil fuel reserves)
  - Fuchs et al. (2023): **+19 bps** (brown borrowers)
  - Altavilla et al. (2024): **+4 to +14 bps** (high emissions)
  - Aiello et al. (2024): **No significant effect** (SSM Guide)
- **Panel Studies**
  - Goss (2011): **-7 to -18** bps (below avg. CSR)
  - Chava (2014): **+25 bps** (environmental concerns)
  - Kleimeier & Sautner (2018): **-11 bps** (carbon disclosure)
  - Kacperczyk et al. (2022): **+3 bps** (SBTi banks, 1 std emissions)
  - Giannetti et al. (2023): **+18 bps** (brown industries)
  - Boermans & Frost (2024): **+19.5 bps** (1 std carbon intensity)
  - Kleimeier & Sautner (2018): **-11 bps** (carbon disclosure)

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# Data

## EBA Fit-for-55 Climate Data Collection (2024)

- Carbon intensity (Scope 1 GES emissions / annual turnover) for largest debtors (top 15 debtors in 22 NACE2 sectors)
  - Banks should obtain this data by asking their debtors, using climate data providers
  - I observe the carbon intensity reported by the 11 French banks and I compute the average of the values reported by all banks

▸ See data collection calendar

## Anacredit

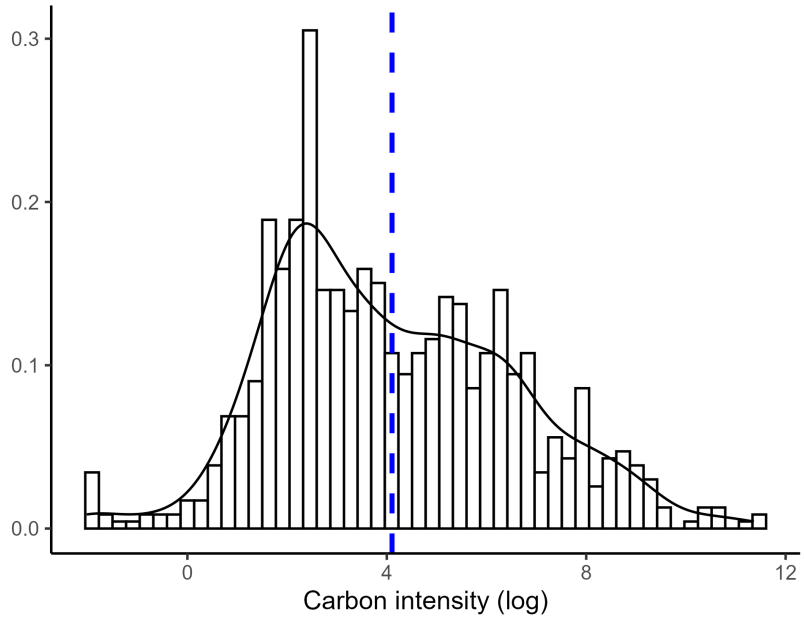
- Loan-level data from bank-firm credit registry of lending in Euro Area
- Main variable: annualized interest rate
- Other controls variables: probability of default, maturity, performing status, ...

**Regulatory reporting FINREP/COREP**: ROA, total assets, CET1 solvency ratio, NPL ratio, provisions ratio

# Final sample based on the climate data

- 1412 firms reported in Fit-for-55, 1154 firms matched with Anacredit
- 667 banking groups in Anacredit giving loans to these firms, among 110 banks participating to the climate data collections (data capacity and greenness)
- 20.7% of debtors are reported by at least 2 banks
- Average credit relationship: 8.9 million euros

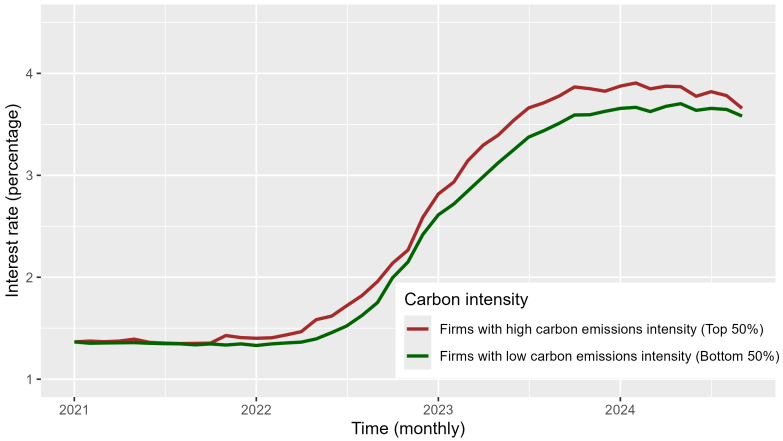
Figure 1: Carbon intensity distribution (log)



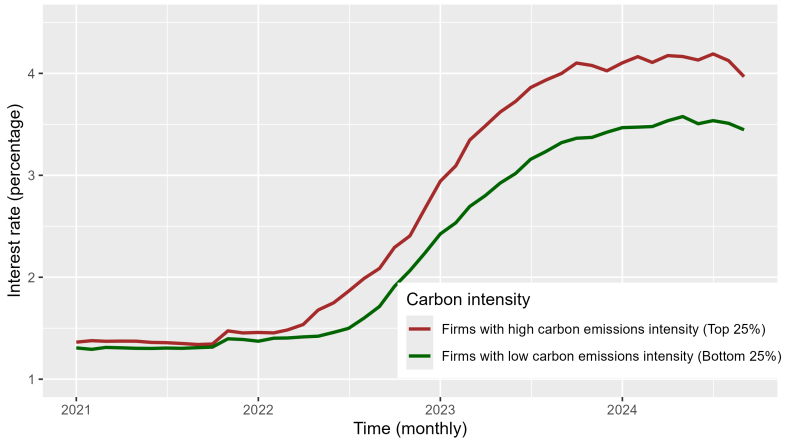
# Descriptive statistics

Figure 2: Interest Rate Differentials by Carbon Intensity

Large definition:
Top 50% vs Bottom 50%




Narrow definition:
Top 25% vs Bottom 25%



# Methodology

- The baseline model is a cross-section OLS as the carbon intensity is not time dependent
- The regressions are saturated with a diversity of fixed effects (time (monthly), bank, firm sector, and sometimes firm, bank-firm, bank-date, firm-date)

$$\begin{aligned}\text{Interest rate}_{b,f,t} =& \beta_1 \text{carbon intensity (log)}_f \\ &+ \beta_2 \text{probability of default (log)}_{b,f,t} \\ &+ \beta_3 \text{maturity (log)}_{b,f,t} \\ &+ \beta_4 \text{non performing status}_{b,f,t} \\ &+ \beta_5 \text{impairment ratio}_{b,ft} \\ &+ \beta_6 \text{protection ratio}_{b,f,t} \\ &+ \beta_7 \text{outstanding amount (log)}_{b,f,t} \\ &+ \theta_{f,t} + \theta_{b,t} + \theta_{b,f,t}\end{aligned} \tag{1}$$

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# Baseline results

- Firms pay an additional 3.8-9.6 bps for each 1 STD of carbon intensity between 2021 and 2024

| | Interest rate | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Carbon intensity | 0.038* | 0.081*** | 0.082*** | 0.087*** | 0.096*** | 0.081*** |
| | (0.020) | (0.024) | (0.024) | (0.026) | (0.024) | (0.024) |
| Probability of default | 0.097*** | 0.096*** | 0.094*** | 0.088*** | 0.093*** | 0.089*** |
| | (0.026) | (0.022) | (0.022) | (0.024) | (0.022) | (0.023) |
| Maturity | 0.100*** | 0.094*** | 0.091*** | 0.098** | 0.084*** | 0.088*** |
| | (0.036) | (0.031) | (0.030) | (0.041) | (0.029) | (0.032) |
| Non-performing loan | −0.072 | 0.011 | 0.013 | 0.041 | 0.095 | 0.039 |
| | (0.176) | (0.112) | (0.103) | (0.103) | (0.098) | (0.083) |
| Impairment ratio | 0.052 | 0.054* | 0.051 | 0.027 | 0.029 | 0.034 |
| | (0.040) | (0.029) | (0.030) | (0.019) | (0.030) | (0.034) |
| Protection ratio | 0.046*** | 0.032** | 0.033** | 0.017 | 0.048*** | 0.038*** |
| | (0.014) | (0.014) | (0.014) | (0.020) | (0.015) | (0.014) |
| Outstanding amount | 0.029 | 0.009 | 0.008 | 0.018 | 0.007 | −0.004 |
| | (0.037) | (0.028) | (0.028) | (0.035) | (0.026) | (0.028) |
| Firm Sector Fixed effects | | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Bank Fixed effects | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Time Fixed effects | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* | *Yes* |
| Bank-Sector Fixed effects | | | | *Yes* | | |
| Sector-Time Fixed effects | | | | | *Yes* | |
| Bank-Time Fixed effects | | | | | | *Yes* |
| Bank controls | | | *Yes* | *Yes* | *Yes* | *Yes* |
| Firm controls | | | *Yes* | *Yes* | *Yes* | *Yes* |
| Observations | 131,653 | 131,653 | 131,653 | 131,653 | 131,653 | 131,653 |
| $R^2$ | 0.490 | 0.556 | 0.565 | 0.705 | 0.624 | 0.653 |
| Adjusted $R^2$ | 0.488 | 0.552 | 0.561 | 0.695 | 0.588 | 0.607 |
| *Note:* | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

# Dynamic estimation

Green firms can be different from brown firms

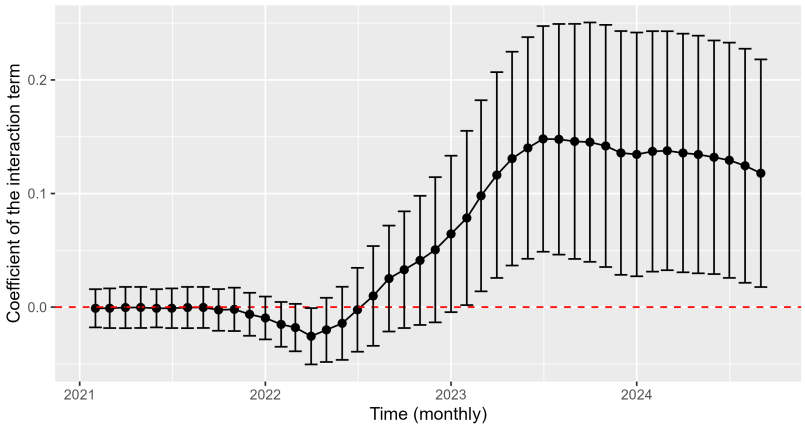
- Introduction of Firm Fixed Effects
- Because of that, no more estimation of the coefficient "Carbon intensity"
- Solution: analyse the impact dynamically. Reference = January 2021

$$\begin{aligned}\text{Interest rate}_{b,f,t} =& \beta_1 \text{carbon intensity (log)}_f \\ &+ \beta_2 \text{carbon intensity (log)}_f \times \alpha_t \\ &+ \theta_{b,t} + \theta_{f,t} + \theta_{b,f,t} \\ &+ \alpha_t + \alpha_b + \alpha_f + \epsilon_{b,f,t}\end{aligned} \tag{2}$$

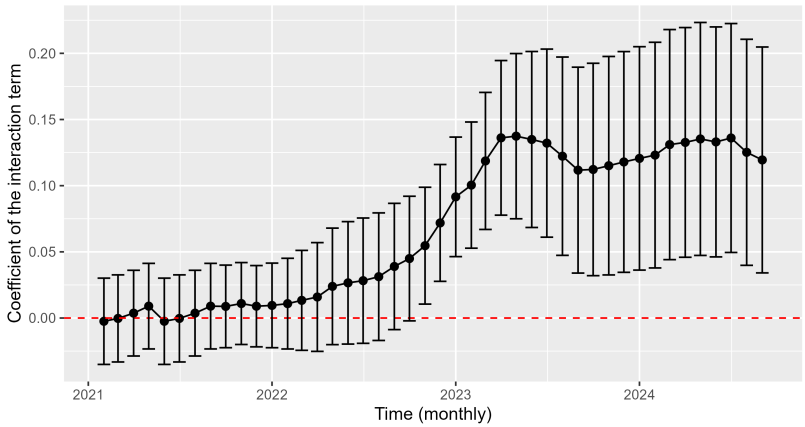
# Dynamic Estimation

- The pricing of climate risk significantly increases starting in Q3 2022 (1 STD = 12 bps).
- The result is robust to a matching procedure between green and brown firms (losest match in terms of default risk and size within the same country, institutional sector and industry): from 131,653 observations to 77,670 observations

## Complete Sample




## Matched Sample

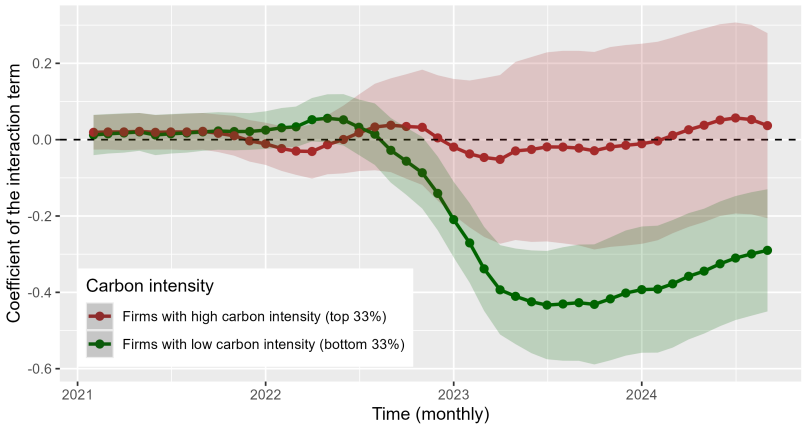



▸ Matching methodology ▸ No impact on credit supply

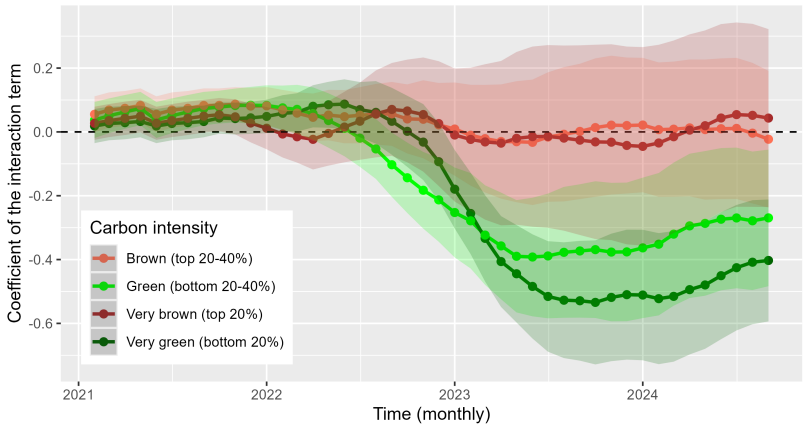
# Green premium or brown penalty

- The sample is divided in 3 or 5 groups based on the distribution of carbon intensity
- Banks support green firms with better loan terms but do not increase costs for the most polluting firms
- Contradicts pure risk management perspective

Decomposition in three buckets




Decomposition in five buckets

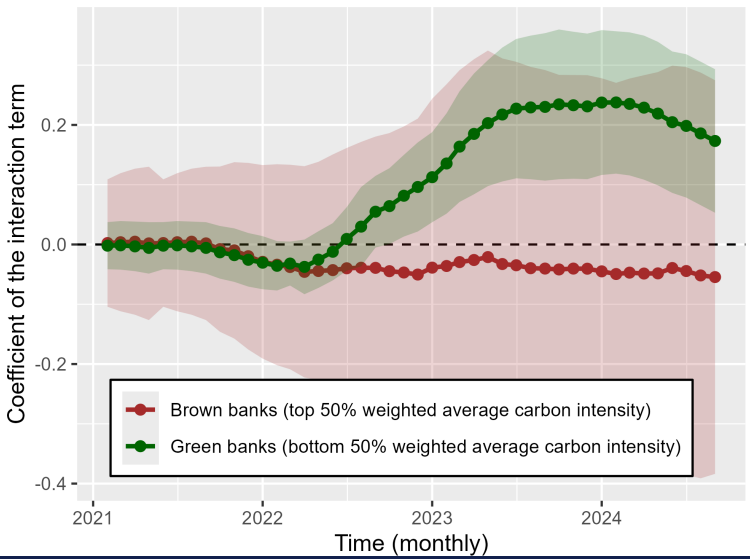


# Do green banks give a higher premium to green firms?

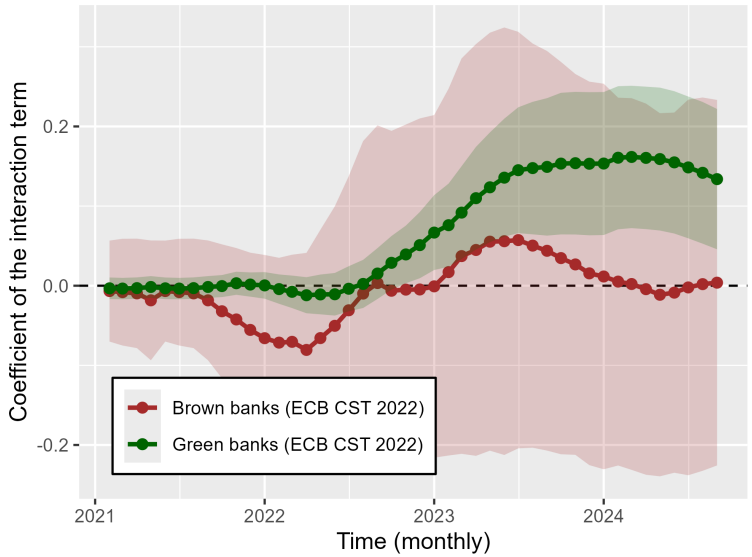
Use of ECB data collection of 2021-2022:

- First approach: banks are classified according to their average carbon intensity of the portfolio at the end of 2020
- Second approach: banks are classified according to their self-declaration on climate interest and climate data capabilities: 20% of banks showed no interest in climate
- Results are similar to Degryse et al. (2023)

Green portfolio end-2020




ECB 2022 ST

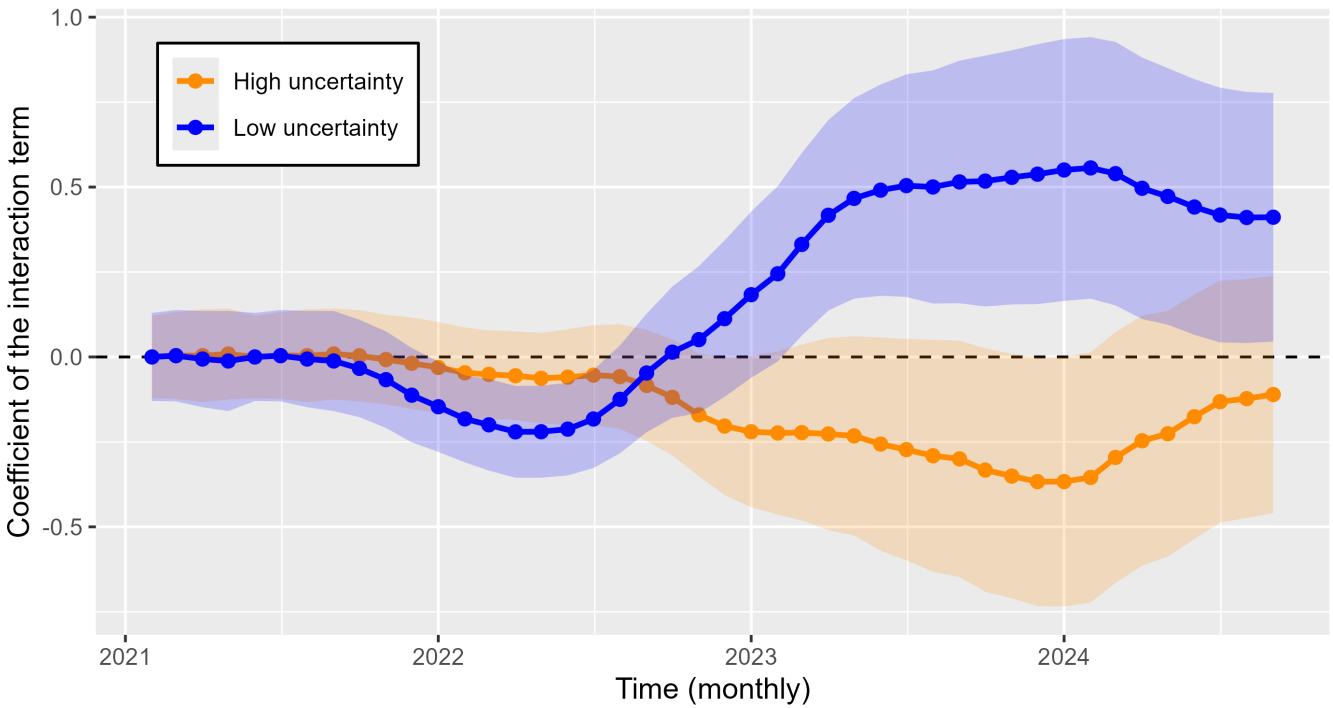


# Uncertainty and climate risk

- According to Berg et al. (2022), there is substantial divergence on what is green between ESG rating agencies. Wang et al. (2024); Zou et al. (2023) show that climate data confusion can impact equity return and bond spread
- Despite the recognition of ESG rating confusion, their effects on the credit market remain inexplored
- I divide the sample into two groups of firms to analyse the impact of green confusion on the pricing of loans to green firms
  - The first group of firms have a standard deviation of carbon emissions reported by all banks lower than the percentile 75 (represented in blue), the second group has a higher standard deviation.
  - Only firms reported by more than 2 banks are considered (3 or 4 banks in the robustness checks)

# Uncertainty and Climate Risk in Banking

- Banks give a lower importance to climate data with high divergence of estimation between data providers in their loan pricing models




▸ Sample to estimate data uncertainty

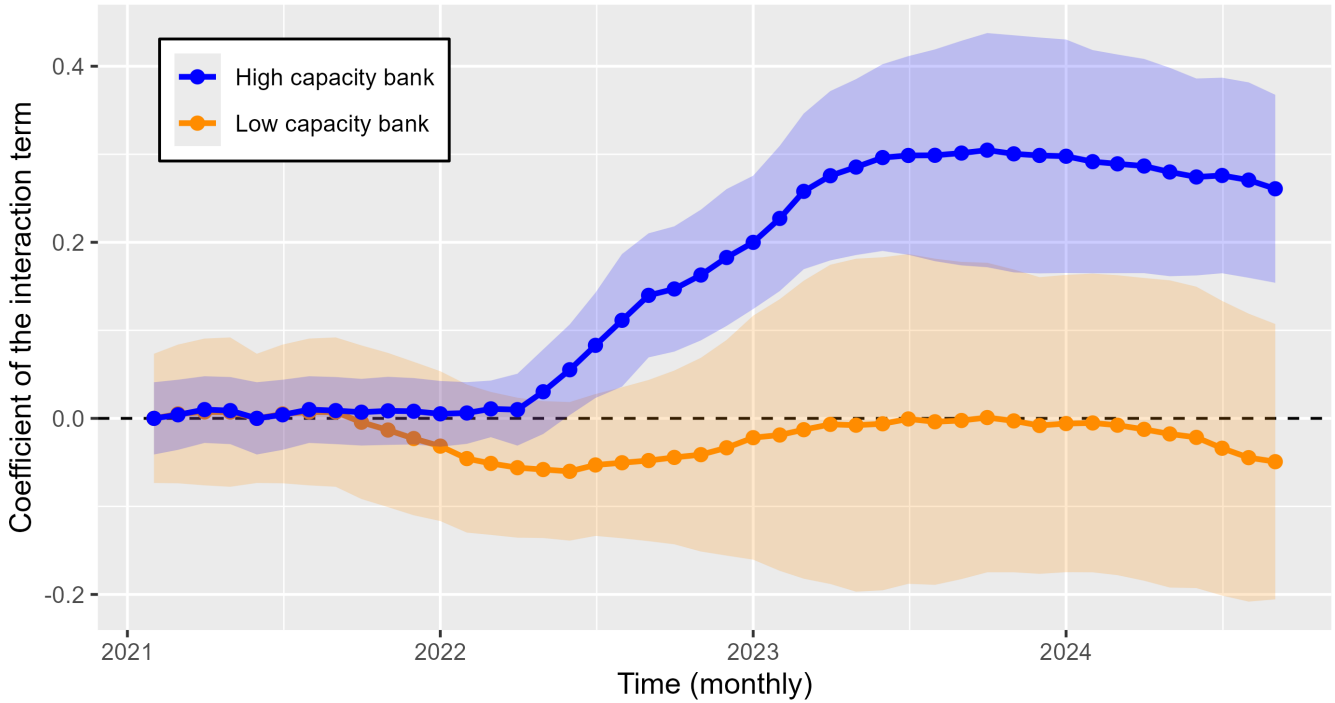
# Capacity to collect climate data

- Some banks may haven't already started to collect climate data and/or didn't integrate them into their systems operationally
- These banks may thus have missing, aberrant or incoherent values in their data reportings
- I use the number of flags given by the ECB to each bank to identify climate incapable banks: I split the sample into two parts based on the median value of flags (97).

# Capacity to collect climate data

- Banks unable to collect climate data (red) do not price carbon emissions when granting loans
- This effect is independent of being a green firm and when controlling for uncertainty

▸ Regression with interaction between green bank and capable bank



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# Conclusion

Novel evidence on how firms exposure to climate-related transition risks - as perceived by banks - affects loan pricing:

- Significant and growing climate risk pricing in European banking since 2022
- "Greenium" of 20-40 basis points for low-emission firms
- Institutional commitment drives effectiveness
- Data inconsistencies and inability to collect climate data create substantial barriers to efficient pricing

Policy implications

- It is not enough to provide incentizes for banks to properly manage climate-related risks, banks also need credible data on climate risks (mandatory audited climate reports with CSRD, BDF climate ratings) and learn how to collect and use it (bottom-up data collection and stress tests).

Aiello, M. A. (2024). Climate supervisory shocks and bank credit lending empirical evidence from microdata.

Altavilla, C., Boucinha, M., Pagano, M., and Polo, A. (2024). Climate risk, bank lending and monetary policy.

Avramov, D., Cheng, S., Lioui, A., and Tarelli, A. (2022). Sustainable investing with esg rating uncertainty. *Journal of financial economics*, 145(2):642–664.

Berg, F., Koelbel, J. F., and Rigobon, R. (2022). Aggregate confusion: The divergence of esg ratings. *Review of Finance*, 26(6):1315–1344.

Degryse, H., Goncharenko, R., Theunisz, C., and Vadasz, T. (2023). When green meets green. *Journal of Corporate Finance*, 78:102355.

Ehlers, T., Packer, F., and De Greiff, K. (2022). The pricing of carbon risk in syndicated loans: Which risks are priced and why? *Journal of Banking & Finance*, 136:106180.

Fuchs, L., Ngyuen, H., Nguyen, T., and Schaeck, K. (2024). Climate stress tests, bank lending, and the transition to the carbon-neutral economy. Technical report, IWH Discussion Papers.

Harrison, C., Partridge, C., and Tripathy, A. (2020). What's in a greenium: An analysis of pricing methodologies and discourse in the green bond market. *Harrison, Caroline, Partridge, Candace and Aneil Tripathy*.

Ho, K. and Wong, A. (2023). Effect of climate-related risk on the costs of bank loans: Evidence from syndicated loan markets in emerging economies. *Emerging Markets Review*, 55:100977.

Javadi, S. and Masum, A.-A. (2021). The impact of climate change on the cost of bank loans. *Journal of Corporate Finance*, 69:102019.

Kacperczyk, M. T. and Peydró, J.-L. (2022). Carbon emissions and the bank-lending channel. *Available at SSRN 3915486*.

Sangiorgi, I. and Schopohl, L. (2021). Why do institutional investors buy green bonds: Evidence from a survey of european asset managers. *International Review of Financial Analysis*, 75:101738.

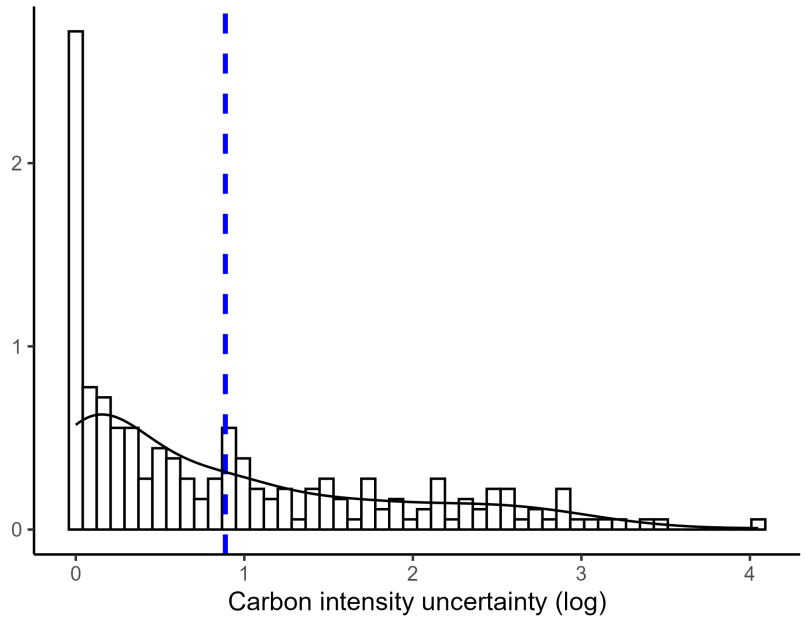
Wang, H., Jiao, S., Ge, C., and Sun, G. (2024). Corporate esg rating divergence and excess stock returns. *Energy Economics*, 129:107276.

Zou, J., Yan, J., and Deng, G. (2023). Esg rating confusion and bond spreads. *Economic Modelling*, 129:106555.

# Green confusion: sample

Table 1: Number of counterparties depending on the number of banks reporting them

| Number of banks reporting a counterparty | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of counterparties reported | 915 | 162 | 52 | 17 | 4 | 3 | 0 | 0 | 1 | 1154 |
| Percentage of counterparties reported | 79.3% | 14.0% | 4.5% | 1.5% | 0.3% | 0.3% | 0% | 0% | 0.1% | 100% |



# Data collections' calendar

| | 2022 data collection | 2024 data collection |
|---|---|---|
| Announcing of the data collection | August 26, 2021 | July 20, 2023 |
| Public hearing | September 14, 2021 | September 28, 2023 |
| Sharing template and template guidance | October 15, 2021 | October 11, 2023 |
| Beginning of data collection | January 21, 2022 | December 1, 2023 |
| First submission | March 7, 2022 | January 23, 2024 |
| Second submission | March 31, 2022 | February 13, 2024 |
| Third submission | Mai 23, 2022 | March 20, 2024 |
| Sharing output report | July 5, 2022 | April 19, 2024 |

# Impact on credit supply

- The primary analysis is on loan pricing, but an alternative regression is estimated to analyse the impact on credit volume (same regression setup)
- **Key finding:** no statistically significant impact in any tested specification.

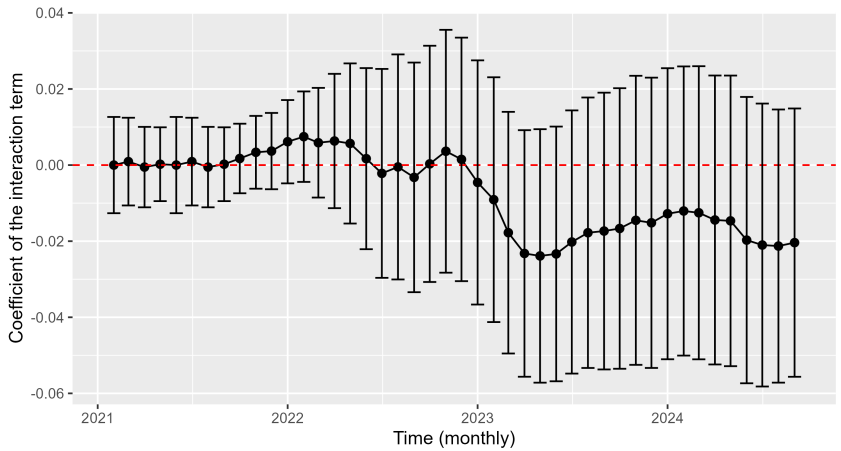



Figure 3: Dynamic OLS results: credit celationship volume

# Matching Methodology: Isolating Climate Risk Impact

**Goal:** Address endogeneity; isolate carbon intensity's effect on loan pricing.

**Approach:** Match green firms with comparable brown firms

1. **Standardize Data:** Default probability  total outstanding amount (log).
2. **Combined Matching:**
   - **Exact Match:** NACE 2 sector, ESA institutional sector, country.
   - **Mahalanobis Distance:** Minimize on default probability  size (log outstanding) *within* exact matches.
   - **Selection:** Green firm $\rightarrow$ closest brown firm (with replacement).
   - **Weighting:** Brown firm weight = number of green firms matched.

# Matching Efficacy: Before vs After

- **Validation:** Compare key firm characteristics (default probability, size) before and after matching.
- **Outcome (2):**
  - **Default Probability:** Strong convergence in the matched sample.
  - **Total Outstanding Amount (Size):** Convergence reduced due to exact matching constraints.

Table 2: Descriptive Statistics: Green vs Brown Firms

| | *6C | | | | | |
|---|---|---|---|---|---|---|
| | **Without Matching** | | | **With Matching** | | |
| **Characteristic** | Green | Brown | Diff. | Green | Brown | Diff. |
| Default prob. (%) | 0.437 | 0.600 | 0.163 | 0.529 | 0.394 | 0.135 |
| Total amount (log) | 19.22 | 18.96 | 0.35 | 19.13 | 18.70 | 0.42 |
| NACE 2 sector | Different | | | Same | | |
| ESA sector | Different | | | Same | | |

# Decomposing Capacity and Greenness

## Table 3: Decomposing capacity and greenness

| | Interest rate | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Carbon intensity:2022 | −0.023 | −0.023 | −0.106 | −0.046 |
| | (0.021) | (0.021) | (0.088) | (0.093) |
| Carbon intensity:2023 | 0.069 | 0.069 | −0.188 | −0.114 |
| | (0.067) | (0.067) | (0.169) | (0.176) |
| Carbon intensity:2024 | 0.030 | 0.030 | −0.214 | −0.142 |
| | (0.071) | (0.071) | (0.173) | (0.182) |
| Carbon intensity:capable bank | −0.117 | | −0.119 | |
| | (0.105) | | (0.109) | |
| Capable bank:2022 | 0.223* | 0.223* | −0.031 | 0.042 |
| | (0.114) | (0.114) | (0.149) | (0.167) |
| Capable bank:2023 | 1.162*** | 1.162*** | 0.062 | 0.121 |
| | (0.263) | (0.263) | (0.726) | (0.762) |
| Capable bank:2024 | 1.387*** | 1.387*** | 0.338 | 0.394 |
| | (0.237) | (0.237) | (0.748) | (0.787) |
| Carbon intensity:capable bank:2022 | 0.162*** | 0.162*** | 0.145 | 0.070 |
| | (0.041) | (0.041) | (0.094) | (0.102) |
| Carbon intensity:capable bank:2023 | 0.275** | 0.275** | 0.364* | 0.308 |
| | (0.107) | (0.107) | (0.204) | (0.219) |
| Carbon intensity:capable bank:2024 | 0.277** | 0.277** | 0.397* | 0.361 |
| | (0.118) | (0.118) | (0.212) | (0.231) |
| Sample | *Greenbanks* | *Greenbanks* | *Brownbanks* | *Brownbanks* |
| Firm Fixed effects | *Yes* | *Yes* | *Yes* | *Yes* |
| Bank Fixed effects | *Yes* | *Yes* | *Yes* | *Yes* |
| Time Fixed effects | *Yes* | *Yes* | *Yes* | *Yes* |
| Bank-Firm Fixed effects | | *Yes* | | *Yes* |
| Bank controls | *Yes* | *Yes* | *Yes* | *Yes* |
| Firm controls | *Yes* | *Yes* | *Yes* | *Yes* |
| Observations | 59,340 | 59,340 | 27,840 | 27,840 |
| $R^2$ | 0.804 | 0.804 | 0.737 | 0.823 |
| Adjusted $R^2$ | 0.797 | 0.797 | 0.731 | 0.816 |