Climate stress tests, bank lending, and the transition to the carbon-neutral economy*

Preliminary Draft, comments are welcome

Larissa Fuchs† Huyen Nguyen ‡ Trang Nguyen § Klaus Schaeck ¶

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Abstract

Does banking supervision affect borrowers' transition to the carbon-neutral economy? We use a unique identification strategy that combines the French bank climate pilot exercise with borrowers' carbon emissions to present two novel findings. First, climate stress tests actively facilitate borrowers' transition to a low-carbon economy through a lending channel. Stress-tested banks increase loan volumes but simultaneously charge higher interest rates for brown borrowers. Second, additional lending is associated with some improvements in environmental performance. While borrowers commit more to reduce carbon emissions and are more likely to evaluate environmental effects of their projects, they neither reduce direct carbon emissions, nor terminate relationships with environmentally unfriendly suppliers. Our findings establish a causal link between bank climate stress tests and borrowers' reductions in transition risk.

Keywords: climate stress test, climate change, syndicated loans, green finance.

JEL Codes: G21, G28, K11.

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†University of Cologne

‡Halle Institute for Economic Research (IWH) and Friedrich Schiller University Jena

§University of Bristol

¶University of Bristol

1 Introduction

Central banks and regulatory and supervisory agencies are at the forefront of the fight against climate change.[1] Draughts and floods pose physical risk, and changing policies and preferences in economic agents' behavior that affect the valuation of assets and liabilities pose transition risk when banks' borrowers are ill-prepared for the decarbonization of their business models. Therefore, supervisory agencies start to conduct climate stress tests to assess the resilience of banking systems to climate change. Despite the key role of supervisory agencies to combat climate change, little is known about whether such efforts facilitate the transition to the carbon-neutral economy.

In this paper, we exploit plausibly exogenous variation in climate stress tests as a proxy for supervisory efforts to tackle climate change and develop a new identification strategy. Our aim is to estimate the effect of banking supervision on borrowers' environmental performance via banks' lending decisions. While climate stress tests are primarily driven by financial stability concerns, we characterize climate stress tests as an information production exercise that uncovers new information about banks' exposure to climate change. We then combine data on climate stress tests with borrower-specific information on carbon emissions.

Our approach is econometrically appealing because it enables us to examine how bank climate stress tests affect lending decisions conditional on borrowers' exposure to transition risk. Our setup also allows disentangling the information value contained in carbon emissions of borrowers from the incremental reduction in information asymmetries available to participating banks from climate stress tests.

[1] Regulation focuses on the development and promulgation of rules under which financial intermediaries operate (Eisenbach et al., 2016), whereas supervision is concerned with the monitoring of financial firms to ascertain compliance with laws and regulations to ensure safe and sound operations. The organization of regulation and supervision varies across jurisdictions, with regulation and supervision being either orchestrated within the central bank or by separate authorities. While climate change affects all dimensions of the regulatory and supervisory environment, climate stress tests are typically performed by supervisory agencies, and we therefore refer to 'supervisory efforts' or 'supervisory actions' to combat climate change in this research.

This information advantage enables improving their understanding, assessment, and management of the long-term consequences of transition risk. In short, we compare bank lending to higher carbon emitters (brown borrowers) with bank lending to lower carbon emitters conditional on whether banks participate in climate stress tests to pin down the role of supervisors' for the transition to the net-zero economy.

We find that climate stress tests inform participating banks' lending decisions above and beyond the available information on borrower-specific exposure to transition risk. Most importantly, high carbon emitters whose banks take part in climate stress tests obtain more credit, albeit at higher loan rates. Such borrowers also take actions to make their business models more resilient toward climate change. In contrast, borrowers whose banks do not participate receive less credit, and show little progress to decarbonize their business models.

While a growing literature examines how banks incorporate climate change into lending decisions (Murfin and Spiegel, 2020; Nguyen et al., 2022; Ouazad and Kahn, 2022), little is known about how borrowers' business models are affected by bank supervisors' actions to address climate change. Borio et al. (2023) argue that it is unrealistic to expect financial institutions to finance the green transition without clear expectation on regulatory changes. By leveraging climate stress test data and combining them with borrowers' exposure to transition risk, our analysis of lending decisions allows establishing a hitherto undocumented mechanism through which supervisory actions affect bank borrowers in their efforts to transform their businesses to the carbon-neutral economy.

Our starting point are theories by Goldstein et al. (2014) that predict stress tests reduce information asymmetries, uncover and release new information, and by Dang et al. (2009) and Gorton and Ordonez (2014) that posit that sudden information shocks trigger information production.

We hypothesize that new information collected during climate stress tests influences how banks lend to brown firms. Changes in bank lending can either facilitate or impede borrowers' transition to the carbon-neutral economy. While borrowers' carbon

emissions allow banks to assess borrowers' transition risk, we argue that participation in climate stress tests causes further reductions in information asymmetries beyond the information obtained via borrowers' carbon footprints. The information-collection exercise of climate stress tests, together with supervisory feedback, deepens and refines these banks' understanding of climate change and the long-term consequences of transition risk. This motivates banks to support borrowers in the transformation of their business models by continuing to provide credit. In contrast, non-participating banks are more likely to evaluate transition risk with a short-term perspective and reduce their exposures to such borrowers.

Our findings underscore that supervisory efforts concerning climate change affect borrowers' actions to make their business models resilient to climate change. We show that high carbon emitters that received loans from climate stress-tested banks are more likely to develop environmental improvement tools, have products produced from environmentally responsible resources, commit in carbon emission reduction targets and are more likely to evaluate environmental effects of their projects, compared to borrowers of non-participating banks. However, such borrowers do not show yet any improvements in total carbon emission or direct carbon emission growth. They neither terminate supply chains with environmentally unfriendly suppliers, nor source more environmentally friendly materials. Funding by climate stress-tested banks is the key driver behind these changes. Despite these borrowers' greater transition risk, banks increase lending to these borrowers by 11% but simultaneously incorporate a transition risk premium of 19 basis points (bsp). Our tests underscore a hitherto undocumented role of climate stress tests beyond the identification of banks' vulnerabilities to climate change. Participating banks' deeper understanding of climate change and transition risk in particular, enables them to support their borrowers on the way to reducing carbon emissions.

Climate stress tests are an ideal vehicle to examine supervisory efforts to address climate change. While similar to financial stability stress tests in terms of resource intensity and objective of identifying vulnerabilities, climate stress tests take a

longer-term horizon to evaluate potential losses when borrower activities do not align with the transition to a carbon-neutral economy. They also do not trigger capital charges, and consequently do not mechanically affect the cost of lending.[2] However, they require participating banks to collect extensive information about exposures to physical and transition risk using scenarios based on carbon prices. This focus on carbon prices reinforces our choice to capture transition risk with borrowers' total carbon emissions. Climate stress tests therefore can also promote the transition towards the carbon-neutral economy because the information acquired during the climate stress tests raises banks awareness for and improves their ability to assess climate transition risks, with corresponding effects on banks' business strategies, risk-management, and governance.

To isolate the causal effect of climate stress tests over and above the information concerning borrowers' transition risk, we built a novel data set. We exploit the first climate stress test whose data are publicly available from the French Prudential Supervision and Resolution Authority (Autorité de contrôle prudentiel et de résolution, ACPR), and combine it with syndicated loan data for banks and borrowers, and merge this information with borrowers' carbon emissions, and data on borrowers' environmental performance from Refinitiv.

The participating nine banking groups operate a universal banking model and represent 85 percent of total assets in the French banking system. Our sample is also representative of other banking systems. Similarly to other European countries, France has a highly developed bank-based financial system with hundreds of smaller banks that, together with foreign banks and a limited number of large institutions supervised by the Single Supervisory Mechanism, provide credit to the economy. These large French banks account for the vast proportion of total assets in the banking system, are represented in our sample, and participated in the climate stress tests. Importantly, the recent availability of data on climate stress tests helps us identify the role of banking

[2]Oehmke and Opp (2022) show that regulating bank capital to address climate risks may not reduce carbon emissions. Higher capital requirements for carbon-intensive borrowers may crowd out lending to green borrowers and increase bank fragility.

supervision for the transition to the carbon-neutral economy, that is distinct from banks' commitments to reducing carbon emissions (Kacperczyk and Peydró, 2021) carbon emission intensity (Ehlers et al., 2020), or news about borrowers harming the environment (Chava, 2014; Anginer et al., 2021).

This research is important because banks in the EU generate more than 65 percent of their interest income from carbon intensive industries European Central Bank (2022). It is therefore crucial to understand how banks respond to this risk and whether supervisors can support the transition to the carbon-neutral economy. Moreover, although many banks already started incorporating sustainability concerns into lending activities, they currently lack detailed business strategies, risk management processes, and governance systems to address challenges related to climate change. They also reveal deficiencies about how to quantify transition risk correctly (European Central Bank, 2022). Our work illustrates how supervisory agencies, via climate stress tests, contribute to reducing uncertainties related to climate change, and influence banks to promote an orderly transition to the carbon-neutral economy. Finally, in contrast to previous studies that document negative effects for borrowers arising from transition risk, our work highlights that banks that participate in climate stress tests reaffirm their commitment to borrowers despite their borrowers' high exposure to transition risk. This finding underscores that banking supervision can actively support the transition to a carbon-neutral economy.

We contribute to several different strands in the literature. First, numerous studies examine how supervisory resources and coverage (Eisenbach et al., 2016; Hirtle et al., 2020; Goldsmith-Pinkham et al., 2016; Ivanov et al., 2022), standards (Kiser et al., 2012; Bassett et al., 2015), intensity (Agarwal et al., 2014; Rezende and Wu, 2014), and enforcement actions affect the performance of banks and their borrowers (Delis and Staikouras, 2011; Danisewicz et al., 2018). We contribute to this literature by estimating how supervisory efforts to address climate change produce new information that enables participating banks to better assess information about borrowers' transition risk and revise lending decisions accordingly.

Second, we also contribute to the literature on stress tests. Morgan et al. (2014) and Flannery et al. (2017) find that stress tests generate valuable information about participating banks. Acharya et al. (2018) and Cortés et al. (2020) show stress-tested banks reduce credit, reallocate lending towards safer borrowers, and raise interest rates for small and medium-sized firms, respectively. Gropp et al. (2019) document that stress-tested banks reduce risk-weighted assets to meet capital requirements, and Kok et al. (2023) find that banks participating in stress tests reduce credit risk. Unlike these studies, our research establishes a direct link from supervisors' climate stress tests to borrowers' actions to make their business models resilient to climate change via banks' lending decisions without triggering capital surcharges. Recently, Acharya et al. (2023) review the current climate stress scenarios employed by regulators and call for more research to be done in this topic to understand the real implications of climate stress tests.

Third, we advance the literature on how banks' lending behavior reacts to climate change. A paucity of studies shows banks respond to information that conveys signals about borrowers' climate change risk by reducing credit supply, charging higher interest rates, or securitizing loans (Chava, 2014; Delis et al., 2019; Anginer et al., 2021; Mueller and Sfrappini, 2021; Müller et al., 2022; Kacperczyk and Peydró, 2021). While our empirical work confirms prior findings that information shocks that signal greater transition risk trigger reductions in credit supply, banks that participate in climate stress tests increase lending. This result is consistent with the view that climate stress tests are a learning exercise for banks' to better understand and assess climate transition risk. They inform banks' business strategies with implications for lending behavior, and, ultimately, they are an important supervisory tool to aid the transition to a carbon-neutral economy. Our results therefore underscore the beneficial effect of conducting climate stress tests that goes beyond their immediate objective of preserving financial stability.

Finally, our work also speaks to the scant literature on the role of financial constraints for firms' propensity to decarbonize their business models. Accetturo et al.

(2022) highlight that credit availability is a key impediment to borrowers' willingness to invest into green technologies. Unlike their work, we show that credit availability increases as a result of banks' participation in climate stress tests, underscoring the real effects of supervisory efforts to tackle climate change.

2 Institutional background

2.1 The French climate stress test

The climate pilot exercise in France, conducted between July 2020 and April 2021, is the first one of its kind. Its findings inform activities by various other central banks and international bodies concerning climate change. The main objectives of the pilot climate exercise are to boost banks' and insurance companies' understanding of climate change risks and strengthen the ability to anticipate and manage such risks in the long run. Another benefit is to identify gaps in terms of data availability related to climate change. Contrary to financial stability stress tests, the pilot exercise does not establish the solvency of the participating institutions. Therefore, the exercise cannot be failed, it does not trigger regulatory capital requirements, and no bank-specific results are published.

The climate stress tests intend to raise awareness for physical and transition risk among financial institutions. However, the exercise uncovered a lack of data concerning physical risk, which requires modelling the impact of rising temperatures between 1.4 and 2.6°C by 2050. One problem arises from the lack of location information of funded or collateralized retail and corporate properties. A further problem arises from lack of data on the location of businesses' production sites and value chains. Both these problems resulted in a focus on transition risk in the pilot exercise.[3] The French setting is therefore particularly well-suited for our analysis that centres on borrowers' environmental risk profiles that convey information about transition risk.

[3]ACPR (2020) states banks‘ assessments of physical risk significantly lagged the analysis of transition risk, reflecting difficulties related to precise information of the geographical location of their exposures.

To establish the effects of transition risk, the climate pilot exercise required banks to simulate three different scenarios based on recommendations by the Network for Greening the Financial System (NGFS) and described in detail in Online Appendix A. The scenarios concentrate primarily on the evolution of carbon prices over a 30-year period from 2020-2050. Although carbon prices are the main drivers of the transition (Bolton and Kacperczyk, 2023), and climate stress tests consequently focus on them, prices of other non-renewable energy sources such as oil, gas, and coal, and any industry using these sources are affected by them (European Central Bank, 2022). Therefore, carbon prices have vast ranging implications for banks and their borrowers. In particular, they affect the long-term viability of borrowers' business models, their creditworthiness, and the values of assets and collateral (Baudino and Svoronos, 2021).

The French climate pilot exercise is forward-looking, follows a bottom-up approach, and combines qualitative and quantitative approaches. The qualitative aspect of the climate pilot exercise highlights the learning dimension for banks and supervisors. Throughout the duration of the exercise, the participating institutions took part in Q&A sessions culminating in bilateral interviews and feedback sessions that helped clarify, refine, and correct risk assessments and issues related to methods, data, reporting consistency, and exposures. Moreover, this process improved banks' understanding of the limits of existing risk management models, bolstered their comprehension of the role of climate change for business models, and mobilised resources to tackle climate change.

The quantitative dimension requires banks to estimate losses they may incur for credit and market risk based on the three transition scenarios, assess their impact, and carry out balance sheet projections. Unlike traditional stress tests that use time frames of three to five years, the French climate pilot exercise takes a long-term perspective from 2020 to 2050 to better accommodate the effects of climate change. It therefore combines a static balance sheet assumption until 2025 with a dynamic balance sheet assumption from 2025 to 2050. The former requires projections for banks' credit risk based on changes in carbon prices applied to loan and investment portfolios. The latter

involves predicting losses using not only changes in carbon prices but also changes in balance sheet composition. This allows analyzing banks' strategies taken to mitigate climate risks by enabling them to consider new risks and corrective actions. Another distinct feature of the exercise is its granular focus. While financial stability stress tests use aggregate asset classes to model expected losses, the climate pilot exercise examines 55 activity sectors to consider heterogeneities across different businesses in the transition to the carbon-neutral economy.

3 Empirical Implications

Our goal of is twofold. First, we aim to establish how the climate pilot exercise initiated by bank supervisors, with its feedback effects to participating banks, shapes banks' view of transition risk and affects lending decisions. Second, we wish to estimate the causal effect of banks' participation in the climate pilot exercise on their borrowers' environmental performance.

3.1 Implications for banks' lending behavior

Of course, it is plausible to expect that the emphasis of the climate pilot exercise on raising banks' awareness for climate risks with feedback sessions and bilateral interviews fosters a profound understanding of climate change in participating banks. Therefore, the climate stress tests have potential to motivate banks to reconsider policies and revenue generation in their lending business with borrowers that display high transition risk, resulting in either favourable or unfavourable adjustments in loan contract terms.

Clearly, the effort of collating data concerning risk exposures generates new and private information that facilitate loan monitoring, and the availability of such information may also trigger loan reviews. Our argument is nested in theories by Goldstein et al. (2014); Dang et al. (2009); Gorton and Ordonez (2014) according to which stress tests and sudden shocks produce new and unique information. It is also consistent with the theory by Diamond (1984) and corresponding empirical evidence

by James (1987), and Lummer and McConnell (1989) that highlight the role of banks for reducing information asymmetries by monitoring borrowers, and, importantly, for using the information to renegotiate loan contract terms.

Moreover, climate stress tests also facilitate information flows with feedback effects for banks, supervisors, and borrowers, and enables revealing and quantifying hitherto undocumented risks. The exercise also reduces opacity related to transition risks. The interactions between supervisors and banks also spread best practices about assessing and managing climate change risks. Banks' participation in the climate pilot exercise may also affect employees' attitudes, beliefs, and values concerning climate change. Further, insights about limits of current risk management models, granular sectoral exposures, insufficient data, and incomplete reporting systems that do not allow assessing climate change risk may result in additional technology investments and greater sensitivity towards climate change risk. Prior work reinforces this view. Hirtle et al. (2020) state that supervisory concerns related to risk management motivate banks to make technology investments. Tarullo (2019) underscores that supervisory expectations related to stress tests encourage banks to upgrade information and risk management systems, boosting the efficiency of lending decisions and allowing more precise assessments of borrowers' transition risk with a long-term perspective.

The specific nature of transition risk further adds to the complexity of assessing borrowers' transition risk. Banks need to consider two key aspects. One, they need to form an opinion about borrowers' ability, willingness, and likelihood to decarbonize their business models, and simultaneously gauge the evolution of carbon-neutral technologies over the maturity of a loan (Bolton and Kacperczyk, 2023; Mueller and Sfrappini, 2022; Müller et al., 2022). Two, the fact that banks generate more than 65 percent of their interest income suggests that banks also need to consider the high dependency from and correlated exposures to carbon-intensive sectors which carries considerable potential for loan losses during the transition process (European Central Bank, 2022). Banks' lending decisions therefore should not only consider current levels of carbon emissions but should also reflect on whether borrowers are able to reduce

carbon emissions in the transition process over the long run, consistent with the 30 year horizon of the climate pilot exercise. Related to this concern, in robustness checks, we also use other measurements of borrowers' exposure to transition risk such as the index developed by Sautner et al. (2023) that also captures opportunities and risks that firms face related to climate change issues, and Reprisk Environmental Index that signals whether borrowers are struggling with the transition to the carbon-neutral economy (Duan et al., 2023).

Against this background, it remains an empirical question whether the reduction in information asymmetries related to borrowers' transition risk arising from the climate stress test triggers changes in bank lending behavior.

If the climate pilot exercise shifts banks' awareness for transition risk towards greater risk-sensitivity, increases uncertainty about borrowers' future cash flows from the projects funded by loans, collateral values, and aggravates concerns about stranded assets, participating banks may initiate reviews of their lending relationships with high-transition risk borrowers. The new information signals acquired during the climate stress test may highlight a systematic underestimation of transition risk, and result in reductions of exposures to borrowers with high-transition risk and higher risk-premiums. Such negative effects from tougher supervision for bank lending have been documented in prior work by Peek and Rosengren (1995), and Ivanov et al. (2022).

On the other hand, the greater awareness for climate change risks with its corresponding investments in better risk management systems, and an evolving culture towards helping borrowers in the transition to the carbon-neutral economy, may dominate the greater risk-sensitivity for these risks. To the extent that the reduction in information asymmetries triggered by the climate pilot exercise results in a favourable updating of banks' beliefs about borrowers' ability to adjust to the carbon-neutral economy, banks may expand lending to such borrowers, potentially at lower loan rates. Supervision could, in line with Chaly et al. (2017), therefore contribute to a stable provision of financial services.

These two countervailing effects will only be reflected in the data as long as other factors, such as resource constraints, executives' personal views on climate change and short-term incentives that shape banks' lending policies, concerns about inflating green bubbles, long-term relationships with high-transition risk borrowers, and legacy assets do not interfere with and mute the information signals gleaned during the climate pilot exercise. Another factor that may dampen the effect of the climate pilot exercise is that higher exposures to climate risks do not attract regulatory capital surcharges. Our empirical estimates will pick up the net effect of these competing forces.

3.2 Implications for borrowers' environmental performance

We next turn to the effect of banks' participation in the climate pilot exercise on their borrowers' environmental performance. Answering this question illuminates a key issue in the debate on climate change – whether the banking sector, and bank supervision more specifically, can help the transition to the carbon-neutral economy.

A widely accepted view among economists is that supervision imposes costs and constraints on banks (Bernanke et al., 2006). Even in the absence of capital requirements as in our setting, these costs and constraints transmit via banks' lending decisions to the real economy (Ivanov et al., 2022). Costs arise from investments in data collection related to climate change risk, enhancements of information and risk management systems, and, importantly, a review of exposures motivated by revisions of the estimates on credit and market risk during the transition process. Constraints come in the form of banks' greater awareness for climate change risks reflected in higher expectations and pressure on borrowers to decarbonize their business models, and banks' anticipation of future capital requirements against climate-related losses that result in reductions in credit supply. In response, it is plausible to expect that borrowers of banks that participate in the climate pilot exercise try to and are encouraged to boost environmental performance.

Whether borrowers of banks participating in climate stress tests indeed boost environmental performance is however also an open question. It is equally plausible that borrowers face formidable obstacles and impediments in the transition to the carbon-neutral economy, and make therefore little or no efforts to make their business models resilient to climate change. Potential challenges range from executives' short-term incentives who delay restructuring business models and shy away from investments that deplete earnings in the short run, lack of control of supply chains, and immaturity of carbon-neutral technologies and infrastructure, to industry-specific reasons where the transition to net zero is difficult to achieve, e.g. in coal mining.

4 Data and descriptive statistics

We combine several different data sets for this research. We start by manually collecting the list of banks that voluntarily participate in the French climate pilot exercise conducted by the ACPR from the Banque de France. The climate stress tests take place on the parent- or headquarter level. We carefully check each bank's name and location details to identify these banks.

Online Appendix B provides an overview of the 9 participants in the climate pilot exercise. They either operate a universal banking model, focus on retail customers, or are public development banks. These banks also display heterogeneities in terms of their commitments to helping the transition to a carbon-neutral economy. Only 4 banks are members of the Science Based Targets Initiative which requires them to set a target for greenhouse gas emissions, 6 of them are members of the Net Zero Banking Alliance in which they commit to lending and investment portfolios with net-zero emissions by 2050, and 3 banks are not members of either one of these initiatives. Six of them are supervised by the Single Supervisory Mechanism of the European Central Bank.

To understand whether banks' participation in the climate pilot exercise affects borrowers' actions to decarbonize their business models, we establish a link between banks and their borrowers via lending activities. We therefore retrieve data on loan

contracts from Thomson Reuters LPC's Dealscan. We include all Euro-denominated syndicated loans provided by all French and non-French banks extended to French borrowers between 2017 and 2023. Syndicated loans are well-suited for our analysis because Gustafson et al. (2021) show that such loans are actively monitored with lead banks demanding information from borrowers on a regular basis. We exclude SIC codes from 6000 to 6999 to remove financial firms, and focus on lead arranger(s) following the approach used by Ivashina (2009). Participants are excluded from our sample because lead arrangers play the key role in setting and negotiating loan terms with borrowers before turning to participant lenders.

Our unit of observation to test bank lending behavior is the loan level. We allocate a loan into the treatment group if the name(s) of the participating bank(s) in the climate pilot exercise matches the name of the lead arranger(s) in the Dealscan data. The control group consists of loans provided by banks headquartered outside France that cannot participate in the climate pilot exercise but supply credit to French borrowers. The benefit of this setup is that we can compare borrowers operating in the same macroeconomic environment that differ in terms of their lenders' awareness and ability to comprehend and assess risks arising from climate change. Excluding French banks that do not participate in the climate pilot exercise from our sample ensures we have plausibly exogenous variation in treatment, suggesting that both the banks' lending decisions as well as the borrowers' actions to decarbonize their business models are orthogonal to the climate stress test. This approach mitigates concerns arising from unobserved heterogeneities and selection issues.

We further augment the loan-level data with bank characteristics using the Dealscan-Compustat link from Schwert (2018) for the period to 2020 and manually check lenders that appear in the sample in the later period. Borrower characteristics are extracted from Compustat Global by manually checking all borrowers' names to identify their GVKEYs and ISINs.

For carbon emissions and environmental performance, we merge our loan level data with Refinitiv. In the robustness check, we also use the Environmental Risk Index

from RepRisk and climate risk exposures as in Sautner et al. (2023) as alternative measurements of the transition risks. Our final sample for the loan-level analyses consists of 993 unique loans that have information on loan amount, spreads, carbon emissions of borrowers, and borrower characteristics such as size and leverage ratios.

Table 1 reports summary statistics for our main variables and Appendix C shows variable descriptions. Our sample consists of 43.8% of loans originated by banks that participated in the climate stress tests. The average loan amount granted to French borrowers over the sample period is 400 million, with an average maturity of 5 years and an average loan spread of 225 basis points.

[Insert Table 1]

Figure 1 shows average carbon emissions across eight industries. Transportation and utilities have the highest carbon emissions (11.12 million tons of carbon dioxide per firm). On the contrary, on average, wholesale trade and agriculture firms have the lowest carbon emissions in our sample.

[Insert Figure 1]

Our ultimate goal is to compare borrowers' environmental performance conditional on their banks' participation in the climate stress tests. For this purpose, we retrieve detailed data from Refinitiv for 2019 to 2022 on 'short-term' and 'long-term' dimensions of borrowers' environmental profiles. As Refinitiv only has annual information on firms' environmental performance, we aggregate information from syndicated loans to the firm-year level to have information on whether a firm gets at least one loan from stress-tested banks at year *t-1* and merge this information into the borrower-year level information from Refinitiv. We consider the fact that borrowers have environmental improvement tools, offer products with environmental responsible uses, have environmental restoration initiatives, commit to reduce carbon emission, set emission reduction targets in production and evaluate environmental effects of their projects, as short-term performance because these actions can be taken quite

quickly. In contrast, we classify changes in Emission Scores, total emissions growth, direct emissions growth, the probability of having supply chain environmental policies, terminations of contracts with suppliers who are considered to be environmentally unfriendly as well as having environmental criteria for material sourcing as longer-term dimensions as it may take longer time until one can observe these changes.

Table 1 illustrates substantial heterogeneity across borrowers' environmental performance. While 46% commit to in CO2 emission reduction, 5% develop a concrete number for how much carbon emissions should be reduced by 2050, 35% have environmental restoration initiatives, and 5% incorporate environmental evaluation in their projects. On average, firms in our sample have an Emission score of 71, total carbon emission growth of 0.3%, direct carbon emission growth of 0.8%, and 28% of our firms terminate contracts with suppliers that are considered environmentally unfriendly. Our final data set for the analyses of borrowers' environmental performance results in 749 observations for 993 French loans from 7 industries between 2017 and 2022.

5 Identification strategy and identifying assumptions

5.1 Empirical Strategy for the relationship between borrowers' exposure to transition risk and bank lending

We start with a simple model that explores the relationship between banks' lending behavior and borrowers' carbon emissions in the absence of climate stress tests for the period between 2016Q1 and 2022Q2. Results from this first step inform us about how banks decide on credit supply and loan pricing depending on changes in firms' exposure to transition risk without the influence of climate stress tests.

$$Y_{lbft} = \beta \times CarbonEmissions_{f,t-1} + \gamma F_{ft} + \theta L_{lbft} + \delta_b + \delta_{lt} + \delta_i + \varepsilon_{lbft}, \quad (1)$$

where Y_{lbft} is the loan volume or loan spread for a given loan by bank b to a borrower f at time t. $CarbonEmissions_{f,t-1}$ is the natural logarithm of total carbon emissions (measured in tons) of firm f the year before; γF_{ft} is a vector of quarterly borrower characteristics including firm size, and firm leverage; θL_{lbft} is loan maturity;

We include bank-fixed effects, δ_b, to capture bank-specific time-invariant effects; δ_{lt} are loan-type times quarter-year fixed effects to ensure that our results do not reflect differences in loan contract features over time such as whether a loan is revolving or a term loan. Loan-type-time-fixed effects also capture the specific demand for each type of loan during our sample period. In addition, industry fixed effects δ_{lt} capture loan demand from specific sector. ε_{lbft} is the idiosyncratic error term. We cluster standard errors at the ultimate bank parent level to reflect that climate stress tests are applied to the parent level of banking groups in France. The main coefficient of interest is β which identifies whether banks change loan volume or spread if borrowers' carbon emissions changes.

5.2 Difference-in-Difference-in-Differences Specification

The ideal setup to establish the causal effects of climate stress tests on bank lending and its corresponding effects on borrowers' environmental performance assigns climate stress tests to banks in a random fashion. The voluntary nature of the French climate pilot exercise therefore constitutes our main empirical challenge. Banks could participate in the climate stress tests for reasons that may correlate with their lending policies and the composition of the loan portfolio. Similarly, it is possible that banks are subject to stakeholder pressure and consequently commit to helping the transition to a carbon-neutral economy (Kacperczyk and Peydró, 2021).

Our most feasible empirical approximation to generate plausibly exogenous variation in the assignment of the climate pilot exercise is therefore to compare the participating (treatment group) banks with non-French (control group) banks that cannot participate in the exercise but also provide credit to borrowers in France, while simultaneously deleting French banks that could have participated but chose not to do so.

Having restricted our sample to stress-tested French banks and non-stress-tested non-French banks, we apply a triple difference strategy. Ultimately, we are interested in the causal relationship between the French climate stress tests and banks' lending behavior towards borrowers with different levels of transition risk reflected in their carbon emissions. We identify this relationship with the following equation:

$$\begin{aligned} Y_{lbft} = {} & \beta_1 \times HighEmitter_f \times Post_t \times Treated_b + \\ & + \beta_2 \times HighEmitter_f \times Post_t + \beta_3 \times HighEmitter_f \times Treated_b \\ & + \beta_4 \times HighEmitter_f + \beta_5 \times Post_t \\ & + \gamma F_{ft} + \theta L_{lbft} + \delta_b + \delta_{lt} + \delta_i + \varepsilon_{lbft} \end{aligned} \tag{2}$$

where $Post_t$ is a dummy variable equal to 1 for the period after the French climate stress test (2020Q3 onwards), 0 otherwise; $Treated_b$ is a dummy taking on the value 1 for a bank participating in the French climate stress tests, 0 otherwise (other EU banks); all other variables are identical as in Equation 1, except for $HighEmitter_f$ which is a dummy variable equal to 1 if the average carbon emissions of borrower f before 2020 is above the median, and 0 otherwise. Using pre-shock measurement of borrowers' carbon emissions allows us to capture the direct effect of climate stress tests rather than the change in firms' risk exposure. Thus, our main coefficient of interest is now β_1 which indicates whether banks that participate in the climate stress tests change loan volume or spread for higher carbon emitters compared to lower carbon emitters, holding everything else constant.

Last, using annual borrower level information on their environmental performance from Refinitiv, we explore the relationship between climate stress test and changes in borrowers' environmental performance. We use the following specification:

$$\begin{aligned} Y_{ft} = {} & \beta_1 \times HighEmitter_f \times Post_t \times Treated_{f,t-1} \\ & + \beta_3 \times HighEmitter_f \times Post_t + \beta_4 \times HighEmitter_f \times Treated_{f,t-1} \\ & + \gamma F_{ft} + \alpha_f + \tau_t + \varepsilon_{ft} \end{aligned} \tag{3}$$

where Y_{ft} captures either short-term adjustments for environmental performance like having environmental improving tools, having products with environmental responsible uses, having Environmental Restoration Initiatives, committing in emission reduction, developing CO2 Reduction Targets, and incorporating Environmental Evaluation into investment projects, or longer-term adjustments such as Emission Scores, Total Emission Growth, Direct Emission Growth, Having Supply Chain Environmental Policies, Termination of Environmentally Unfriendly Suppliers, Materials Sourcing Environmental Criteria of borrower f at time t; $Treated_{f-1}$ is a dummy taking on the value 1 if borrower f received any loan from a stress-tested bank the year before, 0 otherwise; $HighEmitter_f$ is a dummy variable equal to 1 if the average carbon emissions of borrower f before 2020 is above the median, and 0 otherwise.; γF_{ft} is a vector of borrower control characteristics including firm size, and leverage; α_f and τ_t are firm- and time-fixed effects, respectively.

5.3 Parallel trends

A causal interpretation of the parameters in Equation 2 relies on the parallel trends assumption. This assumption states that, in the absence of bank climate stress tests, stress-tested banks and non stress-tested banks provide loans to borrowers of similar environmental risk profiles and that their characteristics evolve in similar fashions. Following the approach by Imbens and Wooldridge (2009) on normalized difference

methodology, we examine anticipatory trends in firms and banks' characteristics. Table 2 shows that changes in carbon emissions of borrowers linked to two groups of banks are similar prior to the climate stress tests. We also go one step further and compare other banks' and firms' characteristics (size, capital ratios, leverage ratios, and profitability) and find that data on both banks and borrowers satisfy the parallel trend assumptions.

[Insert Table 2]

Next, we ask whether changes in bank lending and interest rates to High Emitters compared to Low Emitters from treated and control banks differ sharply before climate stress tests. If it does, one may be worried about green preferences of these two groups of banks. Following the convention in the literature, we test this assumption by inspecting the dynamic effects of climate stress tests on lending to High vs Low Carbon Emitters 3 years before and 3 years after the event date in 2020.

Figure 2 displays treatment coefficients and confirms the picture that emerged from considering normalized differences. We interact $HigherEmitter$ and $Treat$ with a set of yearly dummies using 2020 as the reference point. We find that all coefficients are not significant before the climate stress test event in 2020 and there is no evidence that parallel trends are absent in our sample.

[Insert Figure 2]

6 Results

In the following, we examine the effect of bank climate stress tests on firm outcomes. First, we investigate how banks react to their borrowers' environmental risks. Next, we evaluate the impact of climate stress tests on bank lending to firms with high-transition risks. As part of this analysis, we also explore heterogeneous adjustments by inspecting the role of long-term lending relationships. Finally, we explore whether stress tests and banks' reaction to it trigger behavioral changes among borrowers.

6.1 Bank lending and firms' exposure to transition risk

Table 3 reports the results from estimating Equation (1) using data between 2016Q1 and 2020Q2 when no climate stress tests or bank climate regulations were introduced. Standard errors are clustered at the bank level.

Column (1) and Column(2) show the effect of a firm' carbon emissions on loan volumes (in natural logs) whereas Column (3) and Column(4) look at loan spreads (in natural logs) . In Column (1) and Column (3), we perform the estimation with loan characteristics, bank-fixed effects, loan-type-time fixed effects, and industry fixed effects without any variables controlling for firm characteristics. We include a vector of borrower control characteristics including firm size, and firm leverage in Columns (2) and Column (4). Column (1) reports that, on average, an increase of 1 ton in borrowers' carbon emission is associated with a 7% reduction in loan volume. However, the result is not significant anymore when we control for borrowers' characteristics. Column (3) shows that an increase of 1 ton in borrowers' carbon emissions is associated with 3.8% increase in loan spreads (or 8.5 bps considering the average loan spread in our sample is 224 bps). The result from this exercise illustrates that in the absence of climate stress tests, there is only limited evidence that banks limit their exposure to high transition firms by reducing credit supply and increasing loan rates.

[Insert Table 3]

6.2 Climate stress tests and bank lending

We now turn to our analysis that focuses on how climate stress tests affect bank lending to higher transition risk firms compared to lower transition risk firms.

We estimate Equation (2) and report the results in Table 4. Column (1) and Column (2) report the effect on loan volumes (in natural logs) and Column (3) and Column (4) look at loan spreads (in natural logs). We control for loan characteristics, bank fixed effects, loan-type-time fixed effects, and industry fixed effects in all specifications.

Additionally, we control for borrower characteristics in Column (2) and Column (4), our preferred specifications.

[Insert Table 4]

The estimates for our coefficient of interest, β_1, are significant and positive for both dependent variables. Following climate stress tests, participating banks increase loan volumes significantly by 11- 15% for High Carbon Emitters. They also significantly increase loan spreads by 5.1 to 8.6 % (equivalent to 11 to 19 bps), ceteris paribus. This result indicates that banks also adjust the risk pricing to reflect the greater transition risk in sticking with such brown borrowers. Figure 2 illustrates the effect of climate stress tests each year after the event. We observe that banks take time to adjust their lending and pricing behaviors. Specifically, we only observe the documented effects from second and third year after after climate stress tests.

We do not view our results to contradict previous findings by Kacperczyk and Peydró (2021) that banks reduce credit for high-transition risk firms. In contrast, we propose that climate stress tests with long-term horizons change banks' risk perspective. Instead of immediately reducing exposure to transition risk, stress-tested banks may want to aid borrowers in the transition towards greener activities. Given their exposure to potential financial losses in future if their borrowers fail to adopt their business models for the carbon-neutral economy, they stick with these firms and provide larger loan volumes. To compensate for the greater risk, they in turn demand higher spreads.

If our conjecture of banks' long-term perspective on transition risk holds true, it is plausible to expect that banks stick with their borrowers even more so if they have a long-term relationship with these firms. In Table 5, we revisit our results from Table 4 and look at the role of long-term relationships between banks and borrowers. We assume a long-term relationship exists if the borrower had at least 1 loan from the lead bank over the past 5 years.

[Insert Table 5]

In all our specifications, we include loan and firm control variables as well as bank fixed effects, loan type-time fixed effects, and industry fixed effects. We cluster standard errors at the bank level. Column (2) and Column (4) highlight that participating banks only increase loan volumes for borrowers they maintain a long-term relationship with. The economic magnitude is considerable: loan volumes increase by 22% after the climate stress tests for higher carbon emitters if borrowers gets credit for their relationship banks. For transactional banks, borrowers only get 6.8% more credit after climate stress tests. Relationship banks also charger higher interest rates (6%) whereas banks that have no relationship with brown borrowers do not adjust transition risk pricing.

Taken together, these results offer novel evidence that borrowers whose banks take a long-term perspective about transition risk grant more credit to aid the transition to less environmentally harmful activities to long-term borrowers, but banks simultaneously price the greater risk. Von Thadden (1995) argues banks might tolerate short-term bad results as long as they can extract long-term rents from lending relationships.

6.3 Climate stress tests and firms' environmental performance

Our final set of analyses homes in on the question of whether borrowers whose banks changed loan volumes and spreads changed their behavior in terms of adjusting environmentally relevant dimensions. Table 6 reports the results from estimating Equation 3.

We find our coefficient of interest, β_1, is significant and positive for all short-term adjustments. After getting a loan from a stress-tested banks, higher carbon emitters are 9.8 percentage points (pp) more likely to have environmental improvement tools, 6.8 pp more likely to offer new products with environmental responsible use. They also 27 pp more likely to engage in environmental restoration initiatives, 17 pp more likely

to commit in reducing carbon emissions, and 9 pp more likely to have a concrete target in carbon emission reduction in their production. Finally, they also 3.7 pp more likely to incorporate environmental aspects in evaluating their investment projects.

[Insert Table 6]

In contrast, Table 7 does not show much signs of improvement in longer term dimensions of transitioning towards becoming more environmentally friendly or source environmentally friendly materials. Borrowers of participating banks show little or no signs (yet) of improving their emissions scores or their direct emission growth. They also do not terminate supply chain links to environmentally unfriendly suppliers. If any, we observe that they are less likely to shift towards environmentally more friendly raw materials. However, these results may reflect that these hard dimensions may take longer time to be achieved. We leave this discussion for future findings.

[Insert Table 7]

7 Robustness Checks

7.1 Falsification tests

We perform two falsification tests to establish that the treatment effects are not observable in the absence of our shock. First, we randomly assign stress-tested banks. Column (1) and Column (2) of Table 8 show that the key coefficient is rendered insignificant. Second, assigning the year of the stress test to a non-stress test year leads to statistically insignificant effects in Column (3) and Column (4).

[Insert Table 8]

7.2 Alternative Measurements of Borrowers' Exposure to Transition Risk

One critique for using the level of carbon emissions to gauge borrowers' exposure to transition risk would be that our measurement picks up other firms' characteristics such as size (Aswani et al., 2023). We alleviate this concern by using carbon emission intensities which are calculated as borrowers' carbon emissions divided by borrowers' total assets to assign High vs Low Carbon Emitters. We report the results in Column (1) and (2) of Table 9. Despite this change, we continue to find that treated banks after the climate stress tests increase loan amounts (17%) and loan spreads (7%) for high carbon emitters.

In Column (3) and (4), we consider that carbon emissions do not reflect how well borrowers are in the transition to a low carbon economy. Another confounding factor would be that banks simultaneously evaluate transition risks and physical risks of borrowers at the same time. Thus, we employ the exposure to climate change index by Sautner et al. (2023) to capture net opportunities and challenges that firms face related to climate change issues. The index also captures firms' exposure to both transition and physical risks. Although we lose some observations when using this index, we still detect the same effects as before. Borrowers with higher exposure to climate change get more credit, albeit at higher prices after their banks participated in climate stress tests.

Finally, in Column (5) and (6), we use Reprisk Environmental Risk Index to capture borrowers' transition risk. Previous literature shows that Reprisk is one of the few sources of ESG data that is not subject to green-washing bias because it relies entirely on negative news coverage by external sources (Berger et al., 2020). Our findings remain intact under these alternative measurements of transition risks.

[Insert Table 9]

7.3 Bank characteristics

One may argue that our results are driven by other bank characteristics such as size, capital, and profitability rather than because of climate stress tests. We tackle this issue by gradually introducing sets of bank characteristics to our main regressions and reports results in Table 10. We do not control for these bank characteristics in our main regressions due to the low coverage from the fuzzy merge between the bank level data and Dealscan.

In Column (1), we include bank size which is the natural logarithm of bank total assets. In Column (2), we further include bank capital ratios which are total equity capitals divided by total assets. In Column (3), we include banks' ROA. In all instances, we find our inferences remain unaffected.

[Insert Table 10]

8 Conclusion

Bank supervisors are pressuring banks to protect themselves from the effects of climate change, and this pressure also affects bank borrowers. We exploit data from the climate pilot exercise conducted by the French prudential regulatory agency that serves as a plausibly exogenous shock to these banks' information production efforts to understand climate change and combine it with data on carbon emissions of borrowers to capture their exposure to transition risk. This enables us to investigate how supervisory activities, via banks' lending policies, shape the transition to the carbon-neutral economy and affect borrowers' actions to decarbonize their business models.

By comparing loan contract features and environmental performance from borrowers whose banks participate in the French climate stress test with such outcomes from borrowers whose banks cannot participate, we can establish the causal effect of the climate stress tests on banks' lending behavior, and, ultimately, on borrowers' transition paths.

Our work illustrates that climate stress tests can be viewed as a learning exercise for banks. We show that the climate pilot exercise triggers reassessments of banks' lending policies because it produces new information signals that improve banks' comprehension of the long-run implications of climate change. Therefore, banks are better able to assess borrowers' transition risk. In other words, supervision, in the form of climate stress tests, is valuable as an information collection exercise that has ramifications not just for loan contracting decisions but also for real outcomes.

Our first novel finding is that banks that take part in the climate pilot exercise increase lending to borrowers despite their higher transition risk. While it is plausible for participating banks to facilitate the transition to the carbon-neutral economy, their support to high-transition risk borrowers does not come for free because they raise loan rates at the same time. This result contrasts with banks that do not participate in climate stress tests. These banks reduce credit supply. The latter finding does not seem surprising. Non-participating banks are not required to spend time and effort collecting information about borrowers' transition plans to assess the long-term effects of climate change, and therefore evaluate transition risk with a short-term perspective. What is surprising and, importantly, also encouraging is our result that participation in climate stress tests reverses banks' assessment of borrowers that are considered more exposed to climate transition risk. These banks update their beliefs about borrowers because of the information acquired during the climate stress tests. Rather than reducing credit, participating banks' deeper comprehension of the transition process results a greater willingness to commit funds to borrowers and support their transition to the carbon-neutral economy.

Our second set of novel findings further reinforces this view. The tests of borrowers' environmental performance shows that higher transition risk borrowers of participating banks are more prone to commit to higher carbon emission targets and more likely to evaluate environmental impacts of their projects. The likelihood that they develop environmental improvement tools, produce goods that use environmental responsible resources, engage in environmental restoration initiatives also increases. These positive

developments need, however, to be considered in light of other findings concerning environmental dimensions that are more difficult to adjust in the long run. We neither observe reductions in direct carbon emissions nor do borrowers terminate contracts with suppliers that are flagged as environmental unfriendly.

Taken together, our results illustrate a role of climate stress tests beyond their primary objective of identifying vulnerabilities in the financial system related to climate change. Climate stress tests are valuable because they reduce information asymmetries between banks and borrowers related to how to measure the effect of climate change, and therefore can also be justified on the grounds that they support the transition to a carbon-neutral economy. They boost banks' understanding of transition risk to engage in 'greener' lending and facilitate borrowers' efforts in the process of making their businesses more resilient towards climate change. To that extent, our research helps complete the understanding of the role of banking supervision in the context of climate change.

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Tables

Table 1: Summary statistics

This table reports the summary statistics for the variables used in Equation (1). The initial sample consists of 993 loan observations between 2017 and 2023 from DealScan database matched with borrower financial information from Compustat Global, and borrower environmental performance from Refinitiv, Reprisk, and Sautner et al. (2023). The latter part of the table shows the variables on soft and hard dimensions of firms' environmental profiles. Appendix A provides the variable definitions in detail.

Variable	Mean	Std. Dev.	Min.	Max.	N
Loan-level data					
Loan Amount (Ln)	6.3013	1.238	2.59	9.0974	993
All In Spread Drawn (bps)	224.68	146.70	20	775	993
Treat	0.4381	0.4964	0	1	993
Post	0.3948	0.489	0	1	993
Maturity	4.6545	2.0012	0.1667	14	993
Revolving Loan	0.4048	0.4911	0	1	993
High Emitter	0.5096	0.5002	0	1	993
Carbon Emission (Ln)	6.5614	6.2093	0	15.0454	993
High Climate Change Exposure	0.4682	0.4995	0	1	487
Reprisk ERI	6.9919	12.35	0	54	993
Borrower Size	8.8254	1.4911	3.5359	13.6764	993
Borrower Leverage Ratio	0.3937	0.2426	0.0003	0.9641	993
Firm-level data					
Treated	0.3053	0.4608	0	1	749
Post	0.1997	0.4001	0	1	749
Env. Improvement Tools	0.1934	0.3952	0	1	749
Products with Env. Responsible Use	0.6584	0.4744	0	1	749
Env. Restoration Initiatives	0.3501	0.4773	0	1	749
Emission Reduction Commitment	0.4618	0.4989	0	1	749
CO2 Reduction Production Target	0.0509	0.2199	0	1	749
Env. Project Evaluation.	0.0534	0.225	0	1	749
Emission Score	71.0339	28.328	0	99.875	749
Total Emission Growth (%)	0.2713	23.2075	-47.618	112.59	749
Direct Emission Growth (%)	0.8079	20.3262	-43.85	103.7037	749
Supply Chain Environmental Policies	0.8527	0.3546	0	1	749
Termination of Env. Unfr. Suppliers	0.2887	0.4534	0	1	749
Materials Sourcing Env. Criteria	0.6132	0.4873	0	1	749

Table 2: Comparisons between treated and control Banks

	Treated		Control		Treated - Control
Variable	Mean	SD	Mean	SD	Norm. diff.
Firms' Environmental Performance					
Δ Carbon Emissions (Ln)	0.087	5.217	0.685	6.500	-0.07
Banks' characteristics					
Δ Bank size	0.008	0.027	0.002	0.035	0.14
Δ Equity/Total Assets	-0.000	0.001	0.000	0.004	-0.13
Δ Loans/ Total Assets	0.143	3.698	0.331	0.866	-0.05
Δ Deposits/ Total Assets	0.000	0.005	0.004	0.026	-0.12
Δ ROA	-0.000	0.001	-0.000	0.003	0.02
Firms' characteristics					
Δ Firm size	0.104	1.658	0.130	1.669	-0.01
Δ Leverage	0.011	0.146	0.002	0.181	0.04
Δ ROA	-0.002	0.028	0.002	0.030	-0.10

This table reports statistics of relevant covariates over the pre-shock period (Q1 2017 to Q2 2020) dividing the sample between treated and control banks. The last column reports normalized differences between the treatment and control groups. Normalized differences are calculated as averages by treatment status scaled by the square root of the sum of the variances. An absolute difference smaller than 0.25 indicates that there are no significant differences between the groups. Firm and bank characteristics are reported as the first differences.

Table 3: How do banks respond to firms' carbon emissions

This table shows the relationship between banks' lending behavior and firms' total carbon emissions. *Loan Amount (Ln)* and *Spread (Ln)* are dependent variables. *Carbon Emissions (Ln)* is the firm total carbon emissions from Refinitiv database. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Loan amount (Ln)		Spread (Ln)	
Carbon Emissions (Ln)	-0.072**	-0.036	0.038**	0.015
	(0.034)	(0.045)	(0.015)	(0.019)
Maturity	-0.097***	-0.097***	0.105***	0.127***
	(0.025)	(0.031)	(0.018)	(0.017)
Spread (Ln)	0.385	0.494		
	(0.338)	(0.390)		
Loan Amount (Ln)			0.045	0.055
			(0.038)	(0.041)
Borrower Size		0.356***		0.158***
		(0.075)		(0.053)
Borrower Leverage		1.791**		-1.030***
		(0.840)		(0.223)
Observations	601	601	601	601
Bank FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Loan Type - Time FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.854	0.874	0.963	0.969
Clustering	Bank	Bank	Bank	Bank

Table 4: Climate stress tests and bank lending to brown firms

This table shows the effect of climate stress tests on banks' lending behavior towards brown firms. *Loan Amount (Ln)* and *Spread (Ln)* are dependent variables. *Treated* is a dummy taking on the value 1 if a bank participates in climate stress tests and 0 otherwise. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of borrower f before 2020 is above the median, and 0 otherwise. *Post* is a dummy variable equal to 1 for the period after the French climate stress test (2020Q2 onwards), 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Loan amount (Ln)		Spread (Ln)	
Treat × High Emitter × Post	0.149***	0.112***	0.051**	0.086***
	(0.043)	(0.035)	(0.024)	(0.030)
High Emitter	2.122***	1.649***	0.557**	1.147***
	(0.346)	(0.345)	(0.238)	(0.418)
Treat × High Emitter	-0.067**	-0.048	-0.036	-0.058*
	(0.033)	(0.032)	(0.023)	(0.033)
High Emitter × Post	2.715***	2.106**	-1.195***	-0.278
	(0.442)	(0.834)	(0.255)	(1.134)
Treat × Post	-0.124***	-0.125***	-0.075***	-0.060**
	(0.037)	(0.034)	(0.025)	(0.026)
Maturity	-0.069*	-0.069	0.145***	0.130***
	(0.039)	(0.042)	(0.016)	(0.017)
Spread (Ln)	-0.296	(0.531)		
	(0.241)	(0.251)		
Loan Amount (Ln)			-0.044	-0.024
			(0.047)	(0.037)
Borrower Size		0.170		-0.232
		(0.103)		(0.194)
Borrower Leverage		0.443		-0.773*
		(0.531)		(0.391)
Observations	993	993	993	993
Bank FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Loan Type - Time FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.853	0.853	0.956	0.963
Clustering	Bank	Bank	Bank	Bank

Table 5: The role of lending relationships

This table shows results on the role of long-term relationships between banks and borrowers for the effect of climate stress tests and lending to brown borrowers. *Treated* is a dummy taking on the value 1 if a bank participates in climate stress tests and 0 otherwise. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of borrower f before 2020 is above the median, and 0 otherwise. *Post* is a dummy variable equal to 1 for the period after the French climate stress test (2020Q2 onwards), 0 otherwise. *Long-term Relationship* is a sample with loans granted to firms from banks having at least one loan with the firm in the last 5 years. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Loan amount (Ln)		Spread (Ln)	
	Long-term Rel.	No Rel	Long-term Rel.	No Rel.
High Emitter × Treat × Post	0.222**	0.068*	0.060**	0.042
	(0.107)	(0.038)	(0.027)	(0.059)
Observations	581	412	581	412
Loan Controls	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.672	0.851	0.833	0.848
Clustering	Bank	Bank	Bank	Bank

Table 6: Short-term adjustments in environmental performance

This table reports regression results for whether a borrower with loans from stress-tested banks changes environmental performance from a short-term perspective. Short-term adjustments in borrowers' environmental profiles include *Resource Efficiency Objectives*, *Environmental Management Training*, *Environmental Restoration Initiatives*, *Emission Reduction Commitment*, *CO2 Reduction Goal In Production*, and *Environmental Project Evaluation*. *Treated* is a dummy taking on the value 1 if a borrower has at least 1 loan from climate stress-tested banks after 2020Q2 and 0 otherwise. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of firms f before 2020 is above the median, and 0 otherwise. *Post* is a dummy variable equal to 1 for the period after the French climate stress test (2020 onwards), 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1) Env. Improv. Tool	(2) Product with Env. Responsible Use	(3) Env. Restoration Initiatives	(4) Emission Reduction Commitment	(5) CO2 Reduction Production Target	(6) Env. Project Evaluation
Treat × Post × High Emitter	0.098***	0.068*	0.270***	0.170*	0.092***	0.037*
	(0.031)	(0.035)	(0.079)	(0.096)	(0.031)	(0.022)
Observations	749	749	749	749	749	749
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.513	0.911	0.789	0.374	0.303	0.891
Number of Firms	184	184	184	184	184	184
Clustering	Firm	Firm	Firm	Firm	Firm	Firm

Table 7: Long-term adjustments in environmental performance

This table reports regression results for whether a borrower with loans from stress-tested banks changes environmental performance from a long-term perspective. Long-term adjustments in borrowers' environmental profiles include *Emission Scores*, *Total Emission Growth*, *Direct Emission Growth*, *Supply Chain Environmental Policies*, *Termination of Environmentally Unfriendly Suppliers* and *Materials Sourcing Environmental Criteria*. $Treated$ is a dummy taking on the value 1 if a borrower has at least 1 loan from climate stress-tested banks after 2020Q2 and 0 otherwise. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of firms f before 2020 is above the median, and 0 otherwise. *Post* is a dummy variable equal to 1 for the period after the French climate stress test (2020 onwards), 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1) Emissions Score	(2) Total Emissions Growth	(3) Direct Emission Growth	(4) Supply Chain Policy	(5) Termination of Env. Unfriendly Suppliers	(6) Materials Sourcing Env. Criteria
Treat × Post × High Emitter	2.702	18.032	4.130	0.005	0.046	-0.299***
	(2.666)	(13.082)	(7.152)	(0.024)	(0.065)	(0.059)
Observations	749	749	749	749	739	749
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.906	0.006	0.023	0.879	0.877	0.868
Number of Firms	184	184	184	184	184	184
Clustering	Firm	Firm	Firm	Firm	Firm	Firm

Table 8: Falsification tests

This table explores the effect of climate stress tests on banks' lending behavior towards brown firms but on the basis of a sample that comprises randomly assigned stress-tested banks (*Placebo Treat*) and a sample that assign the year of the stress test to a non-stress test year (*Placebo Post*). *Loan Amount (Ln)* and *Spread (Ln)* are dependent variables. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of firms f before 2020 is above the median, and 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1) Loan amount (Ln)	(2) Spread (Ln)	(3) Loan amount (Ln)	(4) Spread (Ln)
Placebo Treat × High Emitter × Post	0.115	-0.053		
	(0.144)	(0.060)		
Treated × High Emitter × Placebo Post			0.063	0.006
			(0.039)	(0.010)
Observations	993	993	993	993
Loan Controls	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Loan Type - Time FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.845	0.944	0.838	0.982
Clustering	Bank	Bank	Bank	Bank

Table 9: Robustness checks on alternative measurements

This table reports Robustness Checks using different measurements for borrowers' exposure to transition risk including the level of carbon emission intensity, exposure to climate change index by Sautner et al. (2023), and the Environmental Risk Index ERI from Reprisk. *Loan Amount (Ln)* and *Spread (Ln)* are dependent variables. *Post* is a dummy variable equal to 1 for the period after the French climate stress test (2020 onwards), 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Emission Intensity		Exposure to Climate Change		Reprisk Index	
	Loan Amount	Spread	Loan Amount	Spread	Loan Amount	Spread
Treat × Post × High Transition Risk	0.172*	0.072***	0.329***	0.481**	0.215***	0.147*
	(0.099)	(0.026)	(0.105)	(0.202)	(0.064)	(0.074)
Observations	993	993	479	479	993	993
Loan Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Loan Type - Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.816	0.946	0.833	0.827	0.813	0.912
Clustering	Bank	Bank	Bank	Bank	Bank	Bank

Table 10: Robustness tests on bank characteristics

This table explores the effect of climate stress tests on banks' lending behavior towards brown firms controlling for banks' characteristics such as bank size, bank capital ratio, and bank ROA. *Loan Amount (Ln)* and *Spread (Ln)* are dependent variables. *High Emitter* is a dummy variable equal to 1 if the average carbon emissions of firms f before 2020 is above the median, and 0 otherwise. Standard errors are clustered at the bank level and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Loan Amount (Ln)			Spread (Ln)		
Treat × Post × High Emitter	0.359*	0.357*	0.354*	0.617***	0.307***	0.311***
	(0.201)	(0.204)	(0.202)	(0.082)	(0.050)	(0.054)
Lender Size	0.248	0.209	0.139	0.133	0.459**	0.561**
	(0.147)	(0.148)	(0.166)	(0.207)	(0.203)	(0.230)
Lender Capital		-2.371	-4.795		9.035	13.128
		(6.422)	(6.685)		(9.706)	(9.780)
Lender ROA			8.791			-15.681
			(5.314)			(9.314)
Observations	303	303	302	303	303	302
Loan Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Loan Type - Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.777	0.776	0.774	0.734	0.646	0.640
Clustering	Bank	Bank	Bank	Bank	Bank	Bank

Figures

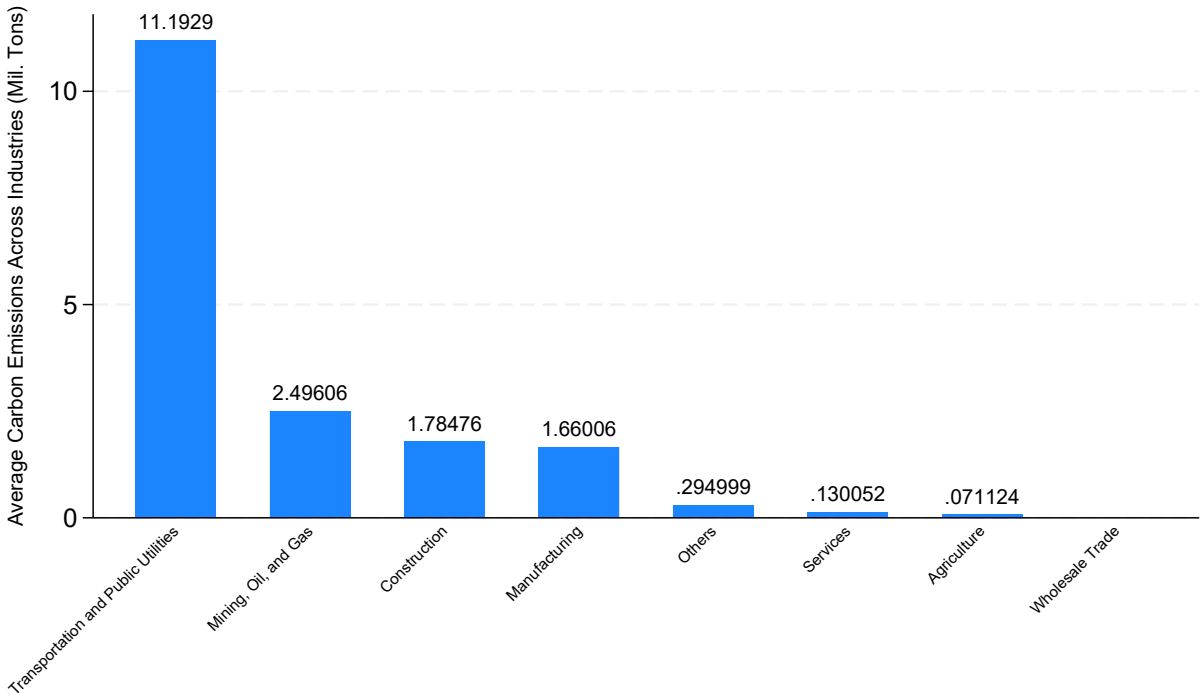

Figure 1: Average carbon emissions across industries

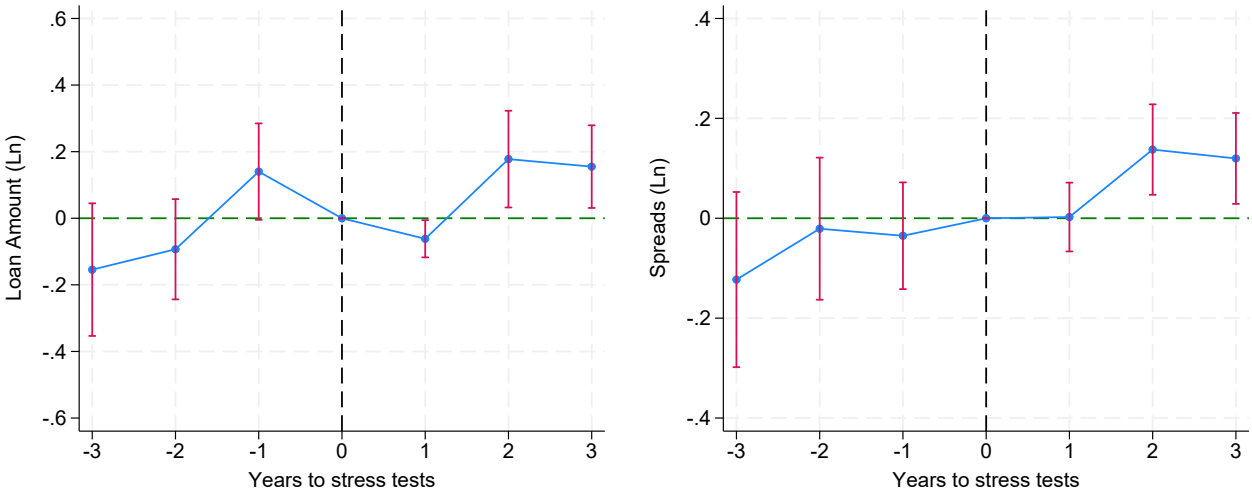

Figure 2: Dynamic effects of climate stress tests on bank lending

Appendix A. French Bank Climate Stress tests

Preceding the stress test exercise, the preparatory phase of the pilot published in April 2019 was based on questionnaires. Despite the voluntary nature of the exercise, 15 insurance and 9 banking groups got involved. Institutions participated as part of a system-wide exercise where scenarios and assumptions were provided by the authorities, a classical bottom-up approach in stress-testing. The 9 banking groups that we focus on cover 85 percent of French banks' total assets illustrating high added value of the sector and underlining the representative nature of results as these groups represent a very significant part of the banking activity in France. Due to the complex interactions with economic and social systems involved, there are several modifications in contrast to standard stress-testing procedures. [4]

First, the exercise adds a forward-looking view of risks over a long-term horizon conditional on the implementation of several alternative scenarios. In particular, the exercise looks at a 30-year horizon ranging from 2020-2050 containing three transition scenarios[5]. Different from the 3-5 years that are considered in traditional stress testing scenarios this period is sufficiently long to integrate the effects of climate change. However, the long time horizon requires a revision of the static balance sheet assumption. Therefore, the pilot exercise combines two assumptions: First a "static balance sheet" assumption until 2025, following a "dynamic balance sheet" from 2025-2050 to analyse the strategies of financial institutions and the actions implemented to mitigate the effects of climate change allowing financial institutions to take new risks into consideration and assess corrective actions. Second, geographical and sectoral scopes are expanded. Due to the fact that the activities of institutions have international impact climate-related risks have to be considered differently based on the geographical areas. Additionally, aggregated asset classes are split into 55 activity sectors allowing for a more granular analysis.

[4] See details here

[5] The network of central banks and supervisors for greening the financial sector (NGFS) serves as a guideline on the construction of climate change scenarios and serves as a basis for two of the scenarios published by the NGFS in June 2020. The third one is a physical risk scenario.

The baseline transition scenario corresponding to an orderly transition is consistent with the narrative of the SNBC, France's roadmap for fulfilling commitments made under the Paris Agreement. It includes a significant increase in the price of carbon where financial institutions face different CO2 emission trajectories. To compare to the baseline, there are two disorderly transition scenarios. The first one is referred to as "late transition". It relies on the assumption that the target for reducing greenhouse gas emissions is not met by 2030 assuming that carbon sequestration technologies are less efficient than expected.

This scenario replicates the aggregate level of emission, carbon price and GDP trajectories of the representative scenario for a "disorderly" transition. It is based on a very high increase in the carbon price in 2030 to maintain carbon neutrality target in 2050 (in particular it rises from 14$ to 704$ per ton of CO2). The second scenario is called the "sudden transition" scenario and combines a sharp increase in the price of carbon that reaches 917$ per ton of CO2 in 2050 and a less favourable evolution of productivity than in the baseline scenario from 2025 onwards. Moreover, renewable-energy technologies are less efficient than expected, implying even higher energy prices and additional investment. It is important to note that contrary to usual stress-testing exercises the scenarios on CO2 emission trajectories do not trigger an economic downturn by 2050 but slower economic growth combining different assumptions in terms of carbon tax trajectories and total productivity levels.

The scenarios on CO2 emission trajectories are based on a set of assumptions modelling the interactions between socio-economic systems and the climate. The three scenarios combine assumptions in terms of trajectory on carbon tax and total productivity levels. The main objective is to measure the consequences of these scenarios that materialise via transition risk on bank balance sheets.

Among the variety of risk categories, they chose to focus on two important financial risks: credit and market risk. For credit risk projections, the banking groups were asked to measure the impact of the various transition scenarios on expected credit

losses. They approximate the annual cost of credit risk[6]. In general, institutions were requested to perform credit risk projections on three portfolios: (i) the corporate portfolio including SMEs; (ii) the retail portfolio; (iii) and the sovereign portfolio using benchmark probabilities of default provided by the ACPR.

Market risk focuses on analysing the impact of financial shocks caused by the implementation of energy transition policies. Specifically, institutions looked at (i) the fair value revaluation of the trading book following an instantaneous market shock induced by the valuation of assets under adverse transition scenarios; and (ii) the impact of market shocks on the counterparty risk in the most sensitive sectors.

Counterparty risk was measured by using the impact of default of the two largest counterparties of the institution. This is especially useful for identifying substantial market positions on carbon intensive counterparties.

[6]expressed in basis points and calculated by dividing the total annualised provisioning flows for each time interval by the average exposure over the same time interval.

Appendix B. Climate stress test participants

Appendix Table B.1. French climate stress test participants

This table shows an overview about business models of 9 banking groups that participated in the French Climate Stress Tests of 2020.

Bank Name	(1) Business Model	(2) Science Based Targets Initiative	(3) NetZero Banking	(4) SSM Supervision
AGENCE FRANÇAISE DE DÉVELOPPEMENT	Public development bank	Not a member	Not a member	No
BNP PARIBAS	Universal bank	Member	Member	Yes
BPCE	Universal bank	Not a member	Member	Yes
CAISSE DES DÉPÔTS	Public development bank	Not a member	Not a member	No
CREDIT AGRICOLE	Universal bank	Member	Member	Yes
CREDIT MUTUEL	Universal bank	Not a member	Member	Yes
LA BANQUE POSTALE	Public retail bank	Member	Member	Yes
SOCIÉTÉ GÈNÉRALE	Universal bank	Member	Member	Yes
SOCIÉTÉ DE FINANCEMENT LOCALE	Public Development Bank	Not a member	Not a member	No

Appendix C Variable Descriptions

Variable	Description	Source
Loan Amount (Ln)	Natural Log of Loan Amount	Dealscan
Loan Spreads	Spread in basis points over Libor	Dealscan
Loan Maturity (Years)	Loan maturity in years	Dealscan
Revolving Loans	Dummy that equals 1 if the loan is revolving, 0 otherwise	Dealscan
Treated	Dummy that equals 1 if a bank participated in the French climate stress tests, 0 otherwise	Authors' Collection
Post	Dummy that equals 1 if after 2020Q3, 0 otherwise	Authors' Collection
High Emitter	Dummy that is equal to one if firms' emissions between 2017 and 2019 is above mean and zero otherwise	Refinitiv
Borrower Size	Natural log of borrowers' total assets	Compustat
Borrower Leverage	Ratio of borrowers' total debts over total assets	Compustat
Borrower ROA	Borrowers' Returns on Total Assets	Compustat
Lender Size	Natural log of borrowers' total assets	Compustat
Lender Capital	Ratio of lenders' equity capital over total assets	Compustat
Lender Deposits	Ratio of lenders' deposits over total assets	Compustat
Lender ROA	Lenders' Returns on Total Assets	Compustat
Env. Improvement Tools	Dummy that equals 1 if a firm reports having at least 1 environmental improvement tool, 0 otherwise	Refinitiv
Products with Env. Responsible Use	Dummy that equals 1 if a firm has at least 1 product that created from environmental responsible resources, 0 otherwise	Refinitiv
Emission Score	Emission scores	Refinitiv
Total Emission Growth	Growth in total emissions	Refinitiv
Direct Emission Growth	Growth in scope 1 emissions	Refinitiv
Resource Efficiency Objectives	Dummy that equals 1 if a firm sets targets or objectives to be achieved on the environmental impact of its supply chain, 0 otherwise	Refinitiv
Env. Restoration Initiatives	Dummy that equals 1 if a firm reports or provides information on sizable company-generated initiatives to restore the environment, 0 otherwise	Refinitiv

Variable	Description	Source
Emission Reduction Commitment	Dummy that equals 1 if a firm commits to carbon emission reduction targets, 0 otherwise	Refinitiv
CO2 Reduction Production Target	Dummy that equals 1 if a firm commits to carbon emission reduction goals in the production process, 0 otherwise	Refinitiv
Env. Project Evaluation	Dummy that equals 1 if a firm evaluates projects on the basis of environmental or biodiversity risks, 0 otherwise	Refinitiv
Supply Chain Environmental Policies	Dummy that equals 1 if a firm reports having environmental related policies for their supply chain, 0 otherwise	Refinitiv
Materials Sourcing Env. Criteria	Dummy that equals 1 if a firm claims to use environmental criteria to source material, 0 otherwise	Refinitiv
Termination of Env. Unfr. Suppliers	Dummy that equals 1 if a firm terminates contracts with suppliers who are environmental unfriendly, 0 otherwise	Refinitiv