Banking on Carbon: Corporate Lending and Cap-and-Trade Policy*

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Abstract

We estimate the effect of carbon pricing policy on bank credit to firms with greenhouse gas emissions. Our analyses exploit the geographic restrictions inherent in the California cap-and-trade bill and a discontinuity in the embedded free-permit threshold of the federal Waxman-Markey cap-and-trade bill. Affected high-emission firms face shorter loan maturities, lower access to permanent forms of bank financing, higher interest rates, and higher participation of shadow banks in their lending syndicates. These effects are concentrated among private firms, suggesting banks are less concerned about the policies' impact on public firms. Overall, banks quickly mitigate their exposure to climate transition risks.

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1 Introduction

Regulators and investors alike anticipate climate change to pose significant risks to the financial services industry, with potential adverse effects on systemic stability.[1] One source of risk is the impact of carbon pricing on the balance sheets of greenhouse gas (GHG) emitting firms and their creditors. The implications of such "transition risks" are currently unknown because most jurisdictions have not implemented climate change policies on a large scale.[2] To the extent that financial institutions have large exposures to GHG emitting firms and limited flexibility to adjust their exposures in a timely manner, climate change policy may adversely impact financial stability. If financial institutions, however, manage their exposure to transition risks appropriately, then such risks should not be seen as a negative externality that prevents swift regulatory action on curbing GHG emissions.

We examine periods of high transition risks when major climate change policies move through the legislative process and identify their effect on corporate lending by exploiting quasi-exogenous variation in regulatory requirements. To assess these effects, we combine facility-level GHG emissions data from the Environmental Protection Agency (EPA) with comprehensive loan-level data on bank lending to private and public firms in the US from the Federal Reserve's Y-14 Collection (Y-14) and the Shared National Credit (SNC) Program.[3] Because cap-and-trade programs are arguably the most prominent climate policy solution to curb GHG emissions, we focus on the two main cap-and-trade bills that have passed or came close to passage in the United States: the California and Waxman-Markey cap-and-trade bills. Both of these bills introduce a legally-binding transition to a low-carbon economy,

[1] A survey conducted by the Bank of International Settlement in April 2020 reports that central banks expect climate change to have potential financial stability implications for the banking system (https://www.bis.org/bcbs/publ/d502.pdf).

[2] Carney (2015) defines transitions risks as *"the financial risks which could result from the process of adjustment towards a lower-carbon economy."* Legislation currently under consideration in the United States Senate requires the Board of Governors of the Federal Reserve System to develop financial risk analyses relating to climate change. Transition risks are explicitly addressed in SEC.3.8 of the bill (https://www.congress.gov/bill/116th-congress/senate-bill/2903/text).

[3] Our data show that lending to high-emission firms in the United States is currently substantial at roughly $750 billion and is concentrated within the largest banks.

and thus, pose transition risks for covered firms. The two bills constitute two independent natural experiments in our study, occurring at different points in time, with firms assigned to treatment and control groups along different dimensions.

We first examine the introduction of California's cap-and-trade bill. In December 2011, California passed the first major cap-and-trade bill of any state in the US, with the cap-and-trade program set to start in January 2013.[4] Therefore, after the passage of the bill but before the effective date of the cap-and-trade program, GHG emitting firms faced substantial transition risks as a result of the unknown effects of the cap-and-trade program. Given this program only affects firms with GHG emissions in California, we estimate the response of firm financing to cap-and-trade policy, and thus transition risks, by varying the fraction of firm emissions in California. We study the response of both public and private firms, using quarterly corporate loan data from the Federal Reserve's Y-14 Collection that is available since 2011.

We find evidence consistent with lenders negotiating loan contracts following the passage of the California cap-and-trade bill in a manner that mitigates their exposure to climate transition risks. Firms that emit a considerable amount of GHGs in California, the treated firms, experience a reduction in loan maturities of approximately 5 months compared to firms with little emissions in California. This reduction is considerable given the average loan maturity of borrowers in our sample is around 30 months. The changes in loan maturity could be explained at least in part by a reduction in permanent forms of bank financing. Specifically, firms with substantial emissions in California exhibit increased reliance on credit line financing at the expense of term loan financing. The share of term loan financing decreases by about 25 percentage points. While we also find that the loans of treated firms face higher interest rates, the total committed credit to these firms does not change significantly.

[4]Following implementation, emissions allowances are bought through auctions or the secondary market. Ex post evidence suggests that high-emission firms had to buy allowances as the auction settlement prices are generally higher than the reservation prices.

These debt structure changes provide lenders with the ability to quickly reduce exposure should firms face difficulties in operating under the cap-and-trade program. Short maturities allow lenders to frequently reevaluate credit relationships (Diamond, 1991; Rajan and Winton, 1995). Unlike term loans, the availability of credit lines is conditional on firms maintaining high cash flow and low credit risk (see, for example, Jimenez, Lopez, and Saurina (2009); Sufi (2009), and Acharya, Almeida, Ippolito, and Perez (2014)), and banks use discretion in preventing small firms from drawing on their credit lines in times of economic and financial stress (Chodorow-Reich, Darmouni, Luck, and Plosser, 2020; Greenwald, Krainer, and Paul, 2020). Further, the higher interest rates are consistent with banks requiring direct compensation for exposure to transition risks.

We complement our results on the California cap-and-trade bill with an analysis of the Waxman-Markey cap-and-trade bill. To date, the Waxman-Markey bill is the federal cap-and-trade legislation that came closest to passage in the US Congress with a peak probability of passage at nearly 60% in 2009.[5] The legislation cleared the US House of Representatives in June 2009, and was under consideration by the US Senate until July 2010. Waxman-Markey carved out an exemption—a "free permit" to emit greenhouse gases—for manufacturing firms with energy intensity exceeding a pre-specified cut-off. This allows us to compare the financing outcomes of manufacturing firms just above and below the free-permit threshold at the end of 2009, when transition risks were high. We are able to isolate the effect of cap-and-trade policy on corporate lending because firms near the free-permit threshold are closely comparable. Our research design is similar to Meng (2017), who studies the economic cost of the Waxman-Markey cap-and-trade program.

As the Y-14 data are not available prior to 2011, we conduct the Waxman-Markey analysis with data from the SNC Program. These data provide comprehensive coverage of the syndicated loan market in the United States. Importantly, despite the different dataset and this second empirical setting differing from the first one in terms of when it occurs and how

[5] This probability is based on prediction markets (Meng, 2017).

firms are split into treated and control firms, we find that the way lenders manage transition risks is qualitatively similar. Firms just below the free-permit threshold experience a reduction in loan maturities of up to 9 months compared to firms just above the threshold after the bill passed the US House of Representatives. Also, while total credit commitments remain unchanged, firms without free permits see a drop in their reliance on term loans and a corresponding increase in credit lines.[6]

These results confirm that corporate lending terms adjust quickly when transition risks are high. For regulators concerned with financial stability, this result is reassuring as it shows that corporate lenders actively manage their exposure to transition risks. However, the results also show that financing conditions for firms exposed to cap-and-trade programs tighten at the same time these firms face potential increases in operating costs from the introduction of carbon pricing. Taken together, these adverse effects may jeopardize the survival of some firms in polluting industries. Therefore, understanding heterogeneity in the effect of cap-and-trade programs on emitting firms is important when designing cap-and-trade programs.

To this end, we show that virtually all of the documented effects are concentrated within the subsample of private firms. In contrast, we observe few significant changes in the debt structure of public firms. The differential effect of cap-and-trade policies on private versus public firms is consistent with private firms facing higher operating costs as a result of cap-and-trade policies. This finding is a potential byproduct of smaller, privately-held companies having greater financial constraints than their public counterparts (Hadlock and Pierce, 2010; Saunders and Steffen, 2011; Mortal and Reisel, 2013; Erel, Jang, and Weisbach, 2015; Ivanov, Pettit, and Whited, 2021). The risks introduced by a cap-and-trade program could amplify such differences, thereby further reducing the ability of private firms to access external finance to change operating activities in anticipation of the cap-and-trade program. Additionally, there could be economies of scale when complying with the new regulation that disadvantages

[6] Unlike the Y-14 Collection, the SNC database does not provide information on interest rates.

smaller private firms. Finally, both anecdotal evidence and our data suggest that smaller private firms have lower emissions efficiency than their public counterparts.[7]

While debt structure is an equilibrium outcome of the negotiation between banks and borrowers, there are unilateral measures that banks can take to reduce transition risk exposure such as selling syndicate loans on the secondary loan market or monitoring borrowers more closely. The SNC data allow us to analyze these two dimensions for the Waxman-Markey cap-and-trade bill. First, we find that banks participate less in the loan syndicates of firms below the free-permit threshold, with shadow banks taking a significantly larger loan share.[8] Second, we find that lenders with large ex ante exposure to high-emission firms reduce their syndicated loan holdings of firms without free permits by more. Finally, firms below the free-permit threshold are more likely to have cash flow covenants in their contracts and more likely to be actively monitored by their lead lenders.

We examine firm balance sheet changes following both the California cap-and-trade bill passage and implementation because the Y-14 data include financial statements for private and public firms. We show that after the passage of the bill, both private and public firms increase cash holdings, likely for precautionary reasons. Private firms increase capital expenditures, potentially driven by equipment or technological upgrades to reduce emissions within California. Following implementation of the regulation, both cash and capital expenditures revert to prior levels, and there are small effects on the profitability of private firms, suggesting ex post adaptation costs were modest.

Overall, by isolating periods of high transition risks around the passage of major cap-and-trade bills, this paper shows that the fluid nature of commercial lending relationships allows banks to adjust their transition risk exposure quickly through loan renegotiation. Further, our findings indicate that banks expect cap-and-trade policy to place a larger burden on private firms and extend current research on the topic, which focuses on public firms. Meng

[7]See, for example, *Here Are America's Top Methane Emitters. Some Will Surprise You*, New York Times, https://www.nytimes.com/2021/06/02/climate/biggest-methane-emitters.html.

[8]Shadow banks are non-bank institutions that are lenders in the primary and secondary syndicated loan markets and include, for example, collateralized loan obligations (CLOs), hedge funds, and mutual funds.

(2017) finds that equity investors of public firms expect only modest economic costs as a result of the Waxman-Markey cap-and-trade bill, which are at the lower end of the distribution of estimates from government agencies and privately-funded studies. Studying the California cap-and-trade program, Bartram, Hou, and Kim (2020) also document a modest impact on public firms as financially constrained public firms are likely to move their emissions out of California into other states. We complement these papers by showing that the effects of cap-and-trade programs on privately-held companies' debt structure are large. Our findings that synthesize banks' expectations of which firms will carry the economic costs of carbon pricing contain valuable insights for the design and implementation of cap-and-trade programs.

An emerging literature investigates how climate risks affect firm financing outcomes. Delis, de Greiff, and Ongena (2019) show that fossil fuel firms with reserves in countries that score high on climate policy indices face higher interest rates on syndicated loans following the adoption of the Paris Climate Agreement of 2015. Seltzer, Starks, and Zhu (2020) find that corporate bonds of firms with poor environmental profiles that operate in US states with stricter environmental regulations pay higher yields and receive lower credit ratings after the Paris Climate Agreement.[9] Antoniou, Delis, Ongena, and Tsoumas (2021) show that when firms are able to store pollution permits, their cost of debt can decrease in the future if they preemptively acquire permits.

Our paper differs from the existing literature in two major ways. First, we study the response of firm financing to the introduction of two well-defined and legally binding regulatory frameworks intended for the transition to a low-carbon economy. Second, our data allow us to distinguish between public and private firms and to comprehensively measure debt contract structure in addition to price, which is crucial for understanding how banks manage transition risks.

Existing evidence on how public and private firms differ in terms of GHG emissions is

[9] Unlike these papers on debt markets, a separate asset pricing literature analyzes how equity and options markets price climate change risks (see, for example, Chava (2014); Bolton and Kacperczyk (2020); Engle, Giglio, Kelly, Lee, and Stroebel (2020); Hsu, Li, and Tsou (2020); Ilhan, Sautner, and Vilkov (2021); Kruttli, Roth Tran, and Watugala (2021)).

limited. Shive and Forster (2020) find that private firms tend to emit less GHG emissions than public firms, while De Haas and Popov (2019) report that a more developed stock market is associated with less emissions. In contrast, we show that private firms face greater difficulty in obtaining financing when required to reduce GHG emissions due to government regulation.

2 Background on the cap-and-trade bills

Cap-and-trade programs are an often discussed solution for curbing GHG emissions and transitioning to a low-carbon economy.[10] Cap-and-trade programs generally cap the total GHG emissions at a threshold that decreases over time. Consequently, a cap-and-trade bill being passed by the legislature introduces the prospect of a legally binding transition to a low-carbon economy.

However, a cap-and-trade program does not explicitly set a price on carbon. Firms get allocated emission permits or need to purchase permits at auctions. These permits can also be traded among firms on a secondary permit market. The goal of a cap-and-trade program is to reduce total GHG emissions but let market mechanisms determine the price on carbon. Thus, the transition risk for firms covered by the cap-and-trade program is twofold. First, there is an ex ante unknown price on carbon. Second, it is unknown how a firm's operations will be affected by a given price on carbon.

2.1 California cap-and-trade bill

The most significant cap-and-trade bill that has been implemented in the United States is the California cap-and-trade program (see, for example, Bartram, Hou, and Kim (2020)).[11] The

[10]Such emissions trading mechanisms are one of the two key forms of carbon pricing policy, the other being a carbon tax (see, for example, https://www.worldbank.org/en/programs/pricing-carbon).

[11]Other cap-and-trade programs that have been implemented in recent years are the European Union's Emissions Trading System and the US Regional Greenhouse Gas Initiative (RGGI). The latter covers a number of Northeastern US states but only caps emissions of utilities.

California cap-and-trade program is the only mandatory cap-and-trade program introduced in any state within the U.S. that covers the majority of firms with high GHG emissions across industries.

The program requires all manufacturing facilities with emissions of more than 25,000 metric tons of carbon dioxide equivalents per year to obtain allowances for their emissions. Carbon dioxide equivalents are defined as the quantity of carbon dioxide that for a given amount of greenhouse gas or mixture of greenhouse gases would generate the same global warming potential. The covered facilities come from a wide range of industries. For example, cement producers, electricity generation, petroleum refining are all covered by the cap-and-trade program.[12] The California Air Resources Board (CARB) is in charge of administering the cap-and-trade program and it obtains and verifies information on each facilities emissions through the Mandatory Reporting Regulation program.[13] Each firm receives some quantity of free allowances to emit greenhouse gases and must purchase the remaining allowances for their operations from quarterly auctions or the secondary market.

The California cap-and-trade regulation was passed by CARB and approved by the Office of Administrative Law on December 22, 2011.[14] The first phase of the program became effective on January 1, 2013, and covered emission from all industries other than fuel suppliers. Emissions from fuel suppliers were set to be covered starting on January 1, 2015.[15] The program's emissions cap was set to decrease by 2 percent annually in 2013 and 2014 relative to the emissions level forecast for 2012. For subsequent years, the emissions cap was set to decrease by 3 percent annually relative to the realized emissions level in 2012. The goal of

[12]Our conversations with the California Air Resources Board confirmed that the range of industries included in the cap-and-trade regulation is so wide that virtually all facilities in California that emit more than 25,000 metric tons of carbon dioxide equivalents per year are part of the cap-and-trade program. A list of the covered industries can be found at https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/guidance/chapter2.pdf.

[13]More information on the California cap-and-trade program can be found at https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

[14]A timeline of the legislative process can be found here: https://www.arb.ca.gov/regact/2010/capandtrade10/capandtrade10.htm.

[15]In practice, the number of firms in California with some fuel-supply emissions is small. These few firms are generally large public firms, for example, Chevron and ExxonMobil.

the cap-and-trade program was to return to 1990 emission levels by 2020.

When the regulation was passed at the of end of 2011, it was unknown how binding the emissions cap would be for covered firms. Lenders and firms were not (fully) aware of the extent to which firms would have to modify production processes to reduce emissions, purchase emission allowances to maintain current levels of emissions, or do both. Additionally, the price of emissions allowances was still unknown at the time of the bill's passage, because the cap-and-trade program does not set an explicit price, but lets the market determine it. All of these unknowns generate transition risks.

The ex post evidence points to high-emission firms having to purchase allowances. In the quarterly auctions since the start of the program, the vast majority of allowances were sold at settlement prices higher than the auction reserve price. The proceeds of these auctions totaled at $24.5 billion up to the first quarter of 2021 and were generated from approximately 330 firms responsible for about 85 percent of California's total GHG emissions.

While this cap-and-trade program only covers a single state in the United States, the economic activity in California is considerable. California had a GDP of $3.1 trillion in 2019, and if California was a sovereign country, its economy would place right behind Germany as the sixth largest economy in the world.[16] Therefore, the introduction of the California cap-and-trade program allows us to study the response of corporate lending to a major economy transitioning away from fossil fuels.

2.2 Waxman-Markey cap-and-trade bill

At the US federal level, no GHG cap-and-trade program has yet been implemented. The cap-and-trade program that came closest to passage in the US Congress was the American Clean Energy and Security Act of 2009, also known as the Waxman-Markey bill.[17] The

[16] This is based on data from the Bureau of Economic Analysis (https://apps.bea.gov/iTable/drilldown.cfm?reqid=70&stepnum=40&Major_Area=3&State=0&Area=XX&TableId=531&Statistic=3&Year=2019&YearBegin=-1&Year_End=-1&Unit_Of_Measure=Levels&Rank=1&Drill=1&nRange=5) and the International Monetary Fund (https://www.imf.org/en/Publications/WEO/weo-database/2019/October).

[17] The text of the bill can be found here: https://www.congress.gov/bill/111th-congress/house-bill/2454/text.

bill passed the U.S. House of Representatives on June 26, 2009, and had a high probability of becoming law while Democrats held a filibuster-proof majority in the Senate and the presidency. The bill ultimately failed to pass in the Senate on July 22, 2010.

The centerpiece of the Waxman-Markey bill was a cap-and-trade program in which the total amount of GHG that can be emitted in a given year would be capped by the federal government relative to GHG emissions in 2005. The cap was set at 3%, 17%, 42%, and 83% below the 2005 emissions level by the years 2012, 2020, 2030, and 2050, respectively. Importantly for the identification strategy discussed in Section 4.2, approximately 15% of all permits would be given for free to selected manufacturing firms covered by the cap-and-trade regulation. These firms could use the free permits to emit GHG. Other manufacturing firms would not receive free permits and would have to buy permits to emit GHG on auctions or the secondary permit trading markets.

Because GHG emitting firms were not required to reduce their emissions by any previous policy, there was significant uncertainty about how firms would be affected by the cap-and-trade policy, and consequently, about the overall economic costs of the Waxman-Markey bill. While the bill was being considered by the US Congress, there was an extensive public debate about the economic cost of the bill, with various sources reporting widely diverging cost estimates. For example, the Heritage Foundation estimated that: *"Cumulative gross domestic product (GDP) losses are $9.4 trillion between 2012 and 2035."*[18] On the other hand, analysis from the Congressional Budget Office (CBO) estimated that *"...the net annual economy wide cost of the cap-and-trade program in 2020 would be $22 billion or about $175 per household."*[19] These diverging estimates reflected the general uncertainty about the impact of the cap-and-trade program on firms.

[18]The Economic Consequences of Waxman-Markey: An Analysis of the American Clean Energy and Security Act of 2009, August 6, 2009. (https://www.heritage.org/environment/report/the-economic-consequences-waxman-markey-analysis-the-american-clean-energy-and).

[19]Estimated Costs to Households From the Cap-and-Trade Provisions of H.R. 2454, June 20, 2009. (https://www.cbo.gov/publication/24918).

3 Data

3.1 Credit data

Our analysis combines greenhouse gas emissions data from the EPA with corporate lending data from the Federal Reserve's Y-14 Collection (Y-14) and syndicated loans data from the Shared National Credit (SNC) Program. Both datasets cover bank borrowing of a wide range of private and public firms. The California cap-and-trade program was signed into law in 2011 and implemented in 2013, which allows us to use the Y-14 data for this analysis. These data have the advantage of providing information on interest rates and capturing bilateral lending in addition to syndicated lending (the SNC data only capture the latter). In other words, the Y-14 data allow us to observe a greater number of smaller firms, typically reliant on bilateral lending, that are covered by the cap-and-trade program. Given the SNC database spans a longer time series than the Y-14 data (1992-present for SNC and 2011-present for Y-14), we use the SNC data for our analysis on the effects of the Waxman-Markey bill while under consideration by the US Congress in 2009-2010.[20]

The Y-14 data come from Schedule H.1 of the Federal Reserve's Y-14Q data collection. The collection contains comprehensive information on the loan portfolio of banks in the United States with total assets exceeding $50 billion.[21] Banks provide granular loan-level data on their corporate loans whenever a loan exceeds $1 million in commitment amount, together with associated financial statement information of the borrower (whenever available). This threshold is considerably lower than the inclusion criteria in the SNC data. For each loan facility, the Y-14 Collection reports the identity of the borrower, loan commitment amount and type, loan interest rate, origination date, maturity date, and drawn amount in

[20] Because the SNC data start earlier than the Y-14 data, we could in theory use the SNC data for the analysis on the California cap-and-trade bill. However, in practice a lot of firms with a large emission share in California only borrow bilaterally, and are thus not covered by the SNC Program.

[21] The panel has grown over time and currently includes 33 institutions. Regulatory changes increased the reporting threshold from $50 to $100 billion as of 2018Q2, thereby leading to the exclusion of four institutions with total assets below $100 billion. Loans in the Y-14 Collection account for roughly three-quarters of total US commercial and industrial lending.

the case of credit lines. We exclude government entities, financials (two-digit NAICS code of "52"), public administration entities (two-digit NAICS code of "92"), utilities (two-digit NAICS code of "22"). Further, we trim the data on maturity and interest rate at the 1% level. We present summary statistics for the Y-14 data used in the analysis on the California cap-and-trade bill in Table 1.[22]

The SNC data come from regulatory reporting associated with the SNC Program, which is an inter-agency agreement among the three main Federal banking regulators – the Board of Governors of the Federal Reserve System (FRS), the Federal Deposit Insurance Corporation (FDIC), and the Office of the Comptroller of the Currency (OCC) – to monitor the syndicated loan market.[23] The SNC program covers all syndicated deals that exceed $20 million and are held by three or more supervised institutions as of the end of each calendar year, which accounts for virtually the entire syndicated loan market.

The SNC dataset contains loan-specific information as of the end of each calendar year from 1992 through 2014 and semi-annual information thereafter. For each loan facility, the data provide the identity of the borrower, including name, industry, and location (state and city), loan type (credit line vs. term loan), loan commitment amount, origination date, maturity date, bank internal risk rating, and drawn amount in the case of credit lines. The SNC data provide a unique opportunity to examine lender responses to cap-and-trade policies because they have complete coverage of the lending syndicate, including shadow bank participation in the syndicate, both at and after loan origination. The summary statistics for the SNC data used in the analysis on the Waxman-Markey bill are presented in Table 2.[24]

[22]See Appendix A in Brown, Gustafson, and Ivanov (2020) for a more detailed description of the Y-14 data.

[23]SNC Program description and guidelines dated May 5, 1998: https://www.occ.gov/news-issuances/bulletins/1998/bulletin-1998-21.html.

[24]Unlike the Y-14 data, the SNC data do not contain information on whether a firm is public or private. To obtain the information on the firm type at the time of the Waxman-Markey bill, we use the historical Compustat dataset and map it to SNC.

3.2 Greenhouse gas emissions

Since 2010, the EPA requires each production facility emitting more than 25,000 metric tons of carbon dioxide equivalents per year to report their emissions. These data comprehensively cover a wide range of industries and a substantial share of total US emissions. Close to 8,000 facilities are required to annually report their emissions. Summing up emissions from these facilities results in approximately 3 billion metric tons of carbon dioxide equivalents, which is around 50 percent of the total US emissions.[25] These emissions data are publicly available on the website of the EPA's Greenhouse Gas Reporting Program.[26] The covered GHGs are Carbon Dioxide, Methane, Nitrous Oxide, and Fluorinated GHGs. The data contain the name and the location of each facility as well as their parent company. By mapping the parent company to the loan data described in Section 3.1, we are able to measure lending to high-emitting firms.[27] The mapping is conducted via a fuzzy string match that is manually verified.

Figure 1 depicts the county-level distribution of high-emission firms in our Y-14 sample as of 2011. For each county, we sum up the emissions of all facilities located in that county. The figure shows that a substantial number of high-emitting facilities are located in California, as indicated by the large number of darker-shaded counties. This geographic distribution suggests that our analysis of California's cap-and-trade regulation is likely to provide valuable insights into the effect of carbon pricing policies on firm financing.

[25] These numbers are based on direct emitters. Indirect emitters, which are facilities that do not generate emissions directly, but produce materials that result in more than 25,000 metric tons of emissions when combusted, are also required to report. Such a facility can be for example a large gas station. We exclude such indirect emitters from our analysis, because they were not covered at the start of the California cap-and-trade program, see Section 2.1.

[26] See https://www.epa.gov/ghgreporting.

[27] A small number of facilities voluntarily report their emissions despite being below the 25,000 metric tons threshold. We exclude these firms due to data quality and selection bias concerns.

3.3 Lending to high-emission firms

We estimate the total credit exposure of banks to high-emission firms using the credit and emissions data. There is substantial interest among policymakers, academics, and investors in understanding the extent to which different types of financial intermediaries hold credit exposure to high-emission firms and whether such exposure is concentrated within a few large financial institutions. These questions have been difficult to answer due to data limitations. While the popular Dealscan database (see, for example, Murfin (2012); Roberts (2015)) contains information on syndicated loans at the point of origination or major renegotiation, it misses subsequent changes in the composition of lending syndicates (Irani and Meisenzahl, 2017) or the utilization of credit lines. The Y-14 and SNC datasets described in Section 3.1 do not have such limitations. Further, these two regulatory datasets allow us to observe lending to both private and public firms.

Figure 2(a) describes the aggregate dynamics in total credit to GHG emitting firms over time for firms that were mapped between the EPA and SNC databases.[28] The aggregate trend in committed credit to high-emission firms is similar to that of all borrowers in the syndicated loan market early in the sample period. Starting in 2014, growth in credit commitments to high-emission firms has slowed down. This slowdown could possibly be due to an increase in attention to climate change. However, it is challenging to test this hypothesis due to the lack of quasi-exogenous variation that would allow for identification. Further, while the growth in credit commitments to high-emission firms have slowed down, Appendix Table A.4 shows that the loan terms of high-emission firms and their risk ratings have remained stable over the sample period. Additionally, Figure 2(b) depicts that the lender concentration has been stable over time. For example, the largest 30 lenders hold close to 90% of all exposure to high-emission firms, while the top 10 lenders hold over 50%. The unchanged terms, risk ratings, and lender concentration are consistent with the absence of a binding policy in the

[28] Details on the emissions of these firms can be found in Appendix Table A.3. Computing the aggregate dynamics with Y-14 data results in a very similar time trend.

US to price carbon emissions at the federal level.

4 Empirical strategy

To the extent that the passage of a cap-and-trade bill increases risks to covered firms because the transition to a low-carbon economy could adversely affect their future profitability, lenders might cut credit or renegotiate loan contracts to gain additional flexibility to adjust exposure quickly should a firm struggle to operate under the cap-and-trade program. Because loan renegotiations occur frequently, bank lenders have the ability to respond to a cap-and-trade bill moving through the legislative process.

There are a number of reasons why loans in the corporate loan market are renegotiated frequently. For example, Roberts and Sufi (2009) show that, on average, commercial loan amounts, maturities, and interest rates are renegotiated once every nine months. Roberts (2015) shows that loan renegotiations happen even more often if one considers additional contract terms such as financial covenants. Financial covenants in loan contracts are set tightly and likely to be tripped, forcing renegotiation (Dichev and Skinner, 2002). Additionally, firms can initiate loan renegotiations to ensure the ability to take on investment projects. For example, capex covenants are typically set tight and frequently renegotiated to allow firms to change or undertake new investment projects (Nini, Smith, and Sufi, 2009). Firms may also initiate renegotiation to relax borrowing base restrictions and ensure availability under credit lines tied to accounts receivable or inventory. We expect that whenever renegotiations happen around the passage of a cap-and-trade bill, lenders are likely to require stricter loan terms for the firms facing the transition risk than for control firms. While firms may have incentives to renegotiate less during times of high transition risks, the highly state-contingent nature of bank loans described above is unlikely to allow firms to significantly reduce renegotiation.

We examine the impact of the cap-and-trade bills along the following major contract dimensions: the natural log of a firm's total loan commitments, a firm's weighted average remaining maturity, the share of a firm's total loan commitments that are in the form of term loans, and the weighted average interest rates on a firm's loans. Our analysis is conducted at the firm level because the renegotiation process typically affects all loans to a given borrower.

By examining these contract dimensions, we assess how banks manage transition risks. First, by analyzing the response of total credit commitments to cap-and-trade policy, we test whether lenders reduce exposure to high-emission firms when facing climate policy uncertainty. Second, we also test whether banks manage transition risks by gaining additional flexibility to cut credit in the future. Shortening loan maturity allows banks to maintain flexibility and greater bargaining power during the loan renegotiation process (Flannery, 1986; Diamond, 1991; Rajan and Winton, 1995). In addition, banks can gain additional flexibility by lending via credit lines instead of term loans, as credit lines generally have tight financial covenants and their availability is conditional on firms maintaining high cash flow (Sufi, 2009; Acharya, Almeida, Ippolito, and Perez, 2014). Further, Chodorow-Reich, Darmouni, Luck, and Plosser (2020) and Greenwald, Krainer, and Paul (2020) show that smaller firms may lose access to credit lines in times of stress.[29] Finally, lenders could also increase loan interest rates as compensation for holding transition risk.[30]

Importantly, changes to loan contract terms represents an equilibrium outcome arrived at during the negotiation process between banks and firms. While banks might try to gain additional flexibility to renegotiate contracts in the future, firms would bargain for contract terms that are more likely to insulate them at least in part against the uncertainty of operating under a cap-and-trade program. Therefore, the direction and magnitude of changes in loan contract terms in response to the introduction of cap-and-trade programs is ultimately an empirical question.

[29]This is in contrast to evidence on public firms that generally shows that large public firms draw on credit lines in periods of distress (Ivashina and Scharfstein, 2010).

[30]The Y-14 data used for our analysis on the California cap-and-trade bill has interest rate information, while the SNC data used for the Waxman-Markey analysis does not. The Y-14 data are available starting in 2011, and cannot be used for the Waxman-Markey analysis.

4.1 Research design for the California bill

Our goal is to test how the passage of the California cap-and-trade bill affects the availability and the terms of credit extended to firms covered by the cap-and-trade program. To this end, we use a difference-in-differences specification, where we split firms into treated and control firms based on the geographic location of a firm's GHG emitting facilities. Importantly, all the firms in the sample have been mapped between Y-14 and the EPA datasets described in Section 3. Therefore, all these firms own high-emission facilities. However, the firms differ in terms of where the facilities are located.

Using the EPA data, we identify whether a firm has production facilities in California and calculate the fraction of the firm's total emissions that come from the California facilities:

$$CA\_Emissions_i = \frac{\sum_{k_i=1}^{K_i} FacilityEmissions_{k_i} \times I_{k_i \in CA}}{\sum_{k_i=1}^{K_i} FacilityEmissions_{k_i}}, \tag{1}$$

where k_i is a facility of firm i, and $I_{k_i \in California}$ is an indicator variable that takes the value 1 if facility k_i is located in California. Figure 3 illustrates the identification strategy and shows that a given firm is considered treated whenever the value of $CA\_Emissions_i$ is larger than a pre-specified threshold.[31] Firms with $CA\_Emissions_i$ below the threshold act as control firms.

The cap-and-trade program is more stringent for a firm emitting a greater fraction of its total emissions in California because such a firm would have to pay a price on a larger share of its emissions. Therefore, we estimate the following regression with data from the Y-14 collection:

$$y_{i,q} = \lambda I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}} + Controls_{i,q} + \psi_i + \phi_{q,ind} + \epsilon_{i,t}, \tag{2}$$

[31] As discussed in Section 2.1, the cap-and-trade bill states that fuel-supply emissions are only covered starting on January 1, 2015, instead of January 1, 2013, as for the other industries. Therefore, we exclude emissions from fuel supply from the EPA data used in this analysis. As otherwise, this delayed treatment of fuel suppliers would distort the analysis.

where q is a quarter. The dependent variables of interest are a firm's weighted average remaining maturity, term loans as a share of total loan commitments, the natural log of a firm's total loan commitments, as well as the weighted average loan interest rates. We restrict the quarterly sample to a pre-period that includes 2011 Q3 and 2011 Q4 and, to avoid quarterly seasonal variation in bank lending to corporate borrowers (see, e.g., Murfin and Petersen (2016)), a post-period that includes 2012 Q3 and 2012 Q4.[32] For this difference-in-differences analysis the "treatment" variable is an indicator that takes the value of one whenever a firm's GHG emissions in California as a fraction of its total emissions exceed 25% or 50%, respectively. We then interact the treatment variable with a "post" indicator variable that takes the value one for 2012 Q3 and Q4. In other words, we compare firms before the bill's passage (in the second half of 2011), to the same firms after the bill's passage (in the second half of 2012). Because the cap-and-trade program started in January 2013, the second half of 2012 should capture the time period when transition risk was the highest. At that point, the transition was set to occur, but neither firms nor lenders had any information on how the firms will operate under the cap-and-trade program. Information on the profitability of firms under the cap-and-trade program slowly arrived once the cap-and-trade program entered the implementation phase in 2013.

The control variables include credit rating fixed effects representing the most conservative rating assigned to each firm by its bank lenders.[33] We include industry-quarter fixed effects based on the 4-digit NAICS code of each firm. After the inclusion of these fixed effects, the comparison between treated and control firms happen within a given industry, which is important as the GHG emissions of a production process vary widely by industry. The inclusion of firm and industry-quarter fixed effects in the regression subsume the uninteracted terms $I_{CA\_Emissions_i > 50\%}$ and $I_{\text{Post CA bill}}$. Given the geographic nature of our treatment, we

[32] Bertrand, Duflo, and Mullainathan (2004) show that limiting the number of time periods included in a difference-in-differences estimation helps avoid the issue of serially correlated errors.

[33] Our measure of credit risk relies on banks' internal ratings for each borrower. As banks use different rating scales, banks are also required to convert their own internal rating scale to a ten-grade S&P scale in order for the measure to be comparable across banks. See Adelino, Ivanov, and Smolyansky (2020) for more detail on banks' internal risk models.

cluster standard errors by the state in which the firm has most of its emissions (Abadie, Athey, Imbens, and Wooldridge, 2017).

4.2 Research design for the Waxman-Markey bill

While the California cap-and-trade program was implemented in 2013, the Waxman-Markey bill cleared the U.S. House of Representatives on June 26, 2009, but ultimately failed to pass in the Senate on July 22, 2010. Despite that, the Waxman-Markey bill is the first federal cap-and-trade program that came close to passage. Such a federal cap-and-trade program would likely have been more binding than a state-level program because firms may be able to avoid state regulation by relocating emitting activity out-of-state (Bartram, Hou, and Kim, 2020).[34] Further, Meng (2017) shows that after the bill passed the House, prediction markets implied a considerable probability, exceeding 50%, of the bill also passing the Senate. Under Waxman-Markey, a subset of manufacturing firms covered by the cap-and-trade regulation would have received approximately 15% of total permits of the cap-and-trade program for free. Following Meng (2017), we use this distinct feature of the bill granting free permits to manufacturing sectors (based on 6-digit NAICS codes) that had energy intensity exceeding 5% and trade intensity exceeding 15% between 2004 and 2006.[35,36] This feature of the bill allows us to estimate a difference-in-differences regression constructing the treatment and control groups with firms around the 5% energy intensity threshold as certain manufacturing sectors fall just below and just above the 5% energy intensity threshold, while being above the 15% trade intensity threshold.[37] Specifically, there should be greater risks about the economic outcomes of firms that do not receive free permits relative to firms that are granted

[34]See also Giroud and Rauh (2019) for an example of firms locating in states with the most favorable corporate income tax rates.

[35]Energy intensity is defined in SEC.763(b)(2)(A)(ii)(II) of the Waxman-Markey bill as *"... dividing the cost of purchased electricity and fuel costs of the sector by the value of the shipments of the sector, ..."*. Trade intensity is defined in SEC.763(b)(2)(A)(ii)(II) of the Waxman-Markey bill as *"... calculated by dividing the value of the total imports and exports of such sector by the value of the shipments plus the value of imports of such sector, ..."*.

[36]We thank Kyle Meng for making these data available on his website.

[37]The trade intensity threshold conditional on being above the 5% energy intensity threshold leaves too few observation for a separate analysis (Meng, 2017).

free permits. Figure 4 illustrates the identification strategy described above.

We use data from the SNC Program for this analysis. Given these data are annual and reported as of year-end, we estimate a baseline regression with two time periods, 2008 and 2009. At the end of 2008, the Waxman-Markey bill was still in the proposal stage and had not been voted on in either chamber of the US Congress. At the end of 2009, the Waxman-Markey bill had just passed the US House of Representatives, was under consideration in the US Senate, and had significant probability of becoming a law.

Our baseline regression is a difference-in-differences specification that takes the form

$$y_{i,t} = \lambda I_{i \in Treated} \times I_{t=2009} + Controls_{i,t} + \psi_i + \phi_t + \gamma_b + \epsilon_{i,t}, \quad (3)$$

where $t = \{2008, 2009\}$, and the variable of interest is the interaction between $I_{i \in Treated}$, which takes the value one if firm i does not receive a free permit under Waxman-Markey and zero otherwise, and an indicator variable that takes the value one in 2009. The dependent variables of interest are again a firm's weighted average remaining maturity, share of term loans, and the natural log of a firm's total loan commitments.[38] Our sample only includes two time periods: 2008 is the pre-period and 2009 is the post-period. We consider two bandwidths around the free-permit threshold of 5% energy intensity. The baseline bandwidth includes firms in manufacturing 6-digit NAICS industries that have an energy intensity between 2% and 8%. The wide bandwidth includes firms in manufacturing 6-digit NAICS industries with an energy intensity between 1% to 9%. Table A.5 in the Appendix shows the energy intensity distribution across sectors. The inclusion of firm and time fixed effects in the regression subsume the uninteracted terms $I_{i \in Treated}$ and $I_{t=2009}$. As in the California analysis, the controls include a firm's credit rating assigned by its lead lender.[39] Because in the syndicated loan market the primary relationship-holder is the lead bank (or the administrative agent),

[38]Unlike the Y-14 data, the SNC data do not include interest rate information.

[39]We include four rating indicator variables in our specifications each of which corresponds to the following risk rating categories: 'special mention', 'substandard', 'doubtful', and 'loss'; 'pass' rating is the omitted category.

we also include lead bank fixed effects. Given that treatment is based on industry, we cluster standard errors by the 6-digit NAICS code of each firm.

5 Baseline results

5.1 The California cap-and-trade bill and credit terms

To answer the question of how banks manage transition risks, we first present estimates of the impact of the passage of the California cap-and-trade bill on firm-level credit outcomes. To the extent that the cap-and-trade program introduces risks about the profitability of affected firms, banks may renegotiate the loan contracts of affected firms to account for such risks. Specifically, banks could either reduce credit commitments or gain flexibility to cut their exposure in the future should firms struggle to operate under the cap-and-trade program. Lenders can gain such flexibility by reducing loan maturities or lending via credit lines instead of term loans. Finally, lenders may increase loan interest rates as compensation for taking on transition risk. Importantly, these approaches to manage transition risks are not mutually exclusive.

Table 3 shows the results from estimating equation (2). Panel A examines the effect on loan commitments. The coefficient estimates for the 25% and 50% California-emissions thresholds are close to zero and insignificant with and without controls. This result suggests that banks do not manage the transition risk stemming from the passage of the cap-and-trade bill by immediately cutting credit to firms covered by the program.[40]

In Panel B, we study the impact on remaining maturity (in months). The estimates are highly significant and negative for all the specifications. The remaining maturity of firms with a substantial share of their GHG emissions in California decreases by 4 to 6 months. This decrease is economically significant as the average maturity in our sample is approximately 30 months, as shown in Table 1. We also find a negative and highly statistically significant

[40]Credit utilization is also unchanged as discussed in Section 6.6.

effect on firms' reliance on term loans as a fraction of total commitments (Panel C). The average term loan share decreases by about 0.25 for firms with substantial GHG emissions in California, which suggests that banks gain flexibility in reducing exposure to such firms by switching term loan lending to credit line lending.[41]

5.1.1 Private and public firms

The previous results provide insights into how banks manage transition risks and into the associated changes in financing conditions for firms covered by a cap-and-trade program. When designing cap-and-trade programs, it is also important to understand the types of firms that face tighter financing conditions as a result of such programs. To investigate potential heterogeneity in the above results, we test if private (smaller) firms are differentially affected compared to public (larger) firms.

A few factors suggest that financing conditions could tighten more for private than for public firms. First, existing studies highlight differences in financing access between private and public firms (Hadlock and Pierce, 2010; Saunders and Steffen, 2011; Mortal and Reisel, 2013; Erel, Jang, and Weisbach, 2015; Ivanov, Pettit, and Whited, 2021). The risks introduced by a cap-and-trade program could further amplify such differences. Additionally, private firms are generally smaller than public firms, and there could be economies of scale when complying with the new regulation. Finally, anecdotal evidence suggests private firms could be more emissions inefficient. For example, the New York Times writes: "*Oil and gas giants are selling off their most-polluting operations to small private companies. Most manage to escape public scrutiny.*"[42] In the emerging literature on the pricing of transition risk, private firms are typically ignored due to the lack of data. While data on public firms' finances are readily available through mandatory public disclosures, private firms are opaque,

[41] In the Y-14 sample, the vast majority of loans are either in the form of term loans or credit lines but there also other types of commitments. To ensure that the reduction in term loans is indeed compensated by an increase in credit lines, we estimate the regression in equation (2) with credit line share instead of term loan share as the dependent variable (not shown). The increase in the credit line share is very similar to the decrease in the term loans share.

[42] The full article: https://www.nytimes.com/2021/06/02/climate/biggest-methane-emitters.html.

and our regulatory datasets are unique in their extensive coverage of private firms.[43]

Using revenues for private firms in the Y-14 data, we compute the emissions inefficiency for each firm, where emissions inefficiency is defined as annual carbon dioxide equivalent emissions (in kg) divided by revenues (in $). Figures 6(a) and 6(b) show the mean and median emissions inefficiency for the five most prevalent industries in our sample as of 2012.[44] Private firms are more emissions inefficient for all but one of the industries based on both the mean and median emissions inefficiency. The exception is business services (including waste management) for which the above empirical pattern holds for the median but not the mean. For some industries such as mining, quarrying, and oil and gas extraction as well as wholesale trade, the differences between private and public firms are large, which is in line with anecdotal evidence. Private firms emit up to 2.5 kg of carbon dioxide equivalents more per dollar of revenue.

In Table 4, we present results separately for public and private firms and document that the effects in Table 3 are concentrated within the subsample of private firms. Private firms show no change in log committed credit (Panel A) but large and significant decreases in maturity (Panel B) and term loan share (Panel C). Maturity decreases by 6 to 9 months for private firms with substantial emissions in California compared to 4 to 6 months for the full sample in Table 3. The differences between private and public firms are even more pronounced when we study the effect on term loan share. Term loans share decreases by about 0.5 for private firms, an effect roughly twice as large as in the full sample in Table 3. There are no significant changes in maturity or term loans share for public firms. In fact, the results are suggestive of increases in log committed credit for public firms, although such increases are only significant in some specifications. These results are consistent with lenders anticipating that private firms will experience disproportionately larger increase in operating costs as a result of the cap-and-trade program than public firms, and that public firms will

[43] Shive and Forster (2020) investigate private firms emissions based on Capital IQ data, which are available for larger private firms that issue publicly traded debt. Our sample comprehensively covers a wider range of private firms irrespective of public capital markets access.

[44] For each of these industries we have at least 10 public and private firms in our sample.

be largely unaffected or might even benefit from the adverse impact of the cap-and-trade program on their privately-held competitors.

It is important to note that the changes in credit commitments, maturity, and term loans share are all equilibrium outcomes arrived at during the contracting process between banks and firms. Another key outcome variable that is part of these negotiations is the interest rate. On the one hand, banks are likely to impose higher interest rates on California firms in response to the uncertainty associated with the cap-and-trade regulation. On the other hand, firms might prefer to keep interest rates, and thus, debt payments, constant but may be willing to accept shorter maturities and larger share in credit line commitments. The outcome of this negotiation process is ultimately an empirical question.

Given that the Y-14 data provide information on loan interest rates, we also estimate equation (2) with weighted average loan interest rates paid by a given borrower as the dependent variable.[45] Table 5 shows that creditors price loans to private firms with exposure to the California cap-and-trade program higher, but we do not find any effect for the subsample of public firms. The effect for private firms is economically large with an estimated interest rate increase of up to 2.3 percentage points. For public firms, the interest rates stays the same or even decreases marginally, which again suggests that banks expect public firms to be largely unaffected by the cap-and-trade program or to even benefit from it. Overall, this result implies that banks require higher compensation for holding transition risk.

5.2 The Waxman-Markey cap-and-trade bill and credit terms

The previous results show that banks react to the transition risks associated with the passage of a cap-and-trade bill by increasing the flexibility to cut credit should firm profitability be substantially negatively affected by the cap-and-trade program. Because the results are based on the California economy, we conduct further analysis to assess their external validity. In

[45] Interest rates in the Y-14 Collection are only available for term loans and drawn credit lines and unavailable for undrawn credit lines. Given this data limitation, we estimate the regression only for term loans and drawn credit lines.

particular, we do not know whether the effects on corporate lending would be similar for a federal cap-and-trade program. However, wide ranging carbon pricing legislation would likely be more effective and needed to combat climate change.

To answer this question, we estimate corporate lending changes in response to the Waxman-Markey cap-and-trade bill using the empirical strategy described in Section 4.2. The estimates of regression equation (3) are reported in Table 6. Overall, the effects on the amount of total credit (Panel A) and on loan structure (Panels B and C) are comparable to the effects we find in the California analysis. The amount of total credit does not exhibit a differential response to the bill for firms just above or below the free-permit threshold. Firms just below the free-permit threshold face a shortening of maturities relative to firms just above the threshold. The difference in maturity response is up to 9 months, which is considerable given that the average maturity of loans to firms in the manufacturing sectors near the free-permit threshold is approximately 35 months over our sample period, as shown in Table 2. The statistical significance is not as high as in the California analysis, but the sample size is also smaller. Additionally, firms below the free-permit threshold exhibit greater reliance on credit lines at the expense of term loans after the Waxman-Markey bill clears the US House of Representatives. The difference is again economically significant as term loans share (credit line share) is approximately 0.1 lower (higher) for firms just below the free-permit threshold than for those just above the threshold.[46]

In Table 6, we also examine whether our results are driven by private firms. Similar to the analysis around the passage of the California cap-and-trade bill, we split the sample into private and public firms and estimate the regression in equation (3) for the two subsamples. While log committed credit does not significantly change for either firm type, we find much stronger effects for private firms. Maturity decreases for private firms without free permits by up to 10 months, but it is largely unchanged for public firms without free permits. Similarly, private firms without free permits experience a large decrease in term loans share of about

[46]Syndicated loans in the SNC database are almost exclusively credit lines or term loans, so an increase in the term loans share implies a lockstep decrease in the credit lines share.

0.25, but there is no change within the subsample of public firms without free permits.

Because firms in our sample receive free permits based on energy intensity, our difference-in-differences estimation could be confounded by developments in the price of energy between 2008 and 2009. The narrow bandwidth around the 5% energy intensity cut-off alleviates this concern because it ensures that our sample consists of firms that do not differ substantially in terms of energy intensity. In addition, the price of energy proxied by Brent crude oil prices increased from December 2008 to December 2009.[47] Therefore, if anything, energy price changes during this period works against the results we document: firms receiving free permits–those with higher energy intensity—will see a greater increase in operating costs due to higher energy prices relative to firms without free permits, but obtain better financing terms according to our analysis, due to the impact of the cap-and-trade bill.

Overall, our analyses of the two independent natural experiments, the California and the Waxman-Markey cap-and-trade bills, yield qualitatively similar results. This is reassuring considering that both the time period and the selection of treated and control firms are different across the two settings. The magnitude of the estimates are also similar in the two sets of analyses which might be surprising considering that the California cap-and-trade bill was passed but the Waxman-Markey cap-and-trade bill ultimately failed. The significant effect of the Waxman-Markey bill on firm financing is likely augmented by the federal nature of the bill. A US-wide cap-and-trade program is likely to be more stringent for firms because a larger share of their emissions would be priced and shifting emissions out of the geographic boundaries of the cap-and-trade program would be more challenging.

6 Mechanism and robustness

This section presents analysis that helps us better understand the mechanism behind banks managing transition risk and shows robustness tests for our baseline results from Section 5. The analyses in this section use features unique to either the SNC data or the Y-14 data,

[47]The price was $43.72 on December 31, 2008, and $78.39 on December 31, 2009.

and therefore, only one of the two natural experiments is generally used to execute a given analysis depending on which dataset makes the analysis feasible.

6.1 Loan share held by shadow banks

Banks may also manage transition risks and reduce exposure to affected firms by selling their share of syndicated loans to shadow banks in the secondary loan market (see Irani and Meisenzahl (2017) on banks exiting syndicates through loan sales) or by simply taking a lower share in loans during the origination/renegotiation process with shadow banks taking a larger share (Berlin, Nini, and Yu, 2020). Shadow banks such as CLOs, hedge funds, private equity funds, and mutual funds invest in a significant share of syndicated loans (Irani, Meisenzahl, Iyer, and Peydro, 2021), and their transition risk management might differ from banks because of their risk appetite or ex-ante exposure to high-emission firms.

Understanding whether banks reduce exposure to transition risk by selling off loans to shadow banks is important for two main reasons. Regulators concerned about transition risk and its impact on financial stability may be interested in understanding the type of institutions holding the transition risk exposure whenever such risks are high. In addition, while loan maturity, interest rates, and credit line share are equilibrium outcomes of the negotiation process between firms and banks, the decision of a bank to sell loans to shadow banks can be unilaterally taken by the bank. Therefore, studying whether or not banks sell syndicated loans to shadow banks allows us to obtain additional evidence on banks' expectation of the effect of cap-and-trade regulation on firms.

To test this hypothesis, we estimate the regression in equation (3) with the fraction of a firm's loans held by shadow banks as the dependent variable. The results are reported in Table 7. We show that shadow banks significantly increase their holdings of syndicated loans of firms without free permits. The coefficient estimate is significant and positive for all the specifications. The magnitude of the estimate shows an increase in the shadow bank share of up to 0.07. This is a considerable increase relative to the average shadow bank share that is around 0.16, as shown in Table 2. Consistent with our previous results, this effect is once again concentrated in private firms. Private firms without free permits exhibit an economically large increase in the shadow bank share of up to 0.11. In contrast, the coefficient estimates are close to zero and insignificant for public firms. Overall, these results suggest that not only do banks change the loan terms of high emitting firms in light of pending cap-and-trade regulation, but they also transfer their risk exposure to other participants in the syndicated loan market.

6.2 Lender exposure to high-emission firms

An important financial stability consideration is the extent to which transition risks are concentrated within specific lenders. Financial stability risks may be mitigated if a rise in transition risks led lenders with high ex ante exposures to quickly transfer some of these risks to less exposed lenders. To rigorously test this hypothesis, we analyze at the lender-firm level if overall lender exposure to high-emission firms affects how lenders buy or sell syndicated loans when transition risk increases. As discussed in the previous section, syndicated loans are traded on a secondary market by a wide range of lenders, and holder information is included in the SNC data.

We first compute the fraction of a given lender's total credit commitment through syndicated loans to a given firm:

$$LenderFirmExposure_{i,l,t} = \frac{FirmLending_{i,l,t}}{TotalLending_{l,t}}, \tag{4}$$

where the numerator is the amount of all syndicated loans of firm i held by lender l in year t, and the denominator is the amount of all syndicated loans (across all borrowers) held by lender l in year t. The summary statistics of this variable are presented in Panel C of Table 2.

We also compute a lender's exposure to high-emission firms as of 2008, that is, the pre-period of the Waxman-Markey analysis:

$$LenderHighEmissionExposure_l = \frac{\sum_{i=1}^{N} FirmLending_{i,l,2008} \times I_{i \in HighEmissionFirms}}{TotalLending_{l,2008}}, \quad (5)$$

where $HighEmissionFirms$ are all the firms that are included in the EPA dataset in its first year.[48] Importantly, the Waxman-Markey analysis focuses on manufacturing firms around the energy intensity threshold for free permits to ensure that our estimates are identified through quasi-exogenous variation within the set of manufacturing firms (as in Meng (2017)). However, firms from other non-manufacturing industries would also have been covered by the Waxman-Markey cap-and-trade program if they had facilities that emitted more than 25,000 metric tons of carbon dioxide equivalents per year. Therefore, we include such firms when computing the $LenderHighEmissionExposure_l$ in equation (5).

We then test whether lenders with large ex ante exposure to high-emission firms sell differentially more of the syndicated loans of treated firms after the passage of the Waxman-Markey cap-and-trade bill by the US House of Representatives. The regression specification is,

$$\begin{aligned} LenderFirmExposure_{i,l,t} = & \lambda_1 I_{l \in HighEmissionLender} \times I_{i \in Treated} \times I_{t=2009} \\ & + \lambda_2 I_{i \in Treated} \times I_{t=2009} + Controls_{i,t} + \omega_{i,l} + \phi_t + \epsilon_{i,l,t}, \quad (6) \end{aligned}$$

where the indicator variable $I_{l \in HighEmissionLender}$ takes the value 1 if lender l had an above median (or top quintile, depending on the specification) $LenderHighEmissionExposure_l$ defined in equation (5). We also include firm × lender fixed effects, $\omega_{i,l}$, to ensure that the estimates capture changes within a firm and lender. $\omega_{i,l}$ subsumes the intermediate interaction term, $I_{l \in HighEmissionLender} \times I_{i \in Treated}$, in addition to firm fixed effects and lender fixed effects. The other variables are as defined for equation (3). Here, the standard errors

[48]The EPA dataset on high-emission firm facilities begins in 2010, which we take as the best available measure of firms with high emissions in 2008.

are double-clustered by industry and lender as the treatment occurs at the industry and lender level.

Figures 5(a) and 5(b) show the distribution of the $LenderHighEmissionExposure_l$ variable of all the lenders included in the regression in equation (6) for the baseline and wide bandwidth, respectively. The median and 80th percentile of these distributions are around 10 and 15 percent.

The results are shown in Table 8. The coefficient estimate on the high-emission exposure interaction term is consistently negative and strongly significant. Also, the coefficient estimates are generally larger for the lenders with high-emission exposure in the top quintile than above the median. The economic magnitude is also considerable. The coefficient estimates are between 0.01 and 0.02, and the average $LenderFirmExposure_{i,l,t}$ shown in Panel C of Table 2 is between 0.03 and 0.04. These results show that lenders' existing exposure to high-emission firms matters for their decision to sell syndicated loans of firms covered by the cap-and-trade program more heavily.

6.3 Firm balance sheet effects

While the focus of the paper is on how transition risk affects corporate lending, our data also allow us to analyze how private and public firm balance sheets are affected by a cap-and-trade program. We conduct this analysis for the California cap-and-trade bill because unlike the SNC dataset, the Y-14 data contain balance sheet information for both private and public firms.

6.3.1 Balance sheet effects around passage of cap-and-trade bill

We estimate the regression model given in equation (2) with firm financial statement variables as the dependent variables. Given that financial statements in Y-14 are updated either annually or biennially, we define the pre-period as the year closest to but no later than 2011 and the post-period as the year closest to but no earlier than 2012. To the extent that firms anticipate being less able to obtain external financing once the cap-and-trade program starts or having unexpected liquidity needs, they could increase their cash buffers for precautionary reasons. Firms could also reorganize their operations to be more emissions efficient under cap-and-trade programs, leading to changes in their investment. Finally, in the baseline analysis in Section 5.1, we show that total credit commitment does not change for firms covered by the California cap-and-trade program. However, the total credit commitment variable only includes lending from banks subject to Y-14 reporting. Therefore, we investigate the robustness of our previous results by testing how firms' total debt on the balance sheet evolves following the passage of the cap-and-trade program because total debt includes borrowing from all sources.

Table 9 presents the results.[49] Panel A shows that there is a significant increase in cash holdings after the passage of the bill for firms with a large emission share in California. The full sample estimate of 0.03 is also economically significant, as the average cash holdings of firms in our sample are around 0.1 as a share of assets, which is shown in Table 1. Interestingly, both public and private firms increase cash holdings, suggesting that both types of firms plan for unanticipated liquidity needs as a result of the cap-and-trade program.

Panel B shows that net capital expenditures also increase significantly after the passage of the cap-and-trade bill, which is driven by private firms. The economic magnitude is again substantial with capital expenditures normalized by assets increasing by about 0.04 for private firms with emissions in California. A potential explanation for this result is that firms invest in equipment upgrades that would allow them to emit less GHG, consistent with research showing that smaller and younger firms rely on older equipment (Ma, Murfin, and Pratt, 2020).

Panel C confirms our earlier results in Tables 3 and 4 by showing that debt normalized by assets remains unchanged for both the full sample and private firms, and exhibits a small

[49]For the sake of simplicity, we show the results for firms with a share of California emissions greater than 50 percent. However, the results are qualitatively the same when using a threshold of 25 percent. Also, due to the smaller sample, the industry fixed effects interacted with the year fixed effects are based on the 2-digit NAICS of the firm.

increase for the subsample of public firms.

6.3.2 Balance sheet effects around implementation of cap-and-trade program

We conduct a similar analysis around the *implementation* of the California cap-and-trade program, which occurred in January 2013. Once again given that financial statements in Y-14 are updated either annually or biennially, we define the pre-period as the year closest to but no later than 2012 and the post-period as the year closest to but no earlier than 2013. We test if the precautionary cash and capital expenditure effects shown in Table 9 revert in 2013 following implementation after the spike in 2012 following bill passage. We also analyze whether total debt changed once the cap-and-trade program started. Finally, we study the impact of the cap-and-trade program on firm sales and profitability.

Table 10 presents the results.[50] In Panels A and B, the estimates show that precautionary cash and capital expenditures revert from their spike in 2012. This suggests that once the cap-and-trade program was implemented, uncertainty decreased and consequently both precautionary savings and investment decreased. In Panel C, we show that debt was not significantly different for high-emission firms in California compared to high-emission firms elsewhere, indicating that even after the implementation of the cap-and-trade program, banks did not cut credit to high-emission firms in California.

Panels D and E present the likely reason for the lack of response in total debt. Panels D shows that while there is an effect on the profitability of private firms after the implementation of the cap-and-trade program, this effect is economically small. EBITDA normalized by assets decreases by approximately 0.02, and the mean EBITDA normalized by assets is around 0.13, as shown in Table 1. Also, there was no effect on the sales of private and public firms shown in Panel E. This result implies that the implementation of the California cap-and-trade program did not significantly limit the production capabilities of firms covered by the program.

[50] Similar to Table 9, for the sake of simplicity, we show the results for firms with a share of California emissions greater than 50 percent to ensure readability.

6.4 Cash flow covenants and active monitoring

In addition to adjusting loan terms or selling syndicated loans to other participants in the syndicated loan market, banks may also differentially monitor firms or include cash flow covenants in loan contracts. The SNC data allow us to measure whether the loans include cash flow covenants and whether the borrower is actively monitored by the lead bank (Gustafson, Ivanov, and Meisenzahl, 2019). Our cash flow covenant and active monitoring measures take the value of one whenever any of the loans of a given borrower have a cash flow covenant or are monitored actively in a given year.

We estimate equation (3) for both the cash flow covenant and active monitoring measures. The results are reported in Table 11. Both of these measures are available only for the subset of loans/borrowers that are reviewed in the annual SNC exam. Therefore, the sample sizes are significantly smaller than in Section 5.2. However, we find evidence that the firms just below the free-permit threshold are more likely to have a cash flow covenant in their loan contracts. The coefficient estimates are about 0.2, which implies that firms without free permits are 20 percent more likely to have cash flow covenants. We also find some suggestive evidence that firms unable to obtain free permits are more likely to be actively monitored that is statistically weaker. The coefficient estimates are positive and economically large with magnitudes of up to 0.14, but mostly insignificant.

6.5 Placebo tests

Given that we use difference-in-differences analyses, we would like to rule out significant differences in pre-trends between the treatment and control groups. This concern is alleviated in this setting because we obtain consistent results under two distinct natural experiments, which split firms into treatment and control groups along different dimensions and occur at different points in time. Additionally, the longer time series available for the SNC data also allow us to test whether we find significant differences around the energy intensity threshold of the Waxman-Markey bill before the bill was passed by the US House of Representatives in 2009. We further examine whether the effects we identify in the previous sections reverse in 2010 after the bill failed in the US Senate.

We re-estimate the regression specification in equation (3) with the following placebo (pre, post) years: (2004, 2005), (2005, 2006), (2006, 2007), (2007, 2008), and (2009, 2010). The regression coefficients are plotted in Figure 7 with the "post" year of each test on the x-axis. The dependent variables in these tests are those for which we previously found a statistically significant effect: maturity and term loans share from Section 5.2, shadow bank share from Section 6.1, and cash flow covenants from Section 6.4.[51]

For all four variables, estimates for the coefficient of interest are not significantly different from zero in the placebo years before 2009. The coefficients only show a significant effect in 2009, which is the true treatment year, when Waxman-Markey cleared the House of Representatives and was under consideration by the US Senate. This result is reassuring as the effects in 2009 do not appear to be driven by violations in the parallel trends assumption. Interestingly, for all four outcome variables, we find that the coefficient estimates revert to pre-2009 levels when comparing 2010 to 2009. This result suggests a rebound in borrowers' financial flexibility after the Waxman-Markey cap-and-trade bill failed in the Senate in July 2010.

6.6 Loan utilization

The baseline analysis presented in Section 5 shows that the total loan commitment is not affected by the passage of cap-and-trade bills. However, this still leaves the possibility that the utilized loan amount changes, either because of a change in credit line utilization or the switch from term loans to credit lines. Particularly, firms might want to reduce their current debt load in light of the uncertainty associated with the cap-and-trade program, and thus, prefer credit lines to term loans because credit lines give them the flexibility to currently utilize less credit. To test this possibility, we estimate the regression specifications in equa-

[51] The cash flow covenant variable is not available prior to 2007. Therefore, the first two-year sample for which we can estimate the regression is (2007, 2008).

tions (2) and (3) with the total utilized loan amount normalized by total loan commitment amount as the dependent variable.

The results are reported in the Appendix in Table A.2. For both the California cap-and-trade bill (Panel A) and the Waxman-Markey cap-and-trade bill (Panel B) the coefficient estimates are economically small and statistically insignificant. These results suggest that the shift from term loans to credit lines is not driven by firms utilizing less credit.

7 Conclusion

Despite widespread discussions of climate change transition risks, we know little about how lenders manage transition risks and how this affects financing to GHG emitting firms. The challenge in estimating the effect of transition risks on corporate lending is that researchers have to identify plausibly exogenous shocks that lead to a low-emissions economy and simultaneously allow for a clear distinction between firms that are and are not affected by this transition. We fill this void by using the passage of major cap-and-trade bills in the United States to isolate periods of high transition risks. We show that cap-and-trade programs lead to significant changes in corporate lending to affected firms. Firms face shortening in loan maturities, lower access to permanent forms of bank financing such as term loans, higher interest rates, lower participation of banks in their lending syndicates, and increased participation of shadow banks. These effects are concentrated among private firms, suggesting banks are less concerned about the impact of cap-and-trade programs on public firms.

The fluid nature of commercial lending relationships allows banks to adjust their credit exposure quickly through loan renegotiation. This paper shows that they do so swiftly, in ways that mitigate their climate transition risk exposure in light of impending cap-and-trade legislation. These findings suggest that, at least in the bilateral and syndicated lending markets, legislation intended to curb GHG emissions and transition to a low-carbon economy is unlikely to pose large, unmanageable risks. The large differential response of private and public firms to cap-and-trade programs that we document in the paper has important implications for the design of cap-and-trade programs to preempt potential adverse effects on the financial health of covered private firms.

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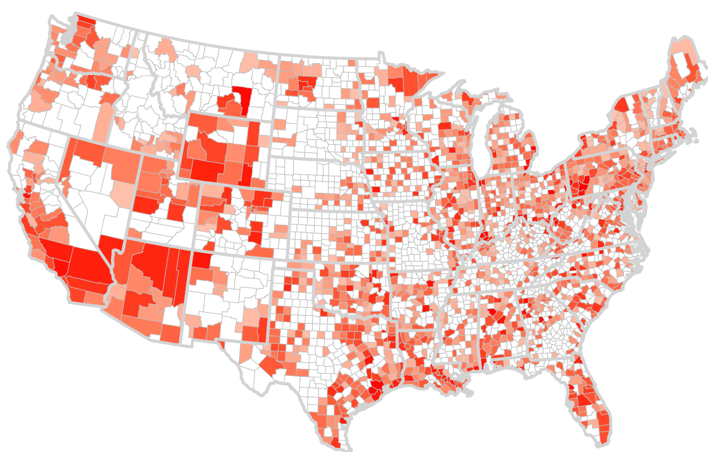
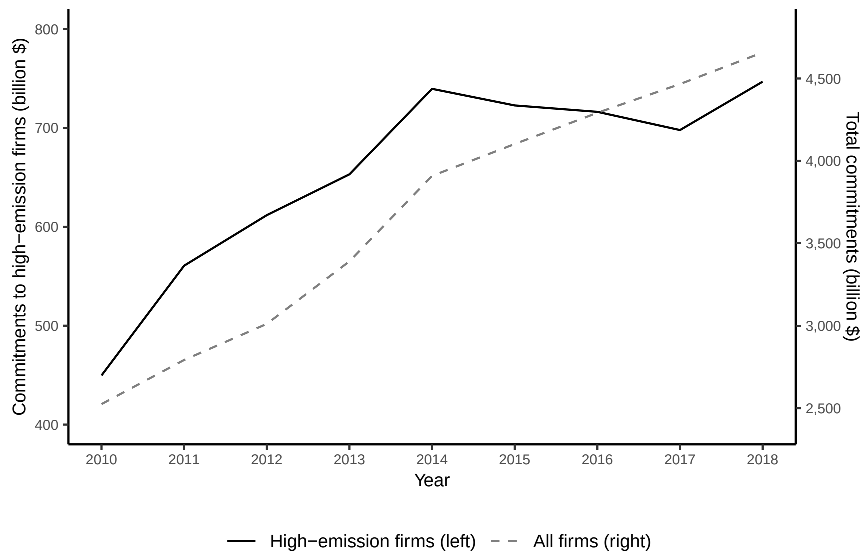
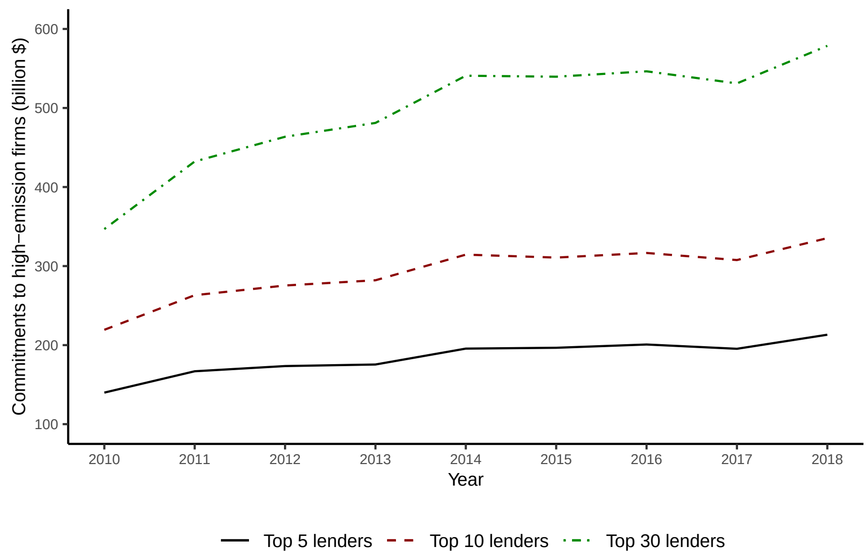


Figure 1: Emissions by county

This figure shows the 2011 GHG emissions by county based on the EPA data on high-emission firm facilities. Only emissions from firms in the Y-14 data are included. Darker shaded counties have higher emissions.



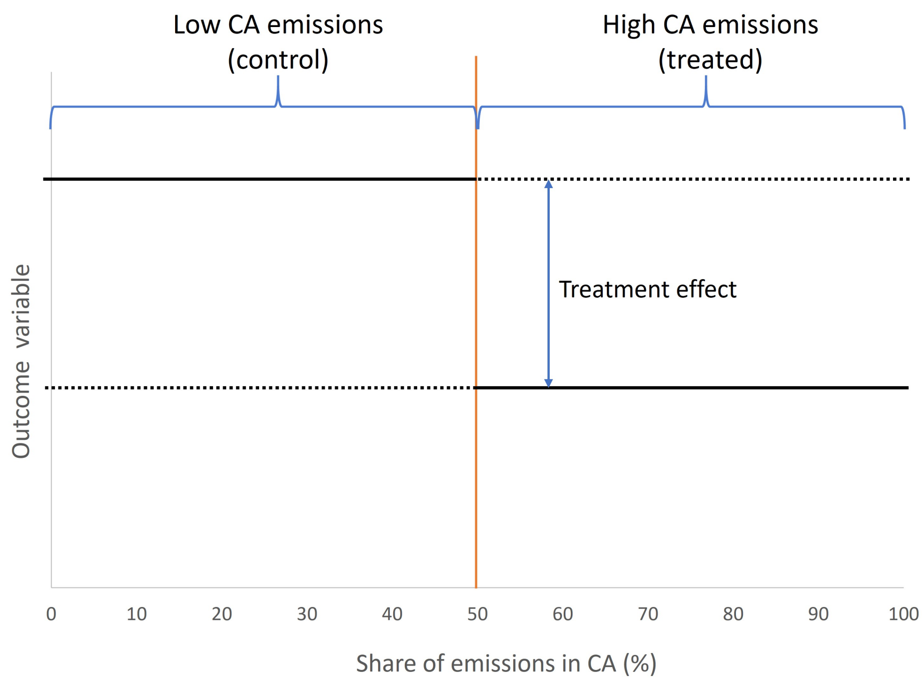
(a) Total credit commitments



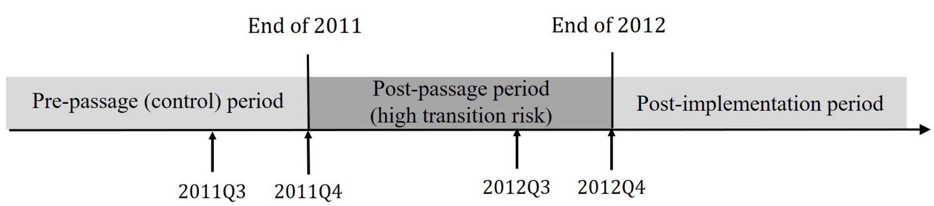
(b) Lender concentration

Figure 2: Credit commitments to high-emission firms

Panel A shows the total credit commitments to high-emission firms (left y-axis) and total credit commitments to all firms (right y-axis) in billion $ based on the SNC dataset. Panel B depicts the share of credit commitments to high-emission firms by the top 5, 10, and 30 lenders.



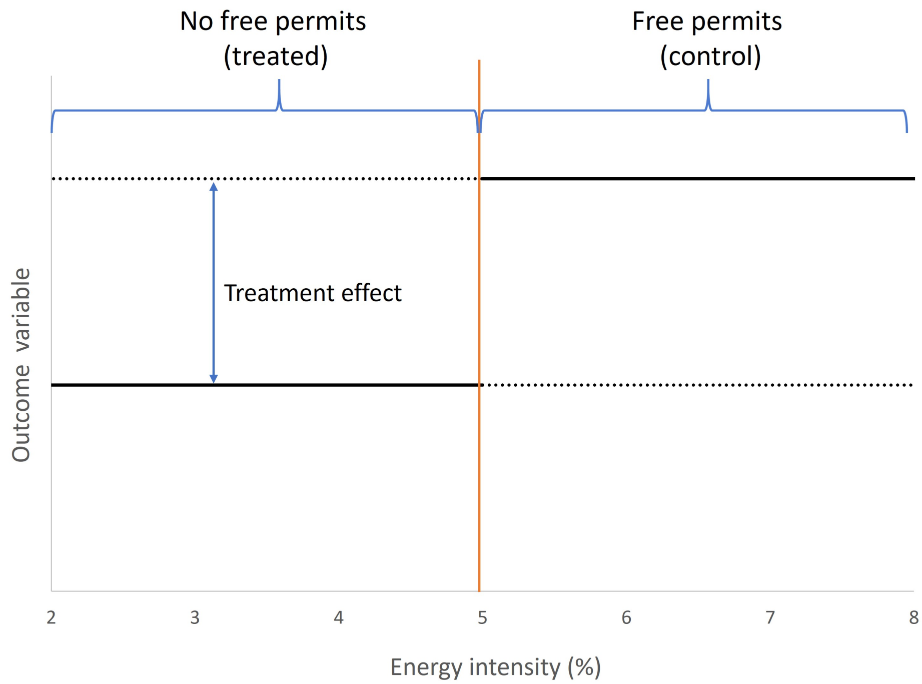
(a) Firm assignment to treated and control groups



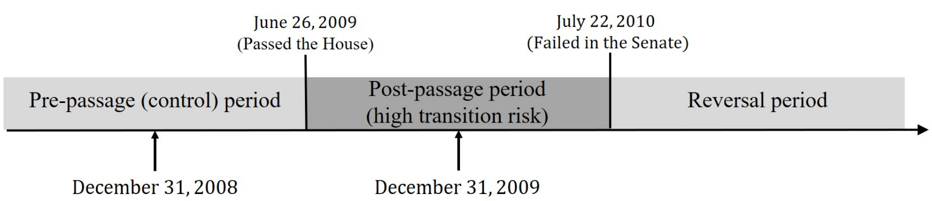
(b) Timeline

Figure 3: Identification strategy for the California cap-and-trade bill analysis

Panel A illustrates the identification strategy that assigns firm treatment by exploiting the share of emissions in California for the analysis of the California cap-and-trade bill. Panel B shows the relevant pre/post timeline for the analysis.



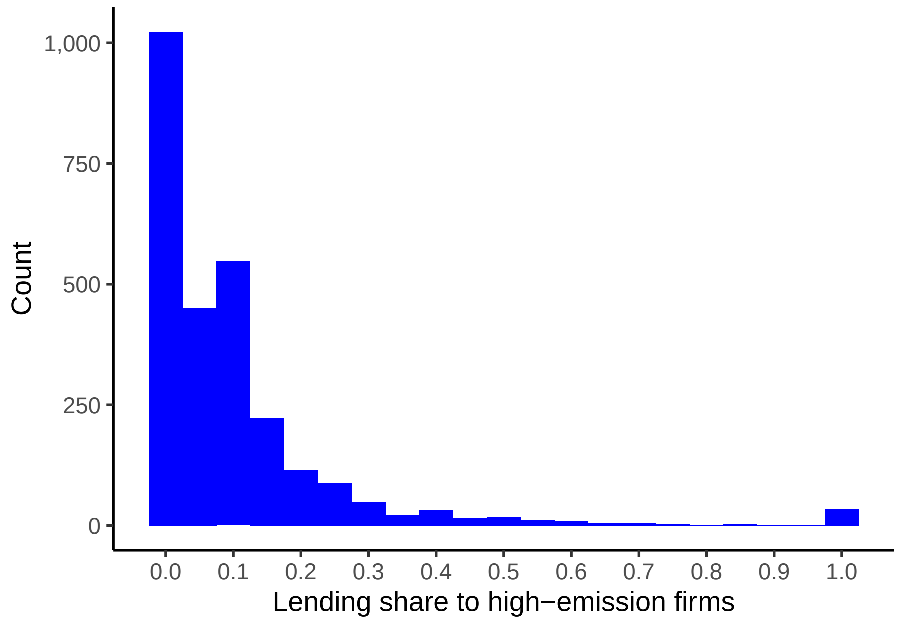
(a) Firm assignment to treated and control groups



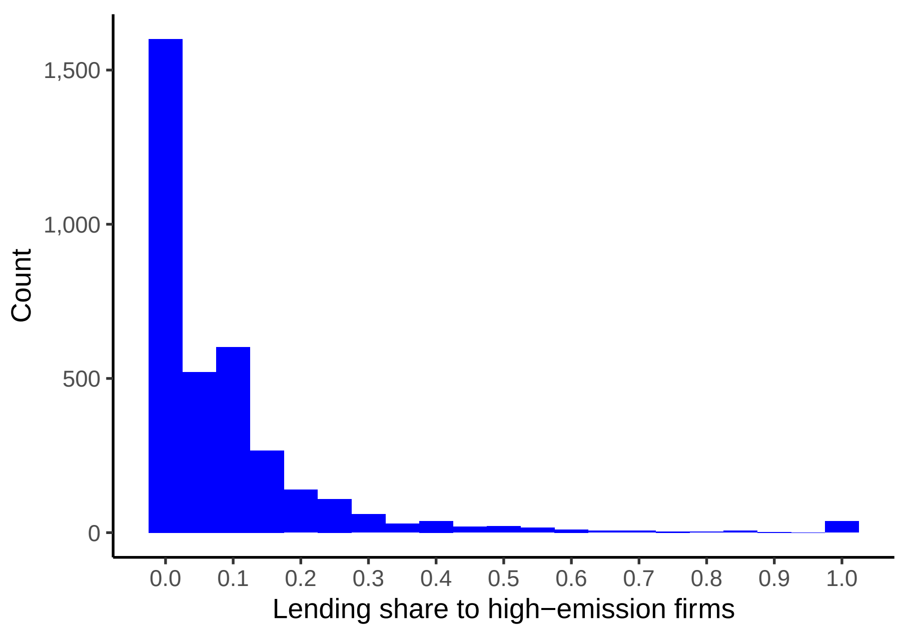
(b) Timeline

Figure 4: Identification strategy for the Waxman-Markey bill analysis

Panel A illustrates the identification strategy that assigns firm treatment by exploiting the free-permit threshold based on energy intensity for the analysis of the Waxman-Markey cap-and-trade bill. Panel B shows the relevant pre/post timeline for the analysis.



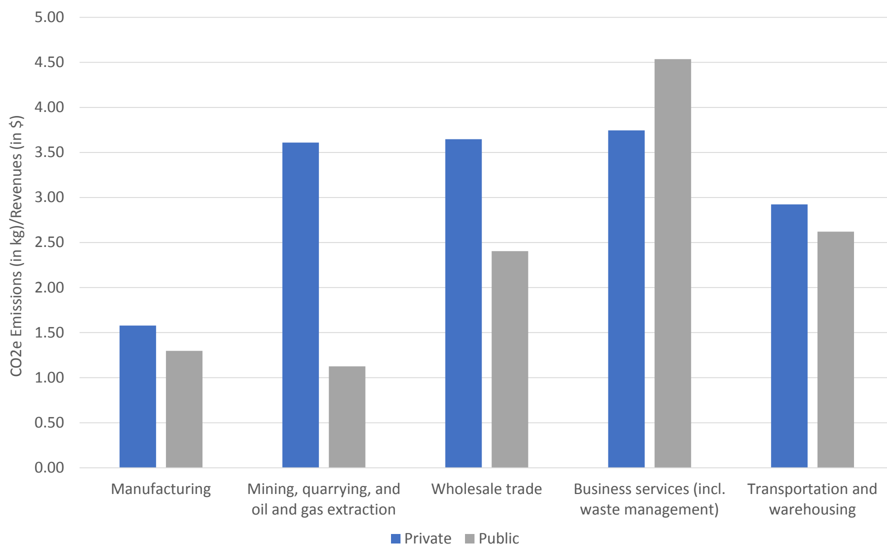
(a) Baseline bandwidth



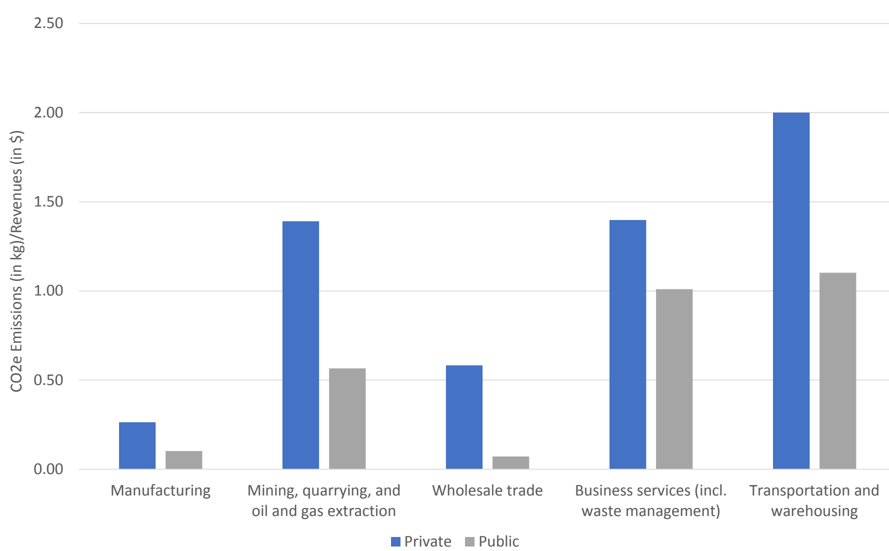
(b) Wide bandwith

Figure 5: Lenders' exposure to high-emission firms

This figure shows the distribution in 2008 of the lenders' credit commitment to high-emission firms normalized by their total credit commitment, $LenderHighEmissionExposure_l$, defined in equation (5). Panel A includes all lenders that lend to firms within the baseline bandwidth of the Waxman-Markey analysis. Panel B includes all lenders that lend to firms within the wide bandwidth of the Waxman-Markey analysis. This variable is used in the analysis shown in Table 8.



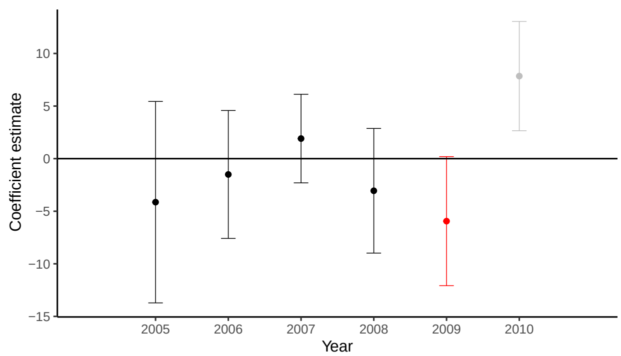
(a) Mean emissions inefficiency



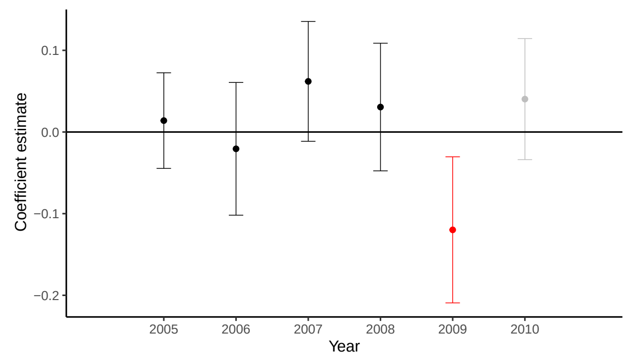
(b) Median emissions inefficiency

Figure 6: Firm emissions inefficiency

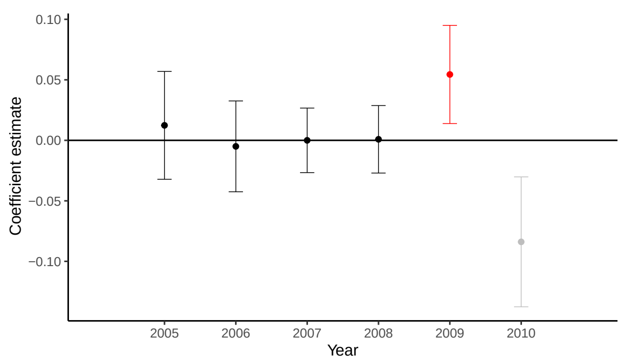
This figure shows the mean and median of firm CO_2e emissions (in kg) divided by revenues (in $) in 2012. Private and public firms are split based on their industry.



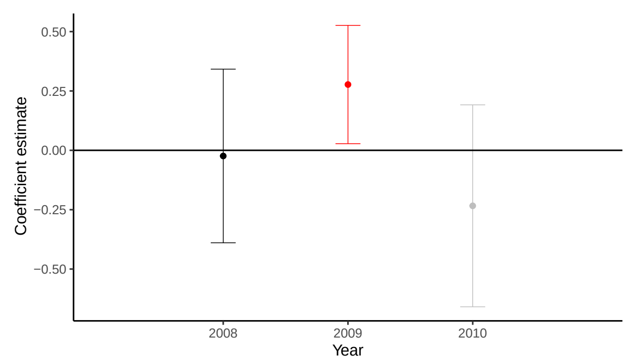
(a) Remaining maturity



(b) Term loans share



(c) Shadow bank share



(d) Cash flow covenants

Figure 7: Placebo tests for the Waxman-Markey cap-and-trade bill

This figure shows the difference, as estimated by the coefficient λ in equation (3), in remaining maturity on loans (Panel A), term loans share of the total credit commitment (Panel B), the shadow bank share of the lending syndicate (Panel C), and the existence of cash flow covenants between firms that are just below (treated) and above (control) the free-permit threshold of the Waxman-Markey cap-and-trade bill. The regression in equation (3) is separately estimated for samples of two consecutive years. Specifically, these samples consist of the years (2004, 2005), (2005, 2006), (2006, 2007), (2007, 2008), (2008, 2009), and (2009, 2010). The year shown on the x-axis is the "post" year for a specific test. The Waxman-Markey bill passed the US House of Representatives in 2009 (red) and failed in the US Senate in 2010 (gray). The cash flow covenant variable is not available prior to 2007. Therefore, the first two-year (pre, post) sample for which we can estimate the regression is (2007, 2008). The bands show the 90% confidence interval.

Table 1: Summary statistics for California cap-and-trade bill analysis

This table reports the summary statistics of the firms included in our analysis of the California cap-and-trade bill. The data are quarterly from 2011 and 2012, except the balance sheet variables which are at an annual frequency. The mean, standard deviation, 10^{th}, 50^{th}, and 90^{th} percentiles are shown.

Panel A: Full sample

	Observations	Firms	Banks	Mean	SD	P10	P50	P90
Total commitment (in m US$)	2977	893	28	331.485	634.392	7.500	105.656	910.522
Interest rates (in %)	2082	684	27	3.022	1.610	1.438	2.590	5.118
Remaining maturity (in months)	2977	893	28	34.480	18.198	7.532	37.647	57.000
Share of term loans	2977	893	28	0.161	0.276	0.000	0.000	0.569
CapEx/Assets	972	505	31	0.030	0.116	-0.078	0.025	0.152
Cash/Assets	995	505	31	0.072	0.085	0.002	0.039	0.189
Debt/Assets	1003	505	31	0.314	0.199	0.062	0.293	0.557
EBITDA/Assets	970	505	31	0.128	0.085	0.045	0.115	0.226
Sales/Assets	1006	505	31	1.104	0.950	0.224	0.858	2.359

Panel B: Firms with California emissions > 25%

	Observations	Firms	Banks	Mean	SD	P10	P50	P90
Total commitment (in m US$)	212	68	27	412.429	1037.605	9.194	95.364	1426.866
Interest rates (in %)	147	52	21	2.718	1.425	1.350	2.313	4.377
Remaining maturity (in months)	212	68	27	28.125	19.394	5.952	24.000	56.200
Share of term loans	212	68	27	0.206	0.353	0.000	0.000	1.000
CapEx/Assets	77	43	30	0.031	0.089	-0.063	0.019	0.119
Cash/Assets	79	43	30	0.114	0.137	0.002	0.046	0.364
Debt/Assets	79	43	30	0.276	0.229	0.001	0.276	0.594
EBITDA/Assets	78	43	30	0.127	0.084	0.039	0.113	0.215
Sales/Assets	79	43	30	1.220	0.968	0.317	0.987	2.493

Panel C: Firms with California emissions > 50%

	Observations	Firms	Banks	Mean	SD	P10	P50	P90
Total commitment (in m US$)	187	61	27	333.928	1,003.618	8.823	84.200	536.049
Interest rates (in %)	127	45	19	2.546	1.182	1.231	2.233	4.250
Remaining maturity (in months)	187	61	27	27.490	19.097	6.000	24.000	56.100
Share of term loans	187	61	27	0.216	0.360	0.000	0.000	1.000
CapEx/Assets	65	34	29	0.039	0.088	-0.047	0.019	0.131
Cash/Assets	66	34	29	0.111	0.137	0.002	0.039	0.356
Debt/Assets	66	34	29	0.280	0.238	0.001	0.279	0.612
EBITDA/Assets	65	34	29	0.126	0.089	0.019	0.112	0.230
Sales/Assets	66	34	29	1.285	1.010	0.365	1.035	2.527

Table 2: Summary statistics for Waxman-Markey cap-and-trade bill analysis

This table reports the summary statistics of the firms included in our analysis of the Waxman-Markey cap-and-trade bill for the two bandwidths described in Section 4.2. The data are annual from 2008 to 2009. The mean, standard deviation, 10^{th}, 50^{th}, and 90^{th} percentiles are shown. Panels A and B show the data for the firm-level analysis. Panel C shows the data for the lender-firm-level analysis in Section 6.2.

Panel A: Baseline bandwidth

	Observations	Firms	Lead banks	Mean	SD	P10	P50	P90
Total committed (in million US$)	397	226	56	19.212	1.220	17.630	19.118	20.960
Remaining maturity (in months)	397	226	56	35.316	17.079	13.973	34.800	56.420
Share of term loans	397	226	56	0.262	0.371	0.000	0.000	0.922
Non-bank share	397	226	56	0.166	0.236	0.000	0.042	0.576
Cash flow covenant	130	95	35	0.454	0.500	0.000	0.000	1.000
Active monitoring	133	96	35	0.150	0.359	0.000	0.000	1.000

Panel B: Wide bandwidth

	Observations	Firms	Lead banks	Mean	SD	P10	P50	P90
Total committed (in million US$)	739	427	71	19.250	1.192	17.715	19.163	20.946
Remaining maturity (in months)	739	427	71	35.017	15.803	14.884	34.700	54.733
Share of term loans	739	427	71	0.243	0.360	0.000	0.000	0.896
Non-bank share	739	427	71	0.153	0.234	0.000	0.017	0.571
Cash flow covenant	235	174	47	0.494	0.501	0.000	0.000	1.000
Active monitoring	242	177	48	0.169	0.376	0.000	0.000	1.000

Panel C: Lender-firm exposure (0 to 1)

	Observations	Firms	Lenders	Mean	SD	P10	P50	P90
Baseline bandwidth	18,043	226	2,790	0.039	0.140	0.000	0.005	0.057
Wide bandwidth	34,103	427	3,671	0.034	0.123	0.000	0.005	0.052

Table 3: California cap-and-trade bill impact on credit

This table reports estimates from the regression specification given in equation (2). We estimate if firms with substantial GHG emissions in California, the treated firms, experience different credit conditions in the third and fourth quarters of 2012 relative to the third and fourth quarters of 2011, that is, before the bill was passed. The dependent variables are the log committed credit in Panel A, maturity (in months) in Panel B, and the term loans share of total committed credit (0 to 1) in Panel C. The independent variable of interest is an indicator variable that takes the value 1 if the quarter is the third or fourth quarter of 2012 interacted with an indicator variable that takes the value 1 if the firm has over 25% or 50% of its total GHG emissions in California and 0 otherwise. Firm and industry-quarter fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Log committed credit

	(1)	(2)	(3)	(4)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	0.004		0.015	
	(0.083)		(0.061)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		0.022		0.030
		(0.093)		(0.072)
Observations	2,717	2,717	2,717	2,717
R2	0.964	0.964	0.965	0.965

Panel B: Remaining maturity (in months)

	(1)	(2)	(3)	(4)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	-4.805**		-3.905**	
	(2.093)		(1.670)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		-5.790**		-4.946***
		(2.302)		(1.633)
Observations	2,717	2,717	2,717	2,717
R2	0.804	0.804	0.807	0.808

Panel C: Term loans share (0 to 1)

	(1)	(2)	(3)	(4)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	-0.241***		-0.245***	
	(0.035)		(0.034)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		-0.258***		-0.262***
		(0.045)		(0.043)
Observations	2,717	2,717	2,717	2,717
R2	0.715	0.718	0.717	0.719

For all panels

	(1)	(2)	(3)	(4)
Controls	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes

Table 4: California bill impact on credit for private and public firms

This table reports estimates from the regression specification given in equation (2). We estimate if firms with substantial GHG emissions in California, the treated firms, experience different credit conditions in the third and fourth quarters of 2012 relative to the third and fourth quarters of 2011, that is, before the bill was passed. The dependent variables are the log committed credit in Panel A, maturity (in months) in Panel B, and the term loans share of total committed credit (0 to 1) in Panel C. The independent variable of interest is an indicator variable that takes the value 1 if the quarter is the third or fourth quarter of 2012 interacted with an indicator variable that takes the value 1 if the firm has over 25% or 50% of its total GHG emissions in California and 0 otherwise. Firm and industry-quarter fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Log committed credit

	Private firms				Public firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	0.037		0.028		0.206***		0.223**	
	(0.211)		(0.146)		(0.064)		(0.086)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		0.044		0.031		0.036		0.058
		(0.235)		(0.160)		(0.099)		(0.113)
Observations	1,548	1,548	1,546	1,546	822	822	822	822
R2	0.953	0.953	0.956	0.956	0.976	0.976	0.977	0.978

Panel B: Remaining maturity (in months)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	-8.701**		-6.318**		0.279		1.617	
	(4.135)		(2.431)		(2.592)		(3.160)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		-8.290*		-5.539*		-2.117		-1.788
		(4.697)		(2.875)		(3.863)		(4.234)
Observations	1,548	1,548	1,546	1,546	822	822	822	822
R2	0.856	0.856	0.861	0.861	0.807	0.807	0.810	0.811

Panel C: Term loans share (0 to 1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	-0.527***		-0.535***		0.011		0.011	
	(0.072)		(0.078)		(0.032)		(0.040)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		-0.491***		-0.498***		0.005		0.001
		(0.096)		(0.103)		(0.036)		(0.043)
Observations	1,548	1,548	1,546	1,546	822	822	822	822
R2	0.772	0.772	0.776	0.776	0.823	0.823	0.829	0.829

For all panels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: California cap-and-trade bill impact on interest rates

This table reports estimates from the regression specification given in equation (2). We estimate if credit to firms with substantial GHG emissions in California, the treated firms, carry different interest (in percent) rates in the third and fourth quarters of 2012 relative to the third and fourth quarters of 2011, that is, before the bill was passed. The independent variable of interest is an indicator variable that takes the value 1 if the quarter is the third or fourth quarter of 2012 interacted with an indicator variable that takes the value 1 if the firm has over 25% or 50% of its total GHG emissions in California and 0 otherwise. Firm and industry-quarter fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	Full sample				Private firms				Public firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	0.667*		0.538*		1.748**		1.013*		0.175		0.082	
	(0.395)		(0.270)		(0.719)		(0.552)		(0.458)		(0.474)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		0.294		0.137		2.299**		1.356		-0.967*		-0.958*
		(0.662)		(0.523)		(1.031)		(0.889)		(0.480)		(0.508)
Observations	1,191	1,191	1,191	1,191	610	610	609	609	390	390	384	384
R2	0.911	0.910	0.919	0.918	0.953	0.954	0.959	0.959	0.916	0.917	0.925	0.927
Controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Waxman-Markey cap-and-trade bill impact on credit

This table reports estimates from the regression specification given in equation (3). We estimate if firms just below the cut-off for free permits under the Waxman-Markey cap-and-trade bill, the treated firms, experience different credit conditions than firms just above the cut-off for free permits, the control firms, at the end of 2009 relative to the end of 2008. The dependent variables are the log committed credit in Panel A, maturity (in months) in Panel B, and the term loans share of total committed credit (0 to 1) in Panel C. The independent variable of interest is an indicator variable that takes the value 1 if the firm would not receive free permits under Waxman-Markey and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2009, that is, the year when Waxman-Markey had been passed by the House of Representatives and was still under consideration in the Senate. The results are shown for the all firms and the subsamples of private and public firms. Firm, year, and lead bank fixed effects are included. The controls are credit ratings described in Section 4.2. Standard errors are clustered by 6-digit NAICS and reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	All firms				Private firms				Public firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Log committed credit												
$I_{i \in Treated} \times I_{t=2009}$	0.039		0.049		-0.072		-0.049		0.107		0.108	
	(0.076)		(0.067)		(0.082)		(0.059)		(0.090)		(0.088)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.054		0.067		0.046		0.053		0.056		0.066
		(0.058)		(0.050)		(0.085)		(0.071)		(0.064)		(0.062)
Observations	342	624	342	624	170	276	170	276	172	348	172	348
R2	0.962	0.964	0.965	0.965	0.959	0.952	0.965	0.954	0.944	0.961	0.945	0.963
Panel B: Remaining maturity (in months)												
$I_{i \in Treated} \times I_{t=2009}$	-5.943		-6.266*		-9.642*		-10.317*		-0.421		-0.532	
	(3.730)		(3.698)		(5.605)		(5.181)		(2.366)		(2.304)	
$I_{i \in TreatedWide} \times I_{t=2009}$		-3.902		-4.075		-7.757		-8.354*		2.001		1.969
		(3.561)		(3.478)		(5.083)		(4.573)		(2.415)		(2.368)
Observations	342	624	342	624	170	276	170	276	172	348	172	348
R2	0.837	0.843	0.844	0.847	0.802	0.842	0.820	0.852	0.924	0.856	0.926	0.858
Panel C: Term loans share (0 to 1)												
$I_{i \in Treated} \times I_{t=2009}$	-0.120**		-0.101		-0.277***		-0.240***		0.060		0.060	
	(0.054)		(0.064)		(0.060)		(0.068)		(0.052)		(0.056)	
$I_{i \in TreatedWide} \times I_{t=2009}$		-0.114**		-0.111**		-0.239***		-0.214***		0.051		0.041
		(0.054)		(0.055)		(0.055)		(0.052)		(0.049)		(0.051)
Observations	342	624	342	624	170	276	170	276	172	348	172	348
R2	0.833	0.827	0.859	0.835	0.834	0.831	0.868	0.842	0.866	0.832	0.876	0.858
For all panels:												
Controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Waxman-Markey cap-and-trade bill impact on shadow bank loan share

This table reports estimates from the regression specification given in equation (3). We estimate if firms just below the cut-off for free permits under the Waxman-Markey cap-and-trade bill, the treated firms, see a larger share of their loans held by shadow banks than firms just above the cut-off for free permits, the control firms, at the end of 2009 relative to the end of 2008. The dependent variable is the loan share held by shadow banks (between 0 and 1). The independent variable of interest is an indicator variable that takes the value 1 if the firm would not receive free permits under Waxman-Markey and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2009, that is, the year when Waxman-Markey had been passed by the House of Representatives and was still under consideration in the Senate. The results are shown for all firms, and subsamples of private and public firms. Firm, year, and lead bank fixed effects are included. The controls are credit ratings described in Section 4.2. Standard errors are clustered by 6-digit NAICS and reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	All firms				Private firms				Public firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$I_{i \in Treated} \times I_{t=2009}$	0.054**		0.054**		0.072**		0.071*		0.025		0.026	
	(0.025)		(0.026)		(0.033)		(0.037)		(0.030)		(0.029)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.066***		0.067***		0.101***		0.107***		0.018		0.019
		(0.023)		(0.022)		(0.028)		(0.026)		(0.028)		(0.027)
Observations	342	624	342	624	170	276	170	276	172	348	172	348
R2	0.873	0.882	0.877	0.883	0.833	0.841	0.841	0.844	0.927	0.926	0.928	0.927
Controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Waxman-Markey cap-and-trade bill and lenders' emission exposure

This table reports estimates from the regression specification given in equation (6). We estimate if lenders with substantial exposure to high-emission firms hold less syndicated loans of firms just below the cut-off for free permits under the Waxman-Markey cap-and-trade bill, the treated firms, than of firms just above the cut-off for free permits, the control firms, at the end of 2009 relative to the end of 2008. The dependent variable is a lender-firm level variable given in equation (4) that measures the credit commitment between a firm and a lender normalized by the total credit commitments of the lender. The independent variable of interest is an indicator variable that takes the value 1 if the firm would not receive a free permit under Waxman-Markey and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2009—the year when Waxman-Markey had been passed by the House of Representatives and was still under consideration in the Senate—and interacted with a third indicator variable that takes the value 1 if the lender has above median (top quintile) exposure to high-emission firms in 2008. The controls are credit ratings described in Section 4.2. Standard errors are double-clustered by 6-digit NAICS and lender and reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I_{i \in Treated} \times I_{t=2009}$	-0.006	-0.011			-0.003	-0.007		
	(0.007)	-0.007			(0.007)	(0.007)		
$I_{i \in TreatedWide} \times I_{t=2009}$			-0.010	-0.013*			-0.009	-0.011
			(0.008)	(0.007)			(0.008)	(0.008)
$I_{i \in Treated} \times I_{t=2009}$	-0.016***				-0.017***			
$\times I_{l \in AboveMedianHighEmissionLender}$	(0.003)				(0.003)			
$I_{i \in Treated} \times I_{t=2009}$		-0.018***				-0.019***		
$\times I_{l \in TopQuintileHighEmissionLender}$		(0.004)				(0.004)		
$I_{i \in TreatedWide} \times I_{t=2009}$			-0.010**				-0.010**	
$\times I_{l \in AboveMedianHighEmissionLender}$			(0.004)				(0.004)	
$I_{i \in TreatedWide} \times I_{t=2009}$				-0.010***				-0.011***
$\times I_{l \in TopQuintileHighEmissionLender}$				(0.003)				(0.003)
Observations	18,043	18,043	34,103	34,103	18,043	18,043	34,103	34,103
R2	0.845	0.845	0.812	0.812	0.846	0.846	0.813	0.812
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Firm-Lender FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: California cap-and-trade bill passage and firm balance sheets

This table reports estimates from the regression specification given in equation (2) estimated with annual firm balance sheet data. We estimate how balance sheets of firms with substantial GHG emissions in California, the treated firms, changed between 2011 and 2012, that is, before and after the bill's passage. The dependent variables are cash/assets (Panel A), CapEx/assets (Panel B), debt/assets (Panel C). The independent variable of interest is an indicator variable that takes the value 1 if the firm has over 50% of its total GHG emissions in California and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2012. Firm and industry-year fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Cash/Assets

	All firms		Private firms		Public firms	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$	0.032***	0.033***	0.026***	0.027***	0.073*	0.074*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.038)	(0.038)
Observations	726	726	430	430	206	206
R2	0.897	0.899	0.901	0.902	0.916	0.917

Panel B: CapEx/Assets

$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$	0.019*	0.019*	0.036***	0.039***	0.010	0.008
	(0.011)	(0.010)	(0.013)	(0.014)	(0.026)	(0.030)
Observations	666	666	394	394	178	178
R2	0.706	0.706	0.726	0.728	0.686	0.691

Panel C: Debt/Assets

$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$	0.010	0.011	-0.011	-0.019	0.123**	0.118***
	(0.018)	(0.020)	(0.021)	(0.018)	(0.046)	(0.042)
Observations	748	748	448	448	204	204
R2	0.874	0.875	0.884	0.889	0.908	0.916

For all panels:

Controls	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 10: California cap-and-trade implementation and firm balance sheets

This table reports estimates from the regression specification given in equation (2) estimated with annual firm balance sheet data. We estimate how balance sheets of firms with substantial GHG emissions in California, the treated firms, changed between 2012 and 2013, that is, before and after the implementation of the cap-and-trade program. The dependent variables are cash/assets (Panel A), CapEx/assets (Panel B), debt/assets (Panel C). The independent variable of interest is an indicator variable that takes the value 1 if the firm has over 50% of its total GHG emissions in California and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2013. Firm and industry-year fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Cash/Assets

	All firms		Private firms		Public firms	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA program}}$	-0.038***	-0.037***	-0.027***	-0.024*	-0.060***	-0.060***
	(0.005)	(0.006)	(0.010)	(0.012)	(0.011)	(0.011)
Observations	1,016	1,016	426	426	540	540
R2	0.886	0.887	0.911	0.914	0.868	0.869

Panel B: CapEx/Assets

	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA program}}$	-0.026***	-0.025***	-0.033***	-0.031**	-0.001	-0.001
	(0.009)	(0.008)	(0.011)	(0.014)	(0.015)	(0.015)
Observations	968	968	404	404	512	512
R2	0.680	0.683	0.735	0.737	0.649	0.654

Panel C: Debt/Assets

	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA program}}$	0.021	0.017	0.020	0.003	0.021	0.021
	(0.013)	(0.014)	(0.019)	(0.020)	(0.019)	(0.019)
Observations	1,004	1,004	436	436	514	514
R2	0.907	0.909	0.924	0.928	0.901	0.906

Panel D: EBITDA/Assets

	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA program}}$	-0.001	-0.002	-0.025**	-0.019	0.015**	0.016**
	(0.005)	(0.006)	(0.011)	(0.013)	(0.007)	(0.007)
Observations	950	950	402	402	496	496
R2	0.843	0.845	0.883	0.887	0.789	0.796

Panel E: Sales/Assets

	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA program}}$	0.009	0.008	-0.022	-0.023	0.003	0.005
	(0.026)	(0.027)	(0.042)	(0.045)	(0.034)	(0.034)
Observations	996	996	434	434	508	508
R2	0.983	0.984	0.985	0.985	0.974	0.975

For all panels:

	(1)	(2)	(3)	(4)	(5)	(6)
Controls	No	Yes	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 11: Waxman-Markey cap-and-trade bill impact on monitoring of firms

This table reports estimates from the regression specification given in equation (3). We estimate if firms just below the cut-off for free permits under the Waxman-Markey cap-and-trade bill, the treated firms, experience different monitoring by lenders than firms just above the cut-off for free permits, the control firms, at the end of 2009 relative to the end of 2008. The dependent variables are indicator variables that take the value 1 if the firm has a cash flow covenant and if a firm is actively monitored by the lead arranger, respectively. The independent variable of interest is an indicator variable that takes the value 1 if the firm would not receive a free permit under Waxman-Markey and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2009—the year when Waxman-Markey had been passed by the House of Representatives and was still under consideration in the Senate. The controls are credit ratings described in Section 4.2. Standard errors are clustered by 6-digit NAICS and reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Cash flow covenants (0 or 1)

	(1)	(2)	(3)	(4)
$I_{i \in Treated} \times I_{t=2009}$	0.277*		0.180	
	(0.149)		(0.127)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.188*		0.193*
		(0.095)		(0.110)
Observations	114	198	114	198
R2	0.904	0.909	0.929	0.914

Panel B: Active monitoring (0 or 1)

	(1)	(2)	(3)	(4)
$I_{i \in Treated} \times I_{t=2009}$	0.136*		0.022	
	(0.071)		(0.061)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.113		0.061
		(0.101)		(0.086)
Observations	115	200	115	200
R2	0.911	0.911	0.933	0.923

For both panels

	(1)	(2)	(3)	(4)
Controls	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes

Appendix A Additional tables

Table A.1: Variables description

This table describes the variables used in our analysis. Some variables are in both the SNC and Y14 datasets, while others are only available in one dataset.

Variable name	Dataset	Description
Active Monitoring	SNC	Defined as a dummy variable taking the value of one whenever any of the loan commitments to borrower i in year t are monitored actively by the lead bank. Specifically, we define active monitoring as field exams of the borrowers conducted by the lead bank as well as third-party appraisals.
Borrower Ratings_SNC	SNC	Four indicator variables that take the value of one whenever at least some fraction of the commitments to borrower i in year t are rated "pass", "substandard", "doubtful", and "loss", respectively, by the lead bank. Otherwise, the value of the indicator variables are zero.
Borrower Ratings_Y14	Y-14	Indicator variables based on the borrower i's credit rating in quarter q. The borrowers's credit ratings are issued by the banks and aggregated across banks for each borrower. As banks use different internal rating scales, the Y-14 Collection requires that banks convert their own internal rating scale to a ten-grade S&P scale in order for the measure to be comparable across banks.
CapEx/Assets	Y14	Defined as net capital expenditure normalized by assets of firm i in year t.
Cash/Assets	Y14	Defined as cash normalized by assets of firm i in year t.
Cash Flow Covenant	SNC	An indicator variable that takes the value of one when a cash flow covenant is present in any of the commitments to borrower i in year t.
Debt/Assets	Y14	Defined as debt normalized by assets of firm i in year t.
EBITDA/Assets	Y14	Defined as EBITDA normalized by assets of firm i in year t.
Interest Rate	Y14	Defined as the interest rate that borrower i pays on term loans and drawn credit lines in quarter q.
Lead Bank Fixed Effects	SNC	These are indicator variables based on the different lead banks in the sample.
LenderFirmExposure	SNC	The amount of firm i's syndicated loans held by lender l in year t normalized by the total amount of syndicated loans held by lender l in year t.
LenderHighEmissionExposure	SNC	The amount of high-emission firms' syndicated loans held by lender l in year t normalized by the total amount of syndicated loans held by lender l in year t.
Public	SNC & Y14	An indicator variable that takes the value of one when the borrower is public and zero when the borrower is private.
Remaining Maturity	SNC & Y14	Defined as the average maturity of the loans of borrower i in year t (quarter q).
Sales/Assets	Y14	Defined as sales normalized by assets of firm i in year t.
Shadow Bank Share	SNC	Defined as the share of the total commitments of borrower i in year t held by shadow bank (non-bank) lenders.
Term Loans	SNC & Y14	Defined as the total dollar amount of terms loans (in millions of US$) to borrower i in year t (quarter q).
Term Loan Share	SNC & Y14	Defined as the share of total commitments to borrower i in year t (quarter q) in the form of term loans.
Total Committed Credit	SNC & Y14	Defined as the total dollar amount of loan commitments (in millions of US$) of borrower i in year t (quarter q).

Table A.2: Cap-and-trade bills impact on loan utilization

This table reports estimates from the regression specifications given in equations (2) and (3), with the utilized credit normalized by the total commitment (between 0 and 1) as the dependent variable. In Panel A, we estimate if the outcome variables of firms with substantial GHG emissions in California, the treated firms, differ from firms without substantial GHG emissions, the control firms, in the third and fourth quarter of 2012 relative to third and fourth quarter of 2011. The independent variable of interest is an indicator variable that takes the value 1 if the quarter is the third or fourth quarter of 2012 interacted with an indicator variable that takes the value 1 if the firm has over 25% or 50% of its total GHG emissions in California and 0 otherwise. Firm and industry-quarter fixed effects are included. The controls are credit ratings described in Section 4.1. Standard errors are clustered by the state in which a firm has its largest GHG emissions and are reported in parentheses. In Panel B, we estimate if the outcome variables of firms just below the cut-off for free permits under the Waxman-Markey cap-and-trade bill, the treated firms, differ from firms just above the cut-off for free permits, the control firms, at the end of 2009 relative to the end of 2008. The independent variable of interest is an indicator variable that takes the value 1 if the firm would not receive free permits under Waxman-Markey and 0 otherwise interacted with an indicator variable that takes the value 1 if the year is 2009, that is, the year when Waxman-Markey had been passed by the House of Representatives and was still under consideration in the Senate. The controls are credit ratings described in Section 4.2. Standard errors are clustered by 6-digit NAICS and reported in parentheses. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: California cap-and-trade bill

	(1)	(2)	(3)	(4)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	0.007		0.009	
	(0.030)		(0.028)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		-0.003		-0.003
		(0.038)		(0.044)
Observations	2,717	2,717	2,717	2,717
R2	0.872	0.872	0.874	0.872
Controls	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes

Panel B: Waxman-Markey cap-and-trade bill

	(1)	(2)	(3)	(4)
$I_{i \in Treated} \times I_{t=2009}$	0.021		0.029	
	(0.043)		(0.042)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.015		0.014
		(0.038)		(0.037)
Observations	296	564	296	564
R2	0.910	0.886	0.913	0.887
Controls	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes

Table A.3: Greenhouse gas emissions of firms

This table reports the GHG emissions of the firms from the EPA data that have been mapped to the syndicated loan data from SNC. For each year, the total GHG emissions are reported in million metric tons (MMT) carbon dioxide equivalent. Further, the emissions are split up by firms and facilities. The last column presents an estimate of the total GHG emissions of the US, which includes transportation, agriculture, etc. (which are not covered by the EPA data on high-emission facilities) taken from the EPA's "US Greenhouse Gas Emissions and Sinks 1990 to 2018" report.

	Total emissons (sample firms)	Number of firms	Avg. emissions (per firm)	Number of facilities	Avg. emissions (per facility)	Total emissions (US economy)
2010	2,248	549	4.094	2,823	0.796	6,979
2011	2,338	689	3.393	3,517	0.665	6,818
2012	2,239	698	3.208	3,591	0.624	6,577
2013	2,259	710	3.182	3,586	0.630	6,767
2014	2,267	734	3.088	3,670	0.618	6,826
2015	2,179	711	3.065	3,781	0.576	6,674
2016	2,116	720	2.939	3,629	0.583	6,526
2017	2,067	713	2.900	3,574	0.578	6,487
2018	2,025	738	2.744	3,583	0.565	6,678

Table A.4: Credit to greenhouse gas emitting firms

This table reports statistics on the syndicated loans to firms with facilities that emit large amounts of greenhouse gas as measured by the EPA data. Panel A reports the total committed credit exposure, and further splits the credit exposure between credit lines and term loans. Also shown is the credit line utilization and the amount of loans held by institutions other than banks in the secondary market. Panel B reports the average maturity of the loans in months and the rating of the loans, that is, the fraction of the loans rated as pass.

Panel A: Total credit (in billion US$)

Year	Total committed credit	Term loans	Credit lines	Credit lines utilized	Credit lines utilized (in %)	Shadow bank share (in %)
2010	450	71	374	35	9	10
2011	561	96	463	51	11	10
2012	612	98	508	56	11	12
2013	653	117	518	47	9	14
2014	740	149	575	61	11	14
2015	723	134	581	58	10	12
2016	716	121	581	56	10	10
2017	698	114	572	52	9	10
2018	747	105	633	70	11	9

Panel B: Terms of credit

	Term loans		Credit lines	
Year	Maturity	Rating	Maturity	Rating
2010	74.23	89.89	58.19	94.71
2011	73.22	89.35	62.77	95.32
2012	72.44	86.15	64.59	94.14
2013	75.89	83.33	69.50	92.73
2014	71.02	85.50	69.92	93.09
2015	69.77	76.31	70.64	89.90
2016	68.58	83.40	71.06	88.43
2017	72.01	86.40	76.37	94.15
2018	71.78	92.96	76.49	95.56

Table A.5: Industries by energy intensity

This table reports the industries and the corresponding six-digit NAICS codes for each energy intensity threshold taken from Meng (2017).

Panel A: Energy intensity [0.01, 0.02)

NAICS	Industry	NAICS	Industry
311320	Chocolate and Confectionery Manufacturing from Cacao Beans	332439	Other Metal Container Manufacturing
311340	Nonchocolate Confectionery Manufacturing	332721	Precision Turned Product Manufacturing
311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing	332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing
311611	Animal (except Poultry) Slaughtering	332911	Industrial Valve Manufacturing
311612	Meat Processed from Carcasses	332912	Fluid Power Valve and Hose Fitting Manufacturing
311613	Rendering and Meat Byproduct Processing	332919	Other Metal Valve and Pipe Fitting Manufacturing
311711	Seafood Canning	332992	Small Arms Ammunition Manufacturing
311821	Cookie and Cracker Manufacturing	332994	Small Arms Manufacturing
311823	Dry Pasta Manufacturing	332996	Fabricated Pipe and Pipe Fitting Manufacturing
311920	Coffee and Tea Manufacturing	332999	All Other Miscellaneous Fabricated Metal Product Manufacturing
311999	All Other Miscellaneous Food Manufacturing	333210	Sawmill and Woodworking Machinery Manufacturing
314110	Carpet and Rug Mills	333314	Optical Instrument and Lens Manufacturing
314999	All Other Miscellaneous Textile Product Mills	333315	Photographic and Photocopying Equipment Manufacturing
315191	Outerwear Knitting Mills	333515	Cutting Tool and Machine Tool Accessory Manufacturing
315211	Men's and Boys' Cut and Sew Apparel Contractors	333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
315212	Women's, Girls', and Infants' Cut and Sew Apparel Contractors	333613	Mechanical Power Transmission Equipment Manufacturing
321912	Cut Stock, Resawing Lumber, and Planing	334413	Semiconductor and Related Device Manufacturing
321999	All Other Miscellaneous Wood Product Manufacturing	334414	Electronic Capacitor Manufacturing
322213	Setup Paperboard Box Manufacturing	334415	Electronic Resistor Manufacturing
323110	Commercial Lithographic Printing	334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
323111	Commercial Gravure Printing	334417	Electronic Connector Manufacturing
323114	Quick Printing	334611	Software Reproducing
323115	Digital Printing	334613	Magnetic and Optical Recording Media Manufacturing
323117	Books Printing	335110	Electric Lamp Bulb and Part Manufacturing
323119	Other Commercial Printing	335311	Power, Distribution, and Specialty Transformer Manufacturing
325320	Pesticide and Other Agricultural Chemical Manufacturing	335921	Fiber Optic Cable Manufacturing
325520	Adhesive Manufacturing	335929	Other Communication and Energy Wire Manufacturing
325992	Photographic Film, Paper, Plate, and Chemical Manufacturing	335931	Current-Carrying Wiring Device Manufacturing
325998	All Other Miscellaneous Chemical Product and Prep. Manuf.	336330	Motor Vehicle Steering and Suspension Comp. (except Spring) Manuf.
326150	Urethane and Other Foam Product (except Polystyrene) Manuf.	336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
326291	Rubber Product Manufacturing for Mechanical Use	336399	All Other Motor Vehicle Parts Manufacturing
326299	All Other Rubber Product Manufacturing	336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	336415	Guided Missile and Space Vehicle Propulsion Unit and Prop. Unit Parts Manuf.
331421	Copper Rolling, Drawing, and Extruding	337122	Nonupholstered Wood Household Furniture Manufacturing
331422	Copper Wire (except Mechanical) Drawing	337124	Metal Household Furniture Manufacturing
332116	Metal Stamping	339992	Musical Instrument Manufacturing
332211	Cutlery and Flatware (except Precious) Manufacturing	339993	Fastener, Button, Needle, and Pin Manufacturing
332212	Hand and Edge Tool Manufacturing	339995	Burial Casket Manufacturing
332214	Kitchen Utensil, Pot, and Pan Manufacturing		

Panel B: Energy intensity [0.02, 0.03)

NAICS	Industry	NAICS	Industry
311222	Soybean Processing	326112	Plastics Packaging Film and Sheet (incl. Laminated) Manuf.
311312	Cane Sugar Refining	326192	Resilient Floor Covering Manufacturing
311411	Frozen Fruit, Juice, and Vegetable Manufacturing	326199	All Other Plastics Product Manufacturing
311412	Frozen Specialty Food Manufacturing	326211	Tire Manufacturing (except Retreading)
311421	Fruit and Vegetable Canning	326220	Rubber and Plastics Hoses and Belting Manufacturing
315119	Other Hosiery and Sock Mills	327215	Glass Product Manufacturing Made of Purchased Glass
321113	Sawmills	331221	Rolled Steel Shape Manufacturing
321211	Hardwood Veneer and Plywood Manufacturing	331222	Steel Wire Drawing
322221	Coated and Lam. Packaging Paper and Plastics Film Manuf.	331491	Nonfer. Metal (except Copper and Alu.) Rolling, Drawing, and Extr.
322222	Coated and Laminated Paper Manufacturing	332991	Ball and Roller Bearing Manufacturing
322291	Sanitary Paper Product Manufacturing	332993	Ammunition (except Small Arms) Manufacturing
324110	Petroleum Refineries	334411	Electron Tube Manufacturing
324122	Asphalt Shingle and Coating Materials Manufacturing	334412	Bare Printed Circuit Board Manufacturing
325411	Medicinal and Botanical Manufacturing	335911	Storage Battery Manufacturing
326111	Plastics Bag Manufacturing		

Table A.5: Industries by energy intensity (continued)

Panel C: Energy intensity [0.03,0.05)

313112	Yarn Texturizing, Throwing, and Twisting Mills	326140	Polystyrene Foam Product Manufacturing
313210	Broadwoven Fabric Mills	327112	Vitreous China, Fine Earthenw., and Other Pottery Prod. Manuf.
324199	All Other Petroleum and Coal Products Manufacturing	331319	Other Aluminum Rolling and Drawing
325131	Inorganic Dye and Pigment Manufacturing	331524	Aluminum Foundries (except Die-Casting)
325132	Synthetic Organic Dye and Pigment Manufacturing	332111	Iron and Steel Forging
325312	Phosphatic Fertilizer Manufacturing	332112	Nonferrous Forging
326113	Unlaminated Plastics Film and Sheet (except Packag.) Manuf.		

Panel D: Energy intensity [0.05,0.07)

325191	Gum and Wood Chemical Manufacturing	327122	Ceramic Wall and Floor Tile Manufacturing
325193	Ethyl Alcohol Manufacturing	331419	Prim. Smelting and Ref. of Nonferrous Metal (except Copper and Alu.)
325199	All Other Basic Organic Chemical Manufacturing	331512	Steel Investment Foundries
325211	Plastics Material and Resin Manufacturing	335991	Carbon and Graphite Product Manufacturing

Panel E: Energy intensity [0.07,0.08)

322121	Paper (except Newsprint) Mills	325188	All Other Basic Inorganic Chemical Manufacturing
322122	Newsprint Mills	331111	Iron and Steel Mills
325182	Carbon Black Manufacturing	331112	Electrometallurgical Ferroalloy Product Manufacturing

Panel F: Energy intensity [0.08,0.09)

322110	Pulp Mills	325110	Petrochemical Manufacturing