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JEL Classification: G15, G21, H23, Q5

Keywords: Carbon taxes, Cross-border lending, climate change

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1 Introduction

There is a near-universal consensus among economists that carbon taxes are the most cost-effective tool to reduce carbon emissions at the scale and speed that is necessary to address the climate crisis[1]. Moreover, pricing carbon induces firms to develop and adopt low-carbon technologies, speeding up the green transition (Acemoglu, Aghion, Bursztyn, and Hemous, 2012; Acemoglu, Akcigit, Hanley, and Kerr, 2016). Yet, at present few countries in the world tax carbon-intensive activities at the required levels.[2] Moreover, the implementation of carbon taxes in the future is plagued by practical difficulties, such as how to measure emissions precisely and how to rebate the proceeds in an efficient and fair manner. The most daunting challenge, however, stems from imperfect global coordination: national authorities may be loathe to impose carbon taxes unilaterally, for fear that the affected economic activities will simply move across borders. This would reduce growth at home while making little difference in terms of aggregate emissions.

We go to the heart of this question by studying the cross-border reallocation of fossil lending by internationally active banks in response to changes in the domestic cost of carbon. Between 1990 and 2020, 25 countries imposed some form of carbon tax. A further 22 countries joined an Emissions Trading Scheme (ETS) which charges certain sectors of the economy for the greenhouse gases they emit. We study the evolution of lending to coal, gas, or oil companies by syndicated creditors, both at home and abroad, around these events. To that end, we employ a comprehensive dataset of more than 2 million bank-firm loan tranches made between 1988 and 2021.

[1] See, for example, the "Economists' Statement on Carbon Dividends", which was originally published in the Wall Street Journal on 16 January 2019 and has since been signed by more than 4,000 economists from around the world.

[2] Estimates of the optimal carbon tax vary depending on model assumptions, ranging from $25 USD to $1,500 USD per ton (see, e.g., Golosov, Hassler, Krussel, and Tsyvinski, 2014; Van der Ploeg and Rezai, 2021).

We focus on lending to fossil fuel companies, such as coal mines and oil extraction companies, because they stand at the source of the carbon dioxide emissions chain. Carbon dioxide is a byproduct of burning fossil fuel in industry, transportation, or energy generation. Because of its sunlight-capturing properties, and in combination with its large quantity already in the atmosphere, carbon dioxide is the main anthropogenic contributor to global warming. Accordingly, global plans to slow down climate change rest heavily on leaving the bulk of existing coal, oil, and gas reserves in the ground (UNFCCC, 2015).[3] At the same time, to the indignation of the international community, financing for companies which extract fossil reserves and produce fossil fuel does not appear to be slowing down. For example, a recent report by a group of NGOs pointed out that world's biggest 60 banks have provided $3.8 trillion USD of financing for fossil fuel companies since the Paris climate deal in 2015, and that overall funding for said companies remains on an upward trend.[4]

Our primary finding is that following an exogenous increase in the price of carbon in the domestic market, banks reduce their fossil lending at home and increase their fossil lending abroad. This reallocation of fossil lending across national borders is immediate, economically meaningful, and statistically significant. In particular, two years after a country adopts a carbon tax, domestic (foreign) fossil lending by banks domiciled in this country is 1.4% lower (8.5% higher). The same effect is in place regardless of whether we look at the imposition of carbon taxes or at the introduction of Emissions Trading Schemes. Moreover, we find that the reallocation of lending in response to carbon taxes is not confined to coal, oil, or gas companies, but it is observed for other carbon-intensive sectors, such as metallurgy and cement production.

[3] According to Meinshausen et al. (2009)'s calculations, more than half of all economically recoverable fossil reserves should be left in the ground if humanity is to have at least a 50% chance of not exceeding temperatures higher by at most 2 degrees Celsius, compared with pre-industrial levels.

[4] See https://www.bankingonclimatechaos.org/wp-content/uploads/2021/10/Banking-on-Climate-Chaos-2021.pdf.

The main result of the paper is visualized in Figures 1 and 2. In these, we plot point estimates and 95-percent confidence banks of a regression where the dependent variable is a dummy equal to one if bank's loan is to a fossil company, and to zero if not. We run the regressions on a sample period that includes two years before and two years after the introduction of a carbon tax in the country. Because we include bank fixed effects, the point estimates should be understood as growth rates in lending to particular categories of firms. The evidence strongly suggests that lending to fossil companies was stable in the years prior to the introduction of the tax. At the same time, the evidence also points to a significant reduction in domestic fossil lending (Figure 1), and a significant increase in foreign fossil lending (Figure 2) in the two years after the tax comes into place in the bank's domestic market.

We confirm that the relationship between shocks to carbon taxes and lending obtains not only for lending to fossil companies, but also for lending to carbon-intensive industrial activities, such as metallurgy and cement production. Moreover, the same effect is observed regardless of whether carbon is prices via a carbon tax or via an ETS. In addition, we confirm the validity of our results by subjecting our data to two falsification tests. First, we demonstrate that the reallocation of fossil lending does not pre-date the introduction of carbon taxes. On the contrary, domestic fossil lending appears to increase on average in the years leading to the carbon tax, after which the trend reverses. Second, we show that economic activities that are associated with a negligible carbon footprint – such as retail trade, wholesale trade, or clean manufacturing – do not respond, one way or another, to the introduction of carbon taxes. We conclude that the statistical relation between changing in carbon taxes and fossil lending appears to be causal.

Our second finding is that certain bank-specific, firm-specific, and host country-specific factors increase the elasticity of fossil lending reallocation to changes in carbon pricing. On the bank side, we find that banks with relatively high fossil exposures are more likely to reallocate fossil lending across national borders. This result appears to provide confirmation for theories arguing that banks prefer to engage in lending practices which do not undermine the value of the assets already in their balance sheets (e.g., Minetti, 2011). At the same time, bank capitalization or profitability does not seem to play a role.

On the firm side, we find that in response to carbon taxes at home, banks are more likely to increase lending abroad to both private and publicly listed fossil companies. At the same time, the effect is around one-third larger in the case of private firms. This is consistent with the notion that in a policy environment which is increasingly hostile to the funding of fossil operations, banks may prefer to avoid the inevitable public scrutiny which comes with lending to listed firms. It is also consistent with the idea that tighter regulation at home may increase bank risk taking abroad (Ongena, Popov, and Udell, 2013).

On the host-country side, we find that banks are more likely to increase lending to countries they are less familiar with. This suggests that the extensive margin of lending is important when it becomes necessary to reduce domestic fossil lending. We also find that banks extend larger loans with shorter maturities to fossil companies in foreign countries with no carbon tax. This result supports the notion that when the carbon tax is not global, banks will look for ways to arbitrage it away.

Our work contributes to several strands of the literature. First, the analysis we present speaks to the growing literature about the effect of climate change on the decision taken by firms and households (Matos, 2020; Giglio, Kelly, and Stroebel, 2021). For example, Alok, Kumar, and Wermers (2020) show that fund managers adjust their portfolios in response to climate disasters. Importantly, expected climate policies play a role, too. Krueger, Sautner, and Starks (2020) show that active investment managers believe climate change to have significant financial implications for portfolio firms, and that considerations of climate risk are important in the investment process. Engle, Giglio, Kelly, Lee, and Stroebel (2020) document that stocks of firms with lower exposure to regulatory climate risk have higher returns during periods with negative news about the future path of climate change. Choi, Gao, and Jiang (2020) explore global stock market data and find that stocks of carbon-intensive firms underperform during times with abnormally warm weather, a period when investors' attention to climate risks are likely to be particularly high. Giglio, Maggiori, Rao, Stroebel, and Weber (2021) show that while properties in a flood zone generally trade at a premium compared to otherwise similar properties, this premium compresses in periods with elevated attention paid to climate risk.

Due to firms' and households' exposure to climate risks, investors in general, and banks in particular, can ask for higher returns on their loans (Bolton and Kacperczyk, 2021; Delis, De Greiff, and Ongena, 2021). This can incentivize the firms to reallocate their operations to jurisdictions with less strict climate policies (Bartram, Hou, and Kim, 2021). We contribute to this literature by providing evidence that in response to a higher cost of carbon, banks take actions to reduce the effect of higher carbon prices on their loan portfolios. In particular, we demonstrate that large international banks react reduce domestic fossil lending and increase foreign fossil lending, after their home country imposes a carbon tax or joins an ETS.

Second, our paper adds to the literature that examines banks' propensity to engage in cross-border lending. Researchers have documented extensively that cross-border lending is one important mechanism whereby shocks to banks' balance sheets are transmitted across national borders (Cetorelli and Goldberg, 2011; Giannetti and Laeven, 2012; Popov and Udell, 2012; De Haas and van Horen, 2013; Hale, Kapan, and Minoiu, 2020; Doerr and Schaz, 2021). This literature has also shown that regulatory arbitrage opportunities can be an important driver of cross-border lending (Houston, Lin, and Ma, 2012; Ongena, Popov, and Udell, 2013; Karolyi and Taboada, 2015), as well as of real decisions by multinational firms (Barrior, Huizinga, Laeven, and Nicodeme, 2012). Closest to our work, Ben-David, Jang, Kleimeier, and Viehs (2021) show that firms headquartered in countries with strict environmental policies perform their polluting activities abroad in countries with relatively weaker policies. Building on their work, Benincasa, Kabas, and Ongena (2021) show that banks' overall lending portfolio is tilted towards foreign lending in countries with stricter environmental regulation. Our paper differs from this work in that we show that carbon taxes induce a reallocation of fossil lending across national borders. Our analysis therefore confirms the notion that lack of tax homogeneity in can reduce the effectiveness of such regulations through the channel of cross-border bank lending. Our paper also differs from the analysis in Ivanov, Kruttli, and Watugala (2020) who show that a California cap-and-trade bill affected credit conditions for high-emissions firms by increasing interest rates and shortening loan maturities. In contrast, we study the cross-border reallocation dimension of the interaction between carbon taxes and lending decisions.

Finally, our paper contributes to the emerging literature which examines the interaction between environmental policies and bank lending. De Haas and Popov (2019) document that economies that rely relatively more on equity than debt financing experience faster reductions in carbon emissions, suggesting that banks are at a comparative disadvantage in funding the development and adoption of low-carbon technologies. Goetz (2019) and Levine, Lin, Wang, and Xie (2019) show that more favorable funding conditions lead firms to reduce their toxic emissions. Degryse, Roukny, and Tielens (2020) argue that banking can cause barriers to the "green" economy as the entry of innovative and "green" firms in polluting industries risks devaluating banks' legacy positions with incumbent clients. Examining the effect of the Paris Agreement on the pricing of carbon-intensive technologies, Delis, De Greiff, Iosifidi, and Ongena (2021) find evidence of a significantly higher cost of bank credit for fossil fuel firms, but only after 2015. Reghezza, Altunbas, Marques-Ibanez, d'Acri, and Spaggiari (2021) show that following the ratification of the Paris Agreement, banks reallocated credit away from polluting firms. They further show that in the aftermath of President Trump's 2017 announcement on the US withdrawal from the

Paris Agreement European banks decreased lending to polluting firms in the United States. Degryse, Goncharenko, Theunisz, and Vadasz (2021) provide evidence that environmentally conscious banks could play a positive role in the green transition by granting cheaper loans to environmentally conscious firms. We contribute to this emerging literature by examining the propensity of banks to extend loans to fossil companies, and by documenting iportant changes in this propensity in respond to shocks to carbon prices.

2 Theoretical mechanisms

Our aim is to investigate the relation between carbon taxes and the domestic-foreign mix of bank lending. Our prior is informed by theoretical and empirical work which has implications for the supply and the demand of bank credit to firms whose operations are affected by the introduction of a price of carbon. Theory offers conflicting predictions about the effect of a carbon tax on bank lending at home and abroad.

On the credit demand side, the reallocation of resources induced by (environmental) regulation takes time and is very costly because it requires large upfront expenditures (Walker, 2013). As a result, the demand for investment should decline for firms hit by a carbon tax. In particular, the tax will force such firms to shift resources which is costly. As a consequence it will depress their investment and demand for loans. In addition, tight carbon budgets implied by climate stabilisation greatly reduce the long-term value of fossil fuels (Krause, Bach, and Koomey, 1989). As a consequence, an optimal carbon price, while socially optimal in that it minimizes the discounted social cost of the transition to clean capital, may prompt the premature retirement of existing polluting capacities (Rozenberg, Vogt-Schilb, and Hallegatte, 2020). This can be associated with significant private costs in the form of stranded assets. This lowers the return on stranded assets, which by implication lowers the demand for loans for legacy projects. Consequently, as the demand for fossil lending at home declines, banks can be expected to increase their credit supply to fossil companies abroad.

The proliferation in stranded assets as a result of optimal carbon pricing also has implications for financial intermediation through the channel of credit supply. For example, Kiyotaki and Moore (1997) argue that when the value of collateral declines for exogenous reasons, banks' willingness to extend credit to the affected firms declines as a result of a tightening of collateral constraints. This should result in a decline in the supply of loans to these firms. By reducing the value of fossil assets, a carbon tax should generate an analogous reduction in the value of collateral at fossil firms, resulting in a reduction in credit to those by their creditors. By implication, these same creditors now have an incentive to increase lending to similar fossil companies in foreign jurisdictions that have not been hit by such shocks.

Moreover, to the extent that a carbon tax will reduce the value of fossil-linked assets that serve as collateral on banks' balance sheets, the introduction of a carbon tax will reduce the supply of credit by banks by squeezing the value of collateral and tightening banks' capital constraints (Holmstrom and Tirole, 1997). The implication of this credit supply shock would be that both domestic and foreign lending to fossil companies would decline.

This short discussion of existing theories allows us to formulate the following hypothesis.

H0. The introduction of carbon taxes in one country is associated with a decline in fossil lending in that country and an increase in fossil lending in other countries.

Testing this hypothesis allows us to assess the relative importance of alternative theoretical mechanisms. A decline in fossil lending at home would be consistent with both demand and supply effects, while an increase in fossil lending abroad would be consistent with both demand and supply effects arising from changes in collateral values, and a decline in fossil lending abroad would be consistent with a dominant role for banks' balance sheet effects.

3 Data

3.1 Data sources and matching

Our data comes from a number of sources. First, we collect information on the date of implementation of carbon taxes from the Carbon Tax Center. While information is also available on the size of the tax, we only classify countries based on a binary criterion (has carbon tax, yes or no). From the same data source, we obtain information on which country joined an Emissions Trading Scheme (ETS) and when. The resulting global data are summarized in Appendix Table 1. This Table makes it clear that between 1990 and 2020, 25 countries imposed some form of carbon tax. During the same period, a further 22 countries joined an ETS which charges some (but typically not all) sectors of the economy for the greenhouse gases they emit.[5] Consequently, 47 countries in the world apply some form of carbon pricing to at least a part of their economy. Of these, 11 (all of the EU member states) both have a carbon tax and are members of an ETS. Figure 2 visualizes our data.

Next, we obtain loan-level data from the DealScan database. DealScan contains comprehensive information on virtually all syndicated loans since the 1980s. We

[5]For example, the EU's ETS covers carbon dioxide, nitrous oxide, and perfluorocarbon emissions from about 11,000 heavy energy-using installations, including power stations and industrial plants, such as oil refineries, steelworks and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals. At the same time, it excludes a number of greenhouse gas emitting sectors, such as agriculture, transportation, and residential buildings. As a result, only 45% of the sources of the EU's greenhouse gas emissions are covered by the ETS.

download all syndicated loans extended to non-financial corporates worldwide, focusing on the period 1998 – 2020. This allows us to observe bank lending behavior before and after each carbon tax event in our dataset. Following the literature, I exclude loans to financial companies (SIC between 6000 and 6999) from the sample Our unit of observation is the volume of syndicated loans issued by bank i to borrower j during year t. To this end, we split each loan into the portions provided by the different syndicate members.

To do so, we make a series of empirical choices. For a start, Dealscan provides exact loan breakdown among the syndicate members for about 25% of all loans. For the rest of the loans, in each case we calculate an average bank share based on each bank's history of loans for which the exact breakdown among syndicated members is known. We then assign this average and calculate the resulting loan size. Finally, for banks for which historical shares are not known, we use a procedure similar to the one applied by De Haas and Van Horen (2013) and Popov and van Horen (2015) and divide the loan equally among the syndicate members. In total we split 263,879 into 2,142,170 bank-firm-loan tranches. The dataset further contains a total of 21,284 banks and 98,126 firms.

In addition to establishing the bank's and firm's identity and constructing loan amounts, we also gather data on loan maturity and loan origination date. All loans are denominated in US dollars. The time unit of observation is the year of loan origination.

Dealscan contains information of the borrowing firm's primary industrial sector. We classify as "fossil loans" loans that have been made to firms in SIC 12 (Bituminous Coal Lignite Mining) and to firms in SIC 13 (Oil and gas wells, exploration, and services). Finally, Dealscan also contains information on both the lender's and the borrower's country, allowing us to match the information in Dealscan to the information on carbon taxes and ETS membership.

Next, we obtain bank-specific information on the lenders in our dataset. To that end, we obtain data on bank balance sheets by merging Dealscan with Bankscope. We do this by using the DealScan-Bankscope link from Schwert (2018). We obtain a match for only about 10.5% of the banks in the starting Dealscan dataset. From Bankscope, we obtain information on a range of bank-specific variables, including equity, regulatory capital, and profitability.

We also obtain firm-specific information on all borrowers in our dataset. To that end, we use the DealScan-Compustat Link from Chava and Roberts (2008) and perform a fuzzy matching based on company names and tickers. In this case, only 12.4% of the firms in Dealscan are matched to Compustat. From there, we obtain information on a range of firm-specific variables, such as sales, employment, output, assets, etc.

3.2 Summary statistics

In Table 1, we present summary statistics of the main variables used in the analysis. The first panel reports the properties of the loans in the sample. Recall that we have calculated the portion that each bank participates in a syndicated loan with. The summary statistics refer to the individual portions rather than to the syndicated loans themselves.

About 4.2% of all loans in the sample are to fossil companies, meaning companies engaged in the extraction and processing of coal, gas, and oil. There is, however, substantial heterogeneity, with a large number of banks making no loans to, and a number lending exclusively to, fossil companies. Once we include non-coal mining, the proportion increases to 5.3%. It goes up further to 7.1% once we include carbon-intensive manufacturing, i.e., metallurgy and cement production. A similar proportion to fossil loans is loans to wholesale (4.2%) and to retail (5.3%) firms. Manufacturing loans, excluding metallurgy and cement, constitute 26.1% of all loans. 95.5% of all loans are to domestic companies, and 4.5% are to foreign ones. The average loan per bank is 4.25 million US dollars, and the average maturity is 56.7 months.

The second panel of Table 1 reports summary information on a number of bank characteristics. A bank's average fossil loan exposure is 0.052, meaning that 5.2% of the lending of the average bank is to fossil companies. This variable is calculated using each bank's lending history in Dealscan. From there, we also calculate a measure of familiarity as the average share of loans to a particular country. This number stands as 0.534, suggesting that the average country with which a bank has a lending relationship gets 53.4% of the bank's loans. This is driven entirely by the very high proportion of domestic loans in the average bank's portfolio.

Finally, from Bankscope we calculate summary statistics on the banks' capitalization and profitability. On average, the banks in the sample have 18.9% equity, and a return on assets of 1.513. We do note the matching from Dealscan to Bankscope yields a sample that is only 10.5% of the original one.

Next, in the third panel we report summary statistics for the main country-specific variables of interest. 10.6% of the loans in the dataset are to countries that have a carbon tax. Alternatively, 19.9% of said loans are to countries that either have a carbon tax or are members of an ETS.

Finally, in the last panel we report summary statistics on firm-specific variables of interest. 39% of the loans in our dataset are to listed firms, and 61% to privately owned firms.

4 Empirical model and identification

Our main econometric model focuses on the relationship between the propensity of a bank to extend fossil loans, both at home and abroad, and the extent of carbon pricing in the bank's domestic market. Our main specification takes the following form:

$$
\begin{aligned}
Fossil\,Loan_{b,f,t} &= \beta_1 Foreign\,Loan_{b,f,t} + \beta_2 Carbon\,Tax_{i,t} \times Foreign\,Loan_{b,f,t} \\
&\quad + \gamma_{b,j} + \mu_{i,t} + \phi_{j,t} + \varepsilon_{b,f,t},
\end{aligned}
\tag{1}
$$

$Fossil\,Loan_{b,f,t}$ is a dummy variable equal to one if during year t, bank b has issued a loan to firm f whose primary SIC code is 12 (Bituminous coal and lignite mining) or 13 (Oil and gas wells, exploration, and services). The same variable equals zero if firm f's primary SIC code is neither 12 nor 13.

We next turn to the main explanatory variables. First, $Foreig\,nLoan_{b,f,t}$ is a dummy variable equal to one if bank b and firm f are domiciled in different countries, and to zero if they are domiciled in the same country. Next, $Carbon\,Tax_{i,t}$ is a dummy variable equal to one if country i, in which bank b is domiciled, has some level of carbon tax during year t, and to zero otherwise. We abstract from the level of the tax itself and classify countries in a binary fashion.

We include a number of dummy interactions to make sure that we hold constant a range of unobservable background forces. First, we include $\gamma_{b,j}$, a matrix of interactions of bank and host-country dummies. This absorbs any time-invariant differences that are common to a bank and firms in a particular country over time, such as information or cultural familiarity. Second, we include $\mu_{i,t}$, a matrix of interactions of home-country and year dummies. This absorbs any time-varying factors that are common to all creditors domiciled in a particular country, such as home-country regulation or the business cycle. Finally, we include $\phi_{j,t}$, a matrix of interactions of host-country and year dummies. This absorbs any time-varying factors that are common to all borrowers domiciled in a particular country, such as host-country regulation or the business cycle. Identification thus rests on exploiting differences between fossil and non-fossil borrowers and their interaction with various lenders, based on whether there is a carbon tax in the lenders' country or not. Finally, $\varepsilon_{b,f,t}$ is the idiosyncratic error term. In all regressions, we cluster the standard errors at the lender level, to account for potential correlation among borrowers within the unit where the lending shock takes place.

We do not include the variable $Carbon\,Tax_{i,t}$ on its own because its direct effect on fossil lending is absorbed by the host-country-year dummy interactions. At the same time, we also estimate specifications that are less saturated with fixed effects, and which therefore allow us to gauge the independent effect of being treated and of the cycle.

The main coefficient of interest β_2 therefore measures whether a bank in a country that has some form of carbon taxation is more or less likely to extend a loan to a fossil company abroad, relative to its propensity to extend a loan to any foreign company abroad. A positive coefficient implies that a carbon tax increases the propensity of banks to engage in foreign fossil lending, at the expense of domestic fossil lending. The point estimate of β_2 thus measures the numerical change in the propensity to extend a fossil loan abroad from switching the bank from the control group (banks in countries with no carbon tax) to the treatment group (banks in countries with a carbon tax).

5 Empirical evidence

5.1 Headline result

We begin by estimating more parsimonious versions of Equation (1), gradually building towards the most saturated specification. In Table 2, column (1), we estimate a specification which includes only one set of dummy interactions, namely host country x year dummies. This specification allows us to hold constant forces that are common to all lenders to the same country at the same point in time, such as local demand. At the same time, it also allows us to include the dummy variable capturing the introduction of a carbon tax in the home country on its own. We then advance the model to include host country x year dummies (column (2)), which allows to control for all domestic trends that are common to banks from different countries lending to the same borrower. We then include bank fixed effects (column (3)), which control for time-invariant bank-specific heterogeneity related to, for example, managerial quality or appetite for risk taking. Finally, the most saturated model in column (4) incorporates interactions of bank x host country dummies. This specification controls for bank-borrower familiarity that may persist over time.

The estimates reported in column (1) point to three separate facts. First, banks are significantly more likely to lend to coal, oil, and gas companies in their domestic market than they are to do the same abroad. Second, carbon taxes are associated with lower domestic fossil lending. The coefficient of -0.0097 suggests that after a carbon tax is introduced in a country, domestic lending to fossil companies declines by about 1 percent. Third, after a carbon tax is introduced in a country, foreign lending to fossil companies increases by about 8 percent. The effect is significant at the 1-percent statistical level and represents a sizeable reallocation of lending across national borders.

In column (2), we include home country x year interactions. These allow us to net out the independent effect of any home country-specific trends, related to the business cycle, regulation, or changes in voters' preferences. As a result, we can no longer identify the independent effect of home country carbon taxes which is now subsumed in the dummy interactions. Armed with this specification, we no longer find any difference in banks' average propensity to extend fossil loans abroad, relative to at home. Importantly, the coefficient of β_2 is still negative and significant at the 1-percent statistical level. The magnitude of the measured coefficient suggests that after a carbon tax is introduced in a country, foreign lending to fossil companies increases by about 7.2 percent.

In column (3), we introduce bank fixed effects. These are enormously important because any difference in banks' propensity to lend to fossil companies abroad, as opposed to in their domestic market, can be relatively fixed over time, without much panel variation existing. We find that this is not the case. Once again, the coefficient of β_2 is negative and significant at the 1-percent statistical level. The point estimate suggests that after a carbon tax is introduced in a country, foreign lending to fossil companies increases by about 6.8 percent. The magnitude of the effect is therefore not dramatically different from columns (1) and (2), suggesting that the effect we measure is relatively stable across specifications.

Finally, in column (4), we introduce and interaction of bank x host country dummies. These control for the possibility that banks' propensity to lend to foreign fossil companies, as opposed to domestic ones, is linked to intrinsic familiarity between a bank and a recipient country, or to a bank-specific business model that favors some countries at the expense of others. In this specification, the coefficient of β_2 continues to be negative and significant at the 1-percent statistical level. The point estimate suggests that after a carbon tax is introduced in a country, foreign lending to fossil companies increases by about 4.3 percent. The magnitude of the effect is now visibly smaller than in the previous three columns, suggesting that some fixed differences related to bank-borrower relationships may indeed be at play.

In all, our evidence is consistent with the idea that carbon taxes lead to a reduction in lending to fossil companies domiciled in the bank's domestic market, and to an increase in lending to fossil companies in the bank's foreign markets.

What is the implied aggregate effect? About 92.5% of all fossil loans in our dataset are domestic. As Table 2 makes it clear, domestic fossil lending declines by about 1% (column (1)), while foreign fossil lending increases by about 4.3% (column (2)). This suggests that overall fossil lending declines by about 0.6%. Of course, this calculation applies to the number of loans as opposed to the overall volume of lending.

In Appendix Table 2, we run the following simplified version of Equation (1):

$$Share\,Foreign\,Loans_{b,t} \;\; = \beta_1 Carbon\,Tax_{i,t} + \gamma_b + \varepsilon_{b,t}, \tag{2}$$

$Share\,Foreign\,Loans_{b,t}$ is calculated as the ratio of foreign loans to total loans, for loans to fossil and for loans to non-fossil companies. This specification is not as tight as Equation (1) because we cannot control for many unobservable factors, such as domestic regulation or voting preferences and foreign demand. We can, however, still control for unobservable bank-specific heterogeneity with bank fixed effects.

The evidence makes it clear that in the case of lending to coal, oil, and gas companies, the share of foreign lending increased by about 6 percentage point after the introduction of a domestic carbon tax (column (1)). This is a sizeable effect which is also significant at the 1-percent statistical level. In the case of non-fossil loans (column (2)), the share of foreign lending increases, too, but this increase is both economically and statistically indistinguishable from zero.

5.2 Parallel trend assumption

One of the underlying assumptions of our empirical approach is that there is no diversion between domestic and foreign fossil lending before the introduction of the carbon tax. If this assumption were to be violated in the data, the test reported in Table 2 would simply capture a long-term trend that is independent of the timing of carbon taxes.

To address this issue formally, we now run the following version of Equation (1):

$$\begin{aligned} FossilLoan_{b,f,t} &= \beta_1 ForeignLoan_{b,f,t} + \beta_2 CarbonTax_{i,t} \times ForeignLoan_{b,f,t} \\ &+ \beta_3 Pre-Trend_{i,t} \times ForeignLoan_{b,f,t} \\ &+ \gamma_{b,j} + \mu_{i,t} + \phi_{j,t} + \varepsilon_{b,f,t}, \end{aligned} \quad (3)$$

Equation (2) differs from Equation (1) in that it includes an interaction of the variable *Foreign Loan* with a pre-trend variable. The latter is constructed to be equal to 1 in 1988, 2 in 1989, and so on, until the year in which a carbon tax is introduced in the country, after which it is held constant. The sample period is the same as before, 1988–2020.

The estimates from this test are presented Table 3, column (1). The point estimate of β_3 makes it clear that if anything, the share of domestic fossil loans was increasing prior to the introduction of the carbon tax. Therefore, the increase in the share of foreign fossil loans after the introduction of said tax reversed a trend that was going in the opposite direction. Moreover, the coefficient of β_2 continues to be significant at the 1-percent statistical level. The magnitude of the measured coefficient suggests that after a carbon tax is introduced in a country, foreign lending to fossil companies increases by about 5.2 percent. This is higher than in the specification in Table 2, column (4), which does not control for a pre-trend.

5.3 Falsification tests

Another potential concern with our results so far is that they are simply indicative of a general internationalization trend that took place at some point during the sample period. As part of this trend, banks expanded their geographic scope of operation, and as a result the share of foreign lending increased. It is possible then that this phenomenon is not confined to fossil lending, but the econometrician is erroneously attributing it to carbon taxes.

To neutralize this criticism, we now look at lending to firms with no fossil projects. Recall that according to the theoretical mechanism we have in mind, carbon taxes reduce the return to fossil-fuel projects, making banks less willing to lend to those. The same mechanism should not apply to sectors with little-to-no fossil assets. In the remainder of Table 3, we look at three such sectors: wholesale (column (2)), retail trade (column (3)), and clean manufacturing (column (4)). The latter includes all manufacturing sectors with the exception of basic metals and cement production. In all three cases, we fail to reject the null hypothesis that carbon taxes in the domestic market have no bearing on the foreign-domestic lending mix. The coefficients of β_2 in these three falsification tests are both numerically and statistically indistinguishable from zero.

We conclude that the main mechanism which we have in mind – i.e., carbon pricing being relevant for fossil lending – is validated in the data.

5.4 Robustness tests

To assess the validity of our main result, we now subject our main test to a number of robust empirical strategies. Broadly speaking, we need to make sure that the main result of the paper is not sensitive to particular choices of empirical proxies for fossil lending and carbon pricing, as well as to a particular sample choice. We report the results of these estimations in Table 4.

In column (1), we modify the main dependent variable to be equal to one if the loan is not only to a coal, oil, or gas company, but also to a company in mining in general. The point estimate of β_2 is still negative and significant at the 1-percent statistical level, and the magnitude of the measured coefficient is higher than the one in column (4) of Table 2. Numerically, it suggests that after a carbon tax is introduced in a country, foreign lending to fossil or mining companies increases by about 5.1 percent.

In column (2), the dependent variable is equal to one if the loan is not only to a coal, oil, or gas company, but also to a company in one of the two most carbon-intensive manufacturing industries. The first industry is "Other non-metallic mineral products" (sector code 32) and it includes cement production, which is responsible for around 7% of annual global carbon emissions. The second one is "Basic metals" (sector code 33) and it includes steel works and primary smelting, which is responsible for around 8% of annual global carbon emissions. The point estimate of β_2 is still negative and significant at the 1-percent statistical level, and the magnitude of the measured coefficient is higher than the one in column (4) of Table 2. Numerically, it suggests that after a carbon tax is introduced in a country, foreign lending to fossil or mining companies increases by about 5.1 percent.

In column (3), we restrict the sample to lead banks only. The idea is that the lead bank is the most important player in the syndicate because it carries the negotiations and often sets the lending conditions. This is also consistent with the approach in some papers using syndicated lending data which even attribute the whole loan to the lead bank (e.g., Giannetti and Laeven, 2012). We note that the main effect documented in this paper survives in this alternative specification, and the point estimate of β_2 is still significant at the 1-percent statistical level. At the same time, the magnitude of the measured coefficient is half as large as the one in column (4) of Table 2. Numerically, it suggests that after a carbon tax is introduced in a country, foreign lending to fossil or mining companies increases by about 2.3 percent.

Finally, in column (4), we modify the variable 'Home country carbon tax' to be equal to one after the introduction of a carbon tax in the home country, or after the home country joined an Emissions Trading Scheme (ETS). An ETS represents an alternative way of forcing carbon-intensive firms to internalize the cost of the carbon externality. As Table 1 makes it clear, twice as many loan segments (a fraction of 0.199 of all observations) are associated with banks from such countries than with banks from countries that have only imposed a carbon tax. Crucially, the point estimate of β_2 is still negative and significant at the 1-percent statistical level, and the magnitude of the measured coefficient is once again higher than the one in column (4) of Table 2. Numerically, it suggests that after a carbon tax is introduced in a country, foreign lending to fossil or mining companies increases by about 5.2 percent.

5.5 Loan characteristics

Our evidence so far strongly suggests that the introduction of carbon taxes in one market leads banks to reduce the incidence of lending to fossil companies in that market, and to increase the incidence thereof in other markets. In Table 5, we examine two other characteristics of fossil loans: their size and their maturity. This allows us to study whether banks not only extend more credit abroad, but they also increase the volume of foreign credit and shorten the maturities of foreign loans.

In column (1), we run a version of Equation (1) where the dependent variable is the logarithm of the loan tranche amount. The evidence suggests that overall foreign lending increases following the introduction of a carbon tax in the domestic market. This is consistent with the evidence in Benincasa, Kabas, and Ongena (2021) who find that tighter environmental regulation is associated with a higher share of total foreign lending. At the same time, we find no increase in average loan amount in the case of fossil lending.

In column (2), we replicate equation (1) with the logarithm of the loan's maturity as a dependent variable. In this case, we find that the maturity of the average foreign loan declines. Importantly, the same is true for fossil loans. The effect is significant at the 1-percent statistical level, and it is four times larger than in the case of non-fossil loans. The implication of the evidence in Tables 2 and 5 is thus that after the introduction of a carbon tax in the bank's domestic market, it extends more loans to fossil companies abroad, and these loans are on average of shorter maturities. This implies that banks make up for the potentially higher risk of lending in foreign markets on the margin of the loan duration.

6 The role of bank, host-country, and borrower heterogeneity

We now ask, what factors at the bank, country, and company level amplify the effect of carbon taxes on banks' fossil lending. Identifying these would help shed light on the microeconomic mechanisms behind the observed reallocation of fossil lending across national borders.

6.1 Bank-specific factors

The first set of factors that we study are related to bank characteristics that can conceivably be correlated with the extent of the response of bank lending to changes in carbon prices. For one, banks that already have significant exposures to the fossil fuel sector may be have a higher incentive to continue lending to fossil companies, by reallocating lending abroad. For example, in Minetti (2011) banks continue funding mature technologies that they have experience with, because new technologies compromise the value of assets already on their balance sheets. By extension, this argument implies that when the price of carbon increases, banks with large fossil exposures will be less likely to switch to financing green technologies and more likely to keep accumulating fossil assets than less exposed banks.

Another possibility is related to banks capitalization and/or profitability. The reallocation to foreign lending may be stronger for less capitalized banks, to the extent that foreign loans are more risky and there exists a positive relationship between bank capital and risk taking (Holmstrom and Tirole, 1997; Ongena, Popov, and Udell, 2013; Jiménez, Ongena, Peydro, and Saurina, 2014). Bank profitability could also play a role, albeit the link is theoretically ambiguous. On the one hand, more profitable banks may be less willing to engage in risk taking (Keeley, 1990), in this case by reallocating lending abroad. On the other hand, higher profitability may loosen bank borrowing constraints, and so more profitable banks may take risk on a larger scale (Martynova, Ratnovski, and Vlahu, 2020), including by increasing foreign lending.

In Table 5, we report version of Equation (1) which include a triple interaction with proxies for bank-specific fossil exposure, capitalization, and profitability. The evidence presented in column (1) strongly suggests that banks with relatively higher fossil exposures are more likely to increase their foreign fossil lending in response to the introduction of carbon taxes at home. At the same time, the level of bank capital (column (2)) and the bank's return on assets (column (3)) do not affect the elasticity of foreign lending to domestic carbon taxes.

Our evidence thus suggests that banks specializing in fossil lending are more likely to keep a steady level of fossil lending in response to carbon taxes, by reallocating some of it to foreign customers.

6.2 Host country-specific factors

6.2.1 Host country carbon tax

We next turn to study the potential role that host country-specific factors play in the reallocation of fossil lending across national borders. One such obvious factor is whether the borrower's country itself has a carbon tax. The literature has already shown that regulatory arbitrage opportunities can be an important driver of cross-border lending (Houston, Lin, and Ma, 2012; Ongena, Popov, and Udell, 2013;

Karolyi and Taboada, 2015). We now push this further argument by asking whether differences in carbon taxes across countries can explain the reallocation of a particular class of loans, those to fossil companies. Our prior is that when a carbon tax is introduced in a country, banks will reallocated fossil loans to foreign countries, especially such that do not have a carbon tax.

We study this question in Table 7. We augment Equation (1) with a triple interaction of a home-country carbon tax dummy, a fossil loan dummy, and a host-country carbon tax dummy. We report this test in column (1). The estimates continue to show that the introduction of carbon taxes is associated with an increase in foreign lending to fossil companies. This increase is larger if the host country has no carbon tax, even though this effect is not statistically significant.

In columns (2) and (3), we take a different perspective by looking at the size and maturity of granted loans. We find that the reallocation of bank credit to countries without a carbon tax is accompanied by an increase in the size of the loan and a decline in the maturity of the loan. This suggests that while carbon tax arbitrage is not associated with a higher number of granted loans, it is associated with a higher overall lending volume. Moreover, these loans are now more short-term than before. We conclude that in order to circumvent the effect of carbon taxes in their domestic market, banks increase both the volume and the riskiness of fossil lending in countries without a carbon tax.

Our evidence thus strongly suggests that in order to be effective form a global perspective, carbon taxes need to be imposed uniformly across the world. If not, their effect will be arbitraged away by large international banks, which will dampen the desired effect on global fossil lending.

6.2.2 Lending familiarity

A second potential factor that can play a role is the extent of familiarity between the creditor and the borrower. Banks may be more willing to lend to borrowers with which they have established relationships (Berger and Udell, 1995). Moreover, this familiarity can play an important stabilizing role when credit markets are hit by shocks (Beck, Degryse, De Haas, and van Horen, 2018). Furthermore, lack of strong relationships or creditor-borrower familiarity can result in a flight away from foreign lending (Giannetti and Laeven, 2012; De Haas and van Horen, 2013). It is natural to hypothesize that such financial links may play a role when banks decide on the direction in which they reallocate fossil lending.

In Table 8, we take this question to the data. To do so, we augment Equation (1) with a triple interaction of a home-country carbon tax dummy, a fossil loan dummy, and a bank-host country measure of lending relationships (or familiarity). The latter variable is constructed as the share of loans by a bank to a specific country out of the bank's total lending portfolio. Higher values thus indicate that a host country has received in the past a relatively higher portion of a bank's credit allocation, pointing to strong familiarity / lending relationships between that bank and that country.

We report the estimates from this regression in column (1). The point estimate on the triple interaction is negative and significant at the 1-percent statistical level. The interpretation of our results is that the introduction of carbon taxes is associated with an increase in foreign lending to fossil companies, and especially to countries that banks are less familiar with. This goes against the idea that banks adjust their lending on the intensive margin, within the sample of customers they already have. On the contrary, it suggests that when pushed to reduce fossil lending by higher carbon prices at home, banks react on the extensive margin, too, increasing fossil lending to customers in less familiar destinations.

6.2.3 Company-specific factors

Finally, we look at the role played by borrower-specific factors. There is for example a large literature on the role that borrower risk plays in creditors' lending decisions (e.g., Ongena, Popov, and Udell, 2013; Jimenez, Ongena, Peydro, and Saurina, 2014). Such heterogeneity can conceivably be important in determining how fossil lending is reallocated across national borders following the introduction of a carbon tax. Moreover, Ivanov, Kruttli, and Watugala (2020) show that in response to the California cap-and-trade bill, banks restricted credit to high-polluting firms, and that this effect was significantly higher for private companies.

In Table 9, we look at one aspect of borrower heterogeneity, namely, whether the borrower is publicly or privately owned. For example, private ownership can signal higher ex-ante risk – e.g., because private firms are more opaque to a creditor. It can also signal higher ex-post risk, as private firms are smaller, have riskier projects, and have access to a less diversified pool of funding sources. At the same time, private firms being younger on average, tend to grow faster (e.g., Gompers and Lerner, 2001), and so lending to them can be more profitable. Therefore, knowing whether banks are more or less likely to reallocate lending abroad to private firms would be informative as to the exact microeconomic mechanisms at play.

The evidence presented in Table 9 suggests that after a carbon tax is introduced in a bank's domestic market, the bank is likely to increase lending to foreign fossil companies, regardless of whether they are public or private. In both cases, the effect is significant at least at the 5-percent statistical level. The increase is less sizeable in the case of public companies (column (1)) than it is in the case of private ones (column (2)). Numerically, the point estimate of β_2 is higher by one third in the case of private companies. At the same time, this difference is not statistically significant, as confirmed by an (unreported) F-test.

7 Conclusion

There is a broad consensus among economists and policy makers that taxing carbon is the most cost-efficient way to price the externality associated with carbon emissions. Increasing the effective price of carbon should reduce emissions, stunting the growth of atmospheric carbon and slowing down climate change. At the same time, not a single country in the world taxes carbon-intensive activities at the levels recommended by economists. This hesitancy is partially driven by free-riding: national authorities are afraid that imposing carbon taxes unilaterally would hurt their economies as carbon-intensive activities migrate to different jurisdictions.

In this paper, we show that such carbon tax arbitraging can indeed happen because of adjustments in multinational banks' lending portfolios. Our main finding is that following an exogenous increase in the price of carbon in their domestic market, banks reduce their lending to coal, oil, and gas companies at home, and increase their fossil lending abroad. This reallocation of fossil lending across national borders is immediate, economically meaningful, and statistically significant. Our analysis suggests that after a carbon tax is introduced in a country, foreign lending to fossil companies increases by at least 4.3 percent. At the same time, because domestic fossil lending declines, overall fossil lending goes down by about 0.6%. We find a similar effect of joining an ETS, as well as in the case of lending to other carbon-intensive sectors, such as metallurgy and cement production.

Our second finding is that there are significant differences within the group of banks, firms, and countries affected by the carbon tax. Banks are much more willing to continue lending to fossil firms by reallocating lending across national borders if they already have relatively large fossil exposures. They are also more likely to increase the amount of fossil lending to countries which do not have a carbon tax themselves. Finally, they are more risky to increase fossil lending to relatively riskier firms.

The facts we document in this paper have a number of implications. First, carbon taxes work, not only in directly affecting the cost of production for carbon-intensive firms, but also by impacting the willingness of banks to extend credit to carbon-intensive projects. Second, to engineer a meaningful reduction in the funding of fossil companies, a carbon tax needs to be global. Third, an effective global carbon tax will hit the hardest the most exposed banks, which calls for acute attention by bank regulators and supervisors. At the same time, policy makers need to be aware that the short-term welfare costs to consumers and workers of adjustments associated with tighter environmental regulation can be substantial (Walker, 2013). Needless to say, a full-blown welfare analysis of carbon taxes is beyond the scope of this paper.

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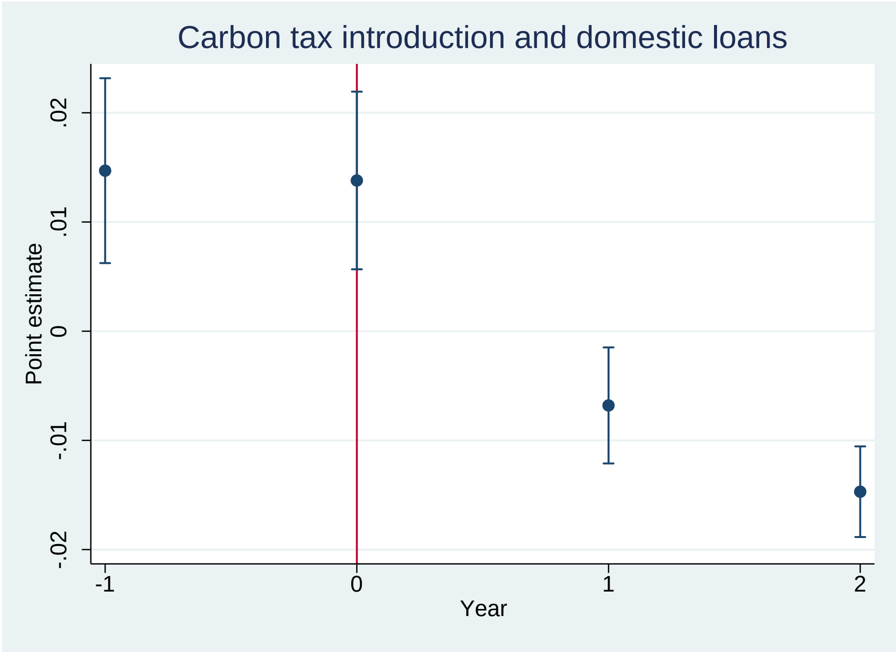
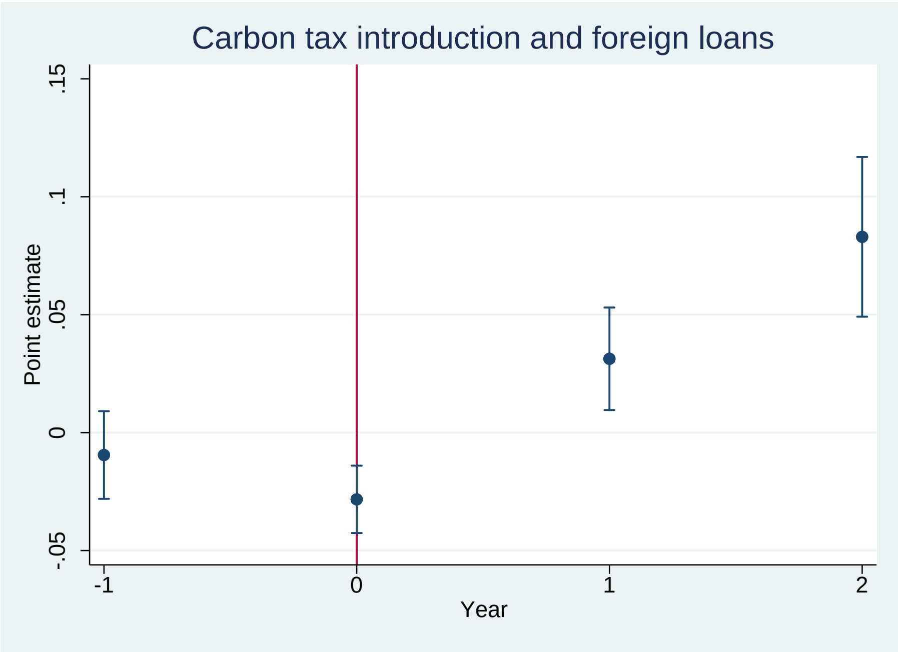
Figure 1. Carbon taxes and the evolution of syndicated lending





Note: The Chart presents regression coefficients and confidence bands for domestic (top) and foreign (bottom) loans to fossil companies (i.e., companies in SIC sectors 12xx and 13xx.) after the introduction of a carbon tax. Annual data from Dealscan.

Figure 2. Countries with a carbon tax, an ETS, or both: 1988–2020

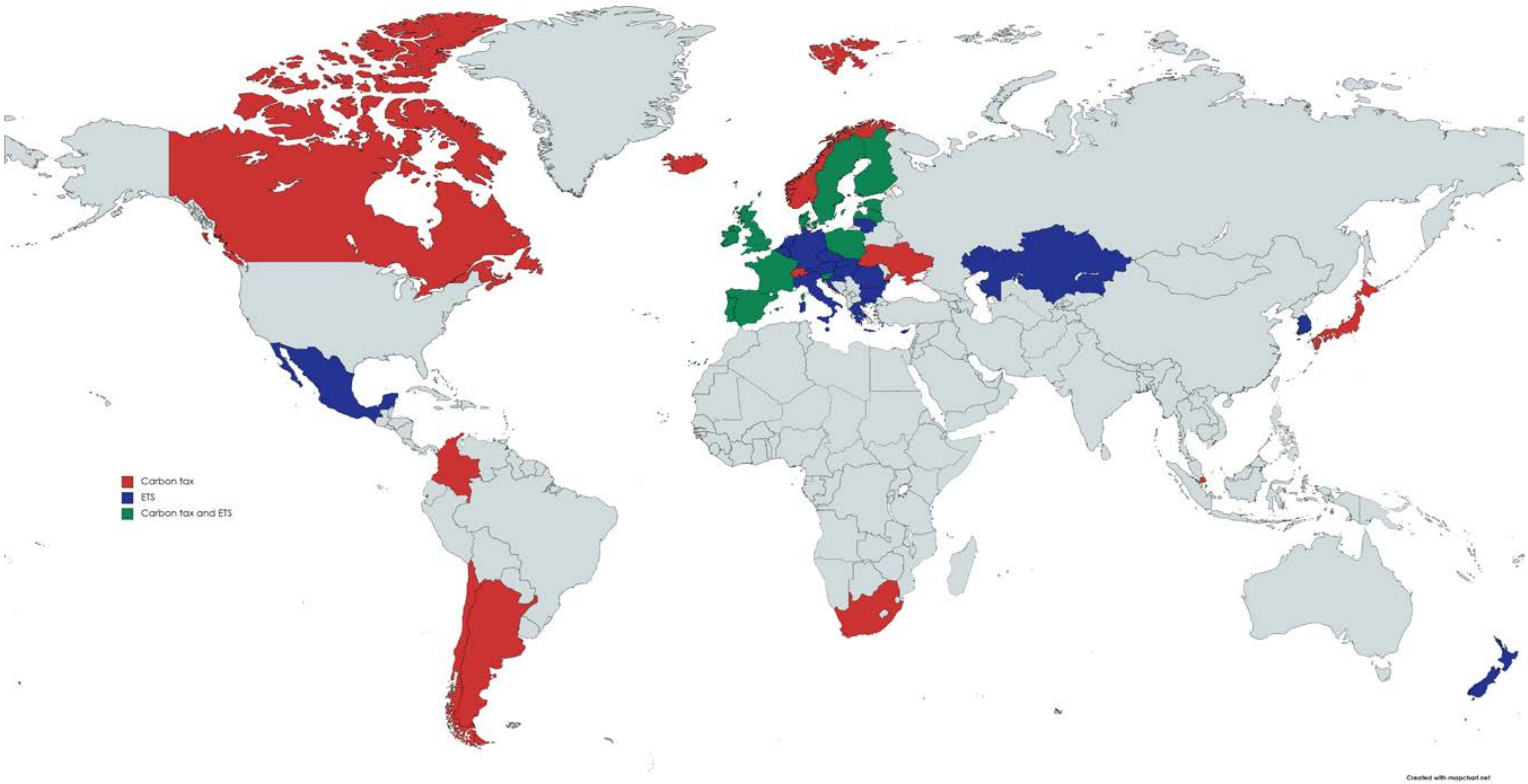


Table 1. Summary statistics

	Observations	Mean	Median	St. dev.	Min	Max
Loan characteristics						
Fossil loan	2,142,170	0.042	0	0.201	0	1
Including all mining	2,142,170	0.053	0	0.224	0	1
Including metallurgy and cement	2,142,170	0.071	0	0.256	0	1
Wholesale loan	2,142,170	0.042	0	0.201	0	1
Retail loan	2,142,170	0.053	0	0.224	0	1
Clean manufacturing loan	2,142,170	0.261	0	0.439	0	1
Foreign loan	2,142,170	0.045	0	0.207	0	1
Log (Loan amount)	2,113,216	6.825	7.354	2.347	1	15.640
Log (Loan maturity)	2,062,739	3.795	4.094	0.752	1	7.100
Bank characteristics						
Fossil exposure	2,137,477	0.052	0.040	0.056	0	1
Capital	235,058	18.898	10.110	25.603	0.776	159.494
ROA	223,216	1.513	0.083	2.335	-11.840	20.98
Familiarity	2,142,170	0.534	0.600	0.381	0.001	1
Country characteristics						
Home country carbon tax	2,142,170	0.106	0	0.308	0	1
Host country carbon tax	2,142,170	0.106	0	0.308	0	1
Carbon tax or ETS	2,142,170	0.199	0	0.399	0	1
Firm characteristics						
Private firm	1,782,530	0.610	1	0.487	0	1

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Including all mining' is a dummy equal to 1 if the loan is to a company in SIC sectors 10xx to and including 14xx. 'Including metallurgy and cement' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx, 13xx, 32xx, and 33xx. 'Wholesale loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 50xx and 51xx. 'Retail loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 52xx—59xx. 'Clean manufacturing loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 20xx—39xx, excluding metallurgy and cement production. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. 'Log (Loan amount)' is the natural logarithm of the loan amount, in USD. 'Log (Loan maturity)' is the natural logarithm of the maturity of the loan, in months. 'Fossil exposure' is the bank's share of fossil loans before the introduction of the carbon tax. 'Capital' is the bank's total equity divided by total assets. 'ROA' is the bank's return on assets. 'Familiarity' is the share of loans between a bank and the respective country out of the bank's total lending portfolio. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Host country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the host country. 'Carbon tax or ETS' is a dummy equal to one after the introduction of a carbon tax in the home country or after the home country joined an Emissions Trading Scheme (ETS). 'Private firm' is a dummy variable equal to one if the firm is private, and to 0 if it is public. The sample period is 1988—2020. Data come from Dealscan, Bankscope, and the Carbon Tax Center.

Table 2. Domestic carbon taxes and fossil lending: Main test

	Fossil loan			
	(1)	(2)	(3)	(4)
Home country carbon tax × Foreign loan	0.0897***	0.0715***	0.0675***	0.0433***
	(0.0070)	(0.0069)	(0.0071)	(0.0073)
Home country carbon tax	-0.0097**			
	(0.0043)			
Foreign loan	-0.0078***	-0.0035	-0.0044*	-0.0053*
	(0.0022)	(0.0025)	(0.0025)	(0.0028)
Bank × Host country dummies	No	No	No	Yes
Home country × Year dummies	No	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes	Yes
Bank fixed effects	No	No	Yes	No
No. Observations	2,141,998	2,141,960	2,136,679	2,117,472
R-squared	0.10	0.12	0.15	0.19

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 3. Domestic carbon taxes and fossil lending: Pre-trend and placebo

	Pre-trend	Placebo		
	Fossil loan	Wholesale loan	Retail loan	Clean manufacturing loan
	(1)	(2)	(3)	(4)
Home country carbon tax × Foreign loan	0.0517***	0.0047	-0.0075	0.0007
	(0.0080)	(0.0062)	(0.0059)	(0.0119)
Foreign loan	0.0397***	-0.0040*	-0.0163***	0.0649***
	(0.0077)	(0.0023)	(0.0017)	(0.0057)
Pre-trend × Foreign loan	-0.0020***			
	(0.0004)			
Bank × Host country dummies	Yes	Yes	Yes	Yes
Home country × Year dummies	Yes	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes	Yes
No. Observations	2,108,040	2,117,472	2,117,472	2,117,472
R-squared	0.19	0.09	0.07	0.14

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Wholesale loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 50xx and 51xx. 'Retail loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 52xx—59xx. 'Clean manufacturing loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 20xx—39xx, excluding metallurgy and cement production. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. 'Pre-trend' is a trend variable until the year of introduction of the carbon tax in the home country. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 4. Domestic carbon taxes and fossil lending: Robustness

	Including all mining	Including metallurgy and cement	Only lead banks	Carbon tax or ETS
	(1)	(2)	(3)	(4)
Home country carbon tax × Foreign loan	0.0509***	0.0285***	0.0230***	0.0518***
	(0.0082)	(0.0080)	(0.0085)	(0.0057)
Foreign loan	-0.0127***	-0.0015	0.0031	-0.0146***
	(0.0032)	(0.0031)	(0.0037)	(0.0032)
Bank × Host country dummies	Yes	Yes	Yes	Yes
Home country × Year dummies	Yes	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes	Yes
No. Observations	2,117,472	2,117,472	812,053	2,117,472
R-squared	0.21	0.16	0.23	0.19

Note: 'Including all mining' is a dummy equal to 1 if the loan is to a company in SIC sectors 10xx to and including 14xx. 'Including metallurgy and cement' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx, 13xx, 32xx, and 33xx. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country (columns (1)–(3)), and a dummy equal to one after the introduction of a carbon tax in the home country or after the home country joined an Emissions Trading Scheme (ETS) (column (4)). 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. In column (3), only lead banks are included. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 5. Domestic carbon taxes and fossil lending: Loan characteristics

	Log (Loan amount)	Log (Loan maturity)
	(1)	(2)
Home country carbon tax × Foreign loan	0.1290***	-0.0317*
	(0.0406)	(0.0180)
Foreign loan	0.0036	0.0426***
	(0.0163)	(0.0075)
Home country carbon tax × Fossil loan	-0.0683**	0.0440***
	(0.0299)	(0.0170)
Foreign loan × Fossil loan	-0.0476	0.0704***
	(0.0463)	(0.0236)
Home country carbon tax × Foreign loan × Fossil loan	0.0819	-0.1274***
	(0.0823)	(0.0329)
Bank × Host country dummies	Yes	Yes
Home country × Year dummies	Yes	Yes
Host country × Year dummies	Yes	Yes
Company fixed effects	Yes	Yes
No. Observations	2,077,085	2,031,475
R-squared	0.86	0.63

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Log (Loan amount)' is the natural logarithm of the loan amount, in USD. 'Log (Loan maturity)' is the natural logarithm of the maturity of the loan, in months. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 6. Domestic carbon taxes and fossil lending: Accounting for bank characteristics

	Fossil loan		
	Fossil exposure	Capital	Profitability
	(1)	(2)	(3)
Home country carbon tax × Foreign loan	0.0282***	0.0538***	0.0611***
	(0.0072)	(0.0174)	(0.0177)
Foreign loan	-0.0131***	-0.0156*	-0.0188***
	(0.0026)	(0.0079)	(0.0082)
Home country carbon tax × Fossil exposure	0.0208***		
	(0.0024)		
Fossil exposure × Foreign loan	0.0121***		
	(0.0023)		
Home country carbon tax × Fossil exposure × Foreign loan	0.0167**		
	(0.0076)		
Home country carbon tax × Capital		0.0001	
		(0.0001)	
Capital × Foreign loan		-0.0001*	
		(0.0001)	
Home country carbon tax × Capital × Foreign loan		0.0005	
		(0.0004)	
Home country carbon tax × ROA			-0.0023
			(0.0021)
ROA × Foreign loan			-0.0004
			(0.0016)
Home country carbon tax × ROA × Foreign loan			0.0035
			(0.0055)
Bank × Host country dummies	Yes	Yes	Yes
Home country × Year dummies	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes
No. Observations	2,117,472	234,248	222,402
R-squared	0.19	0.16	0.16

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Fossil exposure' is the bank's share of fossil loans before the introduction of the carbon tax. 'Capital' is the bank's total equity divided by total assets. 'ROA' is the bank's return on assets. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. The sample period is 1988—2020. Data come from Dealscan, Bankscope, and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 7. Domestic carbon taxes and fossil lending: Accounting for host-country carbon taxes

	Fossil loan	Log (Loan amount)	Log (Loan maturity)
	(1)	(2)	(3)
Home country carbon tax × Foreign loan	0.0403***	-0.1466	0.0457
	(0.0093)	(0.3142)	(0.1483)
Foreign loan	-0.0051*	-0.2045*	0.1113***
	(0.0028)	(0.1080)	(0.0355)
Home country carbon tax × Foreign loan × Host country carbon tax	0.0107	2.2518***	-0.6351**
	(0.0140)	(0.3407)	(0.2615)
Bank × Host country dummies	Yes	Yes	Yes
Home country × Year dummies	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes
Company fixed effects	No	Yes	Yes
No. Observations	2,117,472	83,897	83,042
R-squared	0.19	0.73	0.68

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Log (Loan amount)' is the natural logarithm of the loan amount. 'Log (Loan maturity)' is the natural logarithm of the maturity of the loan. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Host country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the host country. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. In columns (2) and (3), only loans to SIC sectors 12xx and 13xx are included. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 8. Domestic carbon taxes and fossil lending: Accounting for bank-borrower familiarity

	Fossil loan	Log (Loan amount)	Log (Loan maturity)
	(1)	(2)	(3)
Home country carbon tax × Foreign loan	0.0758***	0.1435	-0.0525
	(0.0095)	(0.2864)	(0.1154)
Foreign loan	-0.0012	-0.1389	0.0903**
	(0.0031)	(0.1229)	(0.0404)
Home country carbon tax × Familiarity	-0.0051	-0.1383*	0.0626**
	(0.0045)	(0.0773)	(0.0296)
Familiarity × Foreign loan	0.0061	-0.1692*	0.0298
	(0.0074)	(0.0894)	(0.0349)
Home country carbon tax × Familiarity × Foreign loan	-0.1889***	0.2611	-0.0628
	(0.0181)	(0.2241)	(0.0827)
Bank × Host country dummies	Yes	Yes	Yes
Home country × Year dummies	Yes	Yes	Yes
Host country × Year dummies	Yes	Yes	Yes
Company fixed effects	No	Yes	Yes
No. Observations	2,117,472	83,897	83,042
R-squared	0.19	0.73	0.68

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 13xx. 'Log (Loan amount)' is the natural logarithm of the loan amount. 'Log (Loan maturity)' is the natural logarithm of the maturity of the loan. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Familiarity' is the share of loans between a bank and the respective country out of the bank's total lending portfolio. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. In columns (2) (and (3), only loans to SIC sectors 12xx and 13xx are included. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 9. Domestic carbon taxes and fossil lending: Private versus public firms

	Fossil loan	
	Private firm = 0	Private firm = 1
	(1)	(2)
Home country carbon tax × Foreign loan	0.0386**	0.0518***
	(0.0190)	(0.0094)
Foreign loan	0.0122*	-0.0171***
	(0.0071)	(0.0032)
Bank × Host country dummies	Yes	Yes
Home country × Year dummies	Yes	Yes
Host country × Year dummies	Yes	Yes
No. Observations	684,070	1,083,603
R-squared	0.23	0.20

Note: 'Fossil loan' is a dummy equal to 1 if the loan is to a company in SIC sectors 12xx and 13xx. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. 'Foreign loan' is a dummy equal to one if the loan is to a company domiciled in a foreign country. 'Private firm' is a dummy variable equal to one if the firm is private, and to 0 if it is public. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Appendix Table 1. Year when carbon tax comes into force, by country

Country	Carbon tax	ETS
Finland	1990	2005
Poland	1990	2005
Norway	1991	
Sweden	1991	2005
Denmark	1992	2005
Slovenia	1996	2005
Estonia	2000	2005
Latvia	2004	2005
Austria		2005
Belgium		2005
Cyprus		2005
Czech Republic		2005
Germany		2005
Greece		2005
Hungary		2005
Ireland		2005
Italy		2005
Lithuania		2005
Luxembourg		2005
Malta		2005
Netherlands		2005
Slovakia		2005
Spain		2005
Bulgaria		2007
Romania		2007
Switzerland	2008	
Liechtenstein	2008	
New Zealand		2008
Iceland	2010	
Ireland	2010	2005
Ukraine	2011	
Japan	2012	
Croatia		2013
Kazakhstan		2013
United Kingdom	2013	2005
France	2014	2005
Mexico	2014	
Spain	2014	2005
Portugal	2015	2005
South Korea		2015
Chile	2017	
Colombia	2017	
Argentina	2018	
Canada	2019	
Singapore	2019	
South Africa	2019	
Mexico		2020

Notes: ‘Carbon tax’ is the year in which carbon taxes were first imposed in the country. ‘ETS’ is the year when the country joined an Emissions Trading Scheme. Source: Carbon Tax Center.

Appendix Table 2. Domestic carbon taxes and share of foreign lending

	Share foreign fossil lending	Share foreign non-fossil lending
	(1)	(2)
Home country carbon tax	0.0595***	0.0043
	(0.0119)	(0.0027)
Bank fixed effects	Yes	Yes
No. Observations	12,081	86,723
R-squared	0.35	0.29

Note: 'Share foreign fossil lending' is a variable equal to the ratio of foreign loans to total loans, for loans to companies in SIC sectors 12xx and 13xx. 'Share foreign non-fossil lending' is a variable equal to the ratio of foreign loans to total loans, for loans to companies not in SIC sectors 12xx and 13xx. 'Home country carbon tax' is a dummy equal to one after the introduction of a carbon tax in the home country. The sample period is 1988—2020. Data come from Dealscan and the Carbon Tax Center. All regressions include fixed effects as specified. Standard errors clustered at the bank level appear in parentheses, where *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.