Climate Policy and Corporate Green Bonds

by

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Abstract: We find that green bonds exhibit higher capacity to borrow foreign capital in local currency than regular bonds issued by the same firm, which reduces currency mismatch risk in corporates' balance sheets while increasing that in investors'. We further show that this is driven by climate policy, which attract sustainable, responsible, and impact (SRI) investments that are willing to tolerate higher currency-mismatch risk for holding green bonds. In particular, adopting climate policy triples the probability of local currency green bond issuances in foreign markets. We further document that, as carbon price rises, firms with stronger ESG and financial fundamentals, richer international financing experience, and from countries with better environmental performance, are more capable of issuing local currency green bonds in foreign markets. There is no evidence that green bonds differ from regular bonds in the absence of climate policy.

Keywords: Climate change, carbon price, carbon tax, social impact, green finance, sustainable investing, socially responsible investing, ESG, currency risk
JEL: G18, F34, Q54, Q58

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1. Introduction

Green bonds grow exponentially in recent years, especially after the adoption of Paris Agreement in 2015. By the end of 2020, the global cumulative issuances of green bonds had surpassed $1 Trillion according to Climate Bonds Initiative. Studies have analyzed how green bonds affect funding costs (see for example Karpf and Mandel 2018; Baker et al. 2018; Zerbib 2019; Larcker and Watts 2020), mostly focusing on the US municipal bond market. However, corporate green bonds' implications on international financing risk remain unexplored, even though more than half of them are marketed to foreign investors. Moreover, little is known about the nexus of climate policy and corporate green bonds despite their close linkage. Through enforcing firms to internalize the social cost of their carbon emissions, climate policy enhances the transformation of green bonds into green technology and clean energy, which encourages sustainable, responsible, and impact (SRI) investors to hold green bonds. This paper seeks to understand the relation between corporate green bonds and currency mismatch risk, and explore the role of climate policy in shaping such a relation.

Currency mismatch risk is the key driver of many defaults and bankruptcies during financial crises and liquidity crunches. Most firms have to issue foreign currency denominated bonds to access foreign capital (Maggiori, Neiman, and Schreger 2020; Hale, Jones, and Spiegel 2020; Wu 2020).[1] These firms are exposed to significant currency mismatch risk as their expenditures and revenues are mostly denominated in local currency. When foreign currency appreciates substantially relative to local currency, firms face substantial rise in their debt burden. To reduce their currency mismatch risk, firms can enhance their capacity to borrow foreign capital in local currency. But why would international investors hold bonds denominated in the issuer's local currency instead of theirs and therefore bear the currency mismatch risk?

Could corporate green bonds motivate international investors to tolerate higher currency mismatch risk? The proceeds of green bonds are to finance green production and technology that contribute to mitigate climate change, while those of regular bonds are

[1] According to Wu (2020), more than 90% corporate bonds issued by firms from emerging economies in international capital market are denominated in foreign currency. Even sovereign governments have difficulty borrowing foreign capital in local currency although the situation improves recently (Eichengreen and Hausmann 1999; Ottonello and Perez 2019; Zheng 2020; Bertaut, Bruno, and Shin 2021). Note that small and medium sized firms are not able to access international market and they borrow in local currency bonds in domestic market.

typically not restricted. Rising concern about climate change has accelerated the growth of SRI investing, which direct capital towards green assets. SRI investors are willing to sacrifice financial gains for holding green assets as they derive nonpecuniary benefits from doing so (Hong and Kacperczyk 2009; Baker et al. 2018; Hartzmark and Sussman 2019; Bolton and Kacperczyk 2021; Pástor, Stambaugh, and Taylor 2021; Barber, Morse, and Yasuda 2021). If international SRI investors can also tolerate currency mismatch risk for their climate agenda, green bonds should enable firms to borrow more foreign capital in local currency than regular bonds.

We compare green and regular bonds issued by the same firm and find evidence that, on average, the probability of local currency issuances in foreign markets for green bonds is 9 percentage points or 68% higher than that for regular bonds. It provides evidence that green bonds lower currency mismatch risk in corporates' balance sheets while increasing that in international investors'. The result remains robust when we control for a comprehensive list of bond-level characteristics, or focus on matched samples in which green and regular bonds share similar tenor, size and credit rating, among others. This rules out the possibility that the documented difference between green and regular bonds are driven by conventional bond characteristics.

After demonstrating the difference between green and regular bonds in accessing foreign capital in local currency, we proceed to analyze how climate policy shape the relation between green bonds and currency mismatch risk. Climate policy enforces firms to internalize the cost through carbon tax or Emissions Trading System (ETS). It motivates firms to turn the proceeds of green bonds into carbon reductions so as to save costs of emissions. Thus it increases the credibility of firms' green pledge and reduces the probability of greenwashing, the practices of exaggerating or falsifying environmental commitment to attract capital. Climate policy also enforces information disclosure that enhances the transparency and trackability of carbon emissions. As a result, climate policy enables international SRI investors to better identify green assets and track their social impacts. We therefore expect climate policy to raise the popularity of green bonds among international SRI investors, whose greater risk tolerance enables green bonds to better access foreign capital in local currency.

To investigate the role of climate policy, we compare the difference in the probability of local currency issuances in foreign markets between green and regular bonds of the same firm in the presence of climate policy, relative to that in the absence of climate policy. We control for firm-time fixed effects throughout our empirical analysis to take care of both static and time-varying firm-level characteristics, either observable or unobservable. That is, all firm-level factors that could possibly affect a firm' capacity to issue local currency bonds in foreign markets, such as reputation, credit rating, equity valuations, and international transactions, among others, are controlled for. This allows us to ascribe the deviation of green bonds from regular bonds to their unique characteristics instead of firm's. Our analysis shows that, when climate policy is in position, the probability of local currency issuances in foreign markets for green bonds increases by 8 percentage point, which almost triples that in the absence of climate policy.

We find no evidence that green bonds differ from regular bonds in international financing in the absence of climate policy. It suggests that climate policy is necessary for green bonds to better access foreign capital in local currency than regular bonds. Decomposing the climate policy into market-based carbon price and government-determined carbon tax, we find the former is driving our result. Further analysis reveals that doubling the carbon price increases the probability of local currency green bond issuances in foreign markets by 4.9 percentage points, which more than doubles a firms' capacity to borrow foreign capital in local currency.

Lastly, we investigate who benefits more from climate policy. When carbon price rises, we find that firms with stronger ESG, larger size, higher profitability, and richer international financing experience are more capable of issuing local currency green bonds in foreign markets. Markets that perform better in managing their environments, especially those related to climate change, strengthens their firms' capacity to issue local currency green bonds in foreign markets as carbon price increases. There is no evidence that macroeconomic factors such as monetary policy, foreign exchange regime, currency valuation, current account surplus and international reserve affect the impact of climate policy on corporate green bond issuances in our context, perhaps because they have not yet been connected to climate change.

Our contribution to the literature is threefold. First, it provides new evidence that corporate green bonds reduce currency mismatch risk in corporates' balance sheets. It implies that SRI investors are more tolerant of risk associated with green bonds. Second, it highlights climate policy as a necessary condition for green bonds to better access foreign capital in local currency than regular bonds. The result mitigates potential resistance against climate change by showing how climate policy benefits corporate financing. Third, we show that ESG activities at both firm and market level enhance the impact of climate policy. It suggests that even though ESG could be costly, they do generate positive gains by enabling firms to better access foreign capital at lower risk.

Our work builds upon recent studies on SRI investing especially those related to green bonds. Pástor, Stambaugh, and Taylor (2021) derive from an asset pricing equilibrium model that investors' green preference increases the demand of green assets and reduces their funding cost. Their theoretical implication is well supported by the empirical evidence in Baker et al. (2018) and Zerbib (2019), which show that green bonds are issued at a premium than regular bonds as SRI investors are willing to pay more for green bonds.[2] This is however challenged by Larcker and Watts (2020), which find no difference in the cost of green and regular US municipal bonds that are similar in issuer, issuing date, maturity and credit rating. Karpf and Mandel (2018) document that the US municipal green bonds' premium are time varying, turning from negative to positive since 2014. Pedersen, Fitzgibbons, and Pomorski (2020) reconcile these seemingly controversial findings, proving theoretically that investors are willing to accept lower returns for green assets if the value of ESG is sufficiently recognized by the market, and require similar or even higher returns for green assets otherwise. Oehmke and Opp (2020) highlight coordination among SRI investors and their interaction with return-driven financial investors as additional channels to affect firms' financial constraints and generate social impact. While empirical studies mentioned above mostly focus on US municipal bonds, Tang and Zhang (2020) and Flammer (2021) show that corporate green bond issuances increase the issuer's stock price. We complement these studies by exploring the currency denomination of corporate green bonds in foreign markets and show that green bonds reduce the currency mismatch risk, the key factor underlying many defaults and bankruptcies.

Our work is also closely related to the growing literature on currency denomination of international bonds. Most governments, especially those from emerging economies, are not able to borrow from international investors in their own currency, which is dubbed as "original sin" by Eichengreen and Hausmann (1999). The "original sin" dissipates gradually, especially after the global financial crisis (Arslanalp and Tsuda 2014; Zheng 2020; Aizenman et al. 2021),

[2] Similar evidence is also found in the stock, mutual fund and venture capital market (see, for example, Hong and Kacperczyk 2009; Hartzmark and Sussman 2019; Bolton and Kacperczyk 2021).

because emerging economies improve their economic fundamentals (Ottonello and Perez 2019) and monetary policy credibility (Aguiar et al. 2014; Engle et al. 2020; Aizenman et al. 2021). While most of these studies focus on sovereign bonds, Hale, Jones, and Spiegel (2020) document similar difficulties of issuing local currency corporate bonds in international market, which was mitigated by the ultra low US Fed funds rate after global financial crisis. Large firms rely heavily on international capital market for financing. Despite the recent improvement, most large firms outside the US are still not able to borrow in their local currency (Maggiori, Neiman, and Schreger 2020; Hale, Jones, and Spiegel 2020; Wu 2020). We add to this strand of literature by documenting that issuing green bonds is a potential solution to overcome the difficulty of borrowing foreign capital in local currency, provided that the governments have implemented climate policy.

Finally, our work fits into the literature on climate policy. Studies have well documented that climate policy reduces carbon emissions (Nippa, Patnaik, and Taussig 2021), encourages innovation on green technology (Weber and Neuhoff 2010; Cui, Zhang, and Zheng 2018), motivates multinational enterprises to reallocate production (Hanna 2010; Dechezleprêtre et al. 2019; Koch and Mama 2019; Yu, Cai, and Sun 2021), and reshuffles global supply chains (López et al. 2019; Zhang et al. 2020; Berry, Kaul, and Lee 2021). However little is known about its connection with green bonds even though they pursue the same climate mandate. Our work contributes to the literature by showing that climate policy promotes international issuances of corporate green bonds denominated in local currency and therefore reduce currency mismatch risk in the corporate balance sheet.

The remaining of this paper is organized as follows. Section 2 presents the data, summary statistics and methodology, Section 3 discusses the empirical results, Section 4 performs heterogeneity analysis and robustness checks, and Section 5 concludes with policy implications.

2. Data and methodology

In this section, we describe data used in this study, provides an overview of the corporate green bonds issued worldwide, reports summary statistics for key variables and explains the methodology for our empirical analysis.

2.1 Data source

We summarize the definition and source of each variable in Appendix Table A1 and describe them in detail as follows.

2.1.1 Corporate bonds

We obtain corporate green bonds from Refinitiv Eikon (Eikon hereafter), which labels green bonds according to the use of proceeds. Existing studies argue that bonds issued before 2013 are unlikely to be marketed as green bonds (Larcker and Watts 2020; Flammer 2021). Following their practices, we focus on bonds issued after 2012.[3] There are 1927 green bonds issued by 761 distinct entities between 1 January 2013 and 31 December 2019.[4] For each green issuer, we obtain all of their regular bonds from Eikon. We drop 148 issuers without any records on regular bond issuance because they are likely to be special purpose entity such as Special Purpose Acquisition Companies (SPAC) or projects backed by a collection of many assets (OECD 2015). This leaves us with a final sample of 613 issuers from 55 markets, covering a total of 1758 green bonds and 277399 regular bonds. We focus on firms that issue both green and regular bonds to facilitate within-firm comparison. All bonds refer to corporate bond hereafter unless otherwise specified.

We also obtain from Eikon various measures of bond characteristics, such as issue date, credit rating, bond tenor, coupon rate, coupon type and payment frequency, among others. We control for these bond-specific factors in various robustness checks.

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[3] The total number of the world's corporate green bonds issued before 2013 is 141. Our key result remains robust when we include green bonds issuance before 2013 or issued by special purpose entity. These results (not reported) are available upon request.
[4] The number of green bonds issued between 1 January 2013 and 31 December 2018 is 1188, which is very close with that from Bloomberg (1189) as reported in Flammer (2021).

2.1.2 Climate policy

Data on the timing and stringency of climate policy are from the World Bank. There are 28 markets that have adopted ETS and 21 markets that have implemented carbon tax in our sample. For markets that have multiple ETS or carbon tax initiatives at different subnational level, we focus on the earliest climate policy. Appendix Table A3 lists the markets that have adopted either type of climate policy. World Bank also tracks the annual carbon price and carbon tax as well as associated revenues for each climate policy initiative. The average carbon price has more than doubled, rising from 2013 ($10 per ton) to 2019 ($21 per ton), while the average carbon tax declines by 11% from $41 per ton in 2013 to $37 per ton in 2019 (see the left panel of Appendix Figure A1).[5] The revenues generated from auctioning ETS allowances are 5.62 times as much as that collected from carbon tax (see the right panel of Appendix Figure A1), suggesting a broader coverage or more stringent implementation of ETS than carbon tax.

2.1.3 ESG scores

For each issuer in our sample, we extract their annual environmental, social and governance (ESG) scores between 2013 and 2019 from Eikon. Only 248 out of 613 firms in our sample have ESG data. Other than the overall ESG score, we also obtain its subcomponents on the Environmental (E), Social (S) and Governance (G). By comparing firms with high and low ESG scores, we seek to understand how ESG shape the impact of climate policy on green financing.

2.1.4 Financial fundamentals

We obtain each issuer's financial data from ORBIS, which covers both publicly listed and private firms. There are 363 out of the 613 firms in our sample that have financial data from 2013 to 2019. We are interested in the firms' listing status because publicly listed firms are typically larger and more visible than private firms, which enable them to better capture SRI investors' attention. We measure the firm's size by its total *market capitalization* and *total assets* in USD. Firm's profitability are captured by (i) return on equity (*ROE*), net income

[5] The average statistics include only market-year observations with effective ETS or carbon tax. If we assume carbon price and tax to be 0 for those without effective climate policy, the average carbon price (tax) increases from $5 ($11) in 2013 to $10 ($13) in 2019.

divided by shareholder's equity, and (ii) *profit margin*, net income divided by total revenue. Firm's financial *leverage* is measured by the ratio of debt to assets. We analyze whether firms with relatively strong and weak financial fundamentals respond differently to climate policy.

2.1.5 Environmental performance

Our market-level measures of environmental performance are from Yale Center for Environmental Law and Policy (YCELP) and Center for International Earth Science Information Network (CIESIN). The data reports Environmental Performance Index (EPI) for a large number of markets based on 11 categories and 2 policy objectives. Due to the low time-variation in EPI, we classify markets with good and poor environmental performance based on the EPI in 2020.

2.1.6 Macroeconomic data

We collect a series of annual macroeconomic variables from the World Bank. *Currency appreciation* is calculated as the annual growth in foreign exchange rate, with higher valuation corresponding to greater currency appreciation. *Current account (CA) surplus* is calculated as a ratio of GDP. *Reserve* is the international reserve normalized by GDP. Inflation targeting (*IT*) is a dummy that equals 1 if the market has officially adopted IT and 0 otherwise, which is obtained from Aizenman et al. (2021). *Foreign exchange (FX) regime* is a dummy that equals 1 for fixed or pegged exchange rate regime, which is from Ilzetzki, Reinhart, and Rogoff (2019).

2.2 Green bond overview

The top panels of Figure 1 illustrate the global distribution of corporate green bonds issued between 2013 and 2019. We observe that green bonds concentrate on markets with climate policy, in terms of either total amount or number of green bond issuances. China issued the largest amount of green bonds (B$114), followed by the US (B$54) and then France (B$52). China also led in terms of the number of green bonds issued (366), followed by Sweden (267) and then the US (233).

The bottom panels of Figure 1 demonstrate the global trends of green and regular bonds. Although the amount and number of green bonds are still far behind that of regular bonds, they are growing rapidly, especially after the drafting of Paris Agreement (note that the slope of the solid line becomes steeper after 2015 in both panels), a legally binding international treaty on climate change that aims to limit global warming to below 2 degrees Celsius above pre-industrial levels.

2.3 Summary statistics

We start with comparing green and regular bonds along various characteristics. Panel A of Table 1 shows that the yield to maturity and bid-ask spread for green and regular bonds upon their issuances are not statistically different, which is consistent with Larcker and Watts (2020) and Flammer (2021). This suggests that any documented difference between green and regular bonds is unlikely to be driven by either yield or liquidity. We also show that green bonds have significantly better credit rating, higher coupon rate, bigger size and longer tenor than regular bonds. In the following analysis, we control for these variables, and use manual and propensity score matching (PSM) to rule out the possibility that these differences are driving our results.

Panel B of Table 1 reports the summary statistics for LCF_i, a dummy variable that equals 1 if bond *i* is issued in local currency in foreign markets. In the absence of climate policy, the average *LCF*, which reflects the probability of local currency issuances in foreign markets for a firm, does not differ significantly between green and regular bonds. It suggests that green and regular bonds are comparable in the absence of climate policy. However, when climate policy is in position, the probability of local currency issuances in foreign markets for green bonds is 6.5 percentage points higher than that for regular bonds, which is statistically significant at less than 1% level. The difference in the probability of local currency issuances in foreign markets between green and regular bonds in the presence of climate policy is 7.8 percentage points higher than that before the climate policy, which is statistically significant at the 5% level. The result provides preliminary evidence that climate policy increases the probability of local currency issuances of green bonds in foreign markets.

2.4 Parallel trends

Figure 2 shows that the trend of local currency issuances in foreign markets for green bonds (short-dashed line) in the absence of climate policy is very similar with that for regular bonds (long-dashed line). It also shows that, throughout our sample period, the average probability of local currency issuances in foreign markets for green bonds in the presence of climate policy (solid line) is consistently higher than that for regular bonds. This is in line with the summary statistics that climate policy increases the probability of local currency issuances in foreign markets for green bonds.

2.5 Method

In this section, we explain methodologies applied to analyze the difference between green and regular bonds in accessing foreign capital in local currency, the impact of climate policy on such a difference, and the role of carbon price and carbon tax.

2.5.1 Difference between green and regular bonds

The green preference of SRI investors differs green bonds from regular bonds. If SRI investors are willing to take higher risk of holding green bonds denominated in issuers' local currency, green bonds should be more capable of borrowing foreign capital in local currency than regular bonds. We estimate the following linear probability model to understand whether green bonds differ from regular bonds in terms of the probability of borrowing foreign capital in local currency:

$$LCF_i = \alpha Green_i + c_{f,t} + \varepsilon_i \tag{1}$$

The dependent variable, LCF_i, is a dummy variable that equals 1 if bond i is denominated in local currency and marketed to foreign investors. The green bond indicator, $Green_i$, is a dummy variable that equals 1 for green bonds labeled by Eikon. A positive (negative) and statistically significant coefficient of $Green_i$, α, indicates that green bonds are more (less) capable of raising foreign capital in local currency and therefore lower currency mismatch risk.

Our sample focuses on firms that issue both green and regular bonds. Thus, we are able to control for firm-time fixed effects (FE), $c_{f,t}$, which absorb all firm-specific factors, either static or time-varying, such as credit rating, international trade and investments, and liquidity that may be relevant for the currency denomination of corporate bonds. Here the time indicator t is at monthly frequency in main analysis, and replaced with daily and yearly frequency in robustness checks. The FE also take care of domestic and global macroeconomic factors that may affect bonds' currency denomination. Thus, the documented difference between green and regular bonds can only be driven by bond-level characteristics. Finally, ε_i is the error term.

2.5.2 The role of climate policy

The government's commitment to climate change attracts SRI investments through policy support on information disclosure, clean production, and green innovation, among others. Climate policy generates a positive shock to SRI capitals directed to the market that adopt the policy, which increases the demand of green bonds but not regular bonds. To analyze the role of climate policy on corporate green bonds' capacity to raise foreign capital in local currency, we compare green bonds in the presence and absence of climate policy, relative to regular bonds:

$$LCF_i = \alpha Green_i + \beta Green_i \times Policy_{d,t} + c_{f,t} + \varepsilon_i. \qquad (2)$$

The dummy variable $Policy_{d,t}$ equals 1 if there is an effective climate policy in the form of either ETS or carbon tax in market d at period t, and 0 otherwise. If climate policy promotes local currency green bond issuances in foreign markets, the coefficient of the interaction term $Green_i \times Policy_{d,t}$, β, should be positive and statistically significant.

2.5.3 Carbon price vs carbon tax

To differentiate between the roles of ETS and carbon tax, we replace the climate policy indicator with the market-based carbon price and government-determined carbon tax and estimate the following:

$$LCF_i = \alpha Green_i + \beta_{CP} Green_i \times CP_{d,t} + \beta_{CT} Green_i \times CT_{d,t} + c_{f,t} + \varepsilon_i \qquad (3)$$

The two continuous variables $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of 1 plus carbon price and carbon tax in market d at period t, which equal 0 before the corresponding climate policy was adopted. Using logarithmic transformation facilitates interpretation and comparison of price and tax across markets.[6] The coefficient β_{CP} (β_{CT}) captures how the probability of local currency issuance in foreign markets for green bonds change when carbon price (tax) is doubled. If rising carbon price (tax) increases green bonds' capacity to raise foreign capital in local currency, the coefficient of the interaction term $Green_i \times CP_{d,t}$ ($Green_i \times CT_{d,t}$), β_{CP} (β_{CT}), should be positive and statistically significant.

3. Empirical results

We start with presenting the difference between green and regular bonds in their associations with currency mismatch risk, proceed to analyze the role of climate policy on corporate green financing, and finally discuss which firms and markets benefit from rising carbon price.

3.1 Green bonds and currency mismatch risk

Most firms have to issue bonds denominated in foreign currency to borrow from international investors (Maggiori, Neiman, and Schreger 2020; Hale, Jones, and Spiegel 2020; Wu 2020). Borrowing in foreign currency exposes firms to currency mismatch risk as their main expenditures and revenues are in local currency. Firms can reduce the currency mismatch risk if borrow in their local currency. However, this is generally difficult as international investors prefer assets denominated in their own country's currency instead of the issuers' (Maggiori, Neiman, and Schreger 2020).

We are interested in whether green bonds can mitigate currency mismatch through their attraction to SRI investors. Green and regular bonds are different in the eyes of SRI investors. The proceeds of green bonds are to finance clean production, innovate green technology, improve energy efficiency, and preserve environment, among others, which contribute to reduce greenhouse gases emissions and mitigate climate change. SRI investors derive nonpecuniary benefits from holding green assets (Hong and Kacperczyk 2009; Baker et al. 2018; Hartzmark and Sussman 2019; Bolton and Kacperczyk 2021; Pástor, Stambaugh, and Taylor 2021) and are willing to sacrifice financial gains for social benefits (Pástor, Stambaugh,

[6] We also verify our results by using the original carbon price and carbon tax instead of their logarithmic transformation (not reported, available upon request).

and Taylor 2021). If SRI investors are more tolerant of currency mismatch risk embedded in green assets, green bonds should enable firms to better access foreign capital in local currency than regular bonds.

To test this hypothesis, we estimate Eq.(1) and report the result in column 1 of Table 2. It shows that, on average, the probability of local currency issuances in foreign markets for green bonds is 9.2 percentage points higher than that for regular bonds. Note that the average probability of local currency issuance in foreign markets for regular bonds is 13.5 percentage points, green bonds increases a firm's capacity to borrow foreign capital in local currency by 68%. Given that purely return-seeking investors have no incentive to bear higher currency mismatch risk for holding green bonds, we attribute the difference between green and regular bonds in accessing foreign capital in local currency to SRI investing. It provides evidence that international SRI investors are willing to take higher currency mismatch risk for holding green bonds, which is consistent with the green preference theory of Pástor, Stambaugh, and Taylor (2021).

Our result remains robust after we perform a comprehensive list of checks that control for various bond characteristics and employ manual matching and PSM to compare green and regular bonds of similar characteristics such as tenor, credit rating and size. These results are presented and discussed in Section 4,[7] which rule out the possibility that our finding is driven by bond-level characteristics.

3.2 Climate policy and corporate financing

Climate policy promotes the popularity of green bonds among international SRI investors from at least three channels. First, it increases the information transparency that enables SRI investors to better identify green assets and avoid greenwashing, the practices of exaggerating or falsifying environmental commitment to attract capital. SRI investors are motivated to direct more capital to green assets as transparent information enables them to act more confidently on information (Keller and Yeaple 2013). Second, climate policy encourages innovation of green technology (Weber and Neuhoff 2010; Cui, Zhang, and Zheng 2018) and

[7] These robustness checks are conditional on the presence of climate policy. Additional checks not conditional on climate policy yield similar findings (not reported, available upon request).

adoption of cleaner production, which enhances the social impact of SRI investments. SRI investors should be more willing to accept lower returns and bear higher risk for holding green assets that generate greater social benefits. Third, climate policy increases the likelihood of gathering sufficiently large amount of coordinated SRI investments so as to profit from green holdings while generating social impacts (Oehmke and Opp 2020). Conditional on serving their climate mandate, SRI investors are also attracted by high profitability.

Through enhancing the attraction of green bonds to international SRI investors, climate policy is expected to increase the probability of local currency green bond issuances in foreign markets. To explore the role of climate policy on corporate international financing, column 2 of Table 2 reports the estimation results based on Eq.(2). Consistent with our prediction, the coefficient of the interaction between green bond indicator and climate policy (*Green* × *Policy*) is positive and statistically significant. In particular, the adoption of climate policy increases the probability of local currency issuances in foreign markets for green bonds by 8 percentage points. It means that the probability of local currency green bond issuances in foreign markets conditional on climate policy (12.3% = 4.3% + 8%) nearly triples that without climate policy (4.3%). It provides evidence that climate policy promotes local currency green bond issuances in foreign markets.

The coefficient of *Green* is no longer statistically significant in Column 2 of Table 2. It suggests that, in the absence of climate policy, the difference between green and regular bonds are not statistically different. Thus, climate policy is necessary for green bonds to better access foreign capital in local currency than regular bonds. It implies that international SRI investors are willing to bear higher risk of holding green bonds only if climate policy is in position. In other words, the private sector's efforts to combat climate change through SRI investing depends on government's policy actions to reduce carbon emissions.

3.3 Differentiating carbon price and carbon tax

The coverage and implementation of climate policy vary across markets and over time. We expect more stringent climate policy to attract more international SRI investments and therefore enhances the capacity of green bonds to raise foreign capital in foreign markets further. We measure the stringency of climate policy with carbon price and carbon tax,[8] and evaluate their impacts on local currency green bonds issuances in foreign markets respectively. The time variations in market-driven carbon price and government-determined carbon tax enable us to differentiate their roles in shaping the relation between green bonds and currency mismatch risk.

Column 3 of Table 2 reports the estimation results based on Eq.(3). Consistent with our hypothesis, the coefficient of the interaction between green bond indicator and carbon price (*Green* × *CP*) is positive and statistically significant. In particular, doubling the carbon price increases the probability of local currency green bond issuance in foreign markets by 4.9 percentage points. The average carbon price in our sample is $11.72 per ton, which translates into 12 percentage point increase in the probability of local currency green bond issuances in foreign markets.[9] This number is higher than that in column 2 based on dummy policy indicator (8 percentage points), suggesting that the climate policy disproportionately affects markets in periods with relatively high carbon price. We verify the robustness of this result by controlling for bond-level characteristics and using alternative samples that match green bonds with regular bonds in various dimensions manually or using propensity score in Section 4.2.

The coefficient of the interaction between green bond indicator and carbon tax (*Green* × *CT*) means that, doubling the carbon tax increases the probability of local currency green bond issuances in foreign market by 0.2 percentage point, which is economically small and statistically insignificant. There is no evidence that carbon tax affects green bonds' capacity to raise foreign capital in local currency. This is consistent with the theoretical prediction of Oehmke and Opp (2020) that carbon tax is not effective in attracting SRI investments. The result could also be due to the low coverage of carbon tax. As shown in Appendix Figure A1, even though the carbon tax is much higher than the carbon price on average, its total revenue is only 1/6 of the ETS'.

To check whether our result is driven by the correlation between carbon price and carbon tax, we evaluate their roles separately. Columns 4 and 5 of Table 2 report similar results

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[8] Note that climate policy differs significantly across markets in various dimensions; we interpret the carbon price and carbon tax as an overall reflection of these differences.

[9] The adoption of climate change increases the carbon price from 0 to $11.72, which changes *CP* by $ln(1 + 11.72) - ln(1 + 0) = 2.54$. Multiplying such a change in *CP* with the coefficient of *Green* × *CP* leads to a change in the probability of local currency green bond issuance in foreign markets by $2.54 \times 0.049 = 0.12$.

that carbon price but not carbon tax affect the probability of local currency green bond issuances in foreign markets. The insignificant role of carbon tax explains why the implied impact of carbon price in column 2 is higher than the overall impact of climate policy in column 1, which includes both ETS and carbon tax.

3.4 Which firms benefit more from rising carbon price?

So far, we have documented that rising carbon price promotes local currency green bond issuances in foreign markets. We further analyze how firms' ESG, financial fundamentals, and financing experience shape their response of international green financing to carbon price.

3.4.1 ESG

Do firms with higher ESG scores benefit more from rising carbon price? Green bonds issued by firms with higher ESG scores are more likely to finance sustainable investments and generate social impacts, and less likely to be greenwashing. They should attract more international SRI investors, who derive more nonpecuniary utility from holding green assets that generate greater social impacts (Hong and Kacperczyk 2009; Hartzmark and Sussman 2019; Bolton and Kacperczyk 2021; Pástor, Stambaugh, and Taylor 2021; Barber, Morse, and Yasuda 2021). We therefore expect firms with higher ESG scores to benefit more from rising carbon price in terms of issuing local currency green bonds in foreign markets.

To test the hypothesis, we expand Eq.(3) to include the triple interaction term, *Green* × *CP* × *ESG*, where the dummy variable *ESG* equals 1 if the firm-specific ESG measure is above the sample median and 0 otherwise. The coefficient of the triple interaction term in column 1 of Table 3 is positive and statistically significant. Specifically, in response to doubled carbon price, firms with relatively high ESG scores are 6.7 percentage points more likely to issue local currency green bonds in foreign markets than firms with relatively low ESG scores. The probability for high-ESG firms to issue local currency green bonds in foreign markets (10.9% = 0.42 + 0.067) is 2.6 times of that for low-ESG firms (4.2%). It provides evidence that ESG enables firms to issue more local currency green bonds in foreign markets when carbon price rises.

Delving into the environmental (E), social (S) and governance (G) components, we find similar results in general. In particular, firms with relatively high E scores in resource use (i.e. energy efficiency) and innovation (i.e. green technology), S scores in community (i.e. business ethics) and human rights (i.e. respecting human rights), and G scores in shareholder (i.e. equal treatment of shareholders) and management (i.e. best practice of governance), are more likely to issue local currency green bonds in foreign markets when carbon price rises.

3.4.2 Financial Fundamentals

Firms with stronger fundamentals have more resource and capacity to contribute to society. They are more likely to turn the proceeds of green bonds into green technology and clean energy, which generates greater social impacts and potentially attracts more SRI investments. We therefore expect firms with stronger fundamentals to benefit more from rising carbon price.

To test the hypothesis, we expand Eq.(3) to include the triple interaction term *Green* × *CP* × *Fun*, where the dummy variable *Fun* equals 1 for firms with stronger-than-median financial fundamentals. The coefficients of the triple interaction term are positive and statistically significant in columns 1–5 of Table 4. It means that, when carbon price increases, the probability of local currency green bond issuances in foreign markets is higher for firms that are publicly listed, larger in market capitalization or total assets, and more profitable in terms of either ROE or profit margin. However, we find no evidence that financial leverage affects firms' response to rising carbon price, perhaps because those that are capable of borrowing from foreign markets have relatively low default risk to start with.

3.4.3 Financing experience

Firms with more experience of issuing bonds may better understand international SRI investors' green preference and learn how to customize their bonds to attract SRI investments. They may therefore benefit more from rising carbon price that directs SRI investments to green bonds.

To analyze how financing experience affects firms' response to carbon price, we add the triple interaction term *Green* × *CP* × *Exp* into Eq.(3), where the dummy variable *Exp* equals

1 for firms that are more experienced in a specific form of financing. We measure a firm's financing experience as of period *t* by the number of a particular type of bonds that it issued after 1 January 2013 and before the period *t*, including (i) green bonds, (ii) green bonds in foreign markets, (iii) local currency green bonds in foreign markets, (iv) local currency bonds in foreign markets, and (v) bonds in foreign markets. These measures capture the experience of raising funds from different capital markets in different currencies using different instruments. The coefficients of the triple interaction term are positive and statistically significant in columns 3 and 4 of Table 5 but not the rest. Note that the experience of issuing local currency bonds in foreign markets (column 4) includes that of issuing local currency green bonds in foreign markets (column 3). The similar coefficients of the triple interaction term in columns 3 and 4 suggest that it is the experience of issuing local currency bonds in foreign markets that strengthens the role of rising carbon price in encouraging local currency green bond issuances in foreign markets. While the experience of issuing local currency bonds in foreign markets can be applied to green bonds of similar type, the experience of issuing green bonds, bonds in foreign markets, or green bonds in foreign markets alone does not seem to be sufficient to improve firms' capacity to raise foreign capital in local currency (see columns 1, 2 and 5 of Table 5).

3.5 Which markets benefit more from rising carbon price?

We next explore whether market-level environmental performance and macroeconomic dynamics affect the impact of carbon price on corporate green financing.

3.5.1 Environmental performance

A market's overall environmental performance signals its commitment to sustainable development. It complements climate policy in mitigating climate change, which may increase a market's attraction to SRI investments further and enable firms there to better access foreign capital in local currency.

We add *Green* × *CP* × *EPI* into Eq.(3), where the dummy *EPI* equals 1 for markets with high-than-sample-median EPI. We compare markets with high and low environmental performance index (EPI) across 11 categories and 2 policy objectives and report the estimation results in Table 6. It shows that, in markets that perform better in managing climate change, pollution, ecosystem services, air quality and sanitation or achieving the policy objective of ecosystem vitality and environmental health, firms are more capable of issuing local currency green bonds in foreign markets when carbon price increases. It suggests that good environmental performance enhances a market's attraction to SRI investments.

3.5.2 Macroeconomic fundamentals

Macroeconomic fundamentals could affect firms' capacity to borrow foreign capital in local currency. Inflation targeting (IT) increases the credibility of monetary policy, which refrains governments from printing money to reduce their debt burden. The valuation of local currency is more stable in markets with fixed or pegged foreign exchange (FX) regime than those with floating regime. Both IT and stable FX regime reduce the international investors' risk of holding local currency bonds. Local currency appreciation may attract return-seeking international investors, which increases the demand of local currency bonds. High current account surplus and international reserve reflects a market's income and asset in USD or other foreign currencies, which reduce the likelihood of local currency depreciation and sovereign defaults that may generate spillover effects to corporate bond market. These macroeconomic factors increase the likelihood of local currency bond issuances (Hale, Jones, and Spiegel 2020; Aizenman et al. 2021). However, it is unclear whether they affect green and regular bonds alike.

To understand the roles of these macroeconomic factors on shaping the impact of carbon price on international green financing, we expand Eq.(3) to include the triple interaction term $Green \times CP \times Macro$, where the dummy variable *Macro* equals 1 for markets with relatively appealing macroeconomic characteristics. The coefficient of this triple interaction term is statistically insignificant across columns 1–6 of Table 7. Thus, there is no evidence that these macroeconomic factors affect the role of carbon price in promoting local currency green bond issuances in foreign markets. It suggests that they affect regular and green bonds alike. The irrelevance of these macroeconomic variables for international green financing and its response to carbon price may be because they have not yet incorporated elements of climate change or perceived by investors to be connected to climate change.

4. Further analysis

We further perform heterogeneity analysis and robustness checks based on Eq.(3) in this section.[10]

4.1 Heterogeneity analysis

4.1.1 Dynamic impacts of carbon price

Figure 3 illustrates the dynamic impacts of doubling carbon price on corporate green financing from 2013 to 2019. The probability of local currency green bond issuances in foreign markets escalates in 2015, when the Paris Agreement was drafted, and in 2019, when the Swedish girl Greta Thunberg who sailed across the Atlantic Ocean to avoid carbon emissions attracted significant public attention worldwide and generated an upsurge on climate activism.

4.1.2 Sector-level heterogeneity

We classify bonds into different sectors according to the Standard Industrial Classification (SIC) of their issuers. In response to doubled carbon price, the probability of local currency green bond issuances in foreign markets is the highest for manufacturing firms (11.7%), followed by transport related firms (7.9%) and then financial firms (5.1%). Manufacturing and transport sectors are at the center of carbon emissions, whose green efforts are crucial to mitigate climate change. Our finding that green bonds issued by firms in these sectors are more capable of raising foreign capital in local currency is consistent with Oehmke and Opp (2020), which prove theoretically that SRI investors target dirty industries to optimize their social impact. Financial firms are relatively capable of issuing local currency green bonds in foreign markets, possibly because they have accumulated rich experience in issuing local currency bonds in foreign markets and known well SRI investors' green preference, which enable them to be more responsive to opportunities arisen from rising carbon price.

[10] We document similar results based on Eq.(2), which are not reported but available upon request.

4.1.3 Bond-level heterogeneity

Bond credit rating We classify bonds into three categories according to their broad credit rating and include their interactions with $Green \times CP$ in Eq.(3). The coefficients of the triple interaction term corresponding to senior secured, senior unsecured and unsecured bonds are summarized in the left panel of Figure 5. It shows that the impact of rising carbon price on promoting local currency green bond issuances in foreign markets concentrates on green bonds with high credit rating.

Bond tenor Similarly, we analyze the heterogeneous impact of carbon price on bonds with different tenors. The right panel of Figure 5 shows that rising carbon price promotes local currency issuance in foreign markets for relatively long-term (tenor $\geq$ 5 years) but not short-term (tenor < 5 years) green bonds.

4.2 Robustness checks

4.2.1 Additional control variables

Are green bonds more capable of raising foreign capital in local currency in response to climate policy because of their conventional characteristics such as size and tenor, instead of being green? Intuitively, if simply changing the conventional bond characteristics can increase the access to foreign capital, corporate and sovereign borrowers would not have suffered the currency mismatch risk for so long. To formally address this issue, we control for the bond size in logarithm, coupon rate, and bond tenor to check the robustness of our key result. Columns 1–4 of Table 8 show that the impact of rising carbon price on promoting local currency green bond issuances in foreign markets remains robust, whether we control for one or all of these bond-level variables. Further controlling for a series of bond-level FE related to detailed credit rating, coupon class (zero, fixed, float, etc.), coupon payment frequency, offering type and listed exchange, we document similar results in columns 5–9 of Table 8.

4.2.2 Alternative samples

Matched sample To further address the concerns that some conventional bond characteristics may drive our result, we focus on subsamples with improved comparability between regular and green bonds within the same firm. We first follow the method in Crabbe and Turner (1995), which is also adopted by Larcker and Watts (2020) and Flammer (2021), to manually select a sample of regular bonds that is identical with the green bonds in terms of issuer, issue month, credit rating and bond tenor. Focusing on such a matched sample, we document similar result in column 1 of Table 9 that rising carbon price promotes local currency green bond issuance in foreign markets. We next use propensity score matching (PSM) to select a group of regular bonds that could otherwise be issued as green bonds and repeat the analysis using the matched sample. The result in column 2 Table 9 remains robust. Using different types of algorithm for PSM yields similar robust results (not reported, available upon request).

Excluding firms from the US and offshore markets USD is the only global dominant currency (Maggiori, Neiman, and Schreger 2020), which differentiates US firms from the rest as they are able to issue bonds in their local currency in foreign markets. Our results may be driven by US firms if they dominate our sample. To address this issue, we exclude all US firms from the sample and repeat our analysis. Consistent with the baseline result, we show in column 3 of Table 9 that rising carbon price increases non-US firms' local currency green bond issuance in foreign markets. We also exclude offshore markets from our sample given their unique characteristics in international financial transactions and show in column 4 of Table 9 that the result remains robust.

Green bonds only So far we have been comparing green and regular bonds to evaluate the impact of carbon price. Could our result be driven by the falling probability of local currency regular bond issuances in foreign markets instead of the rising probability of local currency green bond issuances in foreign markets? To rule out this possibility, we restrict the sample to green bonds and repeat the analysis. The result in column 5 of Table 9 shows that, when comparing with itself, the probability of local currency green bond issuances in foreign markets also increases with carbon price.

Markets with climate policy only Some markets in our sample have not yet implemented either ETS or carbon tax. Our results could be challenged if these markets are much more incapable of issuing local currency green bonds in foreign markets than the rest. To address this concern, we focus on the subsample of markets that have implemented climate policy of either kind. The result in column 6 of Table 9 shows that the impact of carbon price remains positive and statistically significant. Further restricting the sample to those that have adopted only ETS, we find similar robust result in column 7 of Table 9.

4.2.3 Alternative fixed effects and clustering

Our main regressions control for firm-time FE throughout our empirical analysis, which absorb all firm-level factors that could possibly affect the probability of local currency green bond issuances in foreign markets. As we focus on monthly variations, one may be concerned about daily factors such as stock price that could affect corporate green bond issuances. We therefore control for firm-date FE instead. Column 1 of Table 10 shows that our baseline result that rising carbon price promotes local currency green bond issuances in foreign markets remains robust.

Others may be concern that our FE are too strict and cost too many degrees of freedom. We therefore replace them with firm-year FE and show in column 2 of Table 10 that the baseline result remains robust. Controlling for firm and time (monthly frequency) FE separately also yield similar result (see column 3 of Table 10).

So far we have been clustering standard error by market. Columns 4–7 of Table 10 shows that clustering the standard error by market-industry, market-year, firm and firm-time also yields the same result.

5. Conclusion

Corporate green bonds can be useful tools to reduce corporate financing risk. Our empirical exercise reveals that, compared to regular bonds from the same firm, green bonds are more capable of borrowing foreign capital in issuer's local currency, which shifts the currency mismatch risk from borrowers' balance sheets to investors'. This is attributed to international SRI investors' willingness to tolerate higher currency mismatch risk for holding green bonds denominated in issuer's local currency instead of theirs. The adoption of climate policy that attract international SRI investments nearly triples green bonds' capacity to raise foreign capital in local currency. There is, however, no evidence that green bonds better access foreign capital in local currency than regular bonds in the absence of climate policy. It suggests that climate policy is a necessary condition for green bonds to better access foreign capital in local currency than regular bonds.

We further show that the impact of climate policy is mainly driven by rising carbon price, suggesting the stringency of climate policy also matters to green bonds' capacity to borrow foreign capital in local currency. Firms with higher ESG scores and from markets with better environmental performance benefit more from rising carbon price. It suggests that both firm- and market-level green actions attract SRI investments disproportionately as the carbon price increases.

Our findings have important implications for policy practice and corporate financing. First, thanks to growing SRI investing, green bonds help strengthen corporations' balance sheets. Second, welfare-improving climate policy, though imposes costs on corporate production, directly benefits corporate through the channel of international green financing. For countries that are considering whether to adopt ETS, it is important to incorporate the financial benefits generated by climate policy into their decision making. Being able to borrow in local currency is particularly important for those with large external debt denominated in foreign currency, which are exposed to substantial default and bankruptcy risk when foreign currency appreciates against local currency. Third, high carbon price, though increases the cost of production, enables firms to better access foreign capital at lower risk. Most emerging economies are hesitant about adopting ETS because their economic growth relies on carbon-intensive production. Given their difficulty to borrow from international investors in local currency and high external debt, the economic benefits they can reap from international green financing may outweigh the economic cost of regulating carbon emissions. From the firm's perspective, given the persistent rising trend of carbon price, they can better access foreign capital at lower currency mismatch risk through issuing corporate green bonds as long as climate policy is in position. This provides a financial incentive for firms to support climate policy instead of lobbying against it.

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Figure 1: Global distribution and trend of green bonds

The top left (right) heatmap illustrates the total amount (number) of green bonds issued in each market from 2013 to 2019, with darker color corresponding to bigger size (larger number). The bottom left (right) panel plots the time trend of the amount (number) of green and regular bonds in solid and dashed lines, respectively.

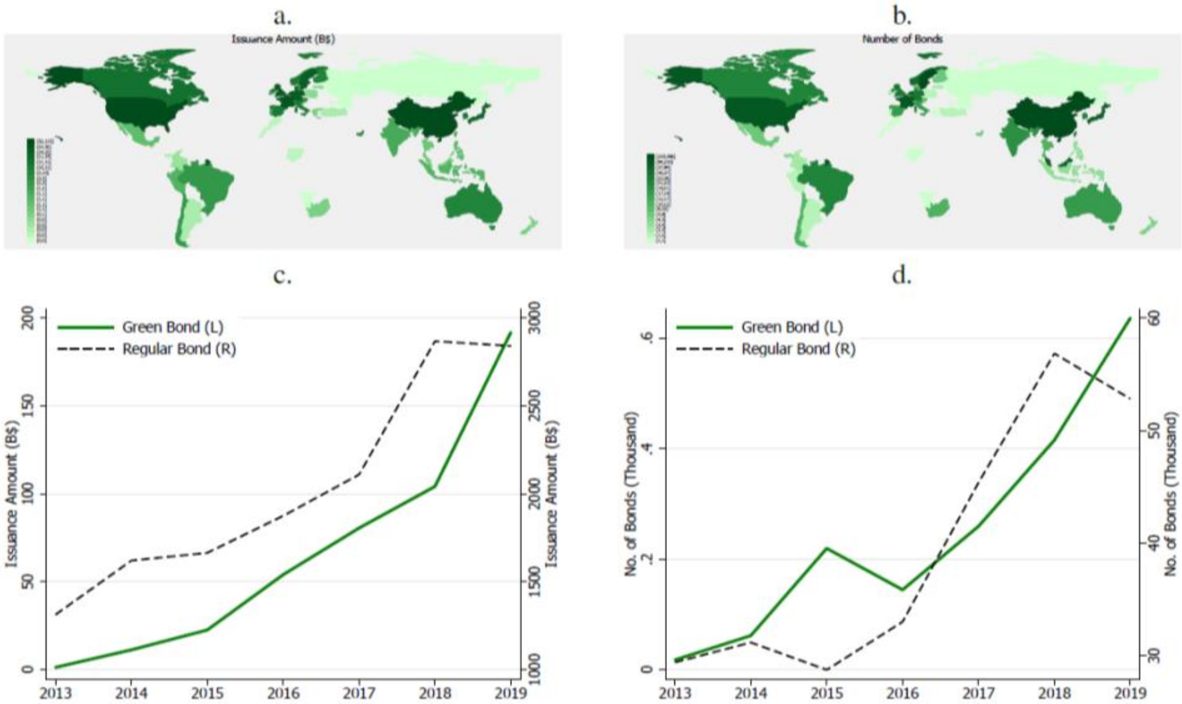

Figure 2: Parallel trends

This figure plots the trend of the average probability of local currency issuance in foreign markets for green bonds before and after the adoption of climate policy in solid and short-dashed lines respectively, and that for regular bonds in long-dashed line.

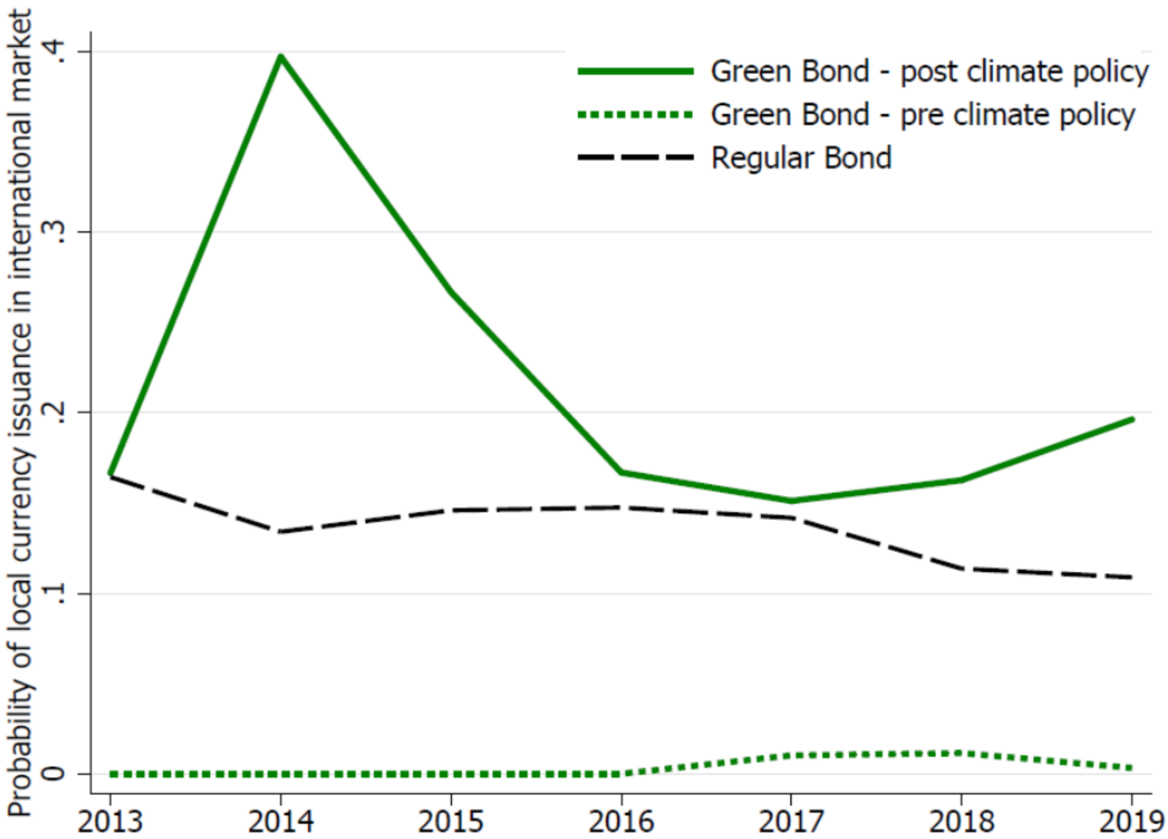

Figure 3: The dynamic impacts of carbon price

This figure summarizes the impact of carbon price on the probability of local currency (LC) issuance in foreign markets for green bonds in each year. The diamond marks the size of impact while the line crossed it represent the 95% confidence interval.

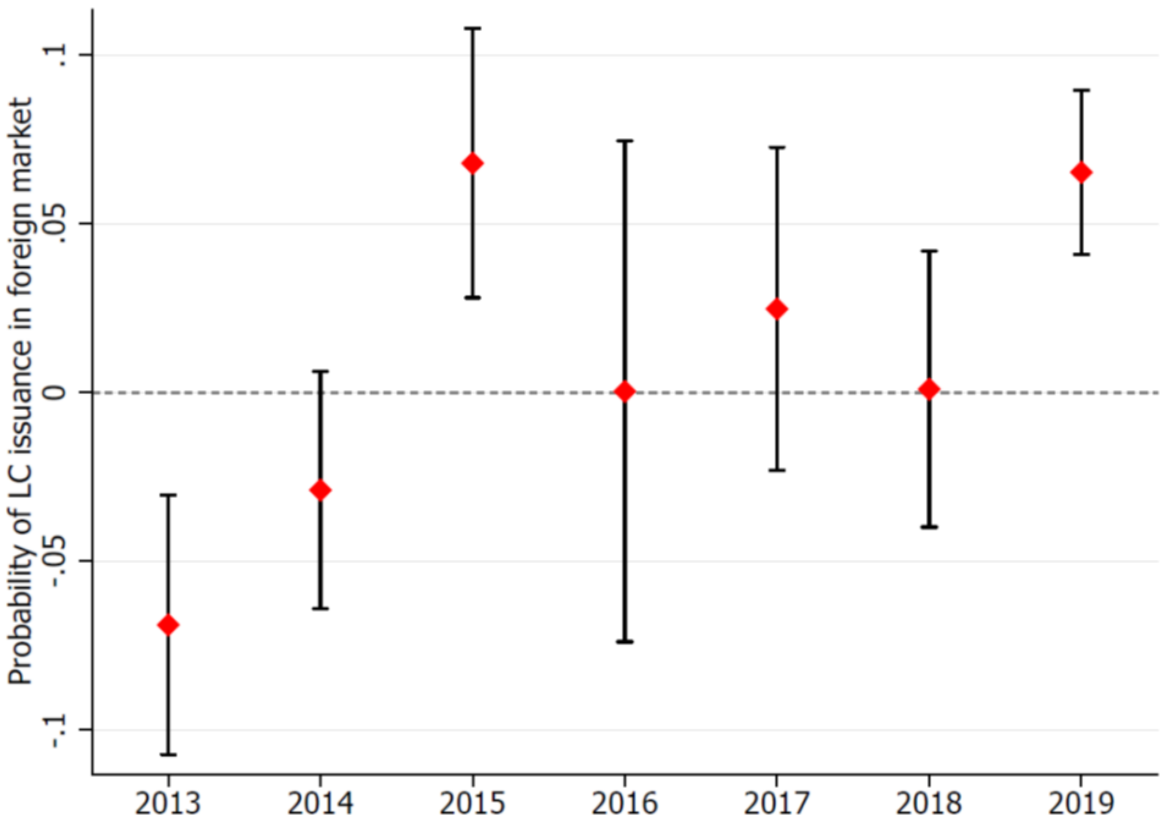

Figure 4: Heterogeneity across sectors

This figure summarizes the impacts of doubling carbon price on the probability of local currency issuance in foreign markets for green bonds issued by firms from sectors specified on the y-axis. The diamond marks the size of impact while the line crossed it represent the 95% confidence interval.

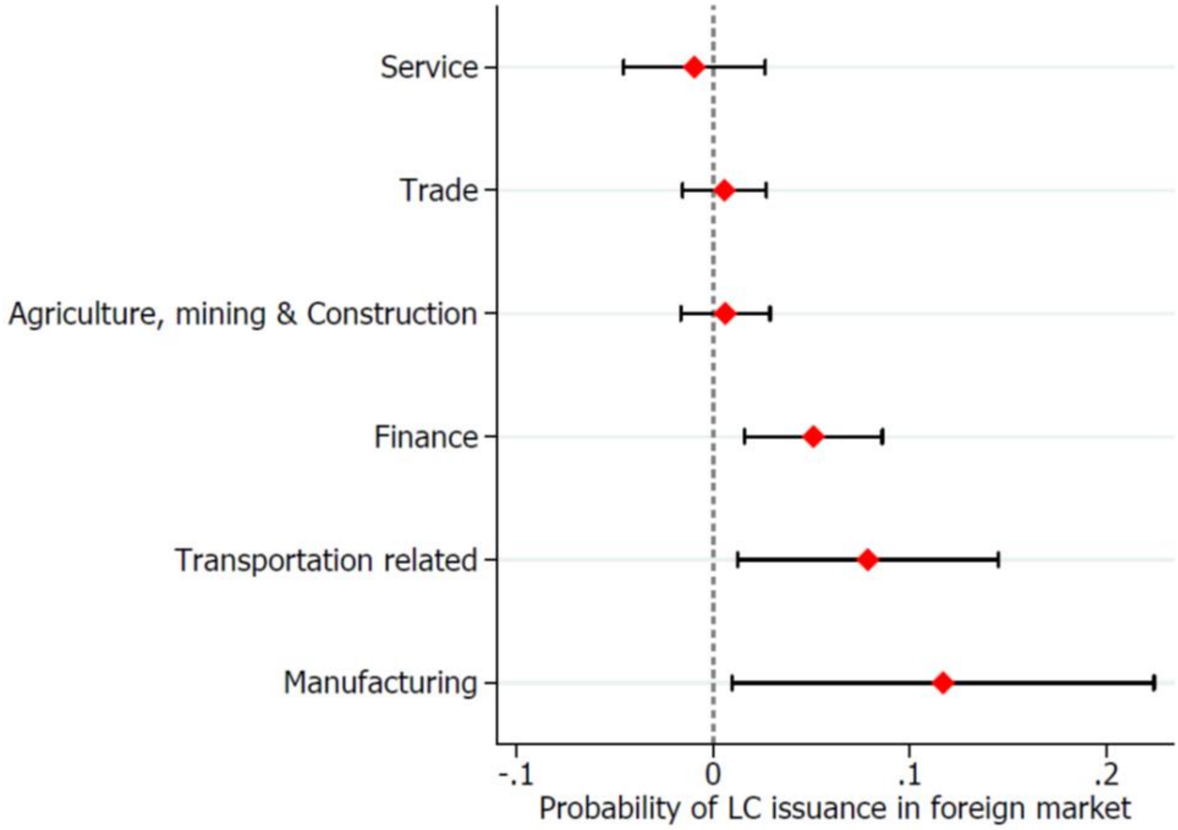

Figure 5: Heterogeneity across bond credit rating and tenor

The left and right panels summarize the impacts of doubling carbon price on the probability of local currency issuance in foreign markets for green bonds with different credit rating and tenors respectively. The diamond marks the size of impact while the line crossed it represent the 95% confidence interval.

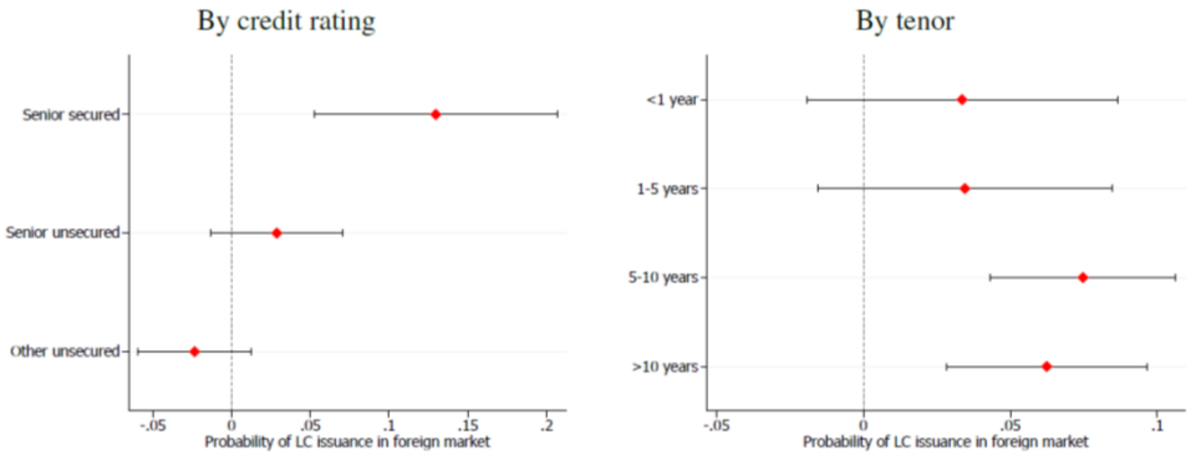

Table 1: Summary Statistics

Panel A reports the mean and standard deviation (SD) of yield to maturity and bid-ask spread upon issuance credit rating, coupon rate (1 highest–3 lowest), the logarithm of bond size or ln(Size), and tenor for green and regular bonds, respectively. It also reports the difference between green and regular bonds and the associated *p* value. Panel B reports similar statistics for LCF_i, a dummy variable that equals 1 if bond *i* is issued in local currency in foreign markets, before and after the implementation of climate policy. The *Difference in Differences* (DID) row reports the differential LCF_i between green and regular bonds after the climate policy in excess of that before the climate policy.

	Green		Regular		Green – Regular	
	Mean	SD	Mean	SD	Difference	*p*-value
Panel A: Balance checks						
Yield to maturity	2.512	14.326	2.906	21.955	-0.394	0.699
Bid-ask spread	0.148	1.115	0.113	2.851	0.035	0.788
Credit rating	2.013	0.508	2.557	0.546	-0.545	0.000
Coupon rate	3.066	2.386	1.786	3.478	1.280	0.000
ln(Size)	18.204	1.928	15.613	2.461	2.592	0.000
Tenor	16.940	272.831	2.250	5.137	14.690	0.000
Panel B: Summarizing LCF_i before and after climate policy						
Before climate policy	0.043	0.030	0.056	0.015	-0.013	0.494
After climate policy	0.216	0.012	0.151	0.007	0.065	0.000
DID					0.078	0.029

Table 2: Climate policy and green bond issuance

This table summarizes the difference between green and regular bonds in international financing and the impact of climate policy on such a difference. The dependent variable is LCF_i, a dummy variable that equals 1 if bond *i* is denominated in local currency and issued in foreign markets. The dummy $Green_i$ equals 1 for green bonds. The dummy $Policy_{d,t}$ equals 1 if there is a climate policy in market *d* at period *t*. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market *d* at period *t*, which equal 0 in the absence of the corresponding climate policy. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF				
	(1)	(2)	(3)	(4)	(5)
Green	0.092***	0.020	-0.011	-0.012	0.063
	(0.030)	(0.017)	(0.034)	(0.036)	(0.040)
Green × *Policy*		0.080**			
		(0.038)			
Green ×*CP*			0.049***	0.052***	
			(0.016)	(0.014)	
Green ×*CT*			0.002		0.016
			(0.017)		(0.015)
Constant	0.114***	0.114***	0.114***	0.114***	0.114***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	275,158	275,158	275,158	275,158	275,158
R-squared	0.489	0.489	0.489	0.489	0.489

Table 3: ESG and the impact of carbon price

This table summarizes how ESG scores affect the impact of carbon price on local currency green bond issuance in foreign markets. The dependent variable is LCF_i, a dummy variable that equals 1 if bond *i* is issued in local currency in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market *d* at period *t*, which equal 0 in the absence of the corresponding climate policy. The dummy variable $ESG_{f,t}$ equals 1 if the specific ESG measure on the top row for firm *f* at period *t* is above the sample median. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		Environmental (E)				Social (S)			Governance (G)		
ESG measures	Overall ESG	Emissions	Resource Use	Innovation	Community	Workforce	Product Responsibility	Human Rights	Management	Shareholders	CSR Strategy
Green	-0.009	0.003	0.011	0.004	0.007	-0.004	0.007	0.006	-0.006	-0.002	-0.007
	(0.035)	(0.025)	(0.025)	(0.027)	(0.025)	(0.029)	(0.028)	(0.029)	(0.030)	(0.027)	(0.033)
Green × *CP*	0.042***	0.030	0.022	0.027**	0.023	0.038**	0.028*	0.031**	0.041***	0.033**	0.037***
	(0.014)	(0.018)	(0.014)	(0.013)	(0.014)	(0.015)	(0.016)	(0.013)	(0.013)	(0.013)	(0.014)
Green × *CT*	0.002	0.004	0.001	-0.000	0.003	0.003	0.002	0.002	0.001	0.002	0.006
	(0.016)	(0.017)	(0.018)	(0.018)	(0.016)	(0.017)	(0.018)	(0.017)	(0.017)	(0.016)	(0.015)
Green ×*CP* ×*ESG*	0.067**	0.073	0.093***	0.093***	0.093**	0.043	0.070*	0.064**	0.050**	0.076***	0.057*
	(0.031)	(0.049)	(0.027)	(0.030)	(0.035)	(0.030)	(0.035)	(0.026)	(0.025)	(0.022)	(0.033)
Observations	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158
R-squared	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489

Table 4: Financial fundamentals and the impact of carbon price

This table summarizes how firms' financial fundamentals shape the impact of carbon price on local currency green bond issuance in foreign markets. The dependent variable is LCF_i, a dummy variable that equals 1 if bond *i* is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market *d* at period *t*, which equal 0 in the absence of the corresponding climate policy. The dummy variable $Fun_{f,t}$ equals 1 if firm *f* is publicly listed in column 1, and if the specific financial measures in the top row for firm *f* at period *t* is above the sample median in columns 2–5. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF					
	(1)	(2)	(3)	(4)	(5)	(6)
Fundamentals	Listed	Market cap	Total assets	ROE	Profit Margin	Leverage
Green	0.001	0.004	0.020	0.004	0.003	-0.008
	(0.029)	(0.028)	(0.027)	(0.030)	(0.030)	(0.033)
$Green \times CP$	0.027*	0.026*	-0.010	0.028**	0.022	0.043***
	(0.014)	(0.013)	(0.018)	(0.012)	(0.016)	(0.015)
$Green \times CT$	0.002	0.002	0.008	-0.000	0.003	-0.003
	(0.017)	(0.018)	(0.014)	(0.013)	(0.016)	(0.016)
$Green \times CP \times Fun$	0.066**	0.087***	0.099***	0.054***	0.076**	0.042
	(0.032)	(0.023)	(0.020)	(0.015)	(0.036)	(0.031)
Observations	275,158	275,158	275,158	275,158	275,158	275,158
R-squared	0.489	0.489	0.489	0.489	0.489	0.489

Table 5: Financing experience and the impact of carbon price

This table reports how firms' bond issuance experience shapes the impact of carbon price. The dependent variable is LCF_i, a dummy variable that equals 1 if bond *i* is denominated in local currency (LC) and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market *d* at period *t*, which equal 0 in the absence of the corresponding climate policy. The dummy variable $Exp_{f,t}$ equals 1 if the firm *f*'s experience of issuing the particular type of bonds specified in the top rows, measured by the number of such bonds it issued up to period *t*, is above the sample median. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF				
Experience in	(1)	(2)	(3)	(4)	(5)
Bond type	Green	Green	Green		
Issuing market		Foreign	Foreign	Foreign	Foreign
Currency denomination			Local Currency	Local Currency	
Green	-0.014	-0.010	0.040	0.030	-0.007
	(0.035)	(0.036)	(0.028)	(0.028)	(0.037)
Green ×CP	0.061**	0.046**	-0.012	-0.031**	0.034
	(0.024)	(0.020)	(0.012)	(0.014)	(0.021)
Green ×CT	0.009	-0.000	0.006	0.022	-0.001
	(0.015)	(0.014)	(0.013)	(0.017)	(0.018)
Green ×CP × Exp	-0.030	0.013	0.227***	0.237***	0.033
	(0.026)	(0.033)	(0.036)	(0.038)	(0.025)
Observations	275,158	275,158	275,158	275,158	275,158
R-squared	0.489	0.489	0.490	0.490	0.489

Table 6: Environmental performance and the impact of carbon price

This table summarizes the differential impact of carbon price between markets with good and poor environmental performance. The dependent variable is LCF_i, a dummy variable that equals 1 if bond i is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market d at period t, which equal 0 in the absence of the corresponding climate policy. The dummy variable EPI_d equals 1 if market d's environmental performance indicator (EPI) on the top column is above the sample median. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Ecosystem Vitality							Environmental Health				Policy Objective	
EPI	Climate Change	Pollution emission	Ecosystem Services	Biodiversity	Fisheries	Agriculture	Water Resources	Air Quality	Sanitation	Heavy Metals	Waste Management	Environmental Health	Ecosystem Vitality
Green	0.004	0.005	-0.003	-0.014	-0.010	-0.011	-0.014	0.005	0.005	-0.004	-0.020	0.003	0.005
	(0.036)	(0.036)	(0.027)	(0.033)	(0.033)	(0.038)	(0.033)	(0.038)	(0.038)	(0.038)	(0.034)	(0.036)	(0.038)
Green × *CP*	0.000	0.005	0.036**	0.063**	0.062**	0.048	0.054	-0.000	-0.000	0.025	0.064	0.000	-0.000
	(0.018)	(0.022)	(0.016)	(0.027)	(0.024)	(0.029)	(0.037)	(0.021)	(0.021)	(0.032)	(0.049)	(0.018)	(0.021)
Green × *CT*	-0.009	-0.008	-0.007	0.003	-0.005	0.002	0.004	-0.006	-0.006	-0.002	0.007	-0.009	-0.006
	(0.018)	(0.017)	(0.010)	(0.015)	(0.023)	(0.018)	(0.015)	(0.017)	(0.017)	(0.017)	(0.015)	(0.018)	(0.017)
Green × *CP* × *EPI*	0.061***	0.055**	0.055***	-0.021	-0.019	0.002	-0.007	0.055**	0.055**	0.028	-0.018	0.060***	0.055**
	(0.022)	(0.024)	(0.018)	(0.023)	(0.035)	(0.030)	(0.036)	(0.023)	(0.023)	(0.032)	(0.048)	(0.022)	(0.023)
Observations	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158	275,158
R-squared	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489

Table 7: Macroeconomic fundamentals and the impact of carbon price

This table reports the role of macroeconomic fundamentals in shaping the impact of carbon price. The dependent variable is LCF_i, a dummy variable that equals 1 if bond i is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market d at period t, which equal 0 in the absence of the corresponding climate policy. The dummy variable $Macro_{d,t}$ equals 1 if market d at period t has inflation targeting (IT) and stable foreign exchange (FX) regime in columns 1 and 2, and above-median currency appreciation, current account (CA) surplus, and reserve in columns 3–5, respectively. All regressions control for firm-time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF				
	(1)	(2)	(3)	(4)	(5)
Macro indicator	IT	FX Regime	Currency appreciation	CA Surplus	Reserve
Green	0.005	0.004	-0.004	0.002	0.002
	(0.040)	(0.038)	(0.036)	(0.045)	(0.042)
Green ×CP	0.045***	0.072**	0.045***	0.037*	0.053***
	(0.015)	(0.031)	(0.015)	(0.022)	(0.019)
Green ×CT	0.001	-0.002	0.005	0.005	0.004
	(0.018)	(0.017)	(0.017)	(0.021)	(0.018)
Green ×CP × Macro	0.010	-0.033	0.015	0.016	-0.015
	(0.028)	(0.028)	(0.036)	(0.027)	(0.025)
Observations	466,962	466,962	466,962	466,962	466,962
R-squared	0.384	0.384	0.384	0.384	0.384

Table 8: Additional control variables

This table reports the estimation results after controlling for additional bond-level variables. The dependent variable is LCF_i, a dummy variable that equals 1 if bond i is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market d at period t, which equal 0 in the absence of the corresponding climate policy. Columns 1–4 control for (i) $ln(Size_i)$, the logarithmic bond size, (ii) $Coupon_i$, the coupon rate, (iii) $ln(Tenor_i)$, the logarithmic bond tenor, and (iv) all of the three bond-level variables above. Columns 5–9 control for detailed credit rating, coupon class, coupon payment frequency, bond offering type, and listed exchange related fixed effects (FE). All regressions control for firm-time FE. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Green	-0.043	-0.004	-0.020	-0.040	-0.036	-0.001	-0.034	-0.031	-0.017
	(0.026)	(0.035)	(0.040)	(0.033)	(0.030)	(0.037)	(0.030)	(0.036)	(0.034)
Green × CP	0.041**	0.049***	0.049***	0.041***	0.046***	0.052***	0.048***	0.046***	0.043***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.015)	(0.012)
Green × CT	0.011	0.001	0.002	0.009	0.006	0.000	-0.008	0.000	0.002
	(0.013)	(0.017)	(0.016)	(0.013)	(0.015)	(0.017)	(0.013)	(0.017)	(0.015)
ln(*Size*)	0.004			0.004					
	(0.003)			(0.003)					
Coupon		-0.003**		-0.003**					
		(0.001)		(0.001)					
ln(*Tenor*)			0.006	0.004					
			(0.005)	(0.009)					
Observations	216,240	253,641	274,688	195,911	275,155	275,158	124,964	268,427	259,000
R-squared	0.469	0.502	0.489	0.483	0.493	0.491	0.527	0.499	0.487
Additional FE					credit-rating	coupon class	coupon payment frequency	offering type	listed exchange

Table 9: Alternative samples

This table reports the estimation results using different samples. The dependent variable is LCF_i, a dummy variable that equals 1 if bond i is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market d at period t, which equal 0 in the absence of the corresponding climate policy. Columns 1 and 2 focus on subsamples that improve the comparability between green and regular bonds in various dimensions through manual and propensity score matching respectively. Columns 3 and 4 exclude firms from the US and offshore markets, respectively. Column 5 restricts the sample to green bonds only. Column 6 focuses on markets that have adopted (i) either Emission Trading System (ETS) or carbon tax, while column 7 only looks at markets with ETS. All regressions control for firm-time fixed effects except for column 4, which controls for market and time fixed effects. Heterogeneity robust standard errors clustered by market are reported in the parentheses. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	Manual Matching	PSM	X the US	X Offshore	Green Bonds only	ETS or Carbon Tax	ETS only
Green	-0.052	-0.012	-0.035	-0.009		-0.038	-0.045
	(0.039)	(0.031)	(0.028)	(0.036)		(0.059)	(0.070)
$Green \times CP$	0.052**	0.049**	0.043**	0.045***	0.056**	0.060***	0.064**
	(0.022)	(0.023)	(0.016)	(0.016)	(0.023)	(0.021)	(0.026)
$Green \times CT$	-0.006	0.008	0.013	0.005	-0.081**	0.002	0.001
	(0.017)	(0.025)	(0.014)	(0.017)	(0.036)	(0.017)	(0.017)
Observations	6,095	5,435	241,971	272,049	1,744	253,834	237,907
R-squared	0.417	0.635	0.385	0.495	0.405	0.492	0.487

Table 10: Alternative fixed effects and clustering

This table reports the estimation results using alternative specifications and clustering. The dependent variable is LCF_i, a dummy variable that equals 1 if bond *i* is denominated in local currency and issued in foreign markets. $Green_i$ is a dummy that equals 1 for green bonds. $CP_{d,t}$ and $CT_{d,t}$ are the logarithm of one plus carbon price and carbon tax in market d at period *t*, which equal 0 in the absence of the corresponding climate policy. Columns 1–3 control for firm-date, firm-year, and firm and month fixed effects (FE), respectively. Columns 4–7 control for firm-month FE. Heterogeneity robust standard errors reported in the parentheses are clustered by market in columns 1–3, and by market-industry, market-month, firm, and firm-month in columns 4–7, respectively. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

	Dependent variable: LCF						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green	-0.016	-0.004	-0.006	-0.011	-0.011	-0.011	-0.011
	(0.030)	(0.025)	(0.021)	(0.035)	(0.025)	(0.036)	(0.025)
Green × *CP*	0.037**	0.044***	0.044***	0.049**	0.049***	0.049**	0.049***
	(0.015)	(0.014)	(0.014)	(0.021)	(0.015)	(0.020)	(0.015)
Green × *CT*	0.006	-0.004	-0.004	0.002	0.002	0.002	0.002
	(0.011)	(0.014)	(0.012)	(0.016)	(0.010)	(0.017)	(0.010)
Observations	234,481	278,487	279,157	275,158	275,158	275,158	275,158
R-squared	0.604	0.460	0.430	0.489	0.489	0.489	0.489
Firm-month FE				√	√	√	√
Firm-date FE	√						
Firm-year FE		√					
Firm FE			√				
Month FE			√				
Clustering	market	market	market	market-industry	market-month	firm	firm-month

Figure A1: Average carbon price, tax and revenue

The left panel plots the average global carbon price and carbon tax among those that have adopted corresponding policies over time on solid and dashed line respectively. The right panel plots the average revenue collected from Emission Trading System (ETS) and carbon tax over time in solid and dashed line respectively.

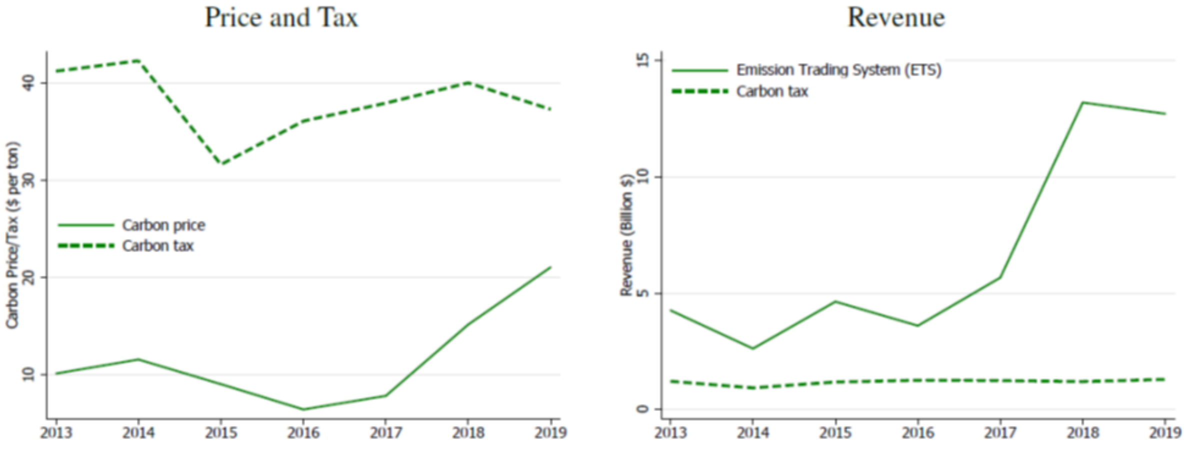

Table A1: Variable definitions

Variable	Definition	Source
Bond-level		Eikon
LCF	A dummy that equals 1 for local currency issuance in foreign market	Eikon
Green	A dummy that equals 1 for green bonds	Eikon
Size	The amount of issuance in USD	Eikon
Tenor	The number of years between the issuance and maturity date	Eikon
Coupon	The coupon rate in %	Eikon
Firm-level		
ESG	A dummy variable that equals 1 for if a firm's ESG measure is above the sample median	
ESG score	Overall scores on environmental (E), social responsibility (S) and governance (G)	Eikon
Emissions	Commitment and effectiveness towards reducing environmental emissions in its production and operational processes	Eikon
Resource Use	Capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management	Eikon
Innovation	Capacity to reduce the environmental costs, and create new market opportunities through new technologies or eco-designed products	Eikon
Community	Commitment to being a good citizen, protecting public health and respecting business ethics	Eikon
Workforce	Effectiveness in providing job satisfaction, a healthy and safe workplace, maintaining diversity and equal and development opportunities	Eikon
Product Responsibility	Capacity to produce quality goods and services, integrating the customer's health and safety, integrity and data privacy	Eikon
Human Rights	Effectiveness in respecting fundamental human rights conventions	Eikon
Management	Commitment and effectiveness towards following best practice corporate governance principles	Eikon
Shareholders	Effectiveness towards equal treatment of shareholders and the use of anti-takeover devices	Eikon
CSR Strategy	Practices to integrate economic (financial), social and environmental dimensions into its day-to-day decision-making processes	Eikon
Fun	A dummy that equals 1 if the financial fundamental is above the sample median	
Listed	A dummy that equals 1 for publicly listed firms	ORBIS
Market cap	Total market capitalization in USD	ORBIS
Total assets	Total assets in USD	ORBIS
ROE	Return on Equity, calculated by the net income divided by shareholder's equity	ORBIS
Profit margin	Net income divided by total revenue	
Leverage	The ratio of debt to total assets	ORBIS

Table A1: Variable definitions (continued)

Variable	Definition	Source
Market-level		
CP	Logarithm of 1 plus carbon price in USD per ton	World Bank
CT	Logarithm of 1 plus carbon tax in USD per ton	World Bank
Currency appreciation	The growth rate of currency appreciation	World Bank
CA surplus	Current account surplus divided by GDP	World Bank
Reserve	International reserve divided by GDP	World Bank
IT	A dummy that equals 1 for inflation targeting	Aizenman et al. (2021)
FX Regime	A dummy that equals 1 for fixed or pegged foreign exchange regime	Ilzetzki, Reinhart, and Rogoff (2019)
Climate Change	Adjusted growth rate of greenhouse gas emission	EPI
Ecosystem Services	Preservation of trees, grassland, and wetland	EPI
Biodiversity	Biodiversity and species habitat	EPI
Fisheries	Status of fish stock and marine trophic level	EPI
Agriculture	Sustainable Nitrogen Management	EPI
Water Resources	Wastewater treatment	EPI
Pollution emission	Adjusted growth rate of SO2 and Nox	EPI
Air Quality	Exposure to PM 2.5, Ozone, and solid fuels	EPI
Sanitation	Sanitation & Drinking Water safety	EPI
Heavy Metals	Lead exposure	EPI
Waste Management	Controlled solid waste	EPI
Environmental Health	Achieving the policy objective of environmental health	EPI
Ecosystem Vitality	Achieving the policy objective of ecosystem vitality	EPI

Table A3: List of markets with ETS and carbon tax initiative

Only ETS		Both ETS and Carbon Tax			Only Carbon Tax
Italy	Australia	Sweden	Japan	Denmark	Colombia
China	New Zealand	United Kingdom	Spain	Switzerland	Mexico
United States	Poland	Canada	Slovenia	Ireland	Singapore
Germany	Greece	Norway	Portugal	Liechtenstein	Chile
Belgium	Ireland	France	Finland	Latvia	South Africa
Austria	Liechtenstein				Argentina
Korea	Latvia				