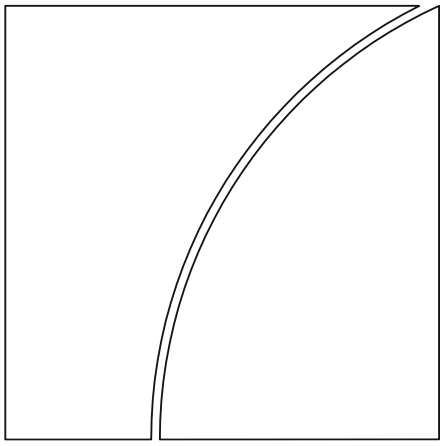

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Monetary and Economic Department

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Sovereign green bonds: a catalyst for sustainable debt market development?[1]

Gong Cheng[2] Torsten Ehlers[3] Frank Packer[4] Yanzhe Xiao[5]

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Abstract: *In traditional bond markets, sovereign bonds provide benchmarks and serve as catalysts for corporate bond market development. Contrary to the usual sequence of bond market development, sovereign issuers are latecomers to sustainable bond markets. Yet, our empirical study finds that sovereign green bond issuance can have quantitative and qualitative benefits for the development of private sustainable bond markets. Our results suggest that both the number and the size of corporate green bond issuance increase more in a jurisdiction after the sovereign debut. The results are more pronounced in countries with stronger climate policies. Sovereign green bond issuance also improves the quality of green verification standards in the corporate bond market more generally, consistent with the aim of fostering third-party reviews and promoting best practice in green reporting and verification. Finally, our work provides evidence that the sovereign debut increases liquidity and diminishes yield spreads of corporate green bonds in the same jurisdiction.*

Keywords: *Green bonds, sustainable bonds, sovereign debt, taxonomies, green verification, bond market development*

JEL classification: *H63, O16, Q01, Q50.*

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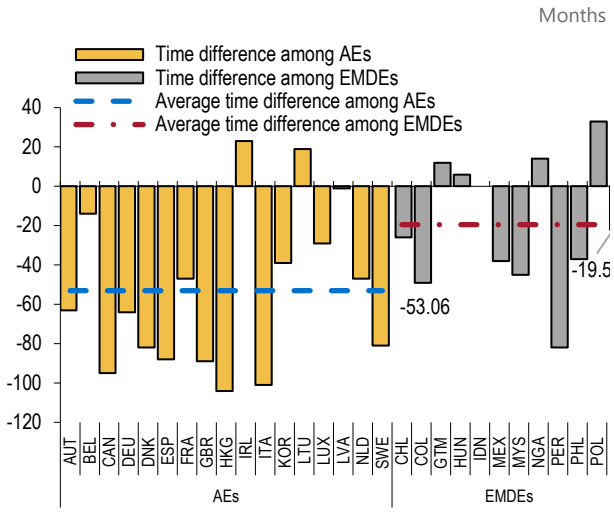
1 Introduction

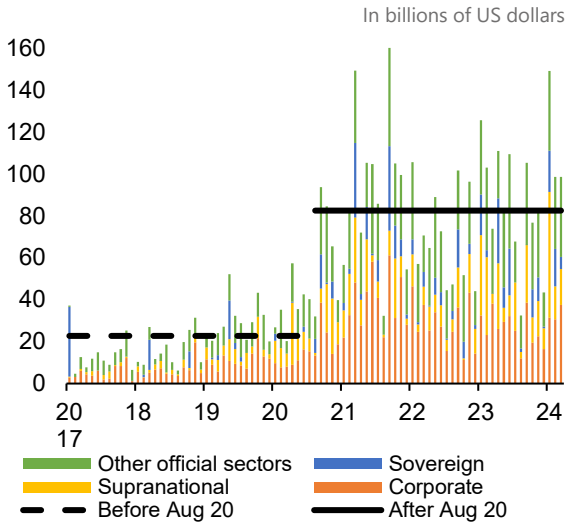
Sustainable bond markets, largely driven by green bond issuance, have grown rapidly in recent years.[6] But contrary to the typical sequence of bond market development, sovereign issuers in most countries entered the sustainable bond market only after other issuers, including corporates (Graph 1 and IMF (2022)). One rationale put forward by policy makers for the issuance of green sovereign bonds has been to foster the development of a market for sustainable bonds with the purpose of deepening the sources of financing for the climate transition. The main research question of this paper is whether sovereign issuance has indeed helped to further develop sustainable bond markets – an issue that, to the best of our knowledge, has not been scrutinized in the literature thus far.

The sustainable bond market — Graph 1

Lag between first corporate sustainable bond issuance and sovereign sustainable bond issuance



Monthly gross issuance, by issuer type



Note: In panel 1, time difference means time between start of sovereign and corporate green issuance. Negative value indicates start of sovereign post-dated corporate green issuance. Panels use International Organization for Standardization (ISO) country codes. Countries include (in the order of appearance) Austria, Belgium, Canada, Germany, Denmark, Spain, France, United Kingdom, Hong Kong, Ireland, Italy, South Korea, Lithuania, Luxembourg, Latvia, Netherlands, Sweden, Chile, Colombia, Guatemala, Hungary, Indonesia, Mexico, Malaysia, Nigeria, Peru, Philippines, Poland, Thailand. AE = advanced economy; EMDE = emerging market and developing economy. In panel 2, the key drivers of this breakup were the generous fiscal support provided in response to the Covid-19 pandemic as well as governments' expanding climate ambitions. "Corporate" includes both financial and non-financial institutions; "Other official sectors" includes bonds issued by agencies and local authorities, as well as covered bonds; "Sovereign" includes bonds issued by central governments.

Source: Bloomberg L.P., and the authors' calculations.

Traditionally, the sequence of development of bond markets in local jurisdictions, in particular in the emerging East Asian economies in the 1990s and early 2000s, was for sovereign issuance to be the principal and earliest venue for developing the bond market (Rethel and Sinclair (2014), IMF (2002)). In part, this was due to the desire to finance fiscal deficits (Turner (2002)). Another motivation was to pave the way for

[6] Sustainable bond markets consist on the one hand of "use of proceeds" bonds, which include green, social and sustainability bonds. The proceeds from the sale of these bonds are earmarked for climate and environmental projects in the case of green bonds; projects related to health and education, affordable housing or food security for social bonds; and a mixture of green and social projects in the case of sustainability bonds. A second type is "outcome-based" bonds, which currently includes sustainability-linked bonds. Typically, the coupon payment for these bonds increases if contractually specified sustainability performance targets are not met.

corporate issuers. Bond markets can provide long-term financing at competitive costs and allow the credit risks to be diversified across a broad range of investors – rather than just banks in the case of bank loans – and thereby act as a "spare tire" in case of problems in the banking sector (Laeven (2014), Batten and Kim (2000)).

The empirical literature on bond market development indeed suggests a positive impact of sovereign issuance on a nation's corporate bond market. Yuan (2005) finds that sovereign bonds can make corporate bond markets more complete, improve the information content in prices and increase liquidity in bond markets more generally. Dittmar and Yuan (2008) analyse the impact of the issuance of emerging market sovereign bonds on corporate bonds and find that corporate yields and bid-ask spreads narrow in response. They argue that "sovereign securities act as benchmarks and […] promote a vibrant corporate bond market." Flannery et al (2019) look at the issuance of sovereign bonds in China and similarly find that corporate bonds experienced a decline in yield spreads, bid-ask spreads and price volatility subsequent to sovereign issuance.

The benefits of sovereign issuance for other issuers may also be seen in sustainable bond markets, though the channels are likely to be different given the specificities of sustainable debt instruments. Green and other use-of-proceeds sustainable bonds differ from regular "plain-vanilla" bonds solely by the label that certifies that the funds raised will be invested in sustainable activities (Ehlers and Packer (2017)). Within the broader bond market, sustainable bonds can therefore be seen as a new innovative *segment* with the specific purpose of supporting the financing of sustainable activities (Ando et al (2022), Doronzo et al (2021)). As mentioned above, green sovereign bonds have, thus far, exclusively been issued in jurisdictions where sustainable bond market by other issuers had already occurred. Given that sovereign sustainable bond issuance in all jurisdictions is dwarfed by the scale of already developed conventional sovereign bond markets, the relevant impact of such sovereign issuance is most likely to be felt in the already outstanding sustainable bond segment.[7]

In the case of green bonds, sovereign issuance could have at least three types of non-mutually exclusive benefits for corporate sustainable bonds. First, it could result in an **increase in the size** of the corporate sustainable bond market, ie sovereign issuance could expand the market for other green bonds. This could for instance be due to a demonstration effect whereby sovereign bond issuance raises awareness and stimulates investor appetite, thereby opening up opportunities for other local issuers. Further, sovereign green bond issuance can signal a strong commitment of the government to green policies, which could entice firms to seek more green financing and prompt investors to shift towards green investment instruments.

In addition, sovereign issuance itself has in recent years contributed to a significant share of sustainable bond issuance (Cheng et al (2022)). Once bond markets reach a critical size, they become more attractive for issuers and investors alike (McCauley and Remolona (2000)). That said, additional sovereign issuance may, however, also have the opposite effect, as it can crowd out other issuers if the demand for sustainable bonds does not increase commensurately (Dittmar and Yuan (2008)). The rapid growth in sustainable bond markets and a small but persistent yield discount for green bonds – often called "greenium" – suggest, however, that demand

[7] Because the creditworthiness of any sovereign's green bonds should be identical as its conventional sovereign bonds, given the identical legal structure governing payment of interest and principal including in the event of default, macroeconomic and institutional factors which affect the trajectory of bond market development more generally (Aman et al (2019), Burger et al (2012), Claessens et al (2007)), are unlikely to distinguish sovereign sustainable bonds from their conventional counterparts.

has been consistently outstripping supply in the market as a whole (Ando et al (2023), Caramichael and Rapp (2022), Zerbib (2019)). One question examined in this paper is whether sovereign bond issuance *per se* has had a significant *additional* effect on the *overall* growth of sustainable bond markets, beyond its simple additive contribution.

Secondly, sovereign green bond issuance can also have benefits for the green corporate bond market by **improving green reporting and verification**. Some previous works have focused on this particular dimension of sustainable bond market development (See Ehlers and Packer (2017), NGFS (2022), IMF GFSR (2022), Aramonte and Packer (2022)). In practice, sovereign green bond issues have adhered to the strictest sustainability reporting and verification methods prevalent at the time of issuance. This stands in contrast to some private green bond issues which have faced allegations of "greenwashing" – the appearance of non-existent sustainability benefits. As reporting and verification is crucial for the signalling value of green bond labels, sovereign bond issuance characterised by strict standards of reporting and verification could set a positive example for corporate and other issues and help to combat perceptions of widespread greenwashing.

A third potential benefit of sovereign green bond issuance—one that is related to both the above-mentioned size and reporting/verification effects—is **improvement in the pricing and liquidity** of sustainable bond markets. Analogous to the case of regular sovereign bonds (Dittmar and Yuan (2008), Yuan (2005)), green sovereign bonds could make the market for sustainable bonds more complete and reduce information asymmetries, which, in turn, could narrow bid-ask spreads and reduce yields for green bonds of private issuers. Sovereign green bonds can also serve as a benchmark for pricing, making it easier for investors to price green corporate bonds and further improve liquidity in such bonds.

To analyse the potential benefits of sovereign green bond issuances on corporate sustainable bonds, we have constructed a comprehensive database of labelled bonds issued by sovereign governments and corporations. The database includes both the variables pertaining to the size of labelled bonds, and also to those variables related to the quality of reporting and verification of green and other labelled bonds. We also include information on the strength of countries' climate policies and their vulnerability to environmental disasters. Our empirical analyses have also been complemented by interviews we conducted with selected sovereign green bond issuers, drawing on their insights on how sovereign green bonds can enhance market development.

Our empirical results suggest that there are indeed benefits of sovereign green bond issuance for the development of sustainable bond markets. First, sovereign green issuance is associated with a greater increase in the size of the market for corporate sustainable bonds – both in the number and the volume of corporate green bond issuance. The results are more pronounced in countries with stronger climate policies. Second, sovereign green bond issuance improves the quality of green disclosure and verification standards in the market more generally, consistent with fostering a culture of using third-party reviews and promoting best practices in green reporting and verification. Leading by example, all sovereigns published frameworks for sustainable bond issuance and committed to allocation/impact reporting and post-issuance external review. Our empirical study indicates that after the sovereign debut, more corporate issuers tended to use green verification than earlier. Finally, our work provides new evidence on the impact of sovereign green bond issuance on market liquidity and pricing. The event study evidence is consistent with the hypothesis that the sovereign debut increases liquidity and diminishes the yield spreads of corporate green bonds.

The rest of this paper is organized as follows. Section 2 presents the database and the empirical strategy. Section 3 describes our results. Section 4 discusses policy implications and concludes. An appendix provides technical details and additional results and robustness checks.

2 Data and methodology

We focus on green bonds in our empirical analysis, as other types of sustainable bonds remain rare in the sovereign space. As there are no binding international standards for green bonds, the identification of these securities varies across data providers. We base our analysis on data from Bloomberg, which has a well-developed methodology for tagging bonds with a green label.

A key identifying characteristic of green bonds, which most financial data providers utilize including Bloomberg, is the adherence to the voluntary Green Bond Principles (GBPs) established by the International Capital Markets Association (ICMA). The key feature of the GBPs, and at the same time the only distinguishing feature vis-a-vis a regular bond without a green label, is the use of proceeds from issuing a green bond for "eligible green projects". While there is no detailed list of eligible green projects in the GBPs, the broadly defined categories for projects provided by ICMA include investments in the area of renewable energy, energy efficiency, clean transportation, green buildings, biodiversity, water management, the circular economy as well as climate adaptation.

Apart from the use of proceeds for eligible green projects, the GBPs have three more core components. One component is that issuers have a process for project evaluation and selection in place. Another is that the proceeds should be managed appropriately. Finally, issuers should provide reports on the use of proceeds on an annual basis. The GBPs further recommend that issuers appoint an external review provider to provide a pre-issuance assessment on whether a bond fulfils the key components of the GBPs.

As the components of the GBPs are recommendations and not strictly required, most data providers allow some leeway in classifying a given bond as green. In the case of Bloomberg, green bonds need to necessarily fulfil the principle of use of proceeds for eligible green projects. The other three GBPs, however, do not necessarily have to be fulfilled. Hence, our dataset includes green bonds which do not have external reviews and green bonds that do not provide regular allocation reports or details on project selection and the management of proceeds.

Other taxonomies and standards have emerged, which build on the GBPs but lay out more concrete and stricter obligation for the issuer. A private sector standard that has been around for some time is the Climate Bonds Standard by the Climate Bonds Initiative. The European Union has recently established an official standard, the EU Green Bond Standard. Bonds that adhere to these stricter requirements are naturally also included in our dataset.

2.1 Data

We use green bond issuance data from Bloomberg and country climate vulnerability and climate policy indices from other sources (Table 1). Subsequently, we merge issuance data with pricing data, in order to examine the impact of sovereign green bond debuts on the liquidity and pricing of corporate green bonds.

2.1.1 Green bond issuance data and external review data

We aggregate the issuance data into quarterly intervals by jurisdiction. The aggregated sample comprises a total of 2,709 corporate green bonds issuance by 63 jurisdictions, including time frame from 2012 Q1 to 2022 Q3. Table 1 provides a description of our key variables.

A key variable in our analysis is the date of the first issuance of a sovereign green bond. The dates and the samples for the various analyses in section 3 are provided in Table A.1 in the appendix.

Table 1. Description of key issuance analysis variables (quarterly frequency)

Variable	Description	Source
A. Dependent variables		
Number of issuance	Number of corporate green bond issues.	Bloomberg L.P.
Share of green bond issuance	Size of corporate green bonds issuance relative to total bond issuance in percentage points –in US dollars using the FX rate at issuance where necessary.	Bloomberg L.P.; Dealogic
Share of verified green bonds	Number of corporate green bond verified by ESG assurance providers relative to total number of corporate green bonds in percentage points – in percentage points	Bloomberg L.P.
B. Explanatory variables: Sovereign debut and global trends on bond market		
Sovereign debut	Dummy equal to one in or after the first sovereign green bond has been issued.	Author's calculation
Log(Cumulative green bond issuance)	Log of cumulative amount of total green bond issuance – in log US dollars.	Bloomberg L.P.
C. Explanatory variables: Country climate vulnerability and climate policy indices		
Vulnerability score	Score measures a country's exposure, sensitivity, and ability to adapt to the negative impact of climate change. Lower scores are better. Values from 0 to 1.	ND-GAIN
Climate change performance index	Index evaluates a country's climate protection policy performance. Higher scores are better. Values from 0 to 100.	Germanwatch

2.1.2 Liquidity and yield data

To provide a more detailed understanding of the influence of a sovereign debut in the green bond market on bond pricing, we conduct an analysis using daily bid-ask spread data for corporate green bonds, alongside the pairing of corporate green bond yields with those of equivalent-maturity government conventional bonds.

To facilitate this calculation, we initially acquired government bond yield data from Bloomberg. We then construct a daily yield curve through linear interpolation or extrapolation, covering maturities ranging from 0 to the maximum maturity found within the government bond yield data of each jurisdiction. The linear extrapolation

method is utilized when the minimum maturity within the government yield data exceeds 0. But we do not extrapolate the yield curve for maturities beyond the maximum maturity observed in the government yield data for any given jurisdiction.

We align the daily government yield data with corporate green bond yield data based on their remaining maturity and then calculate the yield spread as the difference between corporate green bond yields and the interpolated government conventional bond yield in a given jurisdiction. When the remaining maturity exceeds the maximum maturity in the government yield curve, we apply the government yields corresponding to the maximum maturity. In this fashion, we construct a price database that includes both daily corporate green bond bid-ask spread and calculated yield spreads.

Following the construction of the corporate green bond liquidity and yield dataset, we employ an event study methodology to test our hypotheses concerning the impact of sovereign issuance. Each debut issuance of a sovereign green bond is considered as an independent event. First, we identify the issue date of each sovereign green bond for jurisdictions that already have outstanding corporate bonds. This allows us to anchor the corporate green bond liquidity and yield data within a window spanning from six weeks before to six weeks after the sovereign green bond's issue date. To further analyze the impact of sovereign green debut. we also introduce a new variable—the *sovereign greenium,* defined as the sovereign conventional bond yield minus the sovereign green bond yield at the issue date. Additionally, we construct a sample of subsequent sovereign green bond issues (after the debut) to see if the effect of sovereign green bond issuance is limited to the debut only. The final dataset comprises daily green bond liquidity and yield data, involving 14 jurisdictions with 851 green bond issues (both debut and subsequent). Table 2 provides a description of our key variables for the liquidity and yield analysis.

Table 2. Description of key liquidity and yield analysis variables (daily frequency)

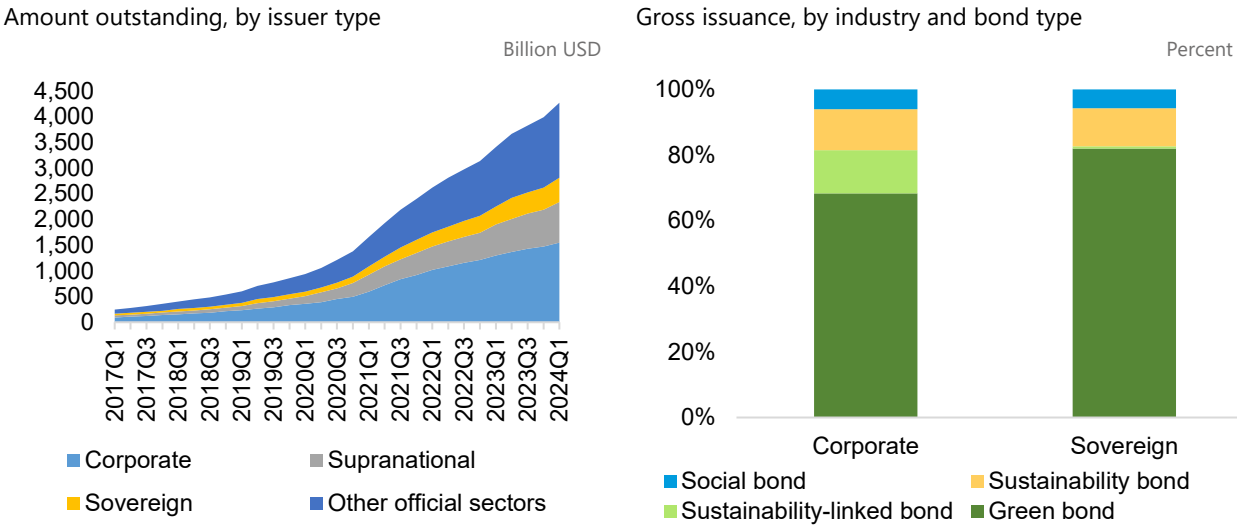
Variable	Description	Source
A. Dependent variables		
Bid ask spread	Spread between corporate green bond bid yield and ask yield in percentage points.	Bloomberg L.P.
Yield spread	Spread defined as corporate green bond yield minus government conventional bond yield in percentage points.	Bloomberg L.P.
B. Explanatory variables: Sovereign issue and country bond market		
Sovereign debut	Dummy equal to one for periods occurring after the initial issuance of sovereign green bond.	Bloomberg L.P.
Subsequent issue	Dummy equal to one for periods occurring after the issuance of each sovereign green bond, excluding the debut issuance.	Bloomberg L.P.
Greenium at issue	Spread defined as sovereign conventional bond yield minus sovereign green bond yield at issue date in percentage points.	Bloomberg L.P.

2.2 Stylised facts

Since 2017, the size of the sustainable bond market has ballooned from $246 billion outstanding to around $4.3 trillion as of Q1 2024 – a more than 17-fold increase over a period of 7 years (Graph 2, left panel). In particular, the market experienced a substantial growth during the pandemic, as evidenced in the quarterly issuance trends. In early 2021, both the quarterly issuance number and amount hit the record highs of 848 and $282 billion, respectively . Even though the momentum has since plateaued and even gradually declined, the overall pace of issuances is still notably higher than seen pre-pandemic.

Green bonds, which is the type of sustainable bond that developed first, constitute by far the largest part of the sustainable bond market (Graph 2, right-hand panel). For sovereign issuers, other types of sustainable bonds remain rare.

Sustainable bond market: outstanding amounts and maturity structure — Graph 2



Note: "Corporate" includes both financial and non-financial institutions; "Other official sectors" includes bonds issued by agencies and local authorities, as well as covered bonds; "Sovereign" includes bonds issued by central governments. Amount outstanding is calculated using total cumulative issuance minus cumulative amount matured as of a given year quarter. For explanation of bond types in right panel, see footnote 6 on page 2.

Source: Bloomberg L.P.; authors' calculations.

Underlying these trends is a notable shift in the composition of issuers, away from corporates towards the official sector including sovereigns. While the corporate sector still plays a dominant role in the market, its overall share has declined markedly over the years. The rapid rise in the non-corporate sector started in the pandemic, driven by the official sector. Both sovereigns and even more so other official sector issuers (such as sub-sovereigns and agencies) now account for about 45% of the amount outstanding and more than half of the issuance volume since the pandemic.

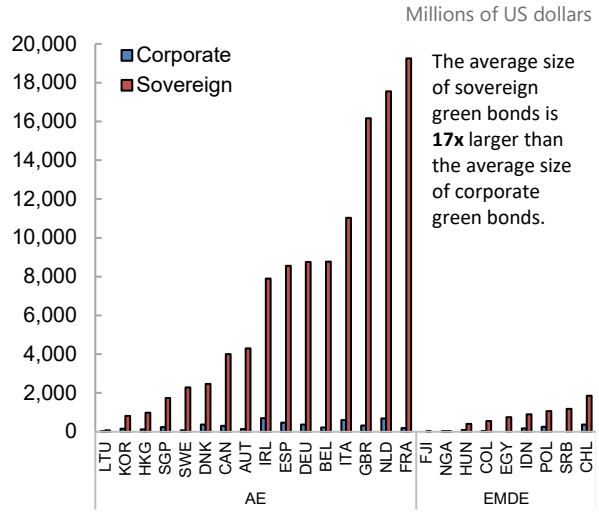
Sovereign green bond issuance has tended to be of very large size, increasing the likelihood that they serve as benchmarks for the corporate green bond market. In all countries which have issued sovereign green bonds, the average issuance size is more than 10 times larger than the average historical issuance size of corporate green bonds in the same market (Graph 3, left-hand panel). Further, the great majority of sovereign green bond issuance has been in local currency and local markets (Graph

3, right-hand panel). In our sample, 11 out of 14 green sovereign bond debuts were in local currency.

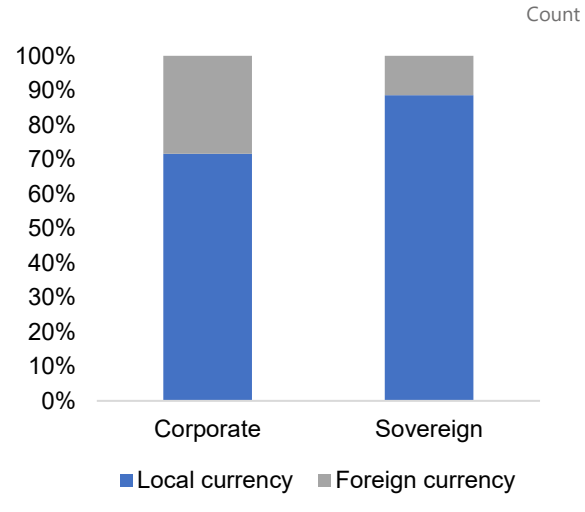
Green bond market: average size and currency

Graph 3

Average size of green bond issuance



Gross issuance (converted into USD) of green bonds by issuer and currency type



Note: In panel 1, only countries issued sovereign green bond are included. Panels use International Organization for Standardization (ISO) country codes. Countries include (in the order of appearance) Lithuania, Republic of Korea, Hong Kong SAR, Singapore, Sweden, Denmark, Canada, Austria, Ireland, Spain, Germany, Belgium, Italy, United Kingdom, The Netherlands, France, Fiji, Nigeria, Hungary, Colombia, Egypt, Indonesia, Poland, Serbia, and Chile. AE = advanced economy; EMDE = emerging market and developing economy.

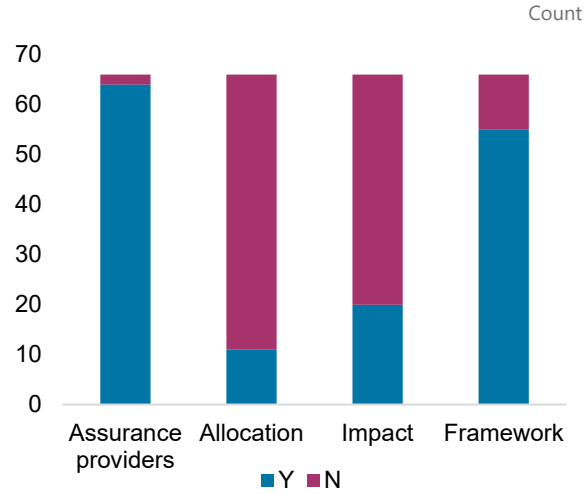
Source: Bloomberg L.P.; authors' calculations.

Looking at the maturity structure of the sustainable bond market, the overwhelming majority of the bonds were issued within the maturities of 3-7 years and 7-15 years, with a roughly even split between the two. Despite the corporate sector having increased their issuance tenors in recent years, it still makes up a large portion of the shorter end of the maturity segment, with 49% of corporate sustainable bonds having a maturity of less than seven years. But for sovereign issuers, nearly 60% of their issuances are longer than 15 years.

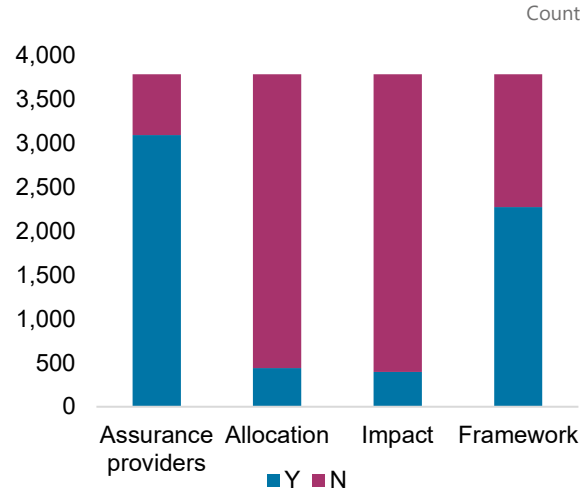
As regards green verification, over 85% of green bonds (both sovereign and corporate) have external reviews, as indicated by the assurance provider category depicted in the graph below (Graph 4). Sovereign green bond issuance stands out in terms of the extent of its reliance on external reviews. Almost all sovereign issuers solicit at least one, and often a variety of external review service providers, building trust among investors and ensuring that the capital raised through these bonds is genuinely contributing to sustainability objectives. The comprehensiveness and the rigorousness of the external review, which can help the issuer demonstrate its commitment to transparency and accountability, still varies elsewhere. Over 70% of green bonds come with an issuance framework. An issuance framework sets out the sustainability-related requirements for a given issuer, including reporting requirements. And only around 10% of green bonds come with an impact assessment, which provides another level of assurance that green bonds do achieve environmental benefits. Specifically, the commitment to impact and allocation reporting are still scant among private issuers.

Green bond external reviews Graph 4

Sovereign bonds, number of issues by review category



Corporate bonds, number of issues, review category



Note: Y indicates number of bonds that have included given review category, N indicate number of bonds that have not included given review category. Assurance providers shows if the issuers' green bond framework or other documentation includes a statement to the effect that the issuer includes name and type of assurance provider for the green bond initiatives. Allocation indicates the availability of an allocation report detailing the current amount to the net proceeds raised through a green bond issuance deployed to eligible green bond projects. Impact indicates the availability of an impact report. Framework indicates the availability of an issuance framework.

Source: Bloomberg L.P.; authors' calculations.

2.3 Empirical strategy

We argue that a sovereign green bond debut spurs the development of green bond markets more generally. *All* countries that have decided to issue sovereign green bonds have published a clear framework stating the motives and other related technical aspects of sovereign green bond issuance including third party reviews (so-called second-party opinions or SPOs), which document the use of proceeds, as well as impact reports, which provide indicators for the environmental impact of the financed projects. The high level of reporting and verification prescribed in the issuance framework signals the country's green commitment, which in turn can incentivise private issuers to follow suit and/or increase their green bond issuance. Moreover, sovereign issuers can promote the use of third-party green reviews and set up standards for the allocation of proceeds and impact reporting, among others. Some sovereign issuers that we have interviewed for this study explicitly mentioned they expect sovereign green bonds to set the benchmark for green standards in the market, even though corporate green bonds issuance in many cases has preceded that by their governments. Finally, when sovereign issuers enter the market, they can affect the pricing and liquidity of labelled bonds.

We thus formulate and test the following three hypotheses in our empirical study:

- Hypothesis 1: The sovereign debut has a ***size effect*** on corporate green bond issuance. We empirically test whether the sovereign debut increases the

number and the share of the amount of corporate bonds issued that is green; even after controlling for existing trends.

- Hypothesis 2: The sovereign debut has a ***reporting and verification quality effect*** on corporate green bond issuance, by setting a benchmark for the use of stringent green reporting and verification mechanisms.
- Hypothesis 3: The sovereign debut improves ***the pricing and liquidity*** in the corporate green bond market.

Our primary empirical strategy consists of panel regressions with country fixed effects. Our strategy is similar to an event study with the sovereign debut used as a shock. The hypotheses 1 and 2 share the general specification, as follows:

$$Corp_{c,t} = \alpha + \beta_1 D\left(SGB\ issuance_{c,t\geq j}\right) + \beta_2 MarketTrend_{c,t-1} + \beta_3 C + \epsilon_{c,t},$$

where the dependent variable $Corp_{c,t}$ can be the number of green corporate issues or the share of issuance amount that is green (hypothesis 1), or the share of corporate green bonds having certain green verification features (hypothesis 2) in a country c at time t. The explanatory variable $D(SGB\ issuance_{c,t\geq j})$ is a dummy equal to one when a sovereign issued a green bond on date j and afterwards (hence the subindex $t \geq j$). $MarketTrend_{c,t-1}$ aims to capture the organic growth of the corporate green bond market and is proxied by a time dummy or cumulative log amount of past green bond issuance. C captures country fixed effects. The frequency of the data used in the regression analysis for the tests of the size effect, and the reporting and verification quality effect is quarterly.

We also interact the sovereign debut with climate characteristics of the issuing countries, such as countries' vulnerability to climate risks and the strength of countries' climate policies. The aim is to identify whether the effect of a sovereign green bond debut depends on a countries' climate-related risks or the strength of its climate policies.

$$Corp_{c,t} = \alpha + \beta_1 D\left(SGB\ issuance_{c,t\geq j}\right) + \beta_2 climate_{c,t} + \beta_3 D\left(SGB\ issuance_{c,t\geq j}\right) \times climate_{c,t} + \beta_4 MarketTrend_{c,t} + \beta_5 C + \epsilon_{c,t},$$

where $\mathrm{climate}_{c,t}$ captures countries' climate characteristics. We use the Climate Change Performance Index (CCPI) by Germanwatch to proxy countries' climate policy strength. And we use a sub-component of Notre Dame Global Adaptation Initiative (ND GAIN) to measure countries' climate vulnerability.

As for tests of hypothesis 3, we adopt an event study testing methodology based on Dittmar and Yuan (2008). We use daily bid-ask spreads and yields from corporate bonds of same jurisdiction taken from a -6 week to +6-week window and use it as our dependent variable. For independent variables, we include the sovereign debut dummy as before, in addition to fixed time effects (for each distinct month and year combination). For these sets of regression analysis and tests, the frequency of the data is daily.

3 Empirical results

Our empirical analysis sets out to test the three hypotheses outlined above. We concentrate on green bonds only, as the issuance of other types of sovereign sustainable bonds remains rare.

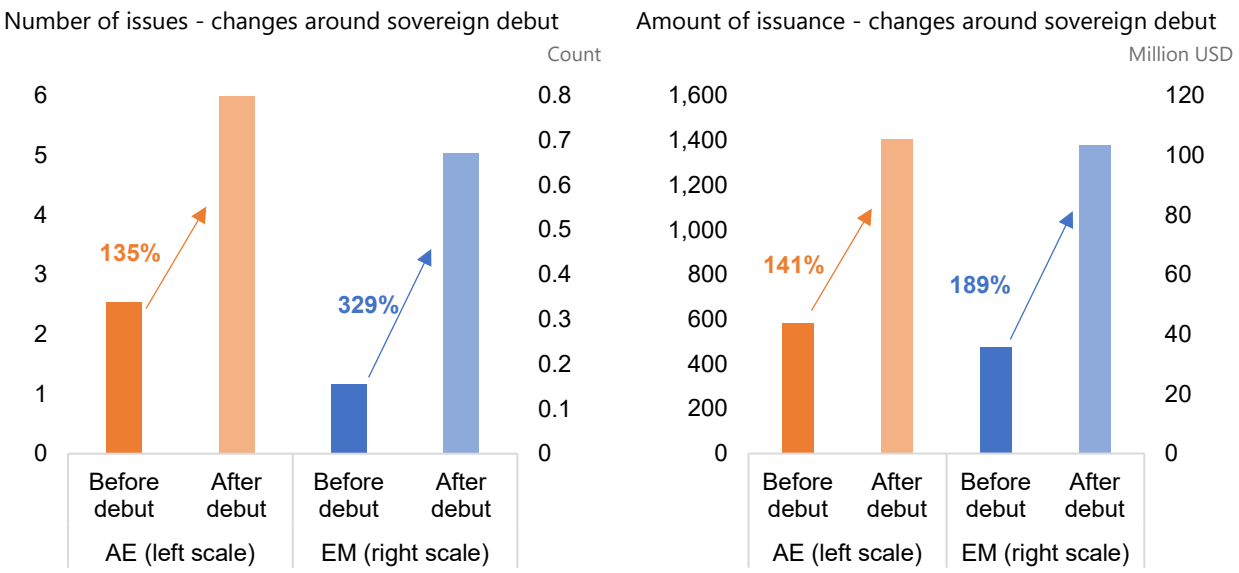
3.1 Size effect: Impact of sovereign debut on corporate green bond issuance

As shown on Graph 5, simple summary statistics of our database indicate a very large increase in the number and the issuance amount of corporate green bonds issued after the sovereign debut. The increase is much larger in emerging market economies, but from very low levels compared with advanced economies.

We run a panel regression to test whether this observation holds empirically in a more general setting, controlling for general market trends. Table 3 exhibits the regression results using the number of corporate green bond issues as a dependent variable. The coefficient β_1 associated with the sovereign debut is positive and statistically significant for both the full sample and the subsample of advanced economies. The size of the coefficient diminishes when additional control variables, or time or country dummies are included. Regression results using the subsample of emerging market economies can be found in Table A.4 in the Appendix.

Table 4 presents the regression results using the share of issuance amounts of corporate green bonds as a dependent variable. The results are broadly in line with those associated with the number of corporate bonds issued. However, the significance of the coefficient β_1 is weaker when including time dummies. This may reflect the fact that the corporate green bond market is expanding rapidly in size globally during the period we examine, making it difficult to identify any additional effect of sovereign green bond issuance in a given country.

Impact of sovereign debut on corporate green bond issuance — Graph 5



Source: Bloomberg L.P.; and the authors' calculations.

Impact of sovereign debut on the number of corporate green bonds issued (share of total)

Table 3

Whole sample					Advanced economies				
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
Sovereign debut	2.899***	1.707***	0.777***	0.801***	Sovereign debut	4.904***	3.772***	1.796***	1.736***
	(0.000)	(0.000)	(0.006)	(0.005)		(0.000)	(0.000)	(0.000)	(0.000)
Cumulative log green bond issuance (t-1)		0.0845***	0.0139	0.00007	Cumulative log green bond issuance (t-1)		0.0959***	-0.0306	-0.0480**
		(0.000)	(0.207)	(0.995)			(0.000)	(0.143)	(0.024)
Constant	1.074***	0.279***	-2.43e-14	1.04e-14	Constant	1.622***	0.401*	-1.16e-13	6.66e-15
	(0.001)	(0.006)	(1.000)	(1.000)		(0.007)	(0.056)	(1.000)	(1.000)
Obs	2709	2709	2709	2709	Obs	1161	1161	1161	1161
Country dummy	No	Yes	No	Yes	Country dummy	No	Yes	No	Yes
Time dummy	No	No	Yes	Yes	Time dummy	No	No	Yes	Yes
r2_w	0.0458	0.0871	0.143	0.144	r2_w	0.102	0.142	0.244	0.245
r2_o	0.0293	0.126	0.108	0.0961	r2_o	0.0825	0.163	0.152	0.140
r2_b	0.00632	0.252	0.121	0.00660	r2_b	0.0470	0.237	0.00944	0.0658

Note: r2_w refers to the R-squared within each group or individual; r2_o means the overall R-squared; r2_b shows R-squared between different groups or individuals. The dependent variable is the share of the total amount of corporate issuance in the jurisdiction that is green.

We further examine whether country characteristics pertaining to the strength of climate policy and climate vulnerability affect the catalytic effect of sovereign green bonds. We interact the sovereign debut with countries' climate policy performance and their climate vulnerability. Graph 6 shows that the marginal effect of sovereign debut strengthens with the strength of countries' climate policy. The stronger a country's climate policy, as measured by CCPI, the larger the impact of sovereign debut on the number of corporate green bonds issued. This is in line with a positive signalling effect of green bond issuance, which increases in strength if government have stronger climate policies. Analogously, corporates are more likely to issue more green bonds after the sovereign debut in countries that are less exposed to climate risks.

Graph A1, reported in the appendix, reproduces the conditional marginal effects, but when the issuance amount of corporate green bonds is used as the dependent variable. Here, the marginal effect of the issuance size does not seem to vary statistically significantly with countries' climate conditions.

Impact of sovereign debut on the amount of corporate green bonds issued

Table 4

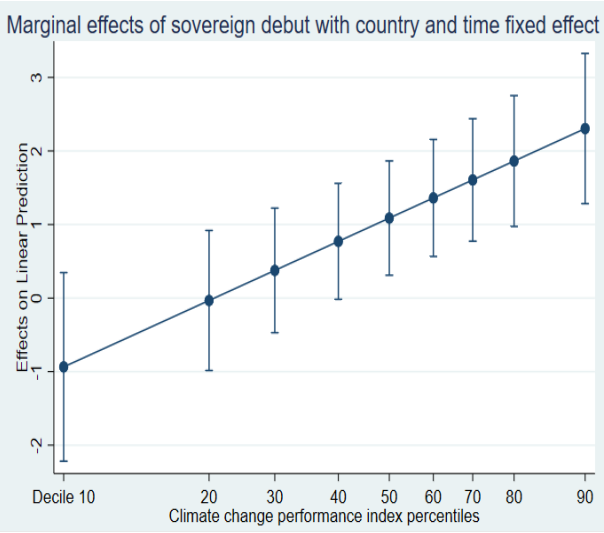
Whole sample					Advanced economies				
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
Sovereign debut	4.164***	2.930***	1.002	1.072	Sovereign debut	5.315***	4.028***	1.142	0.858
	(0.000)	(0.001)	(0.240)	(0.264)		(0.000)	(0.000)	(0.196)	(0.394)
Cumulative log green bond issuance (t-1)		0.132***	0.0226	0.00454	Cumulative log green bond issuance (t-1)		0.168***	0.0221	0.0910**
		(0.000)	(0.464)	(0.905)			(0.000)	(0.535)	(0.041)
Constant	1.441***	0.135	-4.48e-13	8.44e-15	Constant	1.441***	-0.774*	-6.80e-14	-1.33e-15
	(0.000)	(0.686)	(1.000)	(1.000)		(0.000)	(0.077)	(1.000)	(1.000)
Obs	2709	2709	2709	2709	Obs	1161	1161	1161	1161
Country dummy	No	Yes	No	Yes	Country dummy	No	Yes	No	Yes
Time dummy	No	No	Yes	Yes	Time dummy	No	No	Yes	Yes
r2_w	0.0122	0.0220	0.0560	0.0561	r2_w	0.0382	0.0689	0.171	0.173
r2_o	0.00984	0.0200	0.0544	0.0541	r2_o	0.0348	0.0495	0.165	0.160
r2_b	0.00547	0.0238	0.0194	0.00861	r2_b	0.0518	0.00511	0.00234	0.0350

Note: r2_w refers to the R-squared within each group or individual; r2_o means the overall R-squared; r2_b shows R-squared between different groups or individuals.

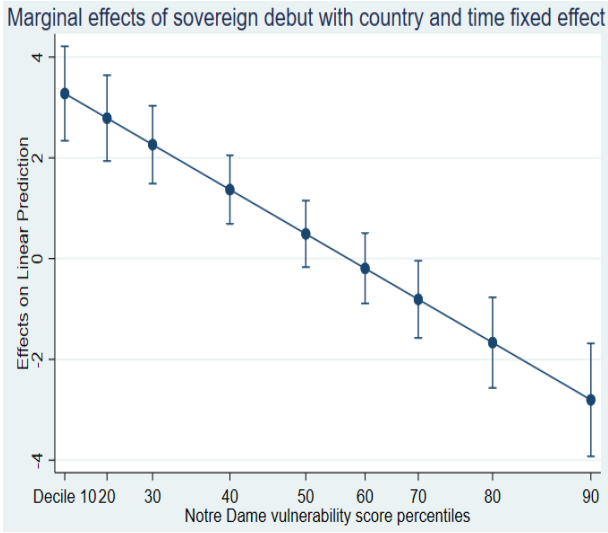
The marginal effect varies conditional on countries' climate policy or vulnerability

Graph 6

Bigger effect when climate policy performance is stronger…



… or climate vulnerability is less severe



Note: The values indicate how the marginal effect of sovereign debut on number of corporate green bond issued varies with climate change performance index or vulnerability, while controlling for cumulative log green bond issuance, country, and time fixed effects. The bands indicate the 95% confidence intervals around the estimated marginal effect.

3.2 Reporting and verification quality effect: Impact of sovereign debut on the green verification of corporate bond issuance

Turning to the reporting and verification quality effect of the sovereign debut on corporate green bonds, Table 5 presents the regression results of the impact of the sovereign debut on the use of green verification by corporate green bond issuers. A larger share of corporate green bonds issued after the sovereign debut have used green verification, either in the form of second party opinion or green bond certification. This result holds when we use different definitions of green verification. However, this result is weakened statistically once time dummy is controlled for.

As robustness checks, we have conducted our empirical tests using alternative definitions of green verification: second-party opinions, green certifications, audits, and others. In addition to Bloomberg data, we have also used data from Climate Bond Initiative. But the results remain similar.

Impact of sovereign debut on green verification of corporate green bonds issued — Table 5

Whole sample					Advanced economies				
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
Sovereign debut	34.44***	35.01***	4.014	3.623	Sovereign debut	42.82***	43.26***	-1.974	-2.949
	(0.000)	(0.000)	(0.123)	(0.171)		(0.000)	(0.000)	(0.632)	(0.481)
Constant	17.94***	17.89***	-3.87e-12	1.39e-13	Constant	28.43***	28.38***	-3.19e-12	1.63e-13
	(0.000)	(0.000)	(1.000)	(1.000)		(0.000)	(0.000)	(1.000)	(1.000)
Obs	2709	2709	2709	2709	Obs	1161	1161	1161	1161
Country dummy	No	Yes	No	Yes	Country dummy	No	Yes	No	Yes
Time dummy	No	No	Yes	Yes	Time dummy	No	No	Yes	Yes
r2_w	0.0647	0.0647	0.266	0.266	r2_w	0.0827	0.0827	0.398	0.398
r2_o	0.0503	0.0503	0.208	0.208	r2_o	0.0763	0.0763	0.323	0.322
r2_b	0.0192	0.0192	0.0192	0.0192	r2_b	0.0578	0.0578	0.0578	0.0578

Note: r2_w refers to the R-squared within each group or individual; r2_o means the overall R-squared; r2_b shows R-squared between different groups or individuals.

3.3 Liquidity and pricing effect: Impact of sovereign debut on the liquidity and yields in the corporate green bond market

As discussed earlier, there is significant evidence in the existing literature that sovereign issuance in conventional markets increases liquidity and diminishes yield spreads in the corporate bond markets of the country more generally. A key theoretical argument is that benchmark government securities can make corporate bonds markets more complete, reducing adverse selection costs and improving liquidity by acting as hedging instruments (Yuan, 2005). However, there is also the theoretical counterargument that government benchmark securities can crowd out the trading of all or some of the existing securities (eg Subrahmanyam, 1991). Yet, Dittmar and Yuan (2008) find reduced liquidity premiums and decreased bid-ask spreads for corporate bonds following issuance of conventional government securities in emerging markets.

Assuming (at least partial) segmentation of conventional and green bond markets, similar arguments and counterarguments may apply to the introduction as well as subsequent issuance of sovereign green bonds. Hypothesis 3 posits that the effect found by Dittmar and Yuan (2008) in conventional markets can be documented in green markets, particularly in the case of the sovereign debut issue.

The event study testing methodology takes daily bid-ask spreads and yield spreads from corporate green bonds of same jurisdiction over a -6 week to +6 week window (ie from 6 weeks before to 6 weeks after the sovereign issue). The yield spread is defined as the corporate green bond yield minus the government conventional bond yield – ie a higher spread implies a higher green bond yield relative to the regular sovereign bond. On the right hand side, time fixed effects are included for each distinct month and year combination, as well as country fixed effects, and corporate issuer fixed events.

Tables 6 and 7 examine the impact of the sovereign green debut issuance on both liquidity, as measured by the bid-ask spread (Table 6), and pricing (Table 7), as measured by the yield spread over conventional government bonds. The empirical results for debut sovereign green issuance are generally supportive of Hypothesis 3. In Table 6, in five out of eight specifications, the sign on the sovereign debut dummy is significantly negative, indicating a statistically significant reduction in the bid-ask spreads, *ceteris paribus*. The largest estimated coefficients are consistent with a reduction in the bid-ask spread rounded up to 1 basis point. In Table 7, yield spreads are reduced subsequent to the sovereign debut event, with statistically significant coefficients, in six out of eight specifications. In these specifications, the effects range between 2 to 9 basis points.

The effect of sovereign green bond issuance on both liquidity and the yield of corporate green bonds is limited to the sovereign debut. The results are not replicated in subsequent sovereign green bond issues. This is consistent with a benchmark effect being provided by the first sovereign issuance from which corporate issuers benefit.

Impact of sovereign debut on bid ask spread of corporate green bonds issued — Table 6

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sovereign debut	-0.00902***	-0.00198***	-0.00756***	-0.00290***	0.000966	-0.00198***	0.000736	0.000966
	(0.000)	(0.000)	(0.000)	(0.004)	(0.345)	(0.000)	(0.697)	(0.345)
Obs	31255	31255	31255	31255	31255	31255	31255	31255
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Country dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.00227	0.741	0.113	0.119	0.746	0.741	0.124	0.746
r2_a	0.00224	0.739	0.112	0.119	0.744	0.739	0.122	0.744
r2_within	0.00227	0.000409	0.000664	0.000262	0.000029	0.000409	0.000005	0.000029

Note: r2_a refers to the adjusted R-squared.

Impact of sovereign debut on yield spread of corporate green bonds issued Table 7

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sovereign debut	-0.0904*** (0.000)	-0.0679*** (0.000)	0.0204 (0.613)	-0.0677*** (0.006)	-0.0232* (0.078)	-0.0679*** (0.000)	-0.0129 (0.779)	-0.0232* (0.078)
Obs	31255	31255	31255	31255	31255	31255	31255	31255
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Country dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.000422	0.922	0.0371	0.0409	0.923	0.922	0.0416	0.923
r2_a	0.000390	0.921	0.0360	0.0405	0.922	0.921	0.0402	0.922
r2_within	0.000422	0.00294	0.000008	0.000242	0.000100	0.00294	0.000002	0.000100

Note: r2_a refers to the adjusted R-squared.

A potential issue with the above estimations is that timing of the sovereign green issues might be endogenous. They could be timed to take place around the time that corporate green bonds spreads are particularly low and liquidity is particularly high, since conditions in the sovereign green space might be expected to be correlated with those in green corporate markets.

As one heuristic check whether this endogeneity might be driving the results, we estimate the regressions, but also including one additional variable we call the sovereign greenium, defined as the sovereign conventional bond yield minus the sovereign green bond yield at issuance during the issuance window. The level of the sovereign greenium can be interpreted as a measure of the relative demand for green bonds at the time of issue. If the demand for green bonds at the price of the regular sovereign bond exceeds the supply of green sovereign bonds, then the yield of green sovereign bond is lower. As a result, the greenium would be higher.

Results are reported for four specifications for both bid-ask and yield spreads in Table 8. Intuitively, the level of the sovereign greenium, ie a relatively higher demand for green sovereign bonds, is in all specifications associated with a reduction in both the bid-ask spread and the yield spread. Statistical significance is more commonly observed in the bid-ask spread regressions (3 out of 4 regressions, vs. 1 out of 4 of the yield spread regressions).

After controlling for the greenium, the coefficients and statistical significance on the sovereign debut variables are generally only marginally affected by the inclusion of this variable. In the cases of both bid-ask and yield spread regressions, the coefficient on the sovereign debut variable is statistically significant with the expected sign in three out of four specifications. Thus, inclusion of a measure of demand for green assets, which should be highly correlated with any tendency for issuance to be timed to be aligned with advantageous market conditions, does not affect the significance of the sovereign debut in increasing liquidity and reducing yields.

Another potential confounding factor in the analysis of the liquidity and price effects is the fact that some of the sovereign green bond issues are in foreign currency. Since foreign currency bonds target foreign markets and investors, the effect on the corporate bonds from domestic issuers could potentially be less strong. Our sensitivity analysis (see appendix Tables A.2 and A.3), however, suggests that the effect is either the same or even stronger for foreign currency bonds.

Impact of sovereign debut on liquidity of corporate green bonds issued interacted with the greenium

Table 8

Bid ask spread					Yield spread				
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
Sovereign debut	-0.0090***	-0.0018***	-0.0071***	0.00117	Sovereign debut	-0.0673***	-0.0666***	0.0227	-0.0222*
	(0.000)	(0.001)	(0.000)	(0.257)		(0.007)	(0.000)	(0.575)	(0.092)
Sovereign greenium at issue	-0.00077	-0.00876**	-0.0583***	-0.0288*	Sovereign greenium at issue	-1.349***	-0.0817	-0.265	-0.136
	(0.883)	(0.031)	(0.005)	(0.058)		(0.000)	(0.115)	(0.602)	(0.484)
Obs	31255	31255	31255	31255	Obs	31255	31255	31255	31255
Corporate issuer dummy	No	Yes	No	Yes	Corporate issuer dummy	No	Yes	No	Yes
Year month time dummy	No	No	Yes	Yes	Year month time dummy	No	No	Yes	Yes
r2	0.00227	0.741	0.114	0.746	r2	0.00439	0.922	0.0371	0.923
r2_a	0.00221	0.739	0.112	0.744	r2_a	0.00433	0.921	0.0360	0.922
r2_within	0.00227	0.000559	0.000912	0.000145	r2_within	0.00439	0.00302	0.000017	0.000116

Note: r2_a refers to the adjusted R-squared.

Finally, in Tables 9 and 10, the regressions for Table 6 and 7 are redone, but for the events where only subsequent sovereign issues are considered, rather than sovereign debuts. The empirical results for subsequent sovereign issuances strongly suggest that sovereign debut issues are distinctive events. Liquidity in green corporate bonds is, if anything, diminished by subsequent green sovereign bond issues, as evidenced by higher bid-ask spreads, ceteris paribus, in all 8 specifications, statistically significantly so in 6 out of 8. Meanwhile, in the yield spread regressions, post-debut sovereign green bond issues result in statistically significantly higher green bond corporate spreads in every regression.

Impact of subsequent sovereign issuance on bid ask spread of corporate green bonds

Table 9

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subsequent	0.00477***	0.00589***	0.00421**	0.00591***	0.00374**	0.00669***	0.00146	0.00126
	(0.000)	(0.000)	(0.024)	(0.000)	(0.024)	(0.000)	(0.561)	(0.468)
Obs	41496	41496	41496	41496	41496	41496	41496	41496
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Sovereign issue event dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.000357	0.500	0.0365	0.0431	0.542	0.542	0.0441	0.544
r2_a	0.000333	0.498	0.0356	0.0427	0.540	0.541	0.0430	0.541
r2_within	0.000357	0.00108	0.000123	0.000570	0.000124	0.00151	0.000008	0.000013

Note: r2_a refers to the adjusted R-squared.

Impact of subsequent sovereign issuance on yield spread of corporate green bonds issued

Table 10

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subsequent	0.119***	0.105***	0.596***	0.146***	0.158***	0.116***	0.150***	0.122***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.002)
Observations	41496	41496	41496	41496	41496	41496	41496	41496
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Sovereign issue event dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.000448	0.502	0.0701	0.134	0.522	0.522	0.135	0.523
r2_a	0.000424	0.501	0.0693	0.133	0.519	0.521	0.134	0.521
r2_within	0.000448	0.000692	0.00509	0.000772	0.000425	0.000882	0.000192	0.000230

Note: r2_a refers to the adjusted R-squared.

4 Conclusion

In this paper, we have pursued an empirical study to test systematically the catalytic effect of the sovereign debut on corporate green bond market development as alluded to in Cheng et al (2022) and IMF (2022). Our findings are three-fold. First, from a *size* perspective, the sovereign debut is associated with an increase in the number and the volume of corporate green bond issues. The stricter a country's climate policy or the less vulnerable the country is to climate risks, the stronger this catalytic effect of its sovereign debut. Second, from a reporting and verification quality perspective, sovereign issuers entering the green and labelled bond market promote best practice in terms of green verification and reporting, inducing corporate issuers to follow suit. Third, the sovereign debut issuance also affects the liquidity and pricing of the corporate green bond market. The debut is a distinctive event for the liquidity and pricing of corporate green bonds; it increases liquidity and diminishes yield spreads in the corporate green bond markets. The same impact is not observed for subsequent sovereign green bond issues after the debut.

Our empirical study shows that sovereigns' entry into the sustainable bond market can spur corporate sustainable bond market development, even when sovereigns are latecomers to the markets. Sovereigns entering the sustainable bond market help to stimulate more growth in private sustainable bond markets as well as improve market liquidity and pricing.

We also see scope for sovereign issuers to improve further market transparency, in line with the recommendations of NGFS (2022). Some jurisdictions have introduced supervisory schemes for green verification providers. To standardise or make mandatory impact reporting is another important step that might be considered in future regimes.

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6 Appendix

6.1 Sovereign green bond debut dates in data samples

Sovereign green bond debut date — Table A.1

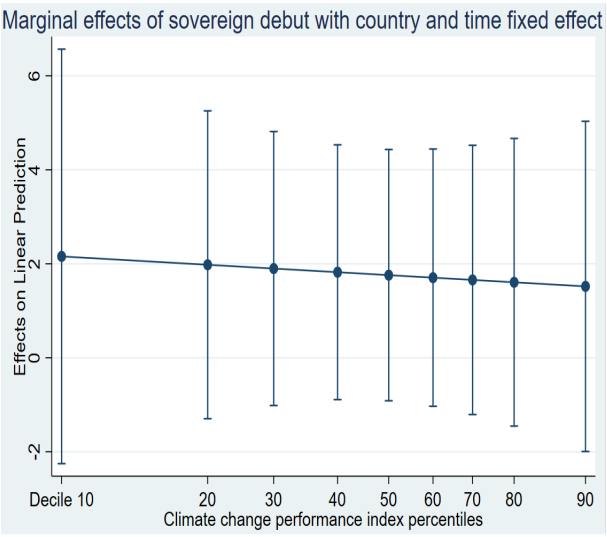
Green bond issuance data and external review data		Liquidity and yield data	
Country	First sovereign green bond issuance date as of Q3 2022	Country	First sovereign green bond issuance date as of October 2022
Poland	12/20/2016	France	1/31/2017
France	1/31/2017	Indonesia	3/1/2018
Fiji	11/1/2017	Netherlands	5/23/2019
Nigeria	12/22/2017	Chile	6/25/2019
Indonesia	3/1/2018	Germany	9/9/2020
Belgium	3/5/2018	Sweden	9/9/2020
Lithuania	5/3/2018	Italy	3/10/2021
Ireland	10/17/2018	Spain	9/14/2021
Netherlands	5/23/2019	United Kingdom	9/22/2021
Hong Kong SAR	5/28/2019	Denmark	1/21/2022
Chile	6/25/2019	Canada	3/29/2022
Hungary	6/5/2020	Austria	5/31/2022
Germany	9/9/2020	Singapore	8/15/2022
Sweden	9/9/2020	Switzerland	10/26/2022
Egypt	10/6/2020		
Italy	3/10/2021		
Spain	9/14/2021		
United Kingdom	9/22/2021		
Serbia	9/23/2021		
Colombia	9/29/2021		
Republic of Korea	10/15/2021		
Denmark	1/21/2022		
Canada	3/29/2022		
Austria	5/31/2022		
Singapore	8/15/2022		

6.2 Marginal effect on corporate green bond issuance size and climate vulnerability

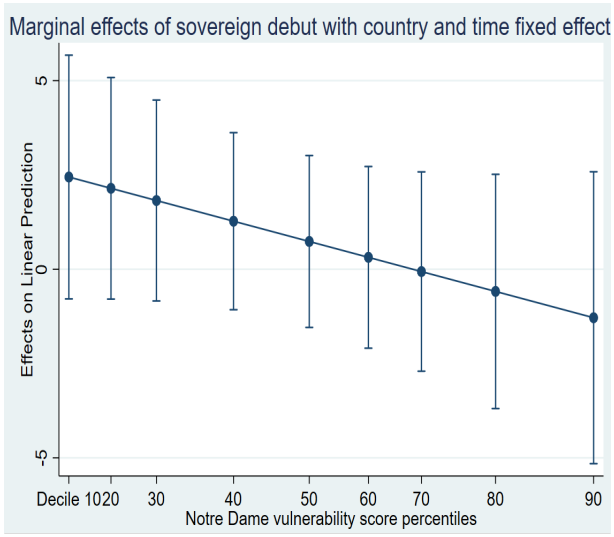
The marginal effect of the issuance size does not vary with country climate conditions

Graph A.1

Marginal effects neither change with climate change performance…



…nor with climate vulnerability



Note: The values indicate how the marginal effect of sovereign debut on amount of corporate green bond issued varies with climate change performance index or vulnerability, while controlling for cumulative log green bond issuance, country, and time fixed effects. The bands indicate the 95% confidence intervals around the estimated marginal effects.

Source: Bloomberg L.P.; authors' calculations.

6.3 Liquidity and price effects depending for foreign currency sovereign green bonds

Impact of subsequent sovereign issuance on the bid-ask spread of corporate green bonds issued

Table A.2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
debut	-0.00768***	-0.00204***	-0.00745***	-0.00267**	0.00175*	-0.00204***	0.00184	0.00175*
	(0.000)	(0.001)	(0.000)	(0.013)	(0.098)	(0.001)	(0.345)	(0.098)
debut_foreign	-0.0127***	0.000566	-0.00173	-0.00224	-0.00623***	0.000566	-0.00875**	-0.00623***
	(0.000)	(0.755)	(0.546)	(0.498)	(0.003)	(0.755)	(0.023)	(0.003)
Observations	31255	31255	31255	31255	31255	31255	31255	31255
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Sovereign issue event dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.00315	0.741	0.113	0.119	0.746	0.741	0.124	0.746
r2_a	0.00308	0.739	0.112	0.119	0.744	0.739	0.123	0.744
r2_within	0.00315	0.000412	0.000676	0.000277	0.000313	0.000412	0.000169	0.000313

Note: r2_a refers to the adjusted R-squared.

Impact of subsequent sovereign issuance on the yield spread of corporate green bonds issued

Table A.3

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
debut	-0.0304	-0.0558***	0.0471	-0.0503*	0.00290	-0.0558***	0.0179	0.00290
	(0.235)	(0.000)	(0.245)	(0.053)	(0.831)	(0.000)	(0.706)	(0.831)
debut_foreign	-0.567***	-0.115***	-0.420***	-0.165**	-0.207***	-0.115***	-0.244***	-0.207***
	(0.000)	(0.000)	(0.000)	(0.039)	(0.000)	(0.000)	(0.010)	(0.000)
Observations	31255	31255	31255	31255	31255	31255	31255	31255
Corporate issuer dummy	No	Yes	No	No	Yes	Yes	No	Yes
Year month time dummy	No	No	Yes	No	Yes	No	Yes	Yes
Sovereign issue event dummy	No	No	No	Yes	No	Yes	Yes	Yes
r2	0.00366	0.922	0.0382	0.0410	0.923	0.922	0.0418	0.923
r2_a	0.00360	0.921	0.0371	0.0406	0.922	0.921	0.0404	0.922
r2_within	0.00366	0.00374	0.00118	0.000378	0.00200	0.00374	0.000218	0.00200

Note: r2_a refers to the adjusted R-squared.

6.4 Robustness checks for the emerging market subsample

Regression results using the EME subsample — Table A.4

	Hypothesis 1				Hypothesis 2				Hypothesis 3			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sovereign debut	0.896***	0.243	-0.0312	0.0782	3.002**	1.829	0.533	1.095	25.31***	26.90***	6.993**	7.360**
	(0.000)	(0.345)	(0.900)	(0.763)	(0.017)	(0.245)	(0.702)	(0.493)	(0.000)	(0.000)	(0.026)	(0.024)
Cumulative log green bond issuance (t-1)		0.0431***	0.0210**	0.00920		0.108**	0.0348	-0.0339		0.108**	0.0348	-0.0339
		(0.000)	(0.028)	(0.366)		(0.012)	(0.507)	(0.589)		(0.012)	(0.507)	(0.589)
Constant	0.405**	0.113	-1.47e-14	2.16e-15	1.462***	0.683	4.45e-13	1.47e-14	9.296***	9.144***	2.21e-12	9.59e-14
	(0.011)	(0.135)	(1.000)	(1.000)	(0.004)	(0.140)	(1.000)	(1.000)	(0.000)	(0.000)	(1.000)	(1.000)
Observations	1505	1505	1505	1505	1505	1505	1505	1505	1505	1505	1505	1505
Country dummy	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time dummy	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
r2_w	0.0120	0.0365	0.0781	0.0789	0.00467	0.00893	0.0426	0.0434	0.0492	0.0492	0.182	0.182
r2_o	0.00461	0.0613	0.0836	0.0747	0.00310	0.0118	0.0423	0.0395	0.0317	0.0317	0.159	0.159
r2_b	0.00522	0.257	0.303	0.234	0.0000122	0.0763	0.0801	0.0588	0.00110	0.00110	0.00110	0.00110

Note: r2_w refers to the R-squared within each group or individual; r2_o means the overall R-squared; r2_b shows R-squared between different groups or individuals.

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