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Greenium fluctuations and climate awareness in the corporate bond market

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ABSTRACT

This study offers a novel explanation for the dynamics of the 'greenium,' that is the negative yield differential of corporate green bonds relative to equivalent conventional bonds. Utilising a matched dataset of green and conventional corporate bonds from January 2014 to July 2022, we find that the 'greenium' in the secondary market responds significantly, even if briefly, to climate policy events. It reaches its peak of 16 basis points shortly after the 2015 Paris Agreement. This response is economically significant as it accounts for 20% of the average yield spread observed in all the bonds within our matched sample. In addition, we find that when natural disasters strike, certified green bonds exhibit a positive return, in stark contrast to the negative performance of conventional bonds. We also show that heightened media coverage of climate change leads to a narrowing of yield spreads for both green and conventional bonds issued by green bond issuers. The impact is even more pronounced for certified green bonds. Taken together, these insights support the view that market sentiment is a key driver of the time variation of the greenium.

1. Introduction

Climate change has become one of the most pressing challenges of our time, and its potential impact on the global economy is increasingly being recognised by academics and policymakers alike. A growing body of literature has been focusing on the role of green bonds as financial tools for funding green projects and, thus, facilitating the green transition. One of the most debated topics in this area is whether green bonds sell at a higher price, the so called 'greenium,' than conventional bonds. This phenomenon has profound implications for companies, investors, and policymakers. The existence of a greenium could potentially encourage companies to adopt more environmentally friendly investments, thus accelerating the shift towards a net-zero economy. However, this also introduces a risk: firms could potentially leverage the greenium to secure cheaper financing while indulging in greenwashing—that is, issuing green bonds without a genuine commitment to environmental responsibility. For policymakers, this underscores the importance of regulatory oversight and transparency in the green bond market to foster authentic green investments and curb potential misuse.

Standard theoretical models suggest that, if identical except for their 'green' label, green and conventional bonds should be priced equally.[1] Thus, a discrepancy in pricing could point to a market inefficiency. Alternatively, this difference could suggest that investors value environmental sustainability more, indicating a shift in their investment preferences. Existing research provides conflicting evidence regarding the presence, magnitude and sign of the greenium (e.g., Baker, Bergstresser, Serafeim, & Wurgler, 2018; Karpf & Mandel, 2018; Larcker & Watts, 2020).

To the best of our knowledge, ours is the first paper to present empirical evidence for the impact on the greenium of increased climate awareness due to major climate policy discussions, political events, natural disasters, and media coverage.

Building on the seminal work of Flammer (2021), which explores the yield differences between green and conventional bonds at issuance, we adopt a distinct approach and arrive at different results. Flammer (2021)'s study employs a univariate difference-in-means approach and concludes that there is no significant difference in yields between green and conventional bonds at issuance. In contrast, we compare the performance of green versus conventional bonds over time within a multivariate regression framework and identify a discernible greenium. Additionally, by focusing our analysis on the yield spread over treasury yields, rather than solely on the yield itself, we effectively minimise potential biases from fluctuating interest rate conditions. This methodological shift enables a comprehensive analysis of the dynamics of the

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[1] Given that the credit profile of green bonds mirrors that of conventional bonds from the same issuer, the pricing dynamics of these two should theoretically align, keeping other factors constant. As such, green bonds and conventional bonds are 'pari passu' in their pricing structures. See *Explaining green bonds*, *Climate bonds initiative*. URL: https://www.climatebonds.net/market/explaining-green-bonds.

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greenium over time and in relation to changes in climate awareness and market sentiment. The identification of a sentiment-driven greenium has practical implications. First, it allows investors to align their investment strategies more effectively with market sentiment. Secondly, it presents an opportunity for companies to coordinate the timing of their green bond issuances with periods of heightened climate awareness.

We contribute to the existing literature in three main ways. Our first contribution is an analysis of the influence of natural disasters on the performance of green bonds. While we note that natural disasters typically have an adverse effect on bond performance, this is not the case with certified green bonds. The result of a negative financial performance when disasters strike aligns with existing studies which have highlighted how such calamities can cause infrastructure damage, property losses, economic activity disruptions, and uncertainty about future prospects in impacted regions (Lanfear, Lioui, & Siebert, 2019; Nagar & Schoenfeld, 2019; Pankratz & Schiller, 2022). This leads to increased risk-aversion and higher yields. However, we show that certified green bonds defy this trend, exhibiting a positive return during such events. Moreover, we find a direct correlation between the severity of the disaster and the divergence in the return of certified green bonds versus conventional bonds. For instance, we observe that as we transition from the scenario with no climate damage to the 99% quantile of the dollar damage distribution, uncertified green bonds demonstrate an increase in yield spread of 8 basis points (equivalent to 10.5% of the average yield spread in the matched sample). On the other hand, certified bonds experience a decline of 13.2 basis points (17.4% of the average yield spread). Our results emphasise the significance of disaster risk for bond pricing while also highlighting the potential hedging advantages for certified green bond holders. This corroborates previous research on the resilience of financial instruments with strong environmental profiles in the aftermath of natural disasters (e.g., Huynh & Xia, 2021; Yang, 2021).

Our second contribution is an examination of the influence of heightened climate awareness on the greenium. We identify two distinct effects linked to a one standard deviation increase in a popular climate awareness indicator, the Media and Climate Change Observatory (MeCCO) World index. First, we see an overall modest reduction in yield spreads of 2.1 basis points (bps) for bonds issued by green issuers. Second, we find a greater reduction of 6.25 bps, equivalent to 8.23% of average yield spreads, for certified green bonds. Both are statistically significant at the 1% level. Our findings are consistent with Huynh and Xia (2020) who show that investors are prepared to pay a premium for bonds issued by companies with high E-scores during periods of heightened climate awareness. This phenomenon can be attributed to a shift in investor sentiment driven by increased media coverage of climate change.

Our research also adds new insights into the role of certifications and external reviews within the green bond market. The literature has yielded various findings on this topic. Prior studies highlight how green bond certifications can lead to a spike in the borrower's stock price post bond-issuance and ignite interest from long-term and green investors (Flammer, 2021). Moreover, only green bonds that have undergone certification are associated with lower borrower's emissions (Fatica & Panzica, 2021) and a persistent greenium (Pietsch & Salakhova, 2022). Building upon these findings, our analysis reveals that certified green bonds are associated with an up to fivefold larger average greenium than uncertified bonds. Furthermore, our findings show that certified green bonds in high-environmental-impact industries[2] enjoy a significantly larger greenium compared to those in less impactful industries. This reflects investors' preference for credible environmental improvements in environmentally material sectors (Ehlers & Packer, 2017; Sangiorgi & Schopohl, 2021). Conversely, non-certified green bonds in these sectors are often viewed with scepticism and may even face a discount, likely due to concerns over greenwashing. These findings have important policy implications. By advancing rigorous certification standards, policymakers can boost investor confidence and help direct capital to high-impact sectors, where it could have the greatest effect in reducing pollution. Therefore, certification could play an important role in achieving environmental targets and supporting the credibility of climate-focused investments.

Our third contribution is a more comprehensive analysis of the dynamic nature of the greenium relative to previous studies (Pietsch & Salakhova, 2022; Zerbib, 2019). We uncover that the fluctuations in the greenium are closely correlated to momentous shifts in climate change policies. For example, in the months following the 2015 Paris Agreement, the greenium broadened from an average of 2 bps to nearly 15 bps, which accounts for 19.76% of the average yield spread in the sample. Conversely, the election of US President Trump and his subsequent decision to withdraw the US from the Paris Agreement coincided with a period in which the greenium gradually declined and eventually faded.

These findings have practical implications for investors aiming to build resilient portfolios. Certified green bonds, in particular, offer greater stability against climate related risks, often holding or increasing in value during extreme weather events.

In the subsequent sections of this paper, we will review previous studies and develop testable hypotheses (Section 2). We will then delve into the description of our data and methodology (Section 3) and discussion of our results (Section 4). Finally, we will conclude the paper by summarising the main findings and their implications (Section 5).

2. Hypotheses development

Unarguably, the existence of a greenium is a focal question in the literature.[3] Theoretical models suggest that green and conventional bonds, holding other factors constant, should exhibit the same price dynamics. Yet, the evolving tastes of investors could potentially affect this relationship. Indeed, investors view companies' commitments to environmental and societal causes as value-enhancing (Chava, 2014). In the specific case of the green bond market, they may be willing to accept lower yields, thus lowering the cost of debt financing for green bond issuers.

However, the existence of the greenium remains a point of debate. Findings on this phenomenon are mixed and vary according to the market analysed, time frame, type of issuing entity (Fatica & Panzica, 2021), entity characteristics (Liaw, 2020), and methodology employed (Larcker & Watts, 2020).

As a result, also the sign of the greenium — whether it represents a premium or a discount — differs among studies. For instance, Baker et al. (2018) and Karpf and Mandel (2018) provide contrasting evidence, identifying a premium and a discount for green bonds, respectively. Pástor et al. (2021) study the case of German sovereign twin bonds and discover a greenium in such market. Larcker and Watts (2020) and Flammer (2021) compare the yields of municipal green bonds and corporate green bonds with their conventional counterparts finding that there is no significant yield differential and suggesting green and conventional bonds are flat-priced. Zerbib (2019) and Hachenberg and Schiereck (2018) find a small but significant

[2] High-environmental-impact industries are defined as those classified by the Sustainability Accounting Standards Board (SASB) with a materiality score of 3 or higher. These include Chemicals, Coal Operations, Construction Materials, Pulp & Paper Products, Metals & Mining, Electric Utilities & Power Generators, Oil & Gas – Exploration & Production, Oil & Gas – Refining & Marketing, Semiconductors, Hotels & Lodging, and Waste Management.

[3] See, for example, Baker et al. (2018), Fatica and Panzica (2021), Flammer (2021), Gianfrate and Peri (2019), Hachenberg and Schiereck (2018), Karpf and Mandel (2018), Larcker and Watts (2020), Pástor, Stambaugh, and Taylor (2021), Pietsch and Salakhova (2022), Zerbib (2019) and Caramichael and Rapp (2024).

premium in favour of green bonds. Such findings underscore the complexity of isolating a greenium effect, highlighting that it may not be uniformly present across all contexts or methodologies.

Interestingly, evidence suggests that also the sector of origination matters. Investors demonstrate a marked preference for green instruments issued by traditionally polluting sectors (Ehlers & Packer, 2017) and asset managers favour green bonds from entities within the industrial, automotive, and utilities sectors (Sangiorgi & Schopohl, 2021), which are conventionally seen as environmentally unfriendly sectors.

Given the lack of consensus on the existence of the greenium in the literature, we first test its presence with the most comprehensive sample of green and conventional bonds to date. This leads to our first hypothesis:

Hypothesis 1. Corporate green bonds trade at a lower yield spread compared to matched conventional counterparts in the secondary market.

Due to the contradictory findings in the literature, we hypothesise that the nature of the greenium may be dynamic and that external factors influence its appearance and disappearance over time. In the literature, the factors that determine the fluctuation of greenium over time have not been studied in depth. However, the concept of a fluctuating greenium could be inferred from several papers. Pietsch and Salakhova (2022) find that the emergence of the greenium in the secondary market in recent years can be attributed to the increased participation of retail investors, who are presumably driven by heightened awareness and concerns regarding climate-related issues. This interpretation aligns with broader evidence on investors' shifting preferences during periods of heightened uncertainty. Kinateder, Campbell, and Choudhury (2021) highlight the role of safe-haven assets in systemic crises, showing that investors tend to reallocate capital into traditionally safer asset classes during episodes of extreme volatility. In this context, Arat, Hachenberg, Kiesel, and Schiereck (2023) find that while green bonds exhibit a persistent greenium in normal market conditions, this premium more than doubles during times of extreme market stress. Furthermore, Seltzer, Starks, and Zhu (2022) indicate that firms with poor environmental profiles have higher yield spreads, particularly when stricter regulatory enforcement is in place and when climate regulatory risks are present. Therefore, we argue that green bonds, representing financial instruments with a relevant environmental component, may exhibit lower yield spreads in correspondence of major climate events. Thus, our second hypothesis is:

Hypothesis 2. The greenium exhibits dynamic fluctuations over time that may lead to periods in which it is statistically significant and others in which it is not.

A major concern for sustainability-oriented investors interested in green bonds is that borrowers' commitment to green projects will not be upheld. We refer to non-compliance with the declared use of proceeds by issuers of green bonds as greenwashing. Especially in absence of strict regulations and enforcement schemes, issuers may decide to attract investors with a taste for sustainability, take advantage of the reputational effect stemming from green bond issuance and then divert the proceeds to other-than-green activities. To partially tackle potential concerns about the authenticity of green bonds, issuers can obtain a certification, subject to the positive assessment of an external reviewer. There is consensus regarding the function and efficacy of certifications. Certified green bonds are associated with greater improvements in the post-issuance environmental performance of issuers (Fatica & Panzica, 2021; Fatica, Panzica, & Rancan, 2021; Flammer, 2021). Moreover, consistent with the findings regarding investors' positive response to voluntary disclosure of green investments (e.g., Martin & Moser, 2016), the announcement of a certified green bond issue causes a more pronounced positive stock price reaction and a greater participation of long-term investors in the ownership structure (Flammer, 2021).

Finally, the size of the greenium strongly depends on the level of greenness determined by the external reviewer (Dorfleitner, Utz, & Zhang, 2021). With these findings in mind, we consider certification a determining factor in our analysis and test whether certification continues to influence the greenium even when controlling for its market sentiment-driven fluctuations over time:

Hypothesis 3. Certification leads to a larger greenium for green bonds in the secondary market even when controlling for variations in market sentiment.

We also scrutinise the influence of natural disasters on green bond performance. We predict that the infrastructural damage and property losses, consequential disruptions in economic activity, and uncertainty over future prospects in disaster stricken regions might promote risk-aversion among investors. This 'risk-off' environment, may stimulate demand for higher returns to offset perceived risk (Johar, Johnston, Shields, Siminski, & Stavrunova, 2022). In such circumstances, heightened investor alertness to climate risks could stimulate increased demand for environmentally responsible investments (IMF, 2021). Thus, certified green bonds, signalling environmental sustainability, could become increasingly attractive to investors in the aftermath of natural disasters. Investors may view such bonds as vehicles for reducing the frequency (via climate risk mitigation projects) and impact (through climate adaptation initiatives) of future calamities.

Hypothesis 4a. The occurrence of natural disasters in the issuer's country affects the magnitude of the greenium.

Hypothesis 4b. The intensity of natural disasters in the issuer's country affects the magnitude of the greenium.

Furthermore, we focus on the potential impact of heightened public attention to climate change on the greenium. First, we hypothesise that heightened public attention to climate change may lead to a decrease in the yield spread for all bonds (including conventional bonds) issued by green bond issuers. This hypothesis stems from the credible signal that green issuers send to the market by issuing green bonds, indicating their commitment to environmental sustainability. As public attention to climate change increases, this commitment may increase the perceived value of all the bonds, green or conventional, issued by these green issuers, leading to a reduction in the yield spread of both types of bonds.

Hypothesis 5a. Both conventional and green bonds issued by green issuers experience a decrease in the yield spread during periods of heightened public attention to climate change.

Second, we postulate that events related to climate change, captured by the media (e.g., international climate summits, the emergence of new transition policies, significant advancements in green technology etc.) may further increase the interest towards certified green instruments. Our last hypothesis is that certified green bonds exhibit superior performance during periods of amplified public awareness of climate change relative to non-certified green bonds.

Hypothesis 5b. Certified green bonds perform better than non-certified green bonds during periods of heightened public attention to climate change.

3. Data and methodology

Our goal is to examine the existence and evolution of the greenium between January 2014 and July 2022 in the secondary market.[4] To

[4] We gather data for green and conventional bonds issued from January 2014 to December 2021. We track secondary market trading for these bonds until July 2022. This ensures that bonds issued towards the end of 2021 have enough observations for the panel regression analysis.

Table 1
Description of variables used in the regression analysis.

Variable	Type	Description
Dependent		
Yield spread	Continuous	The spread of a corporate bond expressed as the difference between the bond's yield to maturity and the yield to maturity of the associated benchmark government bond. The spread is expressed in basis points.
Variables of interest		
Green Bond	Dummy	A variable that takes the value of 1 if the bond is green, and 0 otherwise.
Certified	Dummy	A variable that takes the value of 1 if the bond is both green and certified and 0 otherwise. Certified bonds' adherence to specific standards and guidelines established by recognised third-party organisations, such as the Climate Bonds Initiative, is verified by independent auditors to ensure transparency.
ESG Score	Categorical	A time-varying measure ESG performance obtained from Refinitiv, categorised into four levels, from 'A' to 'D', where 'A' represents the highest performance and 'D' the lowest.
Dummy 5 days post-disaster	Dummy	A binary variable that takes a value of 1 in the five days following a natural disaster related to climate change (i.e., excluding geological disasters) in the country of the bond issuer, and 0 otherwise.
Log(Damages in $m)	Continuous	The natural logarithm of the damages in adjusted million dollars caused by a natural disaster related to climate change in the country where the bond issuer is located.
Rel. Δ MeCCO index	Continuous	A variable representing the relative change (in decimals) in the Media and Climate Change Observatory (MeCCO) World index, which monitors media coverage of climate change and related issues across various forms of media in different countries and regions.
Innovations on MeCCO index	Continuous	A variable representing the innovations on the MeCCO World index, derived from the residuals of an AR1 model on the index.
Control variables		
Bid–ask spread	Continuous	It represents a measure of market liquidity. It is computed as the difference between the ask price and bid price of a bond as a percentage of the mid-price. It is expressed in basis points.
Years to maturity	Continuous	The number of years until the bond reaches maturity.
Amount issued	Continuous	The natural logarithm of the amount issued for the bond.
Coupon rate	Continuous	The coupon rate of the bond, expressed as a percentage.
Rating	Categorical	A set of fixed effects representing the bond rating changes over time.
Currency	Categorical	A set of fixed effects representing the currency denomination of the bond.
Issuer	Fixed Effect	A set of dummies identifying each issuer.
Month	Fixed Effect	A set of fixed effects for each specific month and year.
Quarter	Fixed Effect	A set of fixed effects for each specific quarter and year.
Day	Fixed Effect	A set of fixed effects for each specific day.
Additional Variables		
Market Illiquidity	Continuous	The weighted average bid–ask spread across all bonds in the market, adjusted by outstanding amounts, capturing market-level liquidity.
Issuer Illiquidity	Continuous	The daily average bid–ask spread of bonds issued by each issuer, reflecting issuer-specific liquidity characteristics.
Gamma Illiquidity	Continuous	A bond-specific liquidity measure based on the covariance of consecutive log price changes, as per Bao, Pan, and Wang (2011).
Impact	Dummy	Indicates industries with at least one environmental materiality topic, as per SASB, scoring above zero.
High Impact	Dummy	Indicates industries with a high environmental materiality (SASB score of 3 or higher), signifying significant environmental impact.

this end, we collect information on green and conventional bonds issued by green issuers from the Bloomberg Fixed Income securities database and Refinitiv Datastream. In order to facilitate the comparison process, we limit our sample to bonds with fixed coupon and without embedded options. This results in 15,786 bonds issued by green issuers between 2014 and 2021, of which 790 are green bonds. For each bond, we retrieve the issuer ID, green label (identifying whether a bond is green or not), coupon rate, maturity date, issue date, amount issued in US dollars, rating at issue, and yield spread. Table 1 provides a comprehensive overview of the variables that have been employed in our analysis. Table 2 shows the descriptive statistics of the bond sample. On average, the bonds in the sample have a maturity of 5.90 years and a coupon rate of 1.56%. The credit rating assigned at the time of issue averaged 22.7, which falls within the range of A+ to AA- on the Standard and Poor's (S&P) scale. The average amount issued is $416.6 million, with a minimum of $5.5 million and a maximum of $2 billion. The average yield spread is 75.9 bps. Our analysis of the greenium is based on a sample in which each green bond is matched to an equivalent conventional bond. To determine the most suitable conventional match for each green bond, we use the Mahalanobis Distance (MD) method.[5] The use of MD is particularly suitable for our analysis, as it outperforms other matching techniques when the number of covariates is relatively small and ensures robustness in different settings (King & Nielsen, 2019; Rubin, 1979; Stuart, 2010; Zhao, 2004). Furthermore, MD has been successfully employed in other studies on green bonds (e.g., Bedendo, Nocera, & Siming, 2023; Flammer, 2021), making it a well-established method in this context.

In order to ensure that green and conventional bonds are comparable across different sectors and issuers, we specifically match bonds with the same issuer. This ensures that sector-specific and issuer-specific characteristics are consistent between the matched pairs. The use of MD also ensures that the selected bonds are closely comparable on key bond-level attributes such as coupon rate, issue date, maturity, and issuance amount. However, merely minimising the distance between issue dates through the MD method does not ensure

[5] Ideally, a perfect matching approach would be used, but applying such a methodology would drastically reduce the sample size, as many bonds would not find a match. Using the MD and the matching criteria we applied, ensures a high-quality match while preserving a sufficient sample size.

Table 2

Summary statistics of the bond sample. This table provides a summary of the descriptive statistics for the variables used in the regression analysis. Panel (A) reports the time-varying variables. *Bid–ask spread* indicates the relative bid–ask spread of the bond prices. "Dummy 5 days post-disaster" is a binary variable indicating the immediate aftermath of a disaster. *Rel. Δ MeCCO index* refers to the monthly changes in the Media and Climate Change Observatory (MeCCO) index and *Innovations on MeCCO index* represents the first-order autoregressive model innovations. Panel (B) reports the variables measured at issue. *YTM* is the Yield to Maturity at issue. *Log(issue amount)* is the natural logarithm of the amount issued. Maturity is the maturity of the bond (in years). *Coupon* is the coupon rate in percentage. *Impact* and *High Impact* are dummies that activate if SASB score is ≥1 and ≥3 respectively. *Rating at Issue* refers to the credit rating assigned to a bond, converted into an integer representing a specific Standard and Poor's (S&P) rating. The average rating at issue is 22.7, which corresponds to a rating between A+ and AA-, where 22 represents S&P rating A+ and 23 represents S&P rating AA- (Table A1 of the Appendix displays the full conversion of S&P credit ratings into numerical values). Panel (C) measures the disaster variables when extreme weather events occur. *Damages (in $bn)* represents the total damages in billions of dollars caused by a disaster, while *Log(Damages in $m)* is the natural logarithm of these damages. Panel (D) presents additional variables utilised in the robustness tests, including liquidity measures, and sectoral environmental impact indicators.

Panel (A): time-varying variables						
Variable	Obs	Mean	Std. Dev.	Median	Min	Max
Yield spread (bps)	346,418	75.9	57.7	68.0	−102.0	741.3
Bid–ask spread	346,418	24.25	19.08	19.05	0.00	115.87
Dummy 5 days post-disaster	346,418	0.04	0.19	0.00	0.00	1.00
Rel. Δ MeCCO index	102	0.03	0.21	0.03	−0.51	0.73
Innovations on MeCCO index	102	40.34	1124.23	43.65	−5170.48	2908.64
Panel (B): variables measured at issue						
Variable	Obs	Mean	Std. Dev.	Median	Min	Max
YTM (%)	688	1.58	1.37	1.22	0.00	7.50
Amount issued ($m)	688	416.63	425.50	245.87	5.52	2000
Maturity (years)	688	5.90	3.35	5	1	30
Coupon rate (%)	688	1.56	1.37	1.22	0.11	7.38
Impact	688	0.38	0.48	0.00	0.00	1.00
High Impact	688	0.12	0.33	0.00	0.00	1.00
Rating at issue	688	22.7	2.5	23	17	26
Panel (C): variables measured when extreme weather events occur						
Variable	Obs	Mean	Std. Dev.	Median	Min	Max
Damages (in $bn)	350	2.76	8.26	0.85	0.0002	105.02
Log(Damages in $m)	350	6.45	1.86	6.75	0.79	11.56
Panel (D): additional variables for robustness tests						
Variable	Obs	Mean	Std. Dev.	Median	Min	Max
Market Illiquidity	346,418	22.45	6.36	22.94	0.43	64.01
Issuer Illiquidity	346,418	24.25	14.94	20.97	0.00	115.87
Gamma Illiquidity	344,310	4.22	11.47	1.40	0.00	35.83

an even distribution of issue dates between the groups of green and conventional bonds.[6] This consideration is crucial, as bonds issued at different times can display varying yields influenced by the respective market conditions in those periods. To counter this, we introduce the additional constraint that the issue dates of each pair of matched bonds should not exceed one year. Furthermore, we also refine our regression analysis by focusing on the corporate yield spread over treasury yields, rather than solely on corporate yields. This approach helps us to assess more accurately the relative performance and pricing of green versus conventional bonds, isolating external market influences.

We begin by first selecting conventional bonds that have the same issuer and rating at issue of the selected green bonds. Then, we compute the MD between each green bond and conventional counterparts. Finally, to form each pair, we select the conventional bond with the shortest 'distance' to the original green bond. The final matched sample consists of 344 pairs of green and conventional bonds. For each bond in the matched sample, we obtain the following daily variables from Refinitiv Datastream: yield spreads, which measure the yield differential between the bond and the corresponding benchmark government bond with a similar maturity; and relative bid–ask spreads, expressed as a percentage of the mid-price, to account for differences in liquidity across bonds; credit rating history.

[6] This is because, even when the issue date is incorporated as a dimension in the multi-dimensional MD computation, the minimum MD could still pair bonds that are similar across the other dimensions, such as coupon, maturity, and amount issued, but differ significantly in their issue dates, potentially by a substantial time span.

To further ensure the quality of our matching, we have provided the differences in means between the matched samples of green and conventional bonds in Table 3. This table illustrates the closeness of the two groups after matching, with no statistically significant differences observed between them in terms of the bond characteristics at issue.

Table 4 compares the number and amount issued of green bonds between 2014–2022, for each country in both the full and matched samples. While the total quantity and overall value of green bonds are significantly reduced in the matched sample, the proportional contribution of each country to the total remains stable. The relative contributions of each country do not deviate markedly from those in the full sample. This suggests that the matched sample, though reduced in size, reflects the geographic diversity present in the full sample. Subsequently, we conduct a panel OLS regression analysis to test the hypotheses discussion in Section 2. The baseline model is as follows:

$$Yield\ Spread_{it} = \alpha + \beta \times \textbf{Green Bond}_i + \gamma \times Controls_{it} + \theta_i + \lambda_t + \epsilon_{it} \quad (1)$$

where $Yield\ Spread_{it}$ represents the yield spread of bond i at time t over a comparable Treasury security and Green Bond is a dummy the identifies green bonds. The model includes a set of controls, such as the residual maturity, the bid–ask spread, the amount issued, and the coupon rate of the bond. Furthermore, it includes currency fixed effects and credit rating dummies. θ_i and λ_t represent respectively the issuer and time fixed effects.

Table 3

Characteristics at issue of green bonds and matched conventional bonds. This table compares the characteristics at issue of the matched green vs conventional bonds in our sample. Yield Spread denotes the yield differential between a corporate bond and the associated benchmark government bond. YTM is the Yield to Maturity at issue. Log(issue amount) is the natural logarithm of the amount issued. Maturity is the maturity of the bond (in years). Coupon is the coupon rate in percentage. Rating at Issue refers to the credit rating assigned to a bond, converted into an integer representing a specific Standard and Poor's (S&P) rating. The average rating at issue is 22.7, which corresponds to a rating between A+ and AA-, where 22 represents S&P rating A+ and 23 represents S&P rating AA-. *p*-value represents the *p*-value of the difference-in-means. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The sample is made of 688 bonds issued between 2014 and 2021.

Variable	Label	Obs	Mean	Std. Err.	[95% conf.	interval]	*p*-value
Yield spread (bps)	*(1) Non Green*	344	76.6	2.7	71.4	81.9	
	(2) Green	344	77.6	2.7	72.3	82.9	
Difference (1)-(2)			−1.0	3.8	−8.4	6.5	0.802
YTM (%)	*(1) Non Green*	344	1.61	0.07	1.46	1.76	
	(2) Green	344	1.54	0.07	1.40	1.69	
Difference (1)-(2)			0.07	0.11	−0.14	0.23	0.523
Log(amount issued)	*(1) Non Green*	344	19.26	0.07	19.12	19.39	
	(2) Green	344	19.23	0.06	19.11	19.35	
Difference (1)-(2)			0.03	0.09	−0.15	0.21	0.753
Years to maturity	*(1) Non Green*	344	5.92	0.18	5.55	6.28	
	(2) Green	344	5.87	0.18	5.52	6.22	
Difference (1)-(2)			0.05	0.26	−0.46	0.55	0.862
Coupon rate (%)	*(1) Non Green*	344	1.59	0.08	1.44	1.74	
	(2) Green	344	1.52	0.07	1.38	1.67	
Difference (1)-(2)			0.07	0.11	−0.14	0.27	0.523
Rating at issue	*(1) Non Green*	344	22.7	0.1	22.4	22.9	
	(2) Green	344	22.7	0.1	22.4	22.9	
Difference (1)-(2)			0.0	0.0	0.0	0.2	1.000

Table 4

Comparison of green bond issuance by country - Full vs. Matched Samples. The table shows the number and percentage of green bonds issued by each represented country in the sample, together with the amount issued in billion dollars. The bonds are classified under two distinct samples: the *Full Sample*, and the *Matched Sample*. The *Full Sample* includes the complete universe of fixed coupon green bonds issued by green issuers and reported by both Bloomberg Fixed Income and Refinitiv Datastream. Bonds with optionality features are excluded. The *Matched Sample* represents the subsample of green bonds resulting from the matching methodology applied to pair green and conventional bond in our analysis. The methodology requires a perfect match on the issuer identifier and bond rating at issue and selects the match based on the minimisation of the Mahalanobis Distance computed on coupon rate, the issued amount, the time to maturity, and the issue date.

Country	Full sample				Matched sample			
	Green bonds		Amount issued		Green bonds		Amount issued	
	No.	%	B$	%	No.	%	B$	%
China	211	26.71%	89.70	32.44%	51	14.83%	21.93	16.02%
France	35	4.43%	29.44	10.65%	27	7.85%	23.22	16.96%
Germany	59	7.47%	23.57	8.53%	29	8.43%	13.41	9.80%
Netherlands	24	3.04%	19.95	7.22%	18	5.23%	14.98	10.94%
Japan	171	21.65%	18.63	6.74%	69	20.06%	12.00	8.77%
South Korea	120	15.19%	17.28	6.25%	77	22.38%	8.55	6.24%
Norway	11	1.39%	9.47	3.43%	6	1.74%	6.36	4.65%
United States	15	1.90%	8.15	2.95%	7	2.03%	3.89	2.84%
Italy	11	1.39%	7.55	2.73%	9	2.62%	6.44	4.70%
Spain	6	0.76%	6.09	2.20%	5	1.45%	5.26	3.85%
Cayman Islands	11	1.39%	5.87	2.12%	2	0.58%	1.20	0.88%
Hong Kong	13	1.65%	4.93	1.78%	2	0.58%	0.63	0.46%
British Virgin Islands	12	1.52%	3.78	1.37%	3	0.87%	0.60	0.44%
Canada	6	0.76%	3.62	1.31%	5	1.45%	3.30	2.41%
India	8	1.01%	3.56	1.29%	3	0.87%	1.36	1.00%
Sweden	12	1.52%	3.39	1.23%	9	2.62%	2.79	2.04%
Austria	6	0.76%	3.12	1.13%	4	1.16%	1.87	1.36%
Australia	5	0.63%	2.92	1.05%	4	1.16%	2.69	1.97%
Finland	6	0.76%	2.40	0.87%	3	0.87%	1.94	1.42%
United Kingdom	8	1.01%	2.23	0.81%	2	0.58%	0.95	0.69%
Other	40	5.06%	10.84	3.92%	9	2.62%	3.50	2.56%
Total	790	100%	276.50	100%	344	100%	136.87	100%

Table 5
Determinants of the yield spread (baseline model). This table presents the regression analysis examining the impact of green bond label on corporate bond yield spreads. The analysis employs a Green Bond dummy (which equals 1 for green bonds) in Columns 1–3 and a Placebo dummy (which equals 1 for conventional placebo bonds) in Columns 4–6. Each set of columns tests the relationship under different time fixed effects: quarterly (Columns 1 and 4), monthly (Columns 2 and 5), and daily (Columns 3 and 6), with corresponding standard errors clustered at the quarter-issuer, month-issuer, and day-issuer levels. Control variables include bid–ask spread, years to maturity, natural logarithm of issue amount, and coupon rate, alongside rating, issuer and currency fixed effects. The period of analysis extends from January 2014 to July 2022. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread	(1)	(2)	(3)	(4)	(5)	(6)
Green bond	−2.14***	−2.03***	−1.99***			
	(0.61)	(0.38)	(0.09)			
Placebo				−0.01	−0.02	−0.02
				(0.41)	(0.25)	(0.06)
Bid ask spread	0.43***	0.39***	0.37***	0.40***	0.36***	0.34***
	(0.05)	(0.03)	(0.01)	(0.07)	(0.04)	(0.01)
Time to maturity	2.81***	2.95***	3.00***	3.52***	3.69***	3.78***
	(0.20)	(0.13)	(0.03)	(0.30)	(0.19)	(0.05)
Log(Issue amount)	−1.80**	−1.87***	−1.89***	−2.95***	−3.08***	−3.13***
	(0.71)	(0.44)	(0.11)	(1.02)	(0.62)	(0.14)
Coupon rate	−0.19	−0.15	−0.13	−0.10	−0.11	−0.09
	(1.14)	(0.69)	(0.17)	(1.31)	(0.80)	(0.19)
Rating FE	YES	YES	YES	YES	YES	YES
Currency FE	YES	YES	YES	YES	YES	YES
Issuer FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	NO	NO	YES	NO	NO
Month FE	NO	YES	NO	NO	YES	NO
Day FE	NO	NO	YES	NO	NO	YES
R-squared	0.6015	0.6168	0.6226	0.665	0.6812	0.6873
Bonds	688	688	688	444	444	444
Observations	346,418	346,418	346,418	298,150	298,150	298,150

4. Results and discussion

4.1. Baseline model

First, we investigate whether there are differences in pricing between green and nongreen corporate bonds. We begin by examining whether green bonds exhibit a greenium, meaning they trade at consistently lower spreads than conventional bonds (Hypothesis 1). Differently from previous studies such as Flammer (2021), which employed a univariate difference-in-means approach, our analysis utilises a multivariate regression approach, allowing for a more comprehensive control of various factors affecting bond pricing. We conduct our analysis through multiple regression specifications. The results in Table 5 indicate that green bonds do indeed trade at a slightly lower spread (−2.14 to −1.99 basis points), on average, compared to conventional bonds. The result is statistically significant across specifications 1 to 3. This finding holds true when controlling for bid–ask spreads, years to maturity, issue amount, coupon rate, issuer fixed effects and various time fixed effects. Additionally, we rebuild the matched sample by matching conventional bonds with equivalent conventional bonds (rather than green ones) to run a placebo test. We replace the green bond dummy with a placebo dummy that identifies the newly matched *conventional* (placebo) securities. The results (specifications 4–6) show that there is no statistically significant difference in the yield spread between the newly matched bonds. This provides further support for the hypothesis that green bonds trade at a lower spread compared to conventional bonds.

4.2. Fluctuations over time

Following the previous analysis, we investigate whether the greenium effect varies over time (Hypothesis 2). To test this hypothesis, we introduce an interaction term between the green bond dummy and each month in the sample period. The interaction term allows the effect of *Green bond* to vary across different time periods. The greenium effect is not constant over time, as displayed by Fig. 1, which plots the marginal effect of being labelled as green in each month. Notably, the plot shows a marked increase in the greenium effect starting in November 2015, coinciding with the signing of the Paris Agreement, as indicated by the first red line. Similarly, in the following months, December 2015 and January through April 2016, the coefficients are negative and all statistically significant at the 1% level.[7] In this period, the greenium expanded significantly, with yield spreads reducing by about 16 bps. This increase in demand for green bonds highlights how major policy events can drive price appreciation for certified green bonds.

From November 2016 onwards, however, we observe a progressive reduction of the yield differential between green and conventional bonds, which corresponds to a decrease in the greenium, ultimately reaching zero. This temporal shift coincides with the election of Donald Trump, whose efforts to downplay the effect of climate change culminated in the United States' withdrawal from the Paris Agreement in June 2017. This period of small or no greenium extended until the end of 2020. In particular, the green premium did not witness an immediate rebound following the election of Joe Biden in November 2020. The persistent focus on the COVID-19 pandemic during this period may have overshadowed environmental concerns in the media, potentially impacting investor demand for green bonds. Yet, the scenario changed in February 2021, when President Biden announced the US re-entry into the Paris Agreement. At this point, the greenium regained statistical significance. We conjecture that the weight of the US stance on climate change may have swayed the market of green bonds.

These findings suggest that the greenium effect is not static, but rather dynamic and sensitive to a variety of external factors. Market participants' valuation of green bonds and their willingness to pay a premium for them may depend on the political context, shifts in public sentiment on climate issues, changes in regulatory frameworks, and

[7] Additionally, we note a green discount in 2014. However, this could potentially be an anomaly given that our temporal analysis sample was just beginning at this point and a limited number of observations could have had a disproportionate effect on the coefficients.

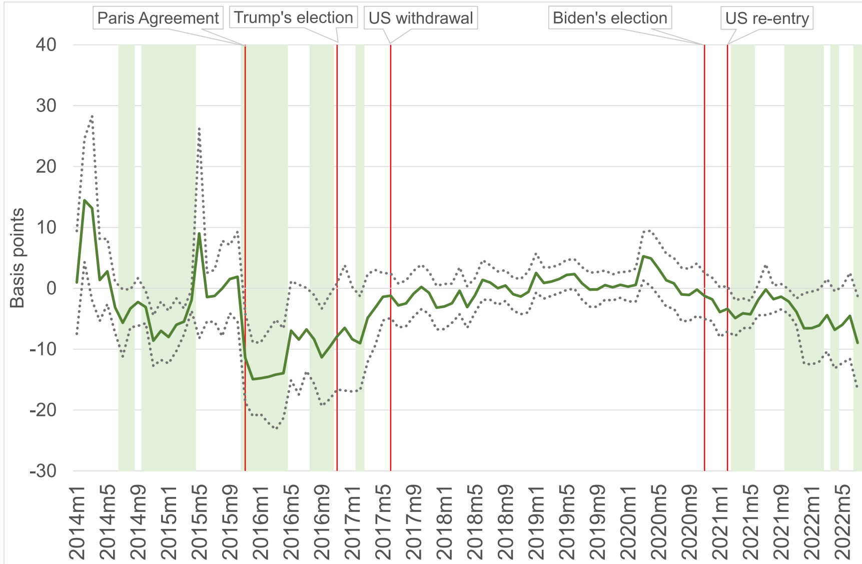

Fig. 1. Marginal effect of the green bond label on the yield spread. This graph shows the marginal effect of the green bond label on bond yield spreads over time. The effect is estimated through the linear regression model in specification (2) of Table 5 with the addition of interaction terms between the green bond dummy and dummies identifying each month within the sample period (January 2014 to July 2022). The solid line represents the estimated effect in bps, while the dotted lines provide the 90% confidence interval. The light green shaded background indicates the months when the greenium is statistically significant at the 10% level. The red lines denote, from left to right, significant events: signing of the Paris Agreement, President Trump's election, the US withdrawal from the Paris Agreement, President Biden's election and the rejoining of the US in the Paris Agreement.

other major global events. The green bond market reflects investor demand to direct wealth toward environmental and climate-friendly projects and initiatives, maintain or enhance green credentials, improve portfolio diversification, and secure support from regulators. Greenium fluctuations highlight the market's sensitivity to these preferences and broader sustainability objectives.

4.3. The role of certification

Next, we investigate the strength of the greenium for certified green bonds Hypothesis 3.

Data on whether a green bond has undergone certification with an external reviewer is collected from the Climate Bonds Initiative (CBI) and incorporated into the specification. By examining the relationship between certification and greenium, we aim to corroborate the results found in the literature about the impact of external reviews on the pricing of green bonds in the market (Dorfleitner et al., 2021; Fatica & Panzica, 2021; Gianfrate & Peri, 2019). Therefore, we add a *Certified* dummy to our baseline specifications in Table 5. Results are reported in Table 6. It is important to clarify that this variable functions as an interaction term between the *Green Bond* label and the certification status, capturing the additional effect of certification beyond the baseline greenium of non-certified green bonds. In this specification, the coefficient on *Green Bond* now isolates the greenium for non-certified green bonds only, while the coefficient on *Certified* represents the incremental effect of certification. Since all certified bonds are also green bonds, the total greenium for certified green bonds is computed as the sum of these two coefficients.

Results show that the *Green* dummy coefficients range from −1.51 to −1.47, while the *Certified* dummy coefficients vary from −7.10 to −7.05, as detailed in Table 6. All coefficients are statistically significant at the 1% level. This analysis reveals that certified green bonds, validated by an external review, exhibit a reduction in yield spread between 8.41 and 8.52 basis points. This effect is over five-fold compared to non-certified green bonds, underscoring the strong market response to external reviews as a means of assuring a green bond's credibility and transparency.

This result may also reflect investors' awareness of the risks associated with greenwashing, where issuers make misleading claims about the environmental benefits of their products or services. The certification process with an external reviewer can help mitigate these risks by providing investors with independent verification of the environmental impact of the bond proceeds.

Table 6
Green certification and bond spreads. This table presents the results of a panel regression model examining the determinants of daily yield spread. The explanatory variables include a Green Bond dummy, which equals 1 for green bonds, a Certified dummy, which equals 1 for certified bonds, the bid–ask spread, time to maturity in years, the natural logarithm of the issue amount, and the coupon rate, as well as rating, currency, issuer fixed effects. Column (1) uses quarter fixed effects; Column (2) uses month fixed effects, and Column (3) uses daily fixed effects. Corresponding standard errors clustered at the quarter-issuer, month-issuer, and day-issuer level are reported in parentheses. Sample period: January 2014 to July 2022. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread	(1)	(2)	(3)
Green bond	−1.47**	−1.35***	−1.31***
	(0.65)	(0.40)	(0.09)
Certified	−7.05***	−7.09***	−7.10***
	(1.09)	(0.69)	(0.17)
Bid ask spread	0.43***	0.39***	0.37***
	(0.05)	(0.03)	(0.01)
Time to maturity	2.82***	2.96***	3.02***
	(0.21)	(0.13)	(0.03)
Log(Issue amount)	−1.73**	−1.80***	−1.82***
	(0.71)	(0.44)	(0.11)
Coupon rate	−0.19	−0.15	−0.13
	(1.14)	(0.69)	(0.17)
Rating FE	YES	YES	YES
Currency FE	YES	YES	YES
Issuer FE	YES	YES	YES
Quarter FE	YES	NO	NO
Month FE	NO	YES	NO
Day FE	NO	NO	YES
R-squared	0.6019	0.6172	0.6230
Bonds	688	688	688
Observations	346,418	346,418	346,418

Table 7

Environmental impact and bond spreads. This table presents the results of a panel regression model examining the determinants of daily yield spread, focusing on the interaction between green bonds and environmental impact. The explanatory variables include a Green Bond dummy, interaction terms between Green Bond and environmental impact measured as Impact (defined as industries with at least one environmental materiality issue identified by SASB) and High Impact (defined as industries with 3 or more environmental materiality issues identified by SASB), a Certified dummy, and interaction terms between Certified and the impact dummies. Other control variables include the bid–ask spread, time to maturity in years, the natural logarithm of the issue amount, the coupon rate, and various combinations of fixed effects. Sample period: January 2014 to July 2022. Standard errors clustered at the quarter-issuer, and month-issuer levels are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread	(1)	(2)	(3)	(4)
*Green bond*Impact*	1.94	1.92**		
	(1.57)	(0.96)		
*Certified*Impact*	−2.51	−2.32		
	(2.53)	(1.57)		
*Green bond*High Impact*			5.15**	5.20***
			(2.16)	(1.34)
*Certified*High Impact*			−12.58**	−12.47***
			(5.85)	(3.57)
Green bond	−2.22***	−2.10***	−2.13***	−2.03***
	(0.61)	(0.38)	(0.66)	(0.41)
Certified	−6.22***	−6.32***	−5.92***	−5.96***
	(1.26)	(0.80)	(1.09)	(0.69)
Bid ask spread	0.43***	0.39***	0.43***	0.39***
	(0.05)	(0.03)	(0.05)	(0.03)
Time to maturity	2.84***	2.98***	2.86***	3.00***
	(0.21)	(0.13)	(0.21)	(0.13)
Log(Issue amount)	−1.82**	−1.89***	−1.84**	−1.91***
	(0.73)	(0.45)	(0.72)	(0.44)
Coupon rate	−0.11	−0.07	−0.27	−0.23
	(1.16)	(0.70)	(1.14)	(0.69)
Rating FE	YES	YES	YES	YES
Currency FE	YES	YES	YES	YES
Issuer FE	YES	YES	YES	YES
Quarter FE	YES	NO	YES	NO
Month FE	NO	YES	NO	YES
R-squared	0.6020	0.6172	0.6021	0.6174
Bonds	688	688	688	688
Observations	346,418	346,418	346,418	346,418

Furthermore, previous literature suggests that the industry sector of the borrower also plays a significant role in determining the strength of the greenium. Investors demonstrate a marked preference for green instruments issued by environmentally unfriendly sectors (Ehlers & Packer, 2017; Sangiorgi & Schopohl, 2021). To investigate this, we further refine our analysis by incorporating the Sustainability Accounting Standards Board (SASB) materiality framework, which categorises industries based on their environmental impact. Specifically, we define two dummy variables:

- **Impact**—for industries with at least one environmental materiality issue identified by SASB,
- **High Impact**—for industries with 3 or more environmental materiality issues, indicating significant exposure to environmental issues.

To assess whether the greenium differs across industries with varying environmental impacts, we interact these dummy variables with the key variables of interest: *Green Bond* and *Certified*. The inclusion of these interaction terms allows us to explore whether industries with higher environmental relevance exhibit a stronger or weaker greenium relative to less impactful industries.

The results from this extended regression analysis are presented in Table 7. It is important to note that the stand-alone variables *Impact* and *High Impact* are omitted from the regression due to the inclusion of issuer fixed effects. From Column (1) of the table, where quarter-by-year fixed effects are used, the yield differential for green, certified bonds in industries with environmental impact can be computed as the sum of the relevant coefficients: −2.22 for the green bond dummy, 1.94 for the interaction between green bonds and environmental impact, −6.22 for the certified bond dummy, and −2.51 for the interaction between certification and environmental impact. These coefficients sum to −9.01 basis points (standard deviation: 1.63; p-value < 0.01), indicating that certified green bonds in industries with environmental concerns enjoy a substantial greenium, reducing the yield spread by 9 basis points relative to conventional bonds in the same industries. This result highlights the critical role that certification plays in assuring investors of the credibility of green bonds, particularly in environmentally impactful industries. In contrast, green, non-certified bonds in industries with environmental impact in Column (1) show no significant greenium, with the sum of the relevant coefficients (−2.22 for the green bond dummy and 1.94 for the interaction term) equalling −0.28 basis points (standard deviation: 1.42). We reach the same conclusion when we use month-by-year fixed effects (Table 7, column 2). When focusing on high-environmental-impact industries, the yield differential of green, certified bonds increases to −15.49 basis points (standard deviation: 5.47; p-value < 0.01) with quarter-by-year fixed effects (column 3), and −15.26 basis points (standard deviation: 3.33; p-value < 0.01) with month-by-year fixed effects (column 4). Conversely, green, non-certified bonds do not enjoy the same favourable treatment in environmental-impact industries, with a yield differential of 3.01 basis points (standard deviation: 2.09) and 3.17 basis points (standard deviation: 1.30; p-value < 0.05), for quarter-by-year and month-by-year fixed effects respectively, indicating. in the latter case, a statistically significant green discount for non-certified green bonds in high-impact industries.

To facilitate the understanding of these effects, we summarise the greenium calculations in Table A2 in the Appendix. The results confirm that certified green bonds consistently exhibit a substantial greenium across all specifications, but the magnitude of the greenium is particularly pronounced in industries with high environmental impact (SASB $\geq$ 3). This is evident in both the quarter-year and month-year fixed effects models, where the certification of bonds in these environmentally impactful industries results in a greenium exceeding 15 basis points. Conversely, non-certified green bonds do not enjoy the same favourable treatment in environmental-impact industries. If we consider the bonds issued in highly environmental impactful industries, in fact, the data suggest that these bonds are viewed with scepticism by investors. For instance, in the quarter-year fixed effects model (Panel A) the spread differential changes sign and becomes positive—albeit it is not significant. In the month-year fixed effects model (Panel B) it even reaches a spread increase of over +3 basis points, significant at the 5% level (*green discount*). This result implies that without certification, the green label alone does not suffice to convince investors of the bond's environmental credibility, probably highlighting concerns over greenwashing.

4.4. Disaster events

Next, we investigate whether the occurrence of significant climate-related natural disasters in the issuer's country is associated with dynamic fluctuations in the greenium of green bonds. To do so, we introduce two variables in our baseline specification: *Dummy 5 days post-disaster* and *Log(Damages in $m)*. The former variable is equal to 1 in the five days following the occurrence of a climate-related natural disaster in the issuer's country, while the latter is the natural logarithm of damages in million dollars caused by disasters, calculated for the 5-day period immediately following each disaster event and set to zero otherwise. We obtain information on the occurrence and damages caused by such disasters from EM-DAT (Guha-Sapir, Below, & Hoyois, 2009), a well-known and widely used database on natural disasters. Fig.

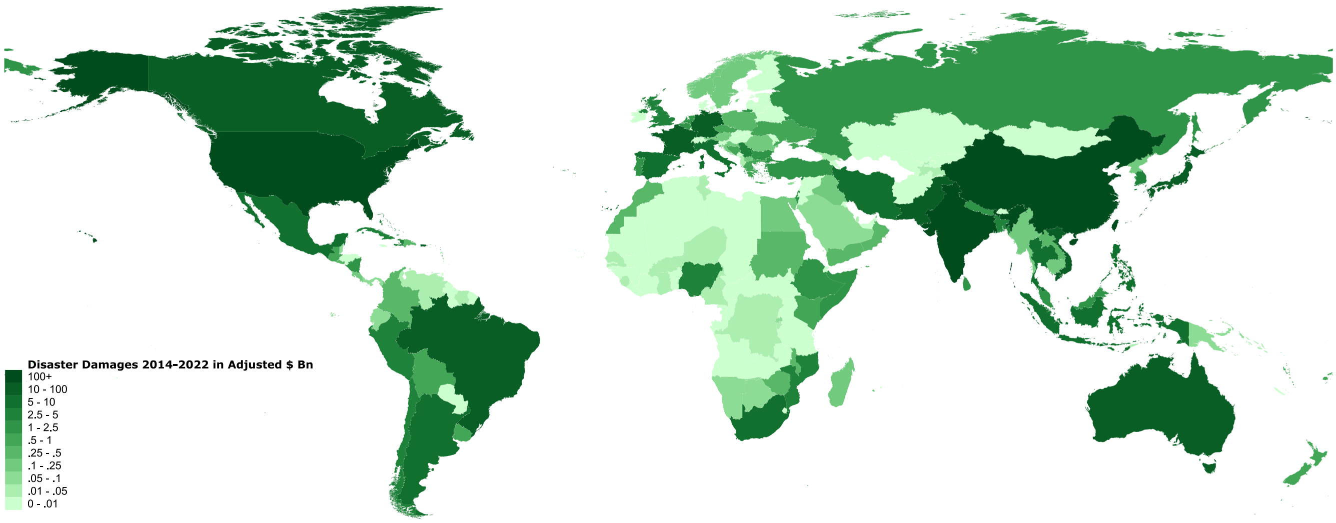

Fig. 2. Global distribution of cumulative climate-related disaster damages by country (2014–2022). This choropleth map displays the cumulative estimated disaster damages in adjusted billion dollars by country worldwide from 2014 to 2022, due to climatological, hydrological, and meteorological natural disasters. The darker the green shade, the greater the damage recorded. Data sourced from the Emergency Events Database (EM-DAT), Centre for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain, Brussels, Belgium.

2 displays the cumulative estimated disaster damages by country worldwide in the period studied. By including these variables in our analysis, we aim to test whether not only the occurrence (Hypothesis 4a) but also the intensity of climate-related natural disasters (Hypothesis 4b) play a role in affecting the magnitude of the greenium.

We carry out three models to scrutinise the effects of the green bond label and disaster events on the yield spread of bonds (Table 8). In all our specifications, we include controls for the bid–ask spread, years to maturity, log of issue amount, bond rating, coupon rate, and implemented fixed effects for issuer and currency. In the first model, we include a green bond dummy variable, a certified green bond dummy variable, and a dummy variable marking five days post-disaster events. Certifications significantly diminish the yield spread, whereas uncertified green bonds see a smaller spread reduction. The disaster dummy variable ranges between 4.36 and 5.34 bps, indicating an increase in the yield spreads in the 5 days following a natural disaster for those bonds issued by companies based in the country affected by the disaster. Additionally, across all specifications, the interaction between certified green bonds and the post-disaster dummy is negative and statistically significant (ranging from −14.40 to −13.90 across the three specifications). Specifically, in column (1), the overall effect of the occurrence of disasters on certified green bonds can be computed as 4.36 - 14.40 = −10.03 bps (Wald t-test −3.06; p-value: 0.002).[8] This indicates that certification more than compensates for the negative impact of natural disasters on the bond spread. Certified green bonds become more attractive to investors than other bonds in such circumstances. The resilience of certified green bonds — demonstrated by the 10.03 bps reduction in yield spreads following disasters — suggests they are less vulnerable to the impact of disasters on bond prices.

Table 9 examines Hypothesis 4b by incorporating *Log(Damages in $m)*, which significantly influences the yield spread across all specifications. The interaction between certified green bonds and this measure of damages shows a statistically significant negative impact. Specifically, in specification (1), the net effect on yield spread for certified bonds — considering both the direct impact of damages (0.72) and their interaction with certification (−2.11) — is −1.39 bps (Wald t-test:

Table 8
Extreme weather events and bond spreads. This table presents panel regressions examining the impact of green bond issuance, disaster events, and certification on bond yield spreads. The analysis employs a Green Bond dummy (1 for green bonds), a Certified dummy (1 for certified bonds with external verification), the dummy "5 days post-disaster" that equals 1 in the five days following extreme weather events as reported in EM-DAT. Each column tests the relationship under different time fixed effect: quarterly (Column 1), monthly (Column 2) and daily (Column 3), with corresponding standard errors clustered at both the quarter-issuer, month-issuer, and day-issuer levels. Control variables include bid–ask spread, years to maturity, natural logarithm of issue amount, and coupon rate, alongside rating, issuer and currency fixed effects. The period of analysis extends from January 2014 to July 2022. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread	(1)	(2)	(3)
Green bond	−1.47**	−1.34***	−1.30***
	(0.66)	(0.41)	(0.10)
Certified	−6.61***	−6.67***	−6.67***
	(1.09)	(0.69)	(0.18)
5 days post-disaster	4.36***	4.73***	5.34***
	(1.51)	(1.13)	(0.59)
*Green bond*5 days post-disaster*	0.13	−0.07	−0.10
	(1.10)	(0.84)	(0.40)
*Certified*5 days post-disaster*	−14.40***	−13.90***	−14.21***
	(3.23)	(2.53)	(1.21)
Bid ask spread	0.43***	0.39***	0.37***
	(0.05)	(0.03)	(0.01)
Time to maturity	2.82***	2.96***	3.02***
	(0.21)	(0.13)	(0.03)
Log(Issue amount)	−1.73**	−1.80***	−1.82***
	(0.71)	(0.44)	(0.11)
Coupon rate	−0.21	−0.16	−0.15
	(1.14)	(0.69)	(0.17)
Rating FE	YES	YES	YES
Currency FE	YES	YES	YES
Issuer FE	YES	YES	YES
Quarter FE	YES	NO	NO
Month FE	NO	YES	NO
Day FE	NO	NO	YES
R-squared	0.6022	0.6175	0.6232
Bonds	688	688	688
Observations	346,418	346,418	346,418

[8] Similarly, in specification (2), the net effect is 4.73 - 13.90 = −9.17 bps (Wald t-test: −3.58; p-value < 0.01), and in specification (3), the net effect is 5.34 - 14.21 = −8.87 bps (Wald t-test: −7.21; p-value < 0.01).

Table 9

Intensity of weather events and bond spreads. This table presents panel regressions examining the impact of green bond issuance, disaster events, and certification on bond yield spreads. The analysis employs a Green Bond dummy (1 for green bonds), a Certified dummy (1 for certified bonds with external verification), *Log(Damages in $m)*, which represents the natural logarithm of damages in million dollars caused by disasters, calculated for the 5-day period immediately following each disaster event and set to zero otherwise. Each column tests the relationship under different time fixed effect: quarterly (Column 1), monthly (Column 2) and daily (Column 3), with corresponding standard errors clustered at both the quarter-issuer, month-issuer, and day-issuer levels. Control variables include bid–ask spread, years to maturity, natural logarithm of issue amount, and coupon rate, alongside rating, issuer and currency fixed effects. The period of analysis extends from January 2014 to July 2022. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread	(1)	(2)	(3)
Green bond	−1.46**	−1.37***	−1.29***
	(0.66)	(0.40)	(0.10)
Certified	−6.64***	−6.74***	−6.70***
	(1.08)	(0.68)	(0.18)
Log(Damages in $m)	0.72***	0.77***	0.86***
	(0.20)	(0.16)	(0.09)
*Green bond*Log(Damages in $m)*	−0.02	0.08	−0.05
	(0.17)	(0.14)	(0.06)
*Certified*Log(Damages in $m)*	−2.11***	−1.72***	−2.08***
	(0.43)	(0.39)	(0.18)
Bid ask spread	0.43***	0.39***	0.37***
	(0.05)	(0.03)	(0.01)
Time to maturity	2.82***	2.96***	3.02***
	(0.21)	(0.13)	(0.03)
Log(Issue amount)	−1.73**	−1.80***	−1.82***
	(0.71)	(0.44)	(0.11)
Coupon rate	−0.21	−0.16	−0.15
	(1.14)	(0.69)	(0.17)
Rating FE	YES	YES	YES
Currency FE	YES	YES	YES
Issuer FE	YES	YES	YES
Quarter FE	YES	NO	NO
Month FE	NO	YES	NO
Day FE	NO	NO	YES
R-squared	0.6022	0.6175	0.6233
Bonds	688	688	688
Observations	346,418	346,418	346,418

−3.22; p-value: < 0.01). This pattern is consistent in specification 2, showing a net effect of −1.27 bps (Wald t-test: −3.52; p-value: < 0.01), and in specification 3, with a net effect of −1.22 bps (Wald t-test: −6.67; p-value: < 0.01).

Figs. 3, 4 and 5 illustrate the estimated margins from specifications (1), (2), and (3) respectively, comparing yield spreads for certified green, uncertified green, and conventional bonds across different percentiles of the variable Log(Damages in $m). As shown in Fig. 3, for uncertified green bonds and conventional bonds, the yield spread increases with the damage percentiles. Specifically, the marginal effect of the yield spread rises from approximately 76 basis points with no damages to around 83 bps at the 99th percentile of damages for uncertified green bonds, and to 81 bps for conventional bonds. In contrast, for certified green bonds, the yield spread decreases with increasing damage percentiles, starting at approximately 69 bps with no damages and decreasing to about 55 bps at the 99th percentile of damages. These patterns are consistently observed in Figs. 4 and 5 as well.

Overall, green bonds are seen to enjoy a narrower yield spread, while certified green bonds reap a larger greenium. Disaster events in the issuer's country increase bond spreads in the five days following their occurrence. The size of the damages caused by disasters also plays a role in increasing the spread. The positive and statistically significant effect of the variables *Dummy 5 days post-disaster* and *Log(Damages in $m)* on bond spreads can be explained by the increased uncertainty and risk associated with natural disasters. When disasters strike, there is often significant damage to infrastructure and property, which can lead to disruptions in economic activity and uncertainty about the future prospects of the affected country (e.g., Botzen and Van Den Bergh, 2009). Moreover, the occurrence of natural disasters can generate a sense of fear, uncertainty, and negative sentiment among investors, even those who are not directly affected by the disaster (Noy, 2009). This sentiment can lead to a risk-off environment, where investors become more risk-averse and demand higher yields to compensate for the perceived increased risk (Johar et al., 2022). The sustainability aspect signalled by certified green bonds is particularly attractive to investors in the aftermath of natural disasters, as these bonds could potentially curtail the impact of future disaster and contribute to rebuilding efforts (IMF, 2021). The interaction between certification and Log(Damages in $m) suggests that the certification's effect is magnified by the severity of the damages caused by natural disasters. This pattern aligns with the idea that investors may favour environmentally sustainable bonds after disasters causing substantial environmental impact. As a result, investing in certified green bonds may be a viable hedging strategy for investors seeking to mitigate the negative impact of natural disasters on their bond investments.

4.5. Heightened public attention to climate change

Building on these findings, we continue testing Hypothesis 5a and 5b, which aim to examine the relationship between periods of heightened public attention to climate change and bonds of green issuers. These hypotheses are motivated by the belief that heightened public attention to climate change may lead to greater demand for green investments. In order to test this, we utilise the MeCCO World Index[9] (Boykoff et al., 2020) as a proxy for the level of public attention to climate change in a given month. MeCCO stands for Media and Climate Change Observatory, which is a research project that tracks media coverage of climate change around the world. The MeCCO World Index is a monthly index that summarises the volume and themes of climate change coverage in 45 countries and regions around the world. The index is calculated based on data collected from a range of sources, including newspapers, television, radio, and online news outlets. The MeCCO World Index is used by researchers, policymakers, and journalists to analyse trends in climate change coverage and public perceptions of climate change around the world (e.g. Romanello et al., 2022; Watts et al., 2021). As displayed in Fig. 6, this index captures global media coverage of climate change and can help gauge the extent to which climate change is receiving public attention. To address the mismatch in the frequency of our independent variable (the monthly MeCCO Index) and our dependent variable (daily yield spreads), we average daily spreads to obtain a monthly average. This approach ensures that each observation of the dependent variable corresponds appropriately in time to our key independent variable, avoiding the potential forward-looking bias that could arise from using daily data in conjunction with a monthly index. Moreover, given the global coverage of MeCCO Index, employing monthly fixed effects in our regression analysis would result in the complete absorption of this key variable. To be able to capture the impact of the MeCCO Index, we opted for quarterly fixed effects. By examining the relationship between the MeCCO World Index and the issuance of green bonds, we can test whether increased public attention to climate change translates into greater demand for green investments.

The regression results, presented in Table 10, demonstrate that both conventional and green bonds benefit from increased attention to climate change, as measured by the climate news index. This heightened attention leads to a reduction in their yield spreads. Specifically, in

[9] Source: MeCCO.

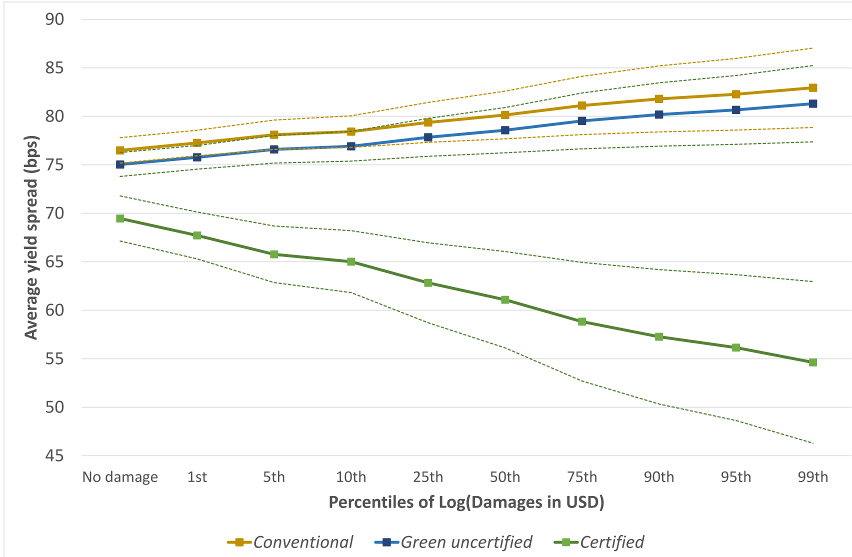

Fig. 3. Relationship between severity of climate events and average yield spreads. The figure shows the marginal effects of yield spreads for certified bonds, uncertified green bonds and conventional bonds for different percentiles of Log(Damages in m$). Marginal effects are obtained from model specification (1) in Table 9 respectively. The solid lines represent the mean values, while the dotted lines represent the 95% confidence intervals.

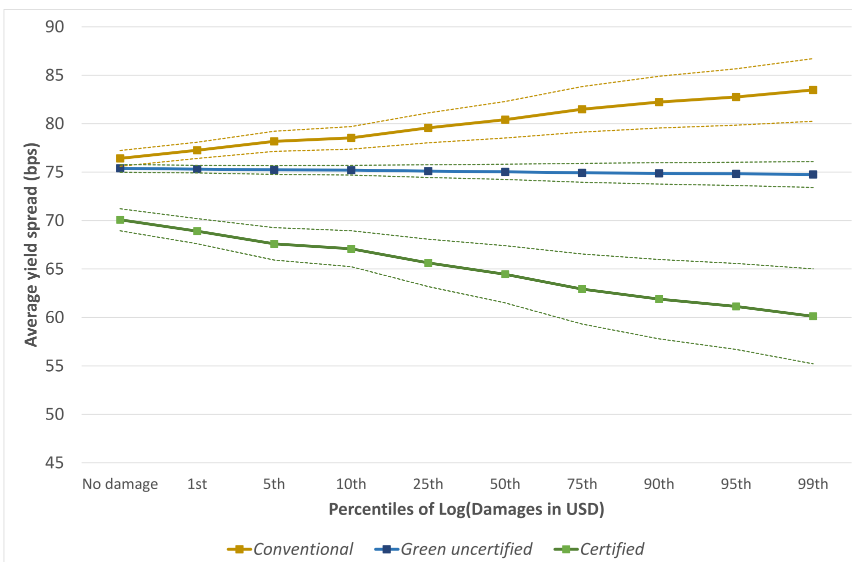

Fig. 4. Relationship between severity of climate events and average yield spreads. The figure shows the marginal effects of yield spreads for certified bonds, uncertified green bonds and conventional bonds for different percentiles of Log(Damages in m$). Marginal effects are obtained from model specification (2) in Table 9 respectively. The solid lines represent the mean values, while the dotted lines represent the 95% confidence intervals.

column (1) the negative coefficient of the index (−10.03) indicates the news effect on conventional bonds, while the lack of significance of the coefficient of the interaction between the index and the Green Bond dummy suggests that the news effect remains unchanged for green bonds. However, the statistical significance of the interaction between the climate news index and the Certified dummy at −19.71 provides evidence that certified green bonds outperform both conventional bonds and non-certified green bonds during periods of heightened public attention to climate change. In column (2), we corroborate the findings using the Innovations on MeCCO index[10] in place of the percentage change on the same index. This result can be explained by the green bond signalling theory as described in Flammer (2021), which suggests that by issuing green bonds companies can credibly signal their commitment to environmental sustainability. This signal extends beyond the specific green project financed by the bond and represents an overall business strategy that emphasises the commitment to environment and the sustainability of the company. As public attention to climate change intensifies, this commitment may increase the perceived value of all bonds issued by these companies, not just their green bonds, leading to a reduction in the yield spread.

The negative coefficient for the interaction between the MeCCO World Index and the Certified status indicates that certification's impact on reducing yield spreads intensifies during periods of heightened public attention to climate change. To understand the economic significance of these coefficients, we consider the standard deviation of the Rel. Δ MeCCO Index, which is 0.21, as reported in Table 2. A standard deviation increase in the Rel. Δ MeCCO Index corresponds to a yield spread reduction of approximately 2.1 basis points (bps)

[10] A variable representing the innovations on the MeCCO World index, derived from the residuals of an AR1 model on the index.

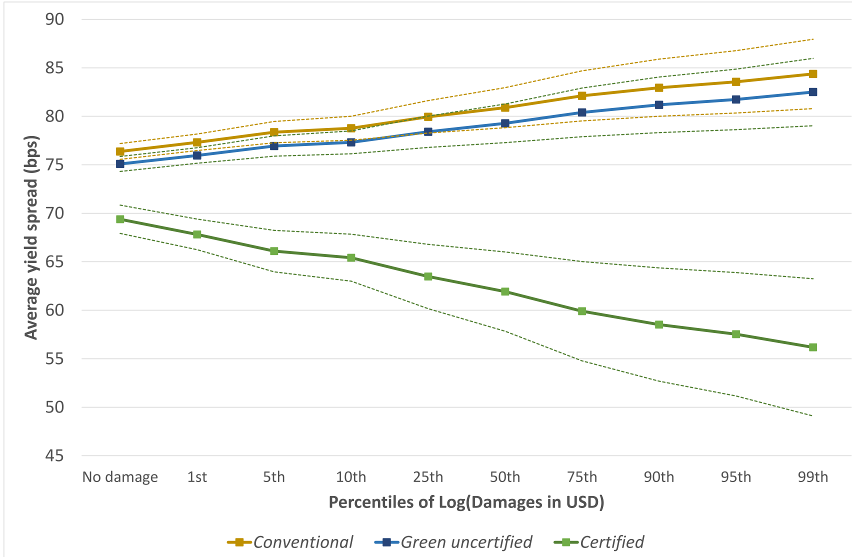

Fig. 5. Relationship between severity of climate events and average yield spreads. The figure shows the marginal effects of yield spreads for certified bonds, uncertified green bonds and conventional bonds for different percentiles of Log(Damages in m$). Marginal effects are obtained from model specification (3) in Table 9 respectively. The solid lines represent the mean values, while the dotted lines represent the 95% confidence intervals.

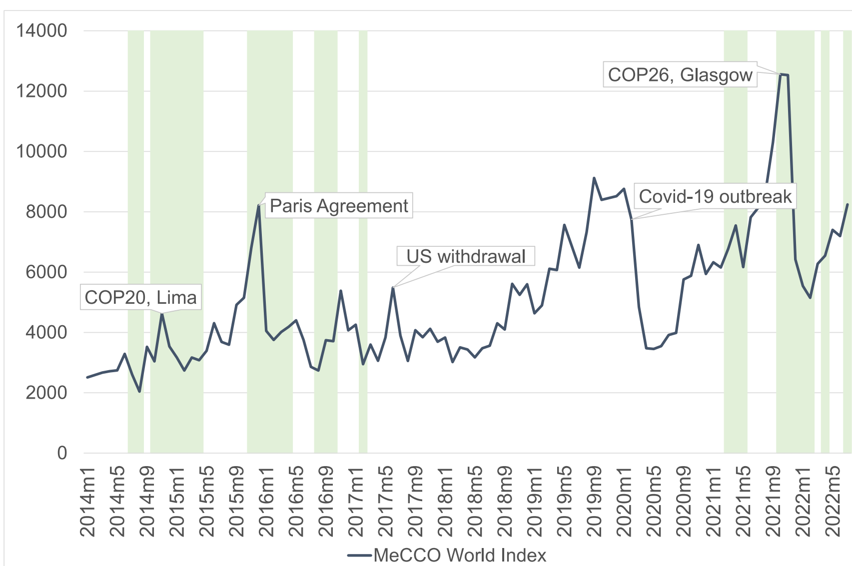

Fig. 6. Media coverage related to climate risk and greenium. This figure displays the Media and Climate Change Observatory (MeCCO) World Index over time, measuring the amount of media coverage related to climate change in major newspapers. The light green shaded background highlights the months during which the greenium is statistically significant at the 10% level. Sample period: January 2014 to July 2022.

for conventional and non-certified green bonds.[11] For certified green bonds, the reduction is more pronounced at 6.25 bps.[12] This translates to 2.77% and 8.23%, respectively, of the average bond yield spreads in our sample. In specification (2), a standard deviation increase in the Innovations on the MeCCO Index leads to a yield spread reduction of approximately 1.35 bps for conventional and non-certified green bonds.[13] Certified green bonds see a larger decrease of 3.82 bps.[14]

4.6. Robustness tests

This section presents a series of robustness tests designed to assess the impact of varying fixed effects, the exclusion of specific time periods, and the consideration of different time windows post-disaster events, among other factors. Below, we detail each of these robustness checks and their implications for our analysis.

Robustness with country, industry, and issuer×time fixed effects. Building on our comprehensive matching strategy, we further tested the robustness of our results by replacing issuer fixed effects with country, industry, and country×industry fixed effects to capture potential country- and industry-specific influences on yield spreads. As shown in Table A3, the inclusion of country and industry fixed effects

[11] Calculated as 0.21×10.03.
[12] Calculated as $0.21 \times (19.71 + 10.03)$.
[13] Calculated as 1124.23×0.0012.
[14] Calculated as $1124.23 \times (0.0012 + 0.0022)$.

Table 10

Climate change news. This table reports panel regressions of daily corporate bond yield spreads on the Media and Climate Change Observatory (MeCCO) World Index, a news-based indicator of climate change awareness. The explanatory variables include the Rel. Δ MeCCO index which is the percentage change in the MeCCO World index (1); Innovations on the MeCCO index (2) which are the innovations of the MeCCO index derived from the residuals of an AR1 model applied to the index; a Green Bond dummy, which equals 1 if a bond is green; a Certified dummy, which equals 1 for certified bonds; the bid–ask spread; years to maturity; the natural logarithm of the issue amount and coupon rate. Differently from the previous regression models, this analysis utilises monthly average yield spreads for each bond. Consequently, the refined sample consists of 21,016 observations. Due to the MeCCO Index being a monthly global measure, fixed effects are set at the quarterly level to prevent the complete absorption of the MeCCO Index in our regression model. Sample period: January 2014 to July 2022. Standard errors clustered at the quarter-issuer level are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Dep. variable: Yield spread (monthly avg)	(1)	(2)
Green bond	−1.7449***	−1.7472***
	(0.6182)	(0.6197)
Certified	−5.7329***	−5.7915***
	(1.0426)	(1.0422)
Rel. Δ MeCCO index	−10.0321***	
	(1.7399)	
*Green bond*Rel. Δ MeCCO index*	2.2257	
	(1.8238)	
*Certified*Rel. Δ MeCCO index*	−19.7077***	
	(6.4365)	
Innovations on MeCCO index		−0.0012***
		(0.0003)
*Green bond*Innovations on MeCCO index*		0.0003
		(0.0003)
*Certified*Innovations on MeCCO index*		−0.0022**
		(0.0009)
Rating FE	YES	YES
Currency FE	YES	YES
Issuer FE	YES	YES
Quarter FE	YES	YES
R-squared	0.6197	0.6029
Bonds	688	688
Observations	21,016	21,016

demonstrates that the greenium remains significant and robust. The coefficient for the Certified variable remains negative and statistically significant in all specifications. Additionally, we applied more granular fixed effects by incorporating quarter × issuer and month × issuer fixed effects, as detailed in Table A13. These refined models were designed to control for any residual unobserved heterogeneity at the issuer level. As with the sector and country fixed effects, this approach did not alter the primary conclusions, further demonstrating the robustness of our findings to variations in the control for unobservable factors.

Exclusion of negative yield spread observations. As seen from the minimum value of the yield spread in Table 2, we observe instances where bonds exhibit a negative yield spread compared to government bonds. Negative yield spreads can indicate illiquidity, which may influence our results. To indirectly account for this, we include bid–ask spreads in our analysis, serving as a measure of liquidity risk. In addition, we have also conducted a test excluding all pair-day observations for which at least one bond in the pair had negative yield spreads. This led to a reduction in our sample size from 346,418 to 335,394 observations. This robustness test, reported in Table A4 of the appendix, supports our initial findings, reinforcing that the observed lower spread for green bonds holds true even when instances of negative yield spreads are excluded.

Exclusion of the Paris Agreement period. Recognising the potential impact of the Paris Agreement on the greenium, we conducted a robustness test by excluding the 12-month period following the COP21 (November 2015 to October 2016). The analysis, shown in Table A5, demonstrates that the greenium persists across all specifications, albeit with a slight reduction of about one-tenth of a basis point. This suggests that the presence of the greenium in the market is robust beyond this significant environmental policy event.

Controlling for ESG Scores. To account for the potential influence of corporate governance and firm-specific ESG performance on bond spreads, we incorporate time-varying ESG score grades from Refinitiv in our robustness tests, as presented in Table A6. The results confirm that the inclusion of ESG scores does not materially affect the relationship between green bond certification and bond spreads, further supporting the robustness of our baseline findings across different model specifications.[15]

Alternative liquidity measures. To investigate the impact of alternative liquidity measures on the greenium, we employ three distinct illiquidity proxies, as presented in Table A7, and Table A8. In Table A7, Columns (1) and (4) use *Market illiquidity*, measured as the weighted average bid–ask spread across bonds in the market by outstanding amount. Columns (2) and (5) control for *Issuer illiquidity*, defined as the daily average bid–ask spread of each issuer. In Columns (3) and (6), we include γ *illiquidity*, based on the measure proposed by Bao et al. (2011). This last illiquidity measure is defined as:

$$\gamma = -\text{Cov}(\Delta p_t, \Delta p_{t+1})$$

where p_t represents the natural logarithm of the bond's clean price. We further assess the effects of liquidity shocks, measured with our alternative indicators, during disaster events. Results are reported in Table A8 and confirm our previous conclusions. In addition, we test the interactions of the Green Bond and Certified dummies with the bid–ask spread in Table A9. The interaction terms are not statistically significant in any of these specifications.

Linearity assumption and quantile regression test. While much of the literature has focused on linear models to analyse the determinants of bond yield spreads (e.g., Caramichael & Rapp, 2024; Fatica & Panzica, 2021; Gianfrate & Peri, 2019; Hachenberg & Schiereck, 2018; Karpf & Mandel, 2018; Pietsch & Salakhova, 2022; Zerbib, 2019), we extend our analysis using quantile regression to explore whether the impact of green bond status varies across different points of the conditional distribution of yield spreads. Quantile regression allows us to capture potential heterogeneity in the effects of covariates, which may be missed by a linear model that only examines the average effect. Our results, presented in Table A10, demonstrate that the greenium is consistently negative and statistically significant across different quantiles (10th, 25th, 50th, 75th, and 90th). This suggests that the greenium is not only present on average but is also robust across the conditional distribution of yield spreads, indicating that investors value green bonds similarly across bonds with both lower and higher yield spreads. These findings highlight the robustness of the greenium beyond linear models, supporting its relevance in different market conditions.

Green certification with issuer-time fixed effects. The effect of green certification on bond spreads was further examined under different issuer-time fixed effects, as reported in Table A13. This analysis reaffirms the influence of green certification, supporting the robustness of our baseline findings under various model specifications.

Extreme weather events. The robustness of our findings concerning the impact of extreme weather events on bond spreads was tested over different time windows (3-day and 7-day post-disaster dummies). Tables A11 and A12 present these analyses, underscoring the consistent effect of extreme weather events and the certification of green bonds

[15] It is important to note that the ESG scores provided by Refinitiv may be subject to backfilling, as highlighted by Berg, Fabisik, and Sautner (2021). This means that the historical scores available today may differ from the ratings investors had access to in real-time during the sample period. While this limitation should be considered when interpreting the results, the robustness tests incorporating ESG ratings still offer useful insights into the role of firm-level ESG performance in bond pricing.

on yield spreads. Furthermore, we tested the robustness of the original models including the *5 days post-disaster* and the *Log(Damages in $m)* under more granular fixed effects. The tests are displayed in Tables A14 and A15, which confirm the relationship between extreme weather events and yield spreads.

Climate Change News Impact. Finally, we tested the robustness of the relationship between climate change news coverage, as captured by the MeCCO World Index, and corporate bond yield spreads. The analyses, utilising quarter× issuer fixed effects and presented in Table A16, confirm the significance of climate change awareness on financial markets, reinforcing our primary analyses under alternative specifications.

Taken together, these robustness tests strengthen our findings. The consistency of results across these tests underscores the robust nature of the greenium and its determinants in the corporate bond market.

5. Conclusion

In our study, we have undertaken an in-depth analysis of the secondary market for corporate green bonds and its underlying dynamics. Our results corroborate the existence of a greenium in the secondary bond market, demonstrating that green bonds generally trade at a premium in comparison to their conventional counterparts. Further, we have identified dynamic fluctuations in the greenium over time, which correspond to major climate change-related events and policy decisions. A striking example of this was the increased greenium around the time of the 2015 Paris Agreement. This result points to the substantial influence that environmental policy changes and climate events can exert on the market sentiment towards green bonds. We also confirm the importance of the external review process in the green bond market. Bonds that have been externally reviewed exhibit an (up to five time) larger greenium than non-certified bonds. This highlights the significance of third-party certification and verification mechanisms in promoting investor trust, incentivising issuers to adhere to high environmental standards and preventing greenwashing practices. Our results show that in environmentally material industries, certified green bonds benefit from an even larger greenium, whereas non-certified green bonds in these industries may face scepticism and, in some cases, even a discount due to concerns over greenwashing. These findings suggest a potential path for governments to shape green bond regulations by advancing rigorous certification requirements or incentivising certification for green bonds, particularly in high-impact industries. Such regulatory approaches could enhance transparency in the green bond market, reduce greenwashing risk, and increase the credibility of climate-focused finance. Aligning green bond market practices with established certification standards may further encourage capital flow towards sustainable projects, thereby supporting climate goals.

Furthermore, this study brings to light the complex nature of the elements influencing green bonds' performance, particularly focusing on the effects of natural disasters and climate change news on bond spreads. The effect of natural disasters in the bond market is complex. Generally, disasters result in increased bond spreads due to various factors like amplified market uncertainty and risk, potential indirect impacts on the issuer through disruptions in supply chains or other economic consequences, leading to diminished demand for bonds from the affected countries. Yet, certified green bonds can also garner a 'green premium' during these events, with the scale of this premium directly being influenced by the extent of disaster damages. These findings underscore the importance in evaluating disaster risk and the potential benefits that certified green bond holders can gain from hedging against such risks. Therefore, these aspects of our study can offer valuable information for entities considering the issuance of green bonds, investors looking for hedging strategies, and policymakers working towards sustainable finance and disaster resilience.

Considering the role of climate change news, we show that a rise in the MeCCO World index — a proxy for global media attention to climate change — is linked to a positive shift in market sentiment towards environmentally responsible investments, shaping public perception and awareness. As investors become more informed about the environmental risks and opportunities associated with their investments, they start to favour companies that are taking proactive steps to mitigate climate change impacts. This increased demand for environmentally responsible investments translates into lower spreads for green and conventional bonds issued by companies that are actively working to address climate change issues, such as the green issuers in our sample. The effect is even stronger for certified green bonds. Thus, investors can benefit by increasing their holdings in certified green bonds, which typically experience a widening of the greenium and offer opportunities for capital appreciation.

Finally, environmental awareness and concern positively impact investor demand for certified green bonds, which in turn could encourage issuers to prioritise environmental sustainability in their business practices. Corporations may also leverage these insights by strategically timing their green bond issuances to periods of heightened climate awareness, such as around key policy announcements, when investor demand and greenium premiums tend to be more favourable. Such timing could allow companies to secure lower financing costs.

CRediT authorship contribution statement

Massimo Dragotto: Conceptualisation, Methodology, Software, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Alfonso Dufour:** Conceptualisation, Methodology, Writing – review & editing, Supervision. **Simone Varotto:** Conceptualisation, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT for proofreading and to improve the flow of the text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.irfa.2025.104281.

Data availability

No.

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