Green Bond Effects on the CDS Market

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Preliminary Draft
2022-12-29

Abstract

The paper investigates CDS spreads reaction to the type of issued bonds, green or conventional. We use an event study based on the CDS spreads reaction for the green bond issuance. First, we find that there is a green bond effect. That is, CDS spreads decline when a green bond is issued, indicating risk reduction and lower debt cost, but increase when a conventional bond is issued. Moreover, we show that the effect is, on average, twice as negative as the coefficients for conventional bonds issued prior to the first green bonds. Second, we analyze the case of multiple issuances. The firm's credibility and reputation is strongly enhanced with a three or more green bond issuance, leading to the appearance of an additional green discount. Finally, we show that the positive reaction of the CDS spread, observed in the case of green bond issuance, exists also for conventional bonds that are issued after the third green issuance. Thus, the reputation effect leads to a spillover effect, where the CDS spread significantly decline when conventional bonds are also issued.

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1 Introduction

Green bonds are a popular instrument to raise and direct capital towards projects that mitigate the climate change risk. Corporations, government agencies, supranational entities, and municipalities issue these bonds mainly in the US, China, and Europe (Swinkels, 2021). The issuance of green bonds echoes sustainability preference among investors (Hartzmark and Sussman, 2019; Riedl and Smeets, 2017). Riedl and Smeets (2017) document that social, rather than financial, motives explain why investors hold socially responsible mutual funds. Hartzmark and Sussman (2019) show that the demand for mutual funds varies as a function of the funds sustainability ratings. Funds with the highest ratings receive $24 billion greater funds flow, and funds with the lowest ratings experience a $12 billion reduction in fund flows.

A growing body of literature shows that the cost of debt pertained to issuing green bonds is not significantly different from that of issuing conventional bonds. This result implies that while investors are willing to invest in eco-friendly projects, they do not forego investment returns (Larcker and Watts, 2020; Flammer, 2021; Zerbib, 2019). Nevertheless, Caramichael and Rapp (2022) recently found that it emerges as of 2019, accompanied with the growth of the sustainable asset management industry. Another strand of literature analyze the impact of green bonds on stock market using event studies. Number of studies obtained the evidence of positive reaction to a green issuance (Baulkaran, 2019; Glavas, 2020; Flammer, 2021; Daubanes et al., 2021). While this literature relies on bond market or stock market data, we examine the impact of issuing green bonds in the CDS market. Since sophisticated investors dominate the liquid CDS market, and given that CDS spreads have standardized features and reflect the issuer's credit risk, CDS spreads are a relevant alternative to bond yields to measure the cost of debt (Bertoni and Lugo, 2018; Barth et al., 2022).

Avdjiev et al. (2020) find that CDS spread decreases significantly subsequent to an issuance of a contingent convertible bond. This type of bonds improves issuer's balance sheet and investors in CDS market would take this into account. We could expect that issuing green bonds have similar effect on CDS market. In fact, issuing green bonds may signal to investors issuing firms' commitment to shift its activities towards green-compatible ones. Given the increasing demand for environmental-compliant products due to social signaling (Bénabou and Tirole, 2006), firms engaged in green projects are more likely to secure higher profits. Such strategic shifting thus, reduces their distress risk than firms that do not seek to invest in green investment. Firms that do not undertake such transition will be exposed to a variety of risks (Krueger et al., 2020). Moreover, Godfrey et al. (2009) and Hoepner et al. (2018) demonstrated negative relationship between ESG and risk. Issuing green bonds also require to disclosure more information on the firm's investment project, which reduces informational asymmetry between firm and investor in line with the argument of Campbell et al. (2014). Thus, this additional information will improve the perception of investors about the firm's risk, which will have an impact on CDS spreads.

We conduct an event study of CDS spreads reaction to the type of issued bonds, green or conventional. We limit the dataset to 5-year maturity CDS of non-financial firms that have issued at least one green bond during the sample period from January 1st, 2011 until December 31, 2021, and are incorporated in North America, Europe, and Japan.[1] To control for the impact not related to our firms, we rely on reference CDS indices associated with the bond issuer's region of incorporation and its rating. Precisely we consider 2 different measures of CDS reaction associated with a given issued bond: i) cumulative adjusted spread return (CAR) (Silaghi et al., 2022); ii) cumulative prediction error (CPE) based on a linear model (Avdjiev et al., 2020; James, 1987). We compare their reaction between the issuance of green bonds and that of conventional bonds. Furthermore, we disentangle the reaction of CDS spreads following the announcement of a new bond issuance from that linked to the bond's features (e.g., amount, seniority, currency, rating), the issuer's characteristics (size, leverage), and the time-varying macroeconomic conditions. We rely on multivariate linear regressions with regional, issuer, and time fixed effects.

First, we examine whether CDS spread react differently upon the type of bonds. As mentioned before, we expect a decrease in CDS spread in the case of green bond issuance. We then investigate the reputation effect by analyzing the dynamics of CDS spreads reaction to multiple issuance of green bonds over time. That is, we study if the effect of green bond, if any, persists to subsequent issues of green bonds. Finally, we analyze whether the green effect is transmitted to conventional bonds. We explain this spillover effect as follows. The firm relies on green bonds to signal the efficiency of its investment strategies (Daubanes et al., 2021). This signal translates into improvement of the issuer's credit risk perception, which contributes to a decrease in the cost of debt of the subsequently issued conventional bonds. As a result, the CDS spread decreases when the green bond is issued, and similar impact on CDS spread appears when a following conventional bond is issued.

Our results are as follows. First, we find that the CDS market reacts differently based on bond type. While the CDS spread increases when a conventional bond is issued, it decreases when a green bond is issued. This is consistent with our hypothesis. This effect is particularly more pronounced for first green bond issuance with respect to the previous conventional bonds. The results show that the effect is largely more negative, on average twice as negative as the coefficients for conventional bonds issued prior to the first green bonds. The effect of the first green bond is also identified by Daubanes et al. (2021), who find that first issuance of green bonds impacts stock returns. When considering all bonds, conventional and green, the CDS spread reaction is no longer crystal-clear, hinting at a possible spillover effect. Second, we investigate the case of multiple issuance. We find that the CDS spread increases following the second green bond issue, but it reverts to be substantially negative in the case of the third and above bond issues. While the first green issue leads to a green discount, the second one does not add much to how firms signal their commitment to green transition. However,

[1] The first corporate green bonds were issued in 2013.

the firm's credibility is strongly enhanced with a three or more green bond issuance, leading to the appearance of an additional green discount. Finally, we show that decrease in the CDS spread, observed in the case of green bond issuance, exists also for conventional bonds that are issued after the third green issuance. Thus, the credibility effect leads to a spillover effect, where the CDS spread becomes negative and significant when conventional bonds are also issued. For all specifications, we use four window sizes to assess the intensity and the duration of the impact. Our results are consistent and robust for all of them.

Our study relates to two strands of the literature. First, we contribute to the literature on the motives of green bonds issuance. Most empirical evidence conclude that the cost of debt is not affected by the green feature of the bond. Analyzing US municipal bonds, Larcker and Watts (2020) find that the greenium is zero. Based on US and Euro bonds, Zerbib (2019) shows that there is a very small negative premium (2 bps). Based on corporate green bonds across the world, Flammer (2021) also finds no impact on the cost of debt for firms issuing green bonds. However, she finds a significantly positive reaction of the stock market to the announcement of green bond issues, particularly for first-time issuers. Tang and Zhang (2020) document that stock prices positively respond to green bond issuance, but they do not find a consistently significant premium for green bonds.

Second, we add to the ongoing research investigating CDS spreads. Barth et al. (2022) document a negatively significant relationship between ESG and credit risk. The effect of bond type is analyzed in Avdjiev et al. (2020) for the case of CoCo bonds. Based on an event study, Avdjiev et al. (2020) find that a CoCo bond issue has a statistically significant impact on the issuer's CDS spread. Further empirical evidence on reactions in the CDS market can be found, for instance, in Silaghi et al. (2022) regarding loan renegotiation announcements, and in Lee et al. (2018) regarding credit rating changes.

The remainder of the paper is structured as follows. In section 2, we develop main hypotheses to test and review the related literature. In section 3, we present the data and empirical approach. Section 4 presents the main results on green bond, reputation and spillover effects. Section 5 concludes.

2 Related literature and hypothesis development

Exposure to environmental risk falls into three dimensions: physical, transitional, and regulatory (Krueger et al., 2020). This risk bears a high cost for firms (Giglio et al., 2021; Ilhan et al., 2021), prompting them to engage in transition toward sustainable businesses (Bénabou and Tirole, 2006, 2010), and thus mitigate this risk (Hoepner et al., 2020; Albuquerque et al., 2019; Sautner et al., 2022). Indeed, Albuquerque et al. (2019) demonstrate that CSR decreases systematic risk and increases firm value. Hoepner et al. (2020) document that a firm's commitment to ESG goals reduces the downside risk of its stock return, thus, its overall risk. Detemple and Kitapbayev (2020) show that switching to green assets improves project value.

Collectively, firms that shift assets from brown to green reap value from both increase in revenues and environmental risk reduction. Everything else being equal, the default probability of firms engaging in the green transition is lower than those that do not.

CDS market provides an ideal setting to measure the firm's credit risk. CDSs are derivative contracts in which protection buyers make regular payments (CDS premium or spread) to protection sellers to insure against the default of a debt issuer (Campello et al., 2018). The onset of CDS trading reduces lenders' incentives to continuously monitor borrowers (Bolton and Oehmke, 2011; Martin and Roychowdhury, 2015) whereas it facilitates for outsiders to observe the risk of default. By switching into green assets, firms will decrease its exposure to environmental risk and will reap positive externalities.

Kölbel et al. (2022) rely on a textual analysis of 10-k report to show that the CDS spreads react to the disclosure of climate change risk. While disclosing the physical risk decreases the CDS spread because of a reduction in uncertainty, revealing the transition risk increases the spread. Barth et al. (2022) document a negatively significant relationship between ESG and credit risk captured by CDS spreads. CDS spreads also react to the type of bonds, as anaylzed in Avdjiev et al. (2020) for the case of CoCo bonds. Based on an event study, Avdjiev et al. (2020) find that a CoCo bond issue has a statistically significant impact on the issuer's CDS spread.[2]

Indeed, disclosure of information reduces the information asymmetry between investors and firms (Campbell et al., 2014; Kölbel et al., 2022). Yu (2005); Bonsall and Miller (2017) find that a firm with higher disclosure on its investment tends to have a lower cost of debt. As issuing green bonds discloses additional information on the green investment project, we could expect similar favorable impact on CDS market. Hence, a firm that embraces the transition to sustainability will reduce its overall risk, reflected in the CDS market, when it issues green bonds.

- **H1a.** The CDS spreads reaction to the bond type, green vs. conventional, captures a green bond effect.

Flammer (2021) provides additional insights on the existence of the green bond effect on equity market. She identifies a substantial effect of the first green bond issuance. Daubanes et al. (2021) reach the same result. We test the reaction of CDS spreads to a firm's issuance of the first green bond.

- **H1b.** There is first green bond effect on CDS market.

The signaling effect explains the importance of the first green bond effect. According to Daubanes et al. (2021), issuing a green bond for the first time brings information about a

[2]Further empirical evidence on reactions in the CDS market can be found, for instance, in Silaghi et al. (2022) regarding loan renegotiation announcements, and in Lee et al. (2018) regarding credit rating changes.

firm's new commitment toward more business appealing to investors. Thus, recurrent issuances of green bonds builds up the commitment's credibility. Firms that frequently issue green bonds will be able to mitigate greenwashing concerns. Therefore, we expect that a certain recurrence level to meet favorable reactions among CDS investors.

- **H2.** Due to the credibility effect, the CDS market reacts more favorably to multiple green bond issuances.

When a firm commits to transitioning its business to an environment-friendly one, it frequently issues green bonds as part of its financing schemes. Thus, it promotes its environmental legitimacy and enhances its credibility among investors (Berrone et al., 2017). De Angelis et al. (2022) show that these firms raise the cost of capital for carbon-intensive firms. In addition, green investors will seek to hold these firms in their portfolios, increasing the demand for bonds issued by these firms. Moreover, recurrent issuance of green bonds increases the information available to investors. As argued above, multiple issuances of green bonds should reduce information asymmetry between firms and investors, and thus such information will be considered when conventional bonds are issued. Investors' positive perception of the firm's risk should thus materialize even in conventional bond issuances.

- **H3**. The reaction of the CDS market to the issuance of conventional bonds benefits from a spillover green bond effect.

3 Data and methodology

Our empirical design investigates whether CDS spreads react differently to the type of bond issued, green or conventional. We complement the analysis by looking at the dynamics of CDS spreads reaction to multiple issuances over time. That is, we explore whether the green bond's effect persists in subsequent issues of green bonds and whether conventional bonds benefit from that effect. Thus, based on an event study, we explore these three effects, green, credibility, and spillover.

3.1 Data

Our dataset is composed of 5-year maturity CDS spreads provided by IHS Markit. Many studies, such as Siriwardane (2019), use the 5-year CDS because of its high liquidity. We limit the dataset to CDS spreads of non-financial firms incorporated in North America, Europe, and Japan, that have issued at least one green bond during the sample period from January 1st, 2011, until December 31, 2021.

We select these three geographical areas because of the liquidity of their CDS markets and the sufficient number of green bonds available. To control for the impact not related to our firms, we rely on CDS indices. For USD-denominated bonds, we consider the CDX North

America IG and HY for investment-grade and speculative-grades or not-rated bonds, respectively. For European bonds, we consider iTraxx Europe for investment-grade bonds and iTraxx Europe XO for speculative-grade or non-rated bonds. Finally, for JPY-denominated bonds, we use iTraxx Japan. We obtain CDS indices from Refinitiv Datastream.

We match the CDS data with bond characteristics data: issuer name, announcement issue date, and bond seniority. Bond data also include the amount issued, denominated currency, initial maturity, and credit ratings at issuance. We restrict our dataset to bonds issued in the following currencies: US dollars (USD), euro (EUR), sterling pounds (GBP), Swiss franc (CHF), Swedish krona (SEK), Norwegian krone (NOK), and Japanese yen (JPY). Following the literature, Lee et al. (2018) and Gredil et al. (2022), we convert credit ratings to numerical scores. We exclude green and conventional bonds announced on the same day by the same issuer. In case of multiple issues of the same bond type, seniority, and currency, announced on the same day by the same issuer, we aggregate the amount issued and use it for the weighted-average maturity and credit rating score. We obtain all this data from Bloomberg. The entire sample has 71 firms that issued 127 green bonds and 1068 conventional bonds, covering around 12% of green bonds from Bloomberg universe for these three regions. [3] Lastly, we obtain firms characteristics from S&P Capital IQ. We match each bond with the issuing firm's characteristics, total assets, and debt ratio, at the time of bond issuance. The number of green and conventional bonds then reduce to 105 and 986, respectively. Matching issuer's characteristics affect little the nature of the sample.[4]

[Table 1 about here.]

Panels A and B of Table 1 provide descriptive statistics by region and by bond rating, respectively. Issuance of green bonds is concentrated in Europe followed by North America and Japan. This is consistent with greater awareness of climate change in Europe than in the US (Bolton and Kacperczyk, 2020). The characteristics of bonds are relatively stable in terms of the amount issued and maturity. The average amount issued differs on the region and the ratings. We have similar observation even after standardizing the size of bond by the size of the issuer measure by total assets. It is largest for North American firms followed by European and Japan peers with important difference for Japan. The average size of a green bond is smaller than that of conventional bonds, which is consistent with the finding by Flammer (2021). In particular, average amount issued of a green bond is twice smaller than that of conventional bond in North America while the difference is much small in the other regions. The size of investment grade bonds is larger than speculative grade ones in average. Extremely long maturity of the green bonds with speculative grade (HY) is explained by the

[3] Prior to matching with CDS data, 386 firms have issued at least once a green bond during the sample period, with a total number of 1076 green bond issues.

[4] Descriptive statistics on the matched sample is available upon request.

fact that the majority of them are perpetual bonds.[5]

[Table 2 about here.]

Table 2 provides descriptive statistics of the main characteristics of the issuers of green bonds in our sample. In this table, we consider only unique firm-year observations by matching issuer of green bonds and announced year with issuer's characteristics at the end of the year prior to the announcement of green bond issuance.[6] North American issuers are bigger than their peers in Europe and Japan in terms of total assets. The leverage ratio of the firms estimated by total debts to total assets is relatively stable across the region.

3.2 Measures of CDS reaction

To measure the CDS reaction, we follow an approach based on an event study. We use the date of announcement of bond issuance as the event date given that all information is disclosed to the market on that date while there is no additional information released on the issue date. We use four window sizes to assess the intensity and the duration of the impact: a short term [-1,1], a window before the event [-10,0] because some information are already available before the official announcement data (Avdjiev et al., 2020), a window [-10,5] to capture equally five days after, and the larger windows [-10,10].

We consider two different measures of a CDS reaction associated with a given bond issuance according to related literature: i) cumulative adjusted spread return (CAR) (Silaghi et al., 2022), and ii) cumulative prediction error (CPE) based on market model (Avdjiev et al., 2020; James, 1987). Our measures of CDS reaction are constructed as follows. We start by computing adjusted returns (AR) and prediction errors (PE). They are based on the bond issuer's CDS spread return adjusted by a reference CDS index, based on currency and rating: CDX IG and CDX HY indices for US firms, iTraxx Europe and iTraxx Europe Crossover for Europeans firms, and iTraxx Japan for Japanese firms. AR is computed as follows:

$$AR_{it} = \frac{\Delta S_{it}}{S_{it-1}} - \frac{\Delta I_{it}}{I_{it-1}}, \tag{1}$$

where S_{it} is the daily five-year maturity CDS spread of the issuer of bond i at date t, I_{it} is the level of the index for the bond i at date t, ΔS_{it} is the change in the CDS spread of the issuer of bond i on day t, computed by $S_{it} - S_{it-1}$, and ΔI_{it} is the change of the index for the bond i on the day t, calculated by $I_{it} - I_{it-1}$. Following (Avdjiev et al., 2020; James, 1987), the prediction error (PE) associated with bond issue i on day t is defined as:

$$PE_{it} = \frac{\Delta S_{it}}{S_{it-1}} - \left(\alpha_i + \beta_i \times \frac{\Delta I_{it}}{I_{it-1}}\right), \tag{2}$$

[5] In order to include perpetual bonds in statistics and regression, we assigned 99 percentile maturity, which is 30.17 years as their maturity.

[6] Decrease in the number of observations is due to multiple issues of green bonds on the same year by the same issuer and absence of firm's characteristics data.

where α_i and β_i are the estimated coefficients from a linear model over an estimation period of 200 business days between $[t-215, t-15]$.

Based on AR and PE, we compute the cumulative AR (CAR) and the cumulative PE (CPE) of firm i over two consecutive days, t_1 and t_2, as follows:

$$CAR_{i,[t_1,t_2]} = \sum_{t=t_1}^{t_2} AR_{it}, \tag{3}$$

$$CPE_{i,[t_1,t_2]} = \sum_{t=t_1}^{t_2} PE_{it}, \tag{4}$$

respectively. If available, we use CDS with no restructuring clause (XR14) for both CAR and CPE, and contracts with other clause types otherwise. In the regression analysis, we control for contract clause type.[7] To avoid any bias from outliers, CAR and CPE are winsorized at their 5th and 95th percentile values. As mentionned before, we use several event windows for robustness of the result: $[-1,1]$, $[-10,0]$, $[-10,5]$. $[-10,10]$.

3.3 Regression Analysis

CDS spreads may be affected not only by the issuance of a new bond, but also by its characteristics (*e.g.*, amount, type, seniority), by the issuer's characteristics (size, credit rating, leverage, industrial sector *etc.*), and by time-varying macroeconomic and market conditions such as the level of interest rates and stock market volatilities (Augustin and Izhakian, 2020; Siriwardane, 2019). To disentangle the reaction of CDS spreads to the announcement of a new bond issuance from the bond's and the issuer's characteristics, we employ the following baseline model including green and conventional bonds:

$$y_{it} = \mu_j + \mu_r + \mu_c + \mu_t + \alpha \times GB_{it} + \beta \times Bond_{it} + \gamma \times Issuer_{it} + \epsilon_{it}, \tag{5}$$

where i indexes bonds, j indexes issuers, r indexes regions, c indexes the type of the CDS contract, t indexes times (quarters) and

$$y_{it} = \begin{cases} \text{Cumulative adjusted spread return of bond } i\text{'s issuer at time } t\ (CAR_{it}) \\ \text{Cumulative prediction error of bond } i\text{'s issuer at time } t\ (CPE_{it}). \end{cases}$$

GB_{it} is a dummy variable that takes the value of 1 for green bonds and 0 otherwise. $Bond_{it}$ are the characteristics of the bond i at time t (maturity, high yield dummy and amount of issuance at date t divided by total asset of issuer at the end of previous year). $Issuer_{it}$ are

[7] CDS with no restructuring clause (XR14) is the standard contract folloowing the CDS Big Bang in April 2009 (Lee et al., 2018; Gündüz et al., 2021; Wang et al., 2021). In addition, XR14 exhibits less missing values than the other CDS contracts in IHS Markit database.

those of bond i's issuer at the end of previous year (leverage ratio). We use fixed effects for the issuer (μ_j), the geographic area (μ_r), the type of the CDS contract (μ_c), and time (μ_t). These time-fixed effects, together with CDS indices incorporated in CAR and CPE, capture time-varying factors. The standard errors of the coefficients are corrected from heteroskedasticity, and clustered at the issuer level. We expect that α is negative if issuing a green bond has a negative impact on the issuer's CDS spread, while issuing a conventional bond has no or a positive impact on CDS spreads.

First, we estimate this baseline model with our full sample (all green and coventional bonds in our sample. Second, we control for the endogenous impact of green bonds on the subsequently issued conventional bonds, that we previously labeled as "spillover effect". For this purpose, we limit our attention to the issuance of conventional bonds in the absence of prior green bond issuance, and we compare them to the first-time green bond issuance. Third, we take more stringent subsample by including the first green bond and the conventional bonds issued immediately prior to the first green bond for each firm to minimize any bias resulting from changes in issuer's characteristics. With the two last regression, we analyze the impact of issuance of first green bonds.

Then, we investigate the effect of multiple issuances of green bonds over time by the same issuer. Specifically, we analyze the persistence of the effect of the first issuance of green bonds to subsequent issues, indicating a "credibility effect".

$$y_{it} = \mu_j + \mu_r + \mu_c + \mu_t + \alpha_1 \times GB1_{it} + \alpha_2 \times GB2_{it} + \alpha_3 \times GB3plus_{it} + \beta \times Bond_{it} + \gamma \times Issuer_{it} + \epsilon_{it}, \tag{6}$$

where $GB1_{it}$ a dummy variable that takes the value of 1 if it is the first green bond of the issuer j and 0 otherwise, $GB2_{it}$ a dummy variable that takes the value of 1 if it is the second green bond of the issuer j and 0 otherwise, and $GB3plus_{it}$ a dummy variable that takes the value of 1 if the issuer j propose a third or more green bonds.[8] A credibility effect should be associated to an increase of the α value ($|\alpha_3| > |\alpha_2| > |\alpha_1|$). As an alternative, we test a model with only two classifications of green bonds as well (first vs. second and above).

Finally, we investigate a "spill-over" effect. That is, we test whether the impact of a conventional bond's issue is different before and after the issuance of a green bond. For this purpose, we limit our attention to the conventional bonds. We consider four cases upon their issue time:

$$y_{it} = \mu_j + \mu_r + \mu_c + \mu_t + \delta_1 \times CB1_{it} + \delta_2 \times CB2_{it} + \delta_3 \times CB3plus_{it} + \beta \times Bond_{it} + \gamma \times Issuer_{it-1} + \epsilon_{it}, \tag{7}$$

where $CB1_{it}$ is a dummy variable that takes the value of 1 if the conventional bond is issued between the first and the second green bond and 0 otherwise, $CB2_{it}$ is a dummy variable that takes the value of 1 if the conventional bond is issued between the second and the third

[8] We limit our sub-division in three sub categories because very few green are issued more than three times.

ones, and $CB3plus_{it}$ is a dummy variable that takes the value of 1 if the conventional bond is issued after the third green bonds. If there is any spillover effect, the coefficients δ will be negative and this effect will become more important as the number of green bonds for a firm increase ($|\delta_3| > |\delta_2| > |\delta_1|$).

4 Empirical results

In this section, we carry out different analysis to investigate the green effect, the impact of issuing green bonds on the CDS spread (Subsection 4.1), to capture the magnitude of the green effect due to multiple issuance of green bonds, the credibility effect (Subsection 4.2), and to analyze the spillover effect of issuing green bonds on conventional ones (Subsection 4.3).

4.1 Green effect

The goal of this section is to investigate the existence of a CDS spread-related discount from issuing green bonds.

[Table 3 about here.]

Table 3 shows the mean of CDS reaction of the issuance of a green bond and that of a conventional bond along with the result of t-test. CDS reaction is measured by CAR (Eq. 3) and CPE (Eq. 4) for 4 event windows. Panel A of Table 3 shows that the difference in means between the two bond types is negative regardless of the measure. When we consider CAR, the difference is significant in all cases.[9] This result indicates that the CDS market reacts differently based on the bond type. While the CDS spread increases when a conventional bond is issued, it decreases when a green bond is issued.

Furthermore, Panels B and C focus on the first green bond issued. Panel B analyses the effect of green issue by taking into account all the conventional bonds that have been issued prior to the first green issuance. In Panel C, we consider the case of the immediately preceding issued conventional bond to the green one. The difference between the two issue types is substantially more negative and becomes, compared to Panel A, statistically more significant for both CAR and CPE. We reject null hypothesis of mean equality at 5% level except for $CAR[-10,10]$ at 10%. Collectively, these results show that the CDS spread decreases to the first issue of green bonds. When considering all bonds, conventional and green, the CDS spread reaction is no longer crystal-clear, hinting at a possible spillover effect that we later investigate.

[Table 4 about here.]

[9] The difference in results between the CAR and CPE measures can be explained by the fact that we consider all conventional bonds that have been issued before and after green bonds issuance.

To disentangle the reaction of CDS spread to an announcement of new bond issuance from bond's and issuer's characteristics, we conduct a linear regression based on CAR and CPE measures. Table 4 reports regression results (Eq. 5) that confirm the existence of significant, in most cases at 1 %, and negative impact of issuing green bonds on CDS spread, regardless of the issued amount or the outstanding leverage (debt level). The estimated coefficients for the Green bond dummy variables are in average -2.2 bps for CAR and -1.6 bps for CPE. It implies the reduction in abnormal CDS spread changes in the case of green bond issuance by -2.2 bps compared to the case of conventional one. This first result shows that our hypothesis (H1a), the existence of a green bond effect, is validated.

[Table 5 about here.]

Table 5 excludes all bonds issued after the first green bonds. Its purpose is to single out the effect of first-time issue of a green bond. The results indicate that the impact of green bond issuance on CDS spread is negative and statistically significant at least at 5% level. We observe that the effect is largely more negative, on average twice as negative as the estimated coefficients reported in Table 4, compared to all previously issued conventional bonds. The coefficients of the first green bond dummy variable are -3.91 (-3.75) bps for the CAR (CPE) measure. Our results show that there is a green bond effect in the CDS market. This effect is particularly more pronounced for the first green bond issuance with respect to the previous conventional bonds. Our findings complement the result of Flammer (2021) and Daubanes et al. (2021), who show a positive reaction in stock market on the issuance of the first green bond, suggesting investor's expectation on higher return. We show that this signal of the commitment toward green projects also generates risk reduction, captured by the reduction in CDS spreads.

[Table 6 about here.]

We further analyze whether the green effect exists for the three regions in our sample data, that is, Europe, North America, and Japan. Table 6 shows that the CDS spread for European and North American firms decreases substantially. The results are less significant, however, in the case of North American firms. While the impact is also negative for Japanese firms, it has limited magnitude and significance. This result is in line with the stronger awareness of the risk of climate change for European investors.

4.2 Credibility effect

In the previous section, we highlight the importance for firms to issue green bonds for the first time. The CDS market reaction to this corporate decision is favorable, and materializes with spread decrease. In this section, we investigate the persistence of the first green bond effect to subsequent issues.

[Table 7 about here.]

Table 7 reports CAR and CPE when taking into account additional green issuances. We point out a hump pattern between the number of issuance and the CDS spread. Contrary to our expectation, the second issue leads to an increase CDS spread, but it reverts to substantially negative level for the third and beyond issues. Indeed, when firms issue green bonds more than three times, investors become more convinced by the firms' commitment to transition toward green business. Hence, they require less premium. Therefore, we argue that, on the CDS market, firms engaged in transitioning their businesses to green ones are perceived as less risky. The increase in CDS spreads observed in the second green issue may be due to the median days since the first issue, 311 days, which is substantially longer than the median of 188 days, between the second and the third issuance. Therefore, we cannot exclude the idea that the second issuance might be interpreted as a "green-washing" maneuver.

[Table 8 about here.]

[Table 9 about here.]

Table 8 and 9 report regression results for CAR and CPE, respectively. In each table, we consider two specifications: i) First issue, and second issues and above, and ii) First issue, second issue, and third issue and above. The first issue is always significantly negative at 10% level at minimum, and the coefficient for the second issue and above is negative but rarely significant (columns 1, 3,5, 7). When we disentangle the effect of the second from the third and above, the effect of the second issue becomes not significant, but the third and above is highly significantly negative (columns 2, 4, 6, 8) at significance level of 1% (except for $CAR[-10,5]$). The coefficients of the green bond dummy variable for the CAR (CPE) measure increase substantially, from -2.51 (-2.3) bps for the 1st green bond to -4.18 (-3.81) for the 3rd and subsequent ones.

Consistently with Table 7, we observe that investors do not consider the second green bond in the same way as they do for other green bonds issue. While the first green issue leads to a CDS green discount, the second one does not convey more information on a firm's commitment to green transition. Yet, the firm's credibility is strongly enhanced with a three or more issuances, prompting an additional CDS green discount. Basse Mama and Fouquau (2021) show the importance of accumulating credibility in the context of environmental innovation. They demonstrate that a firm should undertake a certain number of innovation projects to have a positive impact on its profitability.

Caramichael and Rapp (2022) show that there is a greenium issued in 2019 onward. It means that our credibility effect may not be due to multiple issuance of green bonds, but due to green bonds issued after 2019. We check the robustness of our result to the 2019 effect by inserting interaction term between green bonds dummies and 2019 dummy which takes the value of 1 for the green bonds issued in 2019 onward and 0 otherwise. Table A1 in Appendix shows that the interaction terms are not significant, while the coefficient of the variable GB3 plus is still significant in most cases. This result implies that credibility effect is always consistent and not due to the break found by Caramichael and Rapp (2022) before and after 2019.

4.3 Spillover effect

We refer to spillover effect when a conventional bond issued subsequently to a green bond exhibits negative effect on CDS spreads similar to that of green bonds. Indeed, the spillover effect emerges when CDS market investors perceive the signal of a credible transition of the issuer toward green assets, more profitable and less risky than brown ones, following multiple issuance of green bonds. In such a case, the issuance of conventional bonds is interpreted by investors as funds channeled to green assets. We focus on the subsample composed of conventional bonds and compare the reaction of CDS spreads to their issuance upon whether they were issued before or after a green bond.

[Table 10 about here.]

Table 10 reports regression results, in which we consider three dummy variables to capture how CDS spreads react when conventional bonds are issued: between the first and second issues of green bonds ($CB1$), between the second and third issues ($CB2$), and after the third issue ($CB3plus$). Interestingly, the estimated coefficients for the dummy variables are statistically significant at 10% and negative only for $CB3plus$ (in 6 out of 8 measures). The estimated coefficients for $CB3plus$ is on average equal to -3.5 (-2.41) bps for the CAR (CPE) measure. Given that we consider exclusively conventional bonds, this result suggests that there is a reduction of the CDS spreads reaction to the conventional ones prior to the first green bonds. Therefore, the decrease in the CDS spread observed in the case of green bond issuance, exists also for conventional bonds that are issued after the third green issuance. Potential interpretation of this result is that the credibility effect leads to a spillover effect.

We observe that the scale of the CDS reaction is slightly lower than that of the credibility effect in terms of the estimated coefficients. It is worth noting that this result is not directly comparable due to the fact that this subsample does not include green bonds. For this reason, we conduct a robustness check in Table A2 in the Appendix. In this exercise, we consider full sample and add conventional bonds dummy variables as well as green ones by their issuance order, *i.e.*, the combination of equation (6) and (7). Credibility effect and spillover effect are still significant and, as shown earlier, the spillover effect is slightly lower. This suggests that conventional bonds benefits from credibility effect but are not considered exactly as green bond issuance.

As a second robustness check, we test whether the spillover effect is driven by the 2019 effect found by Caramichael and Rapp (2022). The coefficients of our variable of interest, the dummy variable indicating conventional bonds issued subsequent to the third green bond, is always statistically significant.

[Table 11 about here.]

As is shown in Table 10, the negative coefficient observed in the case of the third dummy implies that the CDS spread of conventional bonds issued after the third green is lower, but not necessarily negative, than the spread observed in the case of conventional bonds issued before the first green bond. To complement this result, Table 11 reports the mean of CAR and CPE for conventional bond issues upon the time of issuance relative to green bonds. We observe negative mean for CAR and CPE only after 3 issuances of green bond. This suggest that the spillover effect exist but only for the firms that issued more than a certain number of green bond issues.

5 Conclusion

We investigate whether CDS spreads reaction differ upon the type of issued bonds, green or conventional. Our event study shows that the CDS spread decreases when a green bond is issued while it increases when a conventional bond is issued. This result is consistent with our hypothesis. This effect is particularly more pronounced for first green bond issuance with respect to the previous conventional bonds. The results show that the effect is largely more negative, on average twice as negative as the coefficients for conventional bonds issued prior to the first green bonds. We investigate as well possible difference by region. Our result is in line with the stronger awareness of the risk of climate change for European investors. The CDS spread for European and North American firms decreases substantially. However, the results are less significant in the case of North American firms.

Second, we analyze the case of multiple issuance with the same methodology. We find that the CDS spread increases following the second green bond issue, but it reverts to decline substantially in the case of the third and above bond issues. While the first green issue leads to a green discount, the second one does not add much to how firms signal their commitment to green transition. However, a three or more green bond issuance leads to the appearance of an additional green discount, which suggest a reputation effect that the firm's credibility is strongly enhanced by multiple issuance.

Finally, by focusing exclusively on conventional bonds, we find spillover effect. We show that the negative impact on the CDS spread exists also for conventional bonds that are issued after the third green issuance.

Our analysis focused only on nonfinancial firms considering that green bonds issued by banks are different because they invest cash proceeds in green loans instead of investing directly on green project. However, as Flammer (2021), we could extend our analysis including green bonds issued by banks to check whether they exhibit difference.

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Table 1. Descriptive statistics at the bond level

Panel A. By region

	Green bonds				Conventional bonds				All			
	NA	EU	JP	Total	NA	EU	JP	Total	NA	EU	JP	Total
Amount Issued (USD bil.)	1.09	0.86	0.19	0.80	2.03	0.90	0.26	1.07	1.97	0.89	0.26	1.04
	(0.74)	(0.65)	(0.23)	(0.68)	(4.59)	(1.22)	(0.25)	(2.82)	(4.46)	(1.13)	(0.25)	(2.67)
Amount Issued/Total assets (%)	4.1	3.8	1.2	3.4	2.4	2.0	1.3	1.9	2.5	2.3	1.3	2.0
	(5.0)	(4.5)	(1.8)	(4.4)	(3.6)	(3.0)	(1.5)	(2.9)	(3.7)	(3.4)	(1.5)	(3.1)
Maturity (yr.)	12.0	12.9	6.3	11.8	16.8	9.7	9.1	11.8	16.5	10.2	8.9	11.8
	(8.1)	(9.0)	(2.5)	(8.5)	(9.5)	(7.7)	(5.6)	(8.5)	(9.5)	(8.0)	(5.5)	(8.5)
Observations	22	86	19	127	348	384	336	1,068	370	470	355	1,195

Panel B. By rating class

	Green bonds				Conventional bonds				All			
	IG	HY	NR or W	Total	IG	HY	NR or W	Total	IG	HY	NR or W	Total
Amount Issued (USD bil.)	0.94	0.86	0.29	0.80	1.48	1.20	0.27	1.07	1.41	1.12	0.27	1.04
	(0.66)	(0.58)	(0.55)	(0.68)	(3.46)	(1.15)	(0.37)	(2.82)	(3.27)	(1.05)	(0.39)	(2.67)
Amount Issued/Total assets (%)	4.0	2.2	2.0	3.4	2.0	4.7	1.4	1.9	2.2	4.2	1.4	2.0
	(4.6)	(1.5)	(4.0)	(4.4)	(3.2)	(3.2)	(1.8)	(2.9)	(3.4)	(3.1)	(2.0)	(3.1)
Maturity (yr.)	11.5	21.5	7.3	11.8	13.6	10.3	8.6	11.8	13.3	12.8	8.5	11.8
	(7.7)	(10.5)	(5.4)	(8.5)	(9.3)	(7.9)	(5.5)	(8.5)	(9.2)	(9.7)	(5.5)	(8.5)
Observations	88	14	25	127	669	49	350	1,068	757	63	375	1,195

Panel A and B of this table provide descriptive statistics by region and by bond rating, respectively. Reported statistics are mean with standard deviation in parentheses. In order to include perpetual bonds in statistics and regression, we assigned 99 percentile maturity, which is 30.17 years as their maturity.

Table 2. Descriptive statistics at the issuer level

	NA	EU	JP	Total
Total Asset (USD bil.)	95.86	69.90	23.78	67.38
	(120.34)	(96.55)	(15.43)	(95.95)
Leverage (%)	38.79	32.31	33.11	33.94
	(11.04)	(18.35)	(14.62)	(16.34)
ROA (%)	6.79	4.76	4.75	5.22
	(4.19)	(2.61)	(2.65)	(3.13)
Firm-year observations	20	51	16	87

This table provides descriptive statistics of the main characteristics of the issuers of green bonds in our sample. In this table, we consider only unique firm-year observations by matching issuer of green bonds and announced year with issuer's characteristics at the end of the year prior to the announcement of green bond issuance. The leverage ratio of the firms is estimated by total debts to total assets. Reported statistics are mean with standard deviation in parentheses.

Table 3. Comparison between green bonds and conventional bonds

	$CAR[-1,1]$	$CAR[-10,0]$	$CAR[-10,5]$	$CAR[-10,10]$	$CPE[-1,1]$	$CPE[-10,0]$	$CPE[-10,5]$	$CPE[-10,10]$	Obs.
Panel A: All green bonds vs. all conventional bonds									
Green bonds	-0.91	-0.80	-0.80	-0.89	-0.70	-0.68	-0.36	-0.64	121
Conventional bonds	0.42	0.21	0.59	0.64	-0.27	-0.30	-0.03	0.16	1,055
Difference	-1.33**	-1.00*	-1.39**	-1.53*	-0.43	-0.38	-0.33	-0.80	
(P-value)	(0.02)	(0.06)	(0.04)	(0.05)	(0.23)	(0.25)	(0.32)	(0.18)	
Panel B: First green bonds vs. all conventional bonds issued before the first green bond									
Green bonds	-1.19	-0.84	-1.60	-1.61	-2.06	-1.75	-1.71	-1.55	52
Conventional bonds	0.52	0.29	0.33	0.68	0.75	0.67	-0.03	-0.09	583
Difference	-1.71**	-1.13	-1.94**	-2.29**	-2.81***	-2.42**	-1.69**	-1.46**	
(P-value)	(0.04)	(0.11)	(0.03)	(0.04)	(0.01)	(0.04)	(0.02)	(0.03)	
Panel C: First green bonds vs. Conventional bonds issued immediately before the first green bond									
Green bonds	-1.11	-0.80	-1.54	-1.52	-1.83	-1.44	-1.68	-1.59	48
Conventional bonds	1.56	1.72	1.17	0.76	2.66	2.31	0.25	0.40	48
Difference	-2.67**	-2.52**	-2.71**	-2.28*	-4.50***	-3.75**	-1.94**	-1.99**	
(P-value)	(0.02)	(0.02)	(0.02)	(0.08)	(0.00)	(0.03)	(0.04)	(0.03)	

This table reports the mean of CAR (Eq. 3) and the CPE (Eq. 4) for the impact of both green and conventional bond issues on CDS spread for various event windows along with the result of *t*-test. Each panel shows the result for different subsample: Whole sample (Panel A), exclusively the issuers with both first green bond and at least one conventional bond before the issuance of the first green bond (Panel B), exclusively the issuers with both first green bond and the conventional bond issued immediately before the first green bond (Panel C). Stars for the row of difference represents the significance of t-test under the alternative hypothesis that the mean of green bonds is smaller than that of conventional bonds. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 4. Impact of green bonds on CDS spread

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
GB	-2.298***	-2.065**	-2.334***	-2.206**	-1.788***	-1.764***	-1.365*	-1.490*
	(0.812)	(0.801)	(0.844)	(1.067)	(0.663)	(0.645)	(0.722)	(0.825)
Maturity	-0.041	-0.040	-0.074**	-0.050	-0.023	-0.027	-0.045	-0.031
	(0.031)	(0.035)	(0.035)	(0.043)	(0.028)	(0.028)	(0.034)	(0.037)
Leverage	-0.105	-0.112*	-0.101	-0.175***	-0.056	-0.069	-0.059	-0.104
	(0.066)	(0.062)	(0.064)	(0.065)	(0.060)	(0.059)	(0.060)	(0.070)
Issued Amount/TA	0.033	0.036	-0.010	-0.123	0.107	0.076	0.012	0.028
	(0.106)	(0.093)	(0.113)	(0.147)	(0.089)	(0.085)	(0.115)	(0.158)
High-Yield	0.153	0.933	0.969	1.585	-2.381***	-1.793***	-1.400	-1.800
	(1.217)	(1.144)	(1.672)	(2.301)	(0.759)	(0.650)	(1.016)	(1.824)
Observations	1,090	1,091	1,081	1,072	1,090	1,091	1,081	1,072
R^2	0.178	0.178	0.193	0.180	0.181	0.175	0.174	0.180

This table reports regression results with CAR, CPE as the explanatory variables for full sample (Eq. 5). GB is dummy variable which is equal to 1 if the bond is green one and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 5. Impact of first green bonds on CDS

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
GB1	-3.512***	-2.859**	-5.262***	-4.019**	-3.551***	-3.333***	-4.404***	-3.714**
	(1.179)	(1.164)	(1.189)	(1.526)	(1.052)	(1.048)	(1.240)	(1.461)
Maturity	-0.089**	-0.093**	-0.126***	-0.098*	-0.047*	-0.059**	-0.082**	-0.068*
	(0.037)	(0.037)	(0.043)	(0.056)	(0.026)	(0.026)	(0.035)	(0.039)
Leverage	-0.114	-0.107	-0.129	-0.181*	-0.075	-0.078	-0.075	-0.131
	(0.086)	(0.077)	(0.092)	(0.097)	(0.080)	(0.079)	(0.091)	(0.111)
Issued Amount/TA	0.010	0.044	-0.061	-0.136	0.066	0.061	-0.029	-0.031
	(0.112)	(0.091)	(0.122)	(0.188)	(0.097)	(0.084)	(0.126)	(0.203)
High-Yield	0.284	0.955	3.292	4.016	0.159	0.715	2.306	3.338
	(2.106)	(2.006)	(2.849)	(3.613)	(1.620)	(1.403)	(1.807)	(2.865)
Observations	813	814	809	806	813	814	809	806
R^2	0.221	0.213	0.227	0.202	0.211	0.199	0.199	0.193

This table reports regression results with CAR, CPE as the explanatory variables (Eq. 5). The sample includes only first green bonds and all conventional bonds issued before the first green bonds. GB1 is dummy variable that takes 1 if the bond is the first green bond of an issuer and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 6. Impact of first green bonds on CDS by the issuer's region

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
EU GB1	-4.568***	-3.966**	-6.437***	-5.713***	-3.904**	-3.652**	-4.447**	-4.079*
	(1.476)	(1.582)	(1.747)	(2.110)	(1.556)	(1.575)	(1.828)	(2.120)
JP GB1	-0.818	-0.649	-3.906**	-3.569	-2.417*	-2.272*	-3.690**	-3.533
	(1.462)	(1.496)	(1.594)	(2.422)	(1.326)	(1.334)	(1.693)	(2.464)
US GB1	-4.938**	-3.568*	-4.764*	-1.371	-4.327**	-4.079**	-5.242**	-3.253
	(2.392)	(2.038)	(2.425)	(2.893)	(1.819)	(1.703)	(2.403)	(2.500)
Maturity	-0.088**	-0.092**	-0.124***	-0.095*	-0.046*	-0.059**	-0.082**	-0.068*
	(0.036)	(0.036)	(0.043)	(0.056)	(0.025)	(0.026)	(0.035)	(0.039)
Leverage	-0.103	-0.099	-0.126	-0.183*	-0.070	-0.073	-0.072	-0.131
	(0.088)	(0.079)	(0.093)	(0.097)	(0.082)	(0.081)	(0.093)	(0.113)
Issued Amount/TA	0.015	0.050	-0.058	-0.131	0.067	0.062	-0.029	-0.030
	(0.114)	(0.093)	(0.121)	(0.191)	(0.099)	(0.086)	(0.128)	(0.204)
High-Yield	0.059	0.776	3.193	4.055	0.062	0.624	2.221	3.336
	(2.098)	(1.981)	(2.801)	(3.485)	(1.651)	(1.437)	(1.864)	(2.859)
Observations	813	814	809	806	813	814	809	806
R^2	0.225	0.216	0.228	0.203	0.212	0.200	0.200	0.193

This table reports regression results with CAR, CPE as the explanatory variables (Eq. 5). The sample includes only first green bonds and all conventional bonds issued before the first green bonds. EU GB1 (JP, US) is dummy variable which is equal to 1 if the bond is the first green bond issued by a firm incorporated in EU (JP, US) and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer's region indicates the region where the issuer is incorporated. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 7. Comparison across the green bonds by issuance order

	$CAR[-1,1]$	$CAR[-10,0]$	$CAR[-10,5]$	$CAR[-10,10]$	$CPE[-1,1]$	$CPE[-10,0]$	$CPE[-10,5]$	$CPE[-10,10]$	Obs.
1st GB	-0.53	-0.31	-1.29	-1.17	-0.78	-0.79	-0.65	-0.87	64
2nd GB	0.70	0.57	3.42	3.20	2.90	2.68	5.29	5.47	24
3rd GB and plus	-2.81	-2.72	-2.93	-3.34	-3.17	-2.90	-3.90	-4.65	33
All GB	-0.91	-0.80	-0.80	-0.89	-0.70	-0.68	-0.36	-0.64	121

This table shows the mean of CDS reaction of the issuance of a green bond by their issuance order. CDS reactions are computed by the CAR and CPE measures in bps with 4 different window sizes. 1st GB (2nd GB) represent the reaction to the first(second) green bond issuance given firm. 3rd GB and plus stands for the reaction to the issuance of all the green bonds after the 2nd one given firm.

Table 8. Impact of Green bond issuance upon issuing order: CAR

	(1) $CAR[-1,1]$	(2) $CAR[-1,1]$	(3) $CAR[-10,0]$	(4) $CAR[-10,0]$	(5) $CAR[-10,5]$	(6) $CAR[-10,5]$	(7) $CAR[-10,10]$	(8) $CAR[-10,10]$
GB1	-2.324**	-2.285**	-1.927*	-1.886*	-3.434***	-3.378***	-2.552*	-2.493*
	(1.100)	(1.096)	(1.072)	(1.068)	(1.187)	(1.180)	(1.395)	(1.388)
GB2 plus	-2.259*		-2.269*		-0.733		-1.698	
	(1.239)		(1.209)		(1.202)		(1.742)	
GB2		-0.132		0.019		2.121		1.458
		(2.196)		(1.925)		(2.132)		(3.025)
GB3 plus		-4.303***		-4.469***		-3.333**		-4.629***
		(0.994)		(1.023)		(1.381)		(1.629)
Maturity	-0.041	-0.036	-0.040	-0.034	-0.078**	-0.072**	-0.051	-0.044
	(0.031)	(0.030)	(0.035)	(0.034)	(0.035)	(0.035)	(0.044)	(0.044)
Leverage	-0.105	-0.109	-0.112*	-0.116*	-0.102	-0.106	-0.175***	-0.180***
	(0.066)	(0.066)	(0.062)	(0.062)	(0.064)	(0.064)	(0.065)	(0.066)
Issued Amount/TA	0.033	0.046	0.036	0.049	-0.011	0.005	-0.124	-0.105
	(0.106)	(0.112)	(0.093)	(0.099)	(0.114)	(0.119)	(0.147)	(0.155)
High-Yield	0.153	0.306	0.932	1.097	0.954	1.176	1.579	1.833
	(1.218)	(1.187)	(1.140)	(1.101)	(1.704)	(1.662)	(2.310)	(2.246)
Observations	1,090	1,090	1,091	1,091	1,081	1,081	1,072	1,072
R^2	0.178	0.181	0.178	0.182	0.195	0.198	0.180	0.184

This table reports regression results with CAR as the explanatory variables (Eq. 6). GB1 (GB2) is dummy variable that takes value of 1 if the bond is the first (second) green bond of an issuer and 0 otherwise. GB2 plus (GB3 plus) is dummy variable that takes value of 1 if the bond is the second (third)and all subsequent green bonds of an issuer and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 9. Impact of Green bond issuance upon issuing order: CPE

	(1) $CPE[-1,1]$	(2) $CPE[-1,1]$	(3) $CPE[-10,0]$	(4) $CPE[-10,0]$	(5) $CPE[-10,5]$	(6) $CPE[-10,5]$	(7) $CPE[-10,10]$	(8) $CPE[-10,10]$
GB1	-2.364**	-2.314**	-2.259**	-2.209**	-2.454**	-2.378**	-2.399*	-2.307*
	(0.940)	(0.933)	(0.935)	(0.928)	(1.092)	(1.083)	(1.235)	(1.230)
GB2 plus	-0.939		-1.032		0.219		-0.153	
	(1.073)		(0.958)		(1.102)		(1.344)	
GB2		1.775		1.738		4.077**		4.749**
		(1.569)		(1.420)		(1.625)		(2.017)
GB3 plus		-3.550***		-3.695***		-3.296***		-4.707***
		(1.006)		(0.897)		(1.242)		(1.348)
Maturity	-0.025	-0.019	-0.028	-0.022	-0.049	-0.041	-0.034	-0.024
	(0.028)	(0.027)	(0.029)	(0.027)	(0.034)	(0.034)	(0.037)	(0.036)
Leverage	-0.057	-0.062	-0.070	-0.075	-0.061	-0.067	-0.106	-0.113
	(0.060)	(0.059)	(0.059)	(0.058)	(0.060)	(0.059)	(0.069)	(0.069)
Issued Amount/TA	0.107	0.123	0.077	0.093	0.011	0.033	0.025	0.055
	(0.088)	(0.095)	(0.085)	(0.091)	(0.114)	(0.121)	(0.157)	(0.166)
High-Yield	-2.381***	-2.186***	-1.793***	-1.593***	-1.414	-1.115	-1.817	-1.421
	(0.749)	(0.712)	(0.655)	(0.599)	(1.037)	(0.978)	(1.817)	(1.732)
Observations	1,090	1,090	1,091	1,091	1,081	1,081	1,072	1,072
R^2	0.182	0.190	0.176	0.184	0.177	0.187	0.181	0.191

This table reports regression results with CPE as the explanatory variables (Eq. 6). GB1 (GB2) is dummy variable that takes value of 1 if the bond is the first (second) green bond of an issuer and 0 otherwise. GB2 plus (GB3 plus) is dummy variable that takes value of 1 if the bond is the second (third)and all subsequent green bonds of an issuer and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 10. Impact of conventional bonds on CDS spread upon previous issuance of green bonds

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
CB1	0.457	0.326	-0.885	-0.814	0.332	0.429	-0.376	0.228
	(1.105)	(1.048)	(1.112)	(1.218)	(0.852)	(0.824)	(0.992)	(1.364)
CB2	-1.035	-1.029	-0.990	-0.418	-1.172	-1.459	-0.754	0.837
	(1.178)	(1.210)	(1.822)	(2.109)	(0.975)	(0.991)	(1.595)	(1.906)
CB3 plus	-2.602*	-2.835**	-4.097**	-4.471**	-2.356*	-2.657**	-2.705	-1.931
	(1.454)	(1.199)	(1.765)	(1.935)	(1.276)	(1.092)	(1.761)	(2.463)
Maturity	-0.032	-0.029	-0.063*	-0.040	-0.021	-0.024	-0.036	-0.023
	(0.029)	(0.034)	(0.037)	(0.045)	(0.025)	(0.026)	(0.035)	(0.036)
Leverage	-0.105	-0.121*	-0.092	-0.162**	-0.041	-0.059	-0.037	-0.071
	(0.069)	(0.065)	(0.073)	(0.074)	(0.067)	(0.066)	(0.074)	(0.083)
Issued Amount/TA	0.071	0.074	0.045	-0.064	0.055	0.032	-0.018	-0.002
	(0.111)	(0.098)	(0.118)	(0.197)	(0.082)	(0.075)	(0.124)	(0.195)
High-Yield	0.740	1.187	2.294	3.544	-1.022	-0.664	0.058	0.045
	(1.887)	(1.738)	(2.251)	(2.961)	(1.193)	(1.154)	(1.434)	(2.743)
Observations	983	984	979	970	983	984	979	970
R^2	0.178	0.184	0.194	0.186	0.167	0.166	0.171	0.179

This table reports regression results with CAR and CPE as the explanatory variables (Eq. 7). We consider a subsample including exclusively conventional bonds. CB1 (CB2) is a dummy variable that takes the value of 1 if the conventional bond is issued between the first and the second green bond (the second and the third one) and 0 otherwise given firm. CB3 plus for all the conventional bonds after the third green bonds given firm. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table 11. Conventional bonds upon previous issuance of green bonds

	$CAR[-1,1]$	$CAR[-10,0]$	$CAR[-10,5]$	$CAR[-10,10]$	$CPE[-1,1]$	$CPE[-10,0]$	$CPE[-10,5]$	$CPE[-10,10]$	Obs.
CB between GB1 and GB2	1.06	0.85	0.65	1.12	0.12	0.29	-0.28	-0.25	138
CB between GB2 and GB3	1.49	1.30	2.85	2.73	-0.26	-0.37	0.83	1.19	55
CB after GB3	-0.27	-0.49	-0.88	-0.75	-1.21	-1.31	-1.87	-1.58	41

This table shows the mean of CDS reaction of the issuance of conventional bonds in bps by the existence of previous issuance of green bonds. CB is conventional bonds. GB1 (GB2, GB3) is the firstly (secondly, thirdly) issued green bond given firm.

Appendix

[Table A1 about here.]

[Table A2 about here.]

[Table A3 about here.]

Table A1. Robustness check: Sensitiveness of the credibility effect before/after 2019

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
GB1	-2.034*	-0.953	-1.916	-2.206	-1.471	-0.535	-1.963	-3.099
	(1.063)	(0.988)	(1.568)	(1.877)	(1.382)	(1.351)	(1.954)	(2.274)
GB1 × $\mathbb{1}(t \geq 2019)$	-0.255	-1.237	-1.855	-0.231	-1.089	-2.248	-0.474	1.201
	(1.686)	(1.627)	(2.277)	(2.708)	(1.796)	(1.733)	(2.467)	(2.846)
GB2	-3.552	-1.521	-3.844	-3.936	-0.480	0.258	0.760	1.271
	(3.384)	(3.284)	(2.723)	(5.076)	(1.586)	(1.406)	(1.220)	(1.796)
GB2 × $\mathbb{1}(t \geq 2019)$	4.992	2.232	8.933**	8.134	3.296	2.143	4.985*	5.250
	(4.374)	(4.085)	(3.863)	(6.300)	(2.795)	(2.591)	(2.640)	(3.654)
GB3 plus	-3.314*	-3.679***	-4.040	-6.678	-3.835**	-3.644***	-4.534	-5.430
	(1.969)	(1.246)	(3.919)	(5.304)	(1.749)	(1.343)	(3.432)	(3.297)
GB3 plus × $\mathbb{1}(t \geq 2019)$	-1.031	-0.868	1.114	2.674	0.433	0.008	1.618	1.008
	(1.900)	(1.407)	(3.705)	(5.205)	(2.038)	(1.535)	(3.598)	(3.912)
Maturity	-0.037	-0.034	-0.074**	-0.047	-0.019	-0.021	-0.043	-0.026
	(0.030)	(0.034)	(0.035)	(0.044)	(0.027)	(0.028)	(0.034)	(0.037)
Leverage	-0.108	-0.117*	-0.105	-0.177***	-0.062	-0.076	-0.065	-0.111
	(0.066)	(0.062)	(0.064)	(0.066)	(0.060)	(0.059)	(0.060)	(0.070)
Issued Amount/TA	0.043	0.044	0.009	-0.091	0.123	0.088	0.041	0.065
	(0.113)	(0.101)	(0.125)	(0.169)	(0.100)	(0.093)	(0.134)	(0.183)
High-Yield	0.415	1.112	1.323	2.024	-2.148***	-1.617***	-1.017	-1.240
	(1.197)	(1.117)	(1.673)	(2.234)	(0.713)	(0.605)	(0.985)	(1.713)
Observations	1,090	1,091	1,081	1,072	1,090	1,091	1,081	1,072
R^2	0.183	0.183	0.203	0.186	0.191	0.186	0.188	0.192

This table reports regression results with CAR and CPE as the explanatory variables . GB1 (GB2) is dummy variable that takes value of 1 if the bond is the first (second) green bond of an issuer and 0 otherwise. GB3 plus is dummy variable that takes value of 1 if the bond is the third and all subsequent green bonds of an issuer and 0 otherwise. $\mathbb{1}(t \geq 2019)$ is dummy variable which is equal to 1 if a bond issued in 2019 onward and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table A2. Robustness check: Spillover effect with full sample

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
GB1	-2.410**	-2.100*	-3.994***	-3.129**	-2.490**	-2.427**	-2.868**	-2.488*
	(1.205)	(1.159)	(1.202)	(1.419)	(1.054)	(1.036)	(1.248)	(1.379)
CB1	0.556	0.391	-0.864	-0.812	0.422	0.503	-0.591	-0.180
	(1.086)	(1.047)	(1.101)	(1.255)	(0.820)	(0.802)	(0.987)	(1.314)
GB2	-0.554	-0.535	1.093	0.334	1.317	1.169	3.245*	4.355**
	(2.450)	(2.146)	(2.498)	(3.443)	(1.651)	(1.529)	(1.857)	(2.169)
CB2	-0.808	-0.955	-1.099	-1.106	-1.141	-1.348	-1.133	0.091
	(1.162)	(1.151)	(1.726)	(1.975)	(0.959)	(0.953)	(1.500)	(1.736)
GB3 plus	-5.137***	-5.532***	-5.231***	-6.674***	-4.366***	-4.718***	-4.792**	-5.531***
	(1.470)	(1.352)	(1.950)	(2.316)	(1.379)	(1.248)	(1.856)	(2.021)
CB3 plus	-2.215*	-2.581**	-3.649**	-4.158**	-1.757	-2.246**	-2.746*	-2.267
	(1.293)	(1.055)	(1.572)	(1.732)	(1.127)	(0.962)	(1.429)	(2.027)
Maturity	-0.041	-0.039	-0.074**	-0.047	-0.023	-0.027	-0.043	-0.025
	(0.029)	(0.033)	(0.035)	(0.044)	(0.026)	(0.026)	(0.034)	(0.036)
Leverage	-0.104	-0.110*	-0.097	-0.169**	-0.057	-0.069	-0.059	-0.108
	(0.065)	(0.061)	(0.067)	(0.068)	(0.059)	(0.058)	(0.063)	(0.073)
Issued Amount/TA	0.040	0.043	-0.001	-0.109	0.117	0.086	0.028	0.054
	(0.111)	(0.098)	(0.118)	(0.152)	(0.092)	(0.087)	(0.117)	(0.162)
High_Yield	0.439	1.261	1.509	2.212	-2.124***	-1.503**	-0.896	-1.164
	(1.229)	(1.130)	(1.631)	(2.180)	(0.749)	(0.648)	(0.946)	(1.681)
Observations	1,090	1,091	1,081	1,072	1,090	1,091	1,081	1,072
R^2	0.184	0.186	0.201	0.186	0.193	0.189	0.189	0.192

This table reports regression results with CAR and CPE as the explanatory variables. GB1 (GB2) is dummy variable that takes value of 1 if the bond is the first (second) green bond of an issuer and 0 otherwise. GB2 plus (GB3 plus) is dummy variable that takes value of 1 if the bond is the second (third)and all subsequent green bonds of an issuer and 0 otherwise. CB1 (CB2) is a dummy variable that takes the value of 1 if the conventional bond is issued between the first and the second green bond (the second and the third one) and 0 otherwise given firm. CB3 plus for all the conventional bonds after the third green bonds given firm. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.

Table A3. Robustness check: Sensitiveness of spillover effect before/after 2019

	(1) $CAR[-1,1]$	(2) $CAR[-10,0]$	(3) $CAR[-10,5]$	(4) $CAR[-10,10]$	(5) $CPE[-1,1]$	(6) $CPE[-10,0]$	(7) $CPE[-10,5]$	(8) $CPE[-10,10]$
CB1	2.123	1.625	0.840	1.594	0.634	0.546	1.565	3.313
	(2.929)	(2.692)	(2.242)	(2.611)	(1.693)	(1.620)	(1.870)	(2.803)
CB1 × $\mathbb{1}(t \geq 2019)$	-1.525	-1.208	-1.760	-2.322	-0.132	0.074	-2.090	-3.145
	(3.029)	(2.855)	(2.364)	(2.780)	(1.687)	(1.695)	(1.877)	(2.740)
CB2	-1.743	-1.867	-3.681*	-4.328*	-1.078	-1.001	-2.057	-1.753
	(1.387)	(1.950)	(1.901)	(2.333)	(1.285)	(1.213)	(2.291)	(2.270)
CB2 × $\mathbb{1}(t \geq 2019)$	1.319	1.350	3.565*	5.332*	0.133	-0.314	1.787	3.694
	(1.746)	(2.597)	(2.109)	(3.095)	(1.615)	(1.401)	(2.164)	(2.295)
CB3 plus	-5.068***	-4.484***	-4.418*	-5.857*	-4.013***	-4.453***	-2.972**	-3.444
	(1.661)	(1.502)	(2.319)	(3.030)	(1.076)	(1.078)	(1.439)	(2.119)
CB3 plus × $\mathbb{1}(t \geq 2019)$	4.283**	2.908*	0.933	2.849	2.639*	2.808*	1.005	3.406
	(1.640)	(1.531)	(2.678)	(3.538)	(1.451)	(1.444)	(1.700)	(2.377)
Maturity	-0.035	-0.031	-0.067*	-0.045	-0.022	-0.025	-0.038	-0.028
	(0.029)	(0.034)	(0.038)	(0.046)	(0.025)	(0.026)	(0.036)	(0.037)
Leverage	-0.110	-0.124*	-0.093	-0.166**	-0.044	-0.062	-0.038	-0.075
	(0.070)	(0.066)	(0.075)	(0.076)	(0.067)	(0.066)	(0.076)	(0.086)
Issued Amount/TA	0.075	0.076	0.038	-0.075	0.058	0.037	-0.020	-0.009
	(0.111)	(0.097)	(0.116)	(0.194)	(0.083)	(0.076)	(0.122)	(0.192)
High-Yield	0.715	1.177	2.354	3.642	-1.055	-0.706	0.096	0.131
	(1.903)	(1.754)	(2.268)	(3.003)	(1.200)	(1.162)	(1.415)	(2.728)
Observations	983	984	979	970	983	984	979	970
R^2	0.181	0.186	0.196	0.189	0.169	0.167	0.173	0.182

This table reports regression results with CAR and CPE as the explanatory variables. We consider a subsample including exclusively conventional bonds. CB1 (CB2) is a dummy variable that takes the value of 1 if the conventional bond is issued between the first and the second green bond (the second and the third one) and 0 otherwise given firm. CB3 plus for all the conventional bonds after the third green bonds given firm. $\mathbb{1}(t \geq 2019)$ is dummy variable which is equal to 1 if a bond issued in 2019 onward and 0 otherwise. High-Yield is dummy variable that takes value of 1 if the rating at issuance is high-yield category, *i.e.*, lower than BBB-(Baa-) and 0 otherwise. Issuer, region of its incorporation, CDS document clause, time (quarter)-fixed effects are included. The reported standard errors (in parentheses) are corrected from heteroskedasticity, and clustered at issuer level. ***,**,* indicate significance at the 1, 5 and 10% level.