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CREDIT SPREAD IN THE EUROPEAN GREEN BOND MARKET: A DAILY ANALYSIS OF THE COVID-19 PANDEMIC IMPACT

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Credit spread in the European green bond market: A daily analysis of the Covid-19 pandemic impact.

Abstract

Financial crises and economic downturns provide a unique opportunity to investigate the behaviour of investors and financial instruments and shed light on the market's anticipation of future economic growth. In view of the current crisis, we examine how the Covid-19 pandemic affected the European green bond market. To this end, we use daily data from Thomson Reuter's Refinitiv and we conduct event studies on corporate credit spread changes over the period from January 1, 2020, to December 31, 2020. Our results reveal that green bonds credit spreads increased significantly after the start of the coronavirus outbreak. However, as the fear of the pandemic eased after the positive news about the vaccine, green bonds' credit spreads fell below conventional bonds. Overall, green bonds showed a higher risk exposure and lower resilience to distress while profiting during an upside. Our paper provides the first evidence on the impact of the Covid-19 pandemic and the announcement of the vaccine effectiveness on the European corporate green bond market. Our results suggest several key points relevant to both investors and issuers under the unprecedented conditions created by the pandemic.

JEL Classification: G10, G12, G41, I18

Keywords: Green bonds, Credit spread, Sustainable investment, Financial innovation, Covid-19 pandemic

1 Introduction

While climate-change related shocks appear inevitable, governments worldwide are trying to reduce the severity of associated disruptions to the economy and financial markets through timely and stringent mitigating actions. Against this background, the financial system plays a crucial role in accelerating the necessary transition from a capitalist and closed economy focused on maximising short-term profits - to a circular and sharing economy - focused on resource preservation, respect for the environment, and consumer safety (Polzin et al., 2017). This transition process certainly requires that large flows of capital be reoriented towards more sustainable investments that integrate ESG (Environmental, Social, and Governance) requirements in decision-making while ensuring the financial system's stability. This is necessary if the European Union is to achieve the objectives set by the 2015 Paris Climate Agreement and the 17 Sustainable Development Goals (SDGs) of the UN 2030 Agenda. In this changing context, green bonds represent a promising financial innovation that fosters the massive reallocation of financial resources needed to transform Europe's economy into a greener and more resilient economy (Flammer, 2021). Green bonds are fixed-income securities whose proceeds are exclusively used to finance new and existing eligible projects that contribute to environmental sustainability. Their structure, financial risks and return characteristics are otherwise analogue to conventional bonds (Flammer, 2021). The green bonds usually undergo a third-party verification to establish that the proceeds are effectively funding projects intended to generate climate or other environmental benefits. Since the European Investment Bank (EIB) pioneered the Green Bonds market by issuing the world's first Climate Awareness Bond (CAB) in late 2007, more than USD269.5 billion have been allocated globally.[1]

The United States had the largest issuance of green bonds by country, with a total value of USD51.1 billion, followed by Germany with USD40.2 billion, and France with USD32.1 billion. China and the Netherlands issued USD17.2 billion and USD17 billion in green bonds, respectively, rounding out the top five. Looking at market share, green bonds currently account for 50% of the total sustainable bond market and 5% of the overall bond market, which indicates their very high potential for growth over the next few years. After the Covid-19 pandemic struck the world in the first quarter of 2020, its unprecedented effects whose extent is still

[1] https://www.climatebonds.net/resources/reports/green-bonds-market-summary-q3-2020

unknown - have shaken global financial markets and caused great turmoil (Ji et al., 2020). Most of the global bond market suffered from higher price volatility and lower trading liquidity as the coronavirus crisis emerged and intensified. The credit spreads worldwide have widened at speed never seen before, reaching record levels. The coronavirus outbreak had an immediate impact on the cumulative sustainable (green, social and sustainability) bond issuance, which since the earliest days of the crisis dropped by 14 per cent compared to the first quarter of 2019, and by 32 per cent compared to the fourth quarter of 2019.[2]

The outbreak of the Covid-19 has a negative effect on the global economy, causing a massive shock in financial markets. At the same time, it has led to a growing focus on sustainability and a greater awareness of ESG risks. Corporates and investors alike have recognised the importance of "green" their portfolios heavily dominated by the utility, financial, and real estate sectors, looking for more responsible investment strategies, including those involving green bonds. In the third quarter of 2020, four high profile auto companies issued debut green bonds to help finance their transitions away from Internal Combustion Engine (ICE) vehicles to electric vehicles (EV). For example, on September 16, 2020, the Volkswagen Group - the second biggest carmaker globally - issued their first green bonds worth USD2.4 billion to finance the development of an extensive electric vehicle programme. The fact that green bonds are a growing subset of the ESG investment universe together with the contentious issue of pricing difference with conventional bonds (i.e., green bond premium) (Larcker and Watts, 2020), confer a particular interest in studying the pricing dynamic of green bonds during the Covid-19 pandemic. In line with the theoretical paradigm relied on the effect of pro-environmental preferences on green bonds yields (Zerbib, 2019), investors are willing to accept lower yields to hold green assets rather than conventional ones with equal risk to affirm their green commitment (Fama and French, 2007). According to with Löffler et al. (2021), this would justify the existence of a "greenium" (i.e., a green bond premium) that makes green bonds a cheaper source of financing for the issuer than other bonds (Gianfrate and Peri, 2019). However, the recent findings from Larcker and Watts (2020) and Flammer (2021) reveal no pricing difference between green and conventional bonds confirming that the green projects can generate competitive returns. The main purpose of this study is to investigate whether corporate green bonds have been more

[2]https://www.moodys.com/research/Moodys-Coronavirus-shrinks-green-bond-issuance-while-spurring-social-bonds–PBC_1227042

resilient relative to conventional bonds in the rampant debt market sell-off during the outbreak of coronavirus disease in the first quarter of 2020. In particular, we empirically analyse the credit spreads of green bonds to compare with conventional ones during the global Covid-19 pandemic. During a period of extreme financial turmoil, credit spreads can serve as a crucial indicator of the degree of tensions in the financial markets (Gilchrist and Zakrajšek, 2012). In such a dynamic scenario, fluctuations in corporate bond credit spreads could reflect a default-risk factor that captures compensation demanded by investors - above and beyond expected losses - for bearing exposure to corporate credit risk. We assume that the Covid-19 pandemic represents an unprecedented economic shock with a variable impact on the different geographical areas of the world depending on the exposure to the pandemic and the effects of the lockdown measures. First, the Covid-19 crisis and the subsequent lockdown measures imposed by governments to contain the spread of the virus is an unexpected shock to global bond markets and numerous other financial markets around the world. Second, unlike the 2008 global financial shock, the Covid-19 pandemic is an exogenous shock originating from a public health crisis and whose devastating consequences are producing severe damage to the real economy and extraordinary volatility on the financial markets. Third, the pandemic resulted in a bond markets crash. Credit spreads on corporate bonds - investment grade and high yield alike - widened above their historical average; liquidity conditions deteriorated substantially for a wide range of bonds, and transaction costs increased sharply. Acharya and Steffen (2020) show that firms with high credit ratings, and especially those operating in industries heavily affected by lockdown measures, increased their bond issuance activities. Moreover, since the Covid-19 breakdown, they drew down their bank credit lines as a precaution. To this end, we examine the relation between the credit spreads of green bonds and the Covid-19 pandemic by using European daily data from Thomson Reuter's Refinitiv and conducting a difference-in-differences analysis inside the period spanning from January 1, 2020 to December 31, 2020. In a similar vein of Albuquerque et al. (2020), we estimate a difference-in-differences regression of daily corporate credit spreads with a Covid-19 event date of February 24, when the financial markets decline accelerated. We include a second event date of November 9, when Pfizer and BioNTech announced their experimental Covid-19 vaccine was more than 90% effective in preventing Covid-19, which was a watershed moment in fighting the coronavirus pandemic. We control for the second event to understand

how credit spreads react to the positive shock given by the announcement of the vaccine efficacy. We add day, country, sector, issuer and rating fixed effects to control for any other unobservable effects and cluster the standard errors by bonds and day. Finally, since the ESG scores are priced by the markets and affect the cost of capital as well as the cost of debt, we control for the ESG rating of the issuing companies.

As discussed in detail below, results show that green bonds generate an extra aggregate credit spread between 0.132% and 0.243% from February 24 until March 31 relative to conventional bonds. From the investors' point of view, this means that, if under ordinary market conditions, green bonds tend to exhibit lower yields relative to their conventional counterparts (Löffler et al., 2021), in periods of heightened market volatility, corporate green bonds behaved like high beta securities, offering higher risk premiums compared to conventional bonds as compensation for the uncertain profitability and a higher risk of default. We find further support for green bond underperformance - given the stronger run-up in their credit spread - when running the robustness tests. Next, we find that the green bond credit spreads narrowed on optimism about Pfizer-BioNTech's Covid-19 vaccine, paying a lower premium compared to conventional ones from November 9, 2020, until the end of December. Several distinct periods can be identified in the behaviour of corporate credit spreads of both green and conventional bonds during the global outbreak of Covid-19. When the virus led to the first crisis in China (the Wuhan lockdown on January 23, 2020), corporate credit spreads remained stable. Only after February 24, when 11 municipalities in Northern Italy entered lockdown, the green bonds' credit spreads started to rise, surpassing conventional bonds and reaching their peak in mid-March 2020. Green bonds' credit spreads fell below the conventional ones in October and retreated significantly after November 9, when U.S.-based Pfizer and Germany's BioNTech revealed positive results from trials of their vaccine. We can deduce that the promising developments on the vaccine front have sparked investors' optimism on the impending end of the Covid-19 pandemic and a possible return to normalcy. Investors - concerned about the broader impact of the coronavirus outbreak - showed renewed confidence in the green bond market over the conventional bond market, giving green bonds issuers the financing needed to recover after the Covid-19 crisis and triggering a pullback in green bonds' credit spreads. Furthermore, the Covid-19 pandemic highlighted the substantial negative impacts of humans on the environment. Hence, it may have led to increased investor

beliefs that consumer demand for green products and services will increase in the long run and that green investment will have a positive impact on the economic recovery in the post-Covid world. Green bonds' credit spreads decreased further in the following month until December 31, 2020, showing greater capacity to profit from upturns.

Overall, our results reveal that green bonds showed a higher risk exposure and a lower resilience to distress than conventional bonds during the Covid-19 crisis, while profiting more of any upside. At the outburst of the pandemic green bonds performed worse than conventional bonds, just to rebound with greater force as the fear of the pandemic eased after the vaccine announcement.

This study makes several contributions to the literature. First, it adds to the growing literature on the financial and economic consequences of the Covid-19 shock by providing novel evidence on the behaviour of green bonds' credit spreads in a comprehensive sample of European issuers. The limited research conducted so far are focused on the effects of the Covid-19 pandemic on bond markets pricing (Bi and Marsh, 2020; Nozawa and Qiu, 2021). However, until now, very little is known about the green bond markets. An exception is the recent article by Naeem et al. (2021), who analyse the level of efficiency of the green and traditional bond markets pre- and during the Coronavirus crisis by examining the presence of asymmetric multifractality. Taking the outbreak of the Covid-19 pandemic as an exogenous shock, our paper uses the event study method and econometric models to investigate the impacts of Covid-19 and of the announcement of the vaccine effectiveness on Europe's green bond market for the first time and analyse the underlying reasons of these impacts. Second, we contribute to the growing literature that studies the green bond market Zerbib (2019). Since this literature focuses mainly on the pricing of green bonds in the market for municipal and sovereign green bonds, there is a lack of studies examining corporate green bonds. The sole exceptions are the recent studies by Tang and Zhang (2020) and Flammer (2021). They find evidence that the stock market responds positively to the issuance announcement of corporate green bonds, especially for first-time issuers and bonds certified by third parties. Our study complements this body of research by examining whether a green bond premium - defined as the yield differential between a green bond and an otherwise identical conventional bond - found in previous studies, persists during the Covid-19 pandemic and after the announcement of the vaccine effectiveness. Finally, this paper contributes to the

recent debate on whether firms with higher ESG ratings are relatively more resilient during crisis periods (Lins et al., 2017; Albuquerque et al., 2020; Ding et al., 2021). We assess this hypothesis by estimating the relation between ESG and credit spreads behaviour during the Covid-19 crisis. Our findings indicate that firms with high ESG scores have higher resilience to adverse shocks (Covid-19).

The remainder of the paper is organised as follows. In the next section, we describe testable prediction. In Section 3, we present our data, summary statistics and methodology. In Section 4, we show the baseline results, and in Section 5, we add some robustness tests to the main outcomes. Section 6 concludes the paper.

2 Testable Predictions

The Covid-19 outbreak revealed the malfunctions in the debt market that pose a threat to the survival of firms. The longer the uncertainty about the future course of the economy is lasting, the higher the risk that companies that are highly leveraged or those that are not highly profitable experience difficulty refinancing expiring bonds and loans, or they only service these at a much higher financial cost. With much less or no incoming revenues in the wake of pandemic-fighting lockdowns and fewer options to deal with this shortfall, even companies that were profitable and with healthy balance sheets before the virus outbreak can quickly run into financial trouble. As it usually happens during periods of market distress, the Covid-19 shock negatively affected investors' attitude toward risk, triggering sell-offs in financial markets. This tendency had an immediate impact on corporate bond markets in Europe, changing the valuation of assets. According to the literature on sustainable and responsible investments (SRI), investors with a preference for environmental and social stocks are more loyal and less sensitive to sustainable funds' performance than to conventional mutual funds' performance (Bollen, 2007; Renneboog et al., 2011; Albuquerque et al., 2020). Furthermore, investors with a longer investment horizon prefer to hold high ESG firms and behave more patiently when incurring a loss (Starks et al., 2017). In line with this literature, we expect green bonds credit spreads to be more stable than conventional bonds during the market turmoil, reflecting a more stable and committed investor base.

Following the segmented capital markets model developed by Heinkel et al. (2001), polluting

firms are held by a subset of investors. Since those investors who are sensitive to the environment choose not to hold them, polluting firms have a less diversified investor base and carry higher systematic risk than green firms with greater valuations. In their empirical study, Tang and Zhang (2020) find evidence that green bond issuance helps firms enlarge their investor base and attract investors with a green mandate and socially responsible funds by signalling firms' dedication to sustainable development. Furthermore, as investing in green bonds reduces portfolio downside risk for investors holding dirty energy stocks or international equity indices (Kuang, 2021), they can be a safe haven asset during the Covid-19 pandemic, delivering less when economic conditions are improving, in exchange for a stronger resilience during downturns. Based on the aforementioned arguments, the escape from the market due to the Covid-19 crisis should be less effective for sustainability-oriented investors. Then the credit spread of green bonds should not increase as much relative to the credit spread of conventional bonds.

Hence, we hypothesise the following:

- **H1a:** Credit spreads of green bonds increase less compared to conventional bonds after February 24, when 11 municipalities in Northern Italy entered lockdown.

On the other hand, some investors would prefer to hold assets with a low environmental impact and avoid low sustainability investments not because they care about the environment per se, but because they rationally view such investments as a way to maximise profits (Nilsson, 2008; Hartzmark and Sussman, 2019) or reduce risk (Godfrey et al., 2009; Gangi et al., 2020). Empirical evidence from Larcker and Watts (2020) and Flammer (2021) confirm that green bonds provide investors with at least the same risk–return trade-off as conventional bonds. Investors might therefore be attracted to green bonds only because of financial reasons. Since the green bond market is impacted by shocks occurring in other financial markets (Reboredo and Ugolini, 2020), the environment of uncertainty and fluctuation in global financial markets caused by the Covid-19 pandemic may have impacted the green bond market, at least in a short term, by potentially providing an incentive for investors – especially those driven by profit - to sell green bonds and focus on more traditional investment instruments. As stated by Zeidan (2020) "amidst a global crisis", the search for financial returns (or minimizing financial losses) takes precedence among all else, in financial markets."

According to the literature (Delmas and Burbano, 2011; Marquis et al., 2016), the significant

pressure from the market to environmentally friendly firms may feed greenwashing practices, consisting of those corporate behaviours that present an obvious discrepancy between the claims about the company's environmental commitment and its environmental performances (Lyon and Montgomery, 2015). Greenwashing is a widespread phenomenon, and green bond issuers could decide to engage in this practice to portray themselves as environmentally responsible but without taking tangible actions. The lack of unified standards to identify a green bond and the limited enforcement of the law for supervising green integrity make the green bond market an environment conducive to greenwashing practices.[3]

The Covid-19 pandemic has increased general awareness of the urgency of the climate change crisis and the need to address environmental challenges and advance sustainability, increasing market pressure on companies to go green (Severo et al., 2021). The changing landscape triggered by Covid-19 might have created the circumstances under which firms are more likely to engage in greenwashing practices to appear socially and ecologically more sustainable and gain legitimacy from the public (Zeidan, 2020). Since greenwashing negatively affects firm performance (Du, 2015; Price and Sun, 2017) and intention to invest (Gatti et al., 2021), we might, then, expect that investors will be more willing to sell green bonds than conventional ones due to the potential risk of greenwashing. Finally, green assets are susceptible to oil market volatility and oil price fluctuations; Therefore, when the crude oil market experiences high volatility regimes, the incentives and interests of the green investments decrease (Dutta et al., 2020). The coronavirus pandemic has negatively impacted the oil industry, reducing the global demand for crude oil and triggering an oil trade war between Saudi Arabia and Russia - the major oil-producing nations (Bourghelle et al., 2021). The high levels of oil price volatility due to the pandemic may have in turn influenced green bonds' credit spreads (Lee et al., 2021). Based on these considerations, we expect green bonds credit spreads to be less stable than those of conventional bonds during the market turmoil. Accordingly, we develop the following alternative hypothesis:

- **H1b:** Credit spreads of green bonds increase more compared to conventional bonds after February 24, when 11 municipalities in Northern Italy entered lockdown.

Investor sentiment (i.e., the optimism or the pessimism that an investor has about the

[3]See "The dark side of green bonds", Financial Times, June 13, 2015: https://www.ft.com/content/16bd9a48-0f76-11e5-b968-00144feabdc0

financial market in the future)[4] can be affected by news published and witnessing an event (Broadstock and Cheng, 2019). Therefore, if the outbreak of the Covid-19 pandemic led to a massive sell-off of global financial assets, the surprising success rate of a coronavirus vaccine trial from Pfizer and BioNTech may represent a game change for the dynamics of the world economy giving a material hard reason for a change in the overall financial market outlook.

In response to the worsening Covid-19 pandemic, the European Commission and the European Central Bank (ECB) took a series of monetary and fiscal policies designed to mitigate and contain the economic repercussions of the coronavirus crisis first and support the economic recovery later (see Table 6. Among these interventions, in July 2020, the European Commission announced the "Next Generation EU" (NG-EU) project - a $e750$ billion package funded through the issue of bonds on the financial markets by the European Commission on behalf of the EU.[5] The package offers financial support to all the Member States -especially those most affected by the pandemic - through a mixture of grants and loans to finance the urgent investments and reforms, in particular in the green and digital transitions. In the years to come, the NG-EU project, mainly through the Recovery and Resilience Plan (RRP) presented by each Member State, will strongly support green-based spending and investments. All those initiatives may have played a strong role in the recovery of the green bond market. In light of the above, we hypothesis the following:

- **H2:** Credit spreads of green bonds decrease more than conventional bonds after the positive shock represented by the announcement of the vaccine effectiveness on November 9, 2020.

3 Data and Sample

3.1 Data

To compile a complete corporate bonds database (both conventional and green) in Europe, we extract all corporate bonds in the Thomson Reuter's Refinitiv fixed income database. We exclude bonds whose issuer's sector is "Government" and "Supranational". Moreover, we exclude

[4]For further information on this topic see Baker and Wurgler (2006).
[5]See Arce Hortigüela et al. (2020)

bonds whose issuer's is not located in Europe and whose currency is different from the euro. Finally, we include only bonds that are labelled as "plain vanilla fixed coupon bond". The above criteria yield 7935 corporate bonds (209 green bonds and 7726 conventional bonds) listed from 1 January 2020 until 31 December 2020. Thomson Reuter's Refinitiv contains information including the amount, maturity, credit rating, issuer, and collateral presence for each bond. We collect daily green credit spread and conventional credit spread data from Thomson Reuter's Refinitiv.

A possible drawback of using bonds is the stale price problem and, in particular, the possibility of infrequent trading among corporate bonds. The stale price problem was study deeply in the financial markets' literature, among others, Diaz and Skinner (2001); Zitzewitz (2006); Qian (2011). The literature focused on the fact that investors can take advantage of mutual funds that calculate their NAVs using stale closing prices by trading based on recent market movements. And the stale price problem is usually linked to ETF or mutual funds (Qian, 2011). Diaz and Skinner (2001) tested arbitrage-free pricing models. They showed that the structure of errors produced by standard statistical yield curve models indicates that even with careful data selection, the liquidity problem remains. The author's evidence that the errors due to illiquidity is modest and controlling bonds by rating category produces no significant bias in the estimations of the yield curve. Moreover, Galliani et al. (2014) investigate the liquidity of the European fixed income market using a large sample of government, corporate and covered bonds. The evidence that corporate bonds may suffer from the stale price problem shows that an important driver of bond liquidity is the size of the bond issue and the importance of rating (they suggest to regulators to create incentives for plain vanilla issues). Hence, taking into account these considerations, we try to solve this issue by considering the corporate bonds that are more liquid. We include only bonds that are "plain vanilla fixed coupon bonds", and we have bonds for which there is information on rating, in line with the suggestion of Galliani et al. (2014); Diaz and Skinner (2001). Finally, Table 1 defines all variables used in the paper. The sample size varies across regression specifications because not all variables are available for all firm-daily observations.

3.2 Summary statistics

Table 2 provides a categorization of corporate green and conventional bonds by industries. Industries are partitioned according to TRBC (The Refinitiv Business Classifications) codes. As can be seen, corporate green bonds are more common in the financial sector and in utilities and oil and gas (energy) sectors where the environment is likely core to the firm's operations (similar with Flammer (2021)). Table 3 shows a breakdown by countries. As is shown, green bonds are especially prevalent in the Netherlands, France, Germany and Italy, in line with Flammer (2021). Table 4 presents corporate and conventional bonds by rating. As is shown, the more significant part of both green and conventional bonds issued have an investment-grade rating. In contrast, a residual part is classified as high yield (especially for green bonds, in relative terms, represent about 3.3% (180/5481) of the total investment-grade bonds, while representing approximately 1.5% (8/546) of total high yield bonds). The econometric analyses do not include bonds for which there is no information on rating. We left with 6027 bonds (188 green, 5839 conventional), of which 5481 are investment grade (180 green, 5301 conventional). In Table 5 we present the summary statistics differentiate between green and conventional bonds. As can be seen, corporate green bonds have relatively large average issuance amounts than conventional ones. The average green bonds issuance amount during the Covid-19 outbreak (Vaccine Announcement) is 700 (706) million euros, while the conventional ones are 245 (253) million euros.[6] The average bond with collateral is about 20% for green bonds, while conventional ones are about 26%. Interesting, the average ESG score of the issuer for both green and traditional bonds is quite similar: 77 for green bonds and 78 for conventional bonds. Finally, we evidence that the average Ln Credit Spread is lower for a green bond than the conventional one (96 b.p. green, 109 b.p. conventional).[7]

3.3 Empirical design

Our econometric approach is based on a difference-in-difference (DID) design used to identify better the effect of the Covid-19 pandemic and the Vaccine on the corporate green bonds credit spreads. The approach has been widely used to evaluate the impact of the Covid-19 pandemic

[6]Since the per Amount Issued is in logarithmic terms, we use the exponential of 20.3675 (19.3174), which is equivalent to 700,636,664.00 (245,154,700.00) million euro for green bonds (conventional bonds).

[7]Since the per Ln Credit Spread is in logarithmic terms, we use the exponential of 4.45 (4.69), which is equivalent to 96 (109) b.p. credit spread (conventional bonds).

in the empirical literature (Brodeur et al., 2021; Albuquerque et al., 2020). To understand the impact of the Covid-19 pandemic, we run the following daily regression for the period from 1 January 2019 to 31 March 2020:

$$\begin{aligned} Credit\ Spread_{i,t} = \beta_0 + \beta_1 Green_i + \beta_2 Covid_t + \\ \beta_3 Green_i \times Covid_t + \beta_4 Collateral_i + \beta_5 Amount\ Issued_i + \\ \beta_6 Time\ FE_t + \beta_7 Country\ FE_c + \beta_8 Issurer\ FE_i + \\ \beta_9 Rating\ FE_i + \epsilon_{i,t} \end{aligned} \tag{1}$$

where the $Credit\ Spread_{i,t}$ variable is the natural logarithm of the daily credit spread of bond i on day t. $Green_i$ is a dummy variable that equals one for bond i that it is classified as "Green Bond" in the Thomson Reuter's Refinitiv fixed income database and zero otherwise. $Covid_t$ equals one from 24 February to 30 April 2020, and zero before this period. proxy of bond size calculated as the natural logarithm of the amount issued by the firm. $Time\ FE_t$ represents day fixed effects, $Country\ FE_c$ is day country effects, $Issurer\ FE_i$ represents issuer fixed effects, $Rating\ FE_i$ is rating fixed effects and $\epsilon_{i,t}$ represents an error term. In all specification, we consider time, country, sector, issuer and rating fixed effects to control any other unobservable effects. Finally, we cluster the standard errors by bonds and day. We are also interested in understanding if the Vaccine effect could be different concerning the Covid-19 pandemic shock. To understand the impact of the Vaccine, we estimate the following equation for the period from 1 October to 31 December 2020:

$$\begin{aligned} Credit\ Spread_{i,t} = \beta_0 + \beta_1 Green_i + \beta_2 Vaccine_t + \\ \beta_3 Green_i \times Vaccine_t + \beta_4 Collateral_i + \beta_5 Amount\ Issued_i + \\ \beta_6 Time\ FE_t + \beta_7 Country\ FE_c + \beta_8 Issurer\ FE_i + \\ \beta_9 Rating\ FE_i + \epsilon_{i,t} \end{aligned} \tag{2}$$

where $Vaccine_t$ equals one from 9 November to 31 December 2020, and zero before this period. To understand our choice of events window for $Covid_t$ and $Vaccine_t$, consider Figure 1. Figure 1 shows the evolution of the natural logarithm of the credit spread for both the green

and conventional bonds, with two dates highlighted: February 24 (Panel A) and November 9 (Panel B). These dates are used to identify the Covid-19 pandemic and Vaccine shock in our DID set up. Following Albuquerque et al. (2020) and Ramelli and Wagner (2020), February 24 is the start of the "fever period", and it is also the first trading day after the first lock-down in Europe (11 municipalities in Northern Italy). Furthermore, for the second part of the analysis, we construct a second event dummy to isolate the effect of Vaccine announcements on corporate green bonds credit spread. November 9 is the day that Pfizer-BionTech announce that their vaccine candidate against Covid-19 was found to be more than 90% effective in preventing Covid-19.[8] The key coefficient in both equations 1 and 2 is β_3. If the coefficient of the DID term (β_3) is positive (negative) on credit spread, then we assume that the Covid-19 pandemic has contributed to increasing (decrease) in the green bond credit spread concerning conventional ones.

4 Empirical Analysis

4.1 Baseline Results

Panel A in Table 7 shows the main results for equation 1. The coefficients associated with *Amount issued* is negative and statistically significant. Moreover, the presence of collateral reduces the bond credit spread. The outcomes show that the coefficient associated with *Green* is negative and significant for all specifications. The green bonds pay a lower premium concerning the conventional ones, in line with Tang and Zhang (2020) and Zerbib (2019). The *Covid* dummy is always positive, evidencing an increase of credit spread after the Covid-19 pandemic shock. The variable of interest *Green*Covid* is positive and statistically significant. The green bonds generate an extra aggregate credit spread of 0.173% after the Covid-19 shocks. These results suggest that green bonds are generally associated with higher credit spread after the Covid-19 pandemic shock supporting our *Hypothesis 1b*.

Next, we investigate if the vaccine's impact on a green bond credit spread differs from the Covid-19 pandemic shock. The results are reported in Panel B of Table 7. The *Vaccine* dummy is always negative, evidencing a decrease of credit spread after the announcement of the

[8] https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-announce-vaccine-candidate-against

effectiveness of the Covid-19 vaccine by Pfizer-BionTech. Our variable of interest *Green*Vaccine* is now negative and statistically significant, suggesting that the green bond credit spread are generally negative affected by the announcement of the Covid-19 vaccine and pays a lower premium concerning the conventional ones (-0.044%). Hypothesis 2 predicting that credit spreads of green bonds decrease more than conventional bonds after the announcement of the vaccine effectiveness on November 9, 2020, is therefore supported. This result supports the argument of Park et al. (2020) on the increased sensitivity of green bonds to positive shocks. As green bonds have experienced rapid growth in recent years, investors view them with hope and react strongly to minor pieces of good news.

5 Robustness Tests

In this section, we provide various robustness tests. To mitigate the potential confounding event, we consider monetary and fiscal interventions by the European Union to support the European economy during the Covid-19 pandemic. Specifically, we introduce two dummy variables that take one on the day of the fiscal and monetary policies announcements, in our baseline model of equations 1 and 2. As shown in Table 7 fiscal supports have a negative impact on credit spread; vice versa, monetary policy supports have a positive but negligible effect on credit spread (the effect is near zero). Our main results are robust to the inclusion of these additional controls.

Second, we conduct a separate analyses on more homogeneous subsets of bonds. We re-estimate the main models splitting the sample into two homogeneous subsets of bonds: Core Europe (Germany, Netherlands, Belgium and Luxembourg) and Mediterranean countries (Italy, Spain, and France). Our results remain virtually the same. We do not find any difference in the impact on the two-subsample considered (Columns 3 and 4 of the Table 7, Panel A for the Covid-19 pandemic and Panel B for the vaccine announcement).

Third, we conduct an alternative robustness test splitting the sample by industry (Financial vs Non-Financial industries). Interesting, we find that our main findings remain unaltered only for the corporate bonds issued by the financial and banking industries (column 5 of table 7, Panel A for the Covid-19 pandemic and Panel B for the vaccine announcement). While, for the other industries, we do not find any statistically significant evidence (column 6 of Table 7,

Panel A for the Covid-19 pandemic and Panel B for the vaccine announcement).

Fourth, we do an alternative segmentation in terms of investment-grade vs high yield bonds based on rating. Interesting, we find that our main findings remain unaltered only for the corporate bonds with an investment-grade rating, in line with Zerbib (2019). While, for the high yield rating, we find a negative statistically significant impact of Covid-19 outbreak on the credit spread of green bonds concerning conventional ones (columns 7 and 8 of Table 7, Panel A for the Covid-19 pandemic and Panel B for the vaccine announcement). We have an explanation for these results. Looking at Panel B of Table 4, it is immediately noticed that there is no green bond issued in our sample with a rating below B. Moreover, there is a large part of conventional bonds with low-rated bonds. The results that we find may depend on this issue. At the same time, replicate the analysis for the class of high yield bonds that have a rating between Ba1-B3 could be more feasible. Unfortunately, since there are few data, the analysis may not be consistent at a statistical level.

Moreover, the decision to issue a green bond might be correlated with other factors such as bond size or the presence of collateral and, therefore, could render the coefficient of the DID term (β_3) in our model inconsistent. To disentangle the possible differences between the treatment and the control group, we further add a robustness test using a PSM technique (Rosenbaum and Rubin, 1985). To solve the issue, we first estimate a probit model as follows:

$$Green_i = \beta_0 + \beta_1 Amount\ Issued_i + \beta_2 Collateral_i + \epsilon_i \tag{3}$$

$Green_i$ is a dummy variable that equals one for bond i classified as "Green Bond" in Thomson Reuter's Refinitiv fixed income database and zero otherwise. $AmountIssued_i$ is the log of the natural logarithm of the Amount issued for bond i during the pre-treatment period; the $Collateral_i$ is a dummy variable equal to one if the collateral was pledged at bond origination, and zero otherwise. ϵ_i is the error term. We then compute the propensity scores using the estimates obtained from the above equation. We also impose the condition that the propensity score must lie within a .01 range of the bond's propensity score. Using a 1:1 matching strategy, the matched sample is similar in bond size and collateral. The matching produces a sample of bonds with similar bond sizes and collateral. Values for bond size are 20.375 (treatment group)

and 20.360 (control group), with p-values of 0.98. The value for collateral is 0.214 (treatment group) and 0.211 (control group), with p-values of 0.96. In the second step, we include only the matched sample from the first step. In order to control for fiscal and monetary policies employed in the European Union, we also control for the European Fiscal and Monetary support. The results reinforce the previous estimates (see column 1 of Table 8 for the Covid-19 pandemic, and column 2 for the Vaccine announcement).

As the next step, we verify whether different our results change when controlling for the ESG rating of the issuing companies.[9] Indeed, ESG scores are priced by the markets and affect the cost of capital and the cost of debt. First, we hand-collected the ISIN for each Issuer using the Datastream excel-addin (since Thomson Reuter's Refinitiv fixed income database gives only the Issuer's name but not the identification code, i.e. ISIN). Second, the ESG score is available only for the listed firms in the stock exchange markets. For this reason, we lose observations in these steps. In the baseline specification, we have 7,935 bonds issued by 810 firms. Matching the ESG score for all the firms listed, we left with 2,845 bonds issued by 393 firms (99 green bonds issued by 56 firms and 2,746 conventional bonds issued by 388 firms).

Then, we re-estimate both equations 1 and 2, and in the first specification, we control only for the ESG score of the bonds' Issuer. In the second specification, we calculate a dummy variable representing the firms with the 75th percentile of the ESG score (higher value of ESG score), which we add as an additional control. Finally, we explore if firms with high ESG scores (ESG_75th) and issued a green bond experiment a lower credit spread concerning conventional one (we interact ESG_75th with $Green$), and if during the Covid-19 pandemic and the Vaccine Announcement behaves differently concerning our main findings ($ESG\_75th * Green * Covid$ and $ESG\_75th * Green * Vaccine$). We find evidence that companies with high ESG scores have greater resilience to adverse shocks (Covid-19), but we do not find any evidence for positive shock (Vaccine Announcement). In contrast, when we include the ESG_75th dummy, we find that firms in the 75th percentile (high ESG ratings) have a lower credit spread, in line with the empirical literature (Albuquerque et al., 2020; Zerbib, 2019). Finally, when we control during the Covid-19 outbreak and the Vaccine Announcement, we do not find evidence that firms with high ESG scores that issued a green bond experience a higher/lower credit spread during

[9]We thank the anonymous reviewer for their insightful comments and suggestions to improve this part of the paper.

negative/positive shocks. From these results, we may infer that the firms that issued green bonds and have a higher ESG score (75th) did not experience an increase in the credit spread concerning conventional ones during the Covid-19 outbreak and the Vaccine Announcement. Finally, our main results are robust to the inclusion of the ESG variables (see Table 9).

6 Concluding Remarks

Green bonds are innovative financial instruments providing access to capital for environment-friendly projects, such as green housing and architecture, sustainable agriculture and forestry, energy savings and renewal, climate adaptation, and emissions reduction projects. Since its inception in 2007 with the first issuance, the green bonds market has evolved dramatically, becoming one of the most dynamic and fast-growing segments of global financial markets. In this paper, we construct a comprehensive dataset covering all corporate green bond issuance in the Euro area during the time spanning from January 1, 2020, to December 31, 2020. We provide the first empirical analysis of the green bond market's reaction to the Covid-19 pandemic. Our empirical analysis suggests that the Covid-19 pandemic had significant impacts on the European green bond market; overall, green bonds showed a higher risk exposure and lower resilience to distress compared to conventional bonds while profiting more of any upside. Specifically, results show an increase in the credit spreads of green bonds compared to conventional ones in the aftermath of the outbreak of the coronavirus pandemic, supporting *Hypothesis 1b*.

These evidences may reflect investor concerns about the objective risk of execution of green projects caused by the pandemic induced recession. The fight against the pandemic quickly became the absolute priority globally, while the climate crisis moved into the background. In this unprecedented context, companies and governments had to postpone plans for green investment and focused their spending on managing the economic fallouts from the Covid-19 pandemic.

The renewable energy sector - heavily dependent on imports from other regions, mainly China, for meeting the equipment and material demand - has been heavily impacted by the Covid-19 pandemic. The reduction in global energy demand following the pandemic-induced lockdowns has had a major impact on investments in renewable energy (Hoang et al., 2021). The lockdown measures implemented to reduce the spread of the virus followed by supply chain disruptions, the large scale of shutting down in production, low traffic, and halting of

non-essential manufacturing activities, have caused significant delays in the deployment of renewable energy projects (Hoang et al., 2021). According to Bloomberg New Energy Finance, installations for solar and wind projects have been reduced by 8% and 12% in 2020, respectively. Some major planned projects were temporarily put-on hold owing to the pandemic, including 3000 MW of combined solar and wind in India (Oxford Business Group, 2021) and 25 GW of wind power in the US (Weko et al., 2020). Up to 150 GW of renewable energy projects will be delayed or cancelled in Asia through 2024 if the recession continues (Frangoul, 2020). In Europe, several countries have stopped auctions for renewable energy or have reduced future volumes (Wigand et al., 2020).

This above-described scenario, together with the increased potential risk of greenwashing due to increasing market pressure on companies to go green (Severo et al., 2021), as well as, the effect of the high levels of oil price volatility (Lee et al., 2021), may have led investors to perceive sustainable investment assets as riskier than conventional ones, triggering sell-off in the green bond market. However, we can assume that after the pandemic was relieved by the positive news about the vaccine, investors - concerned about the broader impact of the coronavirus outbreak - perceived commitment toward environmentally friendly behaviours as a value-enhancing strategy. This led them to regain confidence on the future profitability of green bond and on the ability of their issuers to pay off their debt. As a result, investors started buying green bonds, leading to lower credit spreads as stated by our *Hypothesis 2*.

We attribute the renewed investor confidence to the fact that the Covid-19 pandemic, which threatens firms' survival, may have led to increased investor belief that consumer demand for green products and services would enhance in the long run. They might also anticipate that green investments will have a positive impact on the economic recovery in the post-Covid World. Furthermore, the Covid-19 pandemic has raised investors' awareness of climate change and other environmental issues, highlighting the risks associated with the inevitable and imminent process of green reconversion incorporated in traditional bonds. This may have led investors to demand higher yields for conventional bonds than green ones to compensate for the risk of green reconversion. The appearance of green bonds as a vehicle to finance green projects represents in this context a unique opportunity to promote a green economic recovery, integrating environmental considerations into decision-making processes. In this way, green bonds will

support the achievement of EU objectives in the reduction of national emissions by 2030. This paper has several implications. First, from the issuers' point of view, our results show that green bonds' credit spreads dropped after the positive shock given by the announcement of the vaccine efficacy, alleviating the external finance premium arising from the financial market turmoil. These results highlight the opportunity for issuers to benefit from a diversification of their bondholder base by providing green products, thereby securing the financing needed for a green recovery while enjoying long-term pricing advantages. Second, from the investors' point of view, the results highlight the importance to shift towards greener investment opportunities as part of the fixed-income allocation, financing a green recovery beyond Covid-19. Our findings also confirm the potential of green bonds to become an effective diversifier for investors in traditional assets in times of extreme market turmoil. At its heart is the largest stimulus package ever financed in Europe worth e2.018 trillion to support the recovery after Covid-19 and steer the transition towards a greener, more digital and more resilient Europe (30% of the EU funds, the highest share ever of the European budget, are aimed at fighting climate change). Going forward, there are multiple directions for future research. First, since we use data on the Europe's green bond market, future studies could expand the experimental setting of our study by analysing the impact of the Covid-19 pandemic on the global green bond market and investigate whether our results continue to hold in different contexts. Second, by issuing green bonds, companies credibly signal their commitment to the environment (Flammer, 2021). Future work could investigate the role played by green bond issuers in rebuilding a greener and more resilient economy after this crisis and verify whether the funded green projects have actually produced tangible and measurable improvements in environmental performance post-issuance. Finally, due to the lack of data, in this study, we have not examined the difference between green "use of proceeds" bonds (i.e., bonds earmarked for green projects but backed by the issuer's entire balance sheet) and green "revenue" bonds (green project bonds and green securitized bonds, i.e., bonds backed by the revenue or asset expected from the implementation of the project). Since only for this second type of green bonds, the changing risk of execution or greenwashing would make a difference in terms of credit spread differential towards the traditional bonds, this area warrants further research.

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Figure 1: Evolution of Green Bond vs Conventional Bond.
This figure shows the development of the natural logarithm of the Credit Spread (in basis point) during 2020 for both the Green bonds and Conventional ones. Panel A shows the dynamics of the natural log of the credit spread (green vs conventional) during the Covid-19 outbreak. The vertical line represents the day that the first lock-down in Europe started (Covid, 23 February 2020). Panel B shows the dynamics before and after the Vaccine Announcements. The vertical line represents the day when Pfizer-BioNTech announce the efficacy of their Covid-19 vaccine (Vaccine, 9 November 2020).

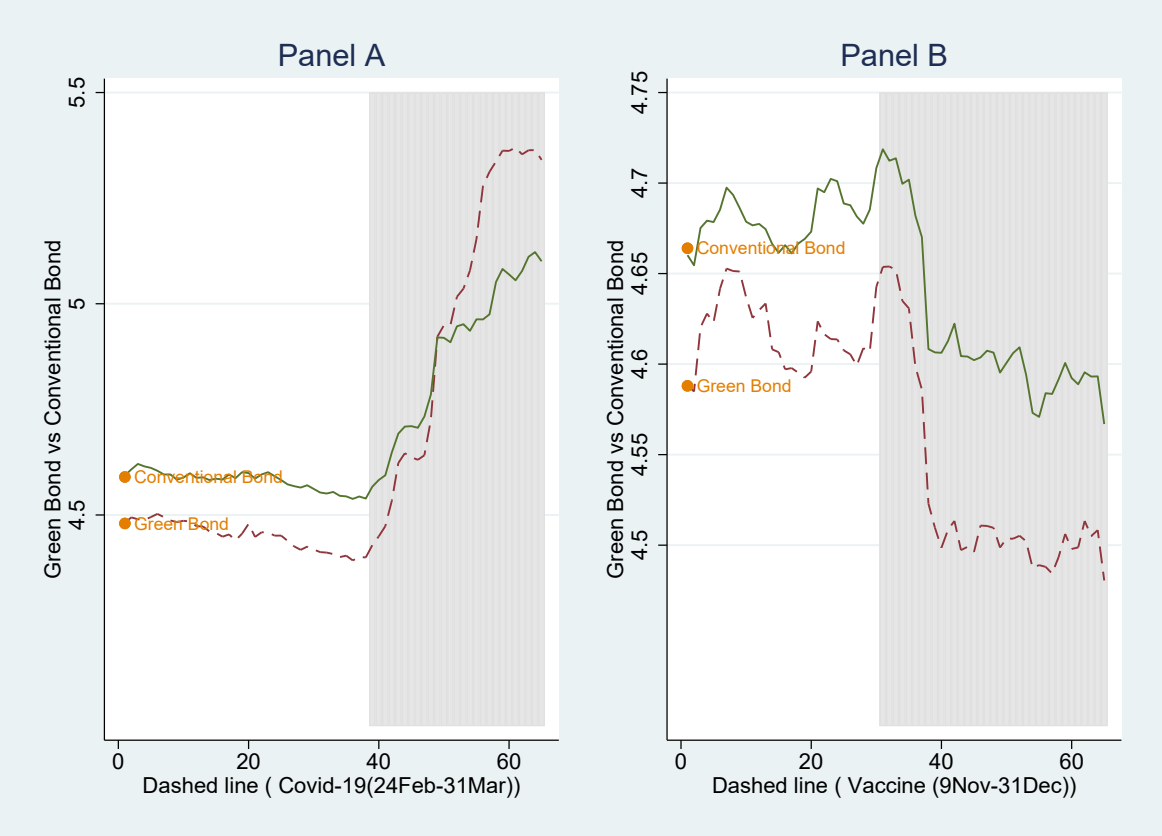

Table 1: Variables, definitions, and sources.

Variable	Definition	Source
Ln Credit Spread	The Credit Spread is expressed as the natural logarithm of the yield (in basis points) difference between the bond and the equivalent government benchmark bond for the bond's denomination currency.	Thomson Reuter's Refinitiv
ESG	ASSET4 ESG Company Rating.	Thomson Reuter's Refinitiv
Green	Dummy variable that equals one if in the Thomson Reuter's Refinitiv database the bonds are labelled as "green bonds" (more precisely, bonds for which the filed "Green Bonds" is "Yes").	Thomson Reuter's Refinitiv
Post Covid	Dummy variable that equals one from 24 February to 31 March 2020, and zero from 1 January 2020 to 23 February 2020 (Albuquerque et al., 2020; Ramelli and Wagner, 2020).	
Post Vaccine	Dummy variable that equals one from 9 November to 31 December 2020, and zero from 1 October to 8 November 2020	
Sector	We use the Refinitiv Business Classification (TRBC) as our industry classification.	Thomson Reuter's Refinitiv
Rating	The rating data are from the Moody's Investors Service historical database. In Moody's Investors Service's ratings system, securities are assigned a rating from Aaa to C, with Aaa being the highest quality and C the lowest quality.	Thomson Reuter's Refinitiv
Collateral	Dummy variable that equals one if collateral was pledged at bond origination, zero otherwise	Thomson Reuter's Refinitiv
Amount Issued	The natural logarithm of the total amount issue of bonds	Thomson Reuter's Refinitiv

Table 2: Corporate Conventional and Green bonds by industry. This table reports the number of corporate conventional and green bonds by industry, using all corporate conventional and green bonds during 2020 listed in euro. Industries are partitioned according to TRBC (The Refinitiv Business Classifications) codes.

Industry	N. Green Bonds	N. Conventional Bonds	Total
Financials			
Banking	76	4755	4831
Financial	50	1661	1711
Mortgage Banking	12	122	134
Real Estate	0	33	33
Industrials			
Service	1	188	189
Utility	35	89	124
Telecommunications	1	117	118
Oil and Gas	10	55	65
Automotive Manufacturer	2	61	63
Chemicals	2	55	57
Beverage/Bottling	0	56	56
Transportation	3	49	52
Gas Utility	3	41	44
Conglomerate/Diversified Mfg	1	38	39
Electronics	2	33	35
Cable/Media	0	35	35
Pharmaceuticals	0	30	30
Containers	2	18	20
Others	9	290	299
Total	209	7726	7935

Table 3: Corporate Conventional and Green bonds by European Countries. This table reports the number of corporate conventional and green bonds by country, using all corporate bonds during 2020 listed in euro.

Country	Green Bonds	Conventional Bonds	Total
Austria	5	420	425
Belgium	2	123	125
Bulgaria	0	1	1
Croatia	0	4	4
Cyprus	0	1	1
Czech Republic	0	24	24
Denmark	2	51	53
Estonia	0	5	5
Finland	4	140	144
France	26	1055	1081
Germany	57	3423	3480
Greece	0	4	4
Hungary	0	2	2
Ireland	2	105	107
Italy	15	311	326
Latvia	1	0	1
Luxembourg	8	254	262
Netherlands	56	728	784
Poland	0	22	22
Portugal	1	28	29
Slovakia	0	50	50
Spain	12	289	301
Sweden	9	173	182
United Kingdom	9	513	522
Total	209	7726	7935

Table 4: Corporate Conventional and Green bonds by rating. This table reports the number of corporate conventional and green bonds by rating, using all corporate conventional and green bonds during 2020 listed in euro. Ratings are partitioned according to Moody's credit ratings classifications codes.

Rating	Green Bond	Conventional Bonds	Total
Investment Grade (IG)			
Aaa	6	1053	1059
Aa1	1	498	499
Aa2	8	154	162
Aa3	12	481	493
A1	12	283	295
A2	12	760	772
A3	45	502	547
Baa1	43	547	590
Baa2	29	723	752
Baa3	12	300	312
Bonds with IG Rating	180	5301	5481
High Yiled (HY)			
Ba1	1	68	69
Ba2	1	133	134
Ba3	0	65	65
B1	2	68	70
B2	2	70	72
B3	2	50	52
C	0	1	1
Ca	0	7	7
Caa1	0	42	42
Caa2	0	28	28
Caa3	0	6	6
Bonds with HY Rating	8	538	546
Bonds with Rating	188	5839	6027
Bonds without rating			
WR (Withdrawn Rating)	2	134	136
No Rating	19	1753	1772
Bonds without Rating	21	1887	1908
Total	209	7726	7935

Table 5: This table reports the summary statistics (number of observations, mean, median, standard deviation (SD), min and max) for all variables. Panel A shows the summary statistics for the sample from 1 January 2020 - 31 March 2020, and Panel B for the sample from 1 October - 31 December 2020. Table 1 defines all variables used in the paper.

Panel A: Covid (1 January 2020 - 31 March 2020)							
	Bonds	Obs.	Mean	Median	SD	Min	Max
Ln Credit Spread	Green	7188	4.565	4.458	0.498	3.493	6.461
	Conventional	255511	4.694	4.520	0.952	0.693	14.075
Collateral	Green	7188	0.208	0.000	0.406	0.000	1.000
	Conventional	255511	0.265	0.000	0.441	0.000	1.000
Amount Issued	Green	7188	20.368	20.208	0.435	18.599	21.307
	Conventional	255511	19.317	20.208	1.752	11.124	22.511
ESG	Green	4698	77.188	79.480	11.360	28.160	93.960
	Conventional	143194	78.437	83.320	12.223	24.360	93.960
Panel B: Vaccine (1 October - 31 December 2020)							
	Bonds	Obs.	Mean	Median	SD	Min	Max
Ln Credit Spread	Green	9502	4.397	4.324	0.480	3.001	6.090
	Conventional	293285	4.573	4.402	1.032	-2.303	17.424
Collateral	Green	9502	0.224	0.000	0.417	0.000	1.000
	Conventional	293285	0.267	0.000	0.443	0.000	1.000
Amount Issued	Green	9502	20.376	20.208	0.428	18.599	21.307
	Conventional	293285	19.351	20.208	1.736	11.124	22.693
ESG	Green	6206	77.423	79.480	11.191	28.160	93.960
	Conventional	170187	78.278	83.250	12.263	24.360	93.960

Table 6: This table reports the Fiscal and Monetary policies support in the European Union during 2020 (Covid-19 pandemic). *Source: European Central Bank, European Council, Eurogroup, European Parliament and European Commission*

EU Fiscal support measures:	Date	Description
Safety net	9 April 2020	The Eurogroup puts forward e500 billion support package
	23 April 2020	The European Council endorsed the support package agreement.
	8 May 2020	The Eurogroup agrees deal on emergency financial support to euro area countries.
	15 May 2020	The credit line was made operational by the ESM Board of Governors.
Protecting workers and jobs		
		A temporary loan-based instrument (SURE) of up to e100 billion to protect workers and jobs, supported by guarantees from EU member states.
	15 May 2020	The European Council reaches political agreement on safety net for jobs and workers (SURE).
	19 May 2020	The EU implement the temporary scheme to support workers (SURE).
	25 September 2020	The European Council approves e87.4 billion in financial support for member states under SURE.
Loan guarantees		
		e 25 billion in government guarantees to the European Investment Bank (EIB) to support up to e200 billion to finance to companies, especially SMEs.
	15 May 2020	The Eurogroup discusses priorities for the EU recovery.
	26 May 2020	President Centeno welcomes EIB agreement on safety net for businesses. Adoption 1 June.
Fiscal rules flexibility		
	23 March 2020	The Finance ministers agree to ease EU fiscal rules in COVID-19 fallout. The aim is to suspend the fiscal adjustment requirements forcountries that are not at their medium-term objective.
Temporary flexibility in the state aide rules		
	8 May 2020	The European Commission adopted a second amendment to extend the scope of the state aid temporary framework to recapitalization and subordinated debt measures to further support the economy in the context of the coronavirus outbreak through September 2021.
Next Generation EU (NGEU) recovery package		
	23 April 2020	The EU leaders work on a recovery fund.
	27 May 2020	The European Council discuss Commission's proposal for MFF and recovery fund.
	17-21 July 2020	The EU leaders agreed a deal on the recovery package and the European budget for 2021-2027.
	10 November 2020	Political agreement reached in negotiations on EU's long-term budget and recovery plan.
	17 December 2020	Long-term EU budget 2021-2027 adopted.
	18 December 2020	The Council and the Parliament reach provisional agreement on the Recovery and Resilience Facility.
ECB Monetary policy measures:	Date	Description
Increasing banks' lending capacity		
	12 March 2020	The ECB Banking Supervision provides temporary capital and operational relief in reaction to coronavirus.
	20 March 2020	The ECB Banking Supervision provides further flexibility to banks in reaction to coronavirus.
	27 March 2020	The ECB asks banks not to pay dividends until at least October 2020.
Ensuring short-term concerns do not prevent lending		
	12 March 2020	The ECB announces measures to support bank liquidity conditions and money market activity.
Supporting access to credit for firms and households		
	12 March 2020	The ECB announces easing of conditions for targeted longer-term refinancing operations (TLTRO III).
	7 April 2020	The ECB announces package of temporary collateral easing measures.
	30 April 2020	The ECB recalibrates TLTRO-III to further support real economy.
	30 April 2020	The ECB announces new pandemic emergency longer-term refinancing operations (PELTROs).
	10 December 2020	The ECB prolongs support via TLTRO-III for banks that lend to the real economy.
	10 December 2020	The ECB extends PELTROs.
Other MP to absorb the shock of the Covid-19		
	18 March 2020	The ECB announces e750 billion Pandemic Emergency Purchase Programme (PEPP).
	4 June 2020	Monetary policy decisions: 1) The pandemic emergency purchase programme (PEPP) increased by e600 billion to a total of e1,350 billion. 2) The horizon for the PEPP will be extended to at least the end of June 2021. 3) The maturing principal payments from securities purchased under the PEPP will be reinvested until at least the end of 2022. 4) Net purchases under the asset purchase programme (APP) will continue at a monthly pace of e20 billion, together with the purchases under the additional e120 billion temporary envelope until the end of the year. 5) Reinvestments of the principal payments from maturing securities purchased under the APP will continue, in full.

Table 7: Difference-in-differences regressions for daily corporate credit spread.
This table reports the results of a difference-in-differences regression of daily corporate credit spread. $Green_i$ equals one for bond i that it is classified as "Green Bond" in the Thomson Reuter's Refinitiv fixed income database and zero otherwise. $Covid_t$ equals one from 24 February to 31 March 2020, and zero before this period. $Vaccine_t$ equals one from 9 November to 31 December 2020, and zero before this period. In column 1, the specification includes the variables "Collateral", "Amount Issued" and time, country, sector, issuer and rating fixed effects, in column 2 includes also the variables Fiscal and Monetary support, in column 3 we split the sample considering only countries defined as Core Europe (Germany, Netherlands, Belgium and Luxembourg), in column 4 we split the sample considering only countries defined as Mediterranean countries (Italy, Spain, and France), in column 5 we split the sample considering only Financial industry, in column 6 we split the sample considering only Non-Financial industry, in column 7 we split the sample considering only bonds that are classified as Investment Grade, and in column 8 we split the sample considering only bonds that are classified as High Yield. In Panel A, we estimate the baseline model of equation 1 for the period from 1 January 2020 to 31 March 2020. In contrast, in Panel B, we estimate the model of equation 2 for the period from 1 October 2020 to 31 December 2020. Standard errors are heteroscedasticity robust. The numbers in parenthesis are t-statistics. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A	(1) Baseline	(2) Fiscal and Monetary Support	(3) Core Europe	(4) Mediterranean Country	(5) Financial Industries	(6) Non-Financial Industries	(7) Investment Grade	(8) High Yield
Green	-0.059**	-0.059**	-0.010	-0.115***	-0.109***	0.075*	-0.060**	0.141***
	(-2.456)	(-2.456)	(-0.224)	(-3.093)	(-3.872)	(1.716)	(-2.520)	(10.806)
Covid	0.584***	0.584***	0.544***	0.648***	0.526***	0.816***	0.571***	0.830***
	(82.584)	(82.584)	(45.656)	(56.590)	(66.918)	(60.993)	(78.659)	(35.755)
Green*Covid	0.173***	0.173***	0.179***	0.175***	0.243***	-0.031	0.185***	-0.113***
	(11.936)	(11.936)	(8.661)	(6.796)	(12.722)	(-1.592)	(12.593)	(-7.129)
Collateral	-0.110**	-0.110**	-0.196**	-0.122**	-0.152***	0.051	-0.104**	0.024
	(-2.468)	(-2.468)	(-1.964)	(-2.485)	(-2.781)	(1.032)	(-2.335)	(0.394)
Amount Issued	-0.106***	-0.106***	-0.111***	-0.125***	-0.106***	-0.130***	-0.109***	-0.048*
	(-18.048)	(-18.048)	(-10.878)	(-12.825)	(-17.336)	(-6.662)	(-19.943)	(-1.862)
Fiscal Support		-0.020***	-0.022***	-0.013***	-0.032***	0.031***	-0.033***	0.130***
		(-8.615)	(-5.465)	(-3.259)	(-13.166)	(5.633)	(-15.832)	(11.269)
Monetary Support		0.005***	0.006***	0.006***	0.006***	0.002	0.004***	0.021***
		(3.792)	(2.707)	(2.964)	(3.997)	(0.618)	(2.754)	(4.374)
Constant	6.182***	6.182***	5.645***	3.806***	6.350***	7.568***	7.174***	4.756***
	(12.274)	(12.274)	(6.994)	(12.230)	(14.630)	(16.463)	(24.192)	(6.691)
Observations	262,699	262,699	96,001	88,019	209,676	53,023	234,977	22,022
R-squared	0.861	0.861	0.872	0.864	0.830	0.942	0.697	0.902
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Issurer FE	YES	YES	YES	YES	YES	YES	YES	YES
Rating FE	YES	YES	YES	YES	YES	YES	YES	YES

Panel B	(1) Baseline	(2) Fiscal and Monetary Support	(3) Core Europe	(4) Mediterranean Country	(5) Financial Industries	(6) Non-Financial Industries	(7) Investment Grade	(8) High Yield
Green	0.004	0.004	0.079	-0.058	-0.018	0.041	0.006	0.159**
	(0.160)	(0.160)	(1.547)	(-1.510)	(-0.481)	(1.270)	(0.202)	(2.128)
Vaccine	-0.104***	-0.104***	-0.097***	-0.118***	-0.082***	-0.188***	-0.099***	-0.214***
	(-25.689)	(-25.689)	(-13.803)	(-18.127)	(-17.361)	(-28.406)	(-24.790)	(-20.554)
Green*Vaccine	-0.044***	-0.044***	-0.057***	-0.030**	-0.070***	0.020	-0.046***	0.023
	(-5.340)	(-5.340)	(-3.961)	(-2.263)	(-5.972)	(1.423)	(-5.508)	(1.074)
Collateral	-0.122***	-0.122***	-0.149	-0.044	-0.150**	-0.022	-0.115**	-0.078*
	(-2.611)	(-2.611)	(-1.579)	(-0.690)	(-2.546)	(-0.611)	(-2.234)	(-1.963)
Amount Issued	-0.153***	-0.153***	-0.140***	-0.192***	-0.151***	-0.189***	-0.154***	-0.137***
	(-22.505)	(-22.505)	(-11.408)	(-16.177)	(-21.601)	(-8.345)	(-23.919)	(-4.839)
Fiscal Support	-0.000	-0.000	-0.000	-0.002	0.001	-0.004	-0.001	-0.008***
	(-0.287)	(-0.287)	(-0.132)	(-1.124)	(0.321)	(-0.920)	(-0.508)	(-3.428)
Monetary Support	0.007***	0.007***	0.008***	0.003	0.009***	-0.002	0.006***	-0.004
	(3.162)	(3.162)	(2.769)	(0.745)	(4.037)	(-0.432)	(2.886)	(-1.335)
Constant	8.157***	8.157***	6.803***	5.013***	7.201***	10.474***	8.564***	10.401***
	(15.644)	(15.644)	(7.874)	(12.487)	(15.363)	(20.389)	(25.528)	(13.714)
Observations	302,787	302,787	110,469	101,088	239,357	63,430	270,366	26,671
R-squared	0.848	0.848	0.843	0.858	0.805	0.954	0.666	0.936
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Issurer FE	YES	YES	YES	YES	YES	YES	YES	YES
Rating FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 8: Robustness checks.

In this Table we replicate the tests from Table 7, column 1, but uses a propensity score matched sample on bonds size ($AmountIssued\_i$) during the pre-treatment period and $Collateral\_i$ as described in Section 5, Equation 3. $Green_i$ equals one for bond i that it is classified as "Green Bond" in the Thomson Reuter's Refinitiv fixed income database and zero otherwise. $Covid_t$ equals one from 24 February to 31 March 2020, and zero before this period. $Vaccine_t$ equals one from 9 November to 31 December 2020, and zero before this period. Standard errors are heteroscedasticity robust. The numbers in parenthesis are t-statistics. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)
	Pscore	Pscore
Green	-0.058**	0.005
	(-2.384)	(0.180)
Covid	0.584***	
	(82.285)	
Green*Covid	0.170***	
	(11.655)	
Vaccine		-0.108***
		(-27.097)
Green*Vaccine		-0.041***
		(-5.249)
Collateral	-0.111**	-0.120**
	(-2.494)	(-2.556)
Amount Issued	-0.107***	-0.153***
	(-18.025)	(-22.374)
Fiscal Support	-0.018***	-0.000
	(-8.068)	(-0.129)
Monetary Policy Support	0.005***	0.007***
	(4.348)	(3.186)
Constant	6.191***	8.139***
	(12.278)	(15.600)
Observations	261,918	300,450
R-squared	0.861	0.848
Time FE	YES	YES
Country FE	YES	YES
Sector FE	YES	YES
Issurer FE	YES	YES
Rating FE	YES	YES

Table 9: Robustness checks.

This table reports the results of a difference-in-differences regression of daily corporate credit spread. $Green_i$ equals one for bond i that it is classified as "Green Bond" in the Thomson Reuter's Refinitiv fixed income database and zero otherwise. $Covid_t$ equals one from 24 February to 31 March 2020, and zero before this period. $Vaccine_t$ equals one from 9 November to 31 December 2020, and zero before this period. ESG is the value of ESG of the bonds' Issuer. ESG_th75 is a dummy variable equal to one if the firm is on the 75th percentile of the ESG score (higher value of ESG score), and zero otherwise. In columns 1-3 we estimate the model for the period from 1 January 2020 to 31 March 2020. In contrast, in columns 4-6, we estimate the model for the period from 1 October 2020 to 31 December 2020. Standard errors are heteroscedasticity robust. The numbers in parenthesis are t-statistics. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1) ESG Score	(2) ESG Score	(3) ESG Score	(4) ESG Score	(5) ESG Score	(6) ESG Score
Green	-0.086***	-0.086***	-0.065**	-0.054*	-0.054*	-0.036
	(-2.951)	(-2.951)	(-2.004)	(-1.712)	(-1.712)	(-1.108)
Covid	0.698***	0.698***	0.698***			
	(66.928)	(66.928)	(66.925)			
Green*Covid	0.136***	0.136***	0.132***			
	(7.653)	(7.653)	(7.327)			
ESG	-0.056***	-0.056***	-0.056***	-0.017	-0.017	-0.017
	(-7.391)	(-7.391)	(-7.388)	(-1.191)	(-1.191)	(-1.332)
ESG_th75		-0.603***	-0.606***		-0.564**	-0.560**
		(-3.064)	(-3.084)		(-2.490)	(-2.478)
ESG_th75*Green			-0.097			-0.078
			(-1.420)			(-0.927)
ESG_th75*Green*Covid			0.024			
			(0.468)			
Vaccine				-0.134***	-0.134***	
				(-25.264)	(-25.264)	
Green*Vaccine				-0.023**	-0.023**	
				(-2.439)	(-2.439)	
ESG_th75*Green*Vaccine						-0.010
						(-0.555)
Collateral	-0.077	-0.077	-0.076	-0.047	-0.047	-0.047
	(-1.356)	(-1.356)	(-1.336)	(-0.727)	(-0.727)	(-0.714)
Amount Issued	-0.095***	-0.095***	-0.095***	-0.154***	-0.154***	-0.153***
	(-10.839)	(-10.839)	(-10.826)	(-16.062)	(-16.062)	(-16.042)
Constant	9.653***	9.653***	9.657***	9.532***	9.532***	9.607***
	(14.270)	(14.270)	(14.270)	(8.465)	(8.465)	(8.932)
Observations	119,043	119,043	119,043	138,771	138,771	138,771
R-squared	0.826	0.826	0.826	0.823	0.823	0.823
Time FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Issurer FE	YES	YES	YES	YES	YES	YES
Rating FE	YES	YES	YES	YES	YES	YES