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The Green Bond Premium - does it appear in the European bond market?

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Abstract

In this paper, we use general bond information and historical time series data after the expansion of the green bond market in 2016. We estimate the yield differential of the green bonds and their conventional twins followed by a regression analysis to test for the characteristics of the green bond premium. The results show that the green bond premium is distributed around zero and suggests there is no green bond premium. Furthermore, the analysis is extended to test the impact of industries and currencies on the premium. We find a few exceptions to the repeated zero distribution, most likely due to lack of data in our sample. This paper contributes with extensive research on the topic of the green bond premium in the growing green bond market in Europe, in addition to adjustments of the methodology from previous studies.

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1.0 Introduction

Environmental Social Governance (ESG) has been one of the most popular terms in portfolio management in recent years (Verheyden et al., 2016). The paper by Verheyden et al. suggests that ESG can contribute with additional information about companies' future performance. Since its inception in 2007, the market for green bonds, which aim to incentivize green investments through cheaper financing has grown. The volume of labeled sustainable debt instruments and the number of varieties have multiplied - especially in the last years. In 2019, nearly $465 billion in green loans were issued across the globe, pushing the cumulative market past $1.1 trillion (Bloomberg NEF, 2020).

The overall purpose of this paper is to contribute with more research on the green bond premium, defined by Zerbib (2019) as the yield differential between a green bond and an otherwise identical conventional bond. We test whether a green bond has a higher yield than an equivalent conventional bond, hence testing if there exists a green bond premium. Furthermore, this paper will contribute with research on industries where green bonds are less prevalent to test if the industry of the issuer has an impact on the green bond premium. Previous papers have incorporated a few points on the connection between industry and the green bond premium in their research, but this has not been their primary focus. Flammer (2018) proposes that the issuance of green bonds is more prevalent in environmental-friendly industries where the environmental aspect is material for the firm's operations. This paper extends the research on the topic of green bonds, and empirically study industry-specific and currency differences in the green bond premium.

The primary motivation for the topic is the literature review "ESG and Socially Responsible Investment: A Critical Review" by Bruno Gerard, 2019. The paper finds that most of the research within this field focuses on Corporate Social Responsibility (CSR) and ESG activities and investor's Social Responsibility (SR) engagement. The paper further discover that few studies that have examined the effect of ESG on bond prices and the evidence from existing articles are inconsistent. Based on the limited research, we are motivated to study this part of the market further. The literature review by Gerard (2019) refers to the two slightly different concepts of CSR and ESG. In later years, there has been a shift from CSR to the more defined concept ESG, concerning more ethical and sustainable practices. The concept combines the environmental and social impact of the firm with its Corporate Governance performance. CSR only encompasses the environmental and social aspects of the firm; hence ESG equals CSR plus governance (Gerard, 2019). All the components of ESG cover a variety of issues related to the environment (e.g., climate change, energy use, water use, carbon emissions), social responsibility (e.g., human rights, gender equality, health, safety), and corporate governance (e.g., shareholder protection, board independence, corruption, reporting) (Galbreath, 2013). Although all three components are critical for a firm to function well, our primary focus is the E in ESG, which is the most relevant for our research related to green bonds.

Previous research on the topic of the green bond premium has mostly used data from the years before the substantial increase of the green bond market starting in 2017. This creates a motivation to contribute with research on the topic by using historical data from 2017 to 2020 to look closer at what influence the past few years has had on the green bond premium. Previous papers such as Zerbib (2019) and Schmitt (2017) find a negative green bond premium in their research using data before 2017. Schmitt (2017) included an analysis of the green bond premium after 2016, and the results suggest that the premium has become slightly positive after the start of the expansion in 2017. Zerbib (2019) and Schmitt (2017), among others, only tests the global or the US bond market. To our knowledge, there is limited research on the topic in the European green bond market; hence why we are eager to contribute with research within this area. We expect that our results will deviate from previous research such as Zerbib (2019) as we examine the premium after the expansion of the market. We expect insignificant results when we test for the explanation of the premium due to our small sample size, which we expect to be consistent with previous literature as aforementioned research by Zerbib (2019) and Schmitt (2017).

For a bond to be categorized as green, it must meet a set of guidelines drawn by The International Capital Market Association (ICMA) called The Green Bond Principles (GBP). These principles are drawn to promote transparency, integrity, and credibility for the green bond market. Green bonds are defined by ICMA (2018, p. 1) as: “any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects". Such eligible green projects can target areas such as renewable energy, energy efficiency, pollution prevention, and control, climate change adaptation and clean transportation (ICMA, 2018). In this paper, we define conventional bonds as all bonds not categorized with Eikon's green label based on the GBP. The sample of different industries in our sample size motivates us to take a closer look at how the green bond premium can differ across the issuers. Also, we expect variations in the number of green bonds issued within the different industries as the GBP makes it hard for issuers to meet the demand for green bonds, especially in non-environmental-friendly industries (Flammer, 2018).

2.0 Literature Review

Gerard (2019) and Zerbib (2017) suggest that there are few existing papers within the ESG and CSR fields focusing on fixed income. Zerbib (2017) contributes with the first academic study testing the cost of investing in green bonds, and several other academicians have subsequently contributed to studies within this field. Zerbib (2019) is based on the methodology from the first version, which was published in 2017. However, the academic literature is still limited, and existing papers use different methodologies and various instruments for indicating if a bond is green. Consequently, the studies contribute with mixed results, and Zerbib (2019) states that no consistent conclusion has yet been drawn on the topic of the green bond premium. Even though no conclusion has been made, most studies conclude that there is a negative green bond premium in the market.

Zerbib (2019) examines the green bond premium from mid-2013 to the year-end 2017 and finds a negative green bond premium of -2.0 bps on average. To examine the yield difference, he matches each green bond with the two closest conventional bonds with the matching criteria being currency, issuer, and similar bond characteristics. Using 110 green bonds and their matched conventional bonds, Zerbib (2019) runs a panel regression to find the yield difference. The research by several recently published studies are inspired by this methodology. Ehlers and Packer (2017) and Hachenberg and Schiereck (2018), are all using the matching method following a panel regression to examine the green bond premium. Both papers find a negative premium but on a different scale. Ehlers and Packer (2017) examines the primary market from 2014 to 2017 and finds a negative premium of 18.0 bps. Hachenberg and Schiereck (2018) test the secondary market and find a negative premium of 1.18 bps.

The papers by Baker et al. (2018) and Karpf and Mandel (2018) are also motivated by the article by Zerbib (2017). Both examine the green bond premium in the US bond market from 2010 to 2016. Baker et al. tests for both corporate and municipal bonds in the primary market, finding that green bonds are issued with a lower yield than conventional bonds, the average yield is 7.0 bps lower. Additionally, Baker et al. (2018) finds that the green bond premium is more prevalent if the bond is externally certified as a green bond. On the other hand, Karpf and Mandel (2018) test for municipal bonds in the secondary market and find a positive green bond premium of 7.8 bps on average. These papers also use different instruments for indicating if a bond is green, where Bloomberg and the GBP are the two most commonly used. Baker et al. (2018) and Karpf and Mandel (2018) use the green flag by Bloomberg, which is the expression for green bonds compared to conventional bonds, for the indication of a green bond. Zerbib (2017) and Zerbib (2019) follows the GBP.

Schmitt (2017) extends the methodology by Zerbib (2017) by including up to twenty comparable bonds instead of Zerbib's (2017) use of two comparable bonds. The author finds a negative green bond premium of -3.2 bps on average. Furthermore, the premium was negative in the years before 2016, whereas it was slightly positive in the years following. The author concludes that the turn in the premium is due to the increased supply for green bonds. Larcker and Watts (2019) compare almost identical green and conventional bonds issued on the same date and by the same issuer. The study tests for the municipal market and by holding the risk and payoffs equal, and finds no yield difference between the two bond types. Flammer (2018) addresses how the issuance of green bonds affects the market value of the issuance. She finds that in environmental-friendly industries, the issuance of green bonds is more prevalent. Furthermore, her main findings suggest that green bond issuance contributes to more long-term investors and attracts investors that value the natural environment. She suggests that the results show that green bonds are not a greenwashing tool, but bonds with a real impact (Flammer, 2018).

3.0 Data

To test for the green bond premium in the European bond market, we collect general information about both active green- and conventional bonds issued in Europe in from issue date to the 1st of March 2020. We also gather the closing bid- and ask yield for the bonds from 1st of January 2017 to 1st of March 2020. This specific time starting period is chosen to be 2017 due to the expansion of the green bond market in the last years (Bloomberg NEF, 2020). The high increase in both supply and market value in the green bond market is shown in Figure 1. We collect all bond information used in this paper from Reuters Eikon, including the industry-specific information. We find the green bond premium by examining the yield difference between the green bond and the synthetic conventional bond.

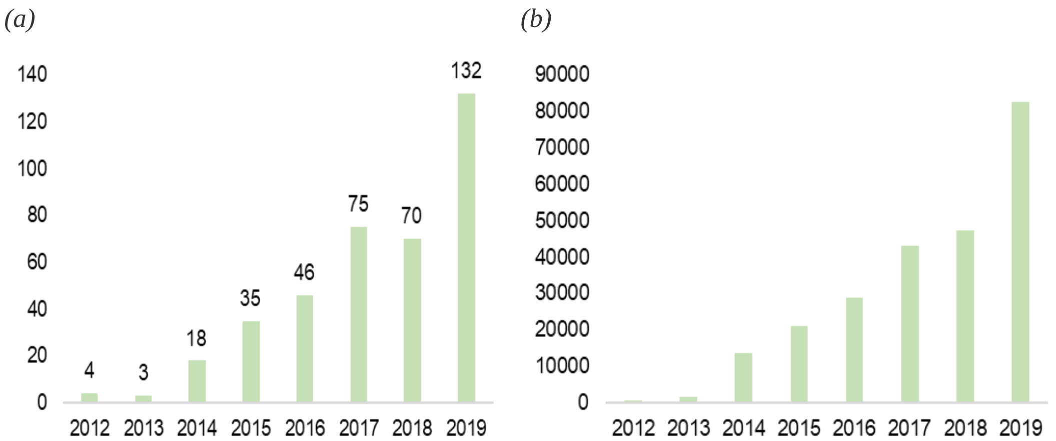

Fig. 1 The evolution of the European green bond market. (a) illustrates the number of total issuance of green bonds in Europe from 2012 to 2019. (b) illustrates the total European green bond market in million USD from 2012 to 2019. All bonds included are active bonds when retrieved 1st of March 2020.

We exclude high yield bonds after we observe that there are limited green bonds within this category. An UBS survey from 2019 finds that of investors in the European bond market, 78% of the institutional investors were considering ESG factors in making their investment decisions. On the high yield side, only 24% of the institutional investors were considering the same. Even though the high yield market has slowly started to follow the ESG trend, the market is not large enough to compare with those of investment-grade (Clifford Chance, 2019). Therefore, the research paper will focus only on the investment-grade bonds. After retrieving all investment-grade bonds, we are left with a data sample consisting of 21.827 conventional bonds and 402 green bonds from the European bond market.

Table 1
Descriptive statistics of the total sample of 408 green bonds. Issued Amount is expressed in USD.

Green bonds: total sample	*Min*	*Average*	*Max*
Coupon	-0.4099	1.2823	11.7100
Issued Amount	239,184	625,307,733	4.409,997,464
Issue Date	27.03.2012	01.01.2018	18.02.2020
Maturity	09.12.2019	07.03.2020	05.06.2031

Table 2
Descriptive statistics of the total sample of 21.827 conventional bonds. Issued Amount is expressed in USD.

Conventional bonds: total sample	*Min*	*Average*	*Max*
Coupon	-0.5000	2.1029	31.0000
Issued Amount	1,000	528,703,634	59,823,360,636
Issue Date	25.10.1989	21.01.2015	09.03.2020
Maturity	03.03.2020	05.11.2026	26.06.3013

4.0 Methodology

This paper will contribute to further research on the green bond premium in Europe over the last year. In addition, we include a test on industries and currencies where green bonds are less prevalent to see if one or the other has an impact on the premium. The main hypothesis to be tested for is if a green bond premium exists in the European bond market. To test the green bond premium, we examine if there exists a yield difference between the green bonds and conventional bonds available in the market. We use the methodology from Zerbib (2019) with deviations relevant for our sample - clearly stated and explained when relevant. In the methodology, we will follow three steps to examine the green bond premium’s existence and explanations. We start with a matching process, followed by the estimation of the green bond premium, ending with an analysis to find the determinants of the premium.

3.1 Matching Process

In the process of finding the green bond premium, we are inspired by Zerbib (2019) and Altman and Kishore (1996) to use a matching process to get a valid basis of comparison when analyzing the difference between the green and conventional bonds’ yield. We process the data by matching each green bond with two corresponding conventional bonds based on decided restrictions. The two corresponding conventional bonds are called a synthetic twin, and its creation is illustrated in Figure 2. More detailed illustrations of the matching process are shown in Figure A1 and A2 in Appendix A. We match the bonds based on the following restrictions being issuer, issue date, coupon, maturity, the amount issued, and currency, as shown in Table 3. Therefore, the matching process creates pairs of one green bond with its synthetic conventional twin.

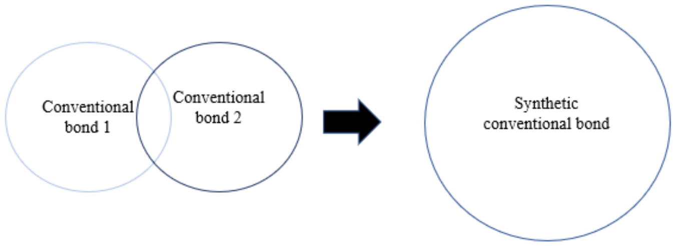

Fig. 2 illustrates the creation of the synthetic twin through the matching process. Through the matching process we find the two conventional bonds with the closest maturity to the green bond. The synthetic conventional bond is created through a merge by the two conventional bonds. More detailed illustrations of the matching process are shown in Figure A1 and A2 in Appendix A.

Table 3
The restrictions used in the matching process is presented in the table. The restrictions can either be equal or it can be set in different ranges.

Attribute	*Restriction*
Coupon	Within 0.7 and 1.3
Maturity	Within 2 years more or less
Amount Issued	Within 0.25 and 4.0
Issuer	Equal
Currency	Equal

The issuer and currency restrictions are set to be exactly equal and eliminate the exchange rate risk and the idiosyncratic risk. Criteria for maturity, the amount issued, issue date, and coupon are set in different ranges. The matching criteria for maturity are set to have a deviation of +/- two years as our data sample eliminates the possibility to set the restriction as precisely equal. Setting the restriction to be equal would be possible in an ideal world, where we have a larger sample size, and the issuers have the same maturity on their bonds. However, to reduce the maturity difference, we choose the synthetic twin by finding the two conventional bonds with the closest maturity to the green bond. If the result shows more than two conventional bonds that match the restrictions, we choose the synthetic twin by finding the two conventional bonds with the closest maturity. Furthermore, we control for some of the liquidity differences through the restriction on the amount issued and the issue date. The criteria for the amount issued is set to be in the range of 0.25 to 4.0 times the green bond issued amount, while the issue date is set with a deviation of +/- two years.

We experience the same problem as Helwege et al. (2014), where the ideal restriction of equal coupon rates reduces our data sample to a large degree. In contrast to Zerbib (2019)'s restriction of equal coupon rates, we set the range of deviation of 0.7 to 1.3 times the green bonds coupon representing a 30% range. We include an analysis of a 10% deviation on the coupon rate to assure that the result is not being biased by a less narrow restriction. To be able to reduce the coupon rate to a 10% deviation, we only match the green bond with one conventional bond. To illustrate the two different ranges, a coupon rate of 1% with a deviation of 30% will give a minimum coupon rate of 0.7% and a maximum coupon rate of 1.3%. With a 10% deviation, the minimum coupon rate will provide a 0.9% coupon rate and the maximum coupon rate of 1.1%.

Zerbib (2019) includes credit rating restrictions for the matching pairs. Our methodology will not match pairs based on credit ratings as the Nordic bond market lacks such information on a significant share of the bonds issued. Our data sample includes only investment-grade bonds as the high yield bonds, which usually have much lower credit rating due to their high risk, have already been excluded. Despite having credit ratings, the Nordic bond market mostly consists of companies that are well known for investors, and many unrated Nordic companies have better research coverage from large banks and brokers than companies with credit rating (EVLI, 2020). In our data sample consisting of bonds from the European bond market, 24% of the green bonds are listed on the Nordic bond market. By including credit rating as a restriction, a large amount of the green bonds would have to be excluded; hence we do not see this as a relevant restriction to be able to support our research question.

The matching process includes the amount issued and issue date to reduce the liquidity difference between the green bonds and their synthetic twin. By including ranges in the matching process's restrictions, there still exists a liquidity difference between the matched green bond and its synthetic twin. To reduce the impact of the liquidity difference, we perform a regression to create an estimated green bond premium without the inference of the liquidity. The regression will include the variables yield and liquidity, explained more thoroughly at a later stage in the paper.

We create a synthetic yield and synthetic liquidity for the created twin based on the distance-weighted average of the two conventional bonds. The synthetic yield creation deviates from Zerbib (2019) as he uses a linear interpolation of the ask yields. We draw the distance-weighted average of the yield from the historical yield data from our sample from 1st January 2017 to 1st March 2020. To reduce the maturity difference, the conventional bond with the closest maturity to the green bond will get the highest weight in the estimation of the synthetic yield. Our data sample includes observations with a negative yield spread, hence why we run a regression both with and without the negative spread to examine the effects it has on the result. To account for the difference in the yield spread, we use the mid spread in the yield calculation to reduce the possible effect of biased data. From this point, we express green bonds as GB and conventional bonds as CB. Each synthetic twin contains two conventional bonds, and these bonds is expressed as $CB1$ and $CB2$.

$$y_{i,t}^{\sim CB} = \frac{d_2}{d_1 + d_2} MidYield_{i,t}^{CB1} + \frac{d_1}{d_1 + d_2} MidYield_{i,t}^{CB2} \quad (1)$$

where $MidYield_{i,t} = \frac{bid_{i,t} + ask_{i,t}}{2}$

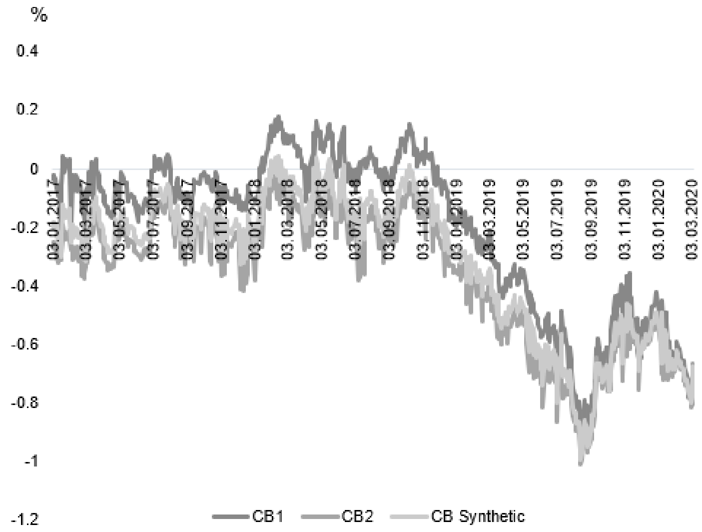

Fig. 3 shows an example of the synthetic conventional bonds' yield compared to yields of the two conventional bonds. In the example, $CB2$ is given a higher weight than $CB1$ as it is in closer in maturity to the GB.

3.2 Estimation of the Green Bond Premium

To test the for the green bond premium, we use the yield difference between the green bonds and their synthetic conventional twin. The yield difference between the green bond and the comparable synthetic conventional bond is calculated by $\Delta\tilde{y}_{i,t} = y_{i,t}^{GB} - y_{i,t}^{\widetilde{CB}}$. Where $y_{i,t}^{GB}$ is the green bond's yield, and $y_{i,t}^{\widetilde{CB}}$ is the yield for the synthetic conventional bonds.

The creation of the synthetic twins reduces the liquidity difference between the green bond and the matched synthetic twin, but it still exists to some extent. Zerbib (2019) makes a liquidity proxy to overcome the liquidity difference in the model. The liquidity proxy reflects the difference in liquidity between the green bond and the comparable synthetic twin:

$$\Delta Liquidity_{i,t} = Liquidity_{i,t}^{GB} - Liquidity_{i,t}^{\widetilde{CB}} \tag{2}$$

Zerbib (2019) further calculates the liquidity for the synthetic, conventional bonds as the distance-weighted average of the conventional bonds' liquidity proxy. Therefore, the liquidity proxy for conventional bonds is defined as:

$$Liquidity_{i,t}^{\widetilde{CB}} = \frac{d_2}{d_1 + d_2} Liquidity_{i,t}^{CB1} + \frac{d_1}{d_1 + d_2} Liquidity_{i,t}^{CB2} \tag{3}$$

Where $d_1 = |GB\ maturity - CB1\ maturity|$ and $d_2 = |GB\ maturity - CB2\ maturity|$

Similar to Zerbib (2019), we use the closing bid-ask spread as a proxy for liquidity where the bid-ask spread is the difference between the bid yield and the ask yield. Some of the observations include opposite signs for bid and ask, which we remove to exclude the extreme values occurring in the sample. The use of the bid-ask spread as a proxy for liquidity is consistent with Fong et al. (2017), where they investigate the quality of several liquidity methods. With a global sample, the authors suggest that the closing bid-ask spread is the best low-frequency measurement for liquidity proxy. By using the bid-ask spread as a proxy for liquidity, the bid-ask spread is included in equation (3) where:

$$Liqudity_{i,t}^{\sim CB} = \frac{d_2}{d_1 + d_2} BA_{i,t}^{CB1} + \frac{d_1}{d_1 + d_2} BA_{i,t}^{CB2} \tag{4}$$

We regress our model through a panel regression to estimate the green bond premium α_i as we want to extract the bond-specific time-invariant, unobserved effects after accounting for the liquidity difference. A panel regression can either be run through a fixed effect regression or through a random effect regression. A fixed-effect model can estimate an individual time-invariant intercept for each bond without any distribution from the other bonds and is the best fit for our panel regression. Fixed effect panel regression does not allow for time-invariant variables; hence there is no possibility to include other variables such as amount issued, coupon, maturity, etc., as these are time-invariant. The only variables we include are the $\Delta\tilde{y}_{i,t}$ as the dependent variable and $\Delta Liquidity_{i,t}$as the independent variable. Extreme values led us to biased results, leading us to winsorize both the yield and the liquidity on a 1% level to remove the extreme values. We define the green bond premium through the unobserved effect in the fixed effect panel regression of $\Delta\tilde{y}_{i,t}$ on $\Delta Liquidity_{i,t}$ being:

$$\Delta\tilde{y}_{i,t} = \alpha_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t} \tag{5}$$

Where α_i is the time-invariant intercepts and $\varepsilon_{i,t}$ being the error terms. We extract the time-invariant intercept α_i from the residual $u_{i,t}$ in the Fixed Effect Panel regression by:

$$u_{i,t} = \alpha_i + \varepsilon_{i,t}$$
$$\alpha_i = \varepsilon_{i,t} - u_{i,t}$$

3.3 The Determinants of the Green Bond Premium

Regression (5) identifies the green bond premium. In the next step, we test if different bond characteristics can explain the green bond premium. We use Zerbib (2019) as a guideline for determining the variables in the model, but with some deviations in the methodology. We include the variables being the amount issued coupon, maturity, industry, and currency. Our data sample includes several currencies; hence we need to treat the different currencies as separate dummy variables. The reference currency is set to be in Euro. Additionally, we include the variable industry in our regression model. Industry is also treated as separate dummy variables with the reference industry being Agency. By incorporating industry as a variable, we can observe if green bonds are more attractive in some industries than others. Also, we include the coupon in the regression to test further if it has a significant impact on the green bond premium. The model is:

$$\alpha_i = \beta_0 + \beta_1 \, Maturity_{\,i} + \beta_2 \ln{(Amount\ Issued)}_{\,i} + \sum_{j=2}^{N\ Currency} \beta D\ Currency_{i,j} + \sum_{j=2}^{N\ Industry} \beta D\ Industry_{i,j} \tag{6}$$

5.0 Results

We start the data processing with the matching process between the green bonds and conventional bonds. We use two different matching processes with a 10% and a 30% deviation in the coupon to assure that the results are not being biased by a less narrow restriction on the coupon rate. From both processes, we get 108 matches consisting of a green bond with its corresponding conventional bond/bonds. The 10% includes 108 green bonds and 108 conventional bonds, while the 30% contains 108 green bonds and 216 conventional bonds. Note that in the matching process with a 10% deviation in the coupon rate, the result only includes one corresponding conventional match to the green bond.

5.1 The Green Bond Premium

The first step in the analysis is to estimate the green bond premium through a panel regression. When creating the variable $\Delta Liquidity_{i,t}$, we observe that the bid-ask spreads include both positive and negative yield spreads; hence we must be careful in the data processing as the presence of negative yield spread can affect the results. We perform the creation of the liquidity variables, both with and without the negative yield spread. The results show minor differences both in the estimation of the constant for $\Delta Liquidity$ and the R^2; hence we choose to go further by excluding the negative yield spread to ensure that the data is relevant for our sample (see Table B1 in Appendix B). The results of the creation of the variables $\Delta\tilde{y}$ and $\Delta Liquidity$ are shown in Table 4 and Table 5. The distribution of $\Delta\tilde{y}$ and $\Delta Liquidity$ are shown in Figure B1 and B2 in Appendix B.

Table 4
Descriptive statistics of the dependent variable $\Delta\tilde{y}$ from the fixed effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)*. The table includes the total sample of $\Delta\tilde{y}$, where $\Delta\tilde{y}$ is the difference between the green bonds yield and its matched conventional bonds' synthetic yield. All values expressed in percentage.

Min.	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.6166	-0.0472	0.0047	0.0251	0.0766	0.7637

Table 5
Descriptive statistics of the dependent variable $\Delta\tilde{y}$ from the fixed effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)*. The table includes the total sample of $\Delta \text{Liquidity}_{i,t}$, where $\Delta \text{Liquidity}_{i,t}$ is the difference between the green bonds bid-ask spread and its matched conventional bonds' synthetic bid-ask spread. All values expressed in percentage.

Min.	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.1643	-0.0152	0.0000	-0.0071	0.0056	0.1053

To ensure that the Fixed Effects model is the panel regression that best fits our model, we perform a Hausman test. This test allows us to test for the efficiency of the fixed effects estimator. The Hausman test results in a rejection of the null hypothesis on a 5% level, which implies that we reject the random effect model, and we continue to use a Within Fixed Effect panel regression. We perform a Wooldridge test and a Breusch-Pagan test to check if there are autocorrelation and heteroscedasticity in our panel data. The results show p-values equal to zero, indicating the presence of both heteroscedasticity and autocorrelation in our data sample. We include two regressions to test for the estimated standard deviations of the model to account for the presence of both heteroscedasticity and autocorrelation.

Table 6 shows the results from the robustness tests Within Fixed Effect panel regression and Driscoll-Kraay. The Within Fixed Effect panel regression accounts for neither heteroscedasticity nor autocorrelation, while Driscoll-Kraay is a robustness standard error estimator that accounts for both heteroscedasticity and autocorrelation.

Table 6
The results of the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ (5) on a 30% level. The regression is performed through a Within Fixed effect panel regression and through Driscoll-Kraay. The dependent variable is $\Delta\tilde{y}_{i,t}$. Std. deviation is presented in the parenthesis.
Note: $* \, p < 0.1$; $** \, p < 0.05$; $*** \, p < 0.01$

	Within	*Driscoll-Kraay*
$\Delta Liquidity_{i,t}$	-0.5657***	-0.5657***
	(0.0268)	(0.0529)
Observations	33,514	33,514
R^2	0.0131	0.0131
F statistics	444.30	114.44
	Df=(1 ; 33 407)	Df(1 ; 829)

The results presented in Table 6 from the two regressions show low R^2 1.31%. The low R^2 is consistent with Zerbib (2019). The inclusion of only one independent variable $\Delta Liquidity_{i,t}$ will reduce the explanation of the model as we exclude several explanatory variables such as other bond characteristics. $\Delta Liquidity_{i,t}$ has a negative coefficient as expected, as higher liquidity should negatively affect the yield. In our result, 1bp increase in the percentage of $\Delta Liquidity_{i,t}$ gives a 0.57bps decrease in $\Delta\tilde{y}$. The economic intuition is that higher liquidity, i.e., a larger bid-ask spread, leads to less favorable bid-ask spreads causing lower yields. The coefficients on liquidity do not vary across the regressions and are significant on a 1% level.

We perform a regression with the 10% coupon to look for any differences between the outputs of the coupon ranges where 108 green bonds are included in this sample. The results in Table 7 and Table 8 show minor differences between the estimated green bond premium a_i with 10% and 30% deviation in the coupon rate. In both regressions, the estimation of the green bond premium is distributed around zero; hence the question can be raised of whether the restriction on coupons has a significant impact on the final result. We observe that the R^2 for the

10% deviation in coupon rate is low compared to the regression with 30% deviation, with 0.31% versus 1.31%, respectively. We continue using the 30% deviation in coupon rates as the restriction for our data sample.

Table 7
Descriptive statistics of the estimated green bond premium a_i from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)* using a 30% deviation in the coupon rate. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). All values expressed in percentage.

Min.	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.7291	-0.0617	-0.0032	-0.0023	0.0600	0.6678

Table 8
Descriptive statistics of the estimated green bond premium a_i from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)* using a 10% deviation in the coupon rate. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). The results from the regression is shown in Table B3 in Appendix B. All values expressed in percentage.

Min.	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.4949	-0.0626	-0.0091	0.0000	0.0593	0.5655

The estimation of the green bond premium a_i is distributed around zero. We also observe a minimum and maximum estimated premium with a coupon on a 30% level at -0.73bps and 0.67bps, respectively. The result deviates from Zerbib (2019) as he obtains a negative premium. Zerbib (2019) uses time-series data from the issue date until 2017, i.e., before the expansion of the green bond market. Our time series only includes data from the 1st of January 2017 to the 1st of March 2020, i.e., after the expansion of the green bond market. The green bond market's evolution should be reflected in the green bond premium, as the market has increased by 92% since 2017. With a growing market, it is expected that the green bond premium will decrease as the demand will be higher in a popular market. The yield will decrease as the demand is higher than the supply of green bonds. Even though our results are inconsistent with Zerbib (2019), both the studies by Schmitt (2017) and Larcker and Watts (2019) are consistent with our results. Schmitt (2017) takes a closer look at the evolution of the green bond premium, finding it to be negative in the years before 2016 and slightly positive after 2016. Larcker and Watts (2019), on the other hand, finds no green bond premium in their results.

We perform regressions testing for the green bond premium without any data from 2020 due to the COVID-19 situation that has impacted the world's economy.

The results presented in Table 9 show minor differences from the regression, including data until the 1st of March 2020. We also observe that the R^2 reduced from 1.31% to 0.34%. It is interesting to notice that the average estimated green bond premium turns from being slightly negative with the inclusion of 2020 data to be somewhat positive when we exclude data from 2020. It is essential to notice that the yield in 2020 can also be affected by other factors such as the supply and demand in the market, interest rates, or other macroeconomic factors. The observations in the regression decreased from 108 to 91 green bonds when we exclude matches issued in 2020. Continuing, we use the total data sample from 1st of January 2017 to 1st of March 2020 due to the minor differences, reduced observations, and macroeconomic factors affecting the market.

Table 9
Descriptive statistics of the estimated green bond premium a_i from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)* with the exclusion of 2020 data. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). The results from the regression is shown in Table B4 in Appendix B. All values expressed in percentage.

Min	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.7090	-0.0680	-0.0114	0.0087	0.0610	0.6515

To make sure that the liquidity proxy captures several ranges of volatility in the bonds in our data sample, we calculate the 10-, 20-, and 30-day rolling annualized volatility during the period of interest in the case of both the green and synthetic conventional bonds, similar to Zerbib (2019). We calculate the rolling average volatility by the rolling average standard deviations of the annualized yields to the corresponding span of days. We create the volatility variables similarly to those in equation (1), where we take the difference between the volatility of the green bonds and synthetical twin. Furthermore, the difference in volatility is an additional independent variable in the panel regression. The results of the individual Hausman's tests indicate that the volatility does not vary with time; hence it is a time-invariant variable. Using Driscoll-Kraay robust standard error estimator for each of the calculated volatilities, we perform the regressions through a random effect panel regression. We find no evidence that a difference in volatility is embedded in the yield differential between the green and conventional bonds. The volatility reflects the risk in the market. The results show that our data sample has a stable volatility, hence the green bond premium should not be affected to a large degree by the volatility as the risk appears to be insignificant. The results are shown Table 10.

Table 10
The results of the Random Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \beta\Delta Volatility_{i,t} + \varepsilon_{i,t}$. The regression is an extension of equation (5) with an inclusion of different volatility measures. The regressions are performed with the robustness test Driscoll-Kraay. The dependent variable is $\Delta\tilde{y}_{i,t}$. Std. deviation is presented in the parenthesis. Note: $*\,p < 0.1$; $**\,p < 0.05$;$***\,p < 0.01$. Descriptive statistics of the estimated green bond premiums are shown in Table 11, 12 and 13.

$\Delta Liquidity_{i,t}$	-0.5774***	-0.5822***	-0.5872***
	(0.0476)	(0.0469)	(0.0470)
$\Delta 10 - day\ volatilty$	-0.0059		
	(0.0208)		
$\Delta 20 - day\ volatilty$		0.0012	
		(0.0185)	
$\Delta 30 - day\ volatilty$			-0.0027
			(0.0042)

Table 11
Descriptive statistics of the estimated green bond premium a_i of the 10% volatility in the Random Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \beta\Delta Volatility\ 10days_{i,t} + \varepsilon_{i,t}$ *(5)*. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). All values expressed in percentage.

Min	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.0919	-0.0045	0.0009	0.0019	0.0082	0.0769

Table 12
Descriptive statistics of the estimated green bond premium a_i of the 20% volatility in the Random Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \beta\Delta Volatility\ 20days_{i,t} + \varepsilon_{i,t}$ *(5)*. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). All values expressed in percentage.

Min	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.1270	-0.0043	0.0012	0.0016	0.0089	0.0760

Table 13
Descriptive statistics of the estimated green bond premium a_i of the 30% volatility in the Random Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \beta\Delta Volatility\ 30days_{i,t} + \varepsilon_{i,t}$ *(5)*. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). All values expressed in percentage.

Min	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.1503	-0.0044	0.0012	0.0013	0.0095	0.0784

The analysis of the different methods of estimating the green bond premium results in the use of the 30% deviation on the coupon rate, exclusion of negative bid-ask spread, and we include data from 1st of January 2017 to 1st of March 2020. The data sample chosen is robustness tested, and the regressions indicate significant results.

5.2 Analysis of the Determinants of the Green Bond Premium

The second step in the analysis is to find explanations for the causes of the green bond premium. We divide the green bond premium (a_i) into separate samples to test each of the main categories; industries and currencies. The majority of the bonds are within the industries being Agency, Banking, Official, and Supranational (Table 14) The currencies are mainly EUR, USD, SEK, and NOK (Table 12). Similar to Zerbib (2019), we use the Wilcoxon signed-rank test to test for the significance of industries and currencies. We only include the industries and currencies with the largest number of observations.

Table 14
Illustration of the industries in our data sample with the number of observations for each industry.

Industry	*Observations*
Agency	32
Banking	38
Electronics	1
Financials	4
Home Builders	4
Mortgage banking	3
Official and Municipal	7
Oil and Gas	1
Real Estate Investment Trust	2
Supranational	16

Table 15
Illustration of the currencies in our data sample with the number of observations for each currency.

Industry	*Observations*
EUR	41
AUD	1
GBP	1
CAD	3
HKD	1
NOK	4
PLN	1
SEK	21
CHF	2
USD	33

The Wilcoxon test presented in Table 16 shows that neither industries nor currencies are significant, meaning that the green bond premium does not vary across the different industries or currencies. A reasonable explanation for the insignificant results can be that our data sample is relatively small compared to the total European green bond market due to the matching process. The insignificant results can also be explained by the matching restriction of equal currencies and equal issuers. If we exclude the restriction of equal currencies and equal industries, we will expect significant results. The economic intuition of currencies can be that for an investor, it should be more attractive to invest in bonds with larger currencies in broader markets such as USD and EUR, compared to NOK or DKK, where the markets are considerably smaller. However, the results can indicate that the restriction of equal currencies removes the reflection of the attractiveness of bonds with different currencies when estimating a_i or the small sample within each currency.

The insignificant results from the Wilcoxon test for industries are as expected. However, we expect green bonds to be more attractive for investors in specific industries where the green bond market is more mature. But, the small sample size and slight variations in the data sample can have an impact on the result; hence it is not reflected in our data sample. It is also interesting to notice the insignificant results due to the exclusion of credit ratings. We expect that some of the effects of credit rating can be reflected in the industry variable. Therefore, the insignificant results can be a result of the matching process or the lack of data on each industry compared to the total European green bond market.

Table 16
The results of a Wilcoxon signed-rank test with continuity correction. The table shows the p-values of the test: $H_0: a_i = 0$ for the largest industries and currencies in our sample. The table also includes number of bonds included in each subsample. Note: $* \, p < 0.1$; $** \, p < 0.05$;$*** \, p < 0.01$

Description	*p-value*	*Number of bonds*
Industry:		
Agency	0.2359	30
Banking	0.6344	38
Financial	0.1782	4
Home Builders	0.5374	4
Mortgage Banking	0.7053	3
Official and Municipal	0.9702	7
Supranational	0.8100	16
Currency:		
USD	0.2896	31
NOK	0.8919	4
EUR	1.000	41
SEK	0.1045	21

Previous research finds few significant results that explain the green bond premium. We expect a low explanation, mainly since the estimated green bond premium is gathered around zero, and it does not show any indications of a high variation. Further, we run a regression with different variables to find explanations of the premium. The tests we perform on the existence of autocorrelation and multicollinearity indicates that we have neither. The test of heteroscedasticity shows clear signs of appearance, leading us to run the regression with a robust variance estimator.

Table 17 presents the results from the test with a robust variance estimator. As expected, we find most of the results to be insignificant. Interestingly, the coupon shows significant results in our regression model. The coupon has a negative impact on the green bond premium with -0.06bps. The impact is close to zero and has a negative sign meaning that the relationship between the coupon and the yield is estimated correctly. Another interesting observation from the results is that the amount issued appears insignificant, reflecting that the bond market demand is covering all sizes of bond issuance. The result can be questioned as we have a small sample size showing a low variation. Additionally, the results show one significant currency being CHF, which have a positive impact on the estimated green bond premium. Even though most currencies appear to be insignificant, we observe that all have a positive impact on the green bond premium. Interestingly, the significant results deviate from the Wilcoxon-test.

Table 17
The results of the OLS regression $of\ a_i = \beta_0 + \beta_1\ Maturity_{\ i} + \beta_2\ ln\ (Amount\ Issued)_{\ i} + \beta_3\ Coupon_{\ i} + \sum_{j=2}^{N\ Currency} \beta D\ Currency_{i,j} + \sum_{j=2}^{N\ Industry} \beta D\ Industry_{i,j}$ (6).Regression (a) includes all the variables in equation (6). The reference currency is Euro and the reference industry is Agency. The amount issued is expressed as the natural logarithm. Regression (b) only includes the dummy variable: Industry, where the reference industry is Agency. Std. deviation is presented in the parenthesis.
Note: $*\ p < 0.1$; $**\ p < 0.05$;$***\ p < 0.01$

	(a)	*(b)*
Constant	-0.5098	-0.0440
	(0.7626)	(0.0356)
Banking	0.0602	0.0648
	(0.0584)	(0.0476)
Electronics	-0.0282	0.0474
	(0.0936)	(0.1983)
Financial	0.1987***	0.1507
	(0.0800)	(0.1038)
Home Builders	0.0193	0.0002
	(0.0779)	(0.1038)
Mortgage Banking	0.0740*	0.0602
	(0.0411)	(0.1181)
Official and Municipal	0.0213	0.0377
	(0.1113)	(0.0819)
Oil and Gas	-0.1768***	-0.1898
	(0.0496)	(0.1983)
Real Estate Investment Trust	0.1869	0.1269
	(0.1227)	(0.1425)
Supranational	0.0086	0.0498
	(0.0542)	(0.0604)
AUD	0.1502	
	(0.1072)	
GBP	0.0035	
	(0.0628)	
CAD	0.1492	
	(0.1009)	
HKD	0.0981	
	(0.1483)	
NOK	0.0215	
	(0.1384)	
PLN	0.0434	
	(0.1140)	
SEK	0.1452	
	(0.1408)	
CHF	0.1663*	
	(0.0905)	
USD	0.1075	
	(0.0789)	
ln(Amount Issued)	0.0216	
	(0.0370)	
Coupon	-0.0585***	
	(0.0247)	
Maturity	0.0000	
	(0.0000)	
R^2	0.1451	0.0512
Adjusted R^2		-0.0377
Root MSE	0.1980	0.1951
F Statistics		0.58(df= 9 ; 96)
Observations	106	106

Figure 4(a) shows that the mean green bond premium in most of the industries are distributed around zero. However, Figure 4 (b), (c) and (d) show the differences between the industries. The industries Agency and Banking, which have the majority of the observations in the data sample, show more considerable variations than the remaining industries. The results also show that industries both have a positive and negative impact on the green bond premium. This can indicate that industries can have a larger impact, but this is probably not reflected in our result as our data sample appears to be too small.

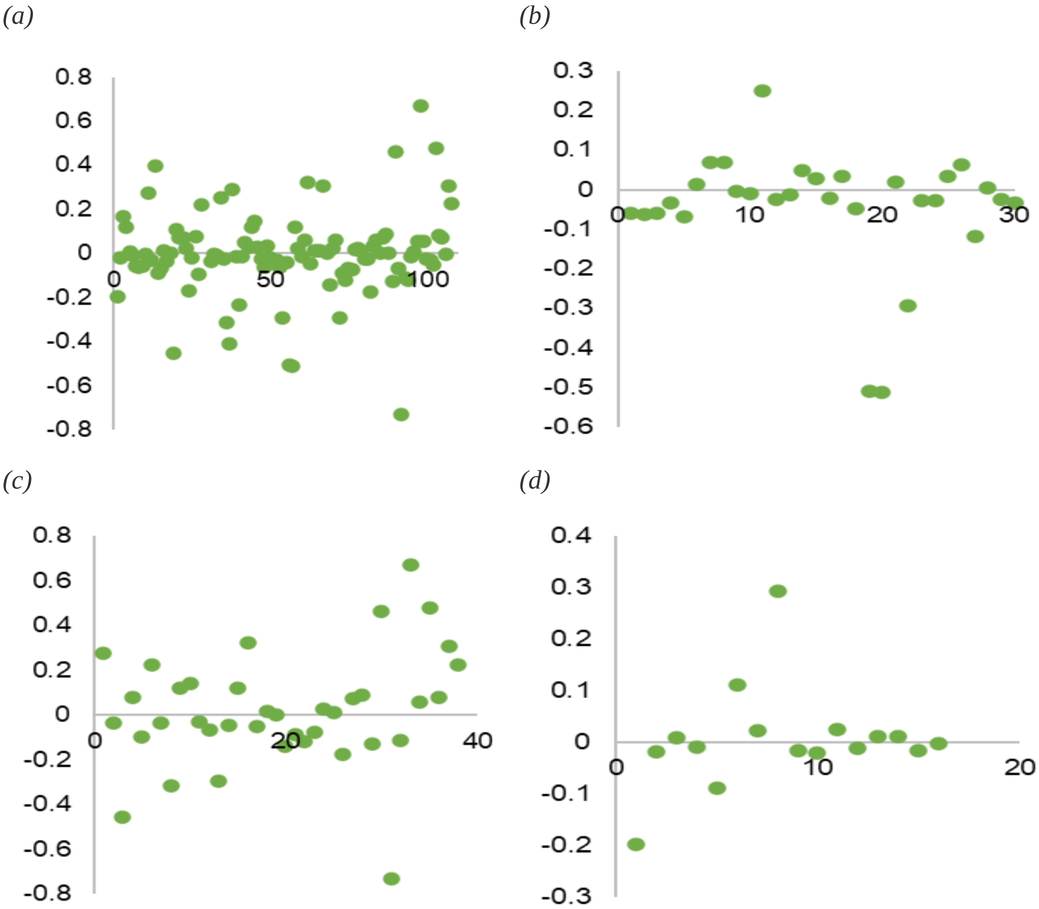

Fig. 4 illustrates four scatter plots of the green bond premium a_i in different industries. (a) shows a scatter plot of all the observations of a_i across all industries. The scatter plot includes 108 observations. (b) shows a scatter plot of all the observations of a_i within the industry Agency. The scatter plot includes 30 observations. (c) shows a scatter plot of all the observations of a_i within the industry Banking. The scatter plot includes 38 observations. (d) shows a scatter plot of all the observations of ai% within the industry Supranational. The scatter plot includes 16 observations. All values expressed in percentage.

We observe that the industries Oil and Gas, Financials, and Mortgage Banking appear to be significant in our results, but this may be because we only have few observations from these industries; hence this is most likely not representable for the industries as a whole. Within Oil and Gas, Financials, and Mortgage Banking, there are four, one, and three observations, respectively. Oil and Gas appears to have a negative impact on the green bond premium, indicating that the green bonds are less attractive within this industry. However, our sample only includes one observation within this industry; hence why this results appears to be a biased conclusion of the market within Oil and Gas. Financials and Mortgage Banking appears to have a positive impact on the green bond premium, indicating that these are industries attracts more investors for green bonds. Unfortunately, these industries do also have few observations; hence we need to be careful when interpreting the results. One can get a green bond premium within different industries as there can be higher demand for conventional bonds compared to green bonds. This cause the yield of conventional bonds to fall, and the difference in yields will favor the green investors.

6. Conclusion

In this paper, we study the green bond premium in the European bond market. We use the methodology by Zerbib (2019) as a guideline with adjustments to examine the premium's existence and explanations. The data sample is detailed, and it includes both general information about green and conventional bonds from the issue date to 1st of March and historical time series data from 1st of January 2017 to the 1st of March 2020. To ensure a representative sample, our data includes all active bonds in the European bond market, excluding high yield bonds as we observe that there are limited green bonds within this category.

The green bond premium is calculated by the yield difference between the green bond and a matched synthetic twin without any inference by the liquidity difference. Due to a smaller data sample than Zerbib (2019), we adjust his methodology, and robustness tests all deviations from his framework. The empirical results from this study indicate that there does not exist a green bond premium in the European bond market after 2016 and the expansion of the market. Zerbib (2019) examines the market before the expansion in 2017, and finds a negative green bond premium, which is inconsistent with our results. However, the results are consistent with Schmitt (2017) and Larcker and Watts (2019) as they find a smaller green bond premium in the years after 2016. We see mostly insignificant results when testing for the effects of industries and currency on the green bond premium. The European green bond market is still limited, and the small data sample can explain the insignificant results.

The methodology by Zerbib (2019) suggests a strict matching process, and it could be interesting to test the expedient of restrictions to that extent. Our methodology deviates from his matching process as it is less strict, but the question can be raised if we still exclude too many observations with too narrow restrictions. The empirical methodology on the green bond premium is an interesting field to look further into as the research is still limited and can benefit from the continually growing market. Additionally, extensive research on the green bond premium can contribute with a more robust and standard framework. Our data sample consists of European bond data, in contrast to previous literature, which includes a more global sample size. Therefore, future work on the European green bond market can gain both from larger sample size and a less restrictive framework.

Further research on the green bond premium is very interesting and highly relevant due to the ongoing market changes with the evolution from CSR to ESG. The growing attention on the E in ESG is GBP's focus when categorizing a bond as green, making it attractive for those who want to make environmental-friendly investments. A green bond premium is hard to achieve as the demand for the green bonds will reduce the yield, hence removing the premium. Achieving a higher yield on conventional bonds is consistent with the theory that the yields must be pushed higher to make the bonds attractive. Looking at the evolution of the green bond market over the past years, we can imagine a future scenario where the ratio between the green bonds and conventional bonds change, where the issuance of green bonds continues to grow, and the supply meets demand. If so, the green bond premium could be prevalent in the future.

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APPENDIX

Appendix A – Methodology

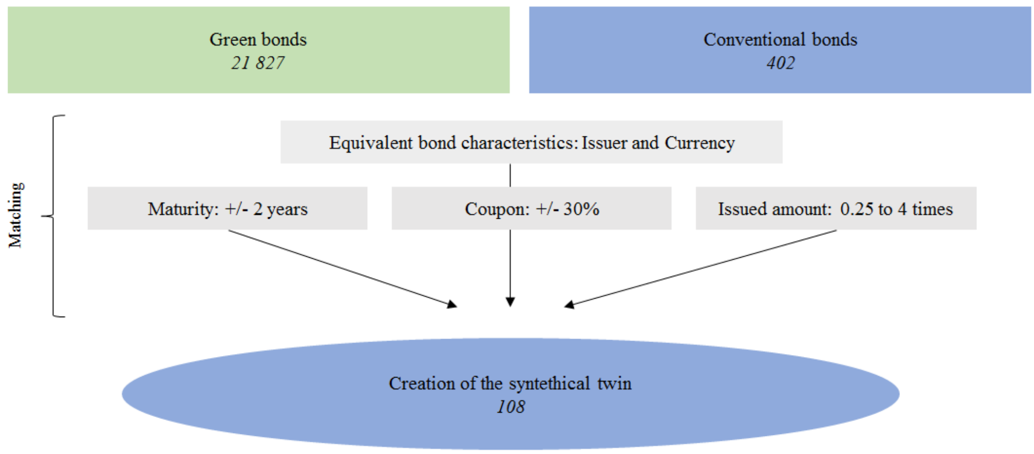

Fig. A1 llustrates the creation of the synthetic twin through the matching method. By matching 21 827 conventional bonds and 402 green bonds on certain restrictions, we are left with 108 synthetic twins.

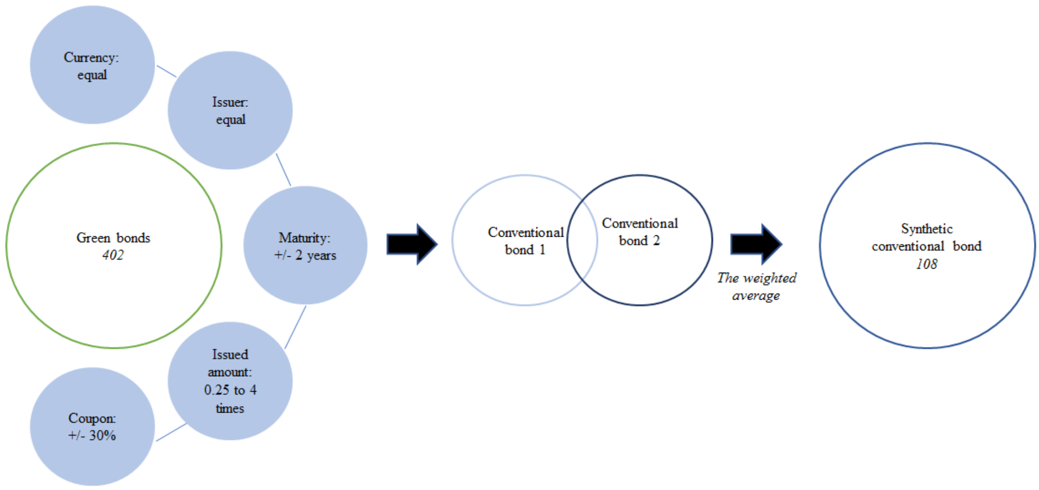

Fig. A2 illustrates the creation of the synthetic twin through the matching method. By matching 21 827 conventional bonds and 402 green bonds on certain restrictions, we are left with 108 synthetic twins.

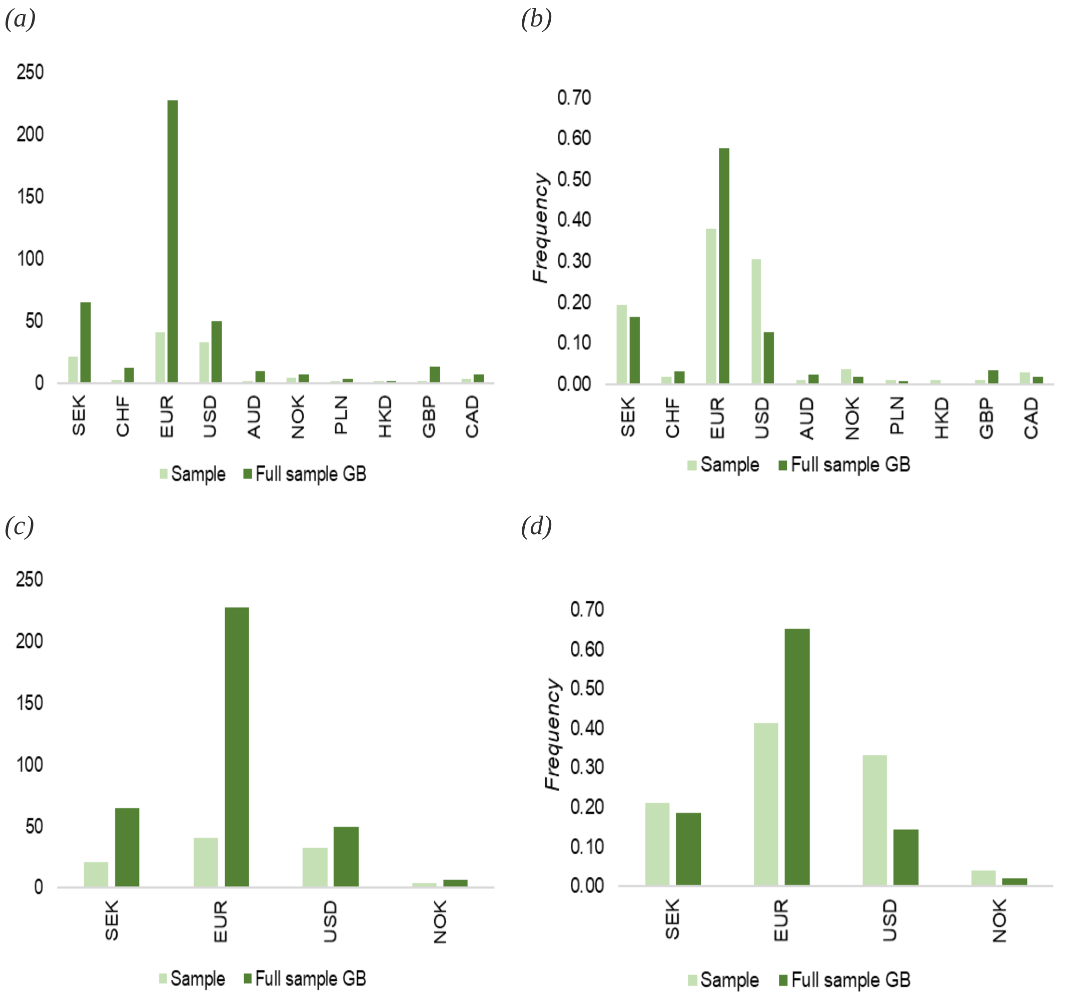

Fig. A3 illustrates the representativeness of the currencies through the frequency of the observations in both the matched sample and the total of sample of green bonds. The matched sample includes 108 observations compared to the full sample of 402 observations. (a) shows number of green bonds in the different currencies in both the matched sample and the full sample of GB. (b) shows the frequency of the green bonds in the different currencies in both the matched sample and the full sample of GB. (c) shows number of green bonds in the largest currencies in both the matched sample and the full sample of GB. (d) shows the frequency of the largest currencies in both the matched sample and the full sample of GB. Note: Sample indicates the matched sample consisting of 108 green bonds. Full sample GB contains the full sample of 402 green bonds.

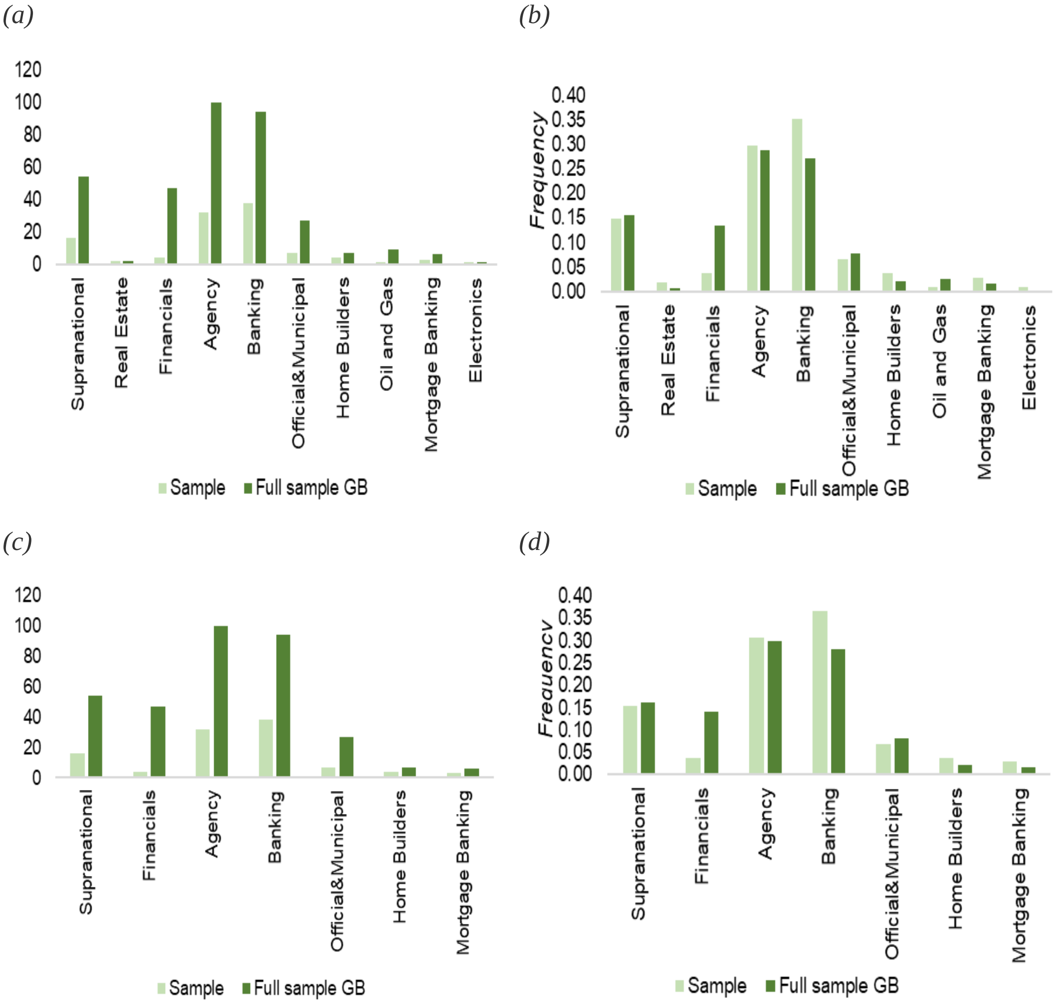

Fig. A4 illustrates the representativeness of the industries through the frequency of the observations in both the matched sample and the total of sample of green bonds. The matched sample includes 108 observations compared to the full sample of 402 observations. (a) shows number of green bonds in the different industries in both the matched sample and the full sample of GB. (b) shows the frequency of the green bonds in the different industries in both the matched sample and the full sample of GB. (c) shows number of green bonds in the largest industries in both the matched sample and the full sample of GB. (d) shows the frequency of the largest industries in both the matched sample and the full sample of GB. Note: Sample indicates the matched sample consisting of 108 green bonds. Full sample GB contains the full sample of 402 green bonds.

Appendix B – Results

Table B1
The results of the Fixed Effect panel *regression* $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ (5) without the exclusion of the negative bid-ask spreads. The regression is performed through a Within Fixed effect panel regression and through Driscoll-Kraay. The dependent variable is $\Delta\tilde{y}_{i,t}$. Std. deviation is presented in the parenthesis. Note: $* \, p < 0.1$; $** \, p < 0.05$;$*** \, p < 0.01$

	Within	*Driscoll-Kraay*
$\Delta Liquidity_{i,t}$	-0.5402***	-0.5402***
	(0.0265)	(0.0525)
Observations	33,580	33,580
R^2	0.0123	0.0123
F statistics	415.55	106.09
	Df=(1 ; 33 473)	Df(1 ; 829)

Table B2
Descriptive statistics of the estimated green bond premium a_i from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)* using a 30% deviation in the coupon rate. The table includes the total sample of a_i where a_i is the time-invariant variable extracted from regression (5). All values expressed in percentage.

Min	*1st Quart.*	*Median*	*Mean*	*3rd Quart.*	*Max*
-0.7248	-0.0620	-0.0032	-0.0021	0.0601	0.6667

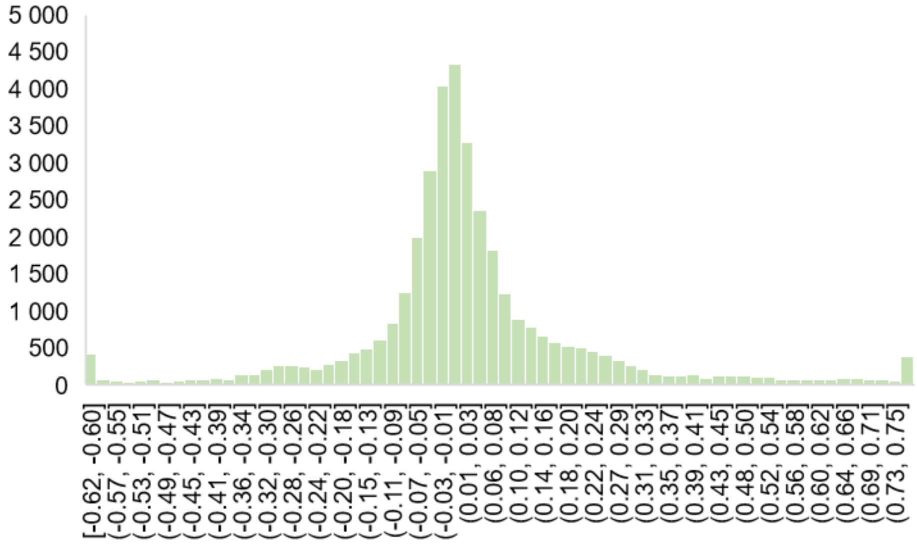

Fig. B1 shows a histogram of the dependent variable $\Delta\tilde{y}_{i,t}$ from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)*. The histogram includes the total sample of $\Delta\tilde{y}_{i,t}$, where $\Delta\tilde{y}_{i,t}$ is the difference between the green bonds yield and its matched conventional bonds' synthetic yield. All values on the x-axis are expressed in percentage.

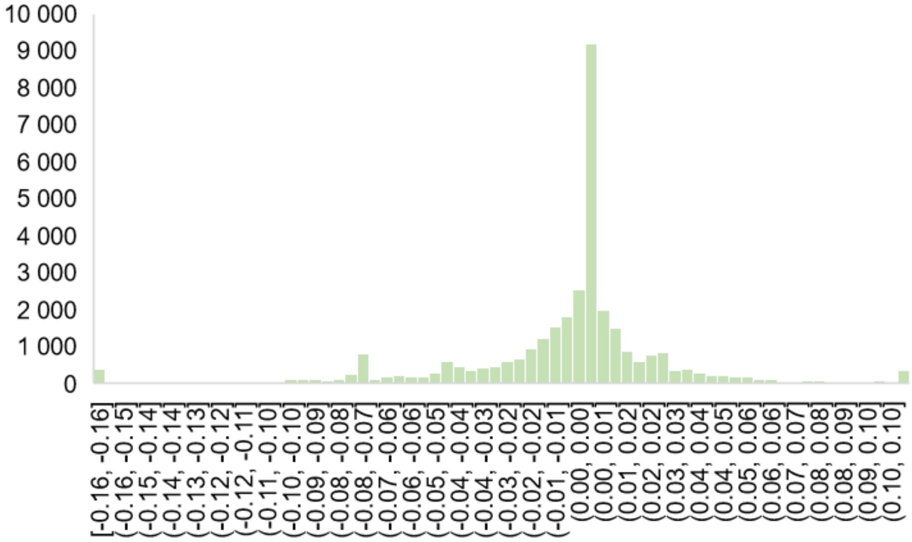

Fig. B2 shows a histogram of the dependent variable $\Delta \text{Liquidity}_{i,t}$ from the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ *(5)*. The histogram includes the total sample of $\Delta \text{Liquidity}_{i,t}$, where $\Delta \text{Liquidity}_{i,t}$ is the difference between the green bonds bid-ask spread and its matched conventional bonds' synthetic bid-ask spread. All values on the x-axis expressed in percentage.

Table B3

The results of the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ (5) with a 10% deviation on the coupon rate. The regression is performed through a Within Fixed Effect panel regression and through Driscoll-Kraay. The dependent variable is $\Delta\tilde{y}_{i,t}$. Std. deviation is presented in the parenthesis. Note: $* \, p < 0.1$; $** \, p < 0.05$; $*** \, p < 0.01$

	Within	*Driscoll-Kraay*
$\Delta Liquidity_{i,t}$	-0.1732***	-0.1732***
	(0.0226)	(0.0278)
Observations	44,515	44,515
R^2	0.0013	0.0013
F statistics	58.94	38.81
	Df=(1 ; 44 406)	Df(1 ; 829)

Table B4

The results of the Fixed Effect panel regression $\Delta\tilde{y}_{i,t} = a_i + \beta\Delta Liquidity_{i,t} + \varepsilon_{i,t}$ (5) without historical data from 2020. The regression is performed through a Within Fixed effect panel regression and through Driscoll-Kraay. The dependent variable is $\Delta\tilde{y}_{i,t}$. Std. deviation is presented in the parenthesis. Note: $* \, p < 0.1$; $** \, p < 0.05$; $*** \, p < 0.01$

	Within	*Driscoll-Kraay*
$\Delta Liquidity_{i,t}$	-0.2917***	-0.2917***
	(0.0291)	(0.0460)
Observations	29,437	29,437
R^2	0.0034	0.0034
F statistics	100.12	40.18
	Df=(1 ; 29 345)	Df(1 ; 781)