Primary market green bond pricing

Is there a difference in issue price between green bonds and non-green bonds in the primary bond market?

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Bachelor Thesis

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Abstract:

In this paper we examine if labelled green bonds are issued at a different issue price relative to par compared to conventional non-green bonds. We use a matching method and estimate the differences in issue price between a set of green bonds and otherwise similar conventional bonds. The result suggests that green bonds tend to be issued at a similar issue price relative to par compared to conventional bonds. This result can however not be interpreted as indicating the non-existence of a green premium, except under a list of strong assumptions which we are not able to control for in this paper. Our study restricts itself to Eurobonds denominated in EUR, USD and SEK, and issued during the time period 2015 to 2019.

Keywords:

Green bonds, primary market, issue price, sustainable finance

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1. Is there a difference in issue price between green bonds and non-green bonds in the primary bond market?

1.1. Introduction

In this paper we study if green bonds are issued at a different issue price compared to otherwise similar conventional bonds in the primary market for Eurobonds. There has been reporting of anecdotal evidence of green bonds being heavily oversubscribed and pricing tighter than expected.[1] While not testing directly if the issue spread is different for green compared to conventional bonds, this paper explores data to empirically test whether the the issue price is different for green bonds or not.

The bond market has long been an important source of capital for sovereigns, municipalities, banks and corporations for the funding of different operations and investments and has grown to become a plus 100 Trillion dollar market. To put that in perspective the global equities market is valued at about 85 Trillion dollars in market capitalization[2] and total global debt is estimated to be at 233 Trillion dollars.[3]

The market for labelled green bonds is a relatively new phenomenon in the bond market but the use of bonds to finance or refinance sustainable investments is not new in itself or necessarily restricted to labelled green bonds. A conventional bond can in principal also be issued with the purpose of financing sustainable investments. And financially, a conventional and a green bond are the same type of debt instruments with the same type of inherent risks. The difference between a green and conventional bond is, in essence, that the issuer of a green bond promises to use the proceeds for green investments, projects or assets and to show how it does this in a transparent manner. This commitment includes presenting additional information compared to in a non green issue. Firstly in the form of a green bond framework which lays forward how the proceeds will be invested and motivates why the use of proceeds is considered green. Secondly, a third party with acknowledged sustainability expertise may be hired to provide an external

[1] https://www.climatebonds.net/files/files/Greenbond_Pricing_Jan_16-March_17.pdf
[2] https://www.sifma.org/wp-content/uploads/2017/08/US-Fact-Book-2018-SIFMA.pdf
[3] https://images.magnetmail.net/images/clients/IIF_2/attach/GDM_Jan4_vf.pdf

review on the green bond framework and the different sustainability aspects related to the issue and issuer. Lastly, starting a period after issuance, the issuer may regularly report on the green impact of the investments. The type of impact reporting varies depending on the type of investments and what metrics are feasible to measure, one example of one of multiple possible metrics that may be reported on is how many tons of CO_2 emissions that are avoided because of the investments. Green projects include, but are not limited to; clean energy, sustainable buildings, water, waste, land-use and sustainable transport.[4] There is no single universal method of determining if a bond is green, rather it is self-labelled as green by the issuer, and can be considered green by an external reviewer such as Sustainalytics or tagged as green by a financial data provider such as Bloomberg. However, harmonised green bond standards are being developed by for example the European Commission.[5] And the green bond principles by the International Capital Markets Association, which are voluntary process guidelines, provide widely adopted guidance for market practitioners.[6]

The green bond market has grown rapidly since its inception just over 10 years ago but is still a niche market compared to the broader bond market. Three per cent of 2018 bond issuances were labelled green and in September 2018 the universe of green bonds amounted to close to 400 Billion dollars in outstanding volume, representing less than one per cent of the overall bond market. The broader universe of climate-aligned bonds, defined as bonds where issuers generate over 75% of revenues from climate-aligned and green business lines, is identified to be close to 1,5 Trillion dollars in outstanding volume. The first labeled green bond was issued by the European Investment Bank in 2007 and other examples of issuers include sovereign nations such as France, financial firms such as commercial banks and non-financials such as Unilever and Apple.[7] S&P forecasts total labelled green bond issuances of USD 180 Billion in 2019.[8]

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[4] *https://www.climatebonds.net/files/reports/cbi_sotm_2018_final_01k-web.pdf*

[5] https://ec.europa.eu/newsroom/fisma/item-detail.cfm?item_id=645336&utm_source=fisma_newsroom&utm_medium=Website&utm_campaign=fisma&utm_content=Green%20bonds%20&lang=en

[6] https://www.icmagroup.org/green-social-and-sustainability-bonds/green-bond-principles-gbp/

[7] *https://www.climatebonds.net/files/reports/cbi_sotm_2018_final_01k-web.pdf*

[8] *https://uk.reuters.com/article/greenbonds-issuance/sp-global-ratings-forecasts-green-bond-issuance-at-180-bln-this-year-idUKL5N1ZT63P*

On the demand side green bonds provide investors with an instrument for environmentally sustainable fixed income investments. In a green bond issue standardized information about the sustainability aspects of the issue are made available for investors to analyse. However, a bond does not necessarily need to be labelled as green in order for it to meet the sustainability criteria investors need to meet to comply with law, internal investment policies or other commitments. In principal, conventional bonds can also meet these standards, given that the issue and issuer comply with the relevant sustainability criteria used by the investor in their due diligence process. In a conventional bond issue, however, the issuer does not need to disclose how proceeds will be invested in the same way as in a green bond issue.

Global sustainable investment exceeded 30 Trillion dollars by 2018, an increase of 34 percent since 2016. This includes a number of sustainable investment standards and strategies across different asset classes. There are different methods for determining whether an investment is sustainable, including negative screening and sustainability themed investing, and not all can be considered equally sustainable.[9] For an investor there may be different motivations for analyzing sustainability aspects of potential investments. For example, a number of institutional investors have identified climate change as posing significant value at risk to long term wealth.[10] Some investors have direct mandates to invest sustainably and ethically. Others, with a total of tens of Trillions in assets under management, have made voluntary commitments to take sustainability criteria into consideration in their decision making processes[11] and to measure, disclose and reduce the carbon footprints of their portfolios.[12] Furthermore, the Bank for International Settlements´ Financial Stability Board has initiated the Task Force on Climate-related Financial Disclosures which is supported by 8 of the 10 largest asset managers and develops voluntary climate-related financial disclosure guidelines.[13] There are also examples of regulatory requirements on investors to disclose information about portfolio sustainability metrics. For example in France where a law was passed in 2015 making it mandatory for institutional

[9] http://www.gsi-alliance.org/wp-content/uploads/2019/03/GSIR_Review2018.3.28.pdf
[10] https://eiuperspectives.economist.com/sites/default/files/The%20cost%20of%20inaction_0.pdf
[11] https://www.unpri.org/about-the-pri
[12] https://montrealpledge.org/
[13] https://www.fsb-tcfd.org/about/

investors to disclose how sustainability aspects such as variables connected to climate change are incorporated into investment policies and, in some cases, risk management.[14]

In light of the growth of the green bond market and the, to the best knowledge of the authors of this paper, limited previous research on the topic of green bond pricing in the primary market we in this paper specifically study the primary market for Eurobonds. We herein compare the issue price of labelled green bonds with otherwise similar/matched conventional bonds. Our sample includes bond issues in EUR, USD and SEK for the time period 2015 to 2019. We restrict our study to the pricing on the primary market because of its more direct implications for the issuers debt cost of capital.

In addition we discuss difference between green and conventional bonds with interviewees who are professionally involved in the green bond market, including people working for a bank and an institutional investor. The interviews however are not a qualitative test or part of our quantitative test. Rather, comments from the some of the interviewees are actualized in the discussion of our results.

The remainder of our paper is structured as follows. We first present previous literature on the topic and explain the theoretical framework. We thereafter lay forward the data and method used for our quantitative test before presenting our results whereafter we critically reflect and discuss upon these. We use the terms conventional, non-green and grey bonds interchangeably for the remainder of this paper.

1.2. Literature review

To the best of the knowledge of the authors of this paper there is no previous study that specifically examines the issue price for green bonds compared to non-green bonds. And the previous literature on the topic of primary market green bond pricing is relatively limited.

Jeffrey Wurgler, George Serafeim, Daniel Bergstresser and Malcolm Baker (2018)[15] show that

[14] https://www.frenchsif.org/isr-esg/wp-content/uploads/Understanding_article173-French_SIF_Handbook.pdf

[15] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3275327

green bonds are issued at a premium to otherwise similar conventional bonds. Their results also support that green bonds are more closely held by investors than conventional bonds i.e. a buy and hold strategy is more common. Furthermore, they show that both these results are more pronounced for issues that are externally certified as green.

There are also studies on the secondary market for green bonds. Zerbib (2018)[16] finds that the yield of a green bond in the secondary market is, on average, 2 bps lower than the yield of a conventional bond, using a matching method and two-step regression procedure. His study covers bonds issued between July 2013 and December 2017. The study furthermore shows that the premium is larger for financial issuer types and lower rated bonds.

The broader research on the primary market for bonds in general is somewhat more extensive. After examining existing literature on similar subjects to ours we find a relevant study, which serves as the most important guideline for our research on the primary market. Giampaolo Gabbi & Andrea Sironi (2005)[17] empirically show the relevance of different factors in determining corporate bonds‘ issuance spreads in the primary market. As there is no theoretical model that is assumed to lie behind bond pricing Giampaolo Gabbi & Andrea Sironi take an agnostic approach, and the empirical analysis investigates which factors affect bond issuance spreads rather than testing any theoretical model. They examine corporate Eurobonds spreads based on five main factors.[18]

Gabbi et al. find that credit ratings given by credit rating institutions Moody’s and S&P is the most important factor affecting the spreads between the yield to maturity of corporate bonds compared to a benchmark risk-free rate. Indeed, they find that a model using only rating variables as explanatory variables for explaining the spread has an adjusted R^2 of 0,790 (statistically significant at the 1% level). They also find that the primary market efficiency and the expected secondary market liquidity has low explanatory power in explaining the spread. The work of Gabbi et al. is valuable for this paper since one of the core elements of this study is to

[16] https://www.chaireeconomieduclimat.org/wp-content/uploads/2018/06/Newsletter-juin-GB-Premium-OD-Zerbib.pdf
[17] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422
[18] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422

identify and match bonds on variables that affect the required issue yield and thus in extension can affect the issue price of a bond.[19]

1.3. Theoretical framework

1.3.1. Pricing of coupon bonds - required yield compensates for risk.

When a bond is issued its fair price is determined by summing up its future cash flows, discounted with the required yield for each respective cash flow. The yield to maturity at issuance, or just issue yield, is the weighted average of the required yields for the respective cash flows. The yield equals the expected return of a bond only if it is held to maturity and all promised cash flows are received in full. For non risk free bonds, the expected return is therefore lower than the yield. The yield curve for a given level of risk plots the required yield for different maturities. The spread between the yield curve for a given level of risk and the risk free rate with the same maturity is a measure of the risk premium demanded for that given level of risk. The risk premium compensates for the additional risk of holding the bond compared to holding a risk free investment. The yield of for example the US 10 year treasury is frequently used as a proxy for the risk-free rate, this can serve as a benchmark for market practitioners when pricing bonds. Corporate coupon bonds are typically priced against the swaprate, this rate reflects the markets´ beliefs about future interest rates. If for example the 5 year swaprate for 3 month London Interbank Offering Rate (LIBOR) is 2 percent and the 3 month LIBOR is .5 percent, then the current belief is that a rolling 5 year investment in 3 month LIBOR will give an annual return of 2 percent over 5 years. The swaprate then serves as a sort of baseline above which riskier investments can be priced.[20]

1.3.2. Type of risks being assessed in the fixed income market.

The pay-off profile for fixed income instruments naturally makes the downside risk of not receiving repayment extra critical. Credit risk is the risk that the issuer might not make promised payments in full, meet other obligations, or even go bankrupt. Investors typically seek guidance

[19] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422
[20] https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2018/01/sou-2017115/

from credit rating agencies such as S&P or Moody´s when assessing the credit risk of a bond. Credit gradings do not give explicit probabilities of default or explicit probabilities of loss in case of default, but they provide investors with an assessment of an issuers long term payment capabilities, which can be used as proxy for the credit risk.[21]

Another risk for bond holders is inflation risk. This is the risk that inflation turns out to be higher than currently expected, leading to a reduction in real return of investment. When inflation rises the yield curve shift upwards as the market requires higher rates in order to be compensated for the higher inflation.

If economic growth is expected to accelerate going forward, the yield curve has a tendency to become steeper because the market will expect future rates to be higher than presently expected. There is an inverse relationship between bond prices and yields, when yields rise the price decreases. Interest rate risk comes from the uncertainty about how market interest rates will evolve in the future. If market interest rates rise already outstanding bonds with lower yields become less attractive and the price of these bonds therefore decreases. The level of interest rate risk may vary depending on whether the coupon payments are based on a fixed rate or an adjustable rate linked to a reference rate such as LIBOR. And all else equal, a bond with a larger portion of cash flows further out in the future will, due to compounding over longer time periods, be more sensitive to changes in interest rates. This level of interest rate risk sensitivity can be expressed by the modified duration of a bond.

When holding a bond there is also liquidity risk which is the risk that the bond cannot be sold quickly enough at a high enough price, for example because the market is not deep enough. The market liquidity is considered to be good if large volumes of a bond can be sold quickly at a low transaction cost without considerably impacting the market price. The liquidity risk is especially relevant for an investor who might sell the bond before it matures.[22]

1.3.3. The process of issuing and pricing a bond.

[21] Jonathan Berk & Peter DeMarzo. Corporate Finance. Global Edition. 4th edition. Chapter 6.
[22] https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2018/01/sou-2017115/

A bond issue can be placed in the market in a few different ways. When an entity decides to issue a bond it typically hires an investment bank to act as an intermediary between the issuer and the investors. One investment bank or a syndicate of banks led by a lead manager may underwrite the bonds, meaning that they bare the risk of the bonds and then resell the bonds to investors. In other cases, the investment bank may simply market the issue without underwriting it, in that case receiving a commission on the bonds sold instead of an underwriting spread. There is a conflict of interest for involved intermediating banks since they on the one hand have the obligation to secure the most beneficial pricing for the issuer, while on the other hand they need to get an as high as possible return from the intermediation.

In the case that the issuer hires a lead manager to intermediate the issue they first discuss the size of the issue and a target for the coupon rate and price. This is provisional and can change before the issue is closed. The issue and its specifics are then formally announced to the market. Between the announcement date until the bonds are formally issued they trade in the so called grey market, this activity gives the lead manager information about how large the interest is from investors to invest in the bond and at what price. Assuming that the grey market works efficiently it reflects the yield required by the market for the bond. During this period the coupon rate can be adjusted. The next key date is the pricing day when the subscription period ends and the final conditions for the issue are agreed on between the issuer and intermediating parties. Depending on how market conditions have evolved between the announcement and the pricing day some of the specifics such as the coupon rate can be adjusted and otherwise a change in the bonds´ issue price relative to par takes care of the final pricing adjustments being required by market participants. The next day is the offering day and this is when the final specifications of the issue are agreed upon, committing the underwriters to buy the bonds from the issuer at the price agreed upon during pricing day. And a short time later, typically two weeks, is the closing day when the bonds are paid for. After the bonds start trading in the secondary market the lead manager may also have the job of stabilizing the price for a short period.

In a bought deal procedure the lead manager or a group of banks instead present the borrower with a bid that specifies the issue price and other specifics. The issuer then has a few hours to

consider the bid and if it accepts the offer the lead manager buys the entire issue before distributing it to investors alone or together with other banks.

And in some issues a fixed price re-offer scheme may be applied meaning that syndicate banks agree not to resell the bonds at a lower price than the initial offer price until the issuance has been completed.

Some of the more experienced and high quality bond issuers such as the U.S government can avoid fees related to the issuing process by instead selling the issue directly to investors through an auction where investors bid directly.

Bond issue prices are quoted as a percentage of par i.e. expressed as the present value of its cash flows divided over the face value, multiplied by 100. The discount rate used for this is the yield to maturity at issuance. Price quotes are stated net of accrued interest which makes quotes for different bonds comparable. Price quotes for bonds are in other words expressed as a percentage of par value converted to point scale. Par value 100 represents 100 per cent of a bond's face value. If a bond trades at 101 and has a face value of USD 1000 this means that the cost of buying each bond is USD 1010. How the coupon rate relates to the yield to maturity at issuance determines if the bond is issued at, below or above par. In other words, after the coupon rate has been set it is changes in the required issue yield that drives changes in the issue price. For a bond that is issued at par, the coupon rate equals the required yield to maturity at issuance. A bond issued at a discount has a coupon rate that is lower than the issue yield and therefore an issue price below 100 and vice versa for a bond issued at a premium.

When intermediating banks structure the issue they set the coupon rate to be equal to the required yield at the time of issuance i.e. at a level that sets the issue price equal to par. The reason behind this is that investors generally prefer to pay par or slightly under for a new issue, typically in the range 99,00 to 100,00.

In accounting terms, if a bond is issued at a premium, the amount received minus the bond's face value (and any accrued interest) is the premium, or premium on bonds payable. This premium on bonds payable is then amortized to interest expenses over the lifetime of the bond, thus reducing

the interest expenses for the issuer. The opposite happens when a bond is sold at a discount.[23]

1.3.4. Green bond frameworks, second opinions and impact reporting.

In contrast to in a conventional bond issue, two additional sources of information are made available in a green bond issue. A green bond framework is to be prepared by the issuer to credibly show how the proceeds will be invested for purposes that are aligned with a sustainable development, something the criteria in the green bond principles for example can be used for. The green bond principles further recommend the issue and green bond framework to be reviewed by a third party with acknowledged expertise in the area. In the case where the issuer hires an intermediating bank it is this bank that hires the second opinion provider. The second opinion statement provides investors with a credible audit of the green aspects of the issue. Once the green bond has been issued, and if it is deemed feasible, the issuer will also give regular reporting on how the investments from the bond perform from a sustainability perspective. For example, such reports may include information about how many kWh of clean electricity that have been generated or how many tons of CO_2 emissions that have been avoided.[24] However, information from impact reports is of course not available to investors during the issuing process.

1.3.5. Eurobonds

Eurobonds are international bonds issued in another currency than the native currency of the issuer, the name does not refer to Europe or the currency Euro itself. For example, a Brazilian company issuing a USD denominated bond and selling it in the UK would be a Eurobond. This is different from foreign bonds which are issued within and regulated by a particular nation's legislation, for example a Swedish company issuing a GBP denominated bond in the UK. Interest payments from Eurobonds are made gross, free of withholding and other taxes. And Eurobonds are typically in bearer form. They are often registered on an exchange to enable certain institutional investors to invest in them and trading of eurobonds is usually done directly over the counter.[25] The term Eurobond as defined in this paper is not to be mistaken to be

[23] Moorad Choudhry. Bond & Money Markets - Strategy, Trading, Analysis. Chapters 3.4.1. and 18.
[24] https://www.icmagroup.org/green-social-and-sustainability-bonds/green-bond-principles-gbp/
[25] Moorad Choudhry. Bond & Money Markets - Strategy, Trading, Analysis. Chapter 18.

connected to the proposal for several Euro area countries to issue a common bond.[26]

1.4. Research Methodology

1.4.1. Matching method

The primary method used in previous literature on bond pricing is based on linear regression models which use the issue spread or issue yield as dependent variable. These methods are based on examining how an as exhaustive as possible list of relevant independent variables affect the bond spread while doing tests to ensure the robustness of the model.[27] This could be an appropriate model to incorporate for comparing green and conventional bond pricing since a variable could be added to the model to examine an eventual effect from the green label. A classification algorithm, such as the logistic regression model, could also be feasible to apply for studying an eventual difference between two classes of bonds. By using this method one could test whether the issue yield or spread has predictive power in classifying a bond as green or conventional.

However, we lack access to a data source that provides information about the bond spread at issuance, this information is only available for the secondary market. Instead we are restricted to examine an eventual difference between green and conventional bonds by looking at the variable issue price. Such a test will not be able to show directly if there is an eventual green premium. Instead, if the issue price is shown to be different for the green bond sample compared to the conventional one it simply means that the coupon rate in relation to the required yield at issuance, on average, is different for that sample. It may be noted however that if the bonds in each pair being examined are identical in all other variables than the green variable, and under the assumption that the bonds have been issued under identical market conditions our test can indicate if green bonds are priced differently.

The very procedure under which bonds are issued in the primary market place can differ to a certain degree from issue to issue and be affected by variables, both rational and more irrational,

[26] http://europa.eu/rapid/press-release_MEMO-11-820_en.htm
[27] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422

which are difficult to observe. This makes it practically impossible to observe two bonds that are identical except for in the green variable and that have been issued under identical conditions. In a real counterfactual framework we would observe each bond priced in both the conventional state and the green-labelled state and this is, of course, not possible.

Instead, we match each green bond in our sample with a non-green bond that is as identical as possible in all aspects except for the specific property of interest, in our case the green bond label. This matching method is known as a direct or model-free approach. To do this we must first identify variables that affect the issue price.

Variables that have been identified to affect the issue price of plain vanilla bonds include the credit quality of the borrower, maturity of the issue, total nominal value, the presence of any option feature, and the prevailing level and volatility of market interest rate.[28]

Gabbi et al. show that there are five main factors which affect primary market spreads for corporate bonds:[29]

(1) the bond issuer default risk

(2) the bond's expected recovery rate in case of default;

(3) the expected liquidity of the secondary market of the bond issue;

(4) the expected tax treatment to which investors will be subject;

(5) the bond's primary market efficiency conditions.

These five factors are used in the following model used by Gabbi et al. to regress the spread:

$$SPREAD_i = f(DEFAULT_i, RECOVERY_i, LIQUIDITY_i, TAX_i, EFFICIENCY_i) + \varepsilon_i$$

Gabbi et al. assign different variables to the 5 different factors used in their model to regress the yield spread for corporate euro bonds. We use this list of variables in combination with the variables identified by Moorad et al. to construct a set of matched pairs of bonds.

[28] Moorad Choudhry. Bond & Money Markets - Strategy, Trading, Analysis. Chapter 18.5.3.
[29] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422

However, we do not have access to all of the variables Giampaolo Gabbi & Andrea Sironi collected and tested. All of Giampaolo Gabbi & Andrea Sironi's independent variables can be found in figure A.1. in the appendix of this paper.

We set up a database with the purpose of matching pairs of green and conventional bonds that are as identical as possible in the variables that have been identified to impact the required yield and in extension the issue price. In addition to this, and in order to determine the eventual impact from a green label on the issue price, we also include a variable that states if the bond is labelled as green. A complete list of variables included in our dataset is presented in the section below.

1.4.2. List of available variables in dataset

Issue price (nummerical): Defined as the present value of the bond's cash flows divided over its face value, multiplied by 100. The yield to maturity at issuance is used as discount rate.

Green bond (binary): Yes/No-variable that returns a "yes" if the bond is labelled as green according to Thomson Reuters´ definition of green bond.

Instrument (factor): Whether the instrument is a bond or a note. Notes and bonds are, to the best knowledge of the authors of this paper, the same type of debt instruments from a financial standpoint.[30]

Coupon type (factor): States the bonds´ type of coupon payment, for example plain vanilla fixed coupon.

Coupon frequency (factor): States at what time intervals coupon payments are made, for example quarterly, semiannually or annually.

Coupon (numeric): Expresses the coupon rate in percent.

Amount issued (numeric): The nominal value of the bond as measured in USD.

[30] Moorad Choudhry. Bond & Money Markets - Strategy, Trading, Analysis. Chapter 1.5.2. outlines that there is in practice no real financial difference between Treasury notes and bonds. And to the best knowledge of the authors of this paper there is no financial difference between bonds and notes for other issuer types either.

Country of Issue (factor): The market in which the security is issued, for example Germany, the United States or the Eurobond market.

Issuer type (factor): Informs if the issuer is an agency, corporation or government/supranational.

Principal currency (factor): The principal currency of the bond issue, for example US dollar or Euro.

Private placement (binary): Yes/No-variable informing whether the bond has been issued to the broader public market or directly to a selected number of investors in a private placement.

Eligible For EU Tax Savings (binary): Yes/No-variable. EIKON does not provide a clear definition of this variable, nor are we able to find another source that to the best of our knowledge provides a clear and explicit explanation of what type of EU tax directive and type of EU tax savings eligibility this variable refers to.

Callable (binary): Yes/No-variable stating whether the issuer has the right, but not the obligation, to redeem the bond prior to maturity.

Putable (binary): Yes/No-variable stating whether the investors have the right, but not the obligation, to demand early repayment of the principle at specified dates.

Seniority (factor): A bond´s seniority determines the level of priority a bond holder has in claiming an issuer's assets in the case of default. One example of such a level is senior unsecured.

Rating (factor): This variable is Standard and Poor's (S&P´s) long term issue credit rating.

Tenor (numerical): The tenor of a bond is the time between issuance and maturity and is expressed in years.

Guaranteed (binary): Yes/No-variable that informs if a third party guarantees the cash flow streams from the bonod under the eventuality of the issuer defaulting on obligations.

Issue date: Expresses the date for when the bond was issued.

1.4.3. Test method

We examine the possible discrepancy in issue price using the Wilcoxon signed rank test. The Wilcoxon signed rank test is a nonparametric test which can be used for testing a random sample of matched pairs of data. The sample of matched pairs of data is ranked in ascending order according to the absolute differences in "issue price", i.e. the variable we study to examine potential discrepancies. The test assumes that the population distribution for the differences in issue price is centered around 0, implying no difference in issue price. The different ranks are then assigned to negative and positive differences in the issue price which are used to determine the Wilcoxon signed rank test statistic T.[31] Where:

T_+ = Sum of the positive ranks

T_- = Sum of the negative ranks

Due to the central limit theorem we can approximate the binomial distribution of the differences with the normal distribution. This allows the test to use a z-value test statistic. Since our sample size is large enough (n>20)[32] we can test the data with the Wilcoxon signed rank test for large samples. Our test is executed in matlab using the "singrank" function. The "signrank" function in matlab allows us to test the null hypothesis that the differences in issue price between the bonds in the pairs follows a distribution with a median of zero against a two sided alternative. Matlab uses the following test statistic for Wilcoxon large samples.[33]

$$Z = \frac{(T_+ - n\cdot(n+1)/4)}{\sqrt{\frac{n(n+1)\cdot(2n+1) - tiedj}{24}}}$$

n = the sample size of the difference x-y

To deal with differences that are equal to zero in a two-sample test, matlab uses

[31] Newbold *with others,* Statistics for Business and Economics, p. 622-625
[32] Newbold *with others*, Statistics for Business and Economics, p. 622-625
[33] https://se.mathworks.com/help/stats/signrank.html

"*[tie_rank,tieadj] = tiedrank(abs(diffxy),0,0,epsdiff)* to obtain the tie adjustment value *tieadj"*.[34] As we test for a general discrepancy in issue price, the test is conducted against a two-sided alternative. The significance level is set to 5 %, the same as the default significance level applied by Matlab for this type of test.[35]

$\alpha = 0,05$

Null hypothesis, h_0 = the paired differences, x-y, have a distribution with a median equal to 0

Alternative hypothesis, h_1 = the paired differences, x-y, have a distribution with a median not equal to 0

Green bond = x

Grey bond = y

Using the test for large samples enables matlab to obtain a z-value for the z test statistic as well as a value for the signed rank test statistic. This then enables matlab to calculate a p-value for the test.

The Wilcoxon signed rank test is well suited for this study since it allows to test for differences in issue price using a relatively small data set and without having to make any assumptions about the type of distribution of the issue price for the population.

1.5. Data sources and sample characteristics

We collected our data samples from the Thomson Reuters database EIKON. We restricted our study to examine notes because at the time of collecting our data the Eikon universe of green notes was considerably larger than the list of green bonds. At the time of data collection the database had data points on a total of 1 859 849 notes. 115 146 of these had a credit rating and issue price attached and of these a total of 356 were green notes.

After restricting the sample to only include eurobonds that are eligible for EU-tax savings, have

[34] https://se.mathworks.com/help/stats/signrank.html
[35] https://se.mathworks.com/help/stats/signrank.html

the issue credit grade AAA and coupon type plain vanilla fixed coupon bonds, which was the by far most frequent coupon type, the sample contained 35 green bonds and 262 non-green bonds. We downloaded these and set up the following rules for the matching procedure, where the bonds in the matched pairs should;

- Have the same tenor and coupon frequency,
- Be issued no more than 12 months apart,
- Have the same binary values for the variables guaranteed, callable, putable and private placement,
- Be senior unsecured and of the same currency.

20 of the green bonds from the sample were matchable with conventional bonds in accordance with the matching rules set out above. We filtered grey bonds according to the matching rules and in cases where multiple grey bonds where matchable with a green bond we placed these separably and applied an excel function[36] to randomly assign one of the applicable conventional bonds to each respective green bond. After this procedure we had a complete list of 20 pairs of bonds, matched in accordance with the rules set out in this paper. Each grey bond was only allowed to be included once i.e. the same grey bond does not appear in multiple pairs.

We then obtained descriptive statistics for the issue prices of the respective bonds in each pair. A complete list of these is presented in Table 1. Moreover we present the differences in issue price between green and conventional bonds as illustrated with a boxplot in figure 2. The absolute differences are shown with similar fashion in figure 3.

[36] Function of the form: =INDEX($A:$A;RANDBETWEEN(1;COUNTA($A:$A));1) where column "A" represents a variable where each observation has a unique value, in our case "issuer name". In cases where multiple of the applicable grey bonds have the same issuer name we add a unique number at the end of each in order for the function to be able to distinguish them.

pairNr	greenIssuePrice	greyIssuePrice
1	99.935	99.8
2	99.6	99.271
3	99.288	100
4	99.714	99.641
5	99.417	100
6	99.176	99.419
7	99.656	100
8	99.688	98.42
9	99.985	99.644
10	100	100
11	100	100
12	99.869	100
13	100	99.926
14	99.76	99.621
15	99.664	100
16	99.859	100
17	99.931	99.731
18	99.594	100
19	100	99.556
20	99.918	99.674

Table 1: *A 20x3 table showing the respective issue prices for the green and grey bond in each pair of bonds.*

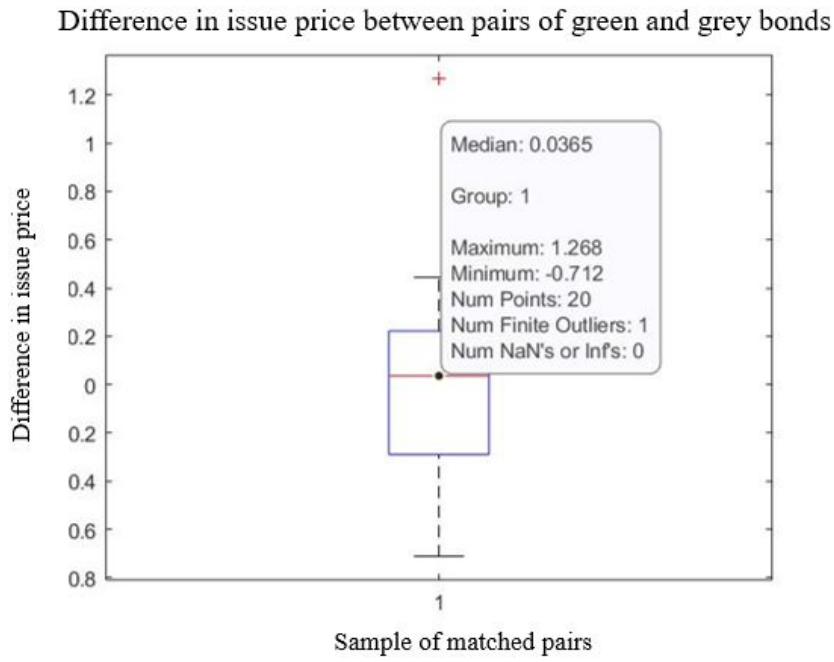

Figure 2: *Boxplot showing the differences in issue price between the pairs of green and grey bonds in the test sample. The median difference is 0,0365 and is marked by the red line in the boxplot.*

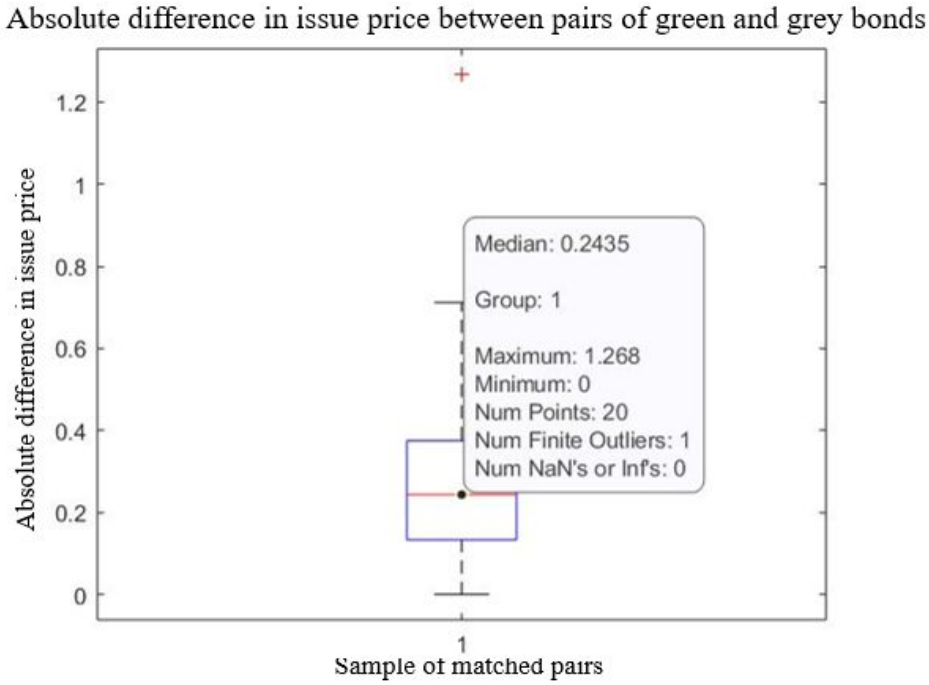

Figure 3: *Boxplot showing the absolute differences in issue price between the green and grey bonds in each pair in the test sample. The median absolute difference is 0,2435 and is marked by the red line in the boxplot.*

1.6. Empirical work/Analysis/findings

The test we conducted shows that green bonds tend to have a similar issue price relative to par compared to conventional bonds. The null hypothesis was not rejected.

We tested the following hypothesis with the wilcoxon signed rank test for large samples:

Null hypothesis: h_0 = the paired differences, (x-y) have a distribution with a median = 0

Alternative hypothesis: h_1 = the paired differences, (x-y) have a distribution with a median $\neq 0$

Significance level: $\alpha = 0,05$

The null hypothesis (h_0) cannot be rejected at the 5% significance level in favor of the alternative hypothesis (h_1). The test yielded a Z-value from the z-test statistic of -0,1089 and wilcoxon signed rank test statistic value of 83. The calculated p-value associated with the z-value was 91,33%. The results from the empirical test supports the null hypothesis that the population distribution of differences in issue price between green (x) and grey (y) bonds does have a median of 0.

```
p =

    0.9133

h =

  logical

   0

stats =

  struct with fields:

          zval: -0.1089
    signedrank: 83
```

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Table 4: *This table illustrates the raw test results as outputted by matlab using the "signrank" test for large samples. Matlab did not reject the null hypothesis at a p-value of 0,9133.*

To further visualize the absolute differences for the test result, the data was plotted in a cumulative distribution function of the absolute differences as seen in figure 6, showing that there is a difference between the pairs, however the data of the numerical values of the absolute differences is concentrated within the 0-0,5 absolute difference range. The probability of finding an absolute difference between 0-0,5 is approximately 80%. The plot also shows that the probability of finding an absolute difference of 0 is approximately 10%. The numerical differences are also plotted in a histogram in figure 7 which illustrates that the differences in issue price are centered around zero which is consistent with the empirical test result from the wilcoxon test.

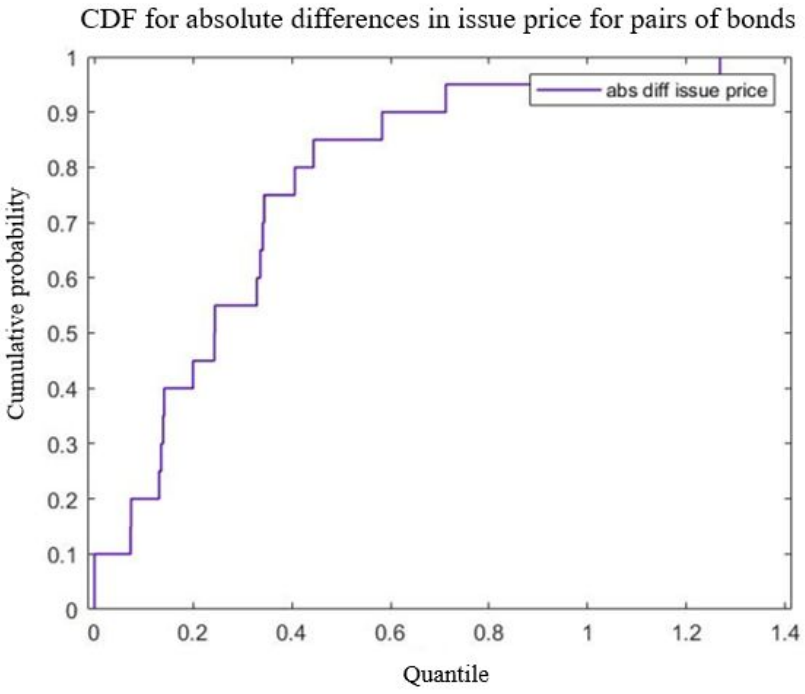

Figure 6: *CDF (cumulative distribution function) with the cumulative probability for the absolute differences in issue price between the pairs of bonds on the y-axis. And the absolute difference in issue price on the x-axis.*

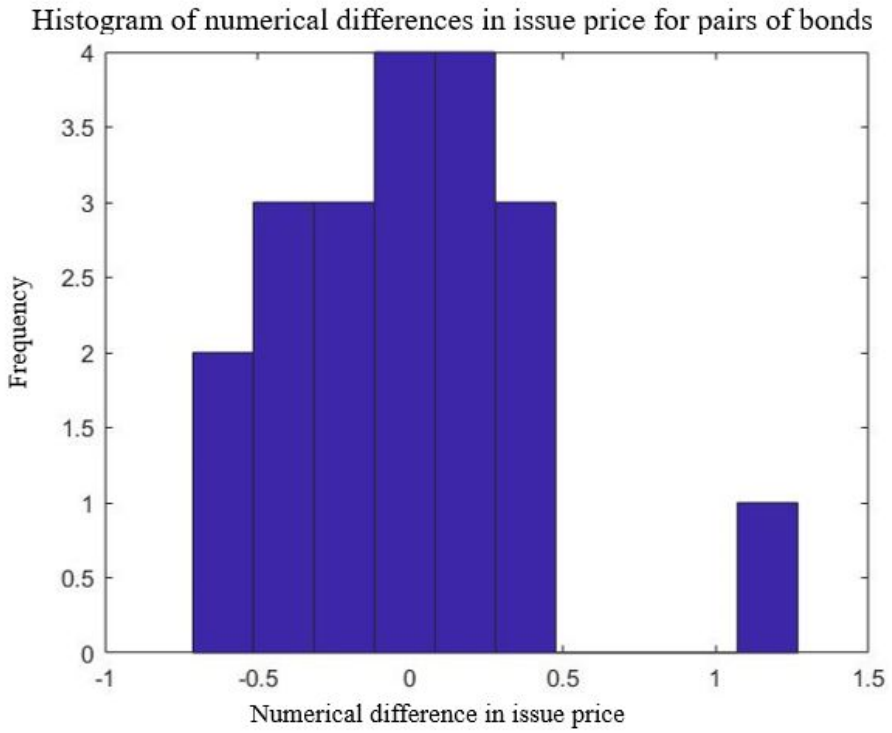

Figure 7: *Histogram of the numerical differences in issue price for the test data. The differences are centered around 0, which is consistent with the wilcoxon test result.*

1.7. Limitations of research

Since the test in this study only includes a sample of the total green bond universe there is risk of sampling error being present. The sample in this study is not perfectly representative for the population of Eurobonds, for example the frequency of different variables such as the currencies included differs between the sample and the population. Our result is not necessarily representative for the broader population of bonds.

The sample size in our test is relatively small and this also poses a limitation to our study. One advantage of the Wilcoxon signed rank test however is that it is non-parametric and can be performed using a relatively small sample size compared to other statistical methods such as a logistic regression. A larger sample size is nevertheless preferable.

The quality of this study depends much on the quality of the data source used. While we

recognize the possibility of errors being present in the raw data we hold this as most unlikely since all raw data has been exported directly from the EIKON database which is a highly regarded source of financial data.

Different aspects related to the matching procedure pose further limitations to this study. First there can be issuer-specific variables impacting the issue price which we are not able to match. Second, an overrepresentation of a certain issuer type such as agency or corporate issuers in one of the groups of bonds examined may distort the matching quality and therefore the result of this paper. In this study for example a corporate bond can be matched with an agency bond and these issuer types may differ in variables that have not been matched on in this study but are nonetheless relevant for the issue price. We recognize this source of uncertainty as a major limitation to this study. And in the cases in this study where a corporate bond is matched with a corporate bond we do not match the bonds on their economic sector. This is yet another limitation. Previous studies by Gabbi et al[37] show that industry dummy variables have statistically significant coefficients even though credit ratings are expected to capture economic outlooks of different sectors. Matching all corporate bonds included in the sample with other corporate bonds in the same economic sector could improve the quality of the matching procedure.

Applying a matching rule for the variable issue amount could also be a way to improve this study. A closer match on the variable issue amount was not feasible due to the limited amount of conventional bonds that fulfilled the other matching criteria and could be matched with the respective green bond. A tighter match on this variable than applied in this study might be preferable. And although, to the best of our knowledge, we have matched pairs of bonds being subject to identical tax treatment we recognize that other factors relating to the taxation rules for Eurobonds can be potential sources of error.

Finally, to compare bonds from the same issuers, in cases where an issuer has issued both green and conventional bonds, could be another way to improve the study since this could better control for idiosyncratic factors.

[37] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422

It is also possible that the difference in issue price stems from variables related to the issue procedure which we are not able to match the pairs of bonds in our study on. For example, in a bond issue, once the coupon rate has been set, any eventual final price adjustments are driven by the required yield which in turn drives the issue price. Thus, how long it takes from that the coupon rate is set until the bond is finally issued and how volatile market interest rates are during this period impacts the issue price. A closer match on the variable issue date than applied in this study would be preferable.

Furthermore, it is possible that a bond issued in a simple underwriting procedure is matched with a bond that has been issued using a different issuing procedure such as an auction, for example. This in turn can affect the process under which the coupon rate is set and how long it takes from that the coupon rate is set until the bonds are issued, and thus it would affect the process during which the issue price is determined. We identify the fact that we are not able to match bonds on variables related to the issuing procedure as another major limitation to this study.

1.8. Discussion

Our result supports that green bonds tend to, on average and all else equal, have a similar issue price relative to par compared to conventional bonds. The result in this paper concerning the non-difference in issue price can have potential implications and be of interest for market participants such as intermediating banks since they generally aim to set the issue price equal to or slightly under par.

Under the assumption that the bonds in the pairs have been issued in an identical issuing procedure the result in this study indicates that the required issue yield for green bonds develops in a similar way as for grey bonds from the time point in the issuing procedure when the coupon rate is set until the bonds are issued. In addition this would indicate that any factors related to the green label with an eventual impact on the required yield at issuance are taken into account prior to when in the issuing procedure the coupon rate is decided on and fixed. Since the coupon rate from the bond announcement is provisional and may be changed up until the pricing day to reflect the markets´ required yield for the bond, if any such green label factors have an impact on

the required yield this may already have been taken into account by a change in the coupon rate. In which case, this study would not be able to catch an eventual effect from a green label since the coupon rate has already been modified to reflect any eventual green factor effect on the required yield at issuance. As discussed in the previous section however we are not able to control for the above mentioned assumption of identical issuing procedures. This is because we do not have access to data points and variables related to the issuing procedure and therefore no such direct conclusions about an eventual impact on bond pricing from the green label can be drawn from this study.

Importantly, the result in this study does not by itself indicate whether there is a green premium or not in the primary market. For any such conclusions to be drawn a set of further assumptions would need to hold and to test for these assumptions is outside of the scope of this study. To explain however, we again recall that once in the bond issuing procedure when the coupon rate has been decided, any eventual final pricing adjustments before issuance take place by a change in the required yield. A change in required yield, given that the coupon rate has already been fixed, drives a change in the issue price. For example a reduction in required yield would drive up the issue price in this situation. Under the assumptions that; 1) a green label affects the required yield and that not all of this has been taken into account by a change in the coupon rate relative to the coupon rate at announcement date, 2) the bonds in each pair are identical except for in the green label and 3) that they have been issued under identical conditions, the result in this paper indicates a similar change in required yield for green bonds and grey bonds from the time that the coupon rate is set until the time of issuance i.e. indicating that a green premium does not exist. This would be contrary to results from recent studies on the topic which have, although not unanimously, indicated the existence of a green premium. For example a study by Wurgler et al[38]. A similar issue price does not however indicate the absence of a green premium by itself. In this study we are not able to control for these three assumptions mentioned above that need to hold for our result to be interpreted as such. Therefore no such direct conclusions about the pricing of green bonds can be drawn from this study.

[38] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3275327

Instead, what can be concluded from this study is that the distribution around par is similar for green bonds compared to conventional bonds at the time of issuance.

For future research this study may be useful as a sort of rough framework for examining if and how a green label impacts bond pricing. For example, the authors of this paper identify research methods that can examine if there is green premium in the primary market as interesting for future studies. We identify such a test using the option adjusted spread as target variable in combination with reducing some of the uncertainties and limitations discussed in the previous section as an interesting method for future research. Such a test could yield more directly interpretable results about green bond pricing and add to the relatively limited research on eventual differences between the pricing of green and conventional bonds. Other methods such as regression models or classification algorithms may also be feasible methods for analysing that research question.

Furthermore, we reason that for such future research two factors related to the green label can be hypothesized as variables with potential impact on the required yield. First, the additional information being available in a green bond issue compared to in a conventional issue could be thought of as having an impact on an investors risk assessment capabilities which in turn could affect the required yield at issuance. Second, the level of demand for green issues could be different than the demand for conventional issues which could affect the issue yield deemed as acceptable by some investors, this could in turn affect the final issue price. While we identify these hypotheses as interesting for future research we do however not test these hypotheses empirically in this paper.

Lastly, and to familiarise ourselves in green bond related questions for future research, we briefly discuss comments on differences between green bonds and conventional bonds from three interviewees who are all professionally involved in the green bond market.

Peter Lööw, head of responsible investments at swedish pension fund Alecta, comments that an improved understanding of sustainability aspects can be helpful for risk assessment. He adds that it is important for Alecta as a long term investor to consider all types of risks and risks connected

to for example climate change can be significant, especially in the long run. A lower required yield must however be compensated by lower risk, whether the difference stems from a green label or something else. He also comments that the sometimes relatively higher demand for green bonds seems to enable pricing some of these issues a few basis points under the curve.[39]

Johan Edin, fixed income origination at DNB Markets, comments that while investors are increasingly taking sustainability aspects into account and show growing interest for green investments it is the credit risk of the issuer up until time of maturity that the market focuses primarily on in their risk analyses. He also adds that the likelihood of risks connected to sustainability materializing up until maturity can differ substantially depending on the maturity/tenor of the bond and the type of issuer.[40]

Mats Andersson, former CEO of Swedish pension fund AP4 and lead author of an investigation about green bonds commissioned by the Swedish government, comments that there is a general conception of a green premium existing and that this seems to be largely explainable by a relatively higher demand for green bonds. He adds that although oversubscription is common for conventional bonds as well, green bonds tend to be relatively more oversubscribed and this can enable green bonds to be priced under the curve more often.[41]

Given the comments from the interviewees we are not able to draw any further conclusions about the reason for the non-difference in issue price observed in this study. Their comments however help us in identifying more concrete questions for future studies connected to green bonds. First, it could be of academic interest to examine which factors can be used to explain what drives investor demand for green bonds in particular, and other types of green debt instruments more generally. An increased understanding of the factors driving demand for green bonds could also be of direct interest to market participants. Second, it can be of academic interest to study to what extent risks related to sustainability and climate are incorporated in the credit risk models used by rating agencies and investors. If such risks are not fully understood or taken into account by investors an improved understanding of this could also be of interest to a range of market

[39] Phone interview 11 april 2019
[40] Interview, 29 april 2019, Stockholm.
[41] Interview, 15 april 2019, Stockholm.

participants.

1.9. Conclusions

This study supports that green bonds do not have a statistically significant different issue price relative to par compared to conventional bonds. This indicates that green Eurobonds, compared to conventional Eurobonds, tend to have a similar relation between their required yield and coupon rate at the time of issuance. Importantly, this result cannot by itself be interpreted as showing the non-existence of a green premium, nor can it be interpreted as showing how or if a green bond label affects the required yield of bonds.

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3. Appendix

Factor	Variable	Description
Default and recovery risk	RATING	Rating dummies equal to 1 if the issue Moodys' and S&P average rating is equal to the corresponding numerical value, 0 if not
	SUBO	A dummy variable that equals 1 if the eurobond is a subordinated one and zero if it is a senior one
	BANK, BUILD, CHEM, COMP, ELE, ENE, ENGI, HEALTH, HOTEL, INDU, INSU, MANU, MEDIA, OIL, RAIL, RETAIL, TELE, TRANS, OTHERINDU	Industry dummies equal to 1 if the eurobond issuer's main activity is in the corresponding industry, 0 if not
	MATU	Time to maturity (in years) of the issue
	CROSS	A dummy variable that equals 1 if the issue has a cross-default clause and zero otherwise. Used only in sub-sample A
	PLEDGE	A dummy that equals 1 if the issue has a negative pledge clause and zero otherwise
	FORCE	A dummy that equals 1 if the issue has a force majeure clause and zero otherwise
Liquidity	AMOUNT	The natural log of the U.S. dollar-equivalent amount of the issue
Tax	COUPON	The annual coupon paid by the bond (percent)
	REG	A dummy variable that equals 1 if the eurobond is a registered one and zero if it is a bearer one
Primary market efficiency	MANAGERS	The number of managers in the issuing syndicate
	FEES	The total gross fees earned by the issuing syndicate
	PRIVATE	A dummy variable that equals 1 if the issue is a private placement one and zero if it is a public one
	FIXED	A dummy variable that equals 1 if the issue is fixed priced and zero if it is open priced
Control variables	AUS, BEL, CAN, FRA, GER, ITA, JNP, NET, SWE, SWI, UK, USA, OTHERCOU	Country dummies equal to 1 if the issuer is from the corresponding country, 0 if not
	DEM, DFL, EUR, FFR, STG, USD, OTHERCUR	Currency dummies equal to 1 if the eurobond is denominated in the corresponding currency, 0 if not
	QI-91, QII-91, . . . , QIV-01	Quarter and year dummies

Figure A.1. Complete list of variables used by Gabbi et.al.[42]

[42] https://www.tandfonline.com/doi/abs/10.1080/1351847032000143422