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Beyond the Hype: Do Bond Investors Forgo Yield When Investing Green?

A Yield Comparison in the Nordic Secondary Bond Market

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Abstract

Mobilizing public and private capital towards environmentally friendly projects is crucial to reaching the goals set by the Paris Agreement. Green bonds are one type of financial security that seeks to attract investment in sustainable companies and projects. Hence, green bonds can be an essential tool in financing the transition.

By comparing yields between green and conventional bonds in the Nordic secondary market, we investigate whether investors forgo yield when investing in green bonds. We use a matching method to compare green and conventional bonds with similar characteristics. This resulted in 119 matched triplets for analysis. We use a two-step regression to investigate the green bond premium in the Nordic secondary market. First, we perform a fixed effect regression on the matched triplets to estimate the green bond premium. Our sample is also divided into sub-samples to investigate if the green bond premium varies between categories. We use the estimated green bond premium for the full sample as a dependent variable in the second regression, to find possible determinants of the green bond premium.

Our findings reveal a significant positive green bond premium of 10 basis points. We find that the highest green bond premium appears for NOK-nominated bonds and bonds with an issue amount below SEK 250 million. Additionally, some bond characteristics seem to affect the size of the green bond premium significantly.

Keywords – NHH, Master Thesis, Nordic Green Bonds, Finance, Nordic Bond Market

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1 Introduction

In response to the urgent threat of climate change, 196 countries signed the Paris Agreement at COP21 in Paris in 2015 (United Nations, 2015). As a legally binding treaty, the overall goal of the Paris Agreement is to limit global warming to below 2 degrees[1] Celsius. Failing to reach this goal is expected to have severe consequences for the planet.

Mobilizing public and private capital towards environmentally friendly projects is crucial for reaching the goals of the Paris Agreement. At the climate conference COP26, held in November 2021, climate finance was one of the main topics. The world needs public finance to develop the required infrastructure for the climate transition and private finance to fund technology and innovation (United Nations, 2021).

Green bonds can be an essential tool to raise climate finance, as the bond amount goes directly to green projects (ICMA, 2021). Issuers' willingness to issue green bonds, and investors' willingness to buy, may affect the development of the green bond market. Although market participants may find it intrinsically rewarding to contribute to the green transition, the performance of green bonds in real market settings is still of great interest. A green bond premium[2] between green and conventional bonds can influence the desire to issue and invest green.

1.1 Motivation

One of our main motivations for this thesis is to understand how financial markets can contribute to the transition toward a more environmentally friendly economy. The green bond market is of particular interest, as it is a relatively new market.

Former research in the green bond market implies that increased green bond issuance can balance yield differences between green and conventional bonds. As the market is developing rapidly, and the increased issuance is observable, we find it interesting to investigate how this affects yields.

[1] Preferably 1.5 degrees, compared to pre-industrial levels.

[2] In this thesis, Green Bond Premium is defined as a difference in yield between the green bond and the conventional bond, where a positive green bond premium indicates that the green bond yield is higher than the conventional bond yield.

1.2 Research Question

This backdrop leads to our research question: *What yields can investors expect from green bonds in the Nordic secondary bond market?*

Our null hypothesis, *H0*, is that green bonds have similar yields as conventional bonds. The first alternative hypothesis, *H1*, is that green bonds have lower yields than conventional bonds, while the second alternative hypothesis, *H2*, is that green bonds have higher yields than conventional bonds.

To investigate these questions, we will analyze the Nordic secondary bond market. We use the same methodology as Zerbib (2019). The analysis includes a matching method to create triplets with one green bond and two conventional bonds with similar characteristics, except for the green label. In addition, we include several restrictions in the matching process to make sure we have as similar bonds as possible. We retrieve price data for the secondary market from Nordic Bond Pricing and Bloomberg Terminal. Our analysis sample consists of 119 triplets.

Of the two conventional bonds, we create a synthetic conventional bond with the same maturity as the green bond. As a result, our 119 triplets consist of one green bond and one synthetic conventional bond. We run a fixed effect regression on the matched sample to isolate the yield differences that are not explained by liquidity differences. The outcome is 119 fixed effects, which represents the green bond premium of each triplet. In addition, we regress bond characteristics on the isolated fixed effects to look for determinants of the green bond premium.

1.3 Contribution to Literature

In former research, the findings of a green bond premium are ambiguous. They do not clearly answer what yields an investor can expect when investing in green bonds in the secondary market. With an extended data amount from the Nordic bond market, we hope our research can contribute to the knowledge for market participants and what they can expect from the Nordic green bond market today.

1.4 Findings

Our findings reveal a positive green bond premium of 10 basis points[3] (bps). This result differs from several other research papers. Even though our results indicate that investors consider green bonds riskier than similar conventional bonds in the secondary market, it also means that they can expect higher yields when investing green. The bond characteristics currency, current coupon rate, difference in current coupon rate between the green and synthetic conventional bond at issuance, and issue amount seem to significantly affect the size of the green bond premium.

1.5 Disposition of the Thesis

This thesis starts with providing relevant background information on our topic of choice. Further on, we will present existing literature on the field, a description of our data and the matching procedure used, the empirical methodology, and our results. Lastly, we will present a discussion of our findings and conclude on our research question.

[3] 10 basis points is 0.1%.

2 Background

This chapter aims to present relevant background insight. It will contain information about climate change and finance, green bonds, bond pricing, portfolio theory, and green bond investors.

2.1 Climate Change and Finance

Several types of financial products seek to attract investments to sustainable companies and projects. These products often promote Environmental, Social, or Governance (ESG) features. Examples of securities within climate finance are green bonds and green equities. However, according to OECD (2017) the green finance mobilization has been far from sufficient. In addition, universal standards for categorizing green assets are missing. The lack of universal standards introduces a challenge of greenwashing, a term used to describe an attempt to appear more environmentally friendly than reality (Laufer, 2003).

Following the Paris Agreement, the European Union (EU) is taking a lead role in accelerating the work to reduce the effects of climate change. In 2019, they launched the European Green Deal, a strategy to make the EU climate neutral by 2050 (European Commission, 2019). An essential part of this strategy is to ensure financing of the green transition. To stimulate green investments and limit greenwashing, a Sustainable Finance Action Plan (SFAP) has been developed. SFAP includes a set of directives and regulations. One example is the EU Taxonomy Regulation. This is a classification system for sustainable activities (European Commission, 2020). EU is also developing its own Green Bond Standard to increase the trustworthiness of green bonds (EU Technical Expert Group on Sustainable Finance, 2019). To be categorized as a green bond in the EU Green Bond Standard, the funds raised should be allocated to projects that are sustainable according to the EU Taxonomy. The regulations are also expected to be implemented in the European Economic Area (EEA) (Finans Norge, 2021). Hence, the Nordic non-EU members will also be affected. Another regulation in EU's SFAP is the Sustainable Finance Disclosure Regulation (European Union, 2019). It requires all asset managers to report on their sustainability.

Unlike other green assets, green bonds allow companies with low ESG-scores[4] to take part in the green transition. According to Cohen et al. (2020), oil, gas, and energy-producing firms are key innovators in the United States' green patent landscape. However, these firms will typically not be categorized as green equities. For example, Nasdaq Green Equity Designation (Nasdaq, 2021) requires more than 50% of revenues and investments to be allocated to green business activities. Hence, many companies can be excluded from green portfolios. By letting these companies access financing to green projects through green bonds, they can contribute to reaching the goals in the Paris Agreement.

2.2 Green Bonds

A green bond is defined by the International Capital Market Association (ICMA) as *"any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects and which are aligned with the four core components of the Green Bond Principles"* (ICMA, 2021). In other words, a green bond has the same characteristics as a conventional bond except for the use of the issued amount.

The Green Bond Principles (GBP), developed by a group of investment banks in 2014, are voluntary process guidelines that aim to recommend transparency, disclosure, and promote integrity in the development of the green bond market (CBI, 2014). Lately, an independent secretariat hosted by the ICMA has performed ongoing monitoring and development of these guidelines.

The four main components of the GBP are (1) Use of Proceeds, (2) Process for Project Evaluation and Selection, (3) Management of Proceeds, and (4) Reporting (ICMA, 2021).

The first component, the use of proceeds (issue amount), is the cornerstone of a green bond. The GBP states that the issued amount should be used in eligible green projects, which should be appropriately described in the legal documentation of the security. According to ICMA (2021), eligible green projects, among other things, contributes to environmental objectives such as climate change mitigation, climate change adaptation, natural resource conservation, and pollution prevention.

[4]ESG-scores measures performance on Key Performance Indicators (KPI's) related to ESG.

The second component elaborates on a framework for the information flow from the issuer to the investor, such as evaluating and selecting green projects. The information should include how the issuer identifies and manages perceived social and environmental risks associated with relevant projects.

The third component, management of proceeds, elaborates on how the issued amount from green bonds should be managed and controlled. For example, the amount should be credited to a sub-account, moved to a sub-portfolio, or otherwise be appropriately tracked by the issuer. The management of proceeds includes a formal internal process linked to the issuer's lending and investments operations for eligible green projects.

The fourth component, reporting, aims to ensure transparency in the issuer's reporting and thus in the green bond market. The reporting should highlight important information which is vital for other market participants.

Note, the green bond principles do not define what project or company that are categorized as *green*. These definitions are left to the issuer to determine. As mentioned in Section 2.1, the EU Green Bond Standard is providing a system for this by requiring the use of proceeds to be aligned with the EU Taxonomy (EU Technical Expert Group on Sustainable Finance, 2019).

2.2.1 Certification Process

As mentioned in Section 2.2, the Green Bond Principles are guidelines but not required to get a green label. However, it is recommended by ICMA (2021) that issuers use an external review provider for green bond issuance. The review should be based on the components of the Green Bond Principles. In addition, ICMA recommends, post-issuance, that issuers use a third party or an external auditor to verify the internal tracking and the allocation of the green bond proceeds.

There are currently 57 certifiers globally that are approved by the Climate Bonds Initiative[5] (CBI, 2021a). Examples of companies that provide an external review in the Nordics are Deloitte, KPMG, EY, Multiconsult, DNV-GL, Kommunal Kredit Public Consulting, and CICERO. Using a third party to certify the green label comes with a cost. According to

[5]The Climate Bonds Initiative (CBI) is an international organization that works solely to mobilize the bond market into climate change solutions (CBI, 2020).

(CBI, 2021b), the certification process has internal and external costs. The internal costs are related to required internal processes and controls to meet certification requirements. The external costs include a certification fee and costs to the certifier pre-issuance and post-issuance. In general, the certification fee is about 0.1 bps of the issued amount. On a USD 500 million bond, this would represent a certification fee of about USD 5000. The total costs depend on the size and complexity of a bond. According to OECD (2016), the relatively high cost for obtaining a second opinion or a third-party review can be an obstacle for green bond issuance, particularly for small issuers lacking knowledge about the verification process.

2.3 The Global Green Bond Market

The Climate Bonds Initiative tracks the global bond market and provides insight to market participants. Among other things, they gather information and statistics on the global bond market.

In April 2021, CBI published the 2020 annual report, which covers the global market of green bonds (CBI, 2021d). By the end of 2020, the total cumulative size of the green bond market since the first green bond issuance in 2007 was USD 1.1 trillion. The total market of bonds globally is about USD 100 trillion, which means that green bonds account for about 1% of the total cumulative value. Measured in total cumulative issuance per country, the US is the most significant green bond issuer with USD 223.6 billion issued. China and France have USD 129.7 billion and USD 123.7 billion issued, respectively. These top 3 countries alone account for about 43% of all green bond issuance.

The annual issuance of green bonds in 2020 was USD 290.1 billion, a 9% increase from 2019. 48% of all the issuance originated from Europe, 22% from North America, and 18% from Asia. Africa and Latin America have below 1% of the total issuance in 2020. As well as in cumulative terms, the US was the largest issuer in 2020 isolated. Germany and France placed 2nd and 3rd on the list, respectively. They issued a total of USD 52.1 billion, which is 18% of the total green bond issuance in 2020. Of the total cumulative issuance globally, Energy is the largest industry group. Real Estate and Transport are 2nd and 3rd, respectively (CBI, 2021d).

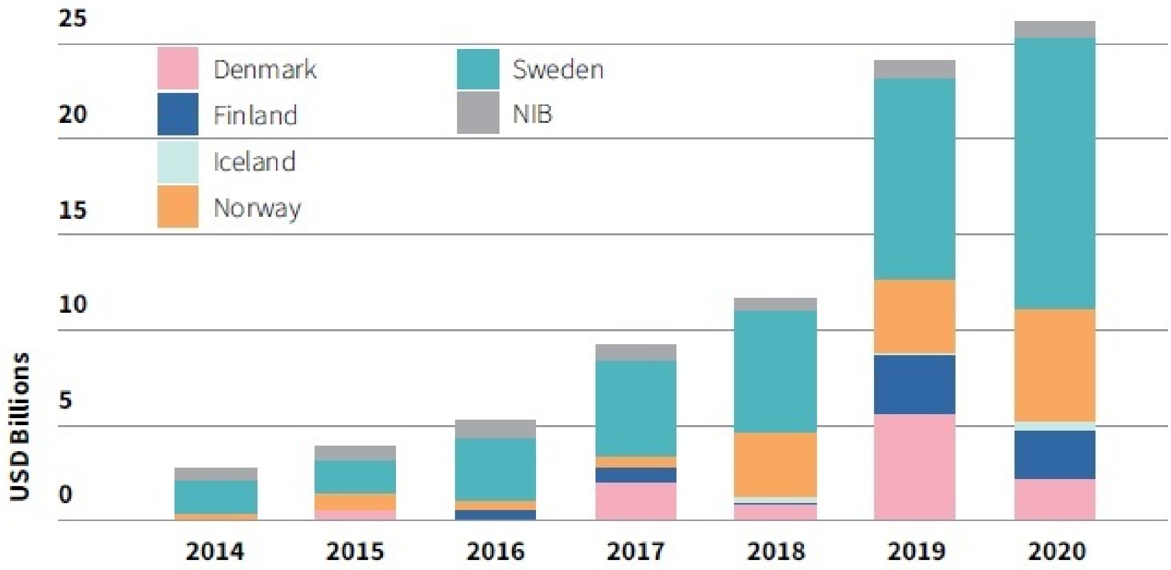
Even though the green bond market is rapidly growing, the demand for green bonds seems to be higher than the supply. A study of the green bond pricing in the primary market for the first half of 2020 by CBI (2020), found that the average oversubscription of EUR green bonds was 5.2 times[6]. The oversubscription resulted in a lower coupon rate of 25 bps on average. The numbers were even higher than the second half of 2019, where the average oversubscription was 2.8 times and the coupon rate was 13.3 bps lower on average (CBI, 2020).

2.4 The Nordic Green Bond Market

By the end of 2020, the green bond market in the Nordics had a cumulative issuance of USD 84.3 billion. This amount is about 8% of the total global cumulative green bond market. From 2018 to 2020, the Nordic market increased more than seven times in cumulative issuance, from USD 11.6 billion in 2018 to USD 84.3 billion by the end of 2020. Sweden accounts for 50% of the total issued amount of the Nordic countries, Norway 20% and Denmark 14%. Finland and Iceland account for 9% and 1%, respectively. The Nordic Investment Bank (NIB), an international financial institution of the Nordic and Baltic, accounts for 7% of the Nordic green bond market. Furthermore, Sweden is 7th in the green bond market globally, considering the cumulative numbers of issuers and the number of instruments. Norway and Denmark are 12th and 16th in the global market, respectively (CBI, 2021c). The development of green bond issuance among Nordic countries is illustrated in Figure 2.1.

[6] As an example, this means that investors were willing to provide USD 520 million when the issuer wanted to raise USD 100 million.

Figure 2.1: Green Bond Issuance in USD Billions per year for the Nordic Market from 2014 to 2020 (CBI, 2020)



The fact that the Nordic green bond market is rapidly developing is also reflected in the number of green bond issuances. The leading market player in the Nordics, Sweden, had a year-over-year (YoY) growth of 26% in 2020. In 2019, the YoY growth in Sweden was 67%. Norway, the second biggest country in the Nordic green bond market, had a YoY growth of 53% in 2020 (CBI, 2021c).

Similar to globally, there have been observations of oversubscription in the Nordic green bond market (Alfred Berg, 2018). These cases indicate that even though the supply of green bonds increases, it still cannot cope with the demand from investors, leading to lower coupon rates at issuance.

Of the total cumulative issuance, 38% are from real estate issuers. Energy and transportation issuers account for 24% and 14% respectively. The high fraction of real estate issuers in the Nordic market is a widely understood and reported phenomenon (CBI, 2021c). Sjöström and Erlandsson (2020) argues that this has to do with the expansionary Swedish real estate market and that it is relatively easy to use newly built properties as green assets for green bond issuance.

According to CBI (2021c), the Nordic countries are recognized as five relatively wealthy states with robust social support systems. The region has adapted to sustainable finance early compared to the rest of Europe, with a social model that motivates public entities to embrace the sustainable finance mechanisms.

2.5 Bond Pricing Mechanisms

The general bond pricing equation (with coupon payments) is given by

$$Price = \sum_{t=1}^{N} \frac{Coupon_t}{(1+YTM)^t} + \frac{FaceValue}{(1+YTM)^t}, \tag{2.1}$$

where $Price$ is the price of the bond, $Coupon$ is the coupon payment (coupon rate multiplied by face value) at time t, $FaceValue$ is the repayment amount at maturity date, and YTM is the Yield to Maturity, the actual return for investors if holding the bond until maturity.

The bond price is the present value of all future coupon payments and the repayment amount of the bond (face value) at maturity. The relationship between a bond price and the yield is inverse. If the bond price increases, the yield decreases, and if the bond price decreases, the yield increases. The coupon rate is considered the issuer's borrowing cost, while the yield is the return for the investor. Bonds can have a floating or fixed coupon rate. A floating rate varies with an underlying reference rate, such as the money market rate NIBOR[7]. Oppositely, a fixed rate does not change with fluctuations in the market rate. Another type of bond is zero-coupon bonds, which do not have regular coupon payments.

2.6 Bond Pricing in the Primary and Secondary Market

2.6.1 Primary Market

The primary market is where bond issuers seek investors for their debt financing. With an initial expectation of issue amount and coupon rate, issuers contact investors to purchase the bond, generally with the help of brokers. An oversubscription could occur if more investors are willing to lend the issuer money to the initial coupon rate. For example, if an issuer seeks to raise USD 100 million, but investors are eager to provide USD 500

[7] The Norwegian Interbank Offered Rate.

million, there is an oversubscription. This situation gives the issuer bargaining power. In other words, if the issuer still want to raise USD 100 million, they have an opportunity to reduce their borrowing cost through lower coupon rates. The investors who accept the reduced coupon rate can buy the bond. Hence, supply and demand influence the coupon rate in the primary market.

The bond can be issued at par (price equal to face value), a premium (higher price than face value), or a discount (lower price than face value). If the bond is issued at par, the YTM is equal to the coupon rate. Zero-coupon bonds will typically be issued at a discount.

The coupon rate at issuance reflects several factors. Primarily, it is the rate of the interest (coupon) paid on the bond. In addition, the size of the coupon rate indicates the level of credit risk that is associated with the bond. Typically, the credit risk is determined by the probability of default. In other words, it is the probability that the issuer will repay the investor when the bond matures. For example, governments are considered to have a low credit risk as the probability for a state's default is lower than most companies. Independent credit rating services provide and publish the credit rating of bond issuers and help determine the coupon rates on bonds. Issuers' credit rating can broadly be categorized as Investment Grade or High Yield. Investment Grade bonds have higher credit rating than High Yield bonds, which normally indicates a lower coupon rate. Furthermore, the maturity of a bond influences the coupon rate at issuance. Bonds with longer maturity are more exposed to changes in interest rate. The increased interest rate risk leads to a higher coupon rate (Veys, 2010).

The primary phase of the bond finishes when the bond has been sold and launched into the market.

2.6.2 Secondary Market

When the bond enters the secondary market, other investors can buy and sell it. Selling a bond means that the financial flows from the bond will be transferred to the buyer of the bond. However, the issuer's capital cost will not be affected. Some bonds trade publicly through stock exchanges, while some are being sold over-the-counter between broker-dealers acting on the clients' behalf or for themselves (PIMCO, 2017).

The bond price and yield to maturity determine the bond value in the secondary market. The YTM is the investor's actual return if the investor holds the bond until maturity. If the investor buys a bond with a lower YTM than the coupon rate, the perceived risk is lower than the coupon rate reflects. Oppositely, a higher YTM than the coupon rate means that investors demand more return for holding the bond. Hence, differences in yield between bonds reflect a risk premium. In this thesis, we investigate the yield difference between green and conventional bonds in the secondary market.

2.7 Portfolio Theory and Green Bond Investors

Early portfolio theory from Markowitz (1952) elaborates on the optimizing problem to maximize the returns on a given level of risk. A more modern approach to the portfolio theory is that investors both look at financial and non-financial factors when selecting investment opportunities. When looking at factors influencing investment decisions, Nagy and Obenberger (1994) found that non-financial factors were important among investors, such as the firm's reputation and ethics. This view is later backed by Barreda-Tarrazona et al. (2011), who found that investors allocate more to funds that provide information about their social responsibilities.

Generally, investing in green and conventional bonds helps diversify the overall portfolio. Research conducted in the Chinese market has shown that green bonds bring improved diversification benefits to the stock-bond portfolio. This was the case for most asset allocation strategies in different market environments, in terms of Sharpe Ratio[8] (Han et al., 2020). Furthermore, bonds have traditionally been seen as complementary to equities (Sjöström and Erlandsson, 2020). For this reason, a portfolio with bonds is considered a hedge against equity market risks. Fixed income portfolios are often a more passive part of the investment portfolio. Bondholders do not have the same direct influence on board members of a company in the same way as equity shareholders. However, bondholders could affect more or less all types of companies with financial flows.

[8]Sharpe Ratio is a measurement to evaluate performance by looking at risk-adjusted returns. It is expressed as excess return over risk-free rate per units of risk (σ), and is defined as

$$\frac{R_p - R_f}{\sigma_p}, \tag{2.2}$$

where R_p is return on portfolio, R_f is risk-free rate and σ_p is standard deviation (risk).

In contrast, equity holders can generally only affect companies listed on a stock exchange. In addition, it is clear evidence globally that companies with high greenhouse gas (GHG) emissions are more affected by the bond market than the equity market, simply because these companies less often use the equity market for financing. Hence, bond investors' sustainability influence on limiting climate change could be substantial.

According to Sjöström and Erlandsson (2020), a growing number of financial market participants include climate change as a decisive factor in their asset management decisions. Among other explanations, investors want to protect the portfolio against financial risk and contribute to limiting climate change. This view is further supported by Han et al. (2020), who states that investors are increasingly focused on ESG-factors in investment decisions.

3 Literature Review

This chapter aims to present relevant literature for findings of the green bond premium and determinants of bond yield. We will first present findings of the green bond premium in relevant research. In the second section, we will shortly present findings of determinants for bond yields.

3.1 Findings of Green Bond Premium

Research has been conducted to determine yield differences between green and conventional bonds in the market. These studies vary in their results, making the consensus of a green bond premium ambiguous. In addition, the studies use different methodologies. In the following, we will present relevant research from the primary and secondary market.

A literature review by MacAskill et al. (2021) was conducted to investigate whether 15 different peer-reviewed academic and industry studies could create a consensus on the existence of a green bond premium. The review examined studies published between 2007 and 2019, which investigated private and public green bond issuance. The findings confirmed an existence of a negative green bond premium[9] within 56% of the primary market and 70% of the secondary market. The bonds were government-issued, investment graded, and followed defined green bond governance and reporting procedures. Due to the wide variation in green bond premium and the limited amount of research at issuance, MacAskill et al. (2021) do not present an average result for the primary market. In the secondary market, an average negative green bond premium of 1 to 9 bps was observed.

Baker et al. (2018) investigated 2083 green US municipal bonds issued between 2010 and 2016 and 19 green US corporate bonds issued between 2014 and 2016. Their findings indicated that green municipal bonds were issued at a negative green bond premium of 6 bps compared to conventional bonds with similar characteristics. The results were found by matching green and conventional bonds, and by regressing after-tax yields on green bond indicators and control variables. Additionally, they found that CBI-certified green bonds were issued at an even higher negative green bond premium of 15 bps.

[9] A negative green bond premium indicates that the yield of the green bond is lower than the conventional bond.

Zerbib (2019) used a matching method followed by a two-step regression to estimate the yield difference between a green bond and an otherwise identical synthetic conventional bond, with global bond data from 2013 to 2017. The synthetic conventional bond is constructed by two conventional bonds with the closest maturity from the same issuer with the same currency, rating, bond structure, seniority, collateral, and coupon type. The results indicated a significant negative green bond premium of 2 bps, whereas the negative premium was even higher for financial bonds and low-rated investment grade bonds. In other words, the estimated yield differences vary across industries and credit rating. Zerbib (2019) argues that previous research conducted suffered from imperfect control of liquidity. To control for liquidity, Zerbib (2019) combined a double restriction in the matching process on issue amount and issue date. Later on, a liquidity proxy was included in the estimation step of the green bond premium.

The same tendency in results was also found by Ehlers and Packer (2017). They studied the yield difference on 21 green and conventional bonds from the same issuer in the primary market. The results indicated a negative green bond premium of 18 bps on the green bonds compared to the conventional bonds. To study the yield difference in the secondary market, they compared green bond indices with global bond indices through hedged returns to control for the difference in currencies. However, they could not find a statistically significant difference between green bond indices and global bond indices.

Other studies conducted reveal different findings. Karpf and Mandel (2018) reports that green bonds on average trade at a higher yield of 7.8 bps compared to conventional bonds, which means that there is a positive green bond premium. The research was conducted by examining the yield of 1880 US municipal green bonds and conventional municipal bonds between 2010 and 2016, using a Blinder-Oaxaca decomposition. The results are statistically significant. Larcker and Watts (2019) compared 640 matched pairs of green bonds with conventional bonds from the same issuer issued on the same date between 2013 and 2018 in the primary market. However, their findings indicated that the difference in yield between green and conventional bonds was close to zero, of 0.45 bps. 85% of the matched pairs had a non-difference in yield of precisely zero.

Finally, some master theses have examined the green bond premium in the Nordic market. Wensaas and Wist (2019), and Dahl and Karlsen (2019) use the same methodology as Zerbib (2019) to investigate the potential green bond premium. Wensaas and Wist (2019) found a slight negative green bond premium of 0.4 bps, which was not statistically significant. However, when they divided the entire sample into sub-samples, they found significant negative green bond premium in the currency SEK, investment grade bonds, and issue amount between SEK 251-500 million. Dahl and Karlsen (2019) investigated the Swedish and Norwegian market and did not find any green bond premium in the primary market. They found a negative green bond premium in the entire sample of 0.8 bps in the secondary market. By investigating Sweden and Norway separately, the results indicated a negative green bond premium of 1.2 bps for Sweden and a positive green bond premium of 1.7 bps for Norway.

3.2 Bond Yield Determinants

This section aims to present the most critical determinants for bond yields. This is relevant, as we in the next chapter will perform a matching method on green and conventional bonds based on different criteria that could affect bond yields.

Research has been conducted for different types of bonds and markets. Afonso et al. (2015), who investigated the determinants of yield spreads, found that bond size, liquidity, maturity, and credit rating are statistically significant in explaining yield spreads. These results are similar to Hamid et al. (2019), who proved that a higher coupon rate causes bond yields to increase and that assets, liquidity, debt levels, profitability, and credit rating together affect bond yields. Hammami and Bahri (2016) proved that credit rating is the most important determinant of bond yields.

There are also several studies investigating separately whether the liquidity of a bond affects yield spreads. Houweling et al. (2005) found that the liquidity premium ranged from 13 to 23 bps, depending on different liquidity proxies. In other words, lower bond liquidity leads to higher bond yields due to increased risk. Dick-Nielsen et al. (2012) found that during the financial crisis in 2008 to 2009, the illiquidity of a bond affected the bond yield more than in regular market situations. The effect is slower and more persistent for investment grade bonds than for high yield bonds. Furthermore, Bao et al. (2011) found that bond illiquidity explains bond yields with sizeable economic significance. In addition, de Jong and Driessen (2012) estimate that the liquidity risk premium for

US long-maturity investment grade bonds is 60 bps annually. Research done by Febi et al. (2018) also indicates that there might be differences in liquidity between green and conventional bonds.

As described in this chapter, the existence of a green bond premium in relevant research so far paint an unclear picture. The green bond premium varies from zero, to positive and negative, both in the primary and the secondary market. The studies conducted on yield spread determinants are more consistent and give us an impression of what one must emphasize in the matching process. Due to the limited amount of issuance of green bonds, most of the research is conducted on global markets. By focusing on the Nordic market, with an extended data amount, our study will hopefully contribute to new knowledge and insight for green bond investors and issuers.

4 Data and Matching Methodology

This chapter describes how we prepare the data set for the analysis with the matching methodology and construction of variables. In addition, we provide an overview and descriptive statistics of our final sample.

4.1 Data Collection and Cleaning

We use Stamdata to identify bonds issued in the Nordic market and retrieve corresponding bond characteristics. Bond yields, ask prices, and bid prices are collected from Nordic Bond Pricing and Bloomberg Terminal. As the Nordic market is the scope of our research, only bonds issued at Nordic stock exchanges[10] are included in our data sample.

We include the green bonds from Stamdata that were issued between 01.01.2013 and 01.10.2021. There are 634 green bonds from 144 unique issuers issued on Nordic Stock Exchanges within this time frame. We only include conventional bonds from the same issuers as the green bonds. This restriction reduces the conventional bond sample to 1789 bonds. These bonds are issued from 45 unique issuers, which indicates that 99 of the green bond issuers do not issue conventional bonds in this research period.

The bond data collected from Stamdata consist of more than 40 different variables. Not all of those are relevant for our research. We create a subset with the variables of interest. This subset includes International Security Identification Number (ISIN), Issuer, Issue Date, Currency, Stock Exchange, Issue Amount, Industry Group, Risk, High Yield/Investment Grade, Green, Maturity Date, Current Return Type, and Coupon Rate. A description of each variable is given in Appendix, Table A0.1.

To be characterized as a green bond on Stamdata, the bonds need to be reviewed by a third party. Hence, all our bonds have been through a certification process, similar to what is mentioned in Section 2.2.1. However, as a universal standard for green bond certification is missing, there are some threats of greenwashing. This means that some bonds can be characterized as green, even if it is not controlled that the raised amount is

[10]Nordic Stock Exchanges from Stamdata: Oslo Stock Exchange (OSE), Nasdaq Nordic (OMX), Nasdaq Copenhagen (KFX), Helsinki Stock Exchange (HEX), First North Sweden (FNSE), Nordic ABM (ABM), First North Denmark (FNDK), Nordic Growth Market (NGM), and First North Finland (FNFI).

used for environmentally friendly purposes.

We create a variable for maturity length by subtracting the maturity date from the issue date. The maturity length variable is given in the number of days. All issue amounts are adjusted to the currency SEK, based on the exchange rate from 24.11.21.

From Nordic Bond Pricing and Bloomberg, we have yield and price data from 2014. We merge the bond characteristics with the price data based on ISIN. As we want to compare yields and bid-ask spread on the green and conventional bonds on the same date, all dates missing an observation from one of the bonds are removed. There is a relatively limited number of trades in the secondary market, which indicates low liquidity. Therefore, some of the yields and prices are based on consensus estimates from analysts in the Nordic bond market.

After we have collected and cleaned the data set, we can continue with the matching procedure.

4.2 Matching Methodology

To investigate whether there is a green bond premium in the Nordic bond market, we want to compare green and conventional bond yields. The matching method for yield comparison described in this chapter is closely related to the method used by Zerbib (2019). The key is to match two similar bonds from the same issuer, where factors that explain the yield are as similar as possible.

The rationale behind choosing two conventional bonds to match with a green bond is to limit potential bias from maturity differences. By having two conventional bonds, we can create a synthetic bond with the same maturity as the green bond. As Zerbib (2019), we will set up the data sample to compare the yield spread between a green bond and a similar synthetic conventional bond. After the matching process, we are left with a data set that allows us to evaluate the difference between the green bond and the synthetic conventional bond, which will be the cumulative effect of the green bond premium, a liquidity differential, and a residual. The matching method is appropriate in our study as there are many issued conventional bonds. Over time, conventional bond issuers have started issuing green bonds. We can then compare green and conventional bonds from the same issuer and remove the issuer-specific characteristics that could affect the potential green bond premium.

One could argue that a standard Ordinary Least Square (OLS) regression could also be used to determine the green bond premium. However, an OLS regression imposes a challenge to control for issuer-specific factors that may affect the difference in yield between green and conventional bonds. Failing to include all relevant variables could lead to biased results.

The restrictions in the matching process are essential to select bonds that are as similar as possible. This makes the yield comparison more accurate. Hence, the method enables us to reduce omitted variable bias and increase the credibility of the estimated effect of the green label in our analysis. We will in the following describe our matching restrictions and the rationale behind the choices we make.

First, we require the conventional bonds to have the same currency, risk (seniority and collateral), credit rating category (High Yield or Investment Grade), industry group, and coupon type (floating, fixed or Zero Coupon) as the matching green bond. In addition, we want to restrict the differences in issue date, issue amount, and coupon size to limit potential liquidity bias. It is important to control for liquidity since it could affect bond yields, as mentioned in Section 3.2.

The issue date of the conventional bonds can be maximum six years before or after the green bond. The amount issued for the conventional bonds cannot be more than four times or less than one-fourth of the green bond. The coupon size cannot be more or less than 80 bps than the green bond. These three restrictions will all contribute to mitigating liquidity bias in our analysis. Later on, we include a liquidity proxy variable to minimize the residual of the potential liquidity bias.

In the matching process, maturity differences are limited by restricting the maturity of the conventional bonds to be no more than two years longer or shorter than that of the green bond. This restriction will make our estimate of the synthetic bond yield more precise in the next step. The maturity differences are, as mentioned, further controlled for after the matching process by creating a synthetic bond of the two conventional bonds in each triplet that has similar maturity as the green bond.

After we have matched the green bond with conventional bonds, some of the green bonds have more than two matched conventional bonds. We select the two conventional bonds with the closest issue date to the green bond and remove the others. If a green bond has either one or zero matches, it is excluded from the data sample. The daily yields within each triplet are retrieved from each bond's issue date until 18.11.2021. The sources used for this purpose are Nordic Bond Pricing (NBP) and Bloomberg, providing daily yields on almost all of our green and conventional bonds. NBP provides prices from the Norwegian bond market, while Bloomberg provides prices from the Swedish bond market. The reason for using different sources is differences in data access and data quality. If a bond or several bonds in each triplet do not have yields available, these triplets will be removed from our data sample. If any of the bonds in the triplet, on a given date, do not have yields available, we remove this line from our data set. We are left with 113 645 observations of yield, ask price, and bid price for the matched sample.

After the matching process, we have 119 triplets in our sample, each containing one green bond and two conventional bonds.

4.3 Adjusting Maturity

The next step is to adjust the maturity of our conventional bonds. We combine the two conventional bonds in each of the triplets and create a synthetic bond with the same maturity as the green bond. This method is the same as in Zerbib (2019). We linearly interpolate or extrapolate the conventional bond yields at the maturity of the green bonds[11]. We interpolate when one of the conventional bonds has shorter maturity than the green bond, and the other has longer maturity. Extrapolation is used when the green bond has shorter or longer maturity than both conventional bonds. We can use interpolation and extrapolation since the general assumption is that the yield curve is increasing since the long-term rate is assumed to be higher due to the risk of change in the interest rate over time. In addition, we have matched bonds in the triplets with close maturity to each other.

The formula for interpolation/extrapolation when creating a synthetic conventional bond yield is given as

[11] Figure of the inter-/extrapolation method is illustrated in Figure A0.1 in Appendix.

$$Y \sim SB = YB1 + \frac{YB2 - YB1}{XB2 - XB1} * (XGB - XB1), \tag{4.1}$$

where Y∼ SB is synthetic conventional bond yield, YB1 is the yield of conventional bond 1, YB2 is the yield of conventional bond 2, XB1 is maturity in days for conventional bond 1, XB2 is maturity in days for conventional bond 2 and XGB is maturity in days for the green bond.

By creating the synthetic conventional bond, we reduce the maturity difference that is not limited in the matching process. The green and the synthetic conventional bond will now have equal maturity. Hence, the potential maturity bias from comparing bonds with different maturities is limited. The data sample will now include matched pairs with one green bond and one synthetic conventional bond. Both bonds now have similar characteristics except for the difference in liquidity. To capture a possible liquidity effect on bond yields, we create a liquidity proxy in the next step.

4.4 Liquidity Proxy

As mentioned in the literature review, liquidity could affect bond yields and should be controlled for. As a result, we want to create a liquidity proxy. The rationale is to identify the liquidity effect on bond yields, which is not captured during the matching process. Some of the liquidity effects are controlled for in the matching process through restrictions on the issue date, issue amount, and coupon size. However, there could still be liquidity residuals. As mentioned before, we use the same methodology as Zerbib (2019). Zerbib (2019) argues that the closing percent quoted bid-ask spread is the best proxy for liquidity since the sources for his bond data do not provide intraday liquidity indicators. In addition, by using a within-regression, Zerbib (2019) is constrained from using issue date and issue amount proxies. These arguments also apply to our data set. Moreover, since we have low-frequency data, Fong et al. (2017) concluded that the closing quoted bid-ask spread is the best liquidity proxy for this purpose.

The closing percent quoted bid-ask spread, $BA_{i,t}$, for bond i at time t is defined as

$$BA_{i,t} = \frac{AskPrice_{i,t} - BidPrice_{i,t}}{(AskPrice_{i,t} + BidPrice_{i,t})/2}, \tag{4.2}$$

where the ask price is the price the seller demands, while the bid price is the price the buyer offers.

Since we have constructed synthetic conventional bonds by two conventional bonds based on their maturity, we need to construct the bid-ask spread in the same way. This is done by defining the distance-weighted average of the bid-ask spread between the two conventional bonds on day t.

Bid-ask spread for the synthetic conventional bond is defined as

$$BA_{i,t}^{SB} = \frac{d_2}{d_1 + d_2} BA_{i,t}^{CB1} + \frac{d_1}{d_1 + d_2} BA_{i,t}^{CB2}, \tag{4.3}$$

where d_1 is |Maturity$_{i,t}^{GB}$ - Maturity$_{i,t}^{CB1}$| and d_2 is |Maturity$_{i,t}^{GB}$ - Maturity$_{i,t}^{CB2}$|.

Finally, by following the same method as Zerbib (2019), we complete the liquidity variable called $\Delta BA_{i,t}$, which is defined as the difference in liquidity between the green and the synthetic conventional bond. The variable will be used as an independent variable to estimate the fixed-effect panel model in the next chapter.

The liquidity variable is defined as the difference in liquidity between the green and the synthetic conventional bond for triplet i on day t. The equation is given as

$$\Delta BA_{i,t} = BA_{i,t}^{GB} - BA_{i,t}^{SB}, \tag{4.4}$$

where $BA_{i,t}^{GB}$ is the closing percent quoted bid-ask spread for the green bond and $BA_{i,t}^{SB}$ is the closing percent quoted bid-ask spread for the synthetic conventional bond.

4.5 Yield Spread

The last step in the preparation of the data set, is to define the yield spread between the green and the synthetic conventional bond. We take the green and the synthetic conventional bond yield for triplet i, on day t, and define the difference in yield as

$$\Delta \tilde{y}_{i,t} = y_{i,t}^{GB} - y_{i,t}^{SB}, \tag{4.5}$$

where $y_{i,t}^{GB}$ is the yield for the green bond and $y_{i,t}^{SB}$ is the yield for the synthetic conventional bond.

The final sample is winsorized at a 1% level to handle potential outliers. This process transforms the extreme values to fit within the boundaries of the rest of the distribution.

4.6 Data Description of Final Sample

To get an overview of the final sample for our research, we investigate the sample construction and composition. This is illustrated in Table 4.1 and Table 4.2, respectively. After the matching process, we have 119 triplets containing one green bond and one synthetic conventional bond.

Table 4.1: Sample Construction

	Numbers of Bonds	Numbers of Issuers
Green Bonds	634	144
Matched Green Bonds	119	32
Matched Conventional Bonds	238	32
Unique Conventional Bonds	160	32
Triplets	119	32

Among the 238 conventional bonds, 160 are unique. This means that some of the conventional bonds are used in several triplets. Initially, we had 144 unique issuers in our data set. By completing the matching process, the number of unique issuers is reduced to 32, which means we lose 112 issuers. This also means that some issuers are represented in several triplets. For example, the Swedish real estate company Vasakronan is the issuer in 36 of our 119 triplets. A complete overview of the number of triplets per issuer can be seen in Appendix, Table A0.2.

As we can see from Table 4.2, the majority of our bonds are SEK-nominated. Of the 119 triplets, only 17 are issued in NOK. This currency distribution is consistent with the fact that the Swedish green bond market is more developed than the Norwegian bond market, as discussed in Section 2.4. None of the Danish and Finnish bonds satisfy the matching requirements. Hence, we exclude them from the final sample.

Even though our data set from Stamdata initially consisted of both high yield and investment grade bonds, our matched sample only includes investment grade bonds. The distribution of triplets within each risk category reveals that 93 triplets are senior unsecured. The number of triplets in the government guaranteed and senior secured category are 13 and 12, respectively. Only one triplet consists of municipality bonds.

75 of the triplets consist of bonds with a floating rate, and 44 consists of fixed-rate bonds. Our final sample does not include zero-coupon bonds.

By investigating the sample distribution within industry group, we see that the sample is unequally distributed. 85 of 119 triplets are related to the real estate industry. The second largest industry group is public sector, with 14 triplets. The third-largest industry group is utilities, with 10 triplets.

Table 4.2: Sample Composition

	Variable	Triplets	% of Each Category
Category			
Currency	SEK	102	85.7%
	NOK	17	14.3%
Credit Rating Category	Investment Grade	119	100%
	High Yield	0	0%
Risk	Government Guarenteed	13	10.9%
	Municipality	1	0.8%
	Senior Secured	12	10.1%
	Senior Unsecured	93	78.2%
Current Return Type	Fixed	44	37%
	Floating	75	63%
Industry Group	Bank	2	1.7%
	Industry	2	1.7%
	Public Sector	14	11.8%
	Pulp, Paper and Forestry	2	1.7%
	Real Estate	85	71.4%
	Transportation	4	3.4%
	Utilities	10	8.4%

4.7 Descriptive Statistics

More features of our data sample are summarized in the descriptive statistics in Table 4.3. Differences between green and conventional bonds in our sample may affect our results. The table shows that the maturity for the green bonds is on average 74 days longer than for the conventional bonds. However, as our matching method combines two conventional bonds to create a synthetic bond with the same maturity as the green bond, a possible maturity difference should be removed. Comparing the green bond sample and the conventional bond sample also reveals differences in average issue date, issue amount, and coupon size. As mentioned earlier, this may affect the liquidity in each sample. We limit the possible bias from these differences by including a liquidity proxy in the first step of our regression.

Table 4.3: Descriptive Statistics of Matched Sample

	Mean	Median	SD	Min	1st quartile	3rd quartile	Max
Green Bonds							
Issue Amount (SEK m)	634.1	500	446.6	100	300	757.5	2500
Issue Date	26.05.17	31.08.17		25.11.13	21.07.16	02.06.18	26.05.21
Maturity (days)	1625	1826	640	730	1096	1826	3652
Maturity Date	07.11.21	04.10.21		20.05.16	17.04.20	20.01.23	26.05.31
Current Coupon Rate	1.021	0.921	0.7142	0.032	0.628	1.172	3.957
Conventional Bonds							
Issue Amount (SEK m)	560	500	402	100	300	639	2272
Issue Date	02.12.16	21.11.16		26.01.12	10.11.15	29.01.18	20.08.21
Maturity (days)	1530	1461	656	633	1096	1827	3654
Maturity Date	09.02.21	10.11.20		07.01.16	12.06.19	26.08.22	07.02.29
Current Coupon Rate	0.967	0.774	0.7418	0.09	0.49	1.15	4.242

The descriptive statistics for bid-ask spread are shown in Table 4.4. The statistics show that the average bid-ask spread is slightly tighter for green bonds than synthetic conventional bonds. This indicates that the liquidity is better for green bonds. The difference in the average bid-ask spread is -0.04%. As mentioned in Section 3.2, higher liquidity is expected to lead to lower yields. This implies that we can expect lower yields from the green bonds than the conventional bonds.

Table 4.4: Descriptive Statistics Bid-Ask Spread

	Mean	Median	SD	Min	1st quartile	3rd quartile	Max
$\text{BA}_{i,t}^{GB}$	0.0016	0.0011	0.0019	0.0000	0.0001	0.0024	0.0332
$\text{BA}_{i,t}^{SB}$	0.0019	0.0013	0.0023	0.0000	0.0004	0.0029	0.0485
$\Delta BA_{i,t}$	-0.0004	-0.0002	0.0015	-0.0061	-0.0011	0.0002	0.0035

The descriptive statistics of the Yields to Maturity in the matched sample is shown in Table 4.5. For the green bonds, the YTM is 0.39% on average. The synthetic conventional bonds have an average YTM of 0.28%. A positive average YTM difference of 10 bps indicates that the green bonds on average trade at higher yields than their synthetic conventional counterpart in the secondary market. However, this is before controlling for differences in liquidity and is not sufficient to conclude on a positive green bond premium.

Table 4.5: Descriptive Statistics Yield to Maturity

	Mean	Median	SD	Min	1st quartile	3rd quartile	Max
$y_{i,t}^{GB}$	0.0039	0.0022	0.0065	-0.0077	-0.0026	0.0063	0.0267
$y_{i,t}^{SB}$	0.0028	0.0013	0.0067	-0.0108	-0.0011	0.0060	0.0236
$\Delta\tilde{y}_{i,t}$	0.0010	0.0005	0.0050	-0.0142	-0.0003	0.0022	0.0206

While the central part of our research is related to yields in the secondary market, descriptive statistics of yield to maturity in the primary market (at issuance) may also be of interest. The previous comparison of the current coupon rate for the green and conventional bonds of our sample does not consider the differences in maturity between the bonds. To limit maturity differences, we interpolate/extrapolate the current coupon rate with the same method as in Equation 4.1. The difference in yields between the green and the conventional bonds in the primary market (Δ*Current Coupon*), is illustrated in Table 4.6. The average difference in the current coupon rate of -0.03% indicates that green bonds are issued at a lower yield than conventional bonds. As mentioned previously, the current coupon rate represents the YTM at issuance. However, the comparison does not consider that the bonds may be issued at different dates. The matching restriction allows a difference of issue date up to six years. During these years, fluctuations in the overall market situation and changes in the company's financial position can affect its current coupon rate through its credit risk. Nevertheless, this overview indicates a negative green bond premium in the primary market. This yield difference is consistent with the observations of oversubscriptions of green bonds in the primary market. As mentioned in Section 2.3, oversubscriptions can reduce the current coupon rate for green bonds at issuance.

Table 4.6: Difference in Current Coupon Rate

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Δ*Current Coupon*	119	−0.030	0.568	−4.301	−0.211	0.006	0.205	1.171

4.8 Our Green Bond Sample and The Nordic Green Bond Market

By investigating the characteristics of our green bond sample compared to the entire Nordic green bond market, we identify some differences. This may affect whether our results can be considered valid for the entire Nordic green bond market. Our sample consists of 119 green bonds, while the Nordic green bond market consists of 634 green bonds. Our sample is not randomly drawn as we only include the green bonds with two conventional counterparts with similar characteristics. The comparison is shown in Appendix, Table A0.3 and Table A0.4.

We observe that the entire Nordic green bond market has an average issue date 832 days after the matched green bond sample. The maturity length is, on average, 28 days shorter for the entire Nordic market. Additionally, the maturity date for the entire Nordic market is on average 802 days after the matched green bond sample.

Our matched green bond sample only consists of bonds issued in SEK and NOK. This differs from the entire Nordic green bond sample, which includes bonds in EUR, DKK, and USD. However, as the Norwegian and Swedish markets are the most developed green bond markets in the Nordic, we do not expect this to affect our results.

We only have investment grade bonds in our matched sample, unlike the entire Nordic green bond market. Most of our matched green bonds (78.15%) are in the risk class senior unsecured. This is similar to the observation from the entire Nordic green bond market, where there are 80.28% senior unsecured bonds. The distribution among industry groups in our green bond sample is similar to the entire Nordic green bond market. Real estate is the largest industry group for both, while the other groups have relatively few observations.

Among all the Nordic green bonds, about 20% of the bonds are zero coupon bonds. We did not have access to price data for zero coupon bonds. Therefore we have not included any in our matched green bond sample.

5 Empirical Methodology

This section describes the empirical methodology used in this thesis. We first perform a fixed effect regression to estimate the green bond premium in the overall sample. The sample is also divided into sub-samples to investigate the green bond premium separately. In the second part, we run an OLS regression to find possible determinants of green bond premium.

5.1 Step 1: Estimation of Green Bond Premium

Similar to Zerbib (2019), we estimate the green bond premium by running a fixed effect (FE) regression with the yield difference, $\Delta\tilde{y}_{i,t}$, as our dependent variable and liquidity difference, $\Delta BA_{i,t}$, as our independent variable. The fixed effect within-model allows us to remove the yield difference between triplets and keep the yield difference within each triplet (Stock and Watson, 2015). The methodology gives us an unobserved effect ρ_i for each triplet i. ρ_i is defined as the green bond premium per triplet by Zerbib (2019). In total, we therefore estimate 119 values of ρ_i, as we have 119 triplets in our sample.

The fixed effect regression is specified as

$$\Delta\tilde{y}_{i,t} = \rho_i + \beta\Delta BA_{i,t} + \epsilon_{i,t}, \tag{5.1}$$

where ρ_i is the green bond premium for triplet i and $\epsilon_{i,t}$ is the residual for triplet i, on day t.

We use several tests to look for unobserved differences between the triplets to determine whether the FE or random effect (RE) model is more preferable to a pooled OLS model. We conduct a Hausman test to test if a FE estimator is more robust than a RE estimator.

Before moving on with our green bond premium estimates, the efficiency of our estimated panel model is tested. Entity-specific factors can make the standard error within each triplet correlated over time. This may violate the FE regression assumption that the standard errors have an unconditional mean of zero (Stock and Watson, 2015). Possible violations are tested using a Breusch-Pagan test for heteroscedasticity, and a Woolridge test, Breusch-Godfrey test, and Durbin-Watson test for serial correlation. The test results affect how we compute standard errors. In the case of heteroscedasticity and/or serial correlation, we compute robust standard errors and include them in our model.

5.1.1 Analysis of Sub-Samples

Another interesting aspect to analyze is whether the green bond premium differs among sub-samples. Therefore, we divide our sample into sub-samples based on bond characteristics. A Shapiro-Wilk normality test can be used to test whether the sub-samples are normally distributed. This is relevant as many statistical tests are based on an assumption of normality. A non-parametric Wilcoxon signed-rank test can be used if the normality assumption is violated. We test the significance and calculate the mean and median of each sub-sample to determine the sign, magnitude, and significance of green bond premium within each sub-sample.

5.2 Step 2: Determinants of Green Bond Premium

As in Zerbib (2019), we want to find possible determinants of the green bond premium. The approach is to estimate a linear OLS model with green bond premium ρ_i as the dependent variable and bond characteristics as independent variables. Due to differences in the data sets, some variables vary from the research in Zerbib (2019). We look at currency, industry group, maturity, coupon type, current coupon rate, risk, and issue amount. As mentioned in the literature review, these variables are important determinants of bond yield in general. We also include the difference in YTM at issuance, Δ *Current Coupon*, in the regression, to investigate if this variable affects the green bond premium. As we observed a negative yield difference in the descriptive statistics of Δ *Current Coupon*, this variable can give us an indication of how dynamics in the primary market affect the yields in the secondary market.

We evaluate the robustness of our linear regression model with a Breusch-Pagan test and calculations of Variation Inflation Factor (VIF) for each variable. The purpose is to look for heteroscedasticity and multicollinearity, respectively.

There might be multicollinearity between the variables Risk and Industry Group, so these variables are not included in the same regression.

The two models are specified as

$$
\begin{aligned}
\rho_i = \beta_0 &+ \sum_{j=1}^{N_{Currency-1}} \beta_1 Currency_j,^1 Currency_j \\
&+ \sum_{j=1}^{N_{HY/IG-1}} \beta_2 HY/IG_j,^1 HY/IG_j \\
&+ \sum_{j=1}^{N_{IndustryGroup-1}} \beta_3 IndustryGroup_j,^1 IndustryGroup_j \\
&+ \beta_4 CouponRate \\
&+ \beta_5 Maturity \\
&+ \beta_6 log(IssueAmount) \\
&+ \beta_7 \Delta CurrentCoupon \\
&+ \epsilon_i,
\end{aligned}
\tag{5.2}
$$

and

$$
\begin{aligned}
\rho_i = \beta_0 &+ \sum_{j=1}^{N_{Currency-1}} \beta_1 Currency_j,^1 Currency_j \\
&+ \sum_{j=1}^{N_{HY/IG-1}} \beta_2 HY/IG_j,^1 HY/IG_j \\
&+ \sum_{j=1}^{N_{Risk-1}} \beta_3 Risk_j,^1 Risk_j \\
&+ \beta_4 CouponRate \\
&+ \beta_5 Maturity \\
&+ \beta_6 log(IssueAmount) \\
&+ \beta_7 \Delta CurrentCoupon \\
&+ \epsilon_i.
\end{aligned}
\tag{5.3}
$$

6 Results

6.1 Green Bond Premium

Our first regression seeks to determine the green bond premium in our sample. We use an F-test, a Woolridge test, a Breusch-Pagan test, and a Honda test to test whether a Fixed Effect (FE) or Random Effect (RE) estimator is to prefer over a pooled OLS model. As we can see from Table 6.1, there is a significant unobserved effect. Hence, we conclude that a pooled OLS is not appropriate for our data set. The result from the Hausman test is also significant at a 1% level, which means that a FE estimator is more effective than a RE estimator.

Table 6.1: Choice of Model

	F-test	Woolridge test	Breusch-Pagan test	Honda test	Hausman test
p-value	2.2e-16	3.719e-08	2.2e-16	2.2e-16	0.003177
Conclusion	Unobserved effect	Unobserved effect	Unobserved effect	Unobserved effect	FE > RE

By estimating the liquidity effects on the yield difference with our liquidity proxy, we can isolate the fixed effects ρ_i to investigate the overall green bond premium in our sample. Results from the regression can be seen in Table 6.3. As expected, our residual tests affirm heteroscedasticity and serial correlation. Hence, we need to include estimates of robust standard errors to increase the efficiency of our model. The residual test results are shown in Table 6.2.

Table 6.2: Residual Tests

	Breusch-Pagan	Woolridge test	Breusch-Godfrey test	Durbin Watson test
p-value	2.2e-16	2.2e-16	2.2e-16	2.2e-16
Conclusion	Heteroscedasticity	Serial correlation	Serial correlation	Serial correlation

As Zerbib (2019) we use Newey-West and Beck-Katz robust estimations of standard errors. Panel data adjusted Newey-West estimated standard errors is a frequently used procedure to compute robust standard errors and limit the bias from heteroscedasticity and serial correlation (Petersen, 2009). However, in data sets with a small number of panels (N) relatively to time observations (T), Beck-Katz's methodology is considered the most effective (Beck and Katz, 1995). Hence, this way of estimating robust standard errors is expected to be helpful in our sample. We include both methods for comparison. The regression output with robust standard errors are shown in Table 6.3. As the output indicates, the liquidity coefficient is not affected by the estimation of standard errors.

Table 6.3: Fixed Effect Regression

	Dependent Variable:		
	Yield Difference $\Delta\tilde{y}_{i,t}$		
		Newey-West robust standard errors	Beck-Katz robust standard errors
	(1)	(2)	(3)
Liquidity Difference $\Delta BA_{i,t}$	1.138***	1.138***	1.138***
	(0.032)	(0.339)	(0.020)
Observations	113,645	113,645	113,645
R^2	0.029	0.029	0.029
Adjusted R^2	0.028	0.028	0.028
F Statistic (df = 1; 113525)	3,338.005***	3,338.005***	3,338.005***
Note:			*p<0.1; **p<0.05; ***p<0.01

Our estimated FE model reveals a positive correlation between yield and liquidity differences. An increase in liquidity difference by one basis point is expected to increase the yield difference by 1.138 bps. This relationship is significant at a 1% level. The explanatory power of the model, measured by R^2, is low at 2.9%. Hence, some of the variation in green bond premium is captured in the error term. However, we consider the model useful, as we controlled for the most important yield determinants in the matching procedure.

We can extract the fixed effects from our model to investigate the green bond premium in our sample. These are summarized in Table 6.4. We observe a positive green bond premium of 0.1% (10 bps) in our overall sample. Hence, the green bonds seem to have higher yields than the conventional bonds in the secondary market.

We use a Wilcoxon signed-rank test to determine if the green bond premium is significantly different from zero. The test reveals a p-value of 0.0001042, which means that the positive green bond premium is significant at a 1% level. Our null hypothesis is that the yields of green and conventional bonds are similar. The results give reason to reject the null hypothesis. We can conclude that investors can expect higher yields from green bonds, as stated in our alternative hypothesis *H2*.

Table 6.4: Green Bond Premium

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
FE ρ_i	119	0.001	0.005	−0.017	−0.0005	0.001	0.003	0.025

As a robustness check, we also run the fixed effect regression with monthly observations. The purpose is to check if the low number of trades in the Nordic bond market affects our results. As in the regression with daily observations, Newey-West and Beck-Katz robust standard errors are estimated and included in the model. The regression output is shown in Table 6.5.

Table 6.5: Fixed Effect Regression with Monthly Observations

	Dependent variable:		
	Yield difference $\Delta\tilde{y}_{i,t}$		
		Newey West Robust Standard Errors	Beck-Katz Robust Standard Errors
	(1)	(2)	(3)
Liquidity	1.038***	1.038***	1.038***
	(0.138)	(0.379)	(0.088)
Observations	5,403	5,403	5,403
R^2	0.026	0.026	0.026
Adjusted R^2	0.004	0.004	0.004
F Statistic (df = 1; 5283)	138.603***	138.603***	138.603***
Note:			*p<0.1; **p<0.05; ***p<0.01

The results from the regression with monthly observations are quite similar to the one conducted with daily observations. The liquidity coefficient of 1.038 is significant at a 1% level. By extracting and investigating the 119 fixed effects from the regression, we find an average green bond premium of 10 bps. This is illustrated in Table 6.6. The result is equal to what we found in the regression with daily observations.

Table 6.6: Green Bond Premium with Monthly Observations

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
FE ρ_i	119	0.001	0.004	−0.011	−0.0003	0.001	0.002	0.019

6.1.1 Green Bond Premium per Sub-Sample

As the green bond premium may differ between bond categories, the data sample is divided into sub-samples based on bond characteristics such as industry group, currency, risk, coupon type, and issue amount (for the green bond). A Shapiro-Wilk normality test reveals that the majority of the sub-samples are not normally distributed. Therefore, we use the non-parametric Wilcoxon signed-rank test to determine the significance of the green bond premium for each sub-sample.

The sign, magnitude, and significance of the green bond premium per sub-sample are summarized in Table 6.7. As shown, most of the sub-samples have a positive green bond premium. The only exception is when the issue amount of the green bond is between SEK 250 and 500 million. However, the negative green bond premium for this sub-sample is not significant. The magnitude and significance of the green bond premium in the rest of the sub-samples also differ.

The results indicate that the largest significant green bond premium appear for bonds issued in NOK, and for issue amounts below SEK 250 million. The green bond premium in the NOK sample is, on average, 49 bps. This is about five times higher than the overall results. In comparison, the green bond premium of SEK-nominated bonds is 3 bps. Green bonds with an issue amount below SEK 250 million have a mean of 26 bps. All these results are significant at a 1% level.

Within industry groups, we observe the highest significant green bond premium for real estate bonds. The average green bond premium for real estate bonds, of 9 bps, is 1 bp lower than the overall result. Floating and fixed rate bonds have an average green bond premium of 11 bps and 7 bps, respectively. Both results are significant.

As mentioned in Section 4.6, Vasakronan is the issuer in 36 of our 119 triplets. We, therefore, investigated the impact of Vasakronan's bonds on the overall green bond premium. If we remove the bonds from Vasakronan, the overall green bond premium is reduced to 7 bps. This indicates that this individual issuer substantially affects the overall sample. However, the positive green bond premium is significantly different from zero also when Vasakronan is left out of the sample.

Table 6.7: Green Bond Premium per Sub-Sample

	Characteristics	Mean	Median	p-value	Sample Size
Currency	SEK	0.0003	0.0005	0.0071***	102
	NOK	0.0049	0.0021	0.0013***	17
Industry Group	Public Sector	0.0002	0.0004	0.0419**	14
	Utilities	0.0021	0.0002	0.4922	10
	Industry	0.0053	0.0053		2
	Real Estate	0.0009	0.0007	0.0069***	85
	Transportation	0.0007	0.0006	0.125	4
	Bank	0.0005	0.0005		2
	PPF	0.0015	0.0015		2
Risk	Senior Secured	0.0005	0.0009	0.4238	12
	Senior Unsecured	0.0012	0.0006	0.0010***	93
	Government Guaranteed	0.0002	0.0004	0.0681*	13
	Municipality	0.0007	0.0007		1
Current Return Type	Floating Rate	0.0011	0.0005	0.0007***	75
	Fixed Rate	0.0007	0.0007	0.099*	44
Issue Amount (SEK million)	$<$250	0.0026	0.0013	0.0007***	13
	250-500	-0.0002	0.0000	0.7859	36
	501-750	0.0012	0.0006	0.0121**	37
	$>$751	0.0014	0.0006	0.0197**	33

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

6.2 Determinants of Green Bond Premium

A linear OLS model is estimated to find possible determinants of the green bond premium. We use green bond premium ρ_i as the dependent variable and bond characteristics as independent variables. The results from the two model specifications 5.2 and 5.3 are shown in Table 6.9.

We need several observations in each category within the explanatory variables to estimate the effects on the green bond premium. Hence, sub-samples with only one observation are removed. In our sample, this is only the case for risk class municipality.

By running a Breusch-Pagan test on the two models, we get a p-value of 0.6833 for model (1) and a p-value of 0.4814 for model (2). This means that our results are not likely to be biased by heteroscedasticity in our residuals. All the variables in the two regressions have a Variance Inflation Factor (VIF) below 10. This indicates that multicollinearity is not a concern. The results from the Breusch-Pagan test and the VIFs are summarized in Table 6.8.

Table 6.8: Breusch-Pagan Test for Heteroscedasticity and Variation Inflation Factors

Test	Results Model (1)	Results Model (2)
Breusch-Pagan Test		
p-value	0.6833	0.4814
Variation Inflation Factor (VIF)		
Currency	2.6107	2.1122
Maturity (years)	2.7035	2.7081
Industry Group	2.4747	–
Risk	–	1.4878
Current Return Type	1.1743	1.0954
Current Coupon	1.9785	1.8089
Δ Current Coupon	1.3388	1.2652
Log Issue Amount	1.2730	1.2530

The results from the linear OLS regression show that some of the bond characteristics have a significant effect on the green bond premium. SEK-nominated bonds seem to decrease the green bond premium by 40 bps in model (1) and 30 bps in model (2). These results are significant at a 1% and 5% level, respectively. We also observe a positive significant coefficient for the variable Δ*Current Coupon*. A one percent increase in the current coupon rate increases the green bond premium by 10 bps. In the second model, the variable issue amount is also significant, indicating that a higher issue amount reduces the overall green bond premium.

Interestingly, the difference in the current coupon rate at issuance also significantly affects the green bond premium. The results reveal that a one percent increase in the difference in the current coupon rate at issuance reduces the green bond premium by 40 bps in model (1) and 30 bps in model (2). Oppositely, a more negative difference in current coupon rate at issuance leads to a higher green bond premium in the secondary market. This indicate that oversubscriptions in the primary market may affect the yields in the secondary market.

Table 6.9: Determinants of the Green Bond Premium

	Dependent Variable: Green Bond Premium ρ_i	
	Model (1)	Model (2)
Currency: SEK	-0.004^{***}	-0.003^{**}
	(0.001)	(0.001)
Maturity (years)	−0.0002	−0.0002
	(0.0003)	(0.0003)
Industry Group: Industry	0.004	
	(0.004)	
Industry Group: Public Sector	0.001	
	(0.003)	
Industry Group: Pulp, Paper and Forestry	0.004	
	(0.003)	
Industry Group: Real Estate	0.001	
	(0.003)	
Industry Group: Transportation	0.002	
	(0.003)	
Industry Group: Utilities	−0.002	
	(0.003)	
Current Return Type: FRN	0.001	0.001
	(0.001)	(0.001)
Risk: Senior Secured		0.00004
		(0.002)
Risk: Senior Unsecured		−0.0002
		(0.001)
Current Coupon	0.001^{*}	0.001^{**}
	(0.001)	(0.001)
Δ Current Coupon	-0.004^{***}	-0.004^{***}
	(0.001)	(0.001)
Log Issue Amount	−0.001	-0.001^{*}
	(0.001)	(0.001)
Constant	0.018	0.022^{**}
	(0.011)	(0.011)
Observations	119	119
R^2	0.422	0.388
Adjusted R^2	0.356	0.337
Residual Std. Error	0.003 (df = 106)	0.003 (df = 109)
F Statistic	6.443^{***} (df = 12; 106)	7.663^{***} (df = 9; 109)
Note:		*p<0.1; **p<0.05; ***p<0.01

7 Discussion

Through a fixed effect regression, we find that the average green bond premium in the Nordic secondary bond market is 10 bps. The result is significant and implies that the yield is higher for green bonds than conventional bonds from the same issuer, with similar characteristics. Our null hypothesis, stating that the yields of green and conventional bonds are similar, can be rejected.

Former research on green bond premium has ambiguous findings. Zerbib (2019) conducted his research in 2018, with data from the global bond market. Our analysis is based on the same methodology as in Zerbib (2019), but the scope is limited to the Nordic bond market. The time frame is also extended to 2021. We find a significant positive green bond premium between green and conventional bonds, where Zerbib (2019) found a significant negative green bond premium.

Our findings are more in line with Karpf and Mandel (2018), who found a significant positive green bond premium of 7.8 bps in the US market between 2010 and 2016. However, they used a different methodology in their research, and the market has developed substantially since 2016.

Wensaas and Wist (2019), who investigated the green bond premium in the Nordic market, found a negative green bond premium of 0.4 bps. This result is not significant. We find a positive green bond premium of 10 bps when investigating the same market and using the same methodology. Dahl and Karlsen (2019) did the same research in the Swedish and Norwegian market. Findings in the overall sample indicated a negative green bond premium of 0.8 bps.

Former research identifies differences between sub-samples. Zerbib (2019), Wensaas and Wist (2019), and Dahl and Karlsen (2019) all found that the green bond premium varies between sub-samples of currency, issue amount, and industry. When looking at the Swedish and Norwegian market separately, Dahl and Karlsen (2019) found a negative green bond premium of 1.2 bps, and a positive green bond premium of 1.7 bps, respectively. Our research also reveals differences between the Swedish and the Norwegian market. The green bond premium for NOK-nominated bonds in our sample is about five times larger than the overall green bond premium of 49 bps. However, the sub-sample of Norwegian green bonds is small, with only 17 triplets. We also observe a green bond premium of 26 bps for bonds with an issue amount below SEK 250 million. Within industry groups, real estate and public sector have an average, significant green bond premium of 9 bps and 2 bps, respectively.

Our results may differ from former research for several reasons. The Nordic green bond market is relatively more developed than the global market. In the Nordic bond market, green bonds have a larger market share of the total bond market. Our results are largely influenced by SEK-nominated bonds. Sweden is the seventh-largest green bond issuer globally, and 14% of Sweden's total bond market consists of green bonds. In comparison, only 1% of the global bond market consists of green bonds. As mentioned in Section 2.4, the Nordic countries are relatively wealthy, and public entities have been more willing to accept the sustainable finance mechanisms (CBI, 2021c). It could explain why the Nordic green bond market is relatively larger than the global green bond market. In addition, there are differences in the industry distribution between the Nordic and the global green bond market. As mentioned, real estate dominates the Nordic green bond market. This is also observed in our sample. Globally, the main part of the issued amount for green bonds is invested in energy. The high number of green bond issuances for real estate projects is a unique feature in the Nordic market.

Compared to similar research in the Nordic market, our results are different. One explanation could be that our research is based on a more extensive data sample. According to credit analysts we have talked to, the quality and routines for trade reporting in the Nordic bond market have changed for the better. This may indicate that data from recent years can be considered more reliable.

As we observe differences in the green bond premium between some sub-samples, the sample composition may have implications for the overall results. Due to the matching restrictions, we only use investment grade bonds in our research. This could limit our research's applicability to the entire green bond market. However, former research in the green bond market also has relatively few observations of high yield bonds. For example, of the 110 triplets Zerbib (2019) analyzed, only 13 were high yield bonds. According to Zerbib's research, the green bond premium for the high yield bonds does not seem to differ significantly from the investment grade bonds. On the other hand, when we regress the current coupon rate on the green bond premium, we get a positive significant coefficient. Generally, the current coupon rate reflects credit risk and interest rate risk. This could indicate that riskier bonds cause a higher green bond premium. High yield bonds have higher credit risk than investment grade bonds and should therefore have higher coupon rates. Hence, including more high yield bonds in the sample could lead to increased green bond premium. The positive relationship we find between the current coupon rate and green bond premium is in line with Wensaas and Wist (2019).

We also find that currency and issue amount significantly affect the overall green bond premium. These observations underline that differences in sample composition between research papers could affect the findings of green bond premium. For example, compared to the entire Nordic green bond market, our sample has a lower average current coupon rate, lower average issue amount, and fewer currencies. A randomly drawn sample from the Nordic green bond market could therefore give different results.

Whether our positive green bond premium is economically plausible is debatable. The result may be related to differences in the primary and secondary market. Investors' demand for green bonds in the primary market seems higher than in the secondary market. As mentioned in Section 2.4, the high demand for green bonds in the primary market has led to lower coupon rates in several cases. This tendency can also be observed in our data set. On average, the difference in yield in the primary market is 3 bps lower for green bonds than for conventional bonds. When we regress the difference in yield (current coupon rate) in the primary market on the overall green bond premium, we find a significant negative relationship. A more negative green bond premium at issuance seems to increase the green bond premium in the secondary market. In other words, investors' perceived risk of the green bond is higher in the secondary market than in the primary market, relatively to conventional bonds. Nevertheless, given that the bonds are issued from the same issuer, the risk should be considered the same. Hence, one can argue that the most plausible would be to expect similar yields between green and conventional bonds from the same issuer in the primary and secondary market.

Other plausible explanations for our results could be signaling effects from issuing green bonds. As mentioned in Section 2.7, more investors consider a company's approach to ESG relevant in investment decisions. Companies that issue green bonds may signal that they care about limiting their negative environmental impact. This can affect the investors' willingness to invest but does not necessarily make the green-labeled bond more attractive than a conventional bond from the same issuer in the secondary market. In our sample, the green bonds are, on average, issued around six months later than the conventional bonds. Suppose the first green bond is issued after the conventional bond. In that case, the perceived risk of the conventional bond can be reduced due to the signaling effect from the green bond issuance. This may lead to lower yields for the conventional bond. In addition, if two bonds with similar characteristics from the same issuer are issued in the market with different coupon rates, one might argue that the bond with the highest coupon rate is more likely to experience higher demand. Higher demand can lead to relatively lower yields in the secondary market. We observe lower yields for conventional bonds in the secondary market in our sample.

The economic impact of our results can be discussed. According to our findings, investors can receive a higher yield (of 10 basis points) if they choose to buy the green bond over a conventional bond from the same issuer and hold the bond to maturity. Normally, higher yield indicate higher perceived risk. However, bonds from the same issuer should not have a different probability of default. Hence, the expectation of higher yields is an incentive to buy the green bond. The liquidity for green bonds, measured in average bid-ask spread, is also slightly higher than for conventional bonds, as mentioned in Section 4.7. This difference could make the green bonds seem more attractive. Zerbib (2019) argues that the small negative green bond premium (of 2 bps) he finds in his research may harm investors' appetite for green bonds. The positive green bond premium in our research is five times higher in absolute terms. Hence, one can argue that our result is sufficient to influence investors' choice of investing in the green bond market.

Changes in supply and demand in the green bond market may affect the green bond premium in the future. Today, the demand seems to be higher in the primary market than in the secondary market. An overall increase in demand may, therefore, reduce the primary market's yields even further. In the secondary market, increased demand may reduce the positive green bond premium we find in our research. If more investors want to include green bonds in their portfolios, lower yields may be accepted in the secondary market.

The increased focus on how finance can contribute to limiting climate change can affect the demand for green bonds. Climate conferences such as the annual UN COP are likely to influence climate policies in the Nordics, as well as globally. Actions to stimulate green investments, such as EU's Sustainable Finance Action Plan, can boost the demand further. As mentioned in Section 2.1, more asset managers will be required to report on their sustainability through the EU's Sustainable Finance Disclosure Regulation. The regulation will make the environmental impact of funds and portfolios more transparent. Hence, more investors might be interested in including green assets in their portfolios. With the implementation of the EU Taxonomy regulation in January 2022, investors may be more secure that their green investments are contributing positively to the environment (European Commission, 2020). This can reduce the fear of greenwashing, which might be a concern in the green bond market today.

The future of the supply of green bonds could be more uncertain. The high demand for green bonds in the primary market may indicate room for more green bond issuance. However, the absence of clear economic benefits for issuers and potential risk of reputation related to greenwashing may limit the development of the green bond market (EU Technical Expert Group on Sustainable Finance, 2019). Additionally, the complex and potentially costly procedures for getting an external review reduce the incentive for issuing green bonds.

Even though the regulations from the EU are supposed to stimulate green investments, it will also impose stricter rules for getting the green label on assets. The EU Taxonomy and the Green Bond Standard can limit the supply of green bonds as the cost and complexity increase. On the other hand, more trustworthy rules may decrease the risk of greenwashing. In a world where green finance is considered crucial for limiting climate change, issuing green bonds could also have a more positive effect on an issuer's reputation. Increased supply of green bonds may reduce the yield differences between green and conventional bonds.

Some limitations of our research need to be addressed. As mentioned in Section 4.1, our bonds are traded relatively infrequently. Low liquidity may reduce the accuracy of our data for yields and prices. In addition, as described in Section 4.8, there are some differences between our sample and the entire Nordic green bond market. Therefore, the validity of our results for the entire Nordic green bond market can be limited.

The interpolation/extrapolation calculation used to adjust maturity assumes that the yield curve is linearly increasing. This assumption does not always hold. However, we limit the maturity difference between the two conventional bonds to be maximum of two years. Hence, potential errors should be of limited size.

The relatively high green bond premium we find in the Norwegian market (49 bps) is based on a limited number of observations. This means extreme values may bias the results, even though the yield data is winsorized at a 1% level.

8 Conclusion

Climate finance is needed to meet the goals of the Paris Agreement. Public and private capital must be allocated to more environmentally friendly projects to which green bonds can contribute. The increasing market for green bonds implies that both issuers and investors are willing to participate in this transition. In contrast to early portfolio theory, this indicates that investors consider both financial and non-financial factors in their investment decisions. Interestingly, our findings reveal that investors do not have to forgo yield by investing in green bonds in the secondary market.

We can point out what investors can expect when investing in green bonds by comparing yields between green and conventional bonds in the Nordic secondary market. Through a matching method, we combined bonds with similar characteristics. Then we performed a fixed effect regression to estimate the green bond premium ρ_i. In addition, we used the green bond premium as the dependent variable to analyze possible determinants.

In this thesis, we aim to find an answer to our research question: *What yields can investors expect from green bonds in the Nordic secondary bond market?*. The significant[12] and positive green bond premium of 10 basis points indicates that investors do receive higher yields from green bonds than conventional bonds from the same issuer in the Nordic secondary bond market. This means that our null hypothesis, stating that there is no difference between green and conventional bond yields, can be rejected. Almost all the sub-samples have a positive green bond premium. The findings indicate that the largest significant green bond premium appear for bonds issued in NOK and for issue amounts below SEK 250 million.

Our analysis of the green bond premium determinants reveals that currency, current coupon, difference in the current coupon, and issue amount have a significant effect on the overall green bond premium.

Our positive green bond premium findings indicate that investors demand a higher yield in the secondary market than in the primary market, compared to conventional bonds. This is based on the observations of oversubscriptions in the primary market, leading to lower yields for green bonds at issuance. The significance of the Δ*Current Coupon* from

[12]The significance test reveals a p-value of 0.0001042. Hence, this result is significant on a 1% level.

the OLS regression supports these findings. Even though this indicates higher perceived risk in the secondary market, the probability of default for bonds from the same issuer is equal. Hence, our results can influence investors' appetite for green bonds.

Variation between our results and former research can be caused by differences in sample composition and investigation period. For example, our sample is heavily influenced by SEK-nominated bonds from the real estate industry. In addition, our research is conducted with data from a wider time frame.

Increased focus on limiting climate change in recent years may have affected the development of green bond market mechanisms. Market trends and climate policies will probably influence the green bond market in the future.

One part of the motivation for this thesis was to investigate the Nordic green bond market with an extended amount of data. Our findings align with previous research that reveals ambiguous consensus on existence of a green bond premium. When the Nordic green bond market develops more in the future, further research can take advantage of the development and hopefully establish a consensus on the green bond premium. This could also include an analysis of the high yield green bond market.

In addition, we observed that yields for green bonds were lower on average than conventional bonds in the primary market. This differs from our findings in the secondary market. Further research could investigate the mechanisms when the yield difference between green and conventional bonds change between the primary and the secondary market.

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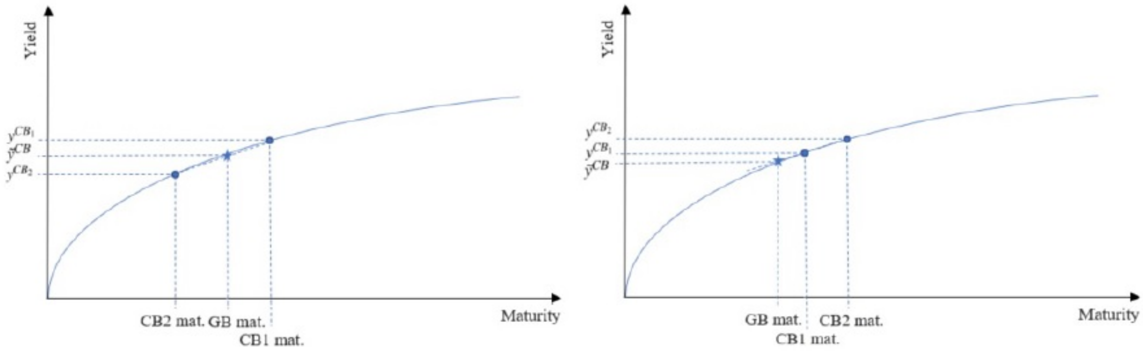
Appendix

Figure A0.1: Interpolation/Extrapolation, Illustration From Zerbib (2019)



(a) Interpolation (b) Extrapolation

Table A0.1: Relevant Variables from Stamdata

Variable	Description
ISIN	International Securities Identification Number. Unique identification number for each bond.
Issuer	The part issuing the bond. Varies from private companies to municipalities and governments.
Currency	The currency the bond is issued in.
Stock Exchange	The stock exchange the bond is issued on.
Issue Amount	The raised bond amount. The values are adjusted to the currency SEK.
Industry Group	Grouping of issuers based on common line of business.
Risk	Features of the bond agreement that affect the risk. Includes seniority (the priority of repayment by default), and collateral (assets used as security for the bond).
HY/IG	High yield/investment grade. Broad categories of credit rating. High yield bonds are the bonds with lowest credit rating and highest probability of default. Investment grade bonds have the highest credit rating and lowest probability of default.
Green	A dummy variable. Has value 1 if the bond is green and 0 if the bond is non-green (conventional).
Maturity Date	The date the bond matures.
Current Return Type	The type of return from the bond. The bond can have a fixed rate, and a floating rate. Bonds without coupon payments are called zero coupon bonds (ZCB).
Current Coupon	The coupon rate (in percentage) at issuance. When the bond is issued at par, the coupon rate equals the yield to maturity at issuance.
Δ Current Coupon	The difference in current coupon rate between the green bond and the synthetic conventional bond.

Table A0.2: Issuer Distribution

Issuer	Number of Bonds
Vasakronan AB (publ)	36
Svensk FastighetsFinansiering (SFF) AB	12
Atrium Ljungberg AB (publ)	9
Rikshem AB	9
Jernhusen AB	4
BKK AS	3
Entra ASA	3
Fabege AB (publ)	3
Örebro kommun	3
Agder Energi AS	2
Castellum AB	2
Hemsö Fastighets AB (publ)	2
Kungsleden AB (publ)	2
Lunds kommun	2
Lyse AS	2
Skanska Financial Services AB	2
Skåne Läns Landsting	2
Specialfastigheter Sverige AB	2
Stockholm Exergi Holding AB (publ)	2
Sveaskog AB	2
Vellinge kommun	2
Västerås Stad	2
Wallenstam AB (publ)	2
DNB Bank ASA	1
Eidsiva Energi AS	1
FastPartner AB (publ)	1
Klövern AB (publ)	1
Norrköpings Kommun	1
Oslo kommune	1
Uppsalahem AB	1
Volvofinans Bank AB (publ)	1
Östersunds kommun	1
SUM	119

Table A0.3: Full Nordic Green Bond Sample

Full Nordic Green Bond Sample			
	Variable		% of Total
	Unique Bonds	634	
	Unique Issuers	144	
Issuance	Issue Date (mean)	05.09.2019	
Maturity	Days (mean)	1596	
	Years (mean)	4.43	
	Maturity Date (mean)	18.01.2024	
Currency	DKK	9	1.42%
	EUR	27	4.26%
	NOK	121	19.09%
	SEK	473	74.61%
	USD	4	0.63%
Yield	High Yield	65	10.25%
	Investment Grade	569	89.75%
Issue amount	Total SEK Million	438 417	
	Mean SEK Million	691.51	
Risk	Government Guaranteed	40	6.31%
	Municipality	1	0.16%
	Senior Secured	45	7.10%
	Senior Unsecured	509	80.28%
	Subordinated	5	0.79%
	Mortgage Bonds (Danish-RO)	2	0.32%
	Tier 3	4	0.63%
	Municipality Guaranteed	6	0.95%
Coupon Type	Fixed	162	25.55%
	Floating	342	53.94%
	Zero Coupon	130	20.50%
Coupon rate	Mean	1.34%	
Industry Group	Industry	37	5.84%
	Utilities	58	9.15%
	Seafood	7	1.10%
	Telecom/IT	1	0.16%
	Pulp, Paper and Forestry	12	1.89%
	Convenience Goods	2	0.32%
	Public Sector	43	6.78%
	Consumer Services	6	0.95%
	Real Estate	393	61.99%
	Finance	27	4.26%
	Shipping	2	0.32%
	Transportation	23	3.63%
	Health Care	1	0.16%
	Bank	19	3.00%
	Government	3	0.47%

Table A0.4: Matched Green Bond Sample

Matched Green Bond Sample			
	Variable		% of total
	Unique Bonds	119	
	Unique Issuers	32	
Issuance	Issue Date (mean)	26.05.2017	
Maturity	Days (mean)	1625	
	Years (mean)	4.51	
	Maturity Date (mean)	07.11.2021	
Currency	SEK	102	85.71%
	NOK	17	14.29%
Yield	High Yield	0	
	Investment Grade	119	100%
Issue Amount	Total SEK Million	75 461	
	Mean SEK Million	634.1	
Risk	Government Guaranteed	13	10.92%
	Municipality	1	0.84%
	Senior Secured	12	10.08%
	Senior Unsecured	93	78.15%
Coupon Type	Fixed	44	36.97%
	Floating	75	63.03%
Coupon Rate	Mean	1.02%	
Industry Group	Industry	2	1.68%
	Utilities	10	8.40%
	Pulp, Paper and Forestry	2	1.68%
	Public Sector	14	11.76%
	Real Estate	85	71.43%
	Transportation	4	3.36%
	Bank	2	1.68%