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The Nordic High Yield Green Bond Market

Construction and Performance Analysis of a Corporate Green Bond Index

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Abstract

The aim of this thesis is to study the Nordic high yield green bonds and their performance in the secondary market from 2019 until today, with a focus on the crisis following the outbreak of the Covid-19 pandemic. The analysis is conducted by constructing and backdating an index of Nordic high yield green bonds, which is then compared to two carefully selected benchmark indices. The index construction is based on Barclays' index methodology.

Using common measures of risk-adjusted return and single-factor CAPM regressions, the analysis finds that green bonds show greater resilience during the period of market turmoil in 2020. However, when one of the benchmarks is reweighted to match the sector composition in the Green Bond Index, the higher returns are no longer statistically significant. When the market liquidity, measured by the average relative bid-ask spread, is analysed, a similar pattern is discovered. The average relative spread for the high yield market excluding oil-related sectors is higher than the average relative spread for green bonds. Still, the difference is lower when adjusted for the sector composition in the green bond market, indicating that green bonds are more liquid than conventional bonds.

The thesis finds that the main reason for the observed outperformance, measured by risk and return, can be attributed to the sector composition of the green bond market. We can therefore not conclude that the returns and liquidity are higher solely because the bonds are labelled as green.

Keywords – Green bonds, high yield, index construction, climate change, sustainable investment, debt and capital markets, corporate bonds, Nordic bond market

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List of Abbreviations

CAPM	Capital Asset Pricing Model
CARG	Compound annual growth rate
CBI	Climate Bonds Initiative
CD	Certificate of deposits
CICERO	Centre for International Climate and Environmental Research
ESG	Environmental, Social and Governance
GBP	Green Bond Principles
HY	High Yield
ICMA	International Capital Markets Associations
IG	Investment grade
IR	Information ratio
ISIN	International Securities Identification Number
MSCI	Morgan Stanley Capital International
NBP	Nordic Bond Pricing
OECD	Organisation for Economic Co-operation and Development
OTC	Over-the-counter
S&P	Standard & Poor's
SR	Sharpe Ratio

1 Introduction

The purpose of this thesis is to study whether Environmental, Social, and Governance factors (ESG) affect the price and performance of bonds in the Nordic high yield market. We do this by comparing the attractiveness and performance of corporate green bonds to the overall high yield corporate bond market. After researching the motivation for sustainable investing in the Nordic market, we believe that green bonds need to display competitive risk and return behaviour for the asset class to grow and help to reorient financial flows away from fossil fuel towards climate-friendly projects. To increase our understanding of this subject, we have created what is, to the best of our knowledge, the first corporate green bond index available for Nordic investors. In doing so, we aim to ease the task of benchmarking the performance of corporate green bonds against prevailing economic trends. An index will allow us to compress the performance of multiple corporate green bonds down to a single time series, giving us an idea of the overall average performance of the bonds. This will again enable us to broaden our understanding of the asset class as a whole, and as we can compare the risk and returns of the index against other indices, better comprehend their pecuniary competitiveness, and their co-movement with the overall market.

When we compare our index to carefully selected benchmark indices, we will better understand whether Nordic investors will benefit from including green bond positions in their portfolios and whether the asset class is useful for hedging portfolio risks and minimizing downside risk. Intrigued by research on the financial benefits of holding sustainable assets, we raise two hypotheses. The first hypothesis is that the Green Bond Index outperforms the benchmarks in terms of higher risk-adjusted returns and better liquidity. The second hypothesis is that Nordic green bonds held up better during the market turmoil caused by the Covid-19 crisis. Our findings can potentially boost the interest in environmentally friendly portfolios and help shape private incentives to mobilize the financial resources necessary for a successful transition to a climate-resilient economy.

At this point, there are several green bond indices, including Standard & Poor's, Bank of America Merrill Lynch and Barclays MSCI (Ehlers and Packer, 2017). However, we are not aware of an index that mirrors the Nordic bond mandate investing universe. When

choosing what investment type to focus on, the authors contemplated creating two indices. One for investment grade bonds and one for high yield bonds. However, the Nordic market for investment grade bonds is mainly dominated by industries that are without high risk of negative ESG events, neither physical (oil spills, pollution, the exploitation of workers) nor transitional (new regulations, policy intervention) (Norsif, 2018). In this universe, ESG would therefore not be much of a differentiation factor on risk or returns, and creating an investment grade green bond index would be a time-consuming endeavour with few decisive differences.

The Nordic high yield market, on the other hand, has a high composition of industries like oil and gas services and shipping. These are industries where negative ESG events, both physical and transitional, have a much higher possibility of occurring due to high levels of carbon emissions, exposure to geopolitical disruptions, and scrutiny from policymakers. We therefore believe that any potential influence of ESG on risk and reward has a higher possibility of occurring in this market. If there are any differences between a green and a conventional index, they will more likely appear here. Based on this notion, we choose to move forward by placing our entire focus on the high yield market and create one single index, mirroring the universe of Nordic high yield bonds. We suggest that the Nordic investment grade market should be the target of a future thesis or research paper on green bonds.

The remainder of the thesis is organized as follows. Section 2 introduces the concept of sustainable investing and green bonds. Section 3 describes various academic research surrounding green bonds, motives for sustainable investing, and how sustainability has affected financial performance in the past. In section 4, we explain the theoretical frameworks most commonly used for portfolio performance analysis and the measurement of liquidity. Section 5 describes the methodological approach used for gathering data and constructing the index, and the empirical methodology used for performance evaluation. Section 6 centers around the empirical results and the analysis of our index compared to its benchmark. Section 7 provides a discussion surrounding our findings and limitations. We give our concluding remarks in section 8.

2 Background

This section provides background information on topics relevant to the thesis. The first section covers sustainable investing, including various drivers and strategies within this topic. The second section introduces one of the most popular sustainable asset classes and the main focus of our thesis, namely green bonds. Third, we study the unique characteristics of the Nordic fixed income market that are important to keep in mind when discussing what future demand for green bonds will look like in the Nordic countries.

2.1 Sustainable investing

Although successful in meeting the needs and desires of an ever-growing population, the acceleration of human enterprise, especially since the Second World War, has led our society to the midst of a planetary crisis: climate change. Dating back to when recordkeeping began in 1880, the six warmest years on record have all occurred since 2015 (WMO, 2021) and in 2019, the average global temperature reached 1.1°C above pre-industrial levels (UNDDR, 2020). Left unchecked, the consequences of future temperature increases, which can potentially amount to a total of 4.8°C by the end of the century (IPCC, 2014), will be catastrophic for the environment and the economy alike. Heatwaves, cropland decline, flooding, and water stress will affect millions of people if no significant action towards mitigating climate change occurs (OECD, 2017). In 2019, floods, storms, and fires around the globe fuelled by climate change resulted in more than USD 100bn worth of damages (Kramer and Ware, 2019). If not correctly dealt with, the effects of reduced crop yields, increased spread of diseases, and rising seas consuming coastal cities could cut the world economy by as much as USD 23tn in 2050 (Swiss Re Institute, 2021).

Governments around the world have undertaken several actions and commitments in an effort to fight and mitigate climate change, and many countries are aiming for a net-zero emissions world by 2050 (United Nations, 2020). The most important initiative undertaken by governments is arguably the Paris Climate Agreement which was adopted in 2015. The agreement aims to contain the rise of global temperatures at below 2°C compared to pre-industrial levels by reorienting financial flows away from fossil fuels and towards environmentally-friendly development. It is estimated by the OECD (2017) to require a

cumulative investment of USD 105tn in sustainable infrastructure over the next 15 years. This staggering amount, which is higher than the current combined market capitalization of all manageable assets globally,[1] tells us two things: Firstly, it tells us that there is a dire need for sustainable financing going forward. Secondly, that the funding necessary to mitigate climate change is simply too large to be funded by the public sector alone. The private sector, including pension funds, mutual funds, and insurance companies, needs to at least partially finance these investments if the targets of the Paris Agreement are to be met.

With initiatives like the Paris Agreement, the political support for addressing climate change is gaining momentum and offering strong signals for future investment patterns. The finance sector has seen the urge to act on the matter (EY, 2019), and as a result, sustainable investing has become increasingly popular among investors in recent years.

Sustainable investing has many definitions and branches. In the context of this thesis, it means for investors to consider how a company acts concerning environmental, social, and governance (ESG) factors when assembling an investment portfolio (GSIA, 2018).[2] The Environmental (E) dimension concerns a company's impact on the ecosystems of the earth. This dimension includes potential greenhouse gas emissions, the use of natural resources in the production process, pollution and waste, as well as efforts undertaken to make products or services more environmental friendly.

The Social (S) dimension concerns a company's relationship with its most important stakeholders besides the investors; the workforce, the customers, and society. It covers company actions regarding gender equality and human rights, product design and services that transform customers' lives for the better, and its ability to be a good citizen in the communities where it operates. The increased focus on this dimension has brought to light scandalous working conditions and corruption incidents resulting in media outcry and significant loss of reputation[3].

The Governance (G) dimension can be divided into two. On the one hand, you have the

[1] The total market value of all manageable assets in the world amounts to about USD 90tn today (Bloomberg, 2021a)

[2] This thesis will use the terms "sustainable investing" and "ESG investing" interchangeably.

[3] Take, for example, DNB's customer Samherji and the corruption scandal in Namibia which resulted in a reputation loss for DNB and a fine of NOK 400m (Standard & Poor's, 2020).

traditional corporate governance mechanisms that make management act in the long-term shareholders' best interest. On the other hand, in the context of sustainable investing, the dimension means efforts to increase focus on diversity and inclusion, for instance, by representing minorities on the board.

It is widely accepted within financial markets that companies should disclose the ESG-related impacts deemed material to the company. On the one hand, this includes disclosing information on how climate change, the coronavirus and policies for board diversity affect the company's financial position, performance and growth. On the other hand, it requires the company to disclose how their operational activities impact the environment and their most important stakeholders. This concept of double materiality is embedded in the EU's new plan for sustainable finance disclosure regulation (EU, 2019).

Various rating agencies also have firm-level measures of ESG performance, where the higher-rated companies are more attractive for sustainability-conscious investors. Bloomberg (2021a) estimates that assets under management based on ESG strategies amounted to USD 37.8t in 2020 (up 66% from 2016). In Europe, sustainable investing represents 45% of the EUR 24t assets under management (EFAMA, 2020).

2.1.1 Motivating factors and strategies

The most straightforward motivation for sustainable investing comes from social preferences rather than financial motives (Dimson et al., 2013). An investor with social preferences might be willing to forgo some of the potential risk-adjusted return in order to let the fund achieve non-fiduciary goals, or alternatively, pay a premium for a fund with high aligned ESG ratings while delivering the same ex-ante risk-return dynamics. The social preferences reflect ethical standards and values considered important for the investor or external organisations. Investors may also be concerned about reactions from stakeholders unless environmental or social issues are managed. The investor may not find these issues unethical but can worry that continuing certain practices related to these issues may anger regulators, employees, or the general public and cause the firm to lose its social license to operate.

Motivation for integrating ESG in portfolios can also stem from the belief that sustainability

can enhance financial performance, as climate change represents an increasing number of risk factors for long-term investors. As the risk of environmental disaster rises, so does the risk of damaged infrastructure, power outages, and the loss of production facilities in low-lying geographical locations, which all can have an adverse impact on long-term portfolios, as mentioned in section 2.1. Also, as the evidence of man-made climate change due to CO_2 emissions keep piling on, lawmakers' likelihood of policy intervention to limit these emissions is on the rise. These policies may have a dire effect on the income stream of several industries, for instance, those that are highly dependent on carbon emissions in their production process. The possibility of the latter has increased sharply since the signing of the Paris Climate Agreement (Carney, 2015). ESG is also believed to offer increased downside protection in periods of market turmoil, where extra scrutiny is placed on companies' governance, business model and work practices (BoA Merrill Lynch, 2021).

The most obvious counterargument is that ESG-concerned fund managers and asset owners have a binding constraint on their portfolios in that their investment options are limited in nature and cannot fully optimize or diversify it the same way unconstrained fund managers are. Therefore, it is not unreasonable to think that these funds will most likely underperform their competition in risk-adjusted returns. One could also argue that the securities of "brown" companies now can be bought in the market at a discount due to lower demand, which can generate higher returns.

The most basic and popular strategy for sustainable investing in Europe is negative screening and the exclusion or divestment of so-called sin stocks, companies that for instance pollute, create addiction or exploit stakeholders (GSIA, 2018). The logic behind this strategy is that the divestment or exclusion of these companies will increase their cost of capital and thereby make it harder for them to fund future activities, which again will produce more negative externalities. However, as discovered by Cohen et al. (2021), there is a paradox in that the energy sector, which is often excluded in ESG-conscious portfolios, produces more and better green patenting and innovation than almost any other industry. Basing an ESG approach on mere exclusion will therefore mean that clean projects will need to overcome higher hurdle rates in order to be financed which will result in less green innovation. Other strategies for sustainable investing includes impact investing, where investors seek both financial returns and a positive environmental and social impact, as

well as ESG activism, where investors actively engage with the companies they own and try to improve their ESG practices (see e.g. Doidge et al., 2019; Cole et al., 2018). In the next section, we will discuss one of the fastest growing investment options within the universe of sustainable investing.

2.2 Green Bonds

Green bonds, also known as climate bonds, are a key instrument within sustainable finance that has emerged in recent years. This section will cover some basic descriptions of green bonds and their principles of usage, how the market has developed in the past decade, and what the drivers and barriers of future growth are. Lastly, we will briefly present the green bond market in the Nordic countries.

2.2.1 Definitions and principles

Green bonds are fixed-income securities that are issued to finance specific projects with an environmentally friendly label, such as renewable energy, energy-saving buildings and the protection of aquatic and terrestrial ecosystems (Tang & Zhang, 2018). The asset class is similar to traditional bonds in the sense that they are issued by entities to raise capital in order to finance investments and are backed by the entire entity's balance sheet.

The definition of green bonds is important for the purpose and the agenda of the market. The International Capital Markets Association (ICMA) has defined green bonds as "any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible green projects" (ICMA, 2018). However, as it is an asset class still in its infancy, there is still not yet a widely accepted or established definition of what a green-labeled bond is (Financial Times, 2017b). Green bonds are issued by corporations, national and local governments as well as international and supranational organizations.

Today, for the bond to be regarded as green, it needs to be certified by a third party, who then decides whether the bond can be labelled as green or not. This label ensures investors that reliable information is provided about the environmental impact of the project financed with green debt. The most accepted market standard for being certified

is by following the guidelines of the Green Bond Principles (GBP). These guidelines are meant to be used as a tool to create credibility to green bonds and can be described as "voluntary process guidelines that recommend transparency and disclosure, and promote integrity to the development of the Green Bond Market by clarifying the approach for issuance of a Green Bond" (IMCA, 2018). The four components of the Green Bond Principles that any bond must follow to qualify as green are:

- Use of proceeds
- Process for project evaluation and selection
- Management of proceeds
- Reporting

After assuring that all principles are followed, the issuer must then contact an external reviewer in order to provide a second opinion on whether the bond is aligned with market standards and covers all four components. The most prominent reviewers include consulting firms like Sustainalytics, CICERO, KPMG and DNV GL. To be listed on the stock exchanges in countries like Norway and Sweden, and to be listed on the Climate Bonds Initiative's (CBI) green bonds list, the bond has to be certified by the external reviewer. CBI is a not-for-profit international organization that aims to promote green bonds as a form of capital solution for environmental-related projects. They are a prominent player in the green bond market and have defined the Climate Bond Standard, which is adapted by many countries and outlines the requirements for bonds wishing to be Climate Bond Certified (Climate Bond Initiative, 2017).

2.2.2 The corporate green bond market

A growing number of corporate bonds are being issued as green-labeled bonds. Since the issue of the first corporate green bond by Swedish property company Vasakronan in November 2013, the market has grown rapidly, at about a 95% annual growth rate. In 2019, the market for corporate green bonds hit a new record with gross new issuance of USD 114b, which represented 1.6% of total debt issuance world wide.[4] The market faced high

[4]Source: Climate Bonds Initiative (2020), Dealogic (2018), authors' calculations

expectations as we entered 2020. But as the pandemic struck, momentum initially slowed, with corporations and investors instead channeling social bonds earmarked for economic support, healthcare and vaccine development (Bloomberg, 2021b). In September, however, a radical shift in the market commenced, and issuance reached an all-time monthly high. The drive for green bonds is expected to pick up again in 2021 as governments and policymakers seek a sustainable economic recovery from the pandemic, with SEB analysts expecting total green bond issuance of USD 500bn (Financial Times, 2021).

2.2.3 Trends and drivers

The rapid and exponential growth of the corporate green bond market can be linked to several initiatives that have been undertaken in recent years in an effort to decarbonize portfolios and promote green investments. In addition to the Paris Climate Agreement discussed in section 2.1, where the demands for clean investments has translated into a huge growth market for green bonds, initiatives have been sparked by investors and asset owners themselves. With the fear of long-term wealth erosion and substantial regulations looming on the horizon, institutional investors and their clients have appealed for more focus on sustainable investment approaches. As a result, initiatives like the Montreal Carbon Pledge[5] and the Portfolio Decarbonization Coalition[6] have been signed in recent years. The former has 180 investors with assets under management over USD 10tn committing to the measurement and public disclosure of their portfolios carbon footprint. The latter consists of 32 investors with assets under management of USD 800bn pledging to consider a company's greenhouse gas emissions when engaging and allocating capital. Despite the sharp rise in recent years, there is still a huge upside to the market, and green bonds still only account for approximately 1% of the global fixed income market.

Furthermore, the opening of separate lists for labelled green bonds in stock exchanges, such as in Oslo, London, Milano, Luxemburg, Shanghai, Shenzhen and Mexico City has provided the market with much needed liquidity and improved both the reputation and attractiveness of green bonds as a unique asset class among issuers and investors.

The Covid-19 pandemic could represent a historic opportunity for governments to speed

[5]http://montrealpledge.org
[6]http://unepfi.org/pdc/

up the green shift. Stimulus packages launched around the world could bring double benefits if they manage to both stimulate economies while simultaneously accelerating green investments. The EU's commitment to spending 30% of the 750 billion EUR coronavirus recovery package on green bonds, thus placing the EU Green Deal at the core of its recovery plan, shows a clear ambition to do just this (Dagens Næringsliv, 2020).

A major challenge for the accelerating growth of the green bonds market has been the absence of a universal standard and definition. As the definition of being green and sustainable differs around the world, there is a need for a commonly accepted classification system for sustainable economic activities. The EU is currently working on such a classification system, a taxonomy, which will be an implementation of stricter definitions of what constitutes environmental-friendly investments. With that taxonomy also comes the EU's own Green Bond Standard, which can be described as a stricter version of the Green Bond Principles discussed in section 2.2.1(see e.g. EU, 2020a,b). The taxonomy will serve as a defence against the practice of making wrong or misleading claims about the company's commitment to the environment, otherwise known as greenwashing. It is set up to protect the investor against uncertainty and misleading claims. The taxonomy will also help guiding the future direction of the economy by setting a minimum standard that aligns with climate and development objectives. The process has been scrutinized, with the EU receiving almost fifty thousand comments on their draft in November 2020. Critics of the proposal argue that the new criteria are too strict, seeing that industries that would generally be considered sustainable are according to the taxonomy not considered "green enough". However, there are others arguing that the criteria will not help in reaching the target made in the Paris Agreement, as the criteria are not strict enough. The EU is expected to implement the taxonomy by January 2022 (Ahlstrand, 2021).

2.2.4 Potential advantages

Although green bonds by definition restrict companies' investment opportunities and should therefore be deemed as inferior to conventional bonds, the asset class should in theory provide both issuers and investors with several advantages. For issuers, green bonds may demonstrate to investors, lenders and other stakeholders the organization's commitment and strategy towards sustainability (Flammer, 2020). Given the increasing

demand for sustainable investment solutions, a wider investor base can be expected. The demand can also lead to better pricing and lower market execution risk. Finally, if investors are willing to trade financial gains for social benefits, issuers can benefit from a lower cost of capital, which in turn will increase the firm value.

For investors, green bonds serve as an asset class that incorporates both sufficient short-term portfolio risk and return balance, as well as lower levels of long-term climate change risk (Climate Bond Initiative, 2017). However, green bonds might come with a premium, which gives issuers a better price and hence a lower yield for investors. In order for the investors to accept this lower return, they will require other benefits by holding green bonds. One of these benefits is greater transparency in the use of proceeds as issuers are often constrained to disclose their environmental performance. This makes investors more confident in that their funds are supporting green projects, and allows them to measure their environmental impact, and thereby comply with their ESG commitments.

In fixed income markets the risks of climate change are less communicated than in equity markets. For equities, climate change risk is a tangible long-term danger as the stock of a company is perpetual. The risk of stranded assets, physical damage and government regulation due to climate change can have a big impact on firm valuation as we approach 2050, the deadline for many countries' goal of carbon neutrality. Bonds, on the other hand, with their shorter maturity, are thought to be less exposed to these risks, which would mean that ESG should have less impact on pricing. However, the demand for green bonds is through the roof and normally faces oversubscription at issuance (Tang and Zhang, 2020), which indicates that there is currently a higher demand than supply. The result of this could end up being that there is better liquidity in green bonds than in their conventional counterpart. The fixed income market in general is plagued by low levels of liquidity, as many of the investors of these instruments are pension funds and insurance companies with a long-term view and a "buy-and-hold" strategy. A fixed income instrument with high levels of liquidity could therefore be very beneficial for investors, especially in periods where they need to sell securities for capital buffers to be upheld. Also, as noted by DNB (Kjennerud and Heen, 2021), green bonds seem to attract a more diverse space of investors, which would also result in improved liquidity and potentially better price stability. If green bonds perform better in periods of market turmoil, as

analyzed later in the thesis, there are even more diversification benefits.

Despite these cited advantages, the continuing growth of the green bond market also faces some serious challenges and disadvantages. As mentioned earlier, there is still no universally accepted legal definition of what a green bond actually is and as a result, none of the Green Bond Principles mentioned in section 2.2.1 confers actionable rights for bond investors and are often not included as direct covenants. Indeed, if the issuers fail to comply with the stated principles, by for instance not using the proceeds for environmentally-friendly projects or through inadequate reporting, the holders of the bonds would not be eligible for early redemption in the event of breach. In other words, there is no guarantee that a green bond remains green throughout its life, and the investors are the ones who bear this risk. Also as mentioned earlier, the investors of green bonds are subject to greenwashing, a concept where the bond issuance is nothing but a marketing gimmick with no real impact on the issuers environmental impact. As the market criteria is based on voluntary compliance only, one can not say for certain that some green bonds actually follow the guidance of the GBP, which again contributes to growing scepticism surrounding the legitimacy of the market. Finally, despite increased buy-side demand and a more expensive and complex issuance process compared to conventional bonds,[7] there is still no clear evidence of pricing benefits for issuers in the form of reduced cost of debt.

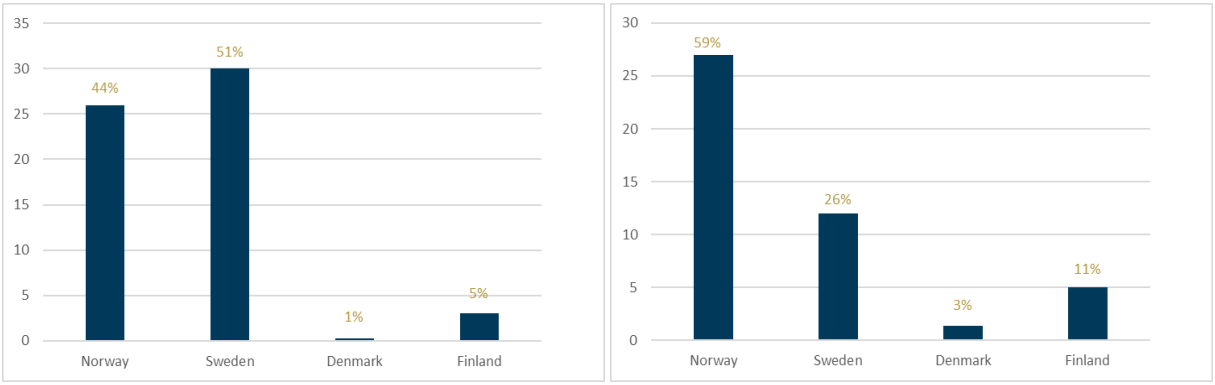
2.3 The Nordic fixed income market

The Nordic economies are widely considered to be among the most politically stable in the world and have firm macroeconomic fundamentals with low unemployment, high levels of education, small socioeconomic differences, and a high GDP per capital (Anndersen et al., 2007). Corporations are in general well governed, which contributes to good opportunities for long-term growth. Because the Nordic governments have strict supervision of the financial markets they are considered to be transparent and safe for investment opportunities.

According to Nordic Trustee (2020), the outstanding volume in the Nordic corporate bond

[7]Getting an external review or second opinion on whether the bond follows the guidelines of the GBP costs between USD 12 000 and 40 000 and the underwriting process in itself is also more expensive for green bonds. Also, the issuers are required to report on the greenness of the bonds on a semi-annual basis.

market contains 56% investment-grade and 44% high yield bonds, and sum up to a total of EUR 106bn. The Norwegian and Swedish markets are by far the largest with respectively 50% and 40% of the total outstanding volume by year-end of 2020. In Denmark, most issuers of investment grade bonds have issued their bonds with EU legislation[8] which is partly why they only represent about 2% of the total Nordic bond market, as seen in figures 2.1a and 2.1b below. (Nordic Trustee, 2020)



(a) The Nordic investment grade market. **(b)** The Nordic high yield market.

Figure 2.1: The Nordic Bond Market 2020, EURbn (Underlying data: Nordic Trustee).

High yield

The high yield corporate bond market has shifted remarkably towards non-oil related industries the past decade. This is shown in figure 2.2 which provides an overview of the industry distribution in 2008 and 2019. We see a clear shift from oil-related industries to a more varied spectrum of real estate, industry and finance. This shift from the oil and gas sector has made the Nordic high yield market less sensitive to oil price fluctuations.

There is a substantial share of non-Nordic issuers in the Norwegian high yield market, accounting for 40% of volumes. In the Swedish market on the other hand, only 10% of new issued volumes in 2020 were issued by non-Nordic companies (Nordic Trustee, 2020). The non-Nordic issuers in the Norwegian high yield corporate bond market are primarily from shipping, oil service and telecommunication sectors, as the Oslo Exchange has a strong position in these industries. However, the share of oil-related non-Nordic issuance has had a considerable decrease in the later years.

[8]Every bond has a 12-character identification code (International Securities Identification Number, ISIN). The two first letters of the code show the bonds legislation. Norwegian bonds start with NO, Danish bonds DK, Swedish bonds with SE, etc. A majority of the Danish bonds are issued with EU legislation and hence an ISIN code that starts with XS (ISIN Organization, 2021).

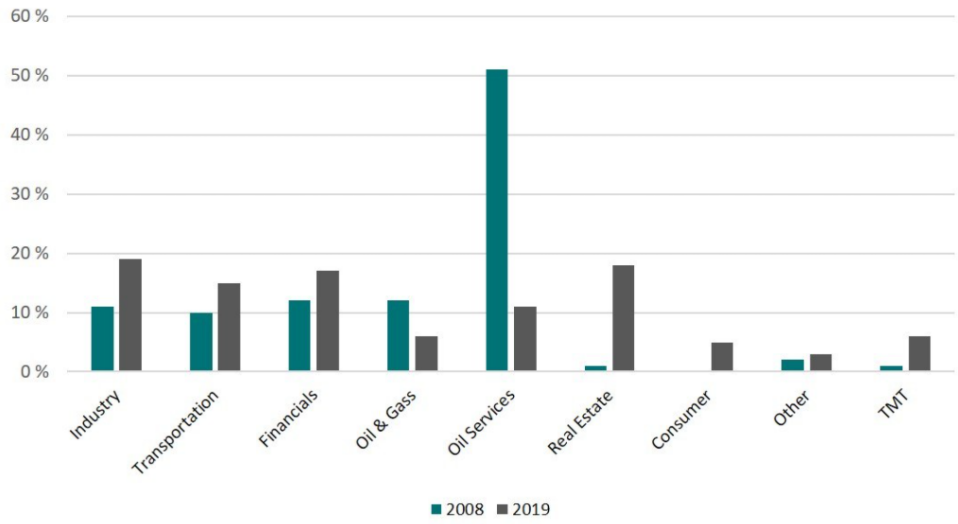


Figure 2.2: Industry distribution in Nordic high yield, 2008 vs 2019 (FIRST Fondene AS, 2021).

Investing in the Nordic high yield credit market gives investors downside protection, as the credit premiums are higher than outside the region. This is partly due to the sector composition and also the fact that the market share of smaller issuers is higher, which is generally compensated for by giving the investors a higher credit premium. The high yield market also offers the opportunity to diversify beyond the equity market. The sector composition in the Nordic high yield market is shown in appendix A1.

2.3.1 The Nordic green bond market

Being a civil law region with high focus on balancing the rights of different stakeholders instead of solely focusing on maximizing shareholder value, the Nordics have the highest ESG-scores in the world (Liang and Renneboog, 2016). As a result, the Nordic green bond market has grown tremendously during the last decade and has put the Nordic countries on the map by its many "firsts". It was Norwegian research institute CICERO who provided the second opinion when the inaugural green bond was issued by the World Bank in 2007. Swedish Vasakronan's green bond in 2013 was the world's first corporate green bond issuance, and the Swedish City of Gothenburg was the first city to do so the same year. Odfjell SE was the first company in the shipping industry to issue a sustainability-linked bond[9] which marked a milestone for a "brown" industry heading

[9]A sustainability-linked bond is a forward-looking instrument where issuers are committing explicitly to future improvements in sustainability outcomes. It differs from green bonds in the sense that the proceeds are not ring-fenced to be applied towards green or sustainable purposes. (ICMA, 2020)

towards greener technology. Oslo Stock Exchange (now Euronext) increased the visibility of green investment choices when they became the first stock exchanges in the world to implement a separate list for labelled green bonds in 2015 (Nordnet, 2020).

The total outstanding volume in the Nordic corporate green bond market has grown about 30-60% annually since 2016 and reached EUR 14bn by the end of 2020. While still trailing Nordic issuance leader Sweden, the Norwegian market stands out with the highest growth rate among the Nordic countries last year, mainly led by increased issuance from the financial and utility sector. Sweden is the largest issuer of the Nordic green bonds and holds approximately 66% of the volume, but the recent years tripling issue volume in Norway has been a sign of increased Norwegian demand by investors. The green bond market in Denmark and Finland has yet to see the same growth as in Norway and Sweden, and the countries contribute 2% and 3.5% to the Nordic green bond market, respectively (Nordic Trustee, 2020).

According to DNB analysts Kjennerud and Heen (2021) 14% of the total high yield bond volume issued in the Nordics in 2020 were labeled as green. So far this year, the share has increased to 21%. The sector composition in the Nordic green high yield market is visualised in figure 2.3:

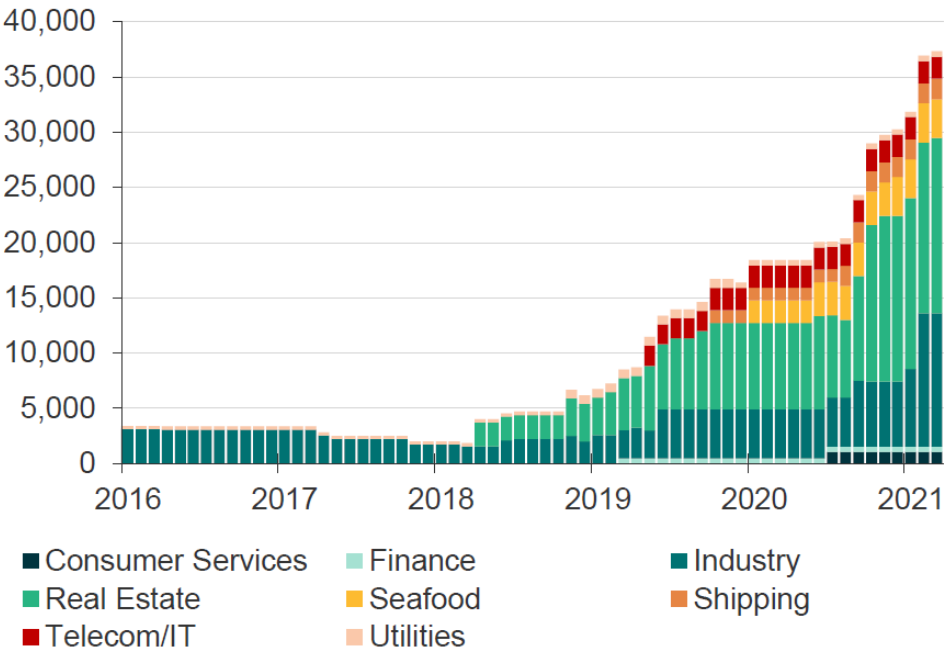


Figure 2.3: Nordic high yield: amount outstanding of green bonds, NOKbn. Underlying data: Stamdata, further calculations: DNB Markets (Kjennerud and Heen, 2021).

Figure 2.4 shows the growth of the Nordic green bond market as a percentage of the overall Nordic corporate bond market for the past five years. We can see that green bonds are representing a larger and larger share of the bond market.

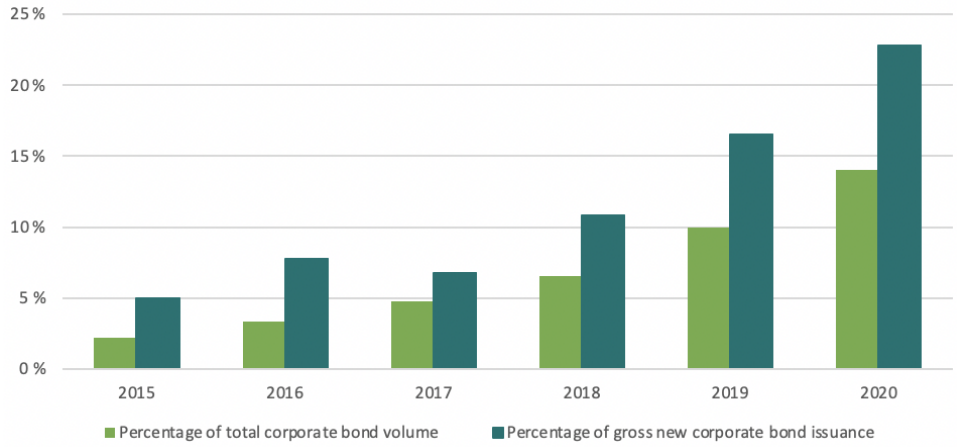


Figure 2.4: The growth of the Nordic green bond market compared to the overall Nordic corporate bond market. Underlying data: Nordic Trustee.

In November 2017, Norway's Government Pension Fund announced that they would intent to divest fossil fuel investments, and since 2015 they have published annual reports on their responsible investments (Norges Bank Investment Management, 2020). This change in investor behavior from such a large-scale fund has brought other asset managers to re-assess their portfolios and align to climate improvement. The Swedish pension fund AP7 also made an active statement when selling its investments in six energy companies which were said to violate the Paris Agreement (AP7, 2017). We clearly see a trend that the pension funds from the region, such as Norway's biggest pension company KLP (2021) and Denmark's largest pension and processing company ATP (2020), integrate sustainability in their investment strategies and lead the way in the transition to a low-carbon economy. In the next section, we will outline the literature review for this master thesis.

3 Literature review

This section will provide an overview of the existing literature on green bonds, investor motivations for sustainable investing and how ESG has affected the performance of investment portfolios.

3.1 Green bonds

An emerging research literature on green bonds is trying to understand their necessity; whether the green label is merely a marketing gimmick and how the risk and return characteristics of green bonds differ from their "brown" counterparts. Within the topic of greenwashing, Flammer (2020) did a study on the environmental performance of companies post the issuance of green bonds and found a significant improvement in ESG rating and a decrease in CO_2 emissions. These findings are inconsistent with the marketing gimmick argument.

Inderst et al. (2012) were among the first to study the benefits of green bonds to investors. Based on low correlation with other fixed income securities, they argued that green bonds provided good diversification benefits and should therefore be viewed as an attractive investment. Other studies look at the yields of the asset class compared to their brown counterparts, with several studies reaching the conclusion of either no yield premium for green bonds (Tang and Zhang, 2020; Climate Bond Initiative, 2017; Larcker and Watts, 2019) or a negative yield premium between 18 and 26 basis points (Ehlers and Packer, 2017; Barclays, 2015; Baker et al., 2018). However, these premiums are measured in the primary market and will not necessarily translate into a significant underperformance in the secondary market, where the primary focus of this thesis is. As explained by Ehlers and Packer, the secondary market investors may price in a different premium than investors in the primary market, and the latter will have decided *ex-ante* whether it is more beneficial to hold the bond to maturity or to cash in the premium.

3.2 Investors

Prospect Theory, first developed by Kahneman and Tversky (1979), tells us that investors are to a higher degree negatively impacted by losses than they are positively impacted by gains of the same magnitude. They should, in other words, be willing to trade off some returns in periods of non-crisis for the downside protection ESG firms seem to offer in periods of crisis. However, the academic research surrounding the topic of investors willingness to trade wealth merely for societal benefits, is mixed. Two securities with the same risk and return characteristic, according to no-arbitrage theory, should be priced identically regardless of ESG-rating. However, a growing amount of academic research suggests that investors are willing to pay a premium for securities that contribute to societal or environmental improvement. Maltais and Nykvist (2020) surveyed investors in Sweden and found that social preferences and business-case incentives, rather than financial incentives are the most important motivational driver for holding green bonds. The investors holding these bonds expressed their willingness to accept the potential of weaker returns to invest according to their own ethical standards. Similarly, Martin and Moser (2016) did a study on how investors respond to news on CSR and found evidence that investors reacted positively to reports of green investments by companies, even when the investments had no implications on future cash flows. The conclusion was in the end that both investors and managers trade off wealth for societal benefits. These findings suggest that investors value sustainability in companies and are willing to give up financial returns in order to invest according to their own social preferences. In such case, an index consisting of green bonds would not necessarily have to provide competitive returns in order to be seen as attractive for investors.

It is, however, questionable whether these results and conclusions are transferable to real market settings. Larcker and Watts (2019) and their research on the United States municipal green bond market concluded that investors in real market settings, when risk and return are known *ex-ante*, appear unwilling to pay extra to invest in environmentally sustainable projects unless the projects provided favorable financial benefits. The greenium, known as the potential extra cost investors are willing to pay to acquire green securities, was essentially zero. They also concluded that although these results wouldn't necessarily be transferable to the corporate bond market, the willingness for investors to pay a

potential greenium would most likely be revealed in the municipal bond market.[10]

The results provided by Larcker and Watts seem to be in line with what Nordic fixed income investors consider their motivation for integrating ESG in their portfolios. A survey of Norwegian institutional fixed income investors undertaken by Norsif (2018) concluded that these investors' primary motivation for ESG integration is to decrease downside risk and increasing risk-adjusted performance. Similarly, Biel and Jansson (2011) surveyed Swedish institutional investors who were mostly motivated by the possibility of reducing financial risk. In other words, to appeal to our targeted investor segment, our Green Bond Index would most likely have to provide return and risk characteristics that are competitive with what the overall market is offering.

3.3 Sustainability and performance

This section will focus on the published literature regarding the performance of socially responsible portfolios, both stocks and bonds. The impact of ESG on mutual fund performance is mixed at best, and there is still no consensus about whether ESG-based investing helps or hurts performance (Gerard, 2018). There are reasons to believe that ESG considerations actually hurt performance and expected returns. Hong and Kacperczyk (2009) show that investing in companies with high ESG performance yields a lower return than investing in companies deemed socially irresponsible, with the reason being that socially irresponsible companies are deemed as riskier by investors, who in turn require a higher return as compensation. Bolton and Kacperczyk (2020a,b) take this notion a step further and present a global sample of companies with high carbon emissions. They find that companies with higher carbon emissions in the US, Europe, and Asia are rewarded with higher stock returns and confirm the existence of a carbon premium. This carbon premium is, among others, the result of investors divesting and negatively screening companies deemed not to be environmentally friendly. As debt markets are less transparent than equity markets[11], it's hard to say whether this carbon premium

[10]Due to the fact that the issuance size of municipal bonds is smaller than for corporate bonds, investors with utility for green investments in the municipal bond market have a higher chance of being the ones who set the price of the bonds. In the much larger corporate bond market, these investors will to a less degree have the capacity to affect bond prices.

[11]Mutual funds and institutions are required to disclose their equity positions on a semiannual basis. However, no such requirement is needed for bond positions.

is transferable to bonds. Views from the other side of the spectrum state that "there is a mounting evidence that funds which observe environmental, social and governance (ESG) standards in their strategies tend to outperform those that don't by a significant margin" (Financial Times, 2017a). Nofsinger and Varma (2014) look at the performance of socially responsible funds during market crises and find a significant outperformance compared to conventional mutual funds during periods of turmoil in the market. This outperformance does, however, come at the cost of underperforming during non-crisis periods. Looking specifically at the performance of socially responsible bond funds from 2001 to 2014, Henke (2016) documents that these funds outperform their conventional counterparts by about 25 basis points a year in the US and about 50 basis points in the Eurozone. Again, the outperformance stems from abnormal returns in periods of marekt turmoil. With the worldwide impact of the Covid-19 crisis on financial markets fresh in mind, these findings are particularly interesting.

On a firm level, different aspects of social responsibility have been examined in recent years. A meta-study conducted by Friede et al. (2015) concluded that 90% of academic research finds a nonnegative relationship between social responsibility and financial performance. Similarly, Eccles et al. (2014) has presented evidence for a positive relationship between sustainability and profitability, where high sustainability firms outperform low sustainability firms, both on stock market performance and accounting based performance. ESG engagement on a firm level also leads to more motivated employees, which again results in positive abnormal financial returns (Edmans, 2012; Jørgensen and Pedersen, 2018). Concerning ESG and the downside risk of firms, Hong et al. (2019) concluded that firms with good ESG-scores receive significantly more lenient sanctions and settlements from lawmakers than firms with low ESG-scores, and that firms with good ESG scores outperform their low ESG counterpart by an average of 2.4% in the stock market in the six months following the date the sanctions are made public.

It is important to note that although these studies mostly look at equity values, they are still relevant for bondholders, as changes in firm value will affect the firm's creditworthiness (Gerard, 2018).

3.3.1 Comparing indices performance

There exists a limited body of literature on the performance of sustainable and socially responsible indices, and most of these focus on the equity markets.

Statman (2000) was the first to make a comparison between a socially responsible and a conventional stock index when he compared the Domini Social Index (Now the MSCI KLD 400) to the S&P 500. His findings were that although the Domini performed better than the S&P 500, none of the differences in risk-adjusted returns were statistically significant. A few years later, he broadened his study to include more stock indices: the Domini Social Index, the Citizens Index, the Calvert Social Index, and the US portion of the Dow Jones Sustainability Index (Statman, 2006). He found that, in general, the socially responsible indices performed better than the S&P 500 while having higher ESG-scores at the same time. Despite high correlations between the socially responsible funds and the S&P 500, tracking errors were substantial.

Ehlers and Packer (2017) contribute to the literature by comparing four green bond indices to the overall market over a 36 month period between July 2014 and June 2017, making it one of the first studies on sustainable bond indices. After analysing and comparing their hedged returns[12] and volatility, the authors found that some of the green bond indices showed slightly better risk-adjusted returns than their conventional peers, although the results were not statistically significant. This outperformance was mostly driven by lower levels of volatility than the rest of the market.

Similarly, Medda and Partridge (2018) look at the financial performance of US municipal green bond indices between October 2014 and October 2017 compared to the overall municipal bond market, with sub-indices for different sectors and states. Interestingly, all indices outperformed their conventional counterparts in terms of both Sharpe Ratio, Information Ratio and alpha. Also, in this study, the outperformance was mostly driven by markedly lower levels of volatility.

Our study will contribute to the literature by looking at the Nordic high yield green bond

[12]The returns in US dollars that can be achieved by hedging the currency exposures of the underlying index. This limits the effect of currency movements and makes the results more comparable across indices that differ in currency composition and exposure. Hedging was done by selling foreign currency forwards at one-month forward rates. This is further explained in section 5.3.3.

market specifically, and analyzing the performance of this asset class over time by creating a green bond index. Further, it will analyze whether the asset class is better equipped at hedging downside risk in periods of market turmoil. As far as our understanding goes, neither has been done in the Nordic marketplace before. The study will therefore contribute valuable insights for investors looking to invest in green bonds in the Nordics.

4 Theory

4.1 Risk and performance analysis

4.1.1 The Capital Asset Pricing Model

The econometric modelling of abnormal returns in this thesis is based on the Capital Asset Pricing Model. This model, called CAPM for short, was developed in various articles by Treynor (1961, 1962), Sharpe (1964), Lintner (1965b,a), and Mossin (1966) and is based on Markowitz's (1952) model on diversification and modern portfolio theory. Markowitz assumes that investors are rational, risk-averse, and views the investment outcome as a probability distribution. The two parameters that form the basis of an investor's portfolio choice are the expected future wealth and risk, measured in standard deviation. The utility function is as follows:

$$U = f(E_w, \sigma_w) \tag{4.1}$$

where E_w stands for expected future wealth and σ_w is the estimated standard deviation of the likely discrepancy between what the expected future wealth is and what the actual future wealth is (Sharpe, 1964). The combination of a risky tangency portfolio and a risk-free asset will therefore be the basis for all mean-variance efficient portfolios (Fama and French, 2004).

The equation of the CAPM is as follows:

$$E(R_i) = R_f + \beta_{iM}[E(R_M) - R_f] \tag{4.2}$$

where $E(R_i)$ is the expected return of the portfolio, R_f is the risk-free rate, and $E(R_M) - R_f$ is the excess return of the market portfolio. β_{iM} measures the correlation of the portfolio return with the excess market portfolio return, and R_f is the return of a risk-free asset with no correlation with the market, otherwise known as a "zero-beta asset" (Fama and French, 2004). Although the CAPM theoretically should be able to price all assets, it should be noted that it is most commonly applied to equity. Extra care should therefore be taken when evaluating risk using the CAPM for fixed-income investments.

4.1.2 Performance Indicators

Risk and performance measurement is an active area for academic research and is essential to investors who want to make informed decisions. Brown and Reilly (2012) presents some of the most famous and widely used measures for assessing the performance of a portfolio – the Sharpe ratio (Sharpe, 1966), the information ratio (Grinold, 1989), and Jensen's Alpha (Jensen, 1968). These performance measures aim to standardise performance results by accounting for the risk taken to achieve portfolio returns. Normally when using risk-adjusted performance measures to compare portfolios, the differences in investment mandates should be kept in mind. However, there is little need for such consideration when analyzing and comparing indices from the same region. The portfolio's benchmark serves as the reference point when performing relative risk adjustments.

The Sharpe Ratio

$$S_p = \frac{r_p - r_f}{\sigma_p} \tag{4.3}$$

The Sharpe ratio is a widely used measure of risk-adjusted performance. It is computed by dividing the portfolios' return in excess of the risk-free rate by its standard deviation. A higher Sharpe ratio indicates that the portfolio is able to generate a higher expected return per unit of risk. The Sharpe ratio allows us to directly compare the risk-adjusted performance of two portfolios, regardless of levels of volatility or benchmark correlation.

The Information Ratio

$$IR_p = \frac{(r_p - r_b)}{\sigma(r_p - r_b)} \tag{4.4}$$

The information ratio is calculated by dividing the mean of the portfolio's return relative to the benchmark's return, otherwise known as the alpha, by the standard deviation of the portfolio's active return, known as the tracking error. The information ratio measures both risk and return in terms of deviations from the reference index. The information ratio is similar to the Sharpe ratio in that they both measure performance per unit of risk, and they are identical when the risk-free rate is used as a benchmark. However, the information ratio can also provide an indication of whether the portfolio is able to outperform its benchmark on a consistent basis.

Jensen's alpha

$$\alpha_i = R_i - R_f - \beta_i(R_M - R_f) \tag{4.5}$$

One of the central assumptions of the CAPM is that all differences in expected return are explained by the portfolio's exposure to the overall market, otherwise known as beta. Beta measures systematic risk and is estimated by regressing the portfolio returns in excess of the risk-free rate on the benchmark's excess return. The alpha is the average return that is left after correcting for the portfolio's beta and can be interpreted as the part of the portfolio returns that can be accredited to the portfolio manager's ability to generate risk-adjusted excess returns. While conventional fund alpha measures the value of active management, the potential alpha for our index will reflect the influence of social screens and future environmental and policy risk on average portfolio risk and return. Unlike the Sharpe ratio or the information ratio that both assume all risk to be relevant, Jensen's alpha assumes that only the risk that cannot be diversified away is important.

4.2 Liquidity

As mentioned in section 2.2.4, green bonds may have the advantage of being a more liquid asset than their conventional or "brown" equivalents in periods where the markets are more volatile. Liquidity measures can therefore be used to detect the risk premium and monitor different aspects of market liquidity.

Foucault et al. (2013) defines liquidity as "the degree to which an order can be executed within a short time frame at a price close to the security's consensus value". If markets are illiquid it means that the investors face higher trading costs because securities are costlier to buy, and sell for less compared to a liquid security. When the market is illiquid, a larger bond purchase or sale will move the market price. The less liquid the market is, the larger the price movements, and hence the more volatile the market.

According to Foucault et al. (2013), there are three types of liquidity. The first is market liquidity, which is the ability to trade a security quickly at a price close to its fundamental value. Second, we have funding liquidity which is the ability to obtain credit at acceptable terms and to meet financial obligations.Funding and market liquidity are mutually reinforcing in good times, and mutually hurting in times of crisis because if

market liquidity dries up it increases the risk of financing trade and margins get higher. Lastly, we have monetary liquidity which is the money supply provided by the central bank. This affects funding liquidity by enhancing banks' ability to lend out money and increase credit. By affecting funding liquidity, monetary liquidity also affects market liquidity, especially during a crisis where monetary expansion is associated with greater liquidity in the bond and stock markets.

In limit order markets, where buy and sell orders are matched in a single marketplace, traders can submit limit orders or market orders. Limit orders are liquidity providers as they form the limit order book, and market orders are liquidity demanders as they are matched against already submitted limit orders. In dealer markets, however, the trade typically happens over-the-counter (OTC) with a dealer that posts quotes to investors. After a trade between an investor and a dealer happens, the dealer goes to the "interdealer market" and trades the security with other dealers in order to get rid of his position. In the OTC markets, the dealers provide liquidity to the investors when posting prices. Corporate bonds are often traded in OTC markets.

4.2.1 Measuring liquidity in bond markets

There are several measures of market liquidity in OTC markets such as the corporate bond market. They can be categorized as price impact measures, volume-based measures and transaction cost measures. The Amihud ratio is the most used price impact measure and measures how much traded volume is needed to change the price one percent (Foucault et al., 2013). Volume-based measures use order and trade size to see whether or not the market can absorb large volumes within a short time period. As we do not have volume data and only limited transaction data for the green bonds, we will not go into detail on these measures.

The quoted bid-ask spread is one of the most widely used liquidity measures in the bond (and stock) market and equals the difference between the highest quoted bid price (b) and the lowest quoted ask price (a). The spread is defined as:

$$S \equiv a - b \tag{4.6}$$

The mid price is defined as:

$$m \equiv \frac{a+b}{2} \tag{4.7}$$

The relative spread is the spread as a percentage of the mid price:

$$s \equiv \frac{S}{m} = \frac{2(a-b)}{a+b} \times 100\% \tag{4.8}$$

5 Methodology

Designing, constructing, and maintaining indices for corporate bonds is a far bigger challenge than creating indices for equities. While a company mostly has only one listed stock on an exchange, the same company can have several bonds outstanding, all with different sizes, maturities, currencies, and yields (Campani and Goltz, 2011). As a result of this, extra caution concerning index objective, criteria, and construction methodology is taken. The first part of this section will therefore provide concrete guidelines and motivations for all decisions undertaken in order to complete our Nordic High Yield Green Bond Index. The second part will provide the methodology for calculating values used in the analysis in chapter 6.

5.1 Index objective

The Nordic High Yield Green Bond Index is composed of a universe of Nordic Bonds aligned with the Green Bond Principles and subject to the eligibility criteria. It is a market value-weighted index designed to replicate and track the performance of green corporate high yield bonds in the Nordic market.

The purpose of this index is to serve investors with a Nordic investment mandate, that are interested in the Nordic green bond market. It is important that the index is a valid representation of the asset class and that it mirrors the market in which ordinary investors actually invest. This makes the methodology an important factor when constructing the index. The eligibility criteria in section 5.2 are based upon best practice combined with our subjective assessment in order to make the index consistent with international practice and the investors' investment mandate. We do not aim to include bonds that are on the periphery of what is considered the Nordic market.

We want our index to be a realistic basis for investment purposes. However, it is also important that it can act as an indicator of the market price of green bonds. Hence, the index must enable the investor to observe the overall performance of the green bond market in aggregate and how this market has evolved over the past years.

Constructing a bond index can seem somewhat more complicated than constructing a

stock index, as these types of securities have very different characteristics. The bond market is larger and changes more frequently as new bonds are issued and existing bonds mature or get called. There can be multiple bonds issued by the same entity which hold different risks. Also, stocks are typically traded in limit order markets where liquidity is high, while bonds are traded OTC with a dealer who posts quotes. This impacts pricing because continuous transaction data are not available for bonds. We get further into this matter in section 5.3.1.

5.2 Eligibility Criteria

The Eligibility criteria are mainly based upon recommended principles such as the S&P Construction Methodology for fixed income securities (2021a) and Bloomberg Barclays Index Methodology (2016). The Nordic bond market differs from the global bond market, which demands some deviation from international bond index practice. This can be seen especially when considering market size and the coupon type, as Nordic bonds are typically smaller and more often have floating interest rates. We therefore also include DNB's practice of index construction in our assessment. A summary of our and the benchmarks' criteria can be found in table 5.1 at the end of this subsection.

It is important that the index is representative of the market targeted in this thesis, and reflects the available investment opportunities. Furthermore, it is also essential that the index is transparent and rule-based so that it is possible to replicate and allows users to understand the composition of the index.

Classification

For a bond to be rated as high yield, it must have a rating of at best BB+ (Fitch and S&P) or Ba1 (Moody's). See appendix A2 for rating overview. If the issuer receives a credit rating from one of the rating agencies as investment grade, the issuer's bond(s) are not eligible for the index. Bonds of issuers in default are also not eligible. Nordic corporate high yield bonds are typically issued without public rating as this is not a requirement in the Nordic market. 52% of the Swedish issued bonds hold a credit rating, whilst in the Norwegian market, the credit-rated volume is barely 27% (Nordic Trustee, 2020). Credit research managers, therefore, compute frequent shadow ratings on new issues based on

international rating agency methods.

Nordic Trustee is the leading provider of bond services in the Nordics (Nordic Trustee, 2021). When we collect the list of green bonds, we use their market and data service provider Stamdata's database. Even though Nordic bonds aren't required to have a credit quality classification, Stamdata distinguishes between investment grade and high yield. We use their classifications to find the bonds in the high yield segment. Since these two types of bonds have very different characteristics and therefore are priced differently, we only make the high yield bonds eligible for inclusion. There are other types of investors in the investment grade market (e.g., banks, insurance companies, and pension funds), which can give this segment better liquidity.

Another aspect that is important to consider when choosing which bonds to include is that there are some investment grade bonds that are mostly traded by high yield investors. Since our purpose is to create an index that matches the investors' actual investment base, these types of bonds should be included in the index. However, since we don't hold information about the buyers, we cannot take this into account. We will therefore use Stamdata's high yield and investment grade rating as our basis for classification.

Green Label

ESG rating is perhaps the key criteria when creating a Green Bond Index. There exist bonds that do not hold the label "green" but would be considered to be green based on the firm's environmental focus. Labelled green bonds only account for some of all bonds that are related to climate-friendly activities. One of the most crucial decisions in this thesis has therefore been whether or not to include unlabelled green bonds in our data set.

We believe that investors, to assure credibility, look for bonds that are labelled as green by an external reviewer[13] when choosing a climate-friendly investment. The external reviews and green label reduces the information asymmetry on greenness which is one of the most challenging aspects of this market segment. Standards, such as the EU Taxonomy and the including EU Green Bond Standard, will help define the green investments. Hovewer, since this taxonomy will not be official in the near future, the green label is currently the

[13]Such as DNV GL, CICERO, etc.

best verification that the investments are fostering climate-friendly activities. The green label is also what qualifies the bonds to Oslo Stock Exchange's list of green bonds and Nasdaq's list of sustainable debt.

Another feature regarding the green label is the question of whether to include *all* ESG-labelled bonds or only the ones that are labelled as green. Social and sustainability bonds are included in the broad sustainability category, but as our impression is that the green bonds are more applicable to the investors, we have chosen to exclude social and sustainability bonds. Sustainability-linked bonds, like the bonds issued by Odfjell SE and Seaspan Corp, are also excluded because the sustainability-linked category also supports investments that are not directly linked to climate-friendly projects.

Legislation

The first two letters of the bond's ISIN code indicate from which country the legislation originates. The Nordic bond markets differ from the US and EU markets as they demands far less documentation, which makes transaction costs substantially lower. We have therefore chosen to exclude Nordic bonds issued with American or European legislation, as the issuers of these bonds pay a higher cost to attract other international investors. We have, on the other hand, included non-Nordic companies that hold Nordic legislation (Nordic ISIN codes).

Amount outstanding

In order to keep the index representative, we require the amount outstanding to be a minimum of NOK 300m. This is a subjective assessment based on interest from ordinary bond investors and fund managers. Smaller bonds have a smaller investor universe, which also lowers the liquidity. Nordic Bond Pricing also states this as a criterion for their Regular Market bond index and Norwegian High Yield Market bond index (Annweiler, 2017). If a bond is partly repaid and the outstanding amount falls below NOK 300m, the bond will be taken out of the index at month-end when the index is rebalanced (see section 5.3.2).

Most institutional American and European investors have size requirements of 200 million

EUR or USD for their high yield indices and 750 million EUR or USD for investment grade. If a bond has a smaller notional, it is not considered an investment opportunity. MSCI, therefore, operates with roughly the same criteria for their indices (MSCI, 2020).

Maturity

Eligibility criteria differ among various indices with regards to their time to maturity. Our index includes bonds with maturity greater or equal to 1 year when measured from the rebalancing date. This is consistent with the MSCI corporate bond methodology (MSCI, 2020) and the previously mentioned Barclays' methodology (2016). MSCI also adds the feature that the new additions must have a maturity greater or equal to 18 months. Since we require at least one year to maturity, all short-term bonds that are issued with maturity $<$ 1 year are excluded.

For the majority of the S&P fixed income indices, the minimum term to maturity is at least one calendar month as of the next rebalancing date. Nordic Bond Pricing (Annweiler, 2017) uses one month as their criteria in their Regular Market bond index and Norwegian High Yield Market bond index.

This one month criterion is important because of how the bonds are priced in the secondary market. Bonds with maturity $<$ 1 year might have pricing that differs from the representative market development. If the bonds were to be included, we could get an abnormal effect when calculating duration, yield, and spreads.

We only face this problem once in the Green Bond Index, with the Scatec bond which terminates in November 2021. This bond is excluded when rebalancing the weights at the end of November 2020.

Coupon type

The Nordic bond market differs from the international market when it comes to having fixed or floating rate. The large amount of floating-rate bonds in the Nordic are present because the general interest rates on loans and mortgages are mostly floating. These bonds are bound to a reference rate, for example, Nibor or Stibor, which makes the bonds less sensitive to interest rate changes.

Most international corporate bond indices exclude floating rate bonds in their data sets. The MSCI Corporate Bond Indices and Bank of America Merrill Lynch Green Bond Index are among them. S&P chooses to not include floating-rate securities in most of their fixed income indices but includes floaters in their Green Bond Index (S&P Dow Jones Indices, 2021b). Nordic Bond Pricing's Regular Market Bond Index and Norwegian High Yield Market Bond Index both include floating rate bonds (Annweiler, 2017).

Since approximately 93% of the Nordic green bonds in our database have floating rates, an exclusion of these would make the index pointless. The only bonds with fixed interest rates are two issued by the same issuer, RE IV LTD (White Peak Real Estate), a Swedish real estate company with operations in China and, one by Kungsleden AB.

Currencies

In our selection of eligible securities, there are bonds listed in the currencies NOK, SEK, EUR and USD. Our index uses NOK as base currency, but we include all currencies in the index. We use forward and spot rates to hedge the return against currency fluctuations. Currency hedging is explained in detail in section 5.3.3.

Other excluded bonds

All **perpetual bonds** are excluded for technical reasons. Most perpetual bonds do have some sort of call feature which allows the issuer to redeem the bond at a fixed date. However, the reason for exclusion is the technical difficulties when calculating the duration of the bond.

Sinkable bonds are bonds that are backed by funds that are set aside in order to ensure principal and interest payments. They are often accompanied by call schedules which mean that the outstanding amount can be repaid by the issuer entirely or in part. Because of the uncertainty concerning when the bonds will be repaid, sinkable bonds are not included.

Private placements will not be traded in the market. These are bonds that are sold to a small number of investors, and will therefore be misleading if they are included since the index is supposed to be a representation of tradable bonds.

Eligibility criteria summarised

The following table is based on the index methodology of Nordic Bond Pricing (2020), DNB (O. A. Kjennerud, personal communication, February 2021)[14], Barclays (2016), and S&P Dow Jones Indices (2021a). As the two latter have a broad list of indices with different criteria, we have selected the most common for all their indices and/or the most comparable to our index.

[14]DNB has not publicly published their index methodology

	Green Bond Index	Nordic Bond Pricing	DNB	Barclays	S&P**
Classification	High yield	High yield	High yield	N/A	Rating required
Market of issue (ISIN)	NO, SE, DK, FI, IS	NO	NO, SE, DK, and a few XS	N/A	All
Minimum size	NOK 300m	NOK 300m	NOK 300m	NOK500m*	NOK, SEK, DKK 1bn USD EUR 250m***
Min. maturity at rebalancing date	>1 year	>1 month	>1 year	>1 year	>1 month
Coupon	Fixed and floating	Fixed and floating	Fixed and floating	Fixed only	Fixed and floating
Currencies	NOK, SEK, EUR and USD	NOK, DKK, GBP, SEK, USD, EUR	NOK, SEK, DKK, USD	N/A	Any
Optionality	Callable and Putable	Callable and Putable	Callable and Putable	N/A	Callable and Putable
Excluded bonds	Private placements Perpetual bonds	Private placements Convertible bonds	Private placements Perpetual bonds	Private placements and more	N/A
Settlement	T+1	T+0	T+1	T+1	T+0
Weights	Value-weighted	Value-weighted	Value-weighted	Value-weighted	Value-weighted
Prices	Bid	Mid	Bid	Bid*	Bid
Price source	DNB	Evaluated market price	DNB	BVAL*	Refinitiv

Table 5.1: Eligibility criteria overview.

** Based on their Pan-European High Yield Index*

*** Criteria for the S&P Green Bond Index*

**** Criteria for high yield bonds included in the S&P Green Bond Index*

N/A is used when the index provider uses different criteria for various indices and there is no obvious comparable index

5.3 Implementation and calculations

5.3.1 Data and price sources

It is important that prices are consistent and reliable throughout the bond period, which can be an issue in an illiquid market. There are several ways of dealing with this issue, and the ones proposed in Campani and Goltz's report (2011) are transaction prices, matrix prices, or dealer prices.

Since the Nordic high yield market is highly illiquid, bonds are not traded on a daily basis. This makes continuous observable transaction prices unavailable, and in addition, transaction prices in this market are usually opaque. Matrix pricing is an approach where one calculates parameters using comparable bonds with similar features (sector, rating, time-to-maturity, etc.) and thereby estimates the prices. This approach lacks the idiosyncratic risk components, and illiquidity would be challenging to cover. The last alternative pricing source is, therefore, dealer pricing. Dealers are continuously providing bid and ask prices for all kinds of bonds in the OTC market. Therefore, using dealer prices solves the consistency problem. According to Campani and Goltz (2011), most corporate bond indices are based on dealer prices.

Finding a reliable pricing source is important. DNB is one of the largest facilitators for corporate green bonds in the Nordic high yield market, and they wish to set competitive prices on as many bonds as possible. In order to keep our pricing source consistent, we have chosen to use DNB as the only pricing source, and we use the bid prices as a basis for our index. A bid price is a price where the dealer is willing to buy the bond and is, therefore, a realistic price at which the investor can sell it once it is in the portfolio. Since our price source comes from only one provider, this might be a limitation of data which will be discussed in section 7.1.

In order to provide a complete overview of all Nordic green bonds, we have used Stamdata's bond database. We filtered the data set according to our eligibility criteria in 5.2. Finally, we collected the relevant information on each bond with help from Ole André Kjennerud in DNB and excluded the perpetual bonds and private placements. Now that we had the complete set of bonds that were going to be included in the index, we obtained and

calculated the necessary data for each trading day and saved it in a database.

Settlement assumptions

Bonds are assumed to settle on the next calendar day (T+1). On the last trading date of each month, the settlement date will be the first calendar day of the following month. This assures that the accrued interest of the last trading day of the month is included when calculating one full month of accrued interest.

Time specification

The bonds are priced only on Oslo Stock Exchange business days at 16:00 Oslo time (GMT+1). When Oslo Stock Exchange closes earlier, we use the last prices available for that day. The currency fixing will be taken at the same time as the bond prices.

The index starts on the first trading day of January 2019 and ends on the last trading day of April 2021. The start date could have been set earlier, but since the number of bonds eligible before 2019 is so few, the index would consist of too much idiosyncratic risk, and it would not be representative of the market.

5.3.2 Weights

MSCI (2020) and a majority of S&P Dow Jones fixed income indices (2021a) weights its corporate bond indices by market value. We use the same approach in the Green Bond Index, where the market value accounts for both market price and accrued interest. The weight of each bond is, therefore, the individual market value divided by the market value of the total portfolio as shown in the following equation:

$$W_i = \frac{MV_i}{\sum_{i=1}^{N} MV_i} = \frac{P_i \times V_i}{\sum_{i=1}^{N} P_i \times V_i} \tag{5.1}$$

Where: W_i = the weight of bond i in the index, and MV_i = is the market value of bond i. P_i is the dirty price at the end of the month, and V_i is the outstanding amount of bond i.

Other indices might weigh each bond by the same factor, while others might use weight caps or other restrictions. An important benefit when using market value weights is that an investor would not have to rebalance her portfolio on a daily basis in order to keep the

composition equal to the reference index. The reason for this lack of need to rebalance the portfolio is because its weights will change automatically. She would only have to rebalance when there are new bonds issued or called. On the other side, a value-weighted index can be vulnerable because it might be that the most highly indebted companies get the largest weights. Companies that are highly indebted might not be able to finance the interest payments, which can make these companies riskier. This is called "the bums problem" (James West, 2017) and is sometimes overlooked by index providers. However, some providers avoid this problem by using capped weights that limit the largest bonds of representing too much of the index.

Rebalancing frequency

The composition of the index is reviewed on a monthly basis. Newly issued bonds that are eligible for the index will be included the following month after issuance. Monthly rebalancing is by far the most used in bond indices because the number of bonds that are issued, called, or matured, is high, at least for larger indices.

5.3.3 Return calculations

These calculation principles are based on the Barclays (2016) Index Methodology[15]. A total return index assumes that all coupons are reinvested in the index at the end of the month. The total return is calculated using the sum of return from price changes, accrued interest, gain/loss from repayments of principal, and currency value changes.

Bond return

The bond's return is the change in value since the start of the month and can be expressed as:

$$R_i = \frac{P_E}{P_B} - 1 \tag{5.2}$$

Where R_i is the return for bond i, P_B is the value at the beginning of the period and P_E is the value at the end of the period.

[15]Pages 57-68

The value at the beginning of the period is calculated as follows:

$$P_B = K_{i,B} + AI_{i,B} \tag{5.3}$$

Where $K_{i,B}$ is the clean price at the beginning of the period, $AI_{i,B}$ is the accrued interest at the beginning of the period.

The value at the end of the period is:

$$P_E = K_{i,E} + AI_{i,E} + C_i + PP_i \tag{5.4}$$

Where $K_{i,E}$ is the clean price at the end of the period, $AI_{i,E}$ is the accrued interest at the end of the period, C_i is coupon paid during the month and PP_i is repayment or paydown during the month for bond i.

Currency return - unhedged

Currency return is calculated for bonds denominated in SEK, EUR, and USD. It is the return from converting the local bond to the base currency NOK. It can be calculated using the following formula:

$$Currency\ return = \left(\frac{Spot_E}{Spot_B} - 1\right) \times \frac{P_E}{P_B} \tag{5.5}$$

Where $Spot_E$ is spot price at the end of the period and, $Spot_B$ is the spot price at the beginning of the period.

By combining equation 5.2 and 5.5 we can express the currency return as:

$$Currency\ return = SR_i \times (1 + R_i) \tag{5.6}$$

Where SR_i is the return (percentage change in value) for currency i and R_i is the bond return from equation 5.2.

We see from this equation that the currency return for an unhedged bond is the return in currency, also called FX appreciation (SR_i) plus the return in the currency of the bond return ($SR_i \times R_i$).

Currency return - hedged

When an investor holds a high yield bond in a different currency, she is exposed to a substantial risk of currency fluctuations. A Norwegian investor who is looking to speculate in these currency fluctuations can buy a foreign security if she believes the NOK is going to depreciate or sell a foreign security if she believes the NOK is going to appreciate over time. A high yield corporate bond could, in theory, be an example of a security that could be used for speculation, but as the Nordic high yield market is less liquid than other markets, we believe that high yield investors are not investing in these bonds to speculate in the currency market. Therefore, we assume that investors hedge their positions against currency fluctuations but not the underlying constituent risk. The currency fluctuations are hedged using one month forward contracts.

When calculating the currency return for a hedged index, we must find the return on the currency hedge. The currency hedge is one month currency forward on the projected future value of the bond and is calculated as:

$$Forward\ return = \left(\frac{Forward - Spot_E}{Spot_B} \right) \tag{5.7}$$

In equation 5.6 we see that the currency return for the unhedged index is a result of currency changes and the bond return during the month. This implies that currency risk cannot be perfectly hedged because the monthly return is unknown at the beginning of the month. Instead, we can expect the portfolio to grow at a rate that is implied by the bond yield. To find the expected growth rate, we follow the methods from Barclays (2016) and Bloomberg indices which set the projected growth rate as follows:

$$Expected\ growth\ rate = \left(1 + \frac{yield}{2} \right)^{1/6} \tag{5.8}$$

The hedged return is the product of the forward return from equation 5.7 and the expected growth rate for bond i calculated in equation 5.8:

$$\begin{aligned} Hedged\ return &= Forward\ return \times Growth\ rate \\ Hedged\ return &= FR \times GR \end{aligned} \tag{5.9}$$

Total return

We get the total monthly return by adding the bond return (equation 5.2), currency return (equation 5.6), and hedge return (equation 5.9).

$$TR_i = R_i + [SR_i \times (1 + R_i)] + FR \times GR \tag{5.10}$$

The total return for the whole index is the weighted sum of the individual bond returns.

$$R_{index} = \sum W_i + TR_i \tag{5.11}$$

We get the index value at time t by adding the daily total return for the index to the index value from the day before, $t - 1$:

$$Index_t = Index_{t-1} \times (1 + R_{index}). \tag{5.12}$$

To calculate get the cumulative return for each time t we use the following equation:

$$cumulative\ return = \frac{Index_t}{Index_B} - 1 \tag{5.13}$$

Where $index_B$ is the index value at the beginning of the period.

In an effort to generate enough observations for robust results, we look at daily index values instead of end-of-month values, which are more commonly used in performance analysis. We get the average daily returns by adding all daily returns and dividing them by the number of trading days in the period. This result, known as the arithmetic mean, will experience that the power of compound interest will inflate the average daily rate of return that would have produced the total cumulative return during a period. We can therefore change the arithmetic mean to a geometric mean, an approach that is also regarded as the industry standard (Jaquier et al., 2003). The geometric mean of daily returns is calculated as follows:

$$\overline{r}_g = \sqrt[T]{\Pi(1 + r_t)} \tag{5.14}$$

with $\overline{r}_g$ being the geometric mean over a period of T days.

Risk calculations

The most common measure of risk and uncertainty for securities is the standard deviation, otherwise known as volatility (Bhowmik, 2013). We calculate the daily standard deviation for our indices and their benchmarks as follows:

$$\sigma_d = \sqrt{1/T \times \Sigma(r_t - \overline{r})^2} \tag{5.15}$$

where σ_d is the daily standard deviation, $\overline{r}$ is the average daily return, and T is the total number of days in the period used to calculate the standard deviation. Annualised and total period standard deviations are measured by multiplying the daily figures by the square root of the number of trading days in the period.

The **tracking error** is an indicator of how much the returns of the index swing compared to its benchmark. It is defined as the standard deviation of the difference in returns between the index and its benchmark.

$$\hat{\sigma}_{rrel} = \sigma(r_t - rb_t) \tag{5.16}$$

Risk-free rate

To be considered as an investment option, a portfolio needs to overcome a minimum hurdle rate, such as the return of a completely safe, liquid investment, otherwise known as the "risk-free rate". A portfolio's return minus the risk-free rate is known as the excess return. As our index and the benchmarks are denominated in Norwegian krone, we use the synthetic yield on a three-month Norwegian Treasury Bill (otherwise known as a Statskasseveksel) as a proxy for the risk-free rate, following the approach of Koller et al. (2015). The rates are obtained from Norges Bank.

5.3.4 Duration

Macaulay duration, sometimes also referred to as credit duration, is the weighted average time to maturity to which the investor receives the remaining cash flow.

$$D_i = \frac{\sum PV(C_t) \times t}{\sum PV(C_t)} \tag{5.17}$$

Where $PV(C_t)$ is the present value of the cash flow (coupon) at time t.

The index weighted Macaulay duration is the weighted sum of the individual bond's duration:

$$D_{index} = \sum W_i \times D_i \tag{5.18}$$

Modified duration describes the price sensitivity of a bond due to changes in the interest rate level. Bonds that have floating interest rates are not very sensitive to interest rate changes since their modified duration would be the time to the next coupon payment. This means a modified duration of a maximum of 0.25 when coupons are paid quarterly. Our eligible green bonds are mostly floating interest bonds which give the index a low modified duration. Modified duration is therefore not something we will analyze further.

5.3.5 Yield

Yield to maturity (YTM) or yield to worst[16] is the interest rate at which the present value of the bond's cash flows equals the market price.

$$P_i = \sum_{t=1}^{T} \frac{C_t}{(1+Y_i)^t} + \frac{FV}{(1+Y_i)^T} \tag{5.19}$$

Where C_t is the coupon at time t, FV is the bond's face value at maturity T.

A good approximation to the average yield for the index can be found by using the duration weighted average sum of the individual bond's YTM.

$$Y_{index} = \frac{\sum Y_i \times D_i \times W_i}{\sum D_i \times W_i} \tag{5.20}$$

[16]The earliest call or retirement date.

High yield corporate bonds tend to be more exposed to defaults and liquidity risk as they have lower trading frequencies.

5.3.6 Credit spreads

An asset swap is an instrument used for hedging against interest rate risk. It is the difference between yield to maturity of the bond and the underlying reference rate (Nibor, Stibor, Euribor, etc.) and is calculated based on the annuity of the present value of the cash flow using zero-coupon rates. It is given by the following expression:

$$ASW\ spread = \frac{P_{irs} - P_i}{A_{irs}} \tag{5.21}$$

Where P_{ibor} is the bond value after it is discounted with the -ibor rate, P_i is the price of the bond and A_{irs} is the -ibor discounted present value of a 1 basis point (bp) coupon stream.

High yield corporate bonds tend to have lower trading frequencies and a higher chance of defaulting and are therefore more exposed to liquidity and default risk. Hence, the expected return is lower than the YTM. When the expected loss increases because of market conditions or idiosyncratic risk, the investors demand higher compensation, and therefore a higher spread.

An asset swap spread can be illustrated in the following figure:

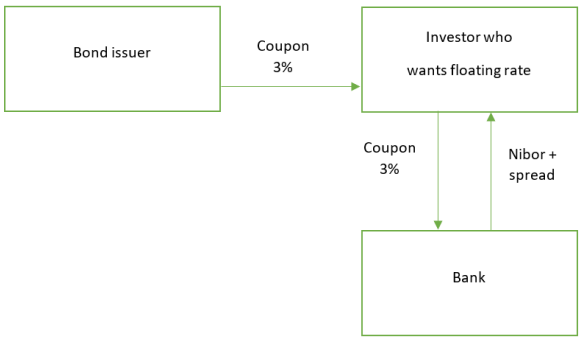


Figure 5.1: Asset swap spread, illustration.

Z-spread

Nordic Bond Pricing only provides measures for the average Z-spread. The Z-spread

also covers credit risk and is very similar to the asset swap spread. The Z-spread is the constant and static spread that is added to the zero-coupon bonds to discount the bond's cash flow so that the discounted cash flow equals the price. The asset swap spread and the Z-spread does not differ much for bonds with shorter maturities and better credit quality unless the bond is mispriced (Choudhry, 2005).

5.4 Risk-adjusted returns

In the following section, the methodology used for calculating daily risk-adjusted returns and confidence intervals is described. r_t, rb_t and rf_t are defined as the portfolio return, benchmark return, and the risk-free asset on day t. T is the total number of trading days used in the sample period.

When choosing a benchmark index, there are several considerations to take. The most important being that it is a representation of the Nordic high yield market so that it becomes a meaningful comparison to our Green Bond Index.

There are very few providers of Nordic high yield bond indices. One of the most widely used as a benchmark by Nordic high yield funds is Nordic Bond Pricing's "Norwegian HY Aggregated Index NOK". This is the benchmark used by, for example, Alfred Berg's Nordic High Yield ESG fund that was launched in March 2021[17]. Furthermore, NBP's hedged index also serves as a benchmark for DNB's "Nordic High Yield A" fixed income fund.

As the Nordics' biggest provider of bond services, Nordic Bond Pricing is perhaps the most objective provider of benchmark indices that cover the Norwegian corporate bond market. We saw from figure 2.1b that Norwegian high yield bonds represent about 59% of the Nordic high yield market. In addition, the oil-related industries, which are present mainly in Norway, now make up a smaller share of the market than in previous years. Less oil-related industries makes the Norwegian bond market more similar to its Nordic neighbours. Because of the high share of Norwegian bonds in the Northern market, and because we see that Nordic funds use this index as their benchmark, we believe Nordic

[17]The authors found that other Nordic HY funds either use a flat hurdle rate as benchmark, or do not use a benchmark at all.

Bond Pricing's index would serve as the most appropriate benchmark for our Green Bond Index.

DNB also provides an index of high yield bonds covering the Nordic market. This index is not approved as an authorised benchmark because DNB is not a publicly recognized index provider due to regulations and their commercial motive. However, investors might use this index unofficially as it is easily accessible in Bloomberg. As this index covers the Nordic high yield bond market as a whole, we will also compare the results of our index to this benchmark.

We argued in section 5.3.3 why we believe investors' aversion to currency fluctuations makes hedged indices preferred. We therefore use NBP's and DNB's hedged indices as a comparison to our hedged index.

	Green Bond Index	Nordic Bond Pricing	DNB
Market	Nordic countries	Norway	Nordic
Credit quality	High yield	High yield	High yield
Number of bonds included*	33	210	233
Base currency	NOK	NOK	NOK
Green Bonds	Included and limited to	Included but not limited to	Included but not limited to
Start date	02/01/2019	02/01/2015	01/10/2015
Average coupon	3.98%	6.07%	6.19%
Average yield	3.89%	7.78%	7.16%
Average duration	3.02	2.36	2.59
Average spread (bp)	369 (ASW)	681 (Z-spread)	590 (ASW)

*as of April 30th, 2021

Table 5.2: Additional summary of our Green Bond Index and the benchmark indices. Average coupons, durations, yields, and spreads are calculated for the period January 2nd, 2019 to April 30th, 2021.

5.4.1 Sharpe ratio

The Sharpe ratios are measured using the methodology presented by Lo (2002). The formula for the daily Sharpe ratio is

$$\widehat{SR}_d = \hat{\mu}_{rx}/\hat{\sigma}_r, \tag{5.22}$$

where Rx_t is the portfolio excess return $r_t - rf_t$, $\hat{\mu}_{rx}$ is the sample average of index excess returns, and $\hat{\sigma}_r$ is the sample standard deviation. The same method is used when calculating the Sharpe ratio of the benchmarks. Annualised and total period Sharpe ratios are computed by multiplying the daily Sharpe ratio by the root of the number of trading days at Oslo Stock Exchange in the sample period. There were 251 trading days in 2019, 254 trading days in 2020 and 82 trading days between January 1st, 2021, and April 30th, 2021, which was the last day that we ran the index. For the entire sample period, the total number of trading days was 587.

$$\widehat{SR}_a = \widehat{SR}_d \times \sqrt{T}. \tag{5.23}$$

This method of annualisation assumes that daily returns have zero autocorrelation and can therefore only be used as an approximation. However, as it is the most conventional method of annualising Sharpe ratios, the results are comparable. 95% confidence intervals around the annualised and total sample Sharpe ratios are computed to understand the level of uncertainty in the estimates. The formula for this is:

$$\widehat{SR}_a \pm 1.96 \times se(\widehat{SR}_a) \tag{5.24}$$

where

$$se(\widehat{SR}_{2019-2021}) = \sqrt{587(1 + (1/2 \times \widehat{SR}_d^2))/T}, \tag{5.25}$$

$$se(\widehat{SR}_{2019}) = \sqrt{251(1 + (1/2 \times \widehat{SR}_d^2))/T}, \tag{5.26}$$

$$se(\widehat{SR}_{2020}) = \sqrt{254(1 + (1/2 \times \widehat{SR}_d^2))/T} \tag{5.27}$$

and

$$se(\widehat{SR}_{2021}) = \sqrt{82(1 + (1/2 \times \widehat{SR}_d^2))/T}. \tag{5.28}$$

The confidence interval formula is an asymptotic approximation that is based on the assumption of normally, independently, and identically distributed daily returns. This assumption is made for simplicity purposes and to be consistent with the way Sharpe ratios are annualised using daily data. The critical value of 1.96 is used when calculating confidence intervals for the other measures of risk-adjusted performance as well.

5.4.2 Information ratio

The formula for the daily information ratio is:

$$\widehat{IR}_d = \hat{\mu}_{rrel}/\hat{\sigma}_{rrel} \tag{5.29}$$

where $rrel_t$ is the relative return on day t, $r_t - rb_t$, $\hat{\mu}_{rrel}$ is the sample average of relative returns, and $\hat{\sigma}_{rrel}$ is the daily tracking error. The annualisation and total sample calculation of daily information ratios, as well as the computing of confidence intervals, are set up the same way as with the Sharpe ratios.

5.4.3 Jensen's alpha

The CAPM regression uses consequently the two benchmarks, NBP Norwegian HY Aggregated Index NOK Hedged and DNB Nordic High Yield Index Hedged as a proxy for the market portfolio. The regression formula is:

$$rx_t = \hat{\alpha}_d + \hat{\beta} bx_t + \varepsilon_t \tag{5.30}$$

where bx_t is the benchmark excess return over the risk-free rate on day t, $rb_t - rf_t$, and rx_t is the portfolio excess return on day t, $r_t - rf_t$. Jensen's alpha is measured on a daily basis as the intercept of an Ordinary Least Squares (OLS) regression:

$$\hat{\alpha}_d = \hat{\mu}_{rx} - \hat{\beta}\hat{\mu}_{bx} \tag{5.31}$$

where $\hat{\beta}$ is the OLS estimate of the slope coefficient in the regression in equation 5.30, and $\hat{\mu}_{bx}$ is the sample average of benchmark excess returns. The annualised and total period alphas are calculated by multiplying the daily alpha by the number of trading days in the respective period. A 95% confidence interval around the annualised and total period alfas is computed by multiplying the OLS standard error of the intercept in the daily regression by the number of trading days in the period. To remove any potential influences of autocorrelation and heteroskedasticity on the excess returns used in our regression, we use the Newey-West procedure (Newey and West, 1987) to create robust standard errors.

6 Analysis and results

In this section, we present the results from an empirical analysis on the performance of our Green Bond Index in recent years. Our index will simultaneously work as a proxy for how ESG affects risk, return, and pricing in fixed income markets. Our main goal is to test whether ESG-investments can lead to a significant difference in performance between climate-conscious and regular indices to help motivate green investments in the Nordic marketplace. We also explore how exposed our index is to periods of turmoil in other markets compared to more conventional indices. To begin our analysis, we look at how the index has performed in the market compared to our chosen benchmarks. Then we study the results of the single-factor CAPM regressions, and furthermore, we look at the liquidity and credit risk of the Green Bond Index compared to the benchmarks.

6.1 Index and benchmark return

Table 6.1 shows some descriptive statistics of the different indices. Our Green Bond Index has had a compound annual growth rate of 4.6% over the period between January 1st, 2019 and April 30th, 2021, which is the highest rate of all three indices. When looking at standard deviations, our index also appears to be less volatile compared to the benchmarks. As a result, our Green Bond Index has had the highest annualised Sharpe Ratio of the three.

As we see in table 6.1, the biggest eye-opener isn't the returns that our index has achieved since 2019, but that the volatility is markedly lower than that of the benchmarks. It is worth noting that a possible source of this difference can stem from the difference in pricing data, previously discussed in section 5.3.1. That being said, this difference in risk levels makes for some interesting findings once we adjust the returns for volatility.

Figure 6.1 illustrates cumulative returns for the three hedged high yield indices Green

	N	Mean return	Standard deviation	CAGR	Annualised Sharpe ratio	Min	Max
Green Bond Index	587	0.018%	0.31%	4.6%	0.84	-4.2%	2.1%
NBP Norwegian HY Index	587	0.018%	0.40%	4.4%	0.70	-3.9%	2.4%
DNB Nordic HY Index	587	0.017%	0.55%	3.9%	0.46	-8.7%	1.5%

Table 6.1: Descriptive index statistics.

Bond Index, NBP Norwegian HY Index, and DNB Nordic HY Index from January 2019 to April 2021. The cumulative return for the three indices throughout this period is 11.05%, 10.53%, and 9.39%, respectively. Our index has generated the highest cumulative return as of April 2021, but the differences between the indices are marginal. However, our Green Bond Index didn't drop nearly as much as the other indices during the financial turbulence caused by the Covid-19 crisis.

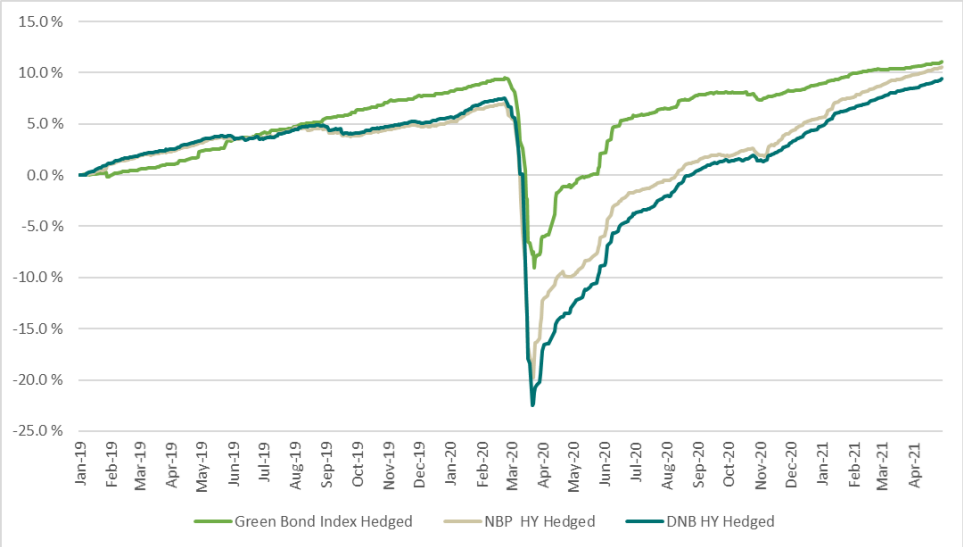


Figure 6.1: The cumulative returns of the Green Bond Index and the benchmark indices.

Table 6.2 shows the returns and standard deviations for different time periods. In 2019, which represents the period before the pandemic, the returns of our Green Bond Index were 7.78%, an outperformance of 2.75 percentage points against NBP's index and 2.3 percentage points compared to DNB's index. It is worth noting that the number of bonds in the Green Bond Index in 2019 was very limited, which makes us view these

	2019	2020	2021
Panel A: Returns			
Green Bond Index	7.8%	1.1%	2.0%
NPB Norwegian HY Index	5.0%	0.9%	4.5%
DNB Nordic HY Index	5.5%	0.1%	4.5%
Panel B: Standard deviation			
Green Bond Index	1.1%	7.4%	0.3%
NPB Norwegian HY Index	0.9%	9.6%	0.5%
DNB Nordic HY Index	0.9%	13.0%	0.4%

Table 6.2: Annualised index returns and risk by year.

results with caution. A small number of included bonds can make the index influenced by idiosyncratic risk and is also a possible answer to why the index had higher volatility than the benchmarks. In 2020, which represents the period with the most market turmoil and high levels of volatility, our index achieved a return of 1.06%, which was 0.19 percentage points better than NBP's index and one percentage point better than DNB's index. In 2021, which represents a time period where markets have started to stabilize, the cumulative return of our index has stagnated, with a total return of 1.97%, a relative return of -2.51 percentage points compared to NBP's index, and -2.49 percentage points compared to DNB's index.

6.2 Risk-adjusted return

Table 6.3 presents measures of risk-adjusted return. To make the results comparable to the other indices, we look at the differences between our index's Sharpe ratio and the Sharpe ratio of the benchmarks. This difference is otherwise known as the Sharpe difference. We observe a positive Sharpe difference compared to both benchmarks for the total time period, which shows that our index has been able to generate more return given its level of risk. When we split up our time period into sub-periods, we observe a significant alpha at the 0.01 level, indicating that the returns are largely driven by the outperformance at the top of the financial turmoil in 2020. We will discuss possible reasons for this outperformance further in section 7. The confidence intervals from the results of the performance analysis can be studied in appendix A7.

We can also look at the information ratio (IR) to get a better understanding of the outperformance of our index. For the IR to be positive, the relative return of our index

	Since inception	2019	2020	2021
Sharpe difference vs NBP HY	0.31	1.49	0.04	-2.59
Sharpe difference vs DNB HY	0.62	1.2	0.12	-4.33
IR GBI vs NBP HY	0.04	1.84	0.03	-5.29
IR GBI vs DNB HY	0.10	1.60	0.11	-6.37
Jensen's alpha GBI vs NBP HY	0.048	0.075	0.076***	0.036
Jensen's alpha GBI vs DNB HY	0.062	0.07	0.07***	0.024

Table 6.3: Sharpe difference, information ratio and alphas of the Green Bond Index compared to benchmarks. For the alphas, *** indicates significance at the 0.01 level.

needs to be positive. Our index has achieved an IR of 0.04 against NBP HY and 0.1 against DNB HY, indicating that our index has been able to outperform the benchmarks on a consistent basis throughout the period. However, in the aftermath of the market stabilisation, it gets outperformed by both benchmarks. In general, both the Sharpe difference and IR vary greatly from one year to another, and as a result, caution should be used when attempting to draw statistically significant conclusions based on these measures.

Table 6.4 shows the regression table for the entire period. Our index has generated positive alphas compared to both conventional high yield counterparts. However, the p-values of both the single-factor regressions were too large for any significant conclusions to be drawn. Both beta coefficients are statistically significant at the 1% level. Our Green Bond Index has a beta of 0.51 compared to NBP Norwegian HY and 0.41 compared to DNB Nordic HY, which are both indicating low levels of systematic risk for our index. However, low levels of R^2 suggest that our index does not generally follow the movement of the benchmarks.

	(1)	(2)
	Green Bond Index	Green Bond Index
NBP Norwegian HY	0.51***	
	(3.83)	
DNB Nordic HY		0.41***
		(4.31)
Intercept (α)	0.0486	0.0622
	(0.89)	(1.20)
N	587	587
R^2	0.423	0.514
t-statistics in parentheses		
* p < 0.1, ** p < 0.05, *** p < 0.01		

Table 6.4: Main regression table with the daily excess returns of our Green Bond Index as the dependent variable. The Newey-West procedure is used to create robust standard errors. The time period is January 2019 to April 2021 (28 months).

To get an understanding of whether our index provided a superior diversification alternative compared to conventional bonds, we regressed all indexes on the Nordic stock market, represented by the VINX Benchmark Index. As this equity index consists of a selection of the largest and most traded Nordic stocks, we concluded that this was a good proxy for the Nordic equity market. We observe a lower beta coefficient for our index compared to the

conventional high yield indices throughout the entire period indicating that green bonds have less correlation with the equity market and is a better diversification alternative. Looking at R^2 we also note that the variation in the bond indices' excess return cannot be explained by the equity market. However, the p-values were too high to draw any significant conclusions. The results from this regression can be studies further in appendix A6.

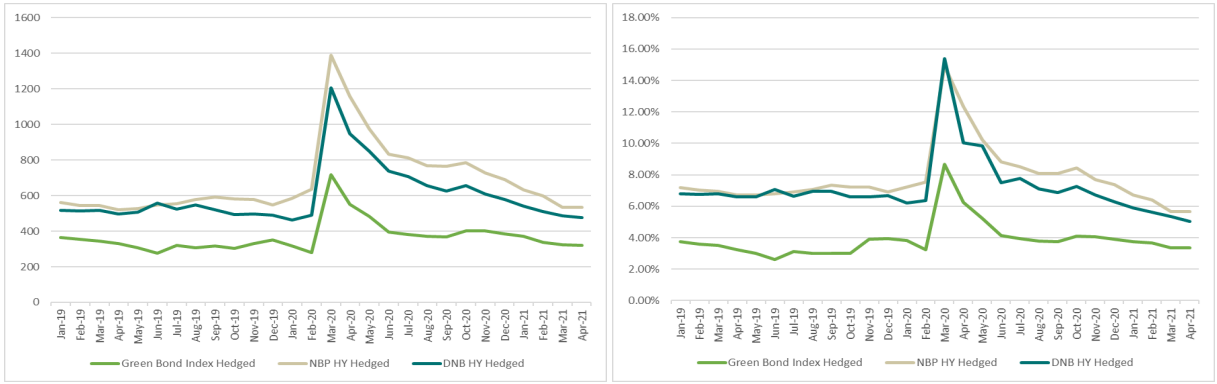
6.3 Liquidity and credit risk

This section aims to study the liquidity of the Nordic green bond market and compare credit risk measures to the benchmark indices. We will dig deeper into the data for our Green Bond Index to understand what drives liquidity and risk in the green bond market. As we do not have the constituent weights for the other indices, we cannot compare the relative spread using the index weights, but in section 6.4.3, we compare the average spread in DNB's index and our Green Bond Index.

6.3.1 Yield and credit spread

The asset swap spread and the Z-spread function as a proxy for risk in the sense that it measures the credit risk associated with bonds. When the spread increases, this means that the expected credit risk increases. As we see from figure 6.2a, when the financial markets took a hit at the beginning of March 2020, the spreads doubled in just a month. The spread measure for Nordic Bond Pricing's index is the Z-spread as they do not provide ASW spread measures for their indices. Though the Z-spread and the ASW spread are not similar measures, they are, in practice, not very different, as explained in section 5.3.6. As a result, the findings in figure 6.2a gives us an indication of risk but can only be used as an approximation.

A high average yield indicates that the issuer is of lower credit quality and is more likely to miss future payments. The high yield is therefore compensation for the exposure to higher risk. We see from figure 6.2b that the average yield in the Green Bond Index is lower than in the benchmark indices, which indicates that the green bonds might be a safer investment. This is consistent with the findings that the Green Bond Index experience less volatility and modern portfolio theory stating that less risk should be compensated



(a) EOM ASW spread and Z-spread (bps). **(b)** EOM average yield.

Figure 6.2: End-of-month spread and yield.

by a lower yield (Markowitz, 1952). We also note that the yield in all indices doubled from the end of February to the end of March 2020, when uncertainty rose.

Credit risk is an essential component when explaining the yield and the yield spread[18] and the correlation of the average spread and average yield for the two securities is 0.93, 0.97, and 0.98 for DNB's index, NBP's index, and our Green Bond Index, respectively.

6.3.2 Relative spread

A liquid market will typically have a narrow bid-ask spread, and conversely, an illiquid market will have a wide spread. To see how the weighted average spread of the green bonds evolved throughout the time period, we used the relative spread of each bond from equation 4.8 at each time t and each bond's respective weights W_i at time t:

$$s_{index,t} = \sum s_{i,t} \times W_{i,t} \tag{6.1}$$

Looking at the result in figure 6.3, we immediately note a sharp increase in spreads when the Covid-19 crisis hit the market. The spread, which had been stable below 0.80% throughout 2019, suddenly made a jump to 4.75% in just a few weeks' time. The spread continued on a high level until June before it gradually decreased and later stabilised around 1%.

[18]The yield spread is the difference between the yield of two securities, often the security of interest and US treasury bonds.

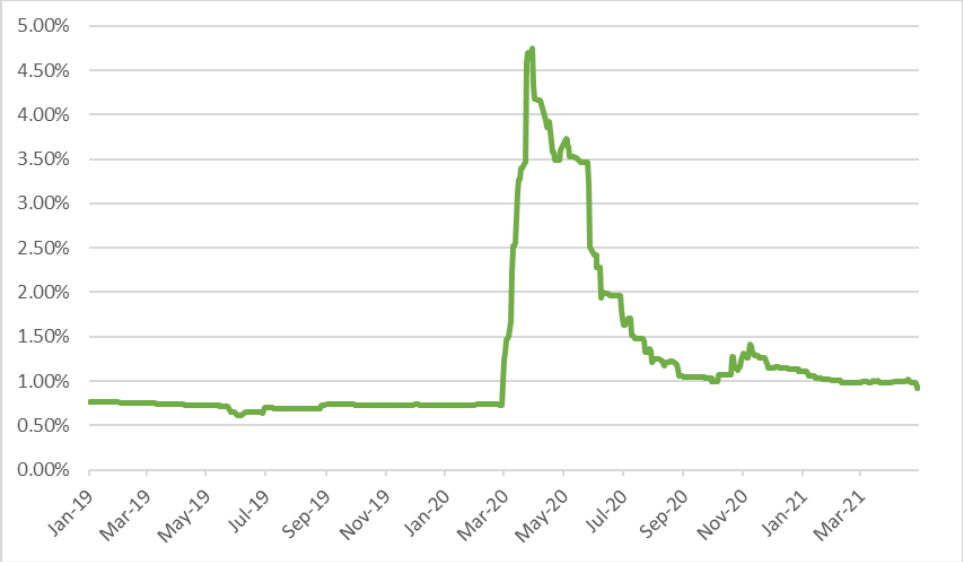


Figure 6.3: Relative spread.

The rapid increase and abnormal spread level indicate that the liquidity in the green bond market dried out and that the securities were challenging to price correctly. Illiquidity is not uncommon during crashes in financial markets when there is a lot of uncertainty about the future and hence the security's fundamental value. During the financial crisis in 2008, the liquidity in financial markets evaporated quickly. Because many market participants wanted to get rid of their positions at the same time, and few investors bought new bonds, the prices fell fast, and the spreads rose. The same happened in March 2020, where the uncertainty regarding the fundamental value of the green bonds resulted in the wide spreads we observe in figure 6.3.

We also note the slight increase in spreads at the beginning of November 2020, where markets were unstable because of the unresolved presidential election in the United States. When the election was settled, and the testing of Pfizer and BioNTech's vaccine showed positive results, the market improved, and spreads got smaller. (Algrøy and Simonsen, 2020)

Table 6.5 shows the correlation coefficients of the relative spread, asset swap spread, and the yield for the Green Bond Index. We see that there is a high correlation between the relative spread and the credit risk measures. So even though we do not have the data for the weighted average relative spread for our benchmarks, we get an idea that the spreads might have had a similar pattern as we saw in figure 6.2.

	Relative spread	ASW spread	Yield
Relative spread	1		
ASW spread	0.94	1	
Yield	0.94	0.98	1

Table 6.5: Correlation coefficients, Green Bond Index.

To better understand the constituents and what was driving the illiquidity in the green bond market, we looked at the relative spread in the different sectors represented in our index. Swedish real estate bonds make up a large part of our index[19], and the real estate sector in total made up on average 43% of the index in 2020[20]. To compare the spread, we therefore first divided the bonds into two groups: real estate and others. Then we reweighted the weights of all real estate bonds so that the sum of real estate bond weights equalled 1, and then did the same for the non-real estate bonds.

The result shown in figure 6.4 was surprising. The green real estate bonds had a remarkably smaller spread during the Covid-19 crisis, and at the very beginning of the crisis they even had a slight decrease. The spread of non-real estate bonds peaked at the end of March, where it reached 6.76%. The standard deviation of the spreads tells us that the variation in the relative spread for the real estate sector is smaller than for the rest of the bonds. The standard deviation is shown in appendix A9.

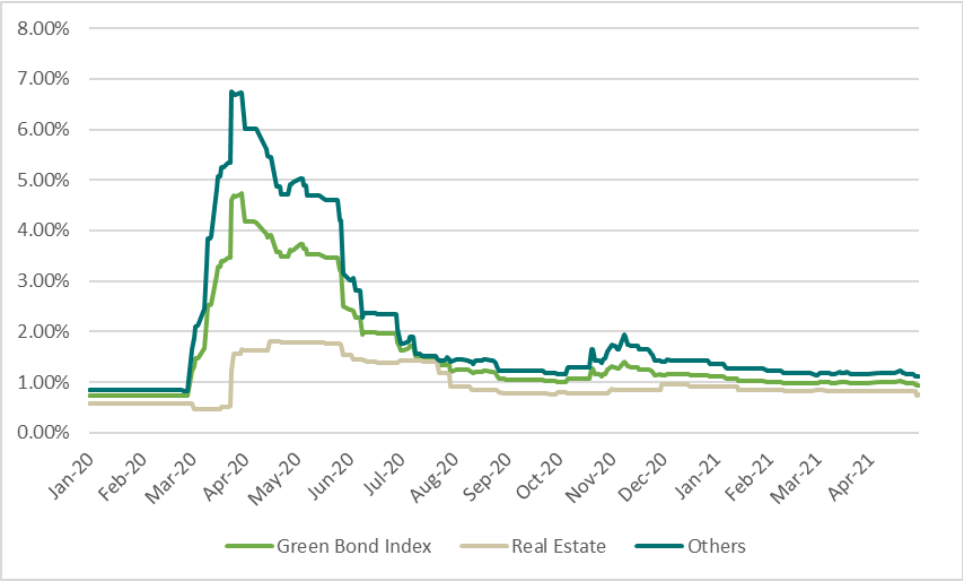


Figure 6.4: Relative spread 2020 and 2021.

[19]See list of included bonds in appendix A4.
[20]An overview of real estate bonds as a share of the total index can be found in appendix A5

6.4 Sector composition of the green bond market

The findings in 6.3.2 made us question why we saw such a small decrease in cumulative returns of our Green Bond Index compared to the benchmarks in 2020. We therefore wanted to test whether the sector composition and the high share of green real estate bonds could be the reason for this outperformance, as we saw that the real estate bonds had a remarkably lower spread.

DNB provides sub-indices for each constituent sector in their index. We collected data for the relevant DNB sub-indices and rebalanced them to start at 100 at the beginning of the period, which ensures less jumps when the sector weights change a lot from one month to the next. This is done by using the following equation:

$$index_{new,j,t} = \frac{index_{j,t}}{index_{j,B}} \times 100 \tag{6.2}$$

where $index_{new,j,t}$ is the new rebalanced index value for sector j at time t, $index_{j,t}$ is the index value for sector j at time t, and $index_{j,B}$ is the index value for sector j at the beginning of the period (2nd of January 2020).

To get the correct sector composition, we used the sector weights from the Green Bond Index to calculate a reweighted synthetic DNB index. The weights are listed in appendix A5.

We used the following equation for the final reweighted DNB index:

$$Index_{reweighted} = \sum W_{j,t} \times index_{new,j,t} \tag{6.3}$$

Where $W_{j,t}$ is the weight of the sector j at time t.

The Green Bond Index consists of a very limited number of bonds in 2019[21], so we find it most relevant to study the years 2020 and 2021 for the following analysis. This ensures that we get more statistically significant and more reliable results that are less affected by idiosyncratic risk.

[21]This is also mentioned as a limitation in part 7.1.

6.4.1 Return

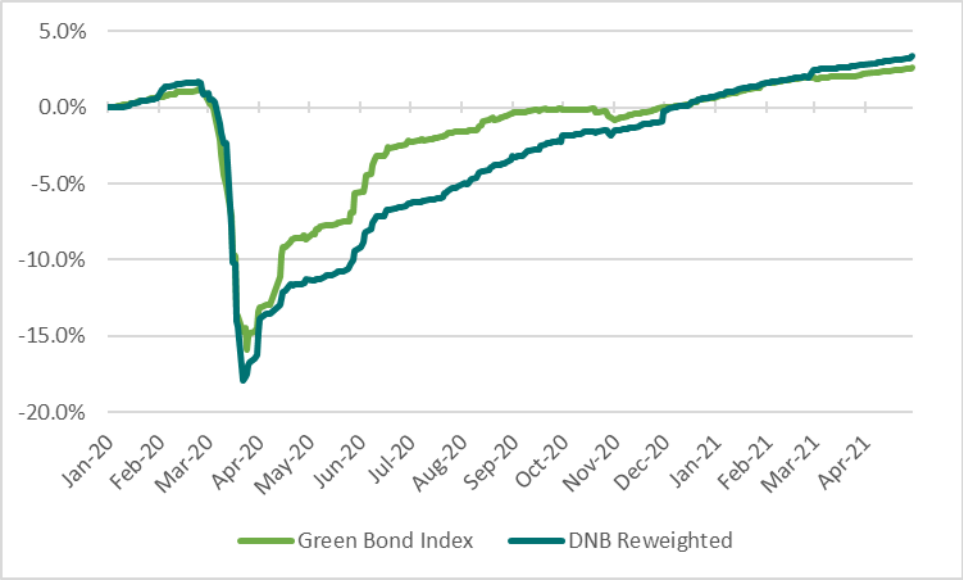


Figure 6.5: Cumulative returns.

Figure 6.5 portraits the cumulative returns of our Green Bond Index compared to the reweighted DNB Nordic HY Index. Now, we see that the indices follow each other much more closely than in the analysis in section 6.1. However, there is still an outperformance during the periods of market turmoil and especially from mid-April to September. When having the same exposure to all sectors as our Green Bond Index, the DNB Nordic HY Index has achieved a cumulative return of 3.75% from January 2020 until April 2021, which is an outperformance of 0.86 percentage points compared to our index. The favourable standard deviation is also, to a larger degree, erased. In terms of risk-adjusted returns, the "brown" benchmark has now slightly outperformed our index in terms of Sharpe ratio, with a Sharpe difference of 0.01 in the period, although this shouldn't be viewed as significant. These findings make us question whether the outperformance of our index can simply be attributed to a higher concentration of the real estate sector and not its "greenness." This can, in such case, potentially delegitimize the financial performance of green bonds as an asset class and ESG as a factor in securities pricing. We will discuss this further in section 7. Although our index has not achieved the same returns as the reweighted benchmark, it should be noted that the index still has markedly lower levels of volatility than the benchmark.

	N	Mean return	Standard deviation	Cumulative return	Cumulative Sharpe ratio	Min	Max
Green Bond Index	336	0.009%	0.41%	2.89%	0.39	-4.22%	2.06%
DNB Nordic HY Index Reweighted	336	0.011%	0.51%	3.75%	0.40	-5.66%	1.63%

Table 6.6: Descriptive statistics of our green bond index compared to the new, reweighted DNB Nordic HY Index from January 2020 until April 2021.

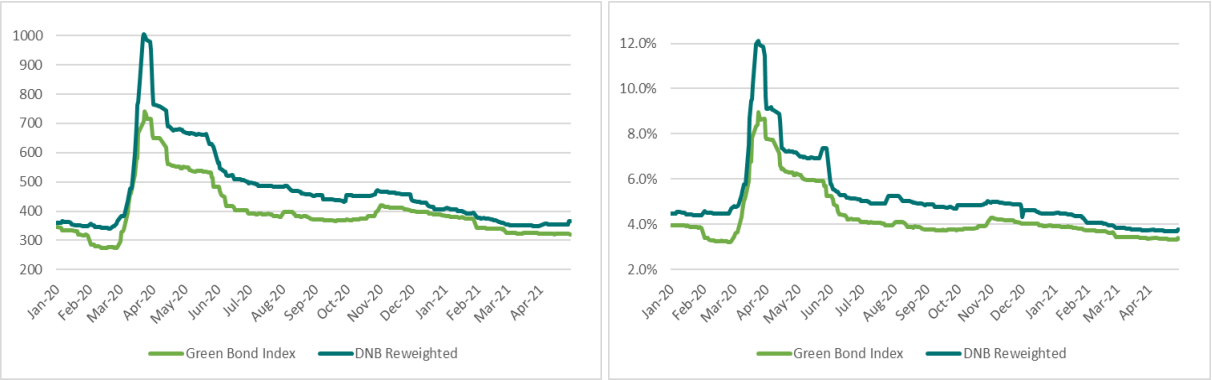
Looking at a linear single-factor regression model with the excess return of the reweighted DNB Nordic HY index as the independent variable, we observe a much higher beta and R^2 than in section 6.2, indicating that the two indices now move more relatively in line with each other.

	(1) Green Bond Index	(2) Green Bond Index
DNB Nordic HY	0.45***	
	(0.0813)	
	5.55	
DNB Nordic HY Reweighted		0.66***
		(0.1168)
		5.64
Intercept (α)	0.000027	0.000012
	(0.00014)	(0.00014)
	0.20	*0.10*
N	336	336
R^2	0.59	0.65
Newey-West standard errors in parentheses		
t-statistics in italic		
* p<0.1, ** p<0.05, *** p<0.01		

Table 6.7: Regression table with daily excess returns of our Green Bond Index as the dependent variable. The time period is January 2020 to April 2021 (16 months).

6.4.2 Yield and credit spread

When accounting for the sector composition in the Green Bond Index, the reweighted DNB index gives a very different result from what we saw in 6.3.1. The reweighted index now has a much lower spread and credit risk than before the reweighting, as shown in figure 6.7. Though the difference between the two indices is not entirely removed, and there is still a difference of, on average, 68 bps. The difference tells us that the green bonds still have a somewhat lower spread, and therefore possibly what some call a "greenium."



(a) ASW spread and (bps). **(b)** Average yield.

Figure 6.6: Spread and yield after reweighting DNB's index.

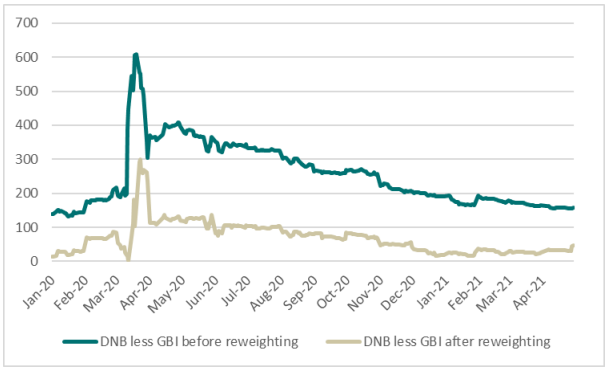


Figure 6.7: ASW spread for DNB's index less Green Bond Index before and after reweighting DNB's index.

6.4.3 Average relative bid-ask spread

We collected the list of constituent bonds in DNB's index[22] and retrieved historical bid and ask prices for all bonds. As we did not have each bond's index weight, we calculated the average relative spread by taking the sum of all bonds' relative bid-ask spread s_i at each time t, divided by the number of bonds in the index at each time t:

$$Average\ Relative\ Spread_t = \overline{s}_{index,t} = \frac{\sum s_i, t}{Number\ of\ bonds_t} \tag{6.4}$$

To have an index that matches the sector composition in the Green Bond Index, we calculated the average relative spread for each sector.

[22] As of 30th of April 2021. This means that bonds that have matured before this date are not included, which can potentially bias the result. However, the number of bonds in DNB's index is much larger than in the Green Bond Index, so we don't see this as a major issue.

$$\overline{s}_{j,t} = \frac{\sum s_{i,j,t}}{Number\ of\ bonds_j, t} \tag{6.5}$$

Where $\overline{s}_j$ is the average relative spread for sector j at time t, and $s_{i,j,t}$ is the relative spread for bond i in sector j at time t.

Then we used the sector weights of the Green Bond Index, shown in appendix 6.4, to get a reweighted average relative spread for DNB's index.

$$\overline{s}_{Reweighted\ index,t} = \sum \overline{s}_{j,t} \times W_{j,t} \tag{6.6}$$

Where $W_{j,t}$ is the weight of sector j at time t.

The result is shown in figure 6.8.

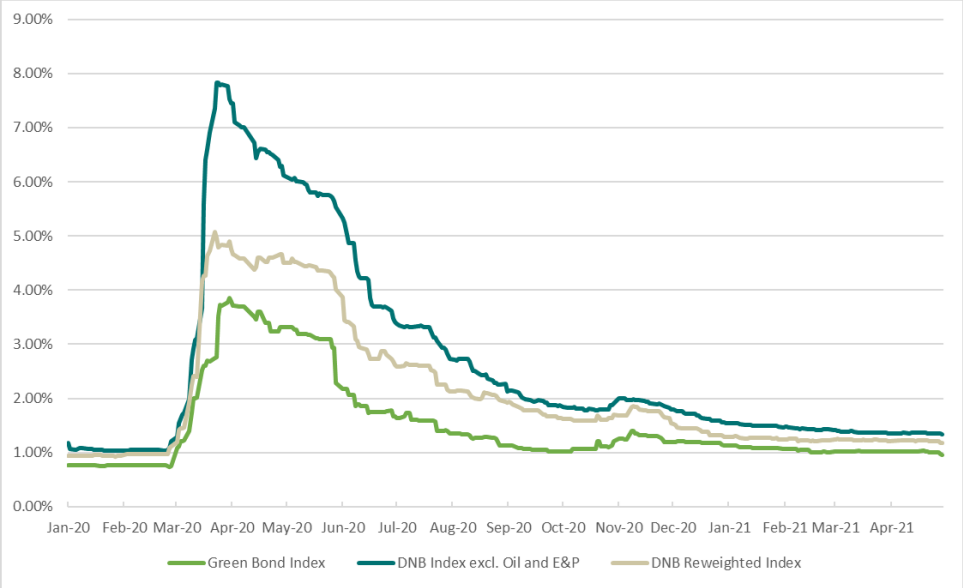


Figure 6.8: Average relative spread for the Green Bond Index, DNB's index excluding oil-related sectors, and DNB's reweighted index.

We can clearly see that during the market turmoil in 2020, the average relative spread was lower in the Green Bond Index than in DNB's index, even when adjusted for the sector composition. Running a simple regression also shows that this difference is significant. This evidence strengthens our impression that green bonds are more liquid.

We also get the same impression when we look at the relative spread solely in the real

estate sector. Even though the standard deviations are quite large, they are lower for the green bonds than for the bonds included in DNB's index.

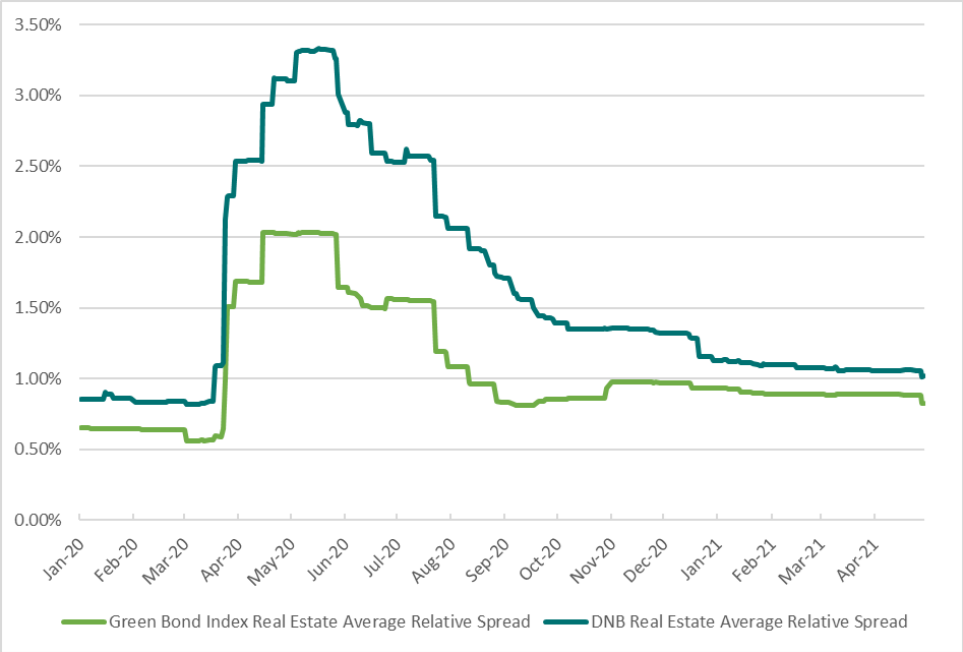


Figure 6.9: Average relative spread for the real estate sector.

Standard deviations for 6.8 and 6.9 can be found in appendix A9.

7 Discussion

In this chapter, we will discuss and reflect upon the results from section 6. We explain why the Green Bond Index outperformed the benchmarks during the crisis in 2020, and displayed lower levels of volatility than the rest of the market over the entire sample period. Finally, we discuss the limitations of data and the model brought on by this analysis and the choice of index methodology.

The results show that our hedged Green Bond Index has been unable to generate significant outperformance over the entire sample period compared to similar hedged high yield indices. This is in line with what was discovered by, among others, Schröder (2007) and Ehlers and Packer (2017). In theory, one would expect green bonds to generate lower returns given the restrictive nature of their investment opportunities and their huge demand amongst investors. However, in a similar fashion to the research of Nofsinger and Varma (2014) and Henke (2016), we showed that during the market crash of 2020, the Green Bond Index held much firmer than the conventional indices, outperforming them significantly in terms of alpha. This gives us an indication that ESG factors has an influence on pricing and that in periods of market turmoil, green bonds proves to be the superior investment alternative in the high yield market. The outperformance has in the aftermath of the crisis vanished as overall market volatility and uncertainty have dampened, giving an indication that the downside risk protection only lasts in crisis periods. At the same time, we find that our Green Bond Index exhibits less volatility across the entire period compared to the rest of the market, also in line with the findings of Ehlers and Packer (2017), as well as Medda and Partridge (2018).

When considering the results from section 6.4 where we reweighted DNB's index, we see that the sector composition might be the key to explaining a large part of the green bonds' resilience during the Covid-19 crisis. The Green Bond Index contains a large share of real estate bonds, and the index is overly exposed to this sector when compared to the Nordic high yield market in total. As the real estate sector experienced less volatility, loss of return, and less illiquidity during the crises, our index is largely driven by these properties. Though adjusting for the sector composition, the green bonds still show that the market accepts a lower credit spread than the benchmark.

A possible explanation might be that the green bond market exhibits greater liquidity, which in crises makes the bonds an attractive investment. In periods of crisis, investors face the risk of overstepping the capital buffers imposed by the government. The superior liquidity-feature of green bonds, mostly stemming from the huge demand among investors, would lessen the risk, as green bonds would be easier to sell. We saw in figure 6.4 that the real estate sector appears to carry greater liquidity by having a lower relative bid-ask spread. Investors might therefore be willing to pay a premium for liquid bonds and accept a lower yield. Friewald's (2011) study on the high yield market in the US shows that bonds have a stronger reaction to changes in liquidity and are more exposed to liquidity risk during financial crises. If Friewald's result is also applicable for the Nordic market, this can explain why the average yield for the green bonds is lower even when correcting for sector differences.

Another explanation can be that issuers of green bonds have a higher credit quality than non-issuers. Green bond issuance is a costly process, so the net benefit of paying a potentially slightly lower coupon, the cost of frequently reporting climate measures, and having a third party supplying a second opinion is not necessarily positive. If the companies that can afford to bear this cost are already the best-performing companies in the high yield segment, the index will give a too optimistic result. In addition, when the market is in an emerging phase, the issuers with lower risk might be over-represented. Thus, the outperformance would not be a result of the bonds being green but a result of the issuers being top of their class.

The high p-values when regressing our index against the re-weighted benchmark confirm our conclusion of insignificant differences in performance across the entire time period. Ergo, we do not have enough evidence to reject the null hypothesis of no significant outperformance of green bonds compared to the overall high yield market. The results from the CAPM regression show that our index has generated a positive alpha compared to the benchmarks. However, considering its small size, the alpha shows that there is not a big difference in performance. In addition, our model does not include the widely accepted Fama-French three and five-factor models (Fama and French, 2004) or the momentum factor presented by Carhart (1997). The absence of these models means that several risk factors might be omitted and that our alpha simply can be the result of

our index's exposure to these factors. We also do not have enough evidence to reject the null hypothesis of significant outperformance in periods of market crisis. This can be attributed to the fact that as of May 2021, we are still in the recession caused by the Covid-19 crisis. As a result, any effort to divide the sample period into a crisis and non-crisis period, as per the methodology of Nofsinger and Varma (2014) and Henke (2016), would be useless, as the entire sample period would be regarded as a crisis period. Any attempt to divide the sample period based on subjective assessments could also result in biased or skewed conclusions. However, during the worst periods of the pandemic, the Sharpe ratios, declined volatility levels, increased liquidity, and reduced asset swap spreads compared to the conventional market tell a story of an asset class that could have the potential to be very attractive for investors in future periods of market turmoil.

The green bond market will be interesting to follow when new regulations are established and we believe that there are few limits to the growth of the asset class. As the market moves forward and more green bonds are issued, one could potentially see a more diverse group of issuers, which could increase the bonds' liquidity even further as they are traded more often. Also, the number of investors having ESG-investments in their mandate will probably continue to grow exponentially, and so will the demand for green bonds.

The future for the asset class is bright, especially as we get closer to 2050. However, only time will tell whether the green bond label will in fact reduce investors' exposure to environmentally-related financial risks. One thing that speaks against this is that exposure to these types of risks is dependent of the entire company's business. When holders of green bonds increase their exposure to companies with high ESG-scores, they also have a claim on the entire company's operations, and not just the parts considered sustainable. In other words, the investor is still exposed to environmental risk, like for instance stricter carbon regulation, if holding green bonds of companies deemed "brown." However, as the upcoming EU taxonomy and green bond standard is implemented, it will bring on new principles for the issuance of green bonds and reporting of sustainability. When this happens, knowledge regarding precisely which environmental risk factors companies are exposed to will also increase. This knowledge will be key for asset owners and managers wanting to manage these risks and use green bonds to hedge them effectively.

7.1 Limitations of the thesis

Nordic Bond Pricing is not basing their index on bid prices like the majority of the index providers we have used as guides. Instead, they use an "evaluated market price ("EVAL"), usually considered as a mid price" (Nordic Bond Pricing, 2020). When comparing our index to Nordic Bond Pricing's index in periods of wide spreads, the mid price will be very different from the bid price. This means that during the Covid-19 crisis in 2020, the NBP index might seem to perform better than our Green Bond Index and DNB's index.

Using bid prices was a very thoughtful choice we made in order for the index to be comparable to an investor's portfolio. When mid prices are used, a portfolio of bonds will appear to be less profitable when spreads increase compared to an index using bid prices.

While experiencing tremendous growth, the high yield green bond market is still small in size. As a result, the number of bonds included in our index is very limited. This has implications in the sense that unsystematic risk might bias our index results as small company-specific events are not a representation of market movement. This is especially important when interpreting the results for 2019, where the number of bonds is ≤ 12, and is the reason why the year 2019 is not included further in our analysis after we reweighted the benchmark. The issue of a small market becomes less important if the green bond market develops and matures.

It should also be emphasized that as the Nordic green bond market is still emerging, it might be too early to draw any definite conclusions on the performance of green bonds compared to their conventional counterparts. The true long-term value of investing in green bonds will, in our opinion, not be revealed after new regulations have been implemented or physical climate change risks have taken place. That being mentioned, the performance of the green bond market so far is still interesting because it describes how this asset class perform during a crisis.

8 Concluding remarks

In order to make financial flows consistent with the pathway towards a low-carbon society and climate-resilient development, major investments in sustainable projects are needed. One relatively new way of financing these projects is through issuing green bonds, where the proceeds are earmarked for environmental-friendly projects. However, despite a rapidly increasing demand for green bonds in recent years, there is still uncertainty regarding the financial benefits of the asset class and how they compare to their conventional counterparts.

In this thesis, we examine the Nordic high yield green bond market. While previous papers have mostly focused on the existence of a potential green bond premium and found results similar to us, this thesis contribute to the literature by creating and backdating an index from 2019 until today and focusing on the asset class' performance in the secondary market over time. Using a CAPM framework and well-known methods of performance evaluation, we analyse the index's performance relative to appropriate benchmarks to see if the green bonds outperform the conventional bond market. Extending the analysis, we control for sector composition in the green bond market by comparing the Green Bond Index to a reweighted benchmark index. Furthermore, the relative bid-ask spread is used as a measure of liquidity to study the liquidity differences, both within the green bond market and compared to the reweighted benchmark. For the performance analysis, we had two hypotheses that we wanted to explore. The first hypothesis of the thesis was that the Green Bond Index would outperform the benchmark in terms of risk-adjusted returns and better liquidity. The second hypothesis stated that green bonds would hold up better during the market turmoil caused by the Covid-19 crisis.

The regression results from the analysis brought by this thesis showed that the Green Bond Index outperformed the benchmarks during 2020, with an alpha of 7.6% against NBP Norwegian HY Index and 7% against DNB Nordic HY Index. Both alphas were significant at the 1% level. However, when having the same exposure to the constituent sectors, the alpha for the Green Bond Index was no longer significant. However, we observed that the index had a much quicker recovery. In the months following the 2020 market crash, the index displayed lower levels of volatility, lower credit spreads, and better

liquidity throughout the period. In general, we observe that our index outperformed the market in the aftermath of the stock market crash caused by the Covid-19 pandemic. Again, the results of this study were insignificant. Based on this, it is hard to draw any significant conclusions regarding whether Nordic high yield green bonds have performed differently throughout the sample period. We can therefore not reject the null hypotheses of no significant outperformance.

Due to the different characteristics of markets in other geographical locations, one should be careful to conclude that the results from this study are transferable to other countries. Green bonds, in for instance emerging markets, could display entirely different risk and return characteristics and would raise opportunities for some interesting future research. Also, due to limitations in our data set, the Nordic green bond market will be interesting for future research when the market matures, as it is still too early to draw any significant conclusion on the performance of green bonds compared to conventional bonds. By this time, a lot more regulations and climate shocks will have taken place, which both have the potential to reveal the true value of green bonds.

This study focuses solely on the green bond market. However, as mentioned in section 2.2.1, green bonds are not the only type of sustainability bond. Social bonds have also surged in recent years, with the proceeds being earmarked for projects mitigating social issues like health care, education, or equality. These bonds are not subject to the same risk characteristics as green bonds[23], and the analysis of how this market has performed would therefore make for some highly interesting research.

[23]The bonds are not to the same degree exposed to climate risk or transitional risk, discussed in section 2.1.1.

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Appendix

A1 Sector composition in the Nordic high yield market

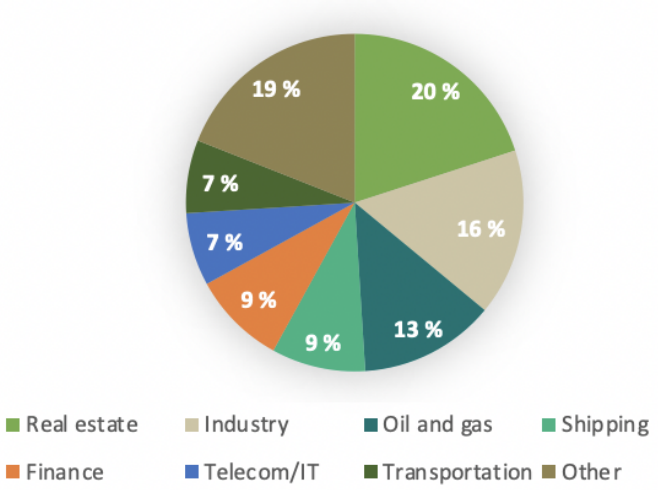


Figure A1.1: Nordic high yield sector composition 2020 (Nordic Trustee, 2021).

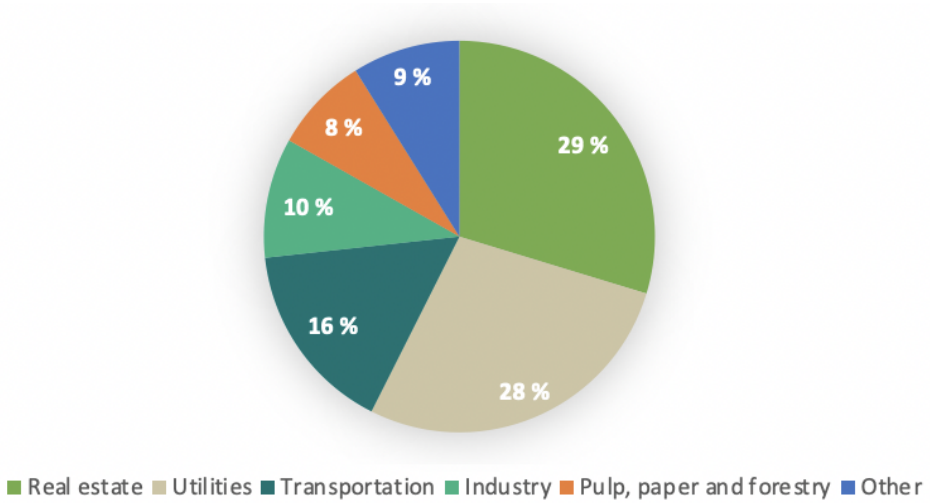


Figure A1.2: Nordic green bond high yield sector composition 2020 (Nordic Trustee, 2021).

A2 Bond Ratings

Risk	Moody's	Standard & Poor's	Fitch	Grade
Lowest Risk	Aaa	AAA	AAA	Investment Grade
Low Risk	Aa	AA	AA	
Low Risk	A	A	A	
Medium Risk	Baa	BBB	BBB	
High Risk	Ba,B	BB,B	BB/B	High Yield
Highest Risk	Caa/Ca/C	CCC/CC/C	CCC/CC/C	
Default	C	D	D	

A3 Total volume and number of green bonds in the Nordic market

		Total volume NOK bn	Number of green bonds
IG	Norway	64	94
	Sweden	160	344
	Denmark	56.8	10
	Finland	4.5	2
	Total	285.4	450
HY	Norway	19.8	20
	Sweden	20	30
	Denmark	3.6	3
	Finland	7.2	4
	Total	47.9	57

Table A3.1: The Nordic Green Bond Market as of April 30th 2021.

A4 Green bonds included in the index

Issuer	ISIN	Country	Sector	Issue date	Maturity
SCATEC ASA	NO0010809684	Norway	Utilities	17/11/2017	17/11/2021
KLOVERN AB	SE0011063163	Sweden	Real estate	04/04/2018	04/04/2022
AB STENA METALL FINANS	NO0010823362	Norway	Industry	01/06/2018	01/06/2023
FASTPARTNER AB	SE0011974351	Sweden	Real estate	30/11/2018	30/05/2022
SAMHALLSBYGGNADSBOLAGET	SE0012256741	Sweden	Real estate	14/02/2019	14/02/2024
KUNGSLEDEN AB	SE0011869692	Sweden	Real estate	07/03/2019	07/03/2023
BASELOAD CAPITAL	SE0011923267	Sweden	Investment comp.	22/03/2019	22/03/2023
MILLICOM INTL CELLULAR	SE0012454841	Sweden	TMT	15/05/2019	15/05/2024
EUROPEAN ENERGY AS	DK0030448238	Denmark	Utilities	20/06/2019	20/09/2023
RE IV LTD	SE0012741064	Sweden	Real estate	05/07/2019	05/07/2022
ALTERA SHUTTLE TANKERS	NO0010866163	Norway	Transportation	18/10/2019	18/10/2024
OFFENTLIGA HUS I NORDEN	SE0013042611	Sweden	Real estate	27/09/2019	27/03/2023
MOWI ASA	NO0010874050	Norway	Seafood	31/01/2020	31/01/2025
CIBUS NORDIC RE AB	SE0014453130	Sweden	Real estate	12/06/2020	12/06/2023
GRIEG SEAFOOD ASA	NO0010885007	Norway	Seafood	25/06/2020	25/06/2025
MOMOX HOLDING GMBH	NO0010886369	Norway	TMT	10/07/2020	10/07/2025
K2A KNAUST ANDERSSON	SE0014731071	Sweden	Real estate	28/08/2020	28/08/2023
ARWIDSRO FASTIGHETS	SE0013719606	Sweden	Real estate	04/09/2020	04/09/2023
BONAVA AB	SE0013887973	Sweden	Real estate	11/09/2020	11/03/2024
BONHEUR ASA	NO0010893332	Norway	Utilities	22/09/2020	22/09/2025
NP3 FASTIGHETER	SE0014956686	Sweden	Real estate	23/09/2020	05/01/2024
NIVIKA FASTIGHETER AB	SE0014855763	Sweden	Real estate	24/09/2020	24/09/2023
MAGNOLIA BOSTAD AB	SE0014956454	Sweden	Real estate	02/10/2020	02/04/2024
OFFENTLIGA HUS I NORDEN	SE0014965919	Sweden	Real estate	12/10/2020	12/04/2024
SIBS AB	SE0014965729	Sweden	Real estate	19/10/2020	19/04/2024
KLOVERN AB	SE0013104205	Sweden	Real estate	16/10/2020	16/04/2024
COREM PROPERTY GRP AB	SE0015192521	Sweden	Real estate	29/10/2020	29/04/2024
RE IV LTD	SE0015195847	Sweden	Real estate	27/11/2020	27/11/2023
AKER HORIZONS AS	NO0010923220	Norway	Investment comp.	03/02/2021	15/08/2025
KLOVERN AB	SE0013104361	Sweden	Real estate	10/02/2021	10/02/2025
SCATEC ASA	NO0010931181	Norway	Utilities	19/02/2021	19/08/2025
KUNGSLEDEN AB	SE0013882941	Sweden	Utilities	30/03/2021	30/03/2028
MAGNOLA BOSTAD AB	SE0015659636	Sweden	Real estate	18/03/2021	18/03/2025

Table A4.1: List of included bonds.

A5 Sector composition in the Green Bond Index

Note that even though the number of bonds is 32 in April 2021, the total number of bonds included in the index is 33. This is because one of the Scatec bonds are excluded from the index at the end of November 2020.

	REAL ESTATE		UTILITIES		SEAFOOD		TRANSPORTATION		MEDIA		INDUSTRY		INVESTMENT		Total	
Jan-19	2	70%	1	16%	0	0%	0	0%	0	0%	1	15%	0	0%	4	100%
Feb-19	2	70%	1	16%	0	0%	0	0%	0	0%	1	15%	0	0%	4	100%
Mar-19	3	72%	1	14%	0	0%	0	0%	0	0%	1	14%	0	0%	5	100%
Apr-19	4	71%	1	12%	0	0%	0	0%	0	0%	1	11%	1	7%	7	100%
May-19	4	71%	1	12%	0	0%	0	0%	0	0%	1	11%	1	7%	7	100%
Jun-19	4	56%	1	9%	0	0%	0	0%	1	21%	1	8%	1	5%	8	100%
Jul-19	4	46%	2	26%	0	0%	0	0%	1	17%	1	7%	1	4%	9	100%
Aug-19	5	45%	2	26%	0	0%	0	0%	1	17%	1	7%	1	4%	10	100%
Sep-19	5	48%	2	25%	0	0%	0	0%	1	16%	1	6%	1	4%	10	100%
Oct-19	5	48%	2	25%	0	0%	0	0%	1	16%	1	7%	1	4%	10	100%
Nov-19	5	42%	2	21%	0	0%	1	14%	1	14%	1	6%	1	4%	11	100%
Dec-19	6	45%	2	20%	0	0%	1	13%	1	13%	1	5%	1	3%	12	100%
Jan-20	6	45%	2	20%	0	0%	1	13%	1	14%	1	5%	1	3%	12	100%
Feb-20	6	39%	2	18%	1	13%	1	11%	1	12%	1	5%	1	3%	13	100%
Mar-20	6	39%	2	18%	1	13%	1	11%	1	12%	1	5%	1	3%	13	100%
Apr-20	6	42%	2	17%	1	13%	1	9%	1	12%	1	5%	1	3%	13	100%
May-20	6	40%	2	17%	1	13%	1	10%	1	12%	1	5%	1	3%	13	100%
Jun-20	6	40%	2	17%	1	13%	1	10%	1	12%	1	5%	1	3%	13	100%
Jul-20	7	39%	2	15%	2	19%	1	10%	1	10%	1	4%	1	2%	15	100%
Aug-20	7	37%	2	15%	2	18%	1	8%	2	15%	1	4%	1	2%	16	100%
Sep-20	8	38%	2	14%	2	18%	1	8%	2	15%	1	4%	1	2%	17	100%
Oct-20	12	44%	3	15%	2	15%	1	7%	2	13%	1	3%	1	2%	22	100%
Nov-20	15	49%	3	14%	2	14%	1	6%	2	12%	1	3%	1	2%	25	100%
Dec-20	18	57%	2	10%	2	12%	1	6%	2	11%	1	3%	1	2%	27	100%
Jan-21	18	57%	2	10%	2	12%	1	6%	2	11%	1	3%	1	2%	27	100%
Feb-21	18	57%	2	10%	2	12%	1	6%	2	11%	1	3%	1	2%	27	100%
Mar-21	19	52%	3	15%	2	10%	1	5%	2	9%	1	2%	2	8%	30	100%
Apr-21	20	53%	4	14%	2	10%	1	5%	2	8%	1	2%	2	8%	32	100%

Table A5.1: Monthly included bonds and sector weights for the Green Bond Index.

A6 Regression table: The Nordic high yield market vs the Nordic equity market

	(1) Green Bond Index	(2) NBP Norwegian HY	(3) DNB Nordic HY
Vinx Benchmark Cap	0.0014	0.0356	0.0703
	(0.04)	(0.86)	(1.05)
Intercept (α)	0.00016	0.00013	0.00009
	(1.12)	(0.59)	(0.30)
N	587	587	587
R^2	0.00	0.01	0.02
t-statistics in parenthesis			
* p < 0.1, ** p < 0.05, *** p < 0.01			

Table A6.1: Regression table with the daily excess return of the VINX equity index as the independent variable and the bond indices as the dependent variable.

The Newey-West procedure is used to create robust standard errors. The time period is January 2019 to April 2021 (28 months).

A7 Performance analysis results

		Since inception	2019	2020	2021
Sharpe ratio	Green Bond Index	1.29 (2.29, 0.28)	6.31 (7.35, 5.27)	0.11 (1.11, 0.84)	7.02 (8.16, 5.88)
	NBP Norwegian HY Index	0.98 (1.98, -0.02)	4.80 (5.83, 3.78)	0.07 (1.07, 0.59)	9.89 (11.16, 8.63)
	DNB Nordic HY Index	0.67 (1.66, -0.34)	5.09 (6.12, 4.07)	-0.01 (0.99, -1.00)	11.36 (12.71, 10.03
Information ratio	Green Bond Index vs NBP	0.04 (1.04, -0.96)	1.84 (2.84, 0.84)	0.03 (1.03, -0.97)	-5.29 (-4.21, -6.38)
	Green Bond Index vs DNB	0.10 (1.10, -0.90)	1.60 (2.60, 0.59)	0.11 (1.11, -0.89)	-6.37 (-5.25, -7.48)
Jensen's alpha	Green Bond Index vs NBP	0.048 (1.05, -0.95)	0.075 (1.08, -0.92)	0.076*** (1.08, -0.92)	0.036 (1.03, -0.97)
	Green Bond Index vs DNB	0.062 (1.06, -0.94)	0.07 (1.07, -0.93)	0.07*** (1.07, -0.93)	0.024 (1.02, -0.98)

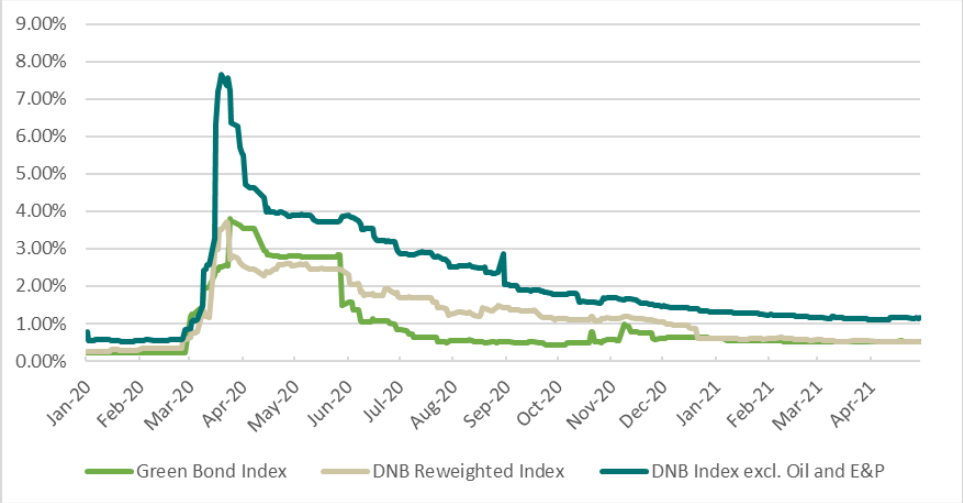
Table A7.1: Performance analysis results

Values for Sharpe ratios, information ratios and alpha along with confidence intervals, since inception (cumulative), and for the different time segments (annualised). For the alphas, *** indicates a significance at the 0.01 level.

A8 Standard deviation of the relative bid-ask spread

Figure A8.1: Standard deviation of the bid-ask spread.

A9 Standard deviation of the average relative bid-ask spread



(a) Standard deviation of the average relative spread for the sector weighted DNB index and the Green Bond Index.

(b) Standard deviation of the average relative spread for the real estate bonds in DNB's index and the Green Bond Index.

Figure A9.1: Standard deviation of the average relative spread.