Erasmus University Rotterdam

ERASMUS UNIVERISTY ROTTERDAM
Erasmus School of Economics
Master Thesis – MSc Financial Economics

Doing good: investing with green-tinted glasses?

The impact of 'green' on bond performance

L.P.H.E. van Bladel [380298]

Supervisor: Prof. dr. O.W. Steenbeek
Second assessor: Prof. dr. M.A. Pieterse-Bloem
Date final version: 14 July 2019

Abstract: In this thesis, the difference in financial performance between green and conventional bonds is explored, to determine the drivers of the bond. There is a small negative price for investors related to the 'greenness' of the bond, -10bps, to be paid when investing in green bonds as opposed to investments in conventional bonds. Even though the majority of the green bonds in the sample have a lower yield-to-maturity compared to their conventional peers, the average difference was slightly positive, +19bps, implying green bonds can possibly yield a better return. Furthermore, the higher the rating of the bonds the bigger the positive impact on the difference in performance, +84bps for Aaa bonds, implying that higher rated green bonds have a better financial performance than their conventional peers. In addition to rating, there is a significant impact based on the issuing currency of the bonds as green bonds issued in EUR have a lower financial performance of -14bps than USD.

Keywords: Green bonds; financial performance; sustainability; ESG; institutional investors.

TABLE OF CONTENTS

1. Introduction

"What does it mean to say that a 'business' has responsibilities?" (Friedman, 1970).

According to Friedman, only people have responsibilities not entire businesses. The main responsibility of executives is to make profit, and to increase the pay-off (wages) for employees. In addition, he states that *there is a social responsibility solely for individuals* not for businesses as the executive would then be spending the money that belongs to the shareholders, which is not his to spend (Friedman, 1970).

Sustainability and climate change, as a section of environmental, social and governance (ESG) factors, have gained momentum in the last decade. Sustainability has made its way into the financial sector as the focus on ethical behaviour has increased and causes image losses for large corporates. Under the pressure of society many green and social initiatives arose adding to the spectrum of financial instruments. As a result green bonds were introduced in 2007, when the European Investment Bank (EIB) and World Bank issued the first green bond, however, guidelines had yet to be established. Since then, the green bond market is experiencing an explosive growth with over €255bn of green bonds that remain outstanding in March 2018 and an expected redemption of €25.5bn in 2019 (ING, 2018). Green bonds are similar to regular bonds, as they too are a debt instrument offering return and the promise to finance or re-finance projects. Similarly to conventional bonds, green bonds can be issued by any organisation, government or financial institution that has a bonding authority (EY, 2016). The main difference is that, in order to classify as a green bond it has to be aligned with the Green Bonds Principle laid out by the International Capital Market Association (ICMA). The principles as laid out by the ICMA try to induce transparency, integrity and accuracy of information and will be further discussed in the literature review.

Green bonds can in principal be issued by any company, organisation or government with a bond issuing authority, which results in various 'brown' companies (whose core business concerns fossil fuels) issuing green bonds for new 'sustainable' energy development projects (International Capital Market Association, sd). Some bonds even though they meet the requirements of the Green Bond Principle are not considered as such by investors and are excluded, such as a utility company issuing a green bond in order to reduce their CO_2 emission in the oil refining process. Or a green bond by a Chinese energy company controversial due to the extrusion of residents and treatment of archaeological and cultural property (PGGM, 2017). The state of the Netherlands

has issued its first bond on May 21st 2019, with a maturity of 20 years, a yearly coupon of 0,57%, and an AAA rating and an eventual size of €5.9bn. The demand for the bond was high: investors had an appetite for more than €21bn (Dobber, 2019). This green bond is the largest green bond issued so far and provides a perspective of the potential the green bond market has in store for the future.

Green bonds are used in various portfolios by large (institutional) investors in order to improve on sustainability, however, researchers have not yet reached consensus on the performance of green financial instruments let alone green bonds. The bond market is in general more liquid and larger than the stock market and bonds have different characteristics with limited upside potential and an obligation to (re-)invest coupon payments in projects.

Worldwide (institutional) investors with $45 trillion worth of assets have publicly committed to responsible investing, incorporating sustainability with which green bonds can help them. Therefore, the market is only expected to continue growing in the coming years (Climate Bonds, 2019). Large, public investors such as pension funds are have expressed a desire to allocate more of their invested capital to green initiatives to satisfy the public's desire for a more circular and sustainable economy. Dutch pension funds currently have nearly €1,400 billion in various investments (De Nederlandsche Bank, 2018) and could provide a kick-start for green investments *if green financial instruments yield competitive returns in comparison to their 'regular' peers based on risks and returns* (Della Croce , Kaminker, & Stewart, 2011). When the first Green Bond was issued by the Dutch government many institutional investors subscribed and Dutch (pension) investors APG[1] en PGGM[2] participated. APG roughly invested €250m, of which €171m is assigned to ABP, PGGM invested €83,5m (Dobber, 2019). Pension funds have the obligation to make sure that participants have the highest-payoff possible at their retirement, whilst preferring social responsible investing over sin-industries such as the weapon industry (van der Ploeg & Koens, 2015). Both APG and PGGM are using the relatively new Green, Social and Sustainability bonds as an instruments in their investment portfolios to reach their sustainability goals.

Since the first green bond was introduced in 2007, by the European Investment Bank (EIB), little to no research has been conducted with regard to the financial performance of this new financial

[1] Algemene Pensioen Groep N.V., the administer of Algmeen Burgerlijk Pensioenfonds (ABP). ABP is the largest pension fund of the Netherlands with roughly three million participants.
[2] PGGM Coöperatie U.A. is the administer of Pensioenfonds Zorg en Welzijn (PFZW), second largest pension fund of the Netherlands with roughly two and a half million participants.

instrument. Therefore, it seems relevant to compare the *financial* performance of green bonds to 'conventional' bonds as they are regularly used in portfolios that need to perform financially. The lack of previous research on this relatively new financial instrument creates an opportunity to determine the difference in financial performance of green bonds compared to conventional bonds. Additionally, the drivers for the difference in performance of green and conventional bonds can possibly be determined as well as their relative impact.

This thesis aims to answer the following question:

1. *How do green bonds financially perform in comparison to their conventional peers?*

Previous research has been mostly conducted on green mutual funds and indicate that green mutual funds underperform their conventional peers while other research states that there is no significant difference or even that green mutual funds outperform their conventional peers. Therefore, it is interesting to determine the actual financial performance of green bonds compared to conventional bonds before answering the second research question.

2. *What drives the difference in performance of green and conventional bonds?*

Green bonds and conventional bonds are in principal equal financial instruments and the only difference between the two categories is the 'greenness' of the bond. However, it is interesting to analyse what drives the possible difference between the financial performance aside from the fact that one bond is classified as a green bond while the other is classified as a conventional bond.

To answer both research questions the model-free approach is chosen, in addition a small case study is conducted based on the z-spread of the bonds. For the model-free approach a database of green bonds is constructed based on various constraints after which each green bond is individually matched with a conventional bond. The database includes various issuer types, rating, and currencies in order to mimic the actual bond market. Eventually a database of 97 green bonds is matched with 97 conventional bonds and weekly data is extracted from Bloomberg. For the case study similar constraints are used and it will be conducted on 5 corporations that issued green and conventional bonds: TenneT Holding B.V., Iberdrola, ENEL, Naturgy and Unibail-Rodamco.

The remainder of the paper is organised as follows, firstly literature related to green bonds and it's financial performance will be discussed to provide a theoretical framework in which this thesis is to be placed. Secondly, data and methodology will be discussed and finally the results will be analysed in order to come to a conclusion regarding the research questions.

2. Literature

In this literature review, firstly, a brief introduction to ESG investing and green bonds will be given. Afterwards, literature focusing on the financial performance of green instruments and green investments will be discussed, specifically green bonds.

2.1. What is ESG investing?

ESG stands for environmental, social and governance. These factors are more and more included by asset managers into their traditional investment strategies. Often these efforts are consistent with Sustainable Development Goals (SDGs) as determined by the United Nations and can even be in line with the COP21. Both the SDGs and the COP21 include regulatory desires to minimize the CO_2 in order to limit 'climate change'. Many corporations implement new strategies in their business operations to qualify or improve their ESG rating. Degrees of implementation of and approaches to ESG investing differs among investors (Eurosif, 2017), and there is still a long way to go. Investment strategies considering ESG factors have gained momentum over the past decades, and there is a large variety of themes all fitting the trend of social responsible investing. Due to an increase in new products on the market the focus on certain themes has increased, for instance sustainability, impact (on the climate) and human rights. According to Eurosif, it is quite easy to implement stocks, bonds and investments into your portfolio that are associated with the SDGs as developed by the UN and the most popular themes linked to sustainability, climate change and renewable energy. Investors can even check, using the right metrics, what the impact and effectiveness of their investment strategy is (Eurosif , 2016). ESG investing should not be confused with ethical investing as it concerns the material long-term economic aspect rather than ethical or morel perspectives (Humphrey, Lee, & Shen, 2012).

2.1.1 Green bonds

The first green bond was issued by the European Investment Bank in 2007 and since its introduction, the green bond market has rapidly grown. Green bonds are different from 'conventional' bonds as the financing is specifically labelled for a specific green purpose which should result in more sustainability worldwide. Projects financed by the issuance of a green bond often replace existing polluting technologies, or technologies that harm nature and technologies that affect climate change in any other way.

Green bonds are any type of bond instrument compliant with the Green Bond Principle, established by the International Capital Market Association.

2.2. The Green Bond Principle (GBP)

The definitions for green bonds are specified in the Green Bond Principle as set by the International Capital Market Association (ICMA). The GBP was developed in order to provide transparency, integrity, disclosure and accuracy of information. Even though the GBP is a voluntary guideline, all parties issuing a green bond are highly encouraged to follow it. The GBP defines four core components that need to be met (International Capital Market Association, sd):

a) Use of proceeds: A broad range of categories of eligible projects are recognised, however, all proceeds should provide clear environmental benefits. These projects are tested and confirmed by independent agencies. If a company decides to issue a green bond, it is required to be transparent about the issued amount and the project for which it intends to employ the financing;
b) Process for Project Evaluation and Selection: clear communication to investors is required by the issuer. Furthermore, the choice for projects should be reviewed by external parties, this independent review adds to the transparency, which is a cornerstone of the GBP;
c) Management of Proceeds: there should be regular updates and tracking of the proceeds. The issuer is required to credit the net proceeds of a green bond to a sub-account after which it should be processed appropriately using internal processes which are linked to the operations of lending and issuing for green projects. Investors should be updated periodically on the status of the unallocated proceeds. In order to ensure definite transparency, issuers are encouraged to include an external party who can verify the internal processes;
d) Reporting: up to date information regarding the use of proceeds should be provided and the information should include a list of projects to which the proceeds are allocated. Information regarding the status of the use of proceeds should be annually updated until completion of the project. Besides the status of the use of proceeds issuers are encouraged to include the impact the project has if those can be monitored (easily).

As mentioned above, issuers of green bonds are strongly encouraged to involve external parties to review and confirm the status of the green bond to improve transparency. In 2018 a record of 89% of the green bonds was reviewed by an external, third party such as the Climate Bonds Standard. However, Moody's and S&P are also able to provide global ratings regarding green bonds. The leading reviewer is CICERO with 28% of deals volume and 81% deals. This should be put into perspective as Fannie Mae issued more than 1,000 green bonds in 2018 which were

all reviewed by CICERO. Another large player providing external reviews is Sustainalitics which reviewed 43 new issuers accounting for USD 27bn of the market volume issued in 2018 (Climate bonds Initiative, 2018).

These voluntary guidelines leave room for interpretation as the list of projects is subject to debate amongst investors. For example, ABP excludes Spanish energy company, Repsol, from their investment portfolio as the proceeds of the green bond are used to make their oil refining process more energy efficient. However, improvement of energy efficiency is one of the eligible projects listed in the Green Bonds Principle (International Capital Market Association, sd). In contrast, they include British SSE that will use the proceeds to expand their wind mill park and modernise their distribution in order to make it easier to transport 'green' energy. ABP considers the green bond issued by Repsol to be an attempt at 'greenwashing' what is considered a brown or black activity (fossil fuel), even though it is an eligible project category under the Green bond Principle: energy efficiency (ABP, 2017a). This debate will be eliminated when considering purely the financial utility and avoid behavioural considerations investors might make.

2.3. Green bond market

Since the issuance of the first green bond by the European Investment Bank in 2007, the cumulative issuance is $521bn till 2018. The birth of the first green bond has led to an explosive growth of a 'new' financial instrument which allocates its proceeds primarily to renewable energy, 52%.

2.3.1. Green bond issuers

Green bonds can be compared to conventional bonds as they too are a debt instrument offering return and the promise to finance or re-finance projects. Similar to conventional bonds, they may be issued by any government, financial institution or company to raise funds on a voluntary basis. As long as the bond complies with the GBP, any bond issuing authority can issue a green bond (EY, 2016).

The worldwide green bond market came to a cumulative issuance of $521bn since 2007 in 2018. In comparison to the global bond market which exceeds $100 trillion, the green bond market is still in its infancy. Therefore it is logical that 31% of the volume issued in 2018 can be accounted to debut issuers, which remarkably only accounts for 12% of the deal count. Some countries have embraced and use green bonds more than others. The United States of America is responsible for the largest issuing count of green bonds in 2018. In 2018 the USA green bonds issued added

up to $34bn, with 63 issuers and a worldwide market share of 20% of newly issued bonds. Noteworthy is the fact that $20.1bn worth of green bonds issued in 2018 was issued by Fannie Mae. Most of their green bonds are issued in order to transform rental houses into more environmental friendly properties as well as healthier for its inhabitants making them suitable to qualify as green bonds.

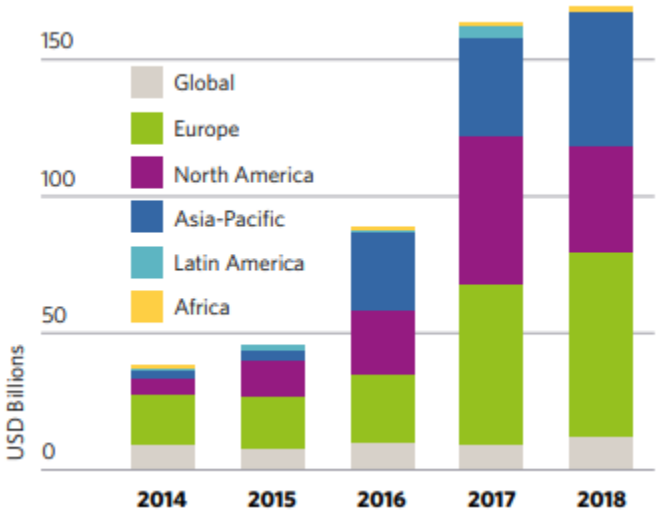

Figure 1 – Yearly issuance per region *(Climate bonds Initiative, 2018)*

After the USA, leading issuers and green bond markets in 2018 are China ($31bn, 18%, 69 issuers), France ($14bn, 8%, 12 issuers), Germany ($7.6bn, 5%, 14 issuers) and the Netherlands ($7.4bn, 4%, 6 issuers). Striking is the fact that the world leader in issuing green bonds was the USA, however, the preferred currency to issue green bonds in was the Euro in 2018, as it represented 40% of the annual market. Green bonds issued in USD represented only 31% of the green bond market in 2018, however, in 2017 the USD was the leading currency with 40% respectively. This shift in currency can be attributed to the large-scale issuance of green bonds by Eurozone sovereigns and other large European issuers. Together the EUR and USD represent c.70% of all green bonds outstanding.

Even though the first green bond was issued in 2007 the market did not rapidly expand until 2015, when the green bond market exploded as many corporates entered the market by issuing green bonds. Since then the average bond size has increased from $184m in 2015 to $320m in 2018 (+74%), excluding all Fannie Mae deals. In 2018 24 green bonds of $1bn or more were issued, the largest green bond being issued until 2018 sized $5.5bn and was issued by the Kingdom of Belgium. In 2019 the Netherlands issued a green bond for $6bn. Overall, most large green bonds are issued by financial corporates and sovereigns.

The largest category of green bonds issued are corporate bonds and represent 45% of the market, either financial corporate or non-financial corporate. Government bonds represent 31% of the market and can be either issued by large sovereigns, local governments, government-backed entities or development banks. The remaining share of issued green bonds are asset-backed bonds (ABS) and loans which constitute the remaining 28% of the market.

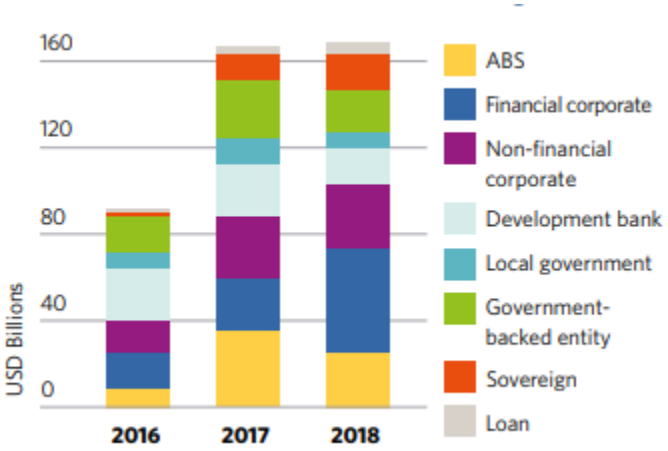

Figure 2 – Type of issuers of Green Bonds *(Climate bonds Initiative, 2018)*

2.3.2. Investors

With increasing market focus on sustainable investing many investors increase their 'green' or 'responsible' stock in their investment portfolios. Investors can include green bonds in their portfolio to cater to the demand of clients or participations as the mainstream desire is to improve on sustainability. Furthermore, investments in green bonds are more transparent than regular issued debt increasing their effectiveness in visibility to improve the climate impact of their investment portfolio. Strikingly, even though there is no consensus regarding the financial performance of the green bonds the high demand is driven by a variety of investors. Investors in green bonds are mainstream institutional investors such as BlackRock[3], APG and PGGM (both manage funds for large pension funds, ABP and PFZW), investors specialised in ESG and responsible investing such as ACTIAM[4], corporates, sovereign and municipal governments and retail investors. Investors are originated from all over the world albeit that some markets are more developed than others (Climate Bonds, 2019).

[3] BlackRock provides support to banks, asset managers and institutional investors, such as pension funds.
[4] ACTIAM provides investment solutions based on responsible strategies for institutional investors, banks and (large) private investors.

2.4. Performance of green financial instruments: academic literature

According to Hong and Kacperczyk (2009), the societal norm against investing in branches that promote vice (triumvirate of sin: alcohol, tobacco, and gaming) causes large institutional investors to shun the so-called 'sin stocks'. However, they find that sin stocks have a higher expected return than comparable stocks, which could be caused by neglect by investors and litigation risk (Hong & Kacperczyk, 2009). A higher expected return allows for a larger pay-off, questioning the intentions of asset managers to aim for the highest pay-off, when intentions are to aim for the highest pay-offs. Large institutional investors such as pension funds are largely influenced by the public's opinion and consequently not only shun sin-stocks and bonds that are proven to be more financially profitable, but also largely include new financial instruments such as green bonds *of which financial performance is relatively unknown.* Other funds tend to be less subjected to social norm, and arbitrageurs like hedge-funds benefit from the situation (Hong & Kacperczyk, 2009).
Even though the paper of Hong and Kacperczyk focusses on the triumvirate of sin, and does not consider sustainability specifically, their findings can be related to a responsible investing point of view as there are two sides to the same coin, namely high returns for the participants (investors) of pension funds but also the desire to "do good" by the public. If the findings from this study could be literally translated to the financial performance of Green Bonds it would suggest that not only green bonds would significantly underperform their financial peers, but so-called 'black' bonds would outperform and increase financial performance of the conventional stock overall. This could be concluded to the fact that 'black' bonds are in many ways similar to sin-stocks, as they are often neglected by institutional investors due to the stigma around fossil fuels and sustainability (fd., 2019) (Grol, sd).

In the past decade, little research on the profitability of green bonds specifically has been conducted, however, several interesting papers regarding ESG and financial performance were written. There seems to be no consensus among researchers due to the limited data, as ESG is relatively new, and vague descriptions of environmental, social and governance investing as well as social responsible investing leaves room to many different interpretations.
Humphrey, Lee and Shen (2012) find that implementing ESG strategy in your investment process and business strategy comes without any significant financial costs *nor* benefits in either risk or return. In addition, approximately 90% of 2000 research papers under consideration in a study dating from 2015 find a nonnegative relation between the financial performances of a corporation as opposed to their ESG efforts (Friede, Busch, & Bassen, 2015).

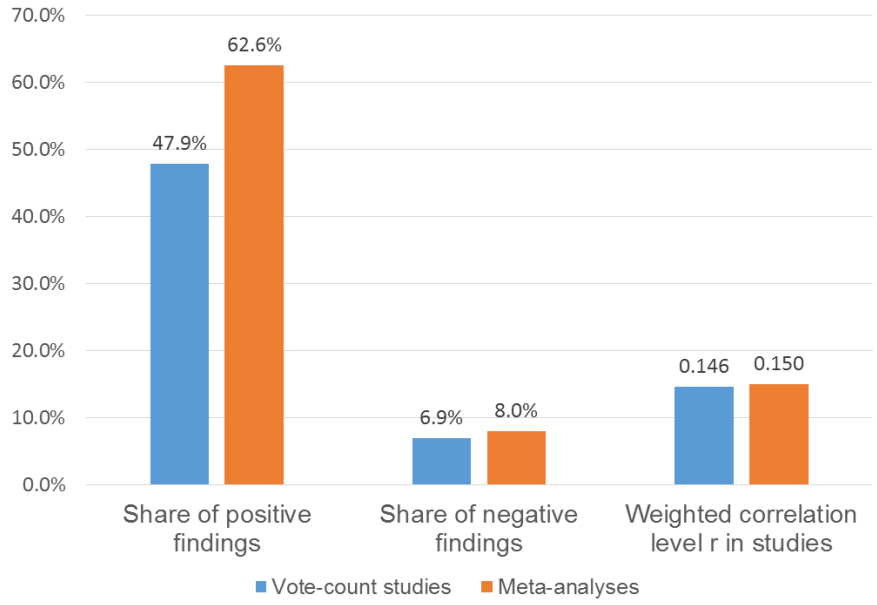

Figure 3 – Summary findings of *(Friede, Busch, & Bassen, 2015)*: approximately 90% of all studies under consideration display a nonnegative relation between ESG investing and returns.

In 2015, Halbritter and Dorfleitner have written a critical review of ESG investing taking into consideration the different systems for rating ESG to eliminate the possibility that the underlying rating approach influences the results. They claim that mutual funds under consideration do not necessarily hold a greater extent of social responsible firms than conventional funds do, but are subject to interpretation. In contrast to other studies, their results argue against previous studies suggesting abnormal returns on ESG portfolios, as they find there is no significant difference in return compared to conventional portfolios, and their Carhart four-factor model even shows a decline in preceding performance over the past years (Halbritter & Dorfleitner, 2015).
Other papers even claim there is a financial price to be paid, a so called negative 'greenium', when implementing socially responsible investment strategies visible when abandoning the mean-variance framework and using a Marginal Conditional Stochastic Dominance. The authors suggest non-financial utility compensates for the loss of financial utility, which can be linked to the nature of the social investments (Belghitar, Clarck, & Deshmukh, 2014).

The Journal of Business Ethics published a paper, in 2015 by Ibikunle and Steffin stating that green mutual funds significantly underperform conventional funds over a 23-year sample period. Furthermore, in line with Hong and Kacperczyk they compare green mutual funds with 'black' mutual funds (focussed on fossil fuels etc) and find evidence that suggests that green mutual funds are beginning to outperform mutual funds, a trend which they expect will remain in the

foreseeable future. In conclusion, momentarily green mutual funds currently underperform, however, due to the (expected) increase of issuing green financial instruments, green mutual funds will slowly start outperforming their financial peers.

In 2018 Tang and Zhang conducted a study focussing on the announcement effects of green bonds and do not find a green premium or 'greenium' even though green bonds tend to be issued at a lower yield spread than corporate bonds issued by similar firms. Furthermore, they find that issuing green bonds increases institutional ownership by 7.9%, mostly driven by pension funds. In contrast to increased institutional ownership by pension funds, they find that hedge funds tend to reduce their interests in those firms. Moreover, they test the effect of green bond issuance on the stock of a company and find that stock liquidity improves making it beneficial for the existing shareholders of the issuer (Tang & Zhang, n/a). The Journal of Banking & Finance published a paper by Olivier Zerbib at the beginning of 2019 that investigated the difference in financial performance of green bonds and their conventional peers. Using the model-free approach he finds a small, significant, negative premium that should not necessarily be considered a reason to decease investing in green bonds as the difference is extremely small.

All together there seems to be no consensus on the performance of green financial instruments, let alone green bonds. Since most research is conducted on investment portfolios or mutual funds in which bonds are considered, it is an interesting addition to consider bonds on a standalone basis. As green bonds are relatively new to the market and explosively growing it seems interesting to not only compare the financial performance of green bonds with conventional bonds. Considering previous research, it would seem that green bonds do not yield a competitive financial performance in comparison to their conventional peers. Yet the drivers of this negative 'greenium' to be paid are not clear. Besides different drivers of the difference between green and conventional bonds, the difference between liquidity risk need to be taken into consideration. Corporate bond spreads are seemingly affected by liquidity risk (Lin, Wang, & Wu, 2011), whilst green bonds spreads appear to be unaffected by liquidity risk (Febi, Schäfer, Stephan, & Sun, 2018). In the table below, all articles discussed are listed.

ESG/Green bonds			
Year	**Authors**	**Title**	**Findings**
2009	Hong and Kacperczyk	The Price of sin: effects of social norms on market	Find that: [1] sin stocks are less held by norm-constrained institutions such as pension plans as compared to mutual or hedge funds that are natural arbitrageurs, [2] they have higher expected returns than otherwise comparable stocks, consistent with them being neglected by norm-constrained investors.
2007	Kempf and Osthoff	The Effect of Socially Responsible Investing on Portfolio Performance	Maximum abnormal returns are reached when investors employ the best-in-class approach, use a combination of several socially responsible screens at the same time, and restrict themselves to stocks with extreme socially responsible ratings.
2015	Halbritter and Dorfleitner	The wages of social responsibility – where are they?	The results suggest that investors should no longer expect abnormal returns by trading a different portfolio of high and low rated firms with regard to ESG aspects.
2008	Renneboog, ter Horst and Zhang	The price of ethics and stakeholder governance: The Performance of socially responsible mutual funds	Using a matching method, Renneboog et. al., compare the returns of socially responsible mutual funds with benchmark funds. They find evidence that socially responsible funds underperform which is not necessarily driven by the ethical characteristic of the funds.
2015	Friede, Bush and Bassen	ESG and financial performance: aggregated evidence from more than 2000 empirical studies	Roughly 90% of all studies considered find a nonnegative relation between ESG and actual performance. More importantly, the large majority of studies report positive findings. The positive ESG impact on performance appears to be stable over time.
2014	Belghitar, Clark and Deshmukh	Does it pay to be ethical? Evidence form the FTSE4Good	Results provide strong evidence that there is a financial price to be paid for socially responsible investing.
2012	Humphrey, Lee and Shen	Does it cost to be sustainable?	Investigate whether implementing a more socially responsible strategy affects comes at a cost. They find evidence that suggests that implementing such strategy does not come at additional (financial) costs.
2015	Ibikunle and Steffin	European Green Mutual Fund Performance: A Comparative Analysis with Their Conventional and Black Peers	Compare the financial performance of green, black and conventional European mutual funds. They finds that green mutual funds significantly underperform conventional mutual funds over the period 1991-2014, however there appears to be no significant difference between the performance of green and black mutual funds during this period. Even though green mutual

			funds significantly underperform conventional mutual funds, they find evidence that suggests that green mutual funds are beginning to outperform their black peers.
2018	Tang and Zang	Do Shareholders Benefit from Green bonds?	Research the effect of green bond issuance on the stock performance of issuers. They find that there is no (positive) respond to the issuance of green bonds, nor a significant green bond premium. However, they do find evidence that the institutional ownership increases as well as liquidity improves after the company decides to issue a green bond.
2019	Zerbib	The effect of pro-environmental preferences on bond prices: Evidence from green bonds	Zerbib finds a small, significant negative influence 'greenness' of a bond has on the financial performance These findings suggest there is little influence of preferences for pro-environmental investing on bond prices which means that investors should support the rapid expansion of new issuance of green bonds.
2006	Bollen	Mutual Fund Attributes and Investor Behavior	Using a matching method, Bollen compares the cash flows into conventional funds with the cash flows into mutual funds. He finds that investors due derive utility from investing in socially responsible options.
2014	Helwege, Huang and Wang	Liquidity Effects in Corporate Bonds Spreads	Helwege et. al. use a matching method to determine the right proxies for the liquidity component of bonds. They come to the conclusion that there is not necessarily a best method.
2017	Fong, Holden and Trzcinka	What Are the Best Liquidity Proxies for Global Research?	Identify different liquidity proxies for low-frequency data that are still high-quality. They find that for lower frequency data, the closing spread can be used as an accurate proxy for liquidity.
2018	Febi, Schäfer, Stephan and Sun	The impact of liquidity risk on the yield spread of green bonds	In this study the authors research what the effect of liquidity risk is on bond spreads. They find evidence that liquidity risk for green bonds is negligible.
2011	Lin, Wang and Wu	Liquidity risk and expected corporate bond returns	Lin, Wang and Wu find evidence that the liquidity risk influences the financial performance of corporate bonds.

3. Data description and model-free approach

In order to analyse if there is a difference in financial performance of green bonds and their conventional peers an empirical model needs to be established. Before deciding upon an approach (financial) variables which impact the performance of a bond and its' intrinsic value need to be determined. These variables need to be descriptive of the financial performance of a bond, yet robustness of the outcomes needs to be ensured. In the next section the dependent variable will be discussed, providing a basis for an empirical framework on which the regressions will be build. Additionally, an alternative method for measuring the performance of green bonds will be discussed along with a method to determine the difference in financial performance.

3.1. Bond performance

3.1.1. Interest rate risk and Default risk

The bond market is one of the most liquid markets for financial instruments, often even larger than the market for stocks. In principal most bonds pay a fixed interest rate (coupon type) and price adjustments can be measured in the return: the yield of a bond. As opposed to stocks, risks explaining bond prices can be easily determined as there are only two main risks: (a) interest rate risk, and (b) default risk. Together these two risks can alter the price of a bond. If the demand for credit tightens or loosens all bonds will be affected or if full repayment of the bond is no longer secure the bond price will change.

The interest rate risk of a bond is determined by:

$$P_{bond} = \sum_{t=1}^{t=T} \frac{coupon}{(1+r_t)^t} + \frac{principal}{(1+r_t)^t} \quad (1)$$

The r_t that equates both sides of the equation is the yield-to-maturity. High coupon bonds tend to be less sensitive than lower coupon bonds as a larger part of the cash is received earlier. Default risk is reflected by the rating of the bond which corresponds with the default probability. In this thesis the rating provided by Moody's was used to determine the default risk of an issuer. Moody's provides a range of ratings between Aaa to D, in the last case the rating would imply a large probability of default. This rating does not equal an actual probability as a risk premium is factored in which may depend on the rating and vice versa.

3.1.2. Liquidity risk

The market size for green bonds and conventional bonds differs substantially. Where the conventional bond market is one of the largest markets for financial instruments, the green bond market is still emerging and experiencing rapid expansion. The difference in size between the two markets may cause a difference in liquidity which affects the bond performance. Even though the Green Bond Principle was created, the market still faces a small lack of transparency and opinionated investors which can result in adverse selection costs (Febi et. al., 2008). Other research conducted on corporate bond spreads have determined that liquidity risk is an important determinant of the financial performance (Lin et. al., 2011). Due to this difference of importance between green and conventional bonds, the difference in liquidity will not be disregarded when constructing the regression models.

3.1.3. Z-spread

Fixed-income analysts and financial analysts at large financial institutions look at the z-spread instead the yield-to-maturity. The z-spread represents the constant spread equalling the price of the bond with the present value of the cash flows if they are added to the yield-to-maturity on each point of the Treasury curve of the spot rate. Therefore the z-spread is a static measure of the financial bond performance as it represents the spread that will be received over the entire Treasury yield curve. The z-spread can be seen as an indication of the risk premium between two financial instruments as it equals the difference between the quoted rates of a (corporate) bond and the Treasury yield curve. Moreover, the z-spread tends to provide a better indication of performance for shorter dated bonds and bonds which have a better credit-quality and is a measure of the markets perception of the bond performance (Choudhry, 2006).

3.2. Model-free approach

Since this thesis focusses on the difference in financial performance of green and conventional bonds, the model-free approach or direct approach was chosen. Bollen (2006) uses the method of matching when comparing socially responsible funds and conventional funds to determine whether investors derive utility from investing more socially responsibly. Renneboog et. al. (2008), follow this example when they conduct a study determining if investors ‘pay a price’ for social responsible investing as opposed to conventional mutual funds. Most recently Zerbib (2019) mimicked this approach when conducting his research on the financial performance of green bonds. This approach allows for a matching method based on characteristics of the bond that influence the yield yet enabling the researcher to eliminate the default risk of an individual mostly. Following this approach green bonds are individually matched with conventional bonds based on

similar properties, however, the property of interest differs. Even though, yield-to-maturity of a bond is influenced by the credit risk and the default risk, the liquidity of a bond should be considered too as it influences the price of a bond. When using the model-free approach bonds can be compared while controlling for the difference in liquidity as the liquidity proxies used by Helwege et. al. (2014) are incorporated. In addition, using this model assumes that certain risks are completely eliminated as factors influencing this risk are equal among both the database of green and conventional bonds.

3.2.1. Green bond database

Before being able to evaluate the difference in financial performance of green and conventional bonds, a database needs to be constructed. For this purpose Bloomberg was consulted based on characteristics that need to be identical between the green and conventional bonds in order to eliminate risks such as issuer risk. These characteristics are similar to those used by Zerbib (2019) and Helwege et al (2014). The only difference between the bonds being the parameter of greenness of a bond: as the difference in financial performance between green and conventional bonds is the scope of this thesis. In line with Helwege et al (2014), parameters were chosen to limit the effects of liquidity on difference in the bond performance. As the parameters chosen allows the default risk to be 'eliminated' the difference between the green bond yield and the conventional bond yield should equal the effect of the liquidity difference and the 'greenium'.

Bloomberg provides information for a sample of 1,292 bonds for which the use of proceeds are qualified as 'Green Bond/Loan' and have a fixed coupon. Since most green bonds were issued in either EUR of USD, the search was limited to these two currencies reducing the sample to 613 bonds. As most green bonds are issued as a bullet, this screen was added together with the seniority of the bond (senior preferred, senior unsecured, senior non-preferred) necessarily to equal the payment rank of the bonds under consideration. The screens: green bond/loan; fixed coupon; currency; bullet; seniority generated a sample of 415 bonds issued worldwide. Furthermore, all green bonds had a rating which is necessary for matching the green bonds with conventional bonds.

Green bond selection process	
1 Use of Proceeds: Green Bond/Loan	1,716
2 Coupon type: Fixed	1,292
3 Currency: EUR or USD	613
4 Maturity type: bullet	451
5 Payment Rank: Senior Unsec/Pref/Non pref	415

Table 1 - Screens used during the selection process of the green bond database. Only bonds that qualified their use of proceeds as: Green Bond/Loan were considered. In order to be able to make a valuable conclusion, only green bonds with a fixed coupon type, issued in EUR or USD and issued as a bullet were considered. To be able to match the green bond with a conventional bond with an equal default risk the seniority of the bond was included.

After the green bond database was constructed, the green bonds needed to be matched with a similar conventional bond. The same selection process in Bloomberg was used, however, all bonds that listed a use of proceeds: Green Bond/Loan were excluded. Bloomberg provided with a dataset of 40,533 bonds issued that possibly qualified as opponents for the green bonds in the database.

Conventional bond selection process	
1 Use of Proceeds, exclude: Green Bond/Loan	419,836
2 Coupon type: Fixed	268,550
3 Currency: EUR or USD	147,717
4 Maturity type: bullet	53,960
5 Payment Rank: Senior Unsec/Pref/Non pref	40,533

Table 2 - Screen used during the selection process of possible conventional bonds matches. As every green bond needs to be matched with an equal conventional bond all bonds that qualified their use of proceeds as: Green Bond/Loan were eliminated. Furthermore, all screens used in the selection process of the green bond database were matched here. When matching the green bonds with the conventional bonds, currency was matched: if the green bond was issued in EUR, the conventional bond had to be issued in EUR as well. Same holds for USD, this to eliminate currency risk between the two bonds matched in the pair.

The previous screens mentioned are not sufficient for matching the green bonds with a conventional equivalent by the same issuer. In the next step each green bond was hand-matched with a conventional bond based on restrictions of issue date, maturity date and issue amount in line with Zerbib (2019). These differences in issue date, maturity date and issue amount should be restricted to eliminate liquidity risk and differences and maturity bias as much as possible as it substantially influences the yield of a bond (Helwege, Huang, & Wang, 2014). The issue amount

of the conventional bond is restricted to at most 4 times the issue amount of a green bonds or at least 0.25 times the issue amount of a green bonds. In a later stage these constraints will be tested, to analyse and if necessary control for the little liquidity bias left in the sample. The maturity date cannot differ for more than 2 years in order to limit the maturity bias. The issue date cannot differ for more than 6 years, either earlier of later. Research varies in the use of levels of difference in issuance, the difference in issue date was chosen to be similar to the difference as chosen by Zerbib (2019) as it will allow for a broader sample with closer maturity dates.

Matching criteria Green vs Conventional
(i) Issue date: Δ 6 years
(ii) Maturity date: Δ 2 years
(iii) Issue amount Conventional: <4x Green
(iv) Issue amount Conventional: >0,25x Green

Table 3 - Additional criteria used to match each green bond with a conventional bond. These criteria were added to eliminate maturity bias and reduce the liquidity bias as much as possible.

Only the EUR and USD are included in the sample, as 65% of all green bonds in the universe were issued in either of these currencies providing a more in depth results of the regression as this creates the largest and most developed subsection of the market. Furthermore, average issue size increased since the issuance of the first bond. In 2017 and 2018 the average issue size of a green bonds was USD 320m, slightly higher than USD 294m in 2016. Therefore, all most all green issued bonds in the sample had an issue amount larger than USD 300m (which is slightly less than EUR300m), except for 5 green bonds whose issue size was less than USD 300m. These 5 green bonds were included as they were matched conventional bond had a similar size and they represented an issuer of interest (e.g. African Development Bank). As previously mentioned, this thesis controls for seniority, and includes only Senior Unsecured, Senior Preferred and Senior Non Preferred Green Bonds. This variable is identically matched by the conventional bond. Seniority is matched as it determines the payment rank of a bond in event of default. If both bonds are senior instead of subordinated, they both have a first claim in case an issuer defaults. Most senior bonds are unsecured, meaning they are not backed by assets pledged as collateral but are claims against any general asset of the issuer. However, senior (non)preferred bonds are a other type of bond offering regulatory benefits to its issuers. Financial Institutions offer senior (non)preferred debt as it is cheaper the issue and can use a certain percentage of their risk-weighted assets as (non)preferred senior debt. As Financial Institutions are the only issuers in the sample that offer (non)preferred senior bonds this will be added as a control variable. Together

with the previous parameters, these additional criteria to the green bonds selection will provide an additional layer of depth to the regression as it does not include smaller bonds and emerging issuing currencies which could possibly disrupt the outcome due to their limited experience with green bond issuance.

The process of matching provides a sample of 97 green bonds equalling 12.4% of the cumulative issued green bonds since 2007[5] (Climate bonds Initiative, 2018). Within the sample the distribution of types of issuer is as follows: Financial Institutions 47%, Government 30% and Utilities (Corporates) 23%. This distribution is somewhat similar to the entire green bond market where 31% was issued by a financial corporate, development bank or as a loan; 29% was issued by a government-backed entity, sovereign or local-government; and 20% was issued by a non-financial corporate. All corporates in the sample qualified as utilities which is not strange as the top 3 sectors in which issuers operate are transport, energy and water. Furthermore, 54.4% of the green (and conventional) bonds in the sample were issued in EUR, opposed to 45.6% in USD. This seems to be representative of the market were 36% of the green bond universe was issued in EUR and 29% of the green bond universe was issued in USD. In addition, for the rating of the bond, the rating as provided by Moody's has been simplified to Aaa, Aa, A, Baa, Ba and B. The rating is included as there might be difference between different ratings and between sectors. What becomes extremely evident from the descriptive statistics is the enormous difference between the average yield of bonds issued in EUR and USD. Moreover, senior preferred bonds on average have a lower yield-to-maturity than the senior secured bonds have. The entire sample under consideration is described in table 4. All together this table implies a necessity to include sector, rating and currency in the regression as the average yield between those categories differ.

[5] Cumulative issuance of green bonds since 2007 reached $521bn in 2018.

Green bonds data base				
		EUR	USD	Total
Financial				50
Aaa	Average yield	0,17	2,66	1,60
	Average Maturity	2,52	2,99	2,79
	# Green bonds	3	4	7
Aa	Average yield	0,31	2,77	0,59
	Average Maturity	3,26	1,28	3,04
	# Green bonds	8	1	9
A	Average yield	0,50	3,29	1,23
	Average Maturity	4,04	4,44	4,12
	# Green bonds	14	4	18
Baa	Average yield	1,20	4,30	1,98
	Average Maturity	5,28	7,10	5,74
	# Green bonds	9	3	12
Ba	Average yield		4,92	4,92
	Average Maturity		4,94	4,94
	# Green bonds		2	2
B	Average yield		5,30	5,30
	Average Maturity		1,90	1,90
	# Green bonds		2	2
Government				31
Aaa	Average yield	0,41	2,56	2,47
	Average Maturity	8,48	4,41	4,59
	# Green bonds	1	21	22
Aa	Average yield	0,58	2,46	1,83
	Average Maturity	8,27	2,31	4,30
	# Green bonds	1	2	3
A	Average yield	0,46		0,46
	Average Maturity	4,88		4,88
	# Green bonds	2		2
Baa	Average yield		3,83	3,83
	Average Maturity		4,49	4,49
	# Green bonds		4	4
Utilities				15
Aa	Average yield		3,42	3,42
	Average Maturity		3,73	3,73
	# Green bonds		4	4
A	Average yield	0,39		0,39
	Average Maturity	1,44		1,44
	# Green bonds	2		2
Baa	Average yield	1,02	2,61	1,20
	Average Maturity	5,55	0,54	4,99
	# Green bonds	8	1	9
Average yield		0,75	3,12	1,92

Table 4 - Descriptive statistics of the green bond sample used in this thesis. It provides an overview of average yield and maturity per category, rating and currency. In addition it displays the seniority of the bond.

3.2.2. Yield-to-maturity

The mid yield-to-maturity is used as the scope of the thesis wishes to define the difference of financial performance from an (institutional) investor's perspective, however, with consideration of the supply of green bonds in the market. Furthermore, the bid yield-to-maturity and ask yield-to-maturity will be used to determine the liquidity effect on the yield-to-maturity of the bond pairs. The sample of matched green and conventional bonds consists of 8,202 observations constituting into an unbalanced bond-weekly panel for the time period 1-1-2013 till 31-5-2019. The corresponding descriptive statistics for the dataset are presented in table 5.

	Sample: 97 matched bond pairs					
	min	p25	median	mean	p75	max
Days per bond pair (in sample)	8	197	478	595	981	2010
Mid yield of Green bond	-0,23	0,61	1,94	1,88	2,75	5,3
Mid yield of Conventional bond	-0,19	0,63	1,77	1,92	2,77	5,96
Mid yield difference: $\Delta Yi,t$	*-0,79*	*-0,26*	*-0,06*	*-0,04*	*0,16*	*0,77*
Maturity Green bond	0,09	2,46	4,15	4,28	5,8	11,46
Maturity Conventional bond	0,23	2,42	3,45	4,06	5,36	9,97
Amount issued Green bond (bn)	0,02	0,5	0,5	0,67	0,75	1,5
Amount issued Conventional bond (bn)	0,04	0,6	1	1,07	1,46	4,5

Table 5 - Descriptive statistics of the bond dataset. The number of days per bond pair equal the days in the sample for which both the green and the conventional bonds provided observations. Both mid yield-to-maturity of green bonds and conventional bonds are given, as well as the difference between the two yields. The model-free approach depends on the accuracy of the matching of the characteristics, therefore the maturity and amount issued are stated for both green bonds and conventional bonds. The maturity of the bonds is given as measured on 31-5-2019.

4. Empirical framework

In order to approximate the effect of the characteristics of the bonds on the financial performance and eventually determining whether a “greenium” exists a regression model needs to be constructed. This regression model along with the robustness checks will be constructed, based on the parameters and variables discussed in the previous sector, and elaborated on in the following section.

A regression model will be constructed using ordinary least squares approach, and tests for robustness checks, adding all dependent and control variables that influence the yield of a bond. The approach constructed by Zerbib (2019) is followed, however, only includes EUR and USD as those are the main currencies for issuance. Furthermore, in a later process the difference in senior ranks will be added to the regression model. Since the model-free approach is used the regression model as constructed by Zerbib (2019) seems appropriate as it includes all factors that influence the difference between the financial performance of the green bond and the conventional bond pair, however, excludes characteristics that are irrelevant as the bonds in the pair are issued by the same issuer. The characteristics included describe the difference between the bond pairs: currency, amount issued, maturity, issuer type, seniority and rating all are equal within the pair, yet differ between the bond pairs.

As it cannot simply be assumed that green bonds perform worse than conventional bonds, the first step is to determine if green bonds actually perform worse than green bonds. This regression will include all factors that possibly influence the yield-to-maturity of a bond. The only strikingly different factor is the ‘greenness of the bond’.

$$Yield\ to\ maturity = \ \alpha_0 + \ \alpha_1 Green + \ \alpha_2 Amount\ Issued + \alpha_3 Maturity(life\ of\ the\ bond) + \alpha_4 Issuer\ Type + \ \alpha_5 Rating + \varepsilon_i \ (2)$$

In order to determine the difference in performance between the green and the conventional bond, the possible liquidity difference should not be neglected. As mentioned in the literature review, green bonds do not experience an effect of liquidity risk on their financial performance, whereas other research found evidence that corporate bonds’ financial performance is affected by liquidity risk (Febi et. al., 2018) (Lin et. al., 2011). Even though the sample set construction included restrictions to reduce the difference in liquidity it cannot be ignored and needs to be assumed to

affect the difference in performance. This means that the statistical model for the green bond premium will therefore be:

$$\Delta y_{i,t} = p_i + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t} \quad (3)$$

In this regression, the green bond premium (p_i) can be either positive or negative and equals the difference in yield-to-maturity of the green bond and the conventional bond and the difference in liquidity. The green bond premium can further be defined as all factors driving the difference between the yield-to-maturity of green bonds and the yield-to-maturity of conventional bonds:

$$p_i = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Issuer\ Type + \alpha_4 Rating + \alpha_4 Currency + \alpha_5 Payment\ Rank + \varepsilon_i \quad (4)$$

If equation 4 is substituted into equation 3 and rewritten, the green bond premium equals the difference between $\Delta y_{i,t}$ and the difference in liquidity of the bonds:

$$p_i = \Delta y_{i,t} + \beta \Delta Liquidity_{i,t} + \varepsilon_{i,t} (5)$$

4.1. Estimating the liquidity difference

The green and conventional bonds were matched on two proxies that determine the liquidity of the bond, issue date and issue amount, to constrain the effects. Therefore liquidity difference and bias is expected to be minimal. However, to ensure the outcomes of the regression of the green bond premium the liquidity proxy needs to be estimated. The liquidity proxy can be estimated by the daily trading volumes, which are not included in the data set as it consists of weekly data. So an alternative method needs to be constructed with 'lower' frequency data. For this purpose the bid-ask spread will be calculated and used as a liquidity proxy consistent with previous research conducted by (Fong et. al., 2017), (Febi et. al., 2018) and Zerbib (2019). The bid-ask spread equals the difference between the demand and supply in the market and is a reflection of the trading volumes and prices of the bonds in the market. This all represents the liquidity of the market and is therefore a suitable measure to estimate the bias in the database and possibly control for it.

$$\Delta BA_{i,t} = BA_{i,t}^{Green\ bond} - BA_{i,t}^{Conventional\ Bond} \quad (6)$$

From table 6 we can conclude that the difference in liquidity is roughly concentrated around 0. For the purpose of this thesis the measures taken to reduce the liquidity difference between the green and the conventional bond in the pair will be considered adequate. This indicated that the regression of the p_i, the green bond premium, will yield acceptable results.

Liquidity proxy	min	p25	median	mean	p75	max
∆BAi,t	-0,881	-0,100	0	0,003	0,009	0,357

Table 6 - Descriptive statistics of the liquidity proxy estimated based on the bid-ask spread difference of the green bonds and the conventional bonds. $\Delta BA_{i,t}$ is the average difference per pair of bonds in the sample period.

In line with Zerbib's (2019) method, first all variables affecting the 'greenium' will be tested if they are better suited to be included in the regression as fixed effects, as opposed to random effects. When the effects are fixed, the time variable can be eliminated and there is no need to include a distribution or information about other bonds on the market. This means fixed effects are more desirable as the bond market is one of the most liquid and largest markets for fixed income instruments. As the sample was limited with various constraints the results will hold only for the bonds meeting the required characteristics as opposed to a broader category of bonds.
The fixed effects are estimated with a regular *within* regression after which they are tested for efficiency via the Hausman test and various robustness checks such as the Newey-West and Beck-Katz test which estimate standard errors addressing heteroscedasticity which may cause a loss of efficiency.

The Hausman test indicated that the fixed-effects within regression was more suitable to use as opposed to a random-effects approach. Therefore, fixed-effects were constructed to be included into the regression testing the drivers of the green bond premium. The Newey-West test was conducted because it is an extension of the Huber/White/sandwich robust estimator which produces standard errors which are consistent for an ordinary least square regression. In addition Newey-West also considers possible autocorrelation and heteroscedasticity. Moreover, Beck-Katz test provides an estimate of parameters with asymptotic standard errors as to 'correct' for correlation between the bond pair in the entire panel sample. The standard errors of all three tests are significant at a 99% level. Even though the R-squared is relatively weak, c.4%, the coefficient for the bid-ask spread is highly statistically significant, at a 99%-confidence interval, for the regression as well as the Newey-West and Beck-Katz test.

ΔYi,t	Regression Std. Error ***	Newey-West Std. Error***	Beck-Katz Std. Error***
ΔBAi,t	-0,995	-0,995	-0,995
	0,052	0,094	0,288
# observations		8,202	
R-squared		0,0424	
Adj R-squared		0,0423	
F(1, 8200)		362,91	

Table 7 - Standard errors for the regression of the difference in liquidity of the green and the conventional bond on the difference in the yield of the bond pair. All three standard errors are included to control for correlation and heteroskedasticity

4.2. Estimating the greenium

4.2.1. Model-free approach

As tested with a Hausman test, the fixed-effects regression is appropriate to use when estimating the drivers of the green bond premium. As the liquidity difference is very small it will be disregarded in the following steps as the green bond premium is the topic of discussion. The 97 green bond premia will be used for testing the drivers of the difference in financial performance of green bonds and conventional bonds.

Before determining the influence of factors that drive the difference in the yield of green and conventional bonds an overview of all distributions within categories is provided in table 8. As can be observed from the distribution the average positive premium is largest for governments, however, remarkably all observations of the difference between the green bond yield and the conventional bond yield are positive for utilities whereas more than half of the bond pairs issued by government display a negative green bond premium.

The distribution of the difference in yield is always positive for all green bonds rated as Aaa and Baa in the sample whereas at least half of the bonds under consideration that are rated Aa, A, Ba and B have a negative green bond premium. Furthermore, green bonds issued in EUR tend to yield a lower yield-to-maturity on average, -3bps, than bonds issued in USD with an average of +7bps. It also becomes clear that the payment rank of the bond should be added to the regression as the difference between yield-to-maturity for senior unsecured bonds and senior non-preferred tends to be mostly positive (median 0bps and 19bps respectively), whereas more than half of the bond pairs issued in a senior preferred payment rank have a negative green bond premium,

-8bps, and the bond premium is negative on average, -11bps. Noteworthy is the fact that all senior preferred bonds were issued by financial institutions that displays the lowest green bond premium on average, +0.4bps with and more than 50% of the bonds pairs displays a negative green bond premium -3bps.

Greenium (Pi)	median	mean	Pi≠0
Total	-0,002	0,190	***
Issuer Type			
Financial	-0,026	0,004	***
Government	-0,001	0,061	***
Utilities	0,022	0,038	***
Rating			
Aaa	0,002	0,105	***
Aa	-0,076	0,013	***
A	-0,47	-0,001	***
Baa	0,056	0,18	***
Ba	-0,211	-0,211	
B	-0,533	-0,533	
Currency			
EUR	-0,052	-0,025	***
USD	0,000	0,071	***
Payment Rank			
Sr Unsecured	0,000	0,035	***
Sr Preferred	-0,079	-0,107	***
Sr Non Preferred	0,186	0,154	***
*** p<0.01			

Table 8 - Distribution of green bond premium among issuer type, rating, currency and payment rank. All distributions were checked with a Wilcoxon sign-rank test. The Wilcoxon sign-rank test, compares the distribution of the matched pairs.

The distribution of the green bond premium provides an overview of possible factors driving the green bond premium[6]. In order to test the impact of these factors various regressions are constructed on the difference in yield and ultimately determine the impact these factors have of the green bond premium, positive or negative. For the construction of the regression model, a similar approach as Zerbib (2019) was followed.

i. $p_i = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Issuer\ Type + \alpha_4 Rating + \alpha_4 Currency + \alpha_5 Payment\ Rank + \varepsilon_i$

   This the most elaborate version of the regression and includes issuer type, rating, currency

[6] As the liquidity difference between the two bonds in each pair is assumed to be concentrated around zero it is therefore neglected in the formula. Thus $\Delta y_{i,t} = p_i$ is assumed.

and payment rank as control variables and amount issued and the maturity of the bond as independent variable driving the green bond premium.

ii. $p_i = \alpha_0 + \alpha_1 Issuer\ type + \alpha_2 Rating + \alpha_3 Currency + \alpha_4 Payment\ Rank + \varepsilon_i$
Secondly, the independent variables are excluded to assess the impact of the control variables on the regression. Furthermore, this exclusion from the sample creates the opportunity to assess possible the impact size and maturity of the bond on the green bond premium have.

iii. $p_i = \alpha_0 + \alpha_1 Issuer\ type + \alpha_2 Rating + \alpha_3 Currency + \varepsilon_i$
The exclusion of the payment rank creates the opportunity to assess whether the regulatory advantages of issuing a (non-)preferred bond impact the green bond premium significantly. Furthermore, as mostly larger bonds were included it is interesting to determine if there is a significant effect when the independent variable is excluded. Additionally, as the green and conventional bond were matched controlling for maturity it is interesting to test whether excluding the maturity of the bonds significantly impact the outcome of the regression.

iv. $p_i = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Currency + \varepsilon_i$
Eliminating the control variables to assess the impact of the amount issued and the maturity of the bond. The only control variable included is the currency as it has an enormous impact on the yield-to-maturity differences and eliminates the currency risk.

All the above constructed regression display the effect of the drivers on the green bond premium, given the assumption liquidity risk can be removed from the difference in yield because it is concentrated around 0. It will be checked if the assumption was correct by regressing the difference in yield using the templates of the green bond premium drivers as mentioned above, however, with the liquidity added:

i. $\Delta y_{i,t} = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Issuer\ Type + \alpha_4 Rating + \alpha_4 Currency + \alpha_5 Payment\ Rank + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$

ii. $\Delta y_{i,t} = \alpha_0 + \alpha_1 Issuer\ Type + \alpha_2 Rating + \alpha_3 Currency + \alpha_4 Payment\ Rank + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$

iii. $\Delta y_{i,t} = \alpha_0 + \alpha_1 Issuer\ Type + \alpha_2 Rating + \alpha_3 Currency + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$

iv. $\Delta y_{i,t} = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Currency + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$

4.2.2. Z-spreads

An alternative method to determine the difference in financial performance used by market analysts uses the z-spread of a bond which equals its' idiosyncratic risk. In order to determine whether a green bond performs better or worse than conventional, similar conventional bonds issued by the same issuer and several green bonds were used. Requirements for the green bonds was the currency as it had to be issued in EUR, the largest market for green bonds; senior unsecured debt, no regulatory advantages and most green bonds are issued as senior unsecured debt; and the amount outstanding needed to be equal or larger than EUR300.

Before using z-spread as an adequate measure of the difference in financial performance of green and conventional bonds several conventional bonds need to be found that match the restrictions mentioned above. After bonds suitable to match are found these need to be interpolated or extrapolated in order to create an artificial z-spread a conventional bond would have with the same maturity as the green bond. Inter-/extrapolating conventional bonds will make it possible to compare green and conventional bonds which have different maturity dates as it estimates the value of the z-spread for all maturities. As a result, assumptions can be made considering the position of the z-spread of the green bond and the estimation of the z-spread for a bond with the same maturity date. To provide a good estimation of the z-spreads there needed to be at least 3 conventional bonds to use for inter-/extrapolating as the relation between z-spread and life of the bonds is not necessarily a linear relation. This thesis will discuss 5 cases issuers qualifying as "corporates": TenneT Holding B.V., Iberdrola S.A., ENEL, Naturgy and Unibail-Rodamco SE. As inter-/extrapolating the conventional bonds is used to determine the difference in performance an event study is used. For this event study the first four months of 2019 are considered as trading patterns of bonds tend to show a little seasonality. The first months of the year display the least seasonality.

The results of the regressions and the assumptions to be made from inter-/extrapolating conventional bonds to compare with green bonds will be discussed in the next section.

5. Results

The following section will outline the results of the various regressions constructed under the empirical framework. After which, the outcomes from inter-/extrapolating the z-spreads of the bonds will be discussed.

5.1. Model-free approach

The distribution of the green bond premium in the sample are displayed in table 9 and range from a negative 73bps to a positive 80bps and have a of median of -0bps and a mean of 19bps. A negative median corresponds with more than 50% of all the green bond premiums have a negative value implying there is a price to be paid for investing in green bonds.

Greenium	min	p25	median	mean	p75	max
Pi (%)	-0,727	-0,195	-0,002	0,190	0,213	0,804

Table 9 - Displays the distribution of the green bond premium in the sample deduced from the regression build to estimate the difference in yields of green bonds and conventional bonds: $\Delta y_{i,t} = p_i + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$

The variables used in the various regressions are described in table 10. All variables are equal kept equal to the variables in Bloomberg, except for rating these are simplified to: Aaa, Aa, A, Baa, Ba and B.

Descriptive statistics	
Green	The greenness of the bond is determined by the qualification in Bloomberg. This thesis assumes that if a bond qualifies as a green bond in Bloomberg it is green.
Sector	In the sample three different sectors are defined: Financial Instituions, Governments and Utilites (corporates)
Rating	Rating is provided by Moody's and is the rating of the bond as listed in Bloomberg. Ratings were simplified to Aaa, Aa, A, Baa, Ba and B for the sake fo this thesis.
Payment	The payment rank of the bond defines its' seniority. There are three types of senior debt in the database: senior unsecured debt, senior preferred debt and senior non preferred debt.
Currency	In this thesis, only two currencies are recognised: EUR and USD. In all regressions USD is used as a reference currency.

Table 10 – Descriptive statistics of all variables used in the regressions.

Dependent variable YTM		
	Coefficient	Robust Std. Err.
GREEN	-0,099***	0,039
Amount issued	-0,094***	0,030
Maturity (life of the green bond)	0,114***	0,010
Rating		
Aaa	-2,949***	0,089
Aa	-2,513***	0,09
A	-2,381***	0,092
Baa	-1,904***	0,105
Ba	-0,649***	0,108
Issuer type		
Financial	0,057	0,069
Government	-0,147**	0,082
EUR	-2,708***	0,056
Constant	3,235***	0,666
# observations	194	
R-squared	0,970	
Adj R-squared	0,9676	
F-Statistic	525,25(df:11, 182)	

Table 8 - Note: p<0.1*, p<0.05** and p<0.01***. Regression of control variables and independent variables on the yield to maturity of 97 green bonds and 97 conventional bonds (by the same issuer). The reference variables used were, rating: B; Issuer type: Utilities.

The first regression conducted was a regression to verify the difference in financial performance of green and conventional bonds. The results of the regression indicated that green bonds perform 10bps worse than their conventional counterparts do. Furthermore, rating significantly decreases the yield-to-maturity of bonds as well as the bond issued in EUR does. The difference in yield-to-maturity between bonds issued in EUR and USD can easily be explained by the difference in interests rates used as a benchmark, the dollar interest rate is much higher than the negative Euribor.

i. Dependent variable Pi,t = ΔYi,t		
	Coefficient	Robust Std. Err.
Amount issued	0,080	0,065
Maturity (life of the green bond)	-0,000	0,015
Rating		
Aaa	0,842***	0,108
Aa	0,774***	0,102
A	0,726***	0,083
Baa	0,702***	0,117
Ba	0,334***	0,057
Issuer type		
Financial	0,139	0,099
Utilities	0,087	0,136
EUR	-0,143	0,091
Payment rank		
Senior Unsecured	-0,190	0,144
Senior Preferred	-0,292*	0,144
Constant	-0,551***	0,210
# observations	97	
R-squared	0,215	
Adj R-squared	0,1026	
F-Statistic	1,92(df:12, 84)	

Table 9 - Note: p<0.1*, p<0.05** and p<0.01***. Regression of control variables Rating, Issuer type, Currency and Payment rank as well as the dependent variable Amount issued and Maturity as drivers of the green bond premium. There are 6 categories of Moody rating specified: Aaa, Aa, A, Baa, Ba and B (which was used as reference rating). For issuer type there are 3 types specified: Financial, Government and Utilities; Government was used as reference category. Furthermore, as there are only two currencies used in the database, only a dummy variable if the bond was issued in EUR was included. Payment rank is divided into senior unsecured, senior preferred and senior non-preferred, the latter was used as a reference category in the regression.

The first regression includes both all control variables and independent variables that possibly drive the green bond premium:

$$p_i = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Issuer\ Type + \alpha_4 Rating + \alpha_4 Currency + \alpha_5 Payment\ Rank + \varepsilon_i.$$

The results of the regression indicate that both the amount issued and the maturity of the green bond does not influence the green bond premium significantly. However, the rating of the bond does influence the green bond premium significantly. This seems logical as the rating of the bond

is a measure for the default risk a bond has. The highest rating of Aaa has the largest positive impact +84bps and is statistically significant at 99%, as are all outcomes for the rating. The rating that contributes the least to a positive green bond premium is B, which is used as reference rating and if a bond has a rating of B it will not have an effect on the green bond premium. All other ratings all contribute positively. Furthermore, green bonds issued by an issuer qualified as either financial or utilities improves the green bond premium as opposed to an issuer qualifying as a government issuer (+14bps and +9bps) albeit not significant. Green bonds issued in EUR should receive a (not significant) relatively lower return according to this regression, -14bps this. If the bond is issued as senior preferred debt the green bond premium will be lower than bonds issued as senior unsecured or senior non-preferred debt. A senior preferred green bond will yield -29bps significantly less, a senior unsecured bond will yield -19bps less as opposed to a senior non-preferred bond that does not affect the green bond premium. All senior preferred green bonds issued in the sample are issued by financial institutions, therefore it is interesting to see the effect of the issuer type as financial institution if the payment rank is not included in the regression.

ii. Dependent variable $P_{i,t} = \Delta Y_{i,t}$		
	Coefficient	Robust Std. Err.
Rating		
Aaa	0,824***	0,101
Aa	0,765***	0,098
A	0,744***	0,081
Baa	0,727***	0,113
Ba	0,387***	0,002
Issuer type		
Financial	0,119	0,098
Utilities	0,075	0,133
EUR	-0,143*	0,085
Payment rank		
Senior Unsecured	-0,170	0,134
Senior Preferred	-0,279**	0,134
Constant	-0,608***	0,174
# observations	97	
R-squared	0,1938	
Adj R-squared	0,1000	
F-Statistic	2,07(df:10, 87)	

Table 10 – Note: p<0.1*, p<0.05** and p<0.01***. Regression of the control variables rating, issuer type, payment rand and currency as drivers of the green bond premium. For this regression output the same holds as for the regression displayed in table 10. Rating = B, Issuer Type = Government and Payment rank = Senior non-preferred were uses as reference categories.

In the second regression the independent variables amount issued and the maturity of the bond are removed. All coefficients for the rating remain positive and in this regression the Aaa bond has the highest positive effect on the green bond premium +82bps. In addition to a significant outcome for all ratings the senior preferred bond being significant, the coefficient for a green bond issued in EUR is significantly negative, -14bps.

iii. Dependent variable $P_{i,t} = \Delta Y_{i,t}$		
	Coefficient	Robust Std. Err.
Rating		
Aaa	0,824***	0,100
Aa	0,743***	0,098
A	0,724***	0,084
Baa	0,750***	0,106
Ba	0,387***	0,002
Issuer type		
Financial	0,118	0,095
Utilities	0,077	0,130
EUR	-0,151*	0,082
Constant	-0,777***	0,095
# observations	97	
R-squared	0,1653	
Adj R-squared	0,0985	
F-Statistic	2,18(df:8, 88)	

Table 11 – Note: p<0.1*, p<0.05** and p<0.01***. Regression of the control variables rating, issuer type and currency as drivers of the green bond premium. For this regression output the same holds as for the regression displayed in table 10. Rating = B, Issuer Type = Government and Payment rank = Senior non-preferred were uses as reference categories.

Thirdly, the payment rank of the bonds are removed from the regression. The effect of the control variables rating, issuer type and currency are solely tested on the difference in yield of the green and conventional bonds. Removing the payment rank does not significantly change the coefficient for financial institutions as was expected.

iv. Dependent variable Pi,t = ΔYi,t		
	Coefficient	Robust Std. Err.
Amount issued	0,039	0,066
Maturity (life of the green bond)	0,007	0,013
EUR	-0,097	0,063
Constant	0,004	0,092
# observations	97	
R-squared	0,0334	
Adj R-squared	0,0022	
F-Statistic	1,07(df:3, 97)	

Table 12 – Note: p<0.1*, p<0.05** and p<0.01***. Regression of the independent variables, amount issued and maturity and the control variable currency, as drivers of the green bond premium. For this regression output the same holds as for the regression displayed in table 10. Rating = B, Issuer Type = Government and Payment rank = Senior non-preferred were uses as reference categories.

Lastly, the independent variables are tested on the difference in yield, the green bond premium. All control variables are removed except the control variable for currency it had a significant influence in the previous two regressions. None of the coefficients in the regression are significant and only the control variable for the currency seems to attribute negatively to the green bond premium.

For the first four regressions it was assumed that the difference in liquidity between the two matched bonds equalled zero, as the entire distribution was concentrated around zero. In order to check whether this assumption could made the same regressions are performed including ΔBA as a check for the liquidity:

$$\Delta y_{i,t} = \alpha_0 + \alpha_1 Amount\ Issued + \alpha_2 Maturity(life\ of\ the\ bond) + \alpha_3 Issuer\ Type + \alpha_4 Rating + \alpha_4 Currency + \alpha_5 Payment\ Rank + \beta \Delta Liquidity_{i.t} + \varepsilon_{i,t}$$

i. Dependent variable ΔYi,t		
	Coefficient	Robust Std. Err.
ΔBAi,t	-0,635	0,710
Amount issued	0,093	0,072
Maturity (life of the green bond)	-0,000	0,015
Rating		
Aaa	0,895***	0,125
Aa	0,820***	0,121
A	0,753***	0,087
Baa	0,734***	0,127
Ba	0,365***	0,073
Issuer type		
Financial	0,146	0,100
Utilities	0,088	0,135
EUR	-0,138	0,092
Payment rank		
Senior Unsecured	-0,196	0,145
Senior Preferred	-0,294*	0,145
Constant	-0,623**	0,210
# observations	97	
R-squared	0,218	
Adj R-squared	0,0951	
F-Statistic	1,78(df:13, 83)	

Table 13 – Note: p<0.1*, p<0.05** and p<0.01***. Regression of the difference in the yield of green and conventional bonds. The drivers for the difference are specified as control variables and independent variables. The control variables are rating, issuer type, payment rank and the currency. The reference categories for those control variables are: B, Government and Senior non-preferred. Furthermore, there is no reference category for currency as there are only two and a dummy was included. The independent variables are specified as: amount issued, maturity and the difference of the bid-ask spread of the bond pair.

The results of the entire regression including all control and independent variables are displayed in table 14. The coefficient for $\Delta BA_{i,t}$ is negative, albeit not significant: - 64bps. Including the difference in liquidity of the bonds paired does slightly alter the coefficients for all variables. All coefficients for the rating remain significant at a 99% ranging from +90bps (Aaa) to +37bps (Ba) and 0bps for B. The coefficients for issuer type increase too, to +15bps for financial institutions and +9bps for utilities. Equal to the regression without $\Delta BA_{i,t,}$ only the result for the senior preferred bonds is significant, +29bps.

Interesting is the fact that the R^2 is lower for the regression that includes the $\Delta BA_{i,t}$ even though the difference in liquidity is one of the drivers of the difference in yields.

ii. Dependent variable ΔYi,t		
	Coefficient	Robust Std. Err.
ΔBAi,t	0,103	0,829
Rating		
Aaa	0,816***	0,122
Aa	0,758***	0,117
A	0,740***	0,088
Baa	0,721***	0,128
Ba	0,380***	0,053
Issuer type		
Financial	0,119	0,098
Utilities	0,075	0,134
EUR	-0,144*	0,086
Payment rank		
Senior Unsecured	-0,170	0,134
Senior Preferred	-0,279**	0,135
Constant	-0,595***	0,212
# observations	97	
R-squared	0,1939	
Adj R-squared	0,099	
F-Statistic	1,86(df:11, 85)	

Table 14 - Note: p<0.1*, p<0.05** and p<0.01***. Regression of the difference in the yield of green and conventional bonds. The drivers for the difference are specified as control variables and includes only one independent variable. The control variables are rating, issuer type, payment rank and the currency. The reference categories for those control variables are: B, Government and Senior non-preferred. Furthermore, there is no reference category for currency as there are only two and a dummy was included. The independent variable included in the regression is the difference of the bid-ask spread of the bond pair.

Similar to the second regression performed before, the independent variables are removed to determine if it improves the accuracy of the model. Not only does removing the independent variables improve the significance of the coefficient for senior preferred bonds, it also make the coefficient for the currency significant. Issuing bonds in EUR will affect the yield difference of the bonds negatively with -14bps.

iii. Dependent variable ΔYi,t		
	Coefficient	Robust Std. Err.
ΔBAi,t	0,086	0,842
Rating		
Aaa	0,817***	0,123
Aa	0,737***	0,117
A	0,720***	0,090
Baa	0,745***	0,122
Ba	0,381***	0,054
Issuer type		
Financial	0,117	0,096
Utilities	0,076	0,131
EUR	-0,152*	0,083
Constant	-0,765***	0,146
# observations	97	
R-squared	0,165	
Adj R-squared	0,0791	
F-Statistic	1,92(df:9, 87)	

Table 15 - Note: p<0.1*, p<0.05** and p<0.01***. Regression of the difference in the yield of green and conventional bonds. The drivers for the difference are specified as control variables and one independent variable. The control variables are rating, issuer type, and the currency. The reference categories for those control variables are: B and Government. Furthermore, there is no reference category for currency as there are only two and a dummy was included. The independent variables is specified as: the difference of the bid-ask spread of the bond pair.

Removing the payment rank of the bonds affects the outcomes of the regression slightly. Yet same as seen previously, the coefficient for financial institution decreases a little as all senior preferred and non-preferred bonds are only issued by financial institutions in the sample, however, remains insignificant. Furthermore, this regression displays a negative significant effect of bonds issued in EUR, -15bps.

iv. Dependent variable ΔYi,t		
	Coefficient	Robust Std. Err.
ΔBAi,t	1,071	1,167
Amount issued	0,026	0,067
Maturity (life of the green bond)	0,006	0,014
EUR	-0,099	0,063
Constant	0,066	0,107
# observations	97	
R-squared	0,0448	
Adj R-squared	0,0032	
F-Statistic	1,08(df:4, 92)	

Table 16 - Note: p<0.1*, p<0.05** and p<0.01***. Regression of the difference in the yield of green and conventional bonds. The drivers for the difference are specified as independent variables and one control variable. The control variable used is the currency. There is no reference category for currency as there are only two and a dummy was included. The dependent variables are specified as: amount issued, maturity and the difference of the bid-ask spread of the bond pair.

A regression without any control variables other than currency, limited to independent variables only yields no significant returns.

5.2. Z-spreads

In order to determine the difference in financial performance of green and conventional bonds using the z-spreads, all conventional bonds need to be inter-/extrapolated. For this purpose a case study was set up analysing the z-spreads of various corporates.

5.2.1. *TenneT Holding B.V.*

TenneT is a Dutch-German transmission system operator which is owned and controlled by the Dutch government. Over the previous years TenneT has issued various green and conventional bonds which makes an analysis based on z-spreads possible. The green bond under consideration has a remaining life of 1.98year at 6-6-2019 and an issue size of €500m, the conventional bonds used to interpolate have a remaining life of 1.39, 2.67 and 3.70 at 6-6-2019 respectively, they all had an equal issue size of €500m. When interpolating the conventional bonds of TenneT at 23-1-2019 and 17-4-2019 the green bonds has a lower z-spread than an equal conventional bond with the same maturity should have. This corresponds with a better performance of the green bond in comparison with the conventional bond and is trading at a tighter price than the conventional bonds are.

TenneT Holding BV			
ID	Amount Issued (EUR)	Maturity date	Life 6-6-2019
EK9119182	500000000	04-06-21	1,98
EJ9051370	500000000	01-11-20	1,39
EI1353990	500000000	09-02-22	2,67
EI5759788	500000000	21-02-23	3,70

Table 17 - Bonds under consideration used for TenneT Holding B.V., one green bonds and three conventional bonds were considered each with an equal issuing size of €500m.

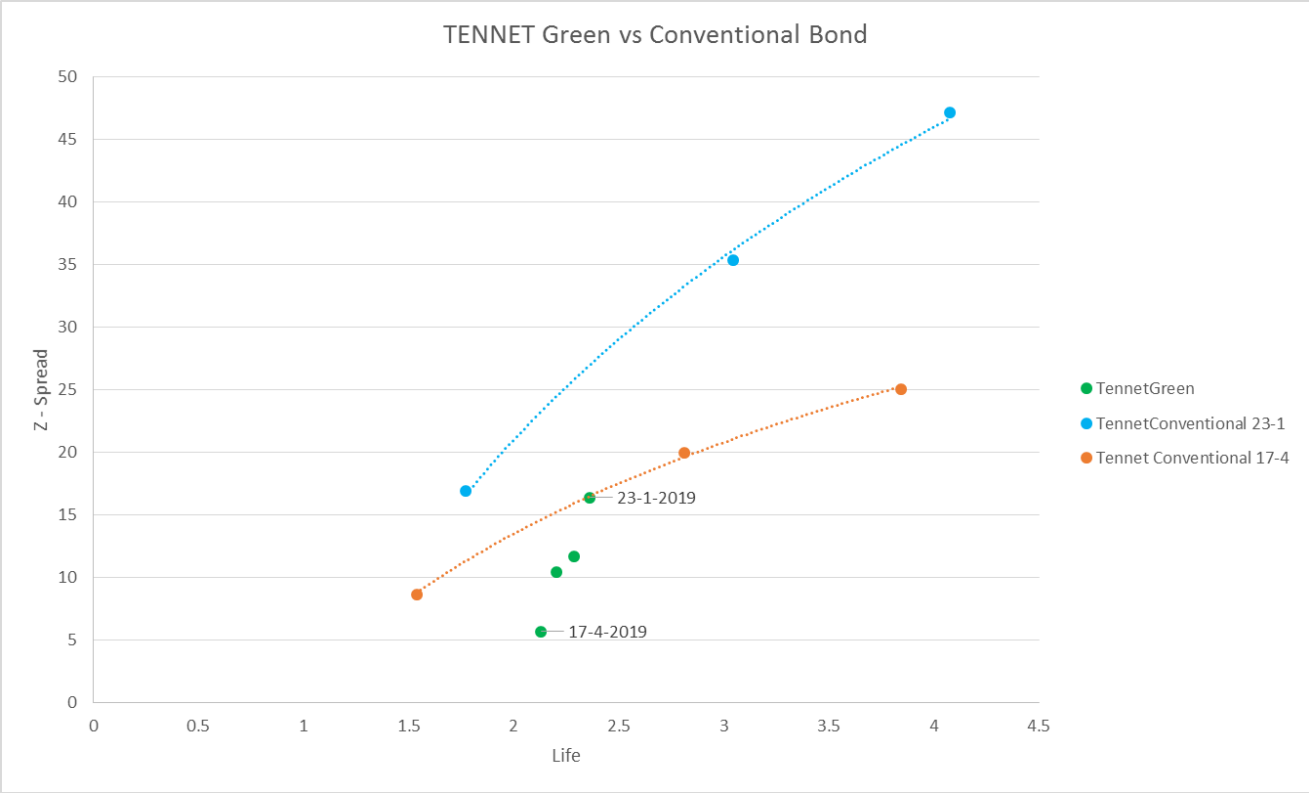

Figure 4 – TenneT green and conventional bonds. The figure shows the interpolation of the conventional bonds and the green bond which is outperforming the conventional bonds based on the z-spreads.

5.2.2. Iberdrola

Iberdrola is a Spanish public multinational company providing electric utility. The company is not owned by the government, and its' largest shareholder is Quatar Investment Holding. Iberdrola is one of the market leaders considering the transition to a more sustainable manner in which to generate, store and transport energy and for this purpose has issued green bonds. The green bond considered for Iberdrola has a remaining life on 6-6-2019 of 3.37 years and the conventional bonds under consideration have remaining lives ranging between 1.42 and 5.33 years.

Furthermore, the green bond has an issued amount of €750m whereas the issued amounts of the conventional bonds ranges between €500m and €1bn. As seen in the regressions constructed in the model-free approach the impact of issue size on the difference in performance is minimal. Interpolating the conventional bonds' z-spreads on 23-1-2019 and 17-4-2019 illustrates that the Iberdrola green bond has a higher z-spread than its conventional equal would have. This implies that the performance of the green bond is worse than the performance of the conventional bonds and corresponds with a wider trading of the green bond in comparison to the conventional bonds.

Iberdrola International BV			
ID	Amount Issued (EUR)	Maturity date	Life 6-6-2019
EK1707232	750000000	24-10-22	3,37
EK5166518	500000000	08-10-24	5,33
UV8018144	500000000	17-09-23	4,27
EK6989967	600000000	27-01-23	3,63
EJ9115480	1000000000	31-01-22	2,64
EJ5246685	500000000	02-01-21	1,56
EJ6990430	600000000	11-11-20	1,42

Table 18 – Bonds under consideration for Iberdrola International B.V. One green bond and 6 conventional bonds were used to interpolate the performance of a conventional bond with an equal remaining life to the green bond.

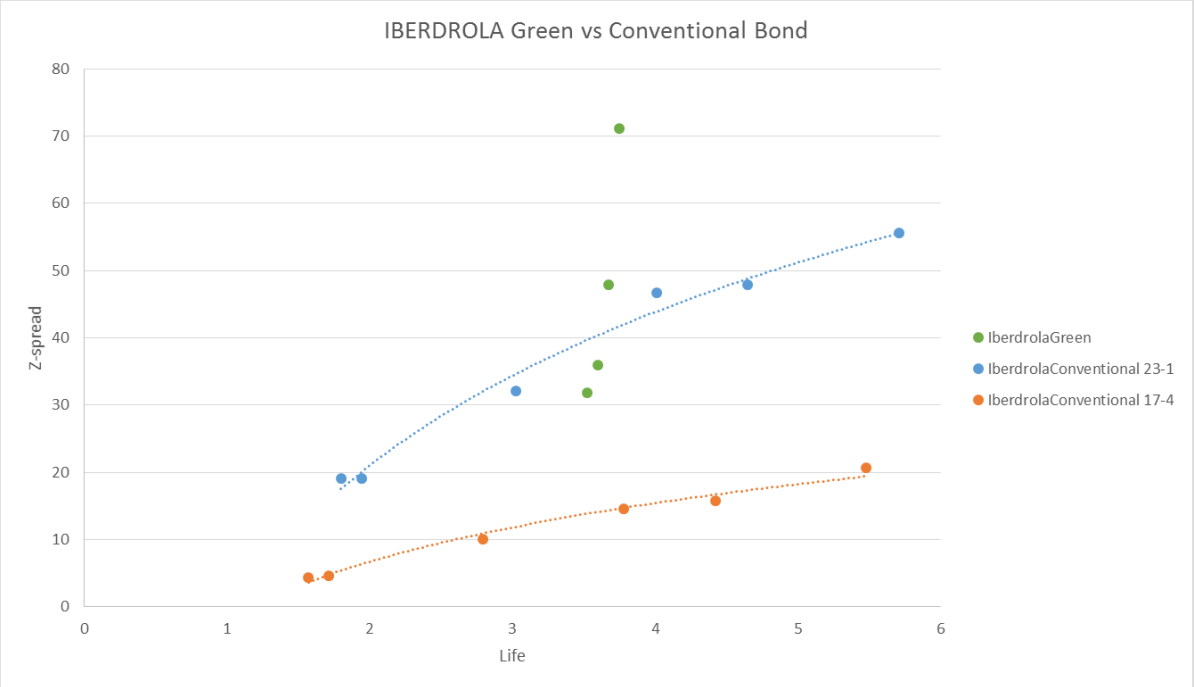

Figure 5 - Iberdrola green and conventional bonds. The figure shows the interpolation of the conventional bonds and the green bond which is outperforming the conventional bonds based on the z-spreads.

5.2.3. ENEL

ENEL (Ente Nazionale per l'Energia elettrica) is the most important Italian generator and distributer of natural gas and energy. It was established as a public company and for a long period enjoyed a monopoly position in the Italian market. After the liberalisation of the Itailian electricity market it was privatised although the Italian government remains one of the main shareholders. In 2016 the company produced 262 terawatt hours of electricity of which one third is estimated to be generated by 'clean' power sources. For the purpose of this clean energy ENEL has issued various green bonds to fund these new projects. The green bonds under consideration have a remaining life outstanding of 6.11 and 5.27 respectively and the conventional bonds are still outstanding for 4.30, 5.63 and 6.97 years. Furthermore, the ENEL green bonds were relatively large and have an issued amount of €1bn and €1,25bn. The conventional bonds were issued at a size of €1,26bn, €1,46bn and €300m. The ENEL green bond that has a remaining life of 6.11years at 6-6-2019 underperforms the conventional bonds at 23-1-2019, however, increasing investor appetite has tightened the pricing which evidently means the green bond outperforms the conventional bonds at 17-4-2019. The ENEL green bond with a remaining life of 5.27 years, however, outperforms the conventional bonds during the entire period under consideration.

Enel Finance International BV			
ID	Amount Issued (EUR)	Maturity date	Life 6-6-2019
AW6935570	1000000000	24-10-22	6,11
AM0720368	1250000000	08-10-24	5,27
LW1575866	1260000000	17-09-23	6,97
EK6992367	1460000000	27-01-23	5,63
ED1529186	300000000	31-01-22	4,30

Table 19 – Bonds under consideration for ENEL. There are two green bonds considered, whereas there are three bonds used to interpolate the performance of the conventional bonds with equal life remaining compared to the green bonds.

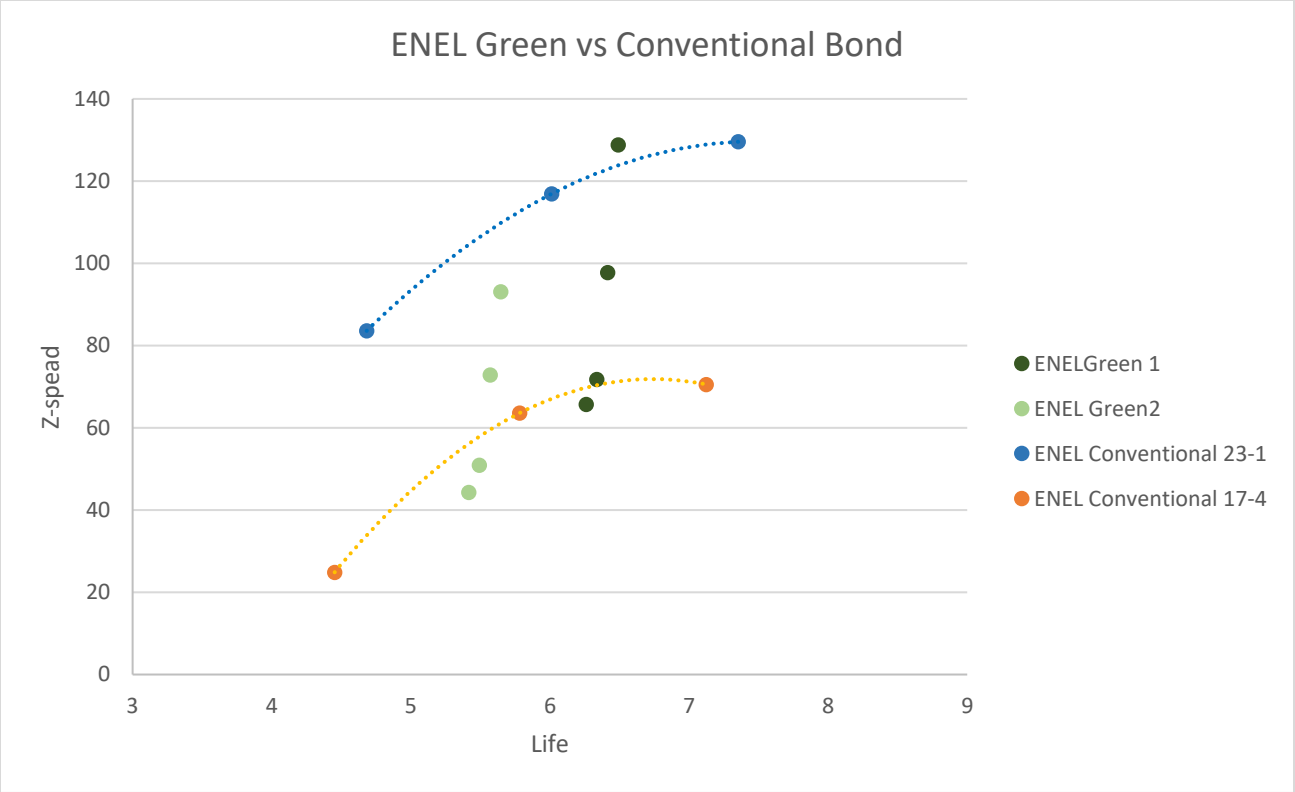

Figure 6 - ENEL green and conventional bonds. The figure shows the interpolation of the conventional bonds and the green bond which is outperforming the conventional bonds based on the z-spreads.

5.2.4. Naturgy

Naturgy Energy Group S.A. is an international energy company that produces, distributes and commercializes natural gas and electrical energy. The main locations for providing the services are Southern Europe and Latin America. Main shareholders of Naturgy are the Spanish bank La Caixa and Repsol, another large energy corporation. Naturgy decided to issue a green bond with a size of €800m in 2017, the funds from this issuance will be allocated to financing wind and solar energy projects. The remaining life of the green bond was 5.94years at 6-6-2019. For extrapolation, four suitable bonds were found with a remaining life ranging between 2.85years and 5.94 years. The green bond is issue size wise the largest bond as the conventional bonds were issued in sizes ranging from €500m to €750m. Extrapolating the bonds illustrates the performance of the green bond compared to its' conventional synthetic equal. The green bond underperforms indicating a wider trading of the bond on both 23-1-2019 and 17-4-2019.

Naturgy FinanceBV			
ID	Amount Issued (EUR)	Maturity date	Life 6-6-2019
AP9355813	800000000	15-05-25	5,94
EK6960679	500000000	21-01-25	5,63
EK0996935	500000000	11-03-24	4,76
EJ5085315	600000000	17-01-23	3,62
EJ6199503	750000000	11-04-22	2,85

Table 20 - Bonds under consideration for Naturgy. There is one green bonds considered, whereas there are four bonds used to interpolate the performance of the conventional bonds with equal life remaining compared to the green bonds.

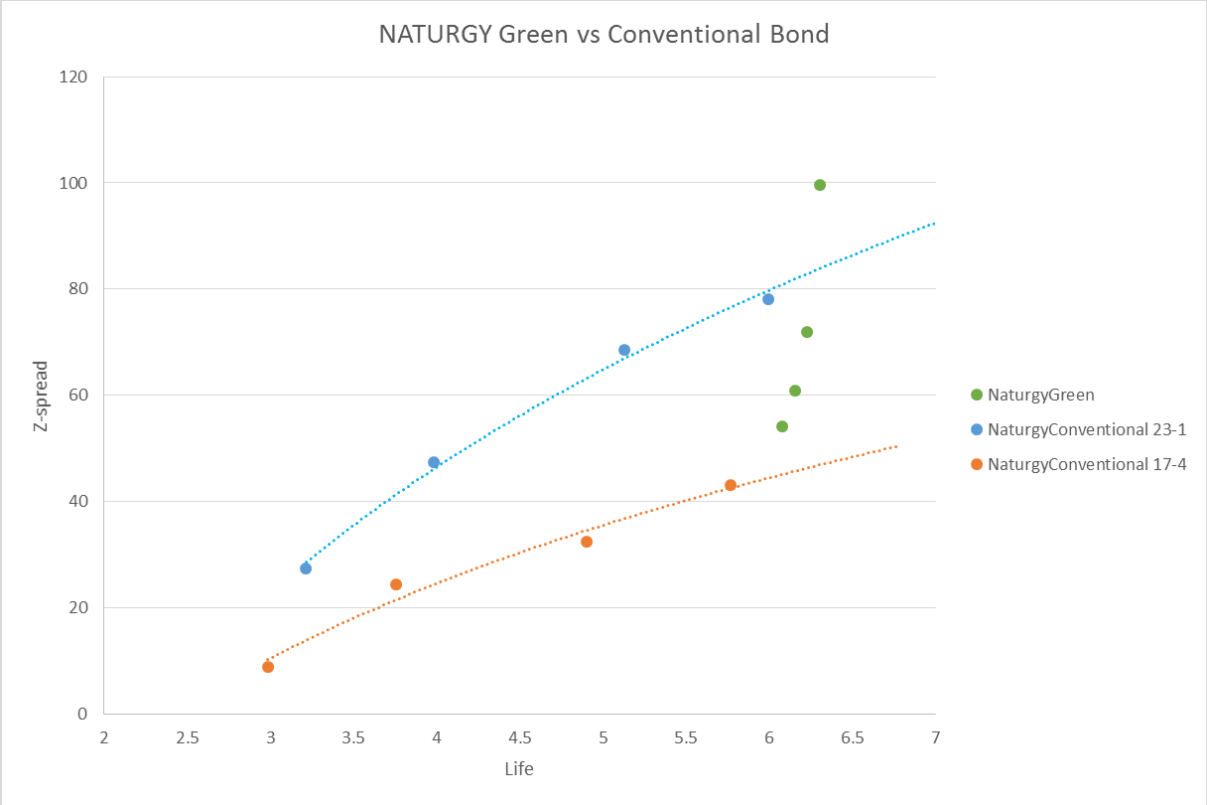

Figure 7 – Naturgy green and conventional bonds. The figure shows the interpolation of the conventional bonds and the green bond which is outperforming the conventional bonds based on the z-spreads.

5.2.5. Unibail-Rodamco SE

In contrast to the previous utility/energy corporations previously analysed is Unibail-Rodamco a commercial real estate company with roots in the Netherlands and France. Recently they have issued various green bonds of which the proceeds are allocated to developing more social, environmental-friendly and sustainable projects as well as improving sustainability during the

construction and operational phases of development projects. In this thesis, two green bonds issued by Unibail-Rodamco are considered with a remaining life of respectively 4.72years and 5.77years and an issue size of €750m and €500m. Unibail-Rodamco issued many conventional bonds of which eight were suited to use for interpolating the financial performance. The remaining life of these conventional bonds ranged from 2.98years till 8.71years and had a varying issue size between €425m-€750m. Interpolating these bonds and matching synthetic z-spread with the maturity of the green bonds indicates that the green bonds and conventional bonds neither underperform nor outperform each other.

Unibail-Rodamco SE			
ID	Amount Issued (EUR)	Maturity date	Life 6-6-2019
EK0810946	750000000	26-02-24	4,72
EK8481864	500000000	14-03-25	5,77
AM5291944	600000000	22-02-28	8,71
JK8585701	500000000	28-04-27	7,89
EK2994862	600000000	04-06-26	7,00
JK2996466	500000000	09-03-26	6,76
AL2808601	500000000	21-02-25	5,71
EJ7063583	700000000	12-06-23	4,02
EK5370268	750000000	17-10-22	3,36
EJ2032518	425000000	30-05-22	2,98

Table 21 - Bonds under consideration for Unibail-Rodamco. There are two green bonds considered, whereas there are eight bonds used to interpolate the performance of the conventional bonds with equal life remaining compared to the green bonds.

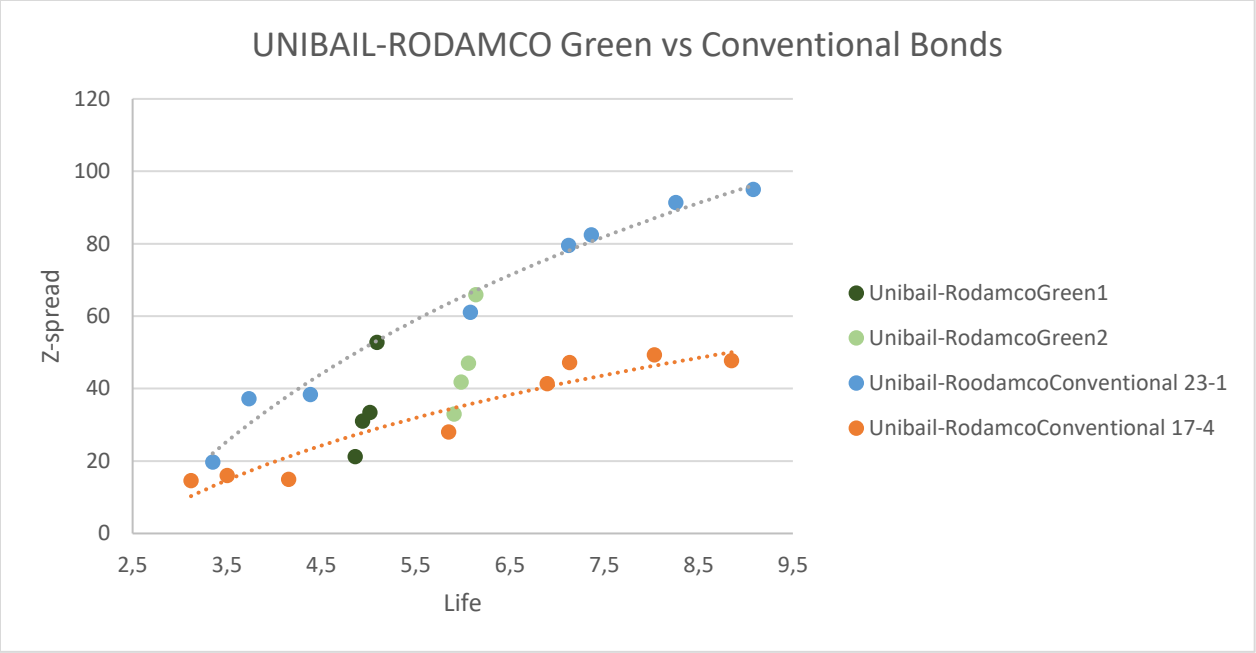

Figure 8 – Unibail-Rodamco green and conventional bonds. The figure shows the interpolation of the conventional bonds and the green bond which is outperforming the conventional bonds based on the z-spreads.

6. Discussion

In this section, the results of the empirical framework will be discussed and analysed, to be able to make conclusions and answer the research questions:

1. *How do green bonds financially perform in comparison to their conventional peers?; and*
2. *What drives the difference in performance of green and conventional bonds?*

All regressions performed in the previous section yield roughly the same results. Firstly, the impact of the greenness of the bond was tested, by testing the impact of the label green on financial performance of bonds equal by issuer, issue size, maturity, rating, seniority and currency the results of the regression imply that there is in fact a negative impact on the yield of a bond. This negative impact equalled -10bps and is statistically significant at 99%, this seems to be in line with previous research of Zerbib (2019) who found a small negative premium of -2bps. Furthermore, a small negative premium supports previous research conducted by Renneboog et. al., (2008), Belghitar et. al., (2014), Ibikunle and Steffen (2015) who found that green mutual funds underperformed their conventional peer and is also in line with Bollen (2006) who suggests that investors derive utility from investing in socially responsible options. However, even though the majority of the sample of green bonds in this thesis has a negative green bond premium the average premium is in fact positive, +19bps. A positive green bond premium seems to compare to the study conducted by Friede et. al., (2015), who state that 90% of 2000 empirical studies considered are yield a nonnegative performance.

After determining there is in fact a price to be paid by investors when deliberately choosing green bonds over conventional bonds the impact of drivers of this difference were determined. Firstly, control variables were used to match the green bonds with conventional bonds in order to limit the differences as well as constraints on the independent variables to control for liquidity bias and maturity bias. As the difference in financial performance of a green bond and a conventional bonds equates the so-called green bond premium or ‘greenium’ and the liquidity difference formulas for these need to be established. Using constraints on the independent variables: issue size and maturity date were used as proxies to estimate the liquidity difference of the bond pair as weekly yield-to-maturity data was used as opposed to intra-day trading volumes. The difference in liquidity can be used by estimating the difference in bid-ask spread of both bonds. As the difference is concentrated around zero, liquidity difference is assumed to be zero for the purpose of this thesis. As the difference in liquidity is assumed to be zero, the difference in the yield of a green bond and a conventional bond equals the green bond premium.

To estimate the impact of drivers on the green bond premium various regressions were constructed including both independent and control variables. These regressions yielded various significant and non-significant results. In the regression including all control and independent variables, rating had a significant positive effect on the green bond premium, except for B which was used as reference rating. If rating increases from B to Aaa, the positive effect on the green bond premium increases from 0bps to +84bps. Another independent variables included in the regression was issuer type, green bonds issued by financial institutions yield a relatively higher yield than their conventional counterparts +14bps. Green bonds issued by issuers qualifying as utilities equally yield a higher yield-to-maturity than their conventional matches, +8.7bps, whereas the difference between green and conventional bonds issued by governments, used as reference value, is minimal 0.0bps. The effects of this control variable is not significant. The third control variable that was added, was currency. As obviously visible in the descriptive statistics the average yield for bonds issued in USD was higher than the average yield for bonds issued in EUR. This is logical as the USD interest rates are much higher than the negative rates EUR interest currently displays. This means that the regression results needs to be controlled for this difference as these rating are benchmarks for all financial instruments issued in this currency. Green bonds issued in EUR yield a lower yield-to-maturity than their conventional peers, +14bps, albeit not significant. Lastly, the control variable for seniority was added. However, financial institutions issue additional types of senior debt other than senior unsecured: senior preferred and senior non-preferred. In the database used for this thesis, this meant that senior unsecured bonds yielded a larger negative difference in yield between green and conventional bonds -19bps. However, only green bonds issued as senior preferred debt yielded a statistically significantly lower yield -29bps than their conventional counterparts at $p<0.1$. The independent variables yielded no statistically significant results yet, the results suggest that a larger issuing size of green bonds improves financial performance with +8bps.

The regression including all independent and control variables resulted in the highest R-squared of 21.48%, removing control or independent variables worsens the R-squared. There is, however, one interesting result from removing either the independent variables or the control variable of payment rank: the negative impact of currency becomes statistically significant at $p<0.1$, yet is still concentrated around -15bps.

As the liquidity difference between the two types of bonds was assumed to zero it was neglected in the first set of regressions. However, to test whether this assumption was done righteously, all regressions are performed again including the difference of liquidity within the bond pair. Even though this slightly increases the R-squared of the regression model it does not result in a statistically significant outcome for the $\Delta BA_{i,t,}$. The impact of the $\Delta BA_{i,t,}$ on the difference in financial performance is extremely limited as it is -64bps, keeping in mind the fact that the difference in the sample was concentrated around zero. Including the difference in liquidity within the bond pair increases the statistically significant positive impact of the rating on the green bond premium, ranging from +90bps for Aaa till +37bps for Ba. Green bonds issued by financial institutions, disregarding the distinction between senior unsecured, senior preferred and senior non-preferred was minimally reduced to +12bps and +8bps for corporates identified as utilities. The impact currency was again negative -15bps and statistically significant at $p<0.1$. Similar to the previous set of regressions the amount issued and maturity does not have a significant impact on the difference between financial performance of green and conventional bonds.

To conclude, in the sample under consideration there is in fact a (negative) green bond premium, implying there is a price to be paid by investors. Significant drivers of differences in financial performance are rating and issuer type. The higher the rating of an issuer the larger the positive effect on the difference in green and conventional bond performance is. This corresponds to smaller negative or even a positive green bond premium. Furthermore, the difference in financial performance of green bonds is positively affected by the fact that they are issued by financial institutions or corporates identified as utilities. Additionally, green bonds issued in EUR tend to have a relatively lower yield-to-maturity compared to its financial peers than green bonds issued in USD, -15bps.

When conducting a case study of 5 corporates that issued both green bond(s) and conventional bonds displayed the difference in financial performance it not necessarily the same among categories of issuers. Even though the case study was merely conducted among 5 companies it displays the difference and depth bonds as a financial instrument have. The green bonds issued by TenneT and ENEL outperformed the conventional bonds issued, implying they are trading more tightly and demand for these bonds is higher than for their conventional peers. On the other hand, Iberdrola and Naturgy issued green bonds that based on their z-spreads underperformed their conventional peers and are trading wider, due to a lower demand than their conventional

peers. The green bonds issued by Unibail-Rodamco are trading roughly the same as they do not out- or underperform their conventional counterparts.

7. Limitations & further research

In this thesis a limited sample of green bonds was used as a control was added for currency to include only EUR and USD. Furthermore, only one conventional bond was used to match the green bond. When there is a desire to broaden the sample of green bonds, researchers could possibly match the bonds on rating solely and not necessarily on issuer at it provides more opportunities for matching. Additionally, all green bonds qualifying for the regression could be matched by synthetically constructed conventional bonds equalling maturity date and the corresponding yield-to-maturity as done by Zerbib, 2019. This thesis only constructed a case study for 5 issuers of green bonds using the z-spreads. Only 5 issuers were used due to the limited access to Bloomberg and the time consuming process of matching bonds. For further research, more related to the market, a larger sample of green bonds with z-spreads could be used to determine the difference in green and conventional bond performance.

It is debatable whether either the guidelines as set in the Green Bond Principle should be sharpened. As this thesis solely recognises whether a bond complies to the GBP it could have included green bonds which are not considered as such by (institutional) investors. This thesis is indifferent to ‘greenwashing’ as its purpose is mainly rational as opposed to adding any behavioural aspects. Due to the higher demand for certain green bonds over the other it is debatable if all bonds labelled as green bonds should be included in the sample when determining the difference in financial performance from the investors perspective. Especially due to the fact that often green bonds are neglected that qualify their use of proceeds as energy efficiency, personally I think that investors should include these bonds in their investment portfolio as these too improve sustainability in the long run.

As the green bond market is rapidly evolving and deadlines for the goals set by the COP21 are approaching it is difficult to see where the market is going. In the Netherlands, certain green investments come with benefits for private investors as they are tax deductible when meeting requirements. Currently the green bond market is hugely overstretched by demand with only limited investment options as compared to the conventional bond market. This entails a certain ‘market’ risk which is not comparable with conventional bonds. The market could be even further overstretched by demand if green bonds receive a fiscally preferable treatment, which can be introduced to reach the sustainability goals. It would be interesting to see the effects of such preferable treatment on the market and measure the actual effectiveness of the rapid expansion of the green bond market.

References

ABP. (2017a). *Duurzaam en verantwoord beleggen 2017.*

ABP. (2017b). *Jaarverslag 2017.*

APG. (2017). *Responsible Investment Report.*

Belghitar, Y., Clarck, E., & Deshmukh, N. (2014). Does it pay to be ethical? Evidence from the FTSE4Good. *Journal of Banking & Finance, 47*, 54-62.

Bollen, N. P. (2007). Mutual Funds Attributes and Investor Behavior. *Journal of Financial and Quantitative Analysis* .

Carhart, M. M. (1997, March). On Persistence in Mutual Fund Performance. *The Journal of Finance, 52*(1), 57-82.

Choudhry, M. (2006). The Futures Bond Basis, Second Edition. In M. Choudhry, *The Futures Bond Basis, Second Edition* (Vol. Appendix B: Relative value analysis: Bond spreads).

Climate Bonds. (2019, april 4). *Investor appitite*. Opgehaald van https://www.climatebonds.net/market/investor-appetite

Climate bonds Initiative. (2018). *Green Bonds: The state of the market.*

De Nederlandsche Bank. (2018). *Pensioenen*. Opgeroepen op December 2018, van https://statistiek.dnb.nl/dashboards/pensioenen/index.aspx

Della Croce , R., Kaminker, C., & Stewart, F. (2011). *The role of pension funds in financing green growth initiaties.* OECD Working Papers on Finance, Insurance and Private Pensions; OECD Publishing.

Dobber, J. (2019, May 21). *Eerste Nederlandse groene obligatie vindt gretig aftrek*. Opgehaald van fd.nl.

Eurosif . (2016). *European SRI Study 2016.*

Eurosif. (2017). *SDGs for SRI investors.*

EY. (2016). *Green bonds: a fresh look at financing green projects.*

Fama, E. F., & French, K. R. (2014, September). A Five-Factor Asset Pricing Model. *Fama-Miller Working Paper*.

fd. (2019, May 20). *Nieuwe duurzame obligatie brengt totaal Waterschapsbank boven de €10 mrd*. Opgehaald van fd.nl.

Febi, W., Schäfer, D., Stephan, A., & Sun, C. (2018). The impact of liquidity risk on the yield spread of green bonds. *Finance Research Letters, 27*, 53-59.

Fong, K., Holden , C., & Trzcinka, C. (2017). What Are The Best Liquidity Proxies for Global Research? *Review of Finance, 4*, 1355-1401.

Forbes. (2019, January 31). *Green Bond Market Poised to Hit A Mammoth $200B Valuation in 2019*. Opgehaald van forbes.com: https://www.forbes.com/sites/gauravsharma/2019/01/31/green-bond-market-poised-to-hit-a-mammoth-200b-mark-in-2019/#176135d362de

Friede, G., Busch, T., & Bassen, A. (2015). ESG and financial performance: aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investments, 5*(4), 210-233.

Friedman, M. (1970, September 12). The Social Responsibility of Business is to Increase its Profits. *The New York Times Magazine*.

From, R. (2019). References. *Journal of Banking and Finance, 98*, 39-60.

Galema, R., Plantinga, A., & Scholtens, B. (2008). The stock at stake: Return and risk in socially responsible investment. *Journal of Banking & Finance, 32*, 2646-2654.

Grol, C. (sd). *Tennet wil komende tien jaar €35 mrd investeren*. Opgehaald van fd.nl .

Halbritter, G., & Dorfleitner, G. (2015). The wages of social responsibility - where are they? A critical review of ESG investing. *Review of Financial Economics, 26*, 25-35.

Helwege , J., Huang, J., & Wang, Y. (2014). Liquidity effects in corporate bond spreads. *Journal of Banking and Finance, 45*, 105-116.

Helwege, J., Huang, J. Z., & Wang, Y. (2014). Liquidity effects in corporate bonds spreads. *Journal of Banking Finance, 45*, 105-116.

Hintzen, E., & Loonen, N. (2018, January 11). Pensioenfondsen kunnen vliegwiel zijn in overgang naar duurzame economie. *Het Financieele Dagblad*, p. 9.

Hong, H., & Kacperczyk, M. (2009). The price of sin: The effects of social norms on markets. *Journal of Financial Economics, 93*, 15-36.

Humphrey, J. E., Lee, D. D., & Shen, Y. (2012). Does it cost to be sustainable? *Journal of Corporate Finance, 18*, 626-639.

Ibikunle, G., & Steffen, T. (2015, September 7). European Green Mutual Fund Performance: A Comparative Analysis with their Conventional and Black Peers. *Journal of Business Ethics*, 337-355.

ING. (2018). *Green bonds: Momentum supported by initiatives.*

International Capital Market Association. (2018a). *Green Bond Principles: Voluntary Process Guidelines for Issuing Green Bonds.*

International Capital Market Association. (2018b). *Social Bond Priciples: Voluntary Process Guidelines for Issuing Social Bonds.*

International Capital Market Association. (2018c). *Sustainability Bond Guidelines.*

International Capital Market Association. (sd). *Green, Social and Sustainability bonds*. Opgeroepen op December 2018, van icmagroup.org: https://www.icmagroup.org/green-social-and-sustainability-bonds/

Kempf, A., & Osthoff, P. (2007). The Effect of Socially Responsible Investing on Portfolio Performance. *European Financial Management, 13*(5), 908-922.

Lin, H., Wang, J., & Wu, C. (2011). Liquidity risk and expected corporate bond returns. *Journal of Financial Economics, 99*, 628-650.

Markowitz, H. (1952, March). Portfolio Selection. *The Journal of Finance, 7*(1), 77-91.

NOS. (2018a, October 18). *Fondsen: stagnerend pensioen is niet meer uit te leggen*. Opgeroepen op November 2018, van www.nos.nl:

https://nos.nl/artikel/2255274-fondsen-stagnerend-pensioen-is-niet-meer-uit-te-leggen.html www.nos.nl: https://nos.nl/artikel/2255274-fondsen-stagnerend-pensioen-is-niet-meer-uit-te-leggen.html

NOS. (2018b, November 21). *Pensioenonderhandelingen vastgelopen, en nu?* Opgeroepen op November 2018, van https://nos.nl/artikel/2260202-pensioenonderhandelingen-vastgelopen-en-nu.html

PGGM. (2017). *Annual Responsible Investment Report.*

Renneboog, L., ter Horst, J., & Zhang, C. (2008). The price of ethics and stakeholder governance: the performance of socially responsible mutual funds. *Journal of Corporate Finance, 14*, 302-322.

Sievanen, R., Rita, H., & Scholtens, B. (2013). The Drivers of Responsible Investment: The Case of European Pension Funds. *Journal of Business Ethics*, 137-151.

Tang, D. Y., & Zhang, Y. (n/a). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 1-18.

van der Ploeg, J., & Koens, R. (2015, June 18). *Miljarden pensioengeld naar wapens.* Opgeroepen op December 2018, van https://www.volkskrant.nl/economie/miljarden-pensioengeld-naar-wapens~be2adf60/

Verheyden, T., Eccles, R. G., & Feiner, A. (2016). ESG for All? The Impact of ESG Screening on Return, Risk and Diversification. *Journal of Applied Corporate Finance, 28*(2), 47-55.

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking and Finance*(98), 39-60.