Green bonds: similar yields, similar returns, yet different response to the Donald Trump election

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10-04-2018

Abstract

The green bond market is a growing market in volume, however it is not widely known whether companies can finance less expensively via green bonds compared to non-green investment grade bonds. To investigate this, I analyzed 108 bonds from various countries to see whether a green bond label results in different credit spreads. I found that green bonds do not have significant different credit spreads than their counterparts, weakly significant higher abnormal credit spreads and no significant different daily returns for a two year period. However, if I split the sample in the pre-election period of Donald Trump and the post-election period, I find that green bonds are significantly lower priced than their counterparts in the post-election period. So organizations are likely to have more expensive debt financing regarding green bonds, during times of a US president that is reluctant to address the climate change problem.

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2. Introduction

In the third quarter of 2017, the green bond market reached an all-time high according to the Financial Times (Allen, 2017). In 2016 issue volume reached 97 billion dollars and in 2017 it is estimated that it has grown to 125 billion dollars (The Economist, 2017). This market increase is believed to signal the growing demand of so called “ethically labeled fixed income instruments”. So after the increase in shareholders activism regarding ethical investments in the equity market, the debt market seems to follow.

In 2007, the European Investment Bank (EIB) was the first to issue a green bond and the World Bank followed as well. According to the World Bank a green bond is a debt financial instrument aimed at financing climate related or environmental projects or businesses. For instance a green bond can raise capital for renewable energy projects, energy efficiency and forestry projects (World Bank, 2015). Furthermore, green bonds generally have high credit quality, as they are only investment grade bonds. Nowadays green bonds are not only issued by supranational organizations but issued by corporates, governments and financial institutions as well.

Unfortunately, there are no universal standards that determine when a bond may be classified as green. However, there exist some guidelines for the green label and the compliance can be assured by an external party such as by an external auditor. Examples of guidelines are the green bond principles stated by the International Capital Market Association (ICMA) relating to four components, which are the use of proceeds, process for project evaluation and selection, management of proceeds and reporting (International Capital Market Association, 2017). Other standards are the Climate Bonds Standards issued by the Climate Bonds Initiative, which specify some rules for when a bond can be classified as a climate bond in order for investors to have confidence of the beneficial effect on the environment (Climate Bonds Initiative, 2017). These standards are also voluntary, but if the bond issuing organization wants to receive a Climate Bond certification, it has to comply with these standards and the compliance is required to be assured by a certified third party.

Main benefits of green bonds over its counterparts are that issuers can have access to a larger pool of potential investors, such as investors that finance organizations that perform well in Economic Social and Governance (ESG) factors (KPMG, 2014). Also the green bonds are sometimes tax exempt or incorporate tax incentives, therefore investors may require a lower return, which lowers the cost of financing for firms. In addition, green bonds are said to trade at a premium as investors value the environmental impact making financing even less expensive (Nationale Nederlanden, 2018). Yet to the best of my knowledge there is no academic evidence for this statement in journals. There exits some academic evidence about other social and environmental issues, such as the research by Kaspareit and Lopatta (2016), who found that investors value investments that finance organizations with high social and environmental performance and that they penalize firms that perform badly in this area. However, not many research about the matter is conducted in the debt market. Ge and Liu (2015) and Menz (2010) analyzed the effect of high CSR rating on credit spreads, yet there is, for so far known, no research about the market effect of green bond labelling specifically in academic journals. Therefore the main research question of my thesis will be:

RQ: How do investors value green bonds compared to regular investment grade bonds?

A widely used proxy for valuation in the debt market are credit spreads, which incorporate the difference between the yield of a debt instrument and the risk free yield. Riskier investments require higher returns and have therefore higher spreads. Spreads and bond prices have an inverse relationship. As I use credit spreads as a measure of valuation, the first sub-research question will be as follows:

SRQ 1: How do the credit spreads of green bonds differ from similar non-green bonds?

I am primarily interested in whether the green bond label has any behavioral or irrational effect on the valuation by investors. So in order to provide additional evidence that green bonds could be priced differently due to a behavioral reason, I develop a model based on prior literature to estimate normal credit spreads for regular bonds and try to observe whether green bonds have significant abnormal credit spreads compared to their counterparts. So the second sub-question will be:

SQR2: How does the pricing error of green bonds differ from non-green bonds?

Mispricing could revert over time, so the bonds could be more fairly priced according to the model as it moves closer to maturity, as investors might know better how to price it. This could can lead to changes in prices, which could affect the total return of the bonds, leading to the following question:

SQR3: How does the return over green bonds differ from the return over non-green bonds?

After performing Pooled OLS regressions on a panel with daily data of two years and controlling for the term structure and several credit spreads determinants, I find that green bonds on average have slightly higher credit spreads compared to comparable investment grade bonds and have a slightly more positive abnormal yield spread than non-green bonds when a model for normal credit spread is estimated. However these results are mostly not significant, but sometimes weakly significant. So if green bonds are indeed underpriced in two years, it is likely that this underpricing became less prominent in the past two years and that the price of the bond has risen. If this is the case, I could find higher returns for green bond. Yet, I did not find a significant difference in return. Instead, when I plotted a timeseries of the abnormal credit spreads, I found that abnormal credit spreads of green bonds have risen from end 2016 onwards, whilst for non-green bonds, these stayed roughly constant. Since president Trump was elected during November 2016, it is likely that his election had created a belief in the market that green bonds are more risky than regular investment grade bonds or that possible tax incentives might be mitigated. After redoing the analysis, for the pre and post-election period, I find stronger significant underpricing of green bonds in the post-election period and no significant difference in valuation in the pre-election time.

Since most prior research mainly focused on the social and environmental performance of firms via Environmental Social and Governance (ESG) factors or other Corporate Social Responsibility (CSR) measures and its effects on credit spreads, I contribute to the research by analyzing the effect of green bond labels. My research can be relevant to all types of organizations, such as corporates, financial institutions and governments, as they can encounter whether they can finance their projects more or less expensively when they label their bond as green. Furthermore, my thesis can be of use to regulators or policy makers, as they want to see whether the issuance of green labelled bonds has the desired effect, namely low credit spread and more demand for green financing. Also investors could benefit from the research, since an overpricing of green bonds could lead to reversion over time, making them able to profit from the price increase in the future.

3. Literature review

3.1 Credit Spread theory

Credit spreads, the difference between the yield of the bond and the risk free rate, are according to the standard model determined by two general factors. First of all, the credit spreads reflect the risk of default and the expected recovery rate (Collin-Dufresne, Goldstein & Spencer Martin, 2001). Furthermore some studies, for instance by Ericsson and Renault (2006), suggest that credit spreads also reflect a liquidity premium. Collin-Dufresne et al. (2001) investigated the drivers of credit spread changes by using proxies for either default risk, expected recovery rate or liquidity.

Credit spreads of a bond can be seen as a measure of risk of the related security. As bonds are debt instruments, holders of the investments face asymmetrical benefits or losses as a result of firm performance. In contrast to shareholders, bondholders do not directly benefit from higher positive profits and upside potential, but they do face increased default risk related to negative profits. As a bond can be seen as a short put option on the issuer's assets (Merton, 1974). Investors demand higher return for higher risk bond, resulting in higher credit spreads and lower prices. So share prices are affected by performance and future growth, whereas bond prices and credit spreads are related to the downside risk, such as expected default and recovery rate, as perceived by the market.

3.2 Effect sustainability on issuer specific risk

3.2.1 Effect sustainability on issuer performance

So for the green aspect of a green bond to affect the credit spread, the environmental performance of the issuer should affect the actual or perceived default risk or expected recovery rate. As a mediating variable, the profitability of a company affects both the default probability and the expected recovery rate. So environmental performance can affect credit spreads through profitability. A study by Spicer (1978) indicated that pollution control by companies in the paper industry significantly benefited several economic performance factors, such as profitability, size, total risk and systematic risk. This could impose lower default probability and higher recovery rate for the bond, resulting in low credit spreads. Ambec and Lanoie (2008) conducted a meta-analysis about whether it pays to be green for organizations. According to their reviewed literature, lowering pollution and increased social responsible business activities could affect firm performance both through sales and through costs.

Russo and Fouts (1997) found a positive relation between environmental performance and a company's return on assets (ROA). They argued that a company can increase its financial profitability, by increasing environmental performance, as a company's market share and therefore sales might increase due to reduced pollution and environmental management, since the company might attract customers who are sensitive to environmental issues and gain competitive advantage in this way. Companies do not only increase revenue by differentiating themselves environmentally, but they also can increases sales by entering new customer markets (Ambec and Lanoie, 2008). Governments often require for their suppliers that they meet certain environmental criteria, before entering in a contract. Therefore pollution control can result in more clients in the governmental sector for instance.

It seems straightforward that environmental performance increases demand and revenue, however there seems to be a tradeoff between cost efficiency and pollution reduction, as companies need to invest many resources to eliminate environmental effects. Yet, according to Porter and van der Linde (1995), a firm can increase operating performance also on the cost side, through innovations. Hart and Ahuja (1996) confirm this in their study of S&P 500 firms and argue that greener firms are considered to save costs as well, due to increased efficiency. High pollution could be an indication of more extensive use of resources and therefore of inefficiency in the manufacturing process. Also environmental waste prevention during the process is likely to be less expensive than solving the environmental damage.

An example of a method to improve environmental performance is green supply chain management (GSCM), which is aimed at reducing environmental waste through the supply chain. This involves many green project investments, which could be eligible for green bond financing. According to research by Choi and Hwang (2015), GSCM can increase both environmental and financial performance.

Contrarily, there are other studies that conclude that environmental performance and economic performance is a trade-off. For instance, Bragdon and Martin (1972) argue that eliminating the externalities seems to be very expensive, which will result in higher operating costs and therefore lower profitability. A paper by King and Lenox (2001), indicates that the statement "It pays to be green" should be interpreted with caution, since the positive association between environmental management and firm performance might not be due to causality. According to King and Lenox

(2001), it is probable that the observed relation is a result of endogenous unobserved factors, specific to the firms. For instance, a firm with adequate financial performance, might have better risk management or strategic position in general, which will provide the firm with better resources to implement for instance pollution control and socially desirable projects.

3.2.2 Effect sustainability on issuer risk and cost of capital

According to Sharfman and Fernando (2008), environmental awareness might not only increase operating performance of companies, but it might also decrease the weighted average cost of capital. A lower cost of capital means that the firm can finance itself less expensively, since the cost of capital reflects the minimum return a company must generate in order to repay its investors. Furthermore, a lower cost of capital increases the expected enterprise value of a firm, which might attract investors. Sharfman and Fernando (2008) indicate that a reduction of the cost of equity as the main cause of the negative influence of environmental awareness on the cost of capital. They argue that pollution reduction activities will decrease a company's systematic risk, which will reduce a firm's equity beta in the Capital Asset Pricing Model (CAPM) (Sharpe, 1964). The reduced systematic risk could be due to a decreased sensitivity to price increases of unsustainable commodities. In addition a study by Sassen et al. (2016), found that higher Economic Social and Governance (ESG) factors, decrease also idiosyncratic risk, not related to the market risk, measured by the overall residuals of a model that estimates expected stock returns. Idiosyncratic risk can for instance be reduced by lower litigation risk, as a result of better ESG performance.

Furthermore, Sharfman and Fernando (2008) also provided an explanation on why the cost of debt could decrease as a result of environmental risk management. According to their reasoning, a firm's default risk can decline, since the firm is less likely to incur fines as a result of negative externalities to the environment. In addition, Hoepner et al. (2016) hypothesize that corporate sustainability factors influence the cost of debt, as these factor reduces the probability of opportunistic behavior by management. However both studies did not find statistical evidence that the cost of debt will decrease due to environmental risk management. Sharfman and Fernando (2008) argue that this is a result of the increased debt to equity ratio of the firm, as a firm can cope with more debt if their risk of default has declined. This again increases the cost of debt offsetting the direct negative effect of environmental awareness on that part of the cost of capital.

So there are not many studies that find a negative relation between the cost of debt and the social and environmental performance. As the price of the bond is negatively associated with the yield and credit spreads are not expected to be affected by the green aspect of the bond, the price and return of the bond should not be affected as well.

3.3 Effect sustainability on market perception and investor sentiment

3.3.1 Investor sentiment in bond market

Another measure for risk for debt securities is credit rating, which are rating given by external parties, such as Standard & Poor, Moody's and Fitch, that assess the probability of default by the issuer. When assigning a rating, these external parties take into account the performance and risk factors of the issuer (Gray et al., 2006). Credit spreads are highly influenced by these ratings and therefore the market perceives that credit ratings are a relevant indication of actual risk (Duffee,1998). According to Markowitz (1959), investor are rational leading to a situation in which investment prices reflect the underlying risk model. Therefore, credit spreads are expected to move with the risk measures such as ratings. However, many studies such as Kothari and Shanken (1997) indicate that security prices, such as of stocks, do not move in accordance with rational models, as security prices are affected by irrational sentiment as well,

Not only stocks, but the credit spreads do also not fully move in accordance with their traditional models based on rationality (Nayak, 2010). So the market could irrationally believe that there are other factors that influences risk. Nayak (2010) argues that besides models based on the term structure and the credit ratings, credit spreads and therefore bond prices are also affected by news and investor sentiment, similar to stocks. This is in accordance with behavioral finance theory. With this in mind, it could be that a socially desirable label on an investment for instance, could create different investor sentiment or perceived growth potential and risk beyond the effect on the real performance or risk of the underlying issuer. In my thesis I try to analyze this behavioral effect of the green bond label on credit spreads specifically. So I investigate whether there is a (irrational) premium or discount for bonds with a green label, on top of the actual performance, risk factors and term structure.

3.3.2 Behavioral effect social norms and sustainability on equity valuation

Unfortunately there is not much research conducted on sustainable or green investments and abnormal return or credit spreads in the bond market, but there exists many research about social norms and valuation in the equity market. For instance, Hong and Kacperczyk (2009), found that sin stocks, which are shares of companies that are engaged in tobacco, alcohol or gambling, are significantly lower valued than non-sin stocks in the market. A reason for this could be that large institutional investors, such as pension funds, value social norms and therefore have less demand for sin investment products, even if they have higher expected return. Higher return is expected due to a systematic undervaluation of these stocks, resulting in a return premium. Hong and Kacperczyck (2009) relate their findings to the theory of Akerlof (1980), who stated that agents could make decisions which are financially unfavorable compared to another decision, if the other choice would result in loss of reputation. Possibly, if this is the case, it could also be that social responsible investments, such as green bonds, are overvalued due to possible reputational gains for institutional investors.

Bird et al. (2015) confirm this and find that firms who are higher rated related to environmental performance are valued higher than firms that are lower rated and that firms that fail to meet ethical requirement with respect to the environment trade lower. Also, Lourenço et al. (2011), found that a higher Dow Jones Sustainability index for a company will result in higher market value, even when controlling for normal value determinants related to firm performance and size. This indicates that stocks of "sustainable" companies are trading at a premium. Also large profitable firms with low sustainability index were undervalued most by investors, as they often signal high ambition regarding their environmental footprint, but if their score is low, they are likely to be penalized.

Furthermore, Kaspereit and Lopatta (2016) argue that a higher Sustainable Asset Management Group's (SAM) rating will lead to a higher market value of a company. In addition they also investigate that value relevance of sustainability reporting in financial statements. However, they did not find consistent evidence related to this matter, whilst other studies, such as Schadewitz and Niskala (2010) emphasize that sustainability reporting is mostly used to signal environmental performance by managers in order to receive higher equity valuations.

Besides literature on the positive valuation by investors of corporate sustainability and social performance, there exists also literature in which is stated that investors are prepared to pay less for firms which have high environmental performance. For instance, Hassel et al. (2005) indicated that when taking financial information in account, environmental performance information had additional value relevance, but the observed relation was negative. So firms that scored higher in terms of environmental performance were valued lower by investors than their comparable firms. The authors argue that some investors are of belief that environmental performance leads to higher operational costs. Given the fact that the authors control for income and book value, the lower valuation is indeed only likely to be due to belief of higher costs, instead of higher cost in reality.

3.3.3 Behavioral effect sustainability and social norms on credit spreads

So far I have discussed primarily the effect of various sustainability and social norm measures on the equity market. It is likely that firms are penalized in the stock market for low social and environmental performance. Therefore, it could be that socially low performing firms move to the debt market to receive cheaper financing. Yet not many studies are conducted about the matter. However there are some studies, which analyze the influence of sustainable and social measures on the debt market. For instance, a study by Chalabi et al. (2015) investigated whether sin firms, engaged in tobacco, alcohol and gambling received loans with a different credit spread than comparable non-sin firms. Unexpectedly, they found that loans, which financed sin firms had significantly lower credit spreads than non-sin loans. So in this case, firms with lower social performance seem to receive less expensive financing in the debt market. Even when they control for various real risk factors, such as accounting quality, earnings predictability and credit ratings, they found similar results. Therefore, the lower credit spreads seem to be due to the banks perception of risk rather than actual risk.

Whilst Chalabi et al. (2015) analysed the financing of firms with only low social performance, Menz (2010) analysed the effect of Corporate Social Responsibility (CSR) in general on the corporate bond market. He concluded that firms with a high CSR measured by the Sustainable Asset Management Group's (SAM) rating for a firm seemed to lead to higher credit spreads for the Euro corporate bonds, but the results were weakly or not significant. Also this study took already credit ratings into account, which incorporate to some extent governance factors and environmental and social issues as well as firm risk and profitability. So SAM ratings do not seem to provide additional information. Furthermore, the author argues that investors could be sceptic about the idea that social and environmental performance will lead to less risk or more return.

In contrast, Ge and Liu (2015) find that firms with higher CSR are able to finance themselves with a lower cost of debt than firms with low CSR. This seems to be due to both the influence of social performance on real risk and performance indicators, such as credit ratings and the market perception of firms risk. Since, after controlling for the measures the result still holds. As a major explanation, the authors argue that investors perceive firms with higher CSR to have lower information asymmetry and a lower litigation risk. Therefore, higher CSR firms seem to be higher valued.

3.4 Hypothesis development credit spreads

It might be possible to extrapolate the results of social norms and CSR to green bonds as well, despite that there is, to the bet of my knowledge, no research conducted about green bonds. So, as elaborated above, many studies do not find any association between environmental performance and the cost of debt, such as Sharfman and Fernando (2008) and Hoepner (2016), who investigated the effect of social and environmental performance on real risk and therefore the cost of debt and Menz (2010), who focused more on investor perception. Therefore, the first null hypothesis will be:

$H_0 1$ = Green bonds have similar credit spreads as comparable non-green bonds

As the sign of the relationship between green bond labelling and the credit spreads remains ambiguous the alternative hypothesis will be:

$H_a 1$ = Green bonds have different credit spreads than similar non-green bonds

To provide additional evidence on whether the possible effect on the risk premium is likely to be due to investor perception in the market rather than actual risk determinants, I conduct an additional analysis to see whether a pricing model for regular bonds to determine normal yield spreads is also applicable for green bonds. So I analyze whether green bonds are likely to have different abnormal pricing than non-green bonds. Therefore, the second null-hypothesis and alternative hypothesis will be:

$H_0 2$ = Green bonds have similar abnormal credit spreads as comparable non-green bonds

$H_a 2$ = Green bonds have different abnormal credit spreads than comparable non-green bonds

3.5 Hypothesis development bond returns

Investors implement strategies based on the mispricing of securities. Investing in sin-stocks, as mentioned earlier is likely to result in abnormal return, as they are often underpriced and investors require more return for these higher risk stocks. Furthermore, mispriced securities tend to move to their fundamental value in the future, according to Basu (1977), who analyzed valuation and return in the stock market. Overvalued securities tend to underperform and undervalued securities tend to overperform. Houweling and van Zundert (2017) applied this theory to the bond market to see whether a factor investing strategy that invests more in underpriced securities would outperform the market. They indeed found that this strategy resulted in significant market outperformance. With this in mind, it could be that if green bonds have higher abnormal credit spreads, that these spreads decrease to normal levels in the future, resulting in higher holding return. Also if they have negative abnormal credit spreads, it could be likely that the spreads will rise in the future, resulting in negative return.

However, there are also other theories that predict return in another way. For instance, securities that have increased in price are likely to do so in the future as well, as past winners tend to be future winners and past losers tend to be future losers (Jagadeesh and Titman, 1993). In this paper by Jagadeesh and Titman (1993), they provide some evidence that a long position of stocks that were profitable in the past and a short position in stocks that have decreased in value in the past results in significant abnormal returns in a yearly time period. So if green bonds have lower credit spreads compared to non-green bonds, this gap could widen leading to more return in the future according to this momentum theory. Another theory is that low risk securities perform better than high risk securities, as low risk securities tend to be undervalued and high risk securities overvalued (Blitz et al., 2014). So this could predict higher (lower) return for green bonds if they have lower (higher) credit spreads. . Houweling and van Zundert (2017) in their paper about factor investing confirm these hypothesis as well, when applied to the bond market in general. As the effect on return remains ambiguous the third and last null-hypothesis and the alternative hypothesis will be as follows:

$H_0 2$ = Green bonds have similar return as comparable non-green bonds

$H_a 2$ = Green bonds have different return than comparable non-green bond

4. Methodology

4.1 Dependent and independent variable

In order to observe the effect of the classification as a green bond on the perceived risk of the security, I use Pooled Ordinary Least Squares regression with credit spreads as dependent variable and a dummy variable for green bond as the independent variable of interest, which takes the value of 1 if the bond is classified as green bond and 0 if not. For the dependent variable higher credit spread indicate either a higher perceived default risk or expected recovery rate (Fabozzi, 2013). Credit spreads are constructed by the difference between the yield to maturity in percentage of the bond on a given date and the yield to maturity of a German government bond with the closest life to maturity. For instance, if a bond has a life to maturity of three years, the yield of a three year German government bond is used for the spread calculation. A predictive validity framework of the variables and its operationalizations are added in appendix 1.

Green bonds are sometimes tax exempt and therefore the yields cannot be compared to non-tax exempt bonds, due to efficient market theory (Fabozzi, 2013, pp. 106-108). The yield for tax exempt bonds are generally lower, as investors require lower return for those bonds, since they benefit from the tax exemption. So for comparability purposes, I calculate the tax equivalent yield for green bonds issued in a country with tax incentives for green bonds. The tax equivalent yield is the yield to maturity for a bond as if it was not tax exempt and constructed by means of the following formula (Fabozzi, 2013, p.107):

$$Tax\ equivalent\ yield = \frac{Tax\ free\ yield\ to\ maturity\ bond}{1 + tax\ rate}$$

4.2 Control variables

In order to try to mitigate endogeneity via omitted variable bias, I added control variables to the regression model. These factors could be considered as determinants of the perceived or actual credit risk and therefore the spreads, but which could differ between the green bond group and the control group.

Firm financial statement and risk information of the issuer is a widely used determinant of the credit spreads. This includes leverage for instance, which represents the probability of default, but also volatility and sensitivity of performance measures as this represents the expected recovery rate (Collin-Dufresne et al., 2001). A problem with these measures however is that in the sample many bonds are issued by governmental organizations of which no financial information is available. Rating agencies are likely to have access to information specific to the project or organization the bond has financed. Therefore to capture these organization or project specific risk, I used credit ratings of the bonds. According to literature such as Adams et al. (2003) and Gray et al. (2006), credit ratings are influenced by these measures, such as leverage, profitability and volatility, which influence probability of default and expected recovery rate. In order to operationalize the variable, I assigned the value of 10 to AAA ratings and 9 to AA+ ratings and so on to a value of 1 for a BBB- rating, which is the lowest rating for investment grade bonds. Furthermore, I averaged the ratings of Moody's, Fitch and Standard & Poor and converted the credit rating variables in a set of 10 dummy variables, which take the value of 1 if the bond contains the specified rating and 0 otherwise. The reason for using this method is that for this sample of bonds credit ratings have most explanatory power in explaining credit spread, when they are added as dummy variables.

Also life to maturity is used in the regression as control variable, as this is a widely used determinant of credit spreads (Annaert and Ceuster, 1999). The time to maturity is likely to affect perceived default risk and therefore the credit spreads, since there is a higher probability that a firm would default in a longer time period. Also, according to Fons (1994) higher rated bonds are more likely to get downgraded than upgraded in the future, therefore higher spreads could be expected for low risk loans. It could be that due to the sample selection, there is an association between whether a bond is green and the life to maturity of a bond, primarily because green bonds are likely to be younger than non-green bonds, as green bonds are rising in popularity since a few years.

Also the coupon rate is associated with pricing. According to Annaert and Causter (1999), bonds with high coupon rates and the same maturity are likely to have lower credit spreads than lower coupon bonds. However, Hyman et al. (2015) argue that bonds with a higher coupon rate are considered to be associated with higher default risk by investors, as in the case of default, the loss of expected future cash flows is higher. Therefore, high coupon bonds have higher credit spreads, of which Hyman et al. (2015) have found empirical evidence. There could be a difference in coupon rates in the treatment and control sample, which could bias the results. Therefore, the coupon rate is added as a control variable.

According to Chen et al. (2007), illiquidity is often incorporated in credit spreads as well. As illiquidity results in additional risk, since illiquid securities could be difficult to sell when the investors needs end their position due to the increased risk of default for instance or for other risk management purposes. Therefore bonds which are less liquid earn higher yields and thus higher spreads to compensate for the increased risk (Chen et al., 2007). Liquidity is measured by the Bid Ask spread.

Furthermore, credit spreads of green bonds are strongly associated with macro-economic factors, such as the state of the economy and the interest rate (Collin-Dufresne et al., 2001). A higher spot rate for instance resembles a drift to risk neutrality, reducing the default rates and the credit spreads. An unfavorable state of the global business cycle will both increase the default rate and decrease the expected recovery rate. I try to capture these effects by including time fixed effects in the model, which control for unobserved time variant and cross-sectional invariant effects. To operationalize these time variant effects, I used quarterly fixed effects. This could reduce bias, because there could be a different number of observations in the green bond and non-green bond sample during a period.

Lastly, as for stock prices, industry and country wide factors could influence prices as well. For instance sovereign credit ratings affect financial markets of the country as a whole and could increase the cost of debt of the firms, as firms situated in a country which is in financial distress will be perceived as more risky (Almeida et al., 2017). Chava and Jarrow (2004), try to explain default rates for firms and they add industry effects in their model, as defaults within companies in an industry seem correlated. According to Das et al. (2007) and Akhigbe et al. (2014), possible reasons for this are that entities in the same sector are exposed to similar risk factor, organizations could be linked in terms of cash flow and bad news about one firm could be extrapolated to the whole industry by investors.

I cannot rule out the possibility, that the selection of the green bond sample and the control group sample is not completely random or that both groups do not have exactly the same characteristics.

There could be more bonds in the supranational sector for the green bond sample compared to the control sample. To control for this sample selection bias, I included sector dummyies, which are constructed by the DataStream bond sector variables. Furthermore, I included country fixed effects to control for sample selection bias related to the country of the issuer of the bond, which is constructed by the issuer country variable in DataStream. All variable definitions are summarized in appendix 2. The regression for the first hypothesis will be the following;

EQ1:

$$Credit\ Spreads_{it} = \beta_0 + \beta_1 * greenbond_{it} + \sum_{r=1}^{11} \gamma_r * Rating\ dummy's_{ir} + \beta_2 * Life_{\ it} + \beta_3 * Coupon_{it} + \beta_5 * BidAsk_{it} + \sum_{r=1}^{6} \theta_r * Industry\ dummy's_{ir} + County_{fe} + time_{fe} + \varepsilon_{it}$$

Of which i denotes the cross-sectional indicator, which is the bond. The term t denotes a time variable with daily observations. Life indicates the time to maturity in days and Coupon is the yearly coupon rate stated in the prospectus in percentages.

4.3 Methodology pricing error

After controlling for these previous factors that could influence the pricing of the bonds, it can be seen, if green bonds are on average higher priced or lower priced than their non green counter parts. It would be also interesting to investigate whether the green bond classification has any effect on the pricing error of a bond. As, if this is the case, there would be some evidence that investors perceive that green bonds have a different risk profile, not based on regular pricing determinants, but rather on other investor sentiments, giving rise to a behavioural finance explanation.

I used a similar methodology of constructing abnormal pricing, as the study by Houweling and van Zundert (2017), who wanted to construct a portfolio with bonds, which had highest abnormal credit spreads in order to see if this would lead to abnormal returns. They argued that normal credit spreads depend on a set of credit rating dummies, the maturity and the three month change in credit spreads. Similarly, I predicted the normal credit spreads by those three variables. In addition, I also included the coupon rate and country fixed effects in the prediction regression, as these have high explanatory power, which can be observed by an increase of the adjusted R-squared in table 2 when these variables were added. So this results in the following regression equation for the prediction

EQ2:

$$NSpread_{it} = \beta_0 + \sum_{r=1}^{11} \gamma_r * Rating\ dummy's_{ir} + \beta_1 Life_{it} + \beta_2 Coupon_{it} + \beta_3 BidAsk_{it} + \beta_4 \Delta Spread_{it} + Country_{fe} + \varepsilon_{it}$$

In which i denoted the specific bond and t denotes a time variable in days. Delta Spread is the change of the credit spread during 90 days representing the three month credit spread change as in the study by Houweling and van Zundert (2017). These normal credit spread were calculated for the regular non-green bond sample. After estimating the normal credit spread, the abnormal credit spread or pricing error was calculated for the total sample by subtracting the normal credit spread from the actual credit spread during time t. To see whether a green classification has an effect on the pricing error, I performed a pooled OLS regression with the abnormal credit spreads as dependent variable and the green bond dummy as independent variable. Furthermore, to try to mitigate endogeneity, I used similar control variables as in the other credit spread analysis, which results in the following regression equation:

EQ3:

$$ABSpread_{it} = \beta_0 + \beta_1\, green\ bond_{it} + \sum_{r=1}^{11} \gamma_r * Rating\ dummy's_{ir} + \beta_2 Life_{it} + \beta_3 Coupon_{it} + \beta_4 BidAsk_{it} + Country_{fe} + \varepsilon_{it}$$

4.4 Methodology return analysis

For the return analysis, I also used a similar analysis as Houweling and van Zundert (2017), who tried to compare market model alpha’s for different portfolios of bonds. They used the Capital Asset Pricing model (CAPM) and the Fama -French-Cahart 6 factor model. Yet for simplicity, I only used a simple return regression model with beta’s set at one and zero and a simple CAPM. In order to calculate the holding return of the bond, I used the DataStream total return measure, which depends on accrued interest, coupon received and the change in price. Eventually, I calculated the percentage change of the total return index of the bond. The benchmark or market return is the daily holding return for the Bloomberg Barclays Global Aggregate bond index, consisting of only investment grade bonds. For the risk free rate, the yield of a 10 year German government bond is used and converted to a daily yield. So to analyze whether a portfolio of green bonds significantly outperforms a portfolio of similar non-green bonds, the following models are computed:

EQ4, EQ5 and EQ 6:

$$Ret_{it} = \alpha\_ nongreen_i + \alpha\_green_i + Rf_{it} + 0 * (Market\ Ret_{it} - Rf_{it}) + \varepsilon_{it}$$
$$Ret_{it} = \alpha\_nongreen_i + \alpha\_green_i + Rf_{it} + 1 * (Market\ Ret_{it} - Rf_{it}) + \varepsilon_{it}$$
$$Ret_{it} = \alpha\_nongreen_i + \alpha\_green_i + Rf_{it} + \beta_i * (Market\ Ret_{it} - Rf_{it}) + \varepsilon_{it}$$

Ret indicates the holding returns for the bonds, *alpha-nongreen* the outperformance of the non-green portfolio compared to the market and *alpha-green* represents the additional alpha green bonds will generate, when added to the portfolio. A significant and positive *alpha-green* would indicate that investing in green bonds would result in higher outperformance of the market compared to non-green bonds.

5. Sample selection

The ISIN codes for the green bond sample were collected from the Barclays MSCI Green bond Index composition and the composition of a green bond ETF constructed by Seeking Alpha. Initially, I tried to form a non-green sample by searching investment grade bonds issued by the same firms as in the green bond sample, in order to control for firm specific characteristics. However, in this way I was not able to retrieve a control group that was of a more or less equal size as the green-bond sample. Therefore, I randomly selected some investment grade bonds from an ETF, which tracks the Bloomberg Barclays Global Aggregate Bond Index, to increase the sample size of non-green bonds. For both the treatment group and control group, I excluded variable coupon rate bonds, callable bonds, zero coupon bonds, convertible bonds and asset backed securities, which results in a sample of only regular investment grade bonds with a fixed coupon rate in order to remove the effects of bond specific characteristics. This resulted in a total sample of 110 bonds of which 53 are green bonds and 57 are non-green bonds. In appendix 3 a list of ISIN codes of the bonds can be found.

As green bonds are quite new securities, I analyzed historical data of these 110 bonds from July 2015 to July 2017, which results in a sample period of two years. Another reasons for only incorporating two years is that many of these bonds were issued after July 2015 and adding more years would increase missing values. In order to maximize observations I used daily observations, which eventually resulted in 54,526 observations.

Daily time series data for yield to maturity, time to maturity and total return were collected from Thompson Reuters Data Stream. Cross-sectional data, which included ratings from Moody's, Fitch and Standard & Poor, coupon information, maturity dates, sector codes and country codes were retrieved from Data Stream as well. Historical one year to 30 year German government bonds used as risk-free rate for the credit spread calculation and Total Return Index data of the Bloomberg Barclays Global Aggregate bond index were manually extracted from Bloomberg. A list of ISIN codes of these German government bonds is presented in the appendix 3 as well.

When examining the distribution of yield to maturity data stated in appendix 4, I noticed that there was one bond causing outliers in the dataset. The outlier was a bond issued by the Export Import Bank of Korea, which had a reported yield to maturity above 100%, therefore I removed all observations from this bond. Furthermore, I excluded a German Government bond from the control group as it was the same as a German Government bond used for the Spread calculation. Besides it was a negative outlier, since it was the bond with the lowest yield to maturity in the sample. From the histograms in appendix 4, it can be seen that after dropping these bonds, the distribution becomes less skewed. So eventually the sample consisted of 108 bonds of which 53 were green bonds and 55 non green bonds, resulting in 53,454 observations. Additionally, for the regressions is required that all variables used contain no missing values. Consequently, the final sample size consists of 35,867 observations for the main analysis.

6. Results

6.1 Descriptive statistics

When evaluating the descriptive statistics in table 1 we can see that the credit spread for green bonds is slightly higher than for non-green bonds, which is unexpected, since in the United States and the Netherlands there are tax incentives for green bonds resulting in lower yields. However, if only yields are taken into account, we can observe that yields for green bonds are slightly lower. Yet, for both variables the difference is not significant and the t-statistic has a very low value, therefore we cannot conclude anything from these observation. Even though the difference of credit spreads incorporating tax equivalent yields between green bonds and non-green bonds is larger by construction the effect has still relatively low t-statistics and therefore we cannot base any inferences on this. Similarly, the control variables are not statistically different from each other for the samples.

Table 1: Descriptive statistics

In the table some descriptive statistics are presented of variables used in further analysis. The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The descriptive statistics are calculated of panel data for two years resulting in a total set of 37,963 observations. In the left panel the mean, median and standard deviation are presented for the green bond sample and in the middle panel for the control group. The right panel shows the difference of the mean values and the statistics, which are clustered per bond identifier due to correlated observations. T-statistics are computed adjusted for clustered standard errors at the ISIN level.

	Green bonds		Non green bonds		Difference	
Variable	Mean (Median)	SD	Mean (Median)	SD	Difference	t statistic
Yield	1.49	1.28	1.59	1.27	-0.10	-0.35
	(1.33)		(1.41)			
Tax equiv Yield	1.72	1.91	1.59	1.27	0.14	0.44
	(1.40)		(1.41)			
Spread	1.73	1.11	1.70	1.16	0.02	0.09
	(1.46)		(1.47)			
Spread (tax equiv)	1.96	1.71	1.70	1.16	0.25	0.89
	(2.02)		(1.47)			
Average rating	6.34	2.98	6.83	2.75	-0.49	-0.85
	(6.67)		(7.00)			
Life	5.94	3.26	7.20	5.35	-1.25	-1.37
	(4.98)		(5.29)			
Coupon	2.11	1.33	2.66	1.89	-0.54	-1.64
	(2.00)		(2.50)			
BidAsk	0.30	0.25	0.35	0.31	-0.05	-1.03
	(0.20)		(0.24)			
Daily return in %	0.01	0.29	0.01	0.31	0.00	-0.67
	(0.01)		(0.01)			
Obs.	20,263		17,700			

6.2 Credit Spread analysis

When running the regression, we can see in table 2 panel a) that the credit spreads for green bonds are slightly higher in each regression, even when controlling for bond characteristics, country fixed effects, sector dummies and time fixed effects. However in almost all regressions the coefficient is not significant and therefore we cannot conclude that the credit spreads for green bonds are significantly different from the credit spread of non-green bonds. However, in regression 4 in panel 3 we can observe that the coefficient is positive and significant at the 5 percent level. Yet, this result is likely to be observed due to chance, given that all the other regressions provide different results.

Table 2: Credit Spreads

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The total set consists of daily observations for a time period of two years (14-7-2015, 14-7-2017), resulting in 37,319 observations for the regressions. In panel a) the results of multivariate regressions are shown with Credit Spreads as dependent variable, which are not adjusted for tax equivalent yield for green bonds issued in countries with a tax incentive for these bonds. In panel b) the results of multivariate regressions are shown, in which the dependent variable is Credit Spread adjusted for tax equivalent yields for green bonds issued in a country with tax incentives. 10 rating dummies are included as control variables, which depend on the average of the Moody's, Fitch and S&P credit ratings. Furthermore Life is the time to maturity, coupon is the coupon rate of the bond specified in the contract and BidAsk is the percentage difference between ask and bid prics. Sector dummies indicate whether a bond is issued by a financial services firm, supranational organization, government or an industrial company. Also country and quarterly fixed effects are included to control for macro-economic environment. T-statistics are computed adjusted for clustered standard errors at the ISIN level.

Panel A: Spread (no tax equivalent yield)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
C	1.70	2.52	2.64	0.83	1.10	0.72
	(9.03)	(4.25)	(3.97)	(2.98)	(3.02)	(2.37)
Greenbond	0.02	0.10	0.39	0.20	0.16	0.19
	(0.09)	(0.46)	(2.06)**	(1.20)	(1.00)	(1.18)
Rating dummy's	No	Yes	Yes	Yes	Yes	Yes
Life			-0.02	-0.01	-0.01	-0.01
			(-0.85)	(-0.59)	(-0.68)	(-0.54)
Coupon			0.36	0.28	0.27	0.30
			(5.97)***	(4.76)***	(4.75)***	(4.79)***
BidAsk			-0.88	-0.70	-0.72	-0.72
			(-4.09)***	(-3.58)***	(-3.61)***	(-3.54)***
Sector dummy's					Yes	No
Country fixed effects	No	No	No	Yes	Yes	Yes
Quarterly fixed effects	No	No	No	No	No	Yes
Adjusted R-sq	0.001	0.33	0.53	0.71	0.71	0.71
Obs.	37,963	37,963	35,867	35,867	35,867	35,867

Panel B: Spread (tax equivalent yield)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
C	1.70	2.53	2.95	0.63	0.87	0.50
	(9.03)	(4.25)	(5.58)	(2.18)	(2.47)	(1.56)
Greenbond	0.25	0.35	0.71	0.51	0.47	0.51
	(0.89)	(1.45)	(3.15)***	(2.82)***	(2.61)***	(2.80)***
Rating dummy's	No	Yes	Yes	Yes	Yes	Yes
Life			-0.01	0.00	0.00	0.00
			(-0.33)	(-0.12)	(-0.18)	(-0.08)
Coupon			0.42	0.33	0.32	0.34
			(5.32)***	(4.98)***	(4.85)***	(5.02)***
BidAsk			-1.04	-0.80	-0.82	-0.82
			(-4.52)***	(-3.49)***	(-3.53)***	(-3.43)***
Sector dummy's	No	No	No	No	Yes	No
Country fixed effects	No	No	No	Yes	Yes	Yes
Quarterly fixed effects	No	No	No	No	No	Yes
Adjusted R-sq	0.01	0.36	0.56	0.75	0.76	0.76
Obs.	37,963	37,963	35,867	35,867	35,867	35,867

Surprisingly, the life to redemption variable seems not to have a significant effect, whilst we would expect a positive effect of the maturity of a bond on the perceived risk. However, our sample only consists of investment grade bonds, of which the risk of default is not that substantial. So longer life to maturity might not indicate a higher risk of default for investment grade bonds, but this more applies for high-yield securities. When performing a regression with credit spread change as dependent variable and change in life as independent variable, life does have a positive effect on credit spreads in this sample. In contrast to Life, the coupon rate seems to have a significant effect, since the coefficient of Coupon is positive and significant at the 1 percent level for all regressions. So indeed the coupon rate signals compensation for the increased credit risk.

Furthermore, the Bid Ask spread, which is a measure for illiquidity seems to have a significant negative effect on the spreads, while prior literature predicted that illiquidity results in investors demanding higher yields. However, if I use the change variables of the bid ask spread and the credit spreads, a positive change in bid ask spread results in an increase in the credit spreads, which is expected and similar to the maturity variable. A possible explanation for the negative influence in absolute terms could be that there exists a liquidity clientele effect. Possibly investors in bonds in our sample have a preference for less liquid bonds, as they aim to hold them for a longer time period (Huang et al., 2013). Investors who hold safer bonds would allow less liquidity and longer maturity.

Including country fixed effects to the regression increases explanatory power. This is in line with the expectation that sovereign credit risk also seems to signal some increased perceived default risk to the market about the firms in the countries. Credit ratings do not seem to fully incorporate this effect. In contrast we observe that quarterly fixed effects and sector dummies do not increase explanatory power to the model as the adjusted R-squared does not seem to increase very much after including these.

In some countries, there are tax incentives regarding green bonds, which is the case in the United States and the Netherlands. For green bonds issued in these countries, tax equivalent yields were calculated, in order to make tax exempt and non-tax exempt bonds more comparable. In panel B we can observe, when controlling for bond characteristics, that green bonds seem to have higher credit spreads than their non-green counterparts. However, these results should be interpreted with caution, since several assumptions had to be made regarding the effective tax rate, which should be different for every bondholder. In addition, the effect of the green bond almost completely arises by construction.

All in all, the observed results about green bonds are unexpected, since no tax equivalent yields are incorporated in the variable of credit spreads in panel a) of table 2. Therefore we would expect green bonds to have lower credit spreads on average when we do not account for the tax incentive, as this incentive should be priced in according to the efficient market hypothesis.

6.3 Tax incentive analysis

Table 3: Tax incentive analysis

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The total set consists of daily observations for a time period of two years (14-7-2015 -14-7-2017), resulting in 37,865 observations for the regressions. Tax incentive indicates whether a bond is issued in a country where there exist tax incentives for green bonds to stimulate green bond financing for companies. Credit spreads are the dependent variable, 10 rating dummies are included as control variables, which depend on the average of the Moody's, Fitch and S&P credit ratings. Furthermore Life is the time to maturity, Coupon is the coupon rate of the bond specified in the contract. Also country and quarterly fixed effects are included to control for macro-economic environment. T-statistics are computed adjusted for clustered standard errors at the ISIN level.

Panel A: Spread (no tax equivalent yield)				
Variable	(1)	(2)	(3)	(4)
C	1.56	2.52	0.65	0.83
	(7.28)	(4.25)	(2.31)	(3.01)
Greenbond	-0.04	0.18	0.47	0.23
	(-0.13)	(0.78)	(2.17)**	(1.06)
Tax incentive	0.68	0.67	0.60	
	(1.72)*	(2.04)**	(1.86)**	
Greenbond* Tax incentive	0.14	-0.36	-0.37	-0.10
	(0.27)	(-0.78)	(-1.01)	(-0.29)
Rating dummy's	No	Yes	Yes	Yes
Life			-0.02	-0.01
			(-1.02)	(-0.61)
Coupon			0.35	0.28
			(5.96)***	(4.76)***
BidAsk			-0.85	-0.69
			(-3.84)***	(-3.51)***
Country fixed effects	No	No	No	Yes
Adjusted R-sq	0.08	0.37	0.56	0.71
Obs.	37,963	37,963	35,867	35,867

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In order to analyze whether the tax incentive really works according to efficient market theory, I conducted an additional analysis. I added an interaction term for whether the bond was issued in a country where there are tax incentives for green bonds, which are the Netherlands and the United States to the best of my knowledge in this sample and whether the bond was green. A value for 1 for both dummies in the interaction therefore approximately indicates whether the bond is subject to a tax incentive. Regarding the coefficients of interaction term, we can observe that in almost all regressions in table 3 the coefficient is negative, which is expected. However, these results are all insignificant. Therefore, no conclusions can be formed about whether the tax exemption of certain green bonds are actually priced in the market.

After controlling for the tax incentive it can be seen in regression 2), 3) and 4) in table 3 that the coefficient for green bond is positive, indicating a lower pricing of green bonds on average. However the result is insignificant for regression 2) and 4). Only for regression 3) the effect is significant at the 5 percent level. When controlling for country fixed effects, it becomes insignificant. A reason for this is that tax incentive bonds are dependent on in which country they are issued in this analysis. Therefore, country fixed effects could already incorporate the effect of issuing in a country with a tax incentive. This could also be the reason why this coefficient is omitted in regression four. All in all, we can conclude that when controlling for a tax incentive, there exists some minor evidence that green bonds could be priced lower, as they seem to have higher spreads according to table 3, yet in many models this seems insignificant.

6.4 Pricing error analysis

The observed minor difference in pricing observed might be due to firm specific performance factors not incorporated in the control variables in the regressions of table 2 and 3, but it could also be due to mispricing of the bonds in the market as a consequence of perceived risk of the asset relating to investor sentiments. So an analysis of the pricing error of green bonds compared to non-green bonds is performed.

The normal credit spreads are predicted for the non-green bond sample only. So the green classification of a bond is not incorporated in the model. Subsequently the pricing error is computed using the total sample and the green bond sample. In table 4 panel a) we can observe the results for the pricing error for the total sample. It can be seen that green bond classifications positively influence the abnormal spread for regression 2 and 3 in panel a). In regression 3 the coefficient is significant and positive at the 10 percent level and in regression 4, in which more control variables are added, the coefficient is significant at the 10 percent level as well and approaches the 5 percent boundary. This provides minor evidence for a positive abnormal yield, which indicates a slightly negative pricing error due to the inverse price yield relationship.

Table 4: Pricing error

Prediction model (on non-green sample) =

$$NSpread_{it} = \beta_0 + \sum_{r=1}^{11} \gamma_r * Rating\ dummy's_{ir} + \beta_1 Life_{it} + \beta_2 Coupon_{it} + \beta_3 BidAsk_{it} + \beta_4 \Delta Spread_{it} + Country\ fe + \varepsilon_{it}$$

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The total set consists of daily observations for a time period of two years (14-7-2015 -14-7-2017), resulting in 24,912 observations for the regressions. Mispricing is de dependent variable, which is the difference between actual credit spreads and normal credit spreads based on the model above. The control variables are similar to the other tables in the thesis. T-statistics are computed adjusted for clustered standard errors at the ISIN level.

	Abnormal Credit Spreads				
Variable	(1)	(2)	(3)	(4)	(5)
C	0.00	-1.73	-2.07	-0.92	0.13
	(0.00)	(-3.09)	(-3.01)	(-3.09)	(0.21)
Greenbond	0.12	0.24	0.36	0.43	0.19
	(0.41)	(1.20)	(1.77)*	(1.84)*	(0.80)
Tax incentive				0.60	-0.27
				(1.76)**	(-0.45)
Greenbond * Tax incentive				-0.32	-0.03
				(-0.83)	(-0.08)
Rating dummy's		Yes	Yes	Yes	Yes
Life			-0.02	-0.02	-0.02
			(-0.82)	(-1.00)	(-0.65)
Coupon			0.15	0.14	0.08
			(2.43)*	(2.34)**	(1.39)
BidAsk			-0.37	-0.33	-0.15
			(-3.01)	(-1.40)	(-0.70)
Country fixed effects	No	No	No	No	Yes
Adjusted R-sq	0.00	0.52	0.56	0.58	0.72
Obs.	23,922	23,922	23,922	23,922	23,922

A slight negative pricing error might be due the consequence of investors perceiving green investments as more risky and therefore requesting a higher premium for the yield of green bonds, which is in accordance with the results by Chalabi et at. (2015) and Menz (2010). However, if country fixed effects are added to the model the result becomes insignificant. This could be due to similar reasons as mentioned earlier. As the results are weakly significant, the second null-hypothesis cannot be rejected.

6.5 Return analysis

From prior literature, we can conclude that mispriced securities tend to move to their fundamental values in the future (Basu, 1977). Therefore, prices from underpriced securities are likely to rise, leading to higher returns for investors. In order to test this theory, I conduct an analysis of whether a strategy to only invest in green bonds outperforms the market.

When observing table 5, we can see that our total sample significantly outperforms the Bloomberg Barclays Global Aggregate Bond Index by 0.008 percent on a daily level, which is the sum of the alpha of non-green sample and the alpha of the green bond sample in regression 3. Yet the green bond sample does not generate significantly higher alpha compared to a non-green bond sample, since the coefficients are slightly negative and insignificant. For non the market regression the alpha for green bonds is significant. This implies that green bonds are not likely to outperform similar securities in the market.

Table 5: Return Analysis

The return is calculated by the percentage change of the daily updates of total return value from data stream. Market return is the percentage change in the Bloomberg Barclays Global Aggregate Bond Index Total Return. The risk free rate is the 10 year German Government bond yield retrieved from Bloomberg. Sample period (14-7-2015 – 14-7-2017). The regressions are performed for the following Single Index Market model below. The beta coefficient is set at 0 and for regression 1 and 2. For regression three the beta coefficient is estimated.

$$Ret_{it} = \alpha\_nongreen_{it} + \alpha\_green_{it} + Rf_{it} + \beta_i * (Market\ Ret_{it} - Rf_{it}) + \varepsilon_{it}$$

	Market model	Market model	CAPM
Parameter	(1)	(2)	(3)
Alpha if no green bond	0.012	-0.002	0.009
	(5.51)***	(-1.04)	(5.46)***
Additional Alpha green bond	-0.002	0.0004	-0.001
	(-0.64)	(0.18)	(-0.39)
Beta	0	1	Estimated per Bond
Adjusted R-sq	0.00	0.00	0.18
Obs.	31,232	31,232	31,009

So this reversion theory cannot be confirmed. However, it could be for the reason that the market still continues to believe that green bonds are more risky than comparable bonds and therefore reversion of yields could not be observed in the sample period. This does not necessarily contradict the drift to fundamental value theory, as the green bond market is rather immature and the credit spreads could move to their fundamental values sometime in the future, making holding returns expected to be higher in later years.

To see how the abnormal credit spreads for green bonds and non-green bonds have developed in the past two years, I plotted a time series graph, which can be seen in the appendix 5. We would expect for the abnormal credit spreads to move to zero, yet we can observe that the abnormal credit spreads increase at the end of year 2016, while the abnormal spreads of non-green bonds move around zero. So instead of the securities becoming less mispriced, green bonds seem to become more underpriced over time, even when the relatively new market is now maturing.

A possible reason for this is that Donald Trump got elected in November 2016, as this could have created a difference in valuation of green bonds in the market. As Donald Trump denies the climate problem and is likely to put less emphasis on renewable energy, investors might believe that green bonds are more risky compared to similar non-green bonds, because organizations engaged in environmental projects are likely to get less support from the government. Also, possible tax incentives or the anticipation of tax incentives for green investments could be mitigated. So in order to test whether abnormal credit spreads were indeed significantly higher after the election, I performed an additional time series regression analysis shown in table 6.

In the table it can be seen from the constant in regression 1) that the abnormal credit spreads for green bonds were not significantly different from zero. However, in the election period, it can be observed that abnormal credit spreads became on average significantly higher than in the pre-election period at the 1 percent level. By the election period is meant, the time from one day before the election of Donald trump till one day after his inauguration. With the post-election period I indicate the time after the inauguration. It can be seen that this coefficient is still positive and significant at the 1 percent level. If we compare this to the results of regression 2, which was applied to non-green bonds, we can observe that there was no significant difference for the time-periods in the regression for regular investment grade bonds.

Table 6: Trump election

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The total set consists of daily observations for a time period of two years (14-7-2015 ,14-7-2017). The Trump_election dummy represents the time period of election to inauguration (7-11-2016 ,22-1-2017). The post_election dummy represents the period after the inauguration (23-1-2017,14-7-2017). The week after election dummy represents the period (9-11-2016, 19-11-2016). Market ret is the difference between the market return and the risk free rate. Mispricing is de dependent variable for regression 1 and 2, which is the difference between actual credit spreads and normal credit spreads based on the model in table 4. The analysis is conducted for the green bond sample and the normal bond sample. In regression 3 an analysis of the development of returns over time is conducted. Here the dependent variable is the average daily return over all the bonds, of which the difference between green and non-green bonds is computed.

	Green	Non Green	Total
	(1)	(2)	(3)
	Ab Cr. Spreads	Ab Cr. Spreads	Avg Daily return dif
C.	-0.01	0.04	-0.001
	(-0.06)	(0.19)	(-0.31)
Trump_election	0.23	0.01	
	(2.89)***	(0.15)	
Post_election	0.28	-0.14	
	(2.23)***	(-1.65)	
Market ret			-0.03
			(3.45)***
Trump_ week after election			-0.07
			(-2.49)**
Post_ week after election			0.01
			(-0.24)
adjusted R-sq	0.01	0.003	0.04
Obs.	12,796	11,126	405

Furthermore, by regression 3, I tried to analyze whether the total return was affected by the shock of the election of Donald Trump. For this analysis I calculated the mean daily returns over all the green and non-green bonds and computed the difference in return, which led to 405 observations. As a time period for the Trump election I used only a week (7 work days) after the election to investigate whether the shift in spreads could be really due to the election, as return is expected to decrease when there is a large increase in yield and thus decrease in price. Furthermore, I use the week after as election period, because bonds take some time to adjust to news, since the market is less efficient than the stock market. As expected, I find that the difference between daily green bond return percentage and non-green bond return percentage in the election period is 0.07 lower compared to the pre-election period. The result is strongly significant at the 5 percent level, which provides some evidence that the sudden increase in abnormal yields for green bonds was indeed caused by the election of Donald Trump.

6.6 Robustness tests

6.6.1 Time periods

Since the election of Donald Trump seems to have affected to valuation of green bonds, I have conducted an additional robustness test, in which I redo the previous analyses for both the pre-election period and post-election period. Regarding panel a) of appendix table 1 in appendix 6, we can conclude that the credit spreads of green bonds did not differ from the credit spreads of non-green bonds in the pre-election period. As the coefficient of interest is not significant for all the regressions. In regression 1) and 2) in panel a), lower spreads can be observed for green bonds on average, yet not significant. This could be in line with the finding of several corporate reports, in which is not tested for significance, such as in that of Nationale Nederlanden (2018), which state that green bonds trade at a premium due to high demand.

However for the post-election period, stated in panel b) in appendix table 1 in appendix 6, the green bond dummy variable seems to have a positive and significant effect when controlling for the determinants of credit spreads in regression 3. The other regressions are significant at the 1 percent level. Therefore, the credit spreads of green bonds are weakly significantly higher than the credit spreads of non-green bonds. In addition I find stronger results for the analysis of the pricing error of the green bonds in appendix table 2 of appendix 6, of which most regressions are significant at 5 percent level, one at 10 percent level and the most simple regression without control variables is insignificant. So, all in all, only in the post-election period there seems to be an under-valuation of green bonds.

6.6.2 Propensity score matching

To better control for other determinants of the credit spreads, I also performed propensity score matching. In an archival study such as this, it is impossible to select the treatment and control group completely random, or select groups with exactly the same characteristics. With propensity score matching, one is more able to select a treatment and control group that have more similar characteristic. This method assigns propensity scores to the observations, by means of a logistic regression with the treatment variable as dependent variable, which is the green bond dummy in this case. Propensity scores are predicted probabilities of an observation to be in the green bond sample based on the chosen covariates. Subsequently matched pairs are formed of a treatment and a control observation of which the propensity score matches closely. After matching, the effect of the green label treatment can be analyzed based on a set of observations with reasonable similar characteristics.

In table 3 of appendix 7, we can observe after propensity score matching that the average treatment effect (ATE), which is the difference between the mean of the spread in the green bond group and the mean of the spread in the control group, is positive. So credit spreads for green bonds seem to be higher than for similar non green bonds by 0.24. This is comparable to the results of the main analysis. Unfortunately, the statistical program Stata only provides t-statistics on the average treatment effect on the treated (ATT), which is the average difference between spread observations that received the green bond treatment and their comparable observations receiving no treatment. The ATT is positive and significant at the 5 percent level. In the main analysis however I found primarily insignificant results. So the propensity score matching method provides more evidence that green bonds had higher credit spreads over the two year period, which are likely due to the election of Donald Trump in the United States, as was observed in the analyses of the different time periods.

7. Conclusion and Limitations

7.1 Conclusion

All in all, in the sample period of 2 years from July 2015 to July 2017, I do not find enough evidence to reject the first null-hypothesis, which states that green bonds have similar credit spreads as similar non-green bonds. So green bonds seem to have similar risk as regular investment grade bonds as perceived by the market. However, there was weak evidence that the abnormal credit spreads were higher for green bond. Therefore, it seems that it could be that green bonds trade at a discount, as the market could somehow believe that green bonds have additional risk on top of the risk model based on credit spreads determinants. This could be a consequence of irrational perception or other factors not accounted for in the model, which predicts normal credit spreads. However, since the results were weakly significant, I did not find enough evidence to reject the hypothesis that green bonds have similar abnormal credit spreads as non-green bonds. Regarding the third hypothesis, in line with the findings for the other hypotheses, green bonds seem to generate equal returns as their counterparts,. So with this in mind, companies seeking less expensive financing do not seem to gain from issuing green labelled bonds as compared to regular debt issuing and investors are not likely to receive capital gain or loss from the mispricing from green bonds, since there does not seem to be a significant difference in pricing of the two types of securities. Propensity score matching does even provide some evidence for a lower pricing of green bonds, implying that financing with green bonds is more expensive even.

An additional finding in the research is that the abnormal credit spreads of green bonds increased after the election of Donald Trump in the United States, whilst the abnormal risk premia of non-green bonds stayed roughly constant. This could be an indication that the market believes the threatening of breaking the Paris agreement and the denying of the climate change problem by Donald Trump, increases the risk of default or loss of expected recovery rate for green bonds, as entities engaged in environmental projects might lose government support or beneficial attention by the public. This is likely to be the case for US organizations, yet global credit spreads seem to be affected as the sample originates from bonds issued in different countries. Also, investors might loose the anticipation of any tax incentive in the future. Furthermore, in contrast to the main findings, after splitting the sample in the pre-election period and post-election period, green bonds seemed to have significantly higher yield spreads and abnormal yield spread compared to investment grade bond. In the pre-election period, no significant difference was found.

So green bond valuation only differs from normal bond valuation in the Donald Trump era, which is the answer to the main research question. An implication of this findings is that investors might believe that the green label does not imply additional or less risk, unless the government does not favor investments that help tackling the climate problem. In that case the label implies higher risk or the loss of potential tax incentives. Yet this should be interpreted with caution, as only one election was analyzed, which could harm the external validity.

Organizations that want to know whether they can decrease their financing cost by issuing green bonds can benefit from this research, as this thesis implies that green bonds will not decrease nor increase financing costs. From a financial perspective, it might be unwise to issue green bonds, when officials are elected that deny climate problems. Also regulators can learn from this research, as they know that green labels themselves do not decrease the cost of debt. So additional tax incentives might help to reduce the spreads. In addition, investors could use this research for their trading strategies, as green bond do not lead to a difference in return. Hypothetically, investors that seek capital gains could take short positions in green bonds just before an anticipated election of a climate reluctant official in a country.

7.2 Limitations

The results of the thesis should be interpreted with caution, as there are still some limitations. For instance, the model used to estimate credit spreads might not be an adequate model, as there could still be factors for which I did not account. This could lead to an over-(under)estimation of the normal credit spreads and therefore an under-(over)estimation of the abnormal credit spreads, which could bias the results. Also, even when controlling for many factors, there could still be endogeneity, due to samples selection or omitted variable bias, as bonds in the green bond sample might still have different characteristics as bonds in the control group. For instance, I was not able to control for currency effects due to the wide variety of curries in the sample.

Furthermore, country fixed effects and quarterly fixed effects might not capture the macro-economic determinants adequately. The Country fixed effects method assumes that the unobserved factor in the country does vary cross-sectionally, but not over time, while quarterly fixed effects assume the opposite. For further research it might be beneficial to control for the historical GDP rate in the country or the spot rate.

In the research I control for firm or organization specific risk factors by means of the credit ratings, yet it is not known how the rating agencies exactly estimate the ratings. It is still possible that they leave out certain financial factors that determine credit spreads. However, it would be impossible to control for financial information directly, as also bonds of supranational and governmental organizations are included in the analysis. Possibly credit rating agencies already take a green bond label in account, capturing a part of the effect via the ratings, which could enhance underestimation of the effect of the green bond label. Furthermore, the credit ratings which were downloaded from Datastream were the current credit ratings as of 14th of July 2017. So they do not vary over time. This could be a limitation as well, as credit ratings could be downgraded or upgraded. Yet this does not happen frequently or with large magnitudes.

By calculating the tax equivalent yield, many assumptions were used. For instance, I assumed that the investors come from the same country as the borrower, as the investor country cannot be found in the dataset. Furthermore, I am not completely aware in which countries there is an tax incentive. To the best of my knowledge, this is only the case for the Netherlands and some parts the United States. Also the tax rate is often depended on the capital and return for the investor and therefore impossible to determine, so I assumed a tax rate of 30 percent for the tax equivalent yield, which approximates effective tax rates in the US. This resulted in higher spreads by construction, but this was added to indicate the effect a tax exemption theoretically has on the credit spreads.

Theoretically, the spreads of tax exempt securities should be lower. Therefore, this was expected for green bonds. Yet no evidence for this was found, since the coefficient was insignificant. Thus this remains a possibility for future research, which could investigate whether the tax exemption in the green bond market benefits either firms by lower cost of debt or investors due to no difference in yield but lower tax expenses. Future research can for instance analyze Dutch green bonds compared to Dutch non-green bonds or European bonds.

Lastly, future research can focus more on the impact of political events on the credit spreads in the fixed income market or green bond market specifically. For example, instead of analyzing global spreads after election of Donald Trump, future research can analyze US spreads compared to a European control group in order to provide more evidence for a causal effect of the election. A difference in difference design could be useful for this.

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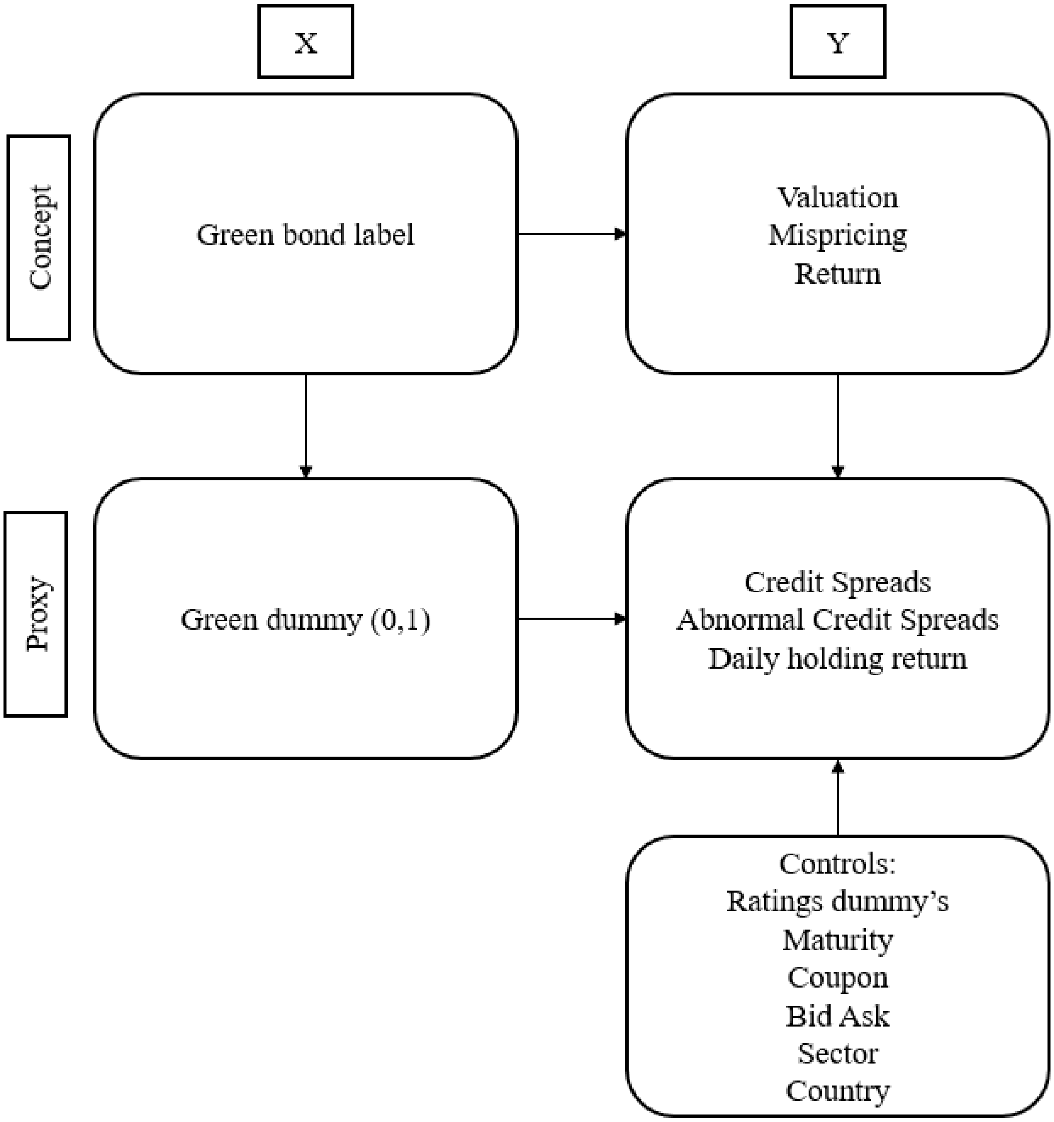
9. Appendices

Appendix 1

Predictive Validity Framework: Libby Box



Appendix 2

Variable Definitions

Variable	Database	Description
Credit Spreads	Datastream	Difference between the yield to maturity of the bond and the yield to maturity of a German Government bond with the closest maturity. Yield is the Yield to redemption of Datastream: RY
Green bond	Composition ETF and Baeclays MSCI Green Bond Index	Dummy variable for whether the bond is a green bond. Value 1 if green and value 0 if non-green
Rating dummy's	Datastream	Average rating computed for the Moody's, Fitch and S&P ratings in a scale from 1 to 10. These ratings are converted into 10 dummy variables. The dummy variable receive value of 1 if the average rating is in the following range: (avgRating-0.5, avgRating+0.5)
Life	Datastream	Time in years to maturity: Example: 548 days =1.5 year
Coupon	Datastream	Coupon Rate
Bid Ask	Datastream	(Ask price -Bid price) / Ask price Datastream code (cmap -cmbp)/ cmap
Sector dummy's	Datastream	Following sectors of issuers: FIN= Financial corporate GOVT= Governmental organisation IND= Industrial corporate PAUT= Public Authorities Estates SUPR= Supranational orgatinsation
Country fe	Datastream	Country codes from Datastream
Tax incentive	Google search	Dummy with value 1 if issuer is in a country in which there are tax incentives for green bonds.In this case value 1 if issuer country = Netherlands or United States
Abnormal Credit Spreads		Residual of model which predicts normal credit spreads based on credit spread determinants
Return	Datastream	Percentage change of data stream RI This is the return on investment, including interest payments, as well as appreciation or depreciation in the price of the bond. The formula used to calculate total return is as follows: Where: $RI_{it} = RI_{t-1} * \frac{P_t + E_t + NC_t + CP_t}{P_{t-1} + A_{t-1} + NC_{t-1}}$ RI = Total Return P = Clean Price A = Accrued Interest NC = Next Coupon. Adjustment made when a bond goes ex-dividend. CP = Value of any coupon received on t or since t – 1. t = Time
Market Return	Bloomberg	Change of total return index of the Barclays Bloomberg Total Aggregate Bond Index
Trump_election		Dummy for time period: (07-11-2016, 22-01-2017)
Post_election		Dummy for time period: (23-01-2017, 14-07-2017)

Appendix 3

Green bonds		
ISIN code	**Issuer Name**	**Country**
AU3CB0220424	INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT	US
AU3CB0242147	WESTPAC BANKING CORPORATION	AU
CA05572ZAA71	BROOKFIELD RENEWABLE ENERGY PARTNERS ULC	CA
CA05573YAD37	BROOKFIELD RENEWABLE POWER INCO	CA
CA68323ACW23	ONTARIO PROVINCE OF	CA
CA68323ADL58	ONTARIO PROVINCE OF	CA
DE000BHY0GU5	BERLIN HYP AG	DE
FR0011637586	ELECTRICITE DE FRANCE SA	FR
FR0011858323	ILE-DE-FRANCE REGION DE	FR
FR0011911247	ENGIE SA	FR
FR0013213295	ELECTRICITE DE FRANCE SA	FR
FR0013234333	FRANCE REPUBLIC OF (GOVERNMENT)	FR
LU0953782009	EUROPEAN INVESTMENT BANK	LU
US00828EBJ73	AFRICAN DEVELOPMENT BANK	CI
US037833BU32	APPLE INCORPORATED	US
US045167DQ35	ASIAN DEVELOPMENT BANK	PH
US06051GGB95	BANK OF AMERICA CORPORATION	US
US268317AS33	ELECTRICITE DE FRANCE SA	FR
US298785HD17	EUROPEAN INVESTMENT BANK	LU
US302154BG39	-	-
US31572UAF30	FIBRIA OVERSEAS FINANCE LIMITED	KY
US44987CAJ71	ING BANK NV	NL
US45950VHX73	INTERNATIONAL FINANCE CORPORATION	US
US500769GU24	KFW	DE
US59284MAA27	MEXICO CITY AIRPORT TRUST	MX
US595620AQ82	MIDAMERICAN ENERGY COMPANY	US
US65562QAW50	NORDIC INVESTMENT BANK	FI
US83416WAA18	SOLAR STAR FUNDING LLC	US
US843646AS92	SOUTHERN POWER COMPANY	US
US89054XAB10	TOPAZ SOLAR FARMS LLC	US
US929043AH00	-	-
XS0773059042	EUROPEAN INVESTMENT BANK	LU
XS0993154748	NEDERLANDSE FINANCIERINGS MAATSCHAPPIJ VOOR ONTW NV	NL
XS1038708522	UNIBAIL RODAMCO SE	FR
XS1051861851	EUROPEAN INVESTMENT BANK	LU
XS1084043451	HERA SPA	IT
XS1087815483	KFW	DE
XS1111084718	AGENCE FRANCAISE DE DEVELOPPEMENT EPIC	FR
XS1218319702	UNIBAIL RODAMCO SE	FR
XS1222727536	NORDIC INVESTMENT BANK	FI
XS1222743061	TRANSPORT FOR LONDON	GB
XS1241581179	TENNET HOLDING BV	NL
XS1280834992	EUROPEAN INVESTMENT BANK	LU
XS1324923520	SOCIETE GENERALE SA	FR
XS1347786797	NORDIC INVESTMENT BANK	FI
XS1351716896	KFW	DE
XS1434560642	SOUTHERN POWER COMPANY	US
XS1437622977	BANK OF CHINA LTD (LUXEMBOURG BRANCH)	LU
XS1437623355	BANK OF CHINA LTD (LUXEMBOURG BRANCH)	LU
XS1509084775	MTR CI CORP LTD	HK
XS1514051694	SNCF RESEAU	FR
XS1527758145	IBERDROLA FINANZAS SA	ES
XS1550149204	ENEL FINANCE INTERNATIONAL	NL

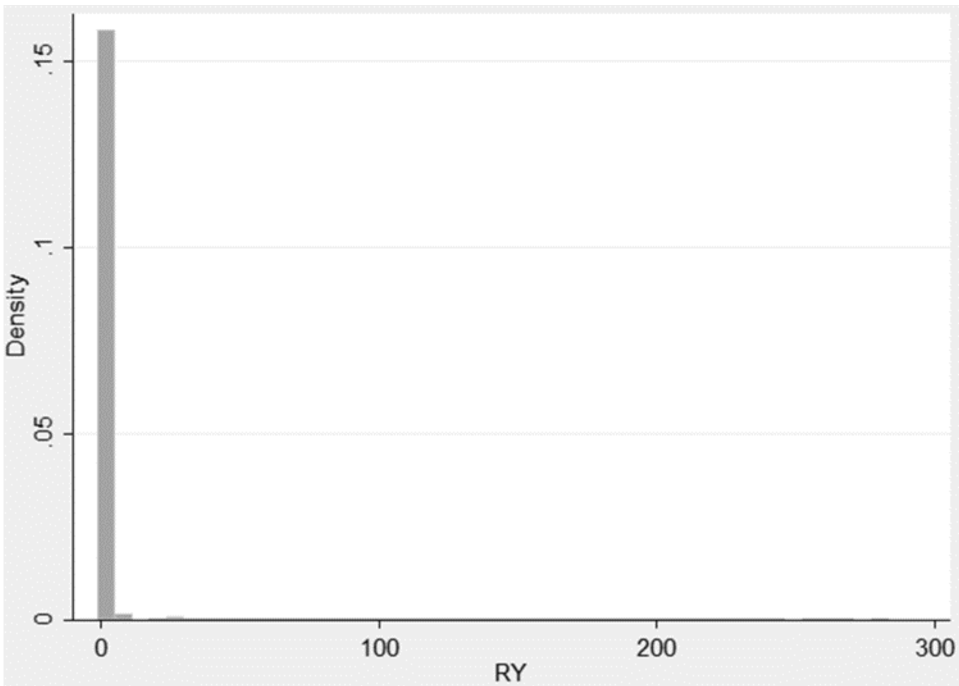
Non-green bonds		
ISIN codes	**Issuer name**	**Country**
AU000KFWHAB1	KFW	DE
AU000KFWHAE5	KFW	DE
AU3CB0227460	ONTARIO PROVINCE OF	CA
AU3CB0229680	ASCIANO FINANCE LTD	AU
AU3CB0231702	INTERNATIONAL FINANCE CORPORATION	US
AU3SG0000284	NEW SOUTH WALES TREASURY CORP	AU
AU3SG0001696	NEW SOUTH WALES TREASURY CORP	AU
BBG0083YCM57	-	-
BBG00GQFPM97	-	-
CA02135ZAS52	ALTALINK LP	CA
CA064151EF61	-	-
CA135087YR94	CANADA (GOVERNMENT)	CA
CA44889ZEQ50	HYDRO-QUEBEC	CA
CA683234MB14	ONTARIO PROVINCE OF	CA
CA74814ZEX74	QUEBEC PROVINCE OF	CA
DE000A0Z1UM6	BAYERISCHE LANDESBANK	DE
DE000A2AARY8	-	-
DE000BHY1372	BERLIN HYP AG	DE
DE000NRW0JV3	NORDRHEIN-WESTFALEN LAND OF	DE
ES00000126C0	SPAIN (KINGDOM OF)	ES
EU000A1G0DK9	EUROPEAN FINANCIAL STABILITY FACILITY SA	LU
EU000A1G1Q17	EUROPEAN UNION	BE
EU000A1Z99B9	EUROPEAN STABILITY MECHANISM	LU
FR0010680041	ENGIE SA	FR
FR0011192392	CAISSE AMORTISSEMENT DE LA DETTE SOCIALE	FR
FR0013244415	BPIFRANCE FINANCEMENT SA	FR
NZLGFDT006C6	NEW ZEALAND LOCAL GOVERNMENT FUNDING AGENCY LTD	NZ
US037833AK68	APPLE INCORPORATED	US
US449786BD37	ING BANK NV	NL
US575718AD3	-	-
US595620AB1	-	-
US929043AG27	VORNADO REALTY LP	US
USF2893TAJ54	ELECTRICITE DE FRANCE SA	FR
XS0206361221	NETWORK RAIL INFRASTRUCTURE FINANCE PLC	GB
XS0416848520	STATOIL ASA	NO
XS0419834931	WALMART INCO	US
XS0513509959	TENNET HOLDING BV	NL
XS0550466469	CREDIT AGRICOLE SA	FR
XS0829360923	GAS NATURAL CAPITAL MARKETS SA	ES
XS0838834561	-	-
XS0903345220	EUROPEAN INVESTMENT BANK	LU
XS0916242497	NORDEA BANK AB	SE
XS0935947977	HERA SPA	IT
XS0942388462	UNIBAIL RODAMCO SE	FR
XS1128148845	CITIGROUP INCO	US
XS1271698612	EUROPEAN INVESTMENT BANK	LU
XS1372838240	VODAFONE GROUP PUBLIC LIMITED COMPANY	GB
XS1493724584	DEUTSCHE BAHN FINANCE GMBH	DE
XS1526233488	-	-
XS1612543121	GENERAL ELECTRIC COMPANY	US
XS1615680151	SNCF RESEAU	FR
XS1619010249	MANITOBA PROVINCE OF	CA
XS1622394143	NEDERLANDSE FINANCIERINGS MAATSCHAPPIJ VOOR ONTW NV	NL
XS1622417290	OESTERREICHISCHE KONTROLLBANK AG	AT
XS1626191792	NEDERLANDSE WATERSCHAPSBANK NV	NL

German Government Bonds

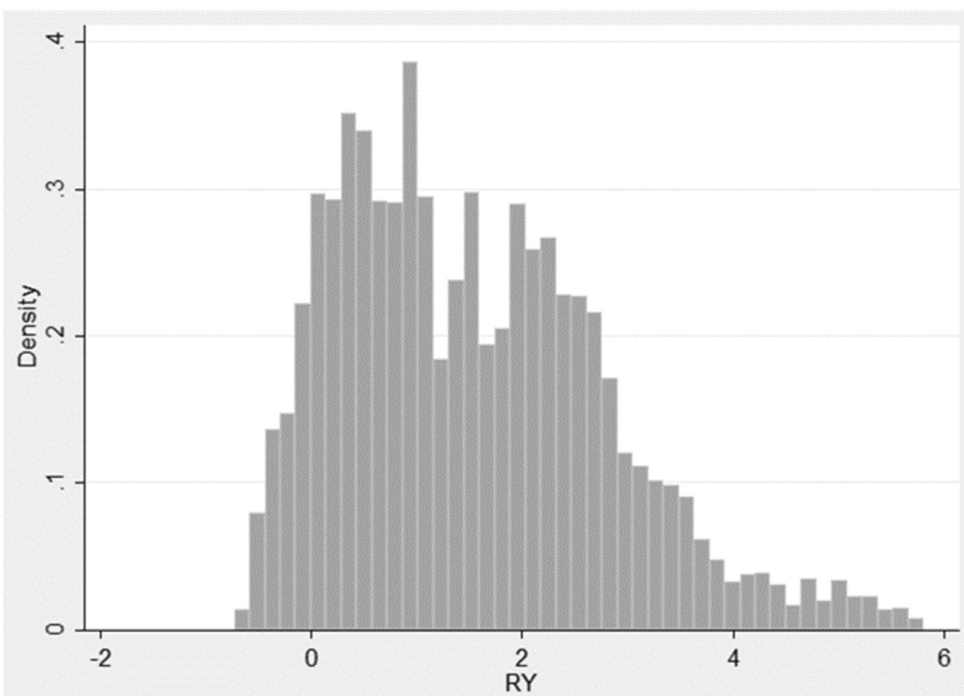
ISIN Code	Maturity Date	Years
DE0001135358	Maturity 4-7-2018	1YR
DE0001135382	Maturity 4-7-2019	2YR
DE0001135408	Maturity 4-7-2020	3YR
DE0001135473	Maturity 4-7-2022	5YR
DE0001135044	Maturity 4-7-2027	10YR
DE0001135176	Maturity 04-01-2031	15YR
DE0001135275	Maturity 04-01-2037	20YR
DE0001102341	Maturity 15-08-2046	30YR

Apendix 4

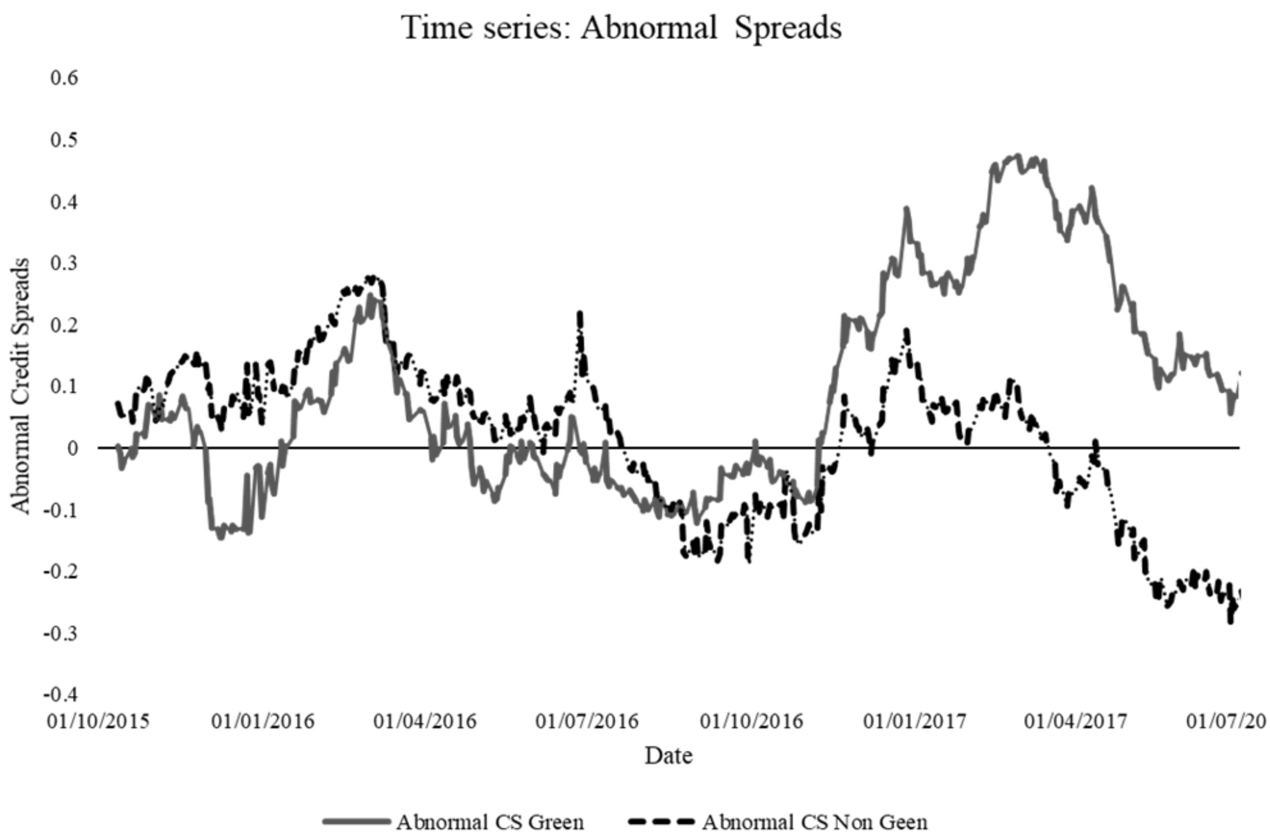
Histogram of yield to maturity before dropping outlier bonds



Histogram of yield to maturity after dropping outlier bonds



Appendix 5


Time series: Abnormal Spreads
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Abnormal Credit Spreads
01/10/2015
01/01/2016
01/04/2016
01/07/2016
01/10/2016
01/01/2017
01/04/2017
01/07/20
Date
Abnormal CS Green
Abnormal CS Non Geen

Appendix 6

Appendix table 1: Credit Spreads

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The total set of panel a) consists of daily observations for a time period of two years (14-7-2015, 6-11-2016), resulting in 20,635 observations for the regressions. In panel a) an b) the results of multivariate regressions are shown with Credit Spreads as dependent variable, which are not adjusted for tax equivalent yield for green bonds issued in countries with a tax incentive for these bonds. In panel b) the results of multivariate regressions are shown for the period after Donald Trump election (7-11-2016, 14-7-2017), resulting in 15,214 observations. 10 rating dummies are included as control variables, which depend on the average of the Moody's, Fitch and S&P credit ratings. Furthermore Life is the time to maturity, coupon is the coupon rate of the bond specified in the contract and BidAsk is the percentage difference between ask and bid price. Sector dummies indicate whether a bond is issued by a financial services firm, supranational organization, government or an industrial company. Also country and quarterly fixed effects are included to control for macro-economic environment T-statistics are computed adjusted for clustered standard errors at the ISIN level.

Panel A: Spread (no tax equivalent yield)_ Pre-election period						
Variable	(1)	(2)	(3)	(4)	(5)	(6)
C	1.76	2.98	2.47	0.71	1.38	0.64
	(8.82)	(7.50)	(3.17)	(2.33)	(3.94)	(1.98)
Greenbond	-0.18	-0.07	0.25	0.09	0.02	0.08
	(-0.67)	(-0.30)	(1.19)	(0.48)	(0.10)	(0.46)
Rating dummy's	No	Yes	Yes	Yes	Yes	Yes
Life			-0.01	-0.01	-0.02	-0.01
			(-0.29)	(-0.38)	(-0.74)	(-0.26)
Coupon			0.33	0.28	0.26	0.27
			(4.79)***	(4.20)***	(4.27)***	(4.19)***
BidAsk			-0.72	-0.59	-0.52	-0.60
			(-3.37)***	(-3.05)***	(-2.99)***	(-2.95)***
Sector dummy's					Yes	No
Country fixed effects	No	No	No	Yes	Yes	Yes
Quarterly fixed effects	No	No	No	No	No	Yes
Adjusted R-sq	0.04	0.38	0.53	0.71	0.74	0.71
Obs.	21,912	21,912	20,653	20,653	20,653	20,653

Panel B: Spread (no tax equivalent yield)_ Post-election period						
Variable	(1)	(2)	(3)	(4)	(5)	(6)
C	1.62	2.02	2.04	1.00	0.91	1.12
	(8.90)	(2.11)	(6.10)	(3.70)	(2.34)	(4.08)
Greenbond	0.28	0.31	0.54	0.32	0.31	0.31
	(1.18)	(1.48)	(3.05)***	(1.94)*	(1.84)*	(1.90)*
Rating dummy's	No	Yes	Yes	Yes	Yes	Yes
Life			-0.02	-0.01	-0.01	-0.01
			(-1.21)	(-0.73)	(-0.29)	(-0.66)
Coupon			0.38	0.29	0.29	0.29
			(6,44)***	(4.74)***	(4.77)***	(4.69)***
BidAsk			-1.13	-0.92	-1.02	-1.01
			(-4.40)***	(-4.15)***	(-4.42)***	(-4.39)***
Sector dummy's					Yes	No
Country fixed effects	No	No	No	Yes	Yes	Yes
Quarterly fixed effects	No	No	No	No	No	Yes
Adjusted R-sq	0.02	0.31	0.57	0.73	0.73	0.74
Obs.	16,051	16,051	15,214	15,214	15,214	15,214

Appendix Table 2: Pricing error

Prediction model (on non-green sample) =

$$NSpread_{it} = \beta_0 + \sum_{r=1}^{11} \gamma_r * Rating\ dummy's_{ir} + \beta_1 Life_{it} + \beta_2 Coupon_{it} + \beta_3 BidAsk_{it} + \beta_4 \Delta Spread_{it} + Country\ fe + \varepsilon_{it}$$

The values are retrieved from a sample of 53 green bonds and a sample of a non-green control group, consisting of 57 bonds. Two non-green bonds were eliminated from the sample, as their yield values were considered as outliers. The set of panel a) consists of daily observations for a time period of the pre-election period of Donald Trump, (14-7-2015, 6-11-2016), resulting in 24,912 observations for the regressions. Panel b) shows the results for the post-election period (7-11-2016, 14-7-2017) Mispricing is de dependent variable, which is the difference between actual credit spreads and normal credit spreads based on the model above. The control variables are similar to the other tables in the thesis. T-statistics are computed adjusted for clustered standard errors at the ISIN level.

Panel A: Abnormal Credit Spreads: pre-election period					
Variable	(1)	(2)	(3)	(4)	(5)
C	0.04	1.25	0.97	-0.99	0.10
	(0.19)	(5.81)	(-3.14)	(-2.39)	(0.14)
Greenbond	-0.05	0.08	0.22	0.29	0.06
	(-0.18)	(0.38)	(0.94)	(1.16)	(0.25)
Tax incentive				0.60	-0.32
				(1.71)*	(-0.48)
Greenbond * Tax incentive				-0.35	-0.03
				(-0.85)	(-0.08)
Rating dummy's		Yes	Yes	Yes	Yes
Life			-0.01	-0.02	-0.01
			(-0.16)	(-0.55)	(-0.18)
Coupon			0.12	0.12	0.06
			(1.63)	(1.66)	(0.87)
BidAsk			-0.18	-0.15	-0.02
			(-0.82)	(-0.59)	(-0.10)
Country fixed effects	No	No	No	No	Yes
Adjusted R-sq	0.01	0.58	0.59	0.62	0.76
Obs.	12,765	12,765	12,765	12,765	12,765

Panel B: Abnormal Credit Spreads: post-election period					
Variable	(1)	(2)	(3)	(4)	(5)
C	-0.05	0.93	0.90	-0.84	0.15
	(-0.30)	(2.60)	(2.60)	(-2.96)	(0.29)
Greenbond	0.30	0.38	0.49	0.55	0.29
	(1.25)	(2.01)**	(2.62)**	(2.50)**	(1.31)
Tax incentive				0.60	-0.19
				(1.75)*	(-0.38)
Greenbond * Tax incentive				-0.29	-0.04
				(-0.73)	(-0.10
Rating dummy's		Yes	Yes	Yes	Yes
Life			-0.02	-0.02	-0.01
			(-1.14)	(-1.09)	(-0.67)
Coupon			0.17	0.16	0.10
			(2.82)***	(2.70)***	(1.61)
BidAsk			-0.64	-0.61	-0.41
			(-2.45)**	(-2.96)***	(-1.77)*
Country fixed effects	No	No	No	No	Yes
Adjusted R-sq	0.01	0.47	0.53	0.56	0.70
Obs.	11,157	11,157	11,157	11,157	11,157

Appendix 7

Appendix table 3: Propensity Score Matching

In panel a) of this table the results are shown of a logistic regression with the green bond dummy variable as the dependent variable and the most explanatory credit spread determinants as covariates. Z-statistics in this case are presented in parentheses. In panel b) Propensity Score Matching results are presented. The average treatment effect on the treated (ATT) is shown, which is the average difference between spread observations, which received the green bond treatment and their comparable observations receiving no treatment. The average treatment effect (ATE) is the difference between the mean of the spread in the green bond group and the mean of the spread in the control group. T-statistics are provided in parenthesis. Stata does not provide t-statistics for the ATE in the psmatch 2 algorithm.

Panel (a): Logistic regression, dependent variable: green bond		Panel (b): Propensity Score Matching results	
C	2.10	Average Treatment Effect on the Treated (ATT)	0.40
	(36.70)		(2.03)**
Rating dummy's	Yes	Average Treatnent Effect (ATE)	0.24
			-
Life	-0.02		
	(-4.14)		
Coupon	-0.63		
	(-50.95)		
BidAsk	-0.60		
	(-10.09)		
Country dummy's	Yes		
Pseudo R-sq	0.20	Obs. Untreated	14,442
Obs.	31,091	Obs. Treated	16,649