SSE Riga Student Research Papers
2017 : 7 (194)

GREEN BONDS – A CHEAPER WAY OF DEBT FINANCING?

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ISSN 1691-4643
ISBN 978-9984-822-34-1

November 2017
Riga

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Acknowledgements

We would like to express our sincere gratitude to our supervisor, Mr. Andris Kotans, for his patience and thoughtful guidance throughout the thesis writing process. We are thankful for the support, detailed and timely feedback, encouragement to continuously improve our work and, most importantly, for the valuable advice and experience we have gained during our cooperation.

We would like to thank the CBL Asset Management team and our friend, Maxim Naruta, for the assistance in gathering the necessary dataset for the quantitative part of this research paper.

Also, we are entirely grateful to Rotary Club Stockholm-Ladugårdslandet and, in particular, to Margareta Redlund Laninge and Britt Marie Bertilsson for the very warm welcome in Stockholm and the amazing program prepared for our visit. In fact, the qualitative part of the research would not be possible without their support.

We thank all of participants of the interviews for their professional insights and expertise that resulted in an essential enhancement of the quality of our thesis.

Finally, we are grateful to the student body of the Stockholm School of Economics in Riga and, especially, the opposition team for the useful comments we received during the presentation of the review of empirical findings, which influenced our final work.

Abstract

This paper compares green bonds and regular bonds by using means of quantitative and qualitative methods operating with the latest data available for the year 2016. First, we design a structural model to determine whether labelling a bond as green has any effect on the yield spread. We discover that "green" factor accounts for a spread reduction of 36 basis points in comparison with regular securities while controlling for common yield spread determinants. Subsequently, we apply the structural model to green and non-green securities separately and find that investors are more sensitive towards changes in risk of default for green bonds than for regular securities. Ultimately, we address the fact that there is lack of academic literature on the determinants of green bond pricing by performing a qualitative study. We conducted semi-structured interviews with green bond issuers, underwriters, and investors to identify green bond trends and peculiarities. We found that although currently investors do pay a premium for green bonds, it is much smaller than suggested by our quantitative study, being in the range of 2 to 5 basis points. This phenomenon is mainly driven by the excess demand present on the market. Finally, we observe that green bonds are less volatile on the secondary market in comparison with their regular counterparties.

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1 Introduction

The environmental disasters the world had seen in the 1980s, in particular the Chernobyl nuclear power plant explosion in 1986 and Exxon tanker oil spill near Alaska in 1989, drew the worldwide attention to the ecological consequences of the accelerated industrial expansion. Individual investors and investment funds around the globe started paying attention to the interaction of companies and the environment, which contributed to the development of socially responsible investment (SRI): an investment practice that includes environmental, social and ethical criteria of an asset into investment decision-making process. The market for SRI underwent a rapid expansion from the end of the previous century with American institutional funds being in the forefront of the industry development, followed by European, Canadian and Australian funds. An important contribution to the development of SRI in Europe was made by national governments that created supportive legal environment by putting forward regulatory initiatives concerning information disclosure or adopting policies that grant a tax advantage to companies involved in specific eco-friendly projects. Another driver of the market growth is the so-called theory of ethical consumerism, in accordance with which consumers are putting higher value on and overpaying for the products and services that are in line with their personal values (Renneboog, Ter Horst & Zhang, 2008).

Despite the pronounced trend of including corporate social responsibility into criteria for estimating an equity investment, the debt market was slow to adjust to the increasing demand of investors for ethical investment instruments. Until 2007 the vast majority of green infrastructure projects aimed at transition of economies to alternative energy sources was financed by national governments that, in turn, had access to global debt markets via bonds issues. However, since the beginning of the 21st century the need to attract private capital to prevent the otherwise imminent climate change became indisputable and prompted companies to issue “climate” bonds. In addition to that, two other prerequisites of green bond market emergence were huge amount of excess capital in possession of pension funds and insurance companies as well as the genuine potential of green infrastructure projects to generate competitive return on investment. The first green bond with the principal value of 1 billion dollars was issued by the European Investment Bank in 2007, however, the market grew significantly and started a rapid worldwide expansion only in 2013, currently being worth more than 80 billion dollars as estimated by the Climate Bonds Initiative (2017). The crucial feature of a green bond that differentiates it from a conventional bond is the predetermined use of proceeds for projects serving low carbon transition purposes. Moreover, green bonds are linked to specific assets instead of companies

and more transparent compared to regular bonds due to mandatory reporting on the use of proceeds.

A large number of academic research papers are dedicated to examination of SRI equity fund performance in support of the hypothesis that investors are willing to overpay for ethical stocks. However, despite multiple attempts undertaken to distinguish between cumulative returns of SRI and conventional funds, there is no consistent evidence that could verify the preferred habitat theory with regards to SRI stocks. Green bonds as a form of SRI on the debt market initially have a higher research potential than SRI equities due to two factors: green bonds are substantially more homogenous than SRI stocks as a result of their attachment to green assets instead of green businesses and they are more likely to be conforming with the green investment standards through obligatory regular reporting. A recent study of Bakshi & Preclaw (2015) has identified a statistically significant spread differential between conventional and green bonds of comparable nature, namely, the yield of green bonds was found be approximately 17 basis points lower, effectively making green bonds a cheaper way of debt financing. At the same time, a study by Bloomberg (2015) which was based on pairwise comparison of green and regular bonds issues by the same companies reported no significant spread differential. Having analyzed the relevant theoretical background, we put forward the following research questions**:**

RQ 1: Do green bonds yield less than comparable regular bonds?

RQ 2: What are the aspects of green bonds that could justify the existence of the premium?

We aim at advancing the previous research on green bonds by verifying the existence of a green bond premium using the most up-to-date data sample (year 2016) and enhancing the methodology of Bakshi & Preclaw (2015) by including more independent variables. Furthermore, we go a step further and test whether there exists any difference between the proportion of yield spread that certain factors account for. In addition, we perform a qualitative study by addressing industry experts to back and explain our quantitative findings as well as to fill in the literature gap in the green bond area. To the best of our knowledge there is no academic work up to date that tries to deal with these questions, thus, indicating novelty of this paper.

We start the paper with a succinct overview of existing literature on socially responsible investing and corporate bonds. We then proceed with outlining the methodology for testing the research questions. Thereafter, the results of the quantitative findings along with a corresponding discussion are presented. Next, we provide and discuss the results of the qualitative findings. Subsequently, the limitations of the paper are acknowledged. Finally, we present our conclusions and implications for further research.

2 Literature review

We start the literature review with a brief description of the concept of socially responsible investment (SRI) and the overview of the empirical evidence obtained by researchers on the implications of incorporating sustainability considerations into a company's business model for the performance of stocks of respective companies. We believe that the market for SRI serves as an important prerequisite of the emergence of the green bond market and the academic literature on the SRI stocks provides relevant background for studying such a novel financial instrument as a green bond. Thereafter, we introduce the reader to the determinants of bond yield spread to form a methodology for identifying the impact of the "green" factor on bonds pricing by investors.

2.1 Socially responsible investment

Socially responsible investment (SRI) is a broad definition of an investment practice that includes environmental, social and ethical criteria of an asset into investment decision-making process. The market for SRI underwent a rapid expansion from the end of the previous century first of all due to environmental disasters with serious ecological consequences forcing national governments to take actions on the legislative level. As a result, governments created supportive legal environment, for example, by requiring mandatory disclosure of social, environmental and ethical characteristics by companies or granting a tax advantage to firms involved in green activities.

The focus of companies on corporate social responsibility matters (CSR) inevitably leads to the question on whether shareholder value maximization should stay the priority of management or it must be replaced by stakeholder value as a key performance metric. Jensen (2001) uses agency costs as the main argument against stakeholder value maximization principle, implying that vague performance indicators impair internal controls of a company. Tirole (2001) adds up on this argument by demonstrating that stakeholder value maximization principle is usually accompanied by flat managerial compensation schemes, which, consequently, has an adverse impact on managerial incentives. Moreover, Shleifer (2004) claims that CSR is not achievable in competitive markets due to higher costs of doing business and suggests that under such conditions competitive market forces may lead to unethical corporate practices.

In contract to the initial sceptical views on the effects of CSR on companies' value, the further research in the area justified the adoption of CSR policies in the competitive markets. Heal (2005) argues that CSR helps to maximize the shareholder value by reducing the costs of conflict between the company and society. Besley & Ghatak (2006) state that CSR leads to a

Pareto improvement for the whole economy based on the idea that only CSR-conscious consumers purchase ethical brands with no adverse welfare effect on the rest of population. Allen at al. (2007) show that stakeholder-oriented economies correspond to less intense competition in product markets, hence, firms charge higher prices and produce lower output, which has a positive effect on firms' value. Information asymmetry in the financial and labor markets is used as another reason to implement CSR strategies: Fisman at al. (2006) prove that CRS acts as a trustworthy signal of product quality, while Brekke & Nyborg (2005) claim that CSR helps to attract motivated employees.

All in all, the implementation of CSR strategies often involves a trade-off between financial returns of a project and its impact on all the stakeholders. Renneboog at al. (2008) argue that companies investing in CSR have a higher potential to create value in the long term due to better reputation and lower potential litigation costs, although such stocks might be undervalued in the short run.

2.2 The performance of SRI funds: empirical evidence

A number of academic research papers are devoted to the assessment of CSR impact on the financial performance of stocks of relevant companies adopting such strategies. The most frequently used approach for these purposes is the comparison of the performance of ethical mutual funds with the performance of conventional funds or passive benchmark portfolios. Another set of papers investigate the issue by constructing investment portfolios based on SRI ratings assigned to specific stocks and evaluating their risk-adjusted returns. However, none of the applied methods produces consistent results across time and regions results. In this section we overview the most significant works on the topic.

One of the earliest attempts to distinguish between performance of SRI-funds and conventional funds belongs to Hamilton et al. (1993), who analyze the sample consisting of 32 SRI-funds and 320 comparable non-SRI funds in the US. They conclude that 17 SRI funds with longer history have a higher Jensen's alpha than comparable non-SRI funds, while SRI-funds with shorter history underperforme the comparable sample of conventional funds. However, both differences were statistically insignificant. A later study by Statman (2000) compares the performance of 31 US-based ethical funds with a reference sample of 62 non-SRI funds of similar size and expense ratios. The average monthly alpha of SRI funds is found to be higher (-0.42%) than the one of conventional funds (-0.62%), but the difference is again not statistically significant. Another study from the US market conducted by Goldreyer & Diltz (1999) discoveres that the average Jensen's alpha for ethical funds is far below the one of non-SRI funds (-0.49% and 2.78% per annum accordingly). The difference is not significant. However,

the authors prove that application of positive screens in relation to SRI stocks significantly improves the portfolio performance.

Empirical evidence on SRI fund performance from European market is inconclusive as well. Luther, Matatko, and Corner (1992) examine the performance of 15 UK-based ethical funds for the period of 7 years and arrived at a conclusion that their financial characteristics are not significantly different from benchmark assets (mean Jensen's alpha of 0.03% per month). Grey et al. (2000) compared 40 ethical funds with 40 conventional funds from 7 European countries using a matched pair approach. The authors reported no significant difference in financial performance, although they pointed out lower volatility of SRI portfolios. Auer & Schuhmacher (2015) identified a set of industries, where certain SRI screens led to significantly lower returns than the passive benchmark indices, while for the rest of industries no consistent relation was discovered.

Bauer, Koedijk and Otten (2005) expand the geographical scope of the research to Germany and the UK in addition the USA. The empirical findings suggest that the US domestic SRI funds (the average monthly alpha of -0.05%) underperform conventional funds of similar nature and the difference is statistically significant. In the UK, on the contrary, domestic ethical funds produce a positive alpha of 0.09% on a monthly basis and generate significantly higher returns than conventional funds. In Germany the difference between SRI and non-SRI fund performance is not statistically different from zero. The study of 440 SRI mutual funds from Continental Europe, the US, the UK and Asia-Pacific region performed by Renneboog et al. (2005) finds the empirical evidence in support of the hypothesis stating that investors are willing to overpay for ethical stocks and are reluctant to invest in companies that do not implement CSR policies. The authors document that SRI funds in several European and Asia-Pacific countries were found to underperform their benchmark indices by statistically significant 5% per annum.

Kempf & Osthof (2007) investigate the impact of SRI screens on the portfolio performance by following a trading strategy based on buying stocks with high SRI rating and selling stocks with low rating. Such strategy, applied for S&P 500 and DS 400 stocks, was found to generate high positive alphas (up to 8.7% on an annual basis using best-in-class approach). At the same time, the study of Brammer, Brooks, and Pavelin (2006) discovers a negative relationship between stock returns and SRI scores for a sample of the UK-listed companies. In particular, the authors identified a negative impact on returns stemming from environmental and employment indicators, while social indicator was found to have a weak positive relation.

2.3 Green bonds as a form of SRI

The increasing worldwide awareness of ecological challenges and growing importance of SRI screens in the portfolios of private and institutional investors prepared reasonable grounds for activating the global debt markets with an intention to finance green infrastructure initiatives. In 2007 the European Investment Bank issued a "Climate Awareness Bond" that effectively was the first "green" bond on the market. The World Bank issued a similar instrument a year later. However, despite the growing appetite of institutional investors for green bonds expressed in the 30-100% oversubscription rate and availability of surplus capital, the green bond market underwent a significant expansion only in 2013 reaching 11 billion dollars of securities issued globally and tripled in the capitalization by 2015, as estimated by OECD (2015). An important milestone in the market development was the Paris Agreement within the United Nations Framework Convention on Climate Change that is in effect from November 4, 2016. The agreement affirms the need to facilitate financial innovation in order to provide sufficient finance flows towards climate-resilient development and adaptation to the consequences of climate change (SEB, 2017).

By definition, a green bond is a debt instrument, the proceeds from which must be used exclusively to finance or re-finance "green" projects, assets or business activities (OECD, 2015). A crucial feature of green bonds is the fact that they are competitive on the returns basis with a bonus in form of positive environmental impact, which differentiates them profoundly from most of SRI equities involving a trade-off between profitability of companies and their interaction with all the stakeholders. The experts from the IEA have estimated the potential reduction in fossil fuel imports to be worth 100 trillion dollars on the global scale from 36 trillion dollar investment in energy efficient buildings and infrastructure needed to contain the climate change, which makes green bonds a profitable investment opportunity with the average payback period of 3 to 5 years (Kidney, 2015).

In 2014 a group of leading investment banks introduced a set of practical guidelines for the corporate issuers, known as Green Bond Principles. The first most important characteristic implies that green bonds are connected with green assets instead of green businesses, allowing a wider range of organizations to access the green capital market. The second distinctive feature is the higher transparency in comparison with regular bonds with regards to actual use of the attracted capital, which is regularly done with the help of independent organizations in order to avoid a conflict of interest. However, there still exists a relatively high degree of flexibility when determining the constituents of a "green" investment purpose, as GBPs do not provide a detailed description, although they name certain investment areas suitable for such projects, including renewable energy, energy efficiency, sustainable waste management, sustainable land use,

biodiversity conservation, clean transportation and sustainable water management (The World Bank, 2015).

In addition to the set of distinctive financial characteristics of green bonds, they used to be associated with a range of non-financial aspects that have an impact on the decision of an entity to issue a labelled green bond. The process of issuance of a green bond is perceived to be more complicated and time consuming than the one of a regular bond, as a company has to define the project characteristics and undergo a third party assessment of project compliance with the green bond principles. However, as stated by SEB bank specialists, for an experienced underwriter these costs are limited to a couple of additional work hours. The expected benefits, on the contrary, are diverse: strengthened relations with investors, diversification of investor base, increased goodwill as the green initiatives are communicated to all the stakeholders and better risk management stemming from cooperation between financial and environmental experts (SEB, 2016).

To summarize, the advantages of green bonds for investors include the possibility to balance risk-adjusted returns and attain environmental benefits, satisfy SRI requirements and enhance risk assessment through the use of independent proceeds reports, while relatively small market size and lack of unified labelling requirements may be viewed as potential threats. As for the companies, the main reasons to issue a labelled green bond are strong investor demand and potential oversubscription, diversification of an entity's investor base, possible lower volatility in secondary market due to more "buy and hold" investors and reputational gains. The disadvantages for the issuers include high costs of labelling, consequent reporting expenses and reputational risks in case the green usage of proceeds is questioned (OECD, 2015).

2.4 Risk components of bond yield spread

A green bond is the same fixed income instrument as a regular bond with only difference being the purpose towards which the funds raised can be attributed to. Thus, it is exposed to the same risks as any other corporate bond. The vast amount of literature is devoted to the analysis and description of the factors that form the positive spread between a bond and a risk-free asset. Bierman & Hass (1975) introduced the three main risks investors are compensated for when holding a bond: 1) Risk of default – danger of bond issuer not being able to deliver promised cash flows; 2) Risk of interest rate changes – potential gain or loss by selling a bond before the maturity date; 3) Liquidity risk – limited possibilities of trading activity.

Along with the technological progress and improvements in data availability researchers have found new factors influencing the yield spread – call and conversion options for bonds and asymmetric tax treatments of bond and its components (Huang & Huang, 2003). In this section

of the literature review we acquaint the reader with the empirical evidence concerning pricing of bonds and the factors determining it.

2.4.1 Risk of default

One of the risks embedded in every single financial instrument is the risk of default – probability that a borrower would not deliver the promised payments to a lender. In the context of bonds, Eom, Helwege, and Huang. (2004) in their paper state that "default occurs when the firm's asset value declines to a prespecified level." It is also common that when a firm defaults on its obligation lenders get partially repaid, thus, limiting their losses. This, in turn, is called expected default loss. As it is customary for every risk an investor is willing to take he or she demands an appropriate return. While most of the researchers acknowledge the presence of default risk component in the yield spread, there are conflicting views on the size of the spread attributable in particular to this factor.

One of the first notable papers on this issue that serves as a starting point for developing structural models even at present times has been written by Merton (1974), where he develops a model for pricing corporate debt including bonds. However, nowadays there are papers that show the impreciseness of the model when it comes to empirical evidence. Jones, Mason, and Rosenfeld (1984) prove that the credit yield spreads anticipated by the model of Merton underestimate the true observed spreads. Nevertheless, the addition of complimentary factors, namely, strategic default, debt issuance patterns, stochastic interest rate and bankruptcy costs, can improve the model and generate spreads comparable with the observed ones (see Anderson & Sundarsen (1996), Collin-Dufrense & Goldstein (2001), Longstaff & Schwartz (1995)).

The absence of the consensus on the best model leads to divergent results of the research papers on the topic. Huang & Huang (2003) in their work develop a calibration approach built on the historical default data. They find that the risk of default can be attributable to only a tiny portion of corporate bond spread for investment grade bonds (credit rating of at least Baa) for all maturities. They also state that the fraction of a spread attributable to credit risk tends to be smaller for shorter term maturities (less than a year to maturity) and larger for junk bonds. This can be explained by the fact that an event of default is very rarely observed within a short time frame. As of precise fraction of a spread due to credit risk Huang & Huang (2003) document that typically it is around 20% for investment grade bonds. The exception being a 10-year Baa rated bond, for which they document credit risk accounting for 30% of the spread. These findings are consistent with Elton, Gruber, and Blake (2001) who document that risk of default accounts for no more than 25% of yield spread as well as with Jones et al. (1984) and Delianedis & Geske (2001).

However, contrary to these findings Longstaff, Mithal, and Neis (2005) conclude that default risk accounts for the majority of the yield spread independent of credit rating. In particular, they report 51% of spread due to default risk for AAA/AA-rated bonds, 56% for A-rated bonds, 71% and 83% for BBB- and BB-rated bonds, respectively. They argue that these results could also be achieved by structural models similar to the ones used in Huang & Huang (2003) and Delianedis & Geske (2001) under condition of larger jump sizes or credit risk premia than in typical calibrations. Nevertheless, the literature clearly agrees on the fact that default risk is not the only component of the yield spread.

2.4.2 Liquidity risk

Many researchers have long argued that liquidity is one of the determining factors in asset pricing. One of the early works on this topic was written by Fisher (1959), which shows the first glimpses on the existence of liquidity factor in bond spread. Building on Fisher's and Amihud & Mendelson's (1986) work Lo, Mamaysky and Wang (2004) argue that liquidity costs hinder trading frequency as investors demand to be compensated for the inability to continuously hedge their risk. As a result, the spread of an illiquid bond will be higher than the one of a liquid bond having similar other characteristics.

To establish the key components of liquidity risk Kamara (1994) summarizes the works of Garbade & Silber (1979), Lippman and McCall (1986), and Kamara (1988) and advocates that the risk depends on two factors, namely, "equilibrium price volatility and the expected length of time required to complete a transaction at a "reasonable" price". Due to the fact that bonds are generally harder to trade than stocks, liquidity premium is likely to explain a part of the yield spread. For example, Kamara (1994) compares two assets (Treasury notes and bills) with the same maturities, which allows to isolate liquidity risk from other risks, and finds that there exists differential liquidity risk. De Jong & Driessen (2005) and Wang, Wu and He (2009) verify the existence of liquidity risk and find that a bond spread contains a significant amount of liquidity premium for both corporate and treasury markets. Moreover, Li et al. (2009) while controlling for bond characteristics and other external factors find that liquidity and information risks positively relate to expected Treasury returns. Chen, Lesmond, and Wei (2007) analyze 4,000 corporate bonds of different credit rating (both investment grade and speculative) using three different liquidity measures and find that liquidity can explain 7% and 22% for investment and speculative grade cross-sectional variation in yields, respectively. In addition, when bid-ask spread is used as the proxy of liquidity, they are able to identify marginal effect of the bid-ask spread change. They document that an increase of the bid-ask spread for one basis point increases yield spread for 0.42 and 2.30 basis points for investment and speculative grade bonds,

respectively. The authors also extend their work to changes in yield spread and uncover that an increase in illiquidity has a positive effect on the yield spread. Longstaff et al. (2005) use credit default swap information to distinct default component from non-default component in a corporate bond spread. They go on studying the non-default component by regressing its average value on various factors including liquidity measured as bid-ask spread. The authors find that the non-default component is indeed closely tied with their liquidity measure as well as with the principal amount outstanding.

An important contribution to the academic literature on liquidity risk was made by Lin, Liu, and Wu (2011). In this work the authors not only determine the components of a corporate bond spread, but also quantify the proportion of a yield spread due to various factors. More specifically, they find the liquidity factor to be responsible for 25%, 24%, 22%, and 20% of the spread for AAA/AA-, A-, BBB-, and BB-rated bonds, respectively. Yet another non-default component the researchers have found to have an impact on a corporate bond yield spread is the tax treatment of income and/or capital gains derived from the return of a bond.

2.4.3 Tax treatment

It is not only believed that personal taxes have an effect on the spread but also empirically proven. Kidwell and Trzcinka (1982) and Trzcinka (1982) successfully incorporate taxes in their model when studying the fiscal crisis of the New York City. In addition, Miller (1977) while studying taxes in the context of capital structure of a firm argues that personal tax rate does have a direct effect on the yield of a bond. Yawitz, Maloney, and Ederington (1985) in their paper develop and consequently test a model of the interaction between taxation and default on the yield spread. They document strong explanatory power of the model suggesting that taxes indeed have an effect on the yield spread. Furthermore, there exists strong academic support of the fact that prices of bonds embed tax effects. Litzenberger and Rolfo (1984b) analyze a set of three government bonds with the same maturity date. They find empirical evidence that verifies the tax option effect discussed by Constantinides and Ingersoll (1984). Other papers in this field include Liu, Wang, and Wu (2003), Kamara (1994) as well as the highly influential work of Elton et al. (2001).

Further on, the focus of researchers was shifted to quantifying the tax rate effect on a yield spread. For example, a study of Cooper and Davydenko (2003) whereby they develop a structural model based on Merton (1974) in order to estimate expected returns on debt and equity, dispense a finding that personal taxes may gauge from 10 to 35 basis points of a corporate bond spread. The reasoning behind taxes affecting the yield spread of bonds is the asymmetric tax treatment. This implies that an investor would potentially earn a different return

for the same bond depending on the tax treatment of a security. For example, personal tax rates differ across the world inviting investors to adjust prices of securities accordingly. In addition, differences in prices across corporate bonds may arise due to dissimilarity of taxes on distinct components of a bond such as tax rates on coupon income, return on principle, premium and discount amortization, and capital gains or losses (Liu, Shi, Wang & Wu 2007).

However, it should be noticed that some academics indeed record results that are in favour of limited tax effect on a bond spread. In their paper Green and Odegaard (1997) investigate the effects of the Tax Reform Act of 1986 on the relative pricing of U.S. Treasury bonds. They advocate for the absence of tax effects in the term structure after the change in taxation rules on fixed-income securities. Nevertheless, contrary to this paper, work of Liu et al. (2007), which examines effects of default risk and taxes on a yield spread, draws the opposite conclusion. The researchers deal with the same shift in the tax regime as Green and Odegaard (1997) by using an estimated tax rate observed directly from bond the yields rather than using the statutory state income tax as proposed by Elton et al. (2001). They find strong evidence supporting the presence of marginal investor's income tax rates in the formation of yield spread. Furthermore, their results propose that major part of a spread is indeed due to the tax effects. Taxes take 60%, 50%, and 37% of the yield spread for AA-, A-, and BBB-rated bonds, respectively. Liu et al. (2006) suggest that personal taxes account for even more of a spread for higher-grade bonds with short maturities.

On the whole the existing literature has been strongly supporting personal taxes as a factor influencing the yield spread of a bond. Even though there were findings suggesting the opposite, papers written later have overturned the conclusions by producing different results. The factor of personal taxes might play a prodigious role in establishing the relationship between the yield of a regular bond and the yield of a green bond due to peculiarities of tax rules across the world**.**

2.5 External factors

Now that we analyzed internal risks embedded in the corporate bond spread, it is vital to mention the external factors that affect the wealth of an investor holding a corporate bond. On the one hand, evidence of specific macroeconomic factors is extremely controversial. For example, Elton, Gruber, and Blake (1995) develop a model for bond pricing in which they include an unexpected change in GDP and an unexpected change in consumer price index along with the variables accounting for the three main aforementioned risks. Nevertheless, Gutierrez, Maxwell, and Xu (2007) document in their paper that the macroeconomic variables do not explain much of the variation and do not affect the model's goodness of fit upon exclusion.

On the other hand, an external factor that creates systematic risk for the market is the change in interest rates as a result of adopting certain monetary policy measures. There exists an inverse relationship between the price of a bond and the interest rate. An investor might incur either profits or losses depending on the direction of change of interest rates if he or she decides to sell a bond before the date of maturity. According to the expectations theory, a country's monetary policy is foreseeable for the short-term horizon and less so for the distant future, therefore, an investor might demand an extra return for a bond with a more distant maturity date. Furthermore, yields for longer maturity bonds are usually higher than the ones of shorter-maturity bonds due to the fact that investor's money is "locked-in" for a longer period of time, and in an event of sudden changes it might be difficult to find a buyer for the security – known as liquidity preference theory.

2.6 Potential reasons for different spread

Having outlined the core factors that determine corporate bond spread, it is important to understand why can a yield of the same maturity and cash flow generating green bond differ from a yield of a regular corporate bond issued not for the environmental purposes. A report from Bakshi & Preclaw (2015) has performed a comparison of green and regular corporate bonds. They document that investors are willing to pay a premium of 17 basis points for green bonds compared to regular bonds controlling for other factors. One of the possible explanations for this phenomenon could be the mismatch between demand and supply of green bonds. Although the market for this type of securities has been evolving at an exponential rate, there is evidence that demand has even outpaced the growth. An article by The Economist (2014) has reported many cases of oversubscription to new issues. The same article states that 55% of the pension-fund assets are exposed to climate risks. Green bonds serve as a hedging instrument for such funds, thus, increasing demand for climate oriented bonds. Another possible explanation, although hard or impossible to quantify, could find itself in a form of non-monetary returns to investors such as psychological benefit, brand value, influence with regulators and other indirect gains (Bakshi & Preclaw, 2015).

Furthermore, the analysts test the hypothesis of green bonds being less volatile than regular bonds, however, the obtained results were inconclusive results. Had the hypothesis turned out to be true, it would mean that green bonds are safer, thus, requiring less premium. Yet another reason why yield spreads might differ is the dissimilar tax treatments for green and non-green securities. The governments may introduce incentives to invest in climate friendly bonds by introducing the so-called tax credits – bond holders receive discounts for their taxes, while issuers do not have to pay interest on their bonds. An example of tax credits is Clean Renewable

Energy Bonds and Qualified Energy Conservation Bonds (QECBs) programs by the U.S. government. The issuers of bonds qualifying for these programs receive cash rebates to subsidize their net interest payments, the notion being defined as direct subsidy bonds. Finally, the government can classify green bonds as tax-exempt bonds, meaning an investor is not required to pay income tax on interest from such bonds. In the U.S. market this is common for municipal bonds, whereas an example of tax-exempt green bonds can be found in Brazil, where the government provided these conditions for financing of projects associated with wind energy.

3 Methodology

3.1 Data & sample selection

The aim of this research is to find whether there exist any differences in pricing of green and non-green bonds using the latest data available. Taking into account the work of Bakschi & Preclaw (2015), who analysed similar issue for data samples up to the year 2015, along with the quality of our data collection tools, we focus on the latest available information only. Thus, all values are taken for the year 2016 and appear as of 30.12.2016 – the last working day of the year. For the purpose of getting access to green bond data we address two sources available to us. The first source is the Climate Bonds Initiative. The organisation provided us with a dataset of 865 bonds which have been labelled as green by their issuers. Along with issuer's name the following information was included in the data file: International Securities Identification Number (ISIN), amount issued and currency, amount issued in US dollars, date of issuance, maturity date, and country of origin. The second source is the Barclays Global Aggregate Bond Index. We obtain constituents of the index and filter out bonds which are labelled as green by the management of the company. Further we merge data from two sources and remove duplicates. We arrive to our final sample by applying the following criteria that limit potential traps we might fall into when extracting data from the available sources:

1) Liquidity is an important factor for getting valid characteristics, otherwise we risk obtaining imprecise values for both dependent and independent variables due to small trading frequency and, as a result, data if present might potentially be erroneous. This is achieved by the following rule of thumb – the issue amount ought to be at least 500 million US dollars for a bond to be considered traded regularly. 500 million USD usually represents the minimum amount of issuance in order for a security to be included into an index. This in turn ensures that investors are informed about existence of a security as they tend follow indices and their constituents closer than stand-alone securities.
2) We then use Bloomberg Terminal platform to extract values for the variables of interest. If there is no information available on at least one of the variables, the observation is excluded from the sample. As a result, we are forced to exclude another 113 bonds which results in sample of 118 observations in total (see Table 1).

Green Bonds	# of observations	Mean	Std. Deviation	Min	Max
OAS	118	96.01297	104.7091	6.54	665.2
Option-adjusted duration	118	5.562797	3.175672	.89	20.37
Return on equity market (%)	118	6.19619	4.763568	-11.2817	17.50691
Default probability	118	1.963797	4.931576	0	32.435
Liquidity (mln. USD)	118	751.864	422.976	500	3,000

Table 1: Summary statistics of green bond sample.

The formation of comparable samples consisting of regular bonds follows the same procedure. As a starting point for construction of our regular bond sample we use the Barclays Global Aggregate Bond Index. It consists of more than 18 thousand bonds and is considered to be one of the most representative bond market indices. Furthermore, the composition of countries and currencies in which green bonds were issued are similar to the Barclay's index. We reduce the control sample by excluding bonds issued by governments for comparison purposes. As Barclay's index is used for both samples of green and non-green securities, we perform a check and make sure that there are no green bonds left in the control sample. After accounting for the abovementioned criteria, we arrive at our final sample of 6,884 bonds (see Table 2).

Grey Bonds	# of observations	Mean	Std. Deviation	Min	Max
OAS	6,884	124.6186	64.11872	-12.2	688.2
Option-adjusted duration	6,884	6.354099	4.366618	.81	23.27
Return on equity market (%)	6,884	7.627199	3.992262	-6.784009	17.50691
Default probability	6,884	2.403796	2.83721	0	20.485
Liquidity (mln. USD)	6,884	968.5371	634.489	500	11,140

Table 2: Summary statistics of regular bond sample.

3.2 "Green" Effect

To address the first research question stated afore, we employ a structural model of bond pricing by performing multi-variate OLS regression. The aim of the regression analysis is to isolate the effect of "greenness" by controlling for other factors that influence the yield spread. Therefore, it is of an upmost importance to establish all the determinants of the yield spread and

find the appropriate measures for them. In order to successfully achieve this, we address the previous academic researches on bonds. The brief survey of literature leaves us with the following main factors that may have an impact on the yield spread (see Table 3).

Name	Effect	Paper
Credit risk	Bigger probability of default implies higher required return. Thus, there exists a direct relationship between the risk of default and the yield spread.	Eom et al. (2004); Anderson & Sundarsen (1996); Collin-Dufrense & Goldstein (2001); Longstaff & Schwartz (1995); Huang & Huang (2003); Elton et al. (2001); Jones et al. (1984); Delianedis & Geske (2001).
Liquidity risk	The more liquid the bond, the less premium investors require.	Amihud & Mendelson's (1986); Lo et al. (2004); Kamara (1994); De Jong & Driessen (2005); Li et al. (2009); Chen et al. (2007); Lin et al. (2011)
Tax benefits	If there exist tax benefits for investors, they require less premium on a bond.	Kidwell and Trzcinka (1982); Trzcinka (1982); Miller (1977); Yawitz et al. (1985); Cooper & Davydenko (2003); Litzenberger & Rolfo (1984b); Liu et al. (2007)
Interest rate change	Inverse relationship between interest rate and return	Bierman & Hass (1975); Elton et al. (1995);
Excess return on a stock market	Positive relationship with the yield spread.	Elton et al. (1995); Fama & French (1993);
Maturity	Longer maturity bonds tend to have higher yield spread than shorter maturity bonds.	Bakshi & Preclaw (2015);
Currency risk	Risk coming from fluctuations in currency. The more unstable the currency is, thee higher premium will be demanded.	Elton et al. (1995); Bakshi & Preclaw (2015);

Table 3. Potential factors and expected effects.

Nevertheless, before including these variables in the regression, we have to make sure that there exists no multicollinearity problem within our selected variables. To ensure the absence of such an issue we conduct the variance inflation factor (VIF) test. This test shows how much variance of a variable is inflated due to the correlation between two or more variables. The general rule of thumb states that if VIF exceeds 4 than further investigation should be carried on, i.e. test pairwise correlation. If, however, VIF reaches a value of 10 or more, multicollinearity problem is very likely to exist, which would require expulsion or change of the variable. After conducting the test, we find that no variable exceeds the value of 10. In fact, only two variables have a VIF value slightly higher than 4 (see Appendix 1). These variables are then tested for pairwise correlation. As expected, there exists significant correlation between regions (see Appendix 2), however, it does not indicate towards multicollinearity (no pairwise correlation exceeds value of |0.6|). Therefore, variables are kept in the regression.

After carrying out the tests for multicollinearity we set out to design our regression which would allow us to isolate the effect of "greenness" if it exists. Due to the lack of appropriate data collection tool and difficulties measuring certain effects we have to exclude one of the variable suggested by the literature - tax effects. We also abstain from including the variable controlling for reaction towards changes in interest rates due to the risk being systematic, thus, affecting both green and non-green bonds as well as due to the nature of our dataset. While it is close to impossible to find precise alternative ways to proxy for tax treatment, we limit the measure of macroeconomic impact on the yield spreads to environment of equity markets of the respective currency. Further, we provide the exact form of our regression as well as the description of each variable:

$$OAS_i = \beta_0 + \beta_1 \cdot Rating_i + \beta_2 \cdot LIQUID_i + \beta_3 \cdot (Rm - Rrf)_i + \beta_4 \cdot DUR_i + \beta_5 \cdot DUSD_i + \beta_6 \cdot DOther_i + \beta_7 \cdot DNA_i + \beta_8 \cdot DRest_i + \beta_9 \cdot DAsia_i + \beta_{10} \cdot DGreen_i + \varepsilon_i$$

1) *OAS*. We follow Bakshi & Preclaw (2015) and choose option-adjusted spread as a dependent variable. Choosing this measure allow us to include bonds which have options embedded in them without the risk of obtaining inaccurate data. The data source defines option-adjusted spread in the following way: "number of basis points the spot curve would have to shift for the present value of cash flows to equal security's price, using bide price."
2) $DEFR$. Company's rating is crucial for pricing a bond due to the fact that it determines the default premium an investor will require for holding a bond. We approach the

selection of proxy for this risk in two ways. In the first method, we create our own classification based on credit agencies' ratings. For the assessment of the credit risk, long-term credit ratings issued by the leading credit agencies (S&P, Moody's, Fitch) were used. All the bonds were assigned a numeric value from 1 to 20 corresponding to their credit rating (see Table 3). S&P credit ratings were used as the primary resource for the regression inputs. In case a bond was not rated by S&P, Moody or Fitch credit rating was used (the priority was given to Moody). The second approach is based on Moody default study carried out in 2016. The organization provides average cumulative issuer-weighted global default rates for companies rated from Ca-C to Aaa, and maturity up to 20 years by analyzing default rates during the time period from 1983 to 2016 (Appendix 3). If a security matures in more than 20 years, we take the value for the last available year (i.e. if a company is rated Aaa and has 35 years to maturity remaining, it would have a probability of default equal to 0.139%). This allows us to measure the risk of default in a more precise manner taking into account the remaining life of a security. Furthermore, the first method assumes linear relationship between credit rating and risk of default, which is not entirely accurate due to a rather convex nature of the relationship. Nevertheless, we perform the analysis with both measures and decide to stick with the second method as it showed better results, and is easier to interpret.

S&P	Moody's	Regression input	S&P	Moody's	Regression input
AAA	Aaa	1	BB+	Ba1	11
AA+	Aa1	2	BB	Ba2	12
AA	Aa2	3	BB-	Ba3	13
AA-	Aa3	4	B+	B1	14
A+	A1	5	B	B2	15
A	A2	6	B-	B3	16
A-	A3	7	CCC+	Caa1	17
BBB+	Baa1	8	CCC+	Caa2	18
BBB	Baa2	9	CCC-	Caa3	19
BBB-	Baa3	10	CC	Ca	20

Table 4. Credit ratings and regression inputs.

3) $LIQUID$. Liquidity, as was determined by several papers, plays an important role in defining the yield spread of a bond and may be responsible for a significant part of it. Although there are several measures of liquidity, we stick to the one proposed by Bessembinder et al. (2008) - volume outstanding - mainly due to the inability to obtain other measures of liquidity such as bid-ask spread or average daily volume traded.
4) $(Rm - Rrf)$. Elton et al. (1995) have argued that the excess return on the stock market can be viewed as a general expectation of economic conditions on the market and, thus,

should have an impact on the yield spread. To proxy for that, we use the returns of the market indices of markets corresponding to the currency in which the security is traded. The following indices are used as proxies for local stock markets:

EUR	Stoxx Europe 600	CHF	Swiss Market index
SEK	OMX Stockholm benchmark	GBP	FTSE All-share index
USD	S&P 500	CAD	S&P/TSX Composite
NZD	S&P/NZX 50	NOK	Oslo SE Benchmark index
AUD	S&P/ASX 200	PHP	Philippines SE PSEi index
ZAR	FTSA/JSE Africa All	MAD	MADEX Free Float Index
BRL	Ibovespa	CNY	Shenzhen CSI 300 Index
TRY	Borsa Istanbul 100	INR	NSE Nifty index
MXN	MSE Total return index	HKD	Hong Kong Hang Seng Index
JPY	Nikkei 225	SGD	MSCI Singapore Free Index

Table 5. Credit ratings and regression inputs.

5) DUR. An important factor for pricing of a bond is its time to maturity. Usually, all risks held constant, the longer the time to maturity, the bigger premium an investor would require because of potential risks he or she faces while holding a bond, i.e. change in macroeconomic environment. Consistent with the previous literature we use option-adjusted duration to proxy for the time to maturity of a bond. Bloomberg defines option-adjusted duration as "the security's price/yield sensitivity calculated by shifting the entire yield curve, based on bid prices."
6) $DUSD$. Yet another risk found by the researchers (Bakshi & Preclaw (2015)) is the currency risk. The more unstable the currency is, the bigger the risk an investor faces. To account for that we use a dummy variable which takes the value of 1 if the currency is US dollar and zero otherwise.
7) $DEUR$. Dummy controlling for curency risk. It takes the value of 1 if the currency of issuance is Euro and zero otherwise.
8) $DOther$. Takes the value of 1 if the currency is not USD or EUR.
9) $DNA, DAsia, DRest, DEurope$. We also include dummie for regions to account for potential differences in investor preferences across regions. However, this may occur only if the law of one price does not hold, which is a reasonable assumption given the fact that there exist certain restrictions as well as transaction costs.

10) $DGreen$. A dummy variable taking the value of 1 if a bond is labelled as green and 0 otherwise.
11) Although we create dummies for region Europe and currency Euro, they are omitted from the regression due to multicollinearity reason and serve as a control group to which respective variables will be compared.

After establishing the impact of the "green" effect in the yield spread using regression analysis, we turn to the scrutiny of the second research question. We address the research question in two steps consisting both of quantitative and qualitative methods.

3.3 Analysis across sub-samples

First, we identify whether the analyzed factors that determine the yield spread have a different effect on green and regular bonds. This will allow us to see if investors perceive various risks in a different manner. To ascertain this, we first separate our full sample into two sub-samples: one with green bonds only, and the other being our control sample. We then perform similar analysis as for the first research question by running the regression for each of the samples with identical variables but one – namely, we exclude the variable GreenDummy as we no longer require a distinction between the type of a bond due to the nature of the research question. Consequently, we end up with the following regressions:

1) $OASGreen_i = \beta_0 + \beta_1 \cdot Rating_i + \beta_2 \cdot LIQUID_i + \beta_3 \cdot (Rm - Rrf)_i + \beta_4 \cdot DUR_i + \beta_5 \cdot DUSD_i + \beta_6 \cdot DOther_i + \beta_7 \cdot DNA_i + \beta_8 \cdot DRest_i + \beta_9 \cdot DAsia_i + \varepsilon_i$
2) $OASGrey_i = \beta_0 + \beta_1 \cdot Rating_i + \beta_2 \cdot LIQUID_i + \beta_3 \cdot (Rm - Rrf)_i + \beta_4 \cdot DUR_i + \beta_5 \cdot DUSD_i + \beta_6 \cdot DOther_i + \beta_7 \cdot DNA_i + \beta_8 \cdot DRest_i + \beta_9 \cdot DAsia_i + \varepsilon_i$

For the purpose of consistency, we keep Europe and Euro as a control group for dummy variables, thus, omitting them from the regression analysis. Having attained coefficients for different samples, we intend to determine whether there exists significant difference in results of corresponding variables. We employ two sample t-test as a mean of analysis (see Figure 1).

$$t^* = \frac{\bar{X}_2 - \bar{X}_1}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

(Figure 1. Two sample t-test)

X_1 stands for the coefficient from the green-bonds regression, while S_1 for standard error of coefficient obtained from the same sample regression. X_2 and S_2 notations are attributed for the sample of regular bonds, respectively.

3.4 Qualitative study

The second step represents a qualitative study. In order to identify the nature of the price premium on green bonds and fill in the gap in the existing academic literature on the topic, we conduct a series of semi-structured interviews with experts involved in the green bond market. More specifically, we aim to gather opinions of all three parties ensuring the functioning of the market, namely issuers, underwriters, and investors. The method of semi-structured in-depth interview grants us greater flexibility in comparison with structured questionnaires to explore a novel topic under condition of limited access to industry experts. Furthermore, it gives us an opportunity to investigate a complex issue in detail.

The participants of the interviews were the following:

Anna Denell	Head of Corporate Social Responsibility at Vasakronan	Issuer	Vasakronan was the first company in the world to issue a green bond in November 2013 (Vasaknonan, 2017)
Christopher Flensborg	Head of Climate & Sustainable Financial Solutions at SEB	Underwriter	SEB bank served as the underwriter for the first green bond on the market issued by EIB in 2007 and stayed the leading global underwriter for 4 years (SEB, 2017)
Helena Lindahl	Portfolio Manager at Storebrand Asset Management Stockholm	Investor	Helena manages a designated green bond fund since 2015 (Lindahl, 15.03.2017)
Mats Andersson	Vice Chairman of Global Challenges Foundation and former CEO at the Fourth Swedish National Pension Fund	Investor, NGO representative	"The Global Challenges Foundation aims to incite deeper understanding of the most pressing global risks to humanity - and to catalyse new ways of tackling them" (GCF, 2017)

Table 6. Participants of semi-structured interviews.

The primary data for the qualitative analysis was collected with the help of the framework for constructing fieldwork strategies and materials described by Arthur & Nazroo (2003). First, in accordance with the framework, at the beginning of an interview we introduce the topic of our research and verify the common understanding of the major terms employed. Second, we inquire about the interviewees' experience with green bonds and their general perception of the market. Third, we asked about their opinions on the specific aspects of the market that are of a particular research interest. Finally, the participants were invited to share their perspectives on the future development of the market and summarize the content of the interview. The approximate list of interview questions is presented in Appendix 4.

With the permission of the interviewees all the conversations were audio-taped and later transcribed. Afterwards, the interview transcripts were sent to the interviewees to get their permission to use the quotations in the body of this paper. When analyzing the obtained data, we focused on the most popular and repeated arguments among the experts. These recurrent themes were used to segregate the data into several selected sub-topics. The data from the interviews was then reviewed and organized within those narrow sub-topics, forming a general hypothesis that is presented in the results section and supported by interview citations.

However, it is important to notice that the limitation of this method that stems from the limited access to industry experts, and the time-consuming process of interviewing is related to a very small number of participants. Hence, the qualitative findings, while playing a significant role in complementing the quantitative results, cannot be considered as universal truth and applied to a broader population. Nevertheless, due to the noteworthy expertize of the interviewees, the conclusions may generally be viewed as valuable professional insights into the topic.

4 Results I. Quantitative findings

Having performed a test with the sample that contains the total number of 7,002 observations (see Table 1 & Table 2) for the first research question, we obtain results that are generally consistent with the existing literature.

OAS	β-coefficient
Amount Issued, mln USD	-1.78e-06**
Return on equity market	4.136762***
Probability of default	8.764177***
Option-adjusted duration	2.498025***
North America	-26.43899***
Rest of the world	18.68738***
Asia	4.325587
USD	-24.50741***
Other currency	-40.38217***
"Green" effect	-35.88591***
Constant	91.38349***
R^2	0.2752
Observations	7,002

Table 7. Regression results obtained from structural model. * - significant at 10% level; ** - significant at 5% level; *** - significant at 1% level.

The option-adjusted duration enters the regression with a positive sign and the β-coefficient of 2.498, which is significant at 1% significance level, meaning that a one-year increase in the option-adjusted duration of a bond increases the option-adjusted spread (OAS) by 2.498 basis points. The return on the equity market is also a significant independent variable: one percentage point increase in the 1-year trailing return on domestic equity market leads to an increase of 4.137 basis points in the OAS of a corporate bond. Similarly, an increase in the probability of default by 1 percentage point inclines widening of the option-adjusted spread by 8.764 basis points, which is significant at 1% significance level. One million increase in the total amount of bonds outstanding (denominated in USD) has a negative impact that is, however, very close to zero. The β-coefficient is significant at 5% level. With regards to the regional characteristics of the financial instruments, bonds issued in North America have a 26.439 basis points smaller spread than the ones issued in Europe. Although the yield spread for Asian bonds is 4.326 basis points bigger compared to European bonds, the coefficient proved to be insignificant. On the contrary, the bonds issued in the rest of the world on average yield 18.687

basis points more compared to the bonds issued on the territory of Europe. These regional dummies are significant at 1% significance level. The currency in which a bond is denominated has a considerable influence on the spread of a bond. More specifically, OAS of the bonds issued in USD or other currency than Euro is less by 24.507 and 40.382 basis points, respectively. The independent variable of a particular interest is the green dummy, which is negative and significant at 1% significance level, meaning that a green bond has a 35.886 basis points smaller spread than a regular bond.

To test our second research question - whether there exists any significant difference between the effect of variables on two samples, we first ran 2 independent regressions (one for each sub-sample). The results obtained for the sample of regular bonds (see Table 8) are generally consistent with the outcomes from the first research question (see Table 7). The probability of default still stands for the largest effect among the non-dummy factors. All other variables also follow the same pattern as the results from the previous regression.

The situation with the sub-sample of green bonds, however, changes completely in comparison to the joint sample. The changes in the option-adjusted duration do not have any significant effect on option-adjusted spread. An increase in return on equity market has a negative impact on option-adjusted spread, however, the outcome is insignificant. A change in the probability of default has a significant effect on OAS: an increase in default probability by one percentage point leads to a 15.171 basis points increase in the spread. The liquidity coefficient is close to zero and negative, but it is still significant at 1% level. Currency dummies behave differently in comparison to the joint sample results. If a bond is issued in US dollars, its OAS increases by 20.044 basis points. Meanwhile, the effect for currencies other than Euro and US dollar is reflected in a 4.446 basis points smaller spread compared to Euro denominated bonds. Both indicators are now insignificant. Variables accounting for the regions are insignificant except ones for Asia and North America. Green bonds that were issued in Asia have a 44.849 basis points larger spread compared to the European bonds, other factors held constant. The result is significant at 1% level. Meanwhile, bonds issued in North America on average have an option-adjusted spread larger by 35.259 basis points in comparison with Europe. The result is significant at 10% level.

Having performed the regression analysis for both sub-samples, we intend to compare the results that proved to be significant in both groups of bonds. Fields painted in grayscale indicate that the coefficients are significantly different at 1% level. An exception is the variable North America, for which the difference is significant at 5% level.

OAS	β-coefficient	
	Green	Grey
Amount Issued, mln USD	-.0000263**	-1.66e-06**
Return on equity market	-1.033774	4.262644***
Probability of default	15.1711***	8.209888***
Option-adjusted duration	-1.06995	2.731732***
North America	35.25854*	-27.44483***
Rest of the world	31.3561	19.76698***
Asia	44.84945***	2.404905
USD	20.0436	-25.59516***
Other currency	-4.445996	-41.49564***
_cons	69.24851***	91.55663***
R^2	0.6155	0.2685
Observations	118	6,884

Table 8. Regression results obtained from samples of green and grey. * - significant at 10% level; ** - significant at 5% level; *** - significant at 1% level

5 Discussion of the quantitative results

The empirical evidence obtained on bond pricing in this research paper is largely consistent with the theoretical background on the topic. The effective duration of a bond proved to be a significant determinant of its spread. Interestingly, the β-coefficient for the option-adjusted duration becomes insignificant for green bonds. If it is not the result of insufficient sample size, this means investors require flat compensation for systematic risk of interest rates change for green bonds. In comparison, regular bonds' investors demand additional compensation for holding a bond longer.

A positive relation between the return on the stock market and the yield of a bond that has been discovered by Fama & French (1993) and Elton et al. (1995) is observed for our sample of bonds as well. Return on domestic equity market is associated with a slightly upward sloping compensation scheme for all bonds (4.137 basis points increase in OAS from 1 percentage point increase in the excess return on the stock market). This signifies a tight interconnection of debt and equity markets: the higher the return on equity market for the past year is, the higher yield on debt instruments is required. The equilibrium price level is achieved via investors switching from debt instruments to equities and the other way around in case they believe one class of the assets brings higher return for the same level of risk. Moreover, such a significant correlation of two markets may be explained with the help of macroeconomic cycles, namely the booming economy and the high returns on equities it generates used to be affiliated with contractionary monetary policy designed to prevent the economy from overheating, and vice versa.

The empirical evidence gathered in this paper on credit risk supports the findings of Huang & Huang (2003) and Elton et al. (2001) by verifying the significance of credit ratings in determination of a bond's yield spread. The effect of an increase in the probability of default by one percentage point has an immediate effect on the option-adjusted spread. The results obtained through the regression analysis along with Moody's data for average cumulative global default rates (Appendix 3) demonstrate that investors are fairly insensitive to changes in credit rating within the higher rated bonds as the probability of default increases only marginally (see Figure 2). However, as bonds lose their investment grade status and migrate to the status of speculative bonds, their pricing becomes highly dependent on the exact current position within the group. This is consistent with the conclusions of Longstaff et al. (2005), who document the increasing proportion of the spread attributable to credit risk for lower rated bonds. Such a sharp increase in investors' sensitivity to marginal changes in the credit rating might be explained by the expanding spread in the default probability for lower graded bonds (see Figure 2).

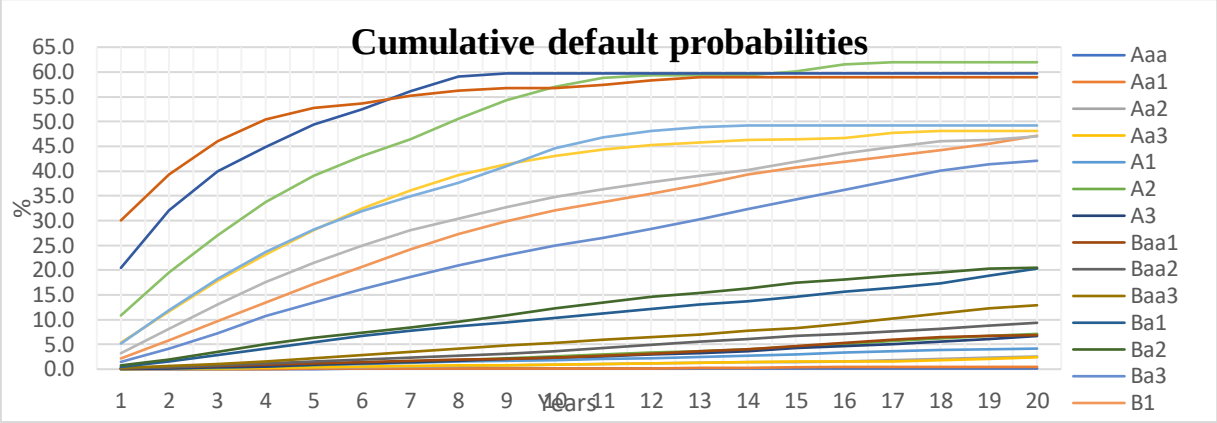

Figure 2. Data on cumulative default probabilities across various ratings and maturity dates by Moody.

Despite the consistent academic support of the theory that liquidity is one of the critical factors in bond pricing, in particular the works of Kamara (1994), De Jong & Driessen (2005) and Li et al. (2009), our liquidity measure (the amount of bonds outstanding) turned out to be significant, however, practically negligible explanatory variable. For both samples of green and non-green bonds it has a small negative significant value, which is partly consistent with our expectations of a negative impact on a bond's OAS from higher liquidity. A probable reason for such results might be the initial liquidity screening applied by us to the green bond sample and by Barclays to the constituents of the Global Aggregate Bond Index. Consequently, all the bonds in our data set are beyond a certain liquidity level, which once being surpassed does not affect the OAS of a bond in a significant manner. Furthermore, the result documented in the analysis might arise from the drawbacks of this particular measure.

The results of regional analysis indicate that bonds issued in North America trade at a lower yield and, consequently, higher price than comparable bonds issued on European continent as a result of overreaching global demand for secure investment opportunities. The regional dummy for Asian region is insignificant for the regular bonds sample, thus, the result is inconclusive. However, in the sample of green bonds, variable Asia becomes significant at 1% level and is positively related to the option-adjusted spread. The difference might come from recent events and tendencies in the eastern part of the world where the main market player – China – is trying to deal with environmental problems, namely, air pollution. Consequently, a lot of capital is raised to solve the problem including self-labelled green bonds, part of which might be considered greenwashing due to the nature of the projects. Therefore, investors may require higher return on these bonds in comparison to non-green ones. The currency analysis shows that bonds issued in USD have higher prices than comparable bonds denominated in Euros, demonstrating the investors' priority to be in possession of assets issued in the global reserve currency.

Finally, the quintessence of this research is the β-coefficient obtained for the green dummy. In line with our expectation and the study of Bakshi & Preclaw (2015), the OAS of the green bonds is indeed significantly less than the one of comparable regular bonds. More specifically, green bonds tend to yield 35.886 basis points less. Hence, this research partly proves the preferred habitat theory in relation to green bonds, meaning investors indeed are paying a premium for bonds that are labelled as "green".

The results from comparing coefficients across samples of green and regular bonds state that green bond investors are less sensitive towards interest rate risk than regular bond investors. Furthermore, if the probability of default increases by one percentage point, green bond investors will demand significantly larger compensation than regular bond investors. This, in turn, might suggest that in case of any issuer uncertainty or distress, investors expect harsher consequences compared to regular bond holders, which is one of the typical characteristics of a developing market. Yet another interesting finding is that values for currencies of issuance are significantly different and have opposite signs. Whereas regular bonds that are issued in US dollars or other currencies have a spread smaller than bonds denominated in Euro by 25.595 and 41.496 basis points respectively, for green bonds the situation is completely different – if a bond is denominated in Euro, it has a spread smaller than one of the bonds issued in US dollars or other currencies. Although this effect might have appeared due to the sample size limitations, it would be worth investigating this phenomenon more closely. One of possible explanations could be the oversubscriptions for Euro denominated bonds. In the next step, we proceed with qualitative analysis of the potential reasons accounting for the different pricing of regular and green bonds.

6 Results II. Qualitative findings

In this part of the research we intend to get an additional perspective on the main drivers of emergence and growth of the green bond market as well as undertake an attempt to define certain financial characteristics of green bonds that make them an attractive investment opportunity and could possibly justify the price premium identified in the first part of our analysis. In the following paragraphs, we present the highlights of the interviews with representatives of all parties engaged in the creation and distribution of green bonds, namely the issuers, underwriters, and investors. The findings are divided into 5 major sub-sections: 1) market growth drivers; 2) price determinants; 3) volatility considerations; 4) liquidity; 5) future outlook of the green bond market.

6.1 Market growth drivers

The future success of a business depends greatly on a company's ability to adapt to changing external factors. Christopher Flensborg, Head of Climate & Sustainable Financial Solutions at SEB, pointed out that climate stress is one of mega-trends that will persist for the next 5-15 years and have a significant impact on the way markets operate alongside with such trends as higher demand for resources correlated with increasing world's population, higher consumption, urbanization, and resource efficiency. The exposure of companies and financial institutions to climate stress that includes flooding, droughts, fires and storms is going to increase tremendously. Green bonds, in turn, serve as a tool to navigate through these issues, keep a stable environment, and minimize the risk coming from environmental accidents, which results in higher future values attributable to green securities.

"*These mega-trends are going to determine the success of future businesses and we as lenders or investors need to understand this to be able to navigate. In case we can identify that and identify values of these issues, we can also discount the values."* (Flensborg, 13.03.2017)

According to Mats Andersson, currently the Vice Chairman of Global Challenges Foundation and the former CEO at the Fourth Swedish National Pension Fund, for long-term investors sustainability is a crucial aspect to consider in order to increase return on investment and lower risk. For example, there is a high probability that in the future a tax on carbon emissions is introduced, and in this case, companies that are not complying with the standards of sustainable investment will be hurt. Fundamentally, volatility and risk-adjusted returns for a pension fund, while being indisputably major and most popular measures of risk, are less vital in the long run than the risk of permanent capital loss stemming from climate change. For such long-term investors, green bonds are not only a way to signal their awareness of such threats and their ability to adapt to changes, but also, in case the green securities they hold are properly

designed, an economically viable way to actually increase their long-term sustainability and lower risk. (Andersson, 14.03.2017)

Furthermore, Helena Lindahl, the Portfolio Manager at Storebrand Asset Management Stockholm, mentioned that while many institutional investors addressed the sustainability aspect within the companies using the power of equity owner, their fixed income portfolio stayed barely inclusive of sustainability considerations. Hence, including green bonds into a fixed income portfolio serves as a feasible way to increase the overall portfolio sustainability level.

"The problem in all pension funds, all asset management firms and all institutional investors is that the equity capital is so much smaller than the actual fixed income capital. For a typical pension asset manager, I think, the split is between 25% equity and 75% fixed income, and that can, of course, vary between different firms. Therefore, we thought a green bond was an excellent tool to enhance the sustainability in our total portfolio. Consequently, we jumpstarted in this assets class." (Lindahl, 15.03.2017)

Moreover, Mats Andersson stressed out that currently, without carbon tax imposed on businesses and in the absence of other financial benefits granted to companies with low carbon emissions, green bonds might act as a tool for investors to select companies that are efficient in other ways of organizing business processes apart from improving their carbon profile (Andersson, 14.03.2017). Helena Lindahl said that it is usually assumed that companies did a thorough work designing their business model before approaching the issue of carbon efficiency.

"*If I invest in corporates that take sustainable issues seriously, namely, all the ESG factors, the human rights issue, the labor market, the governance factor and the corruption, it means for me that they have spent a lot of time thinking about their business model, how they do things, and then they come to address the sustainability issues. It means they have considered all the external factors that might change in the future when working on their business model."* (Lindahl, 15.03.2017)

The latter argument was used by Mats Andersson to explain the outperformance of the fund's equity portfolio with a lower carbon footprint than MSCI World Index by 200 basis points over the past three years (Andersson, 14.03.2017). The green bond fund managed by Helena Lindahl at Storebrand was created in 2015 with the aim to monitor the performance of green securities, the structure being similar to any other bond fund. Since then the fund was performing very well: in the respective category in the Morningstar (intermediary bond funds in Sweden) it is on the top of the list (Lindahl, 15.03.2017).

All in all, from investors' points of view, green bonds play an important role in mitigating the climate change risk, act as a signalling tool to demonstrate their ability to include sustainability considerations into the investment profile, and support investors in selecting

companies with outstanding business models. As from the issuers' perspective, diversification of investor base acts as a key incentive to issue a green bond. In accordance with Anna Denell, Head of Corporate Social Responsibility at Vasakronan, the issue of green bonds helped the real estate company to attract about 35 new investors that were unlikely to purchase regular fixed-income securities of the issuer.

"*As we don't have a public rating, investors do not show much interest in our non-green bonds. It does seem that with the green bond rating does not matter that much. We have a lot of investors who buy only our green bonds, because they demand a rating if they want to buy our regular bond, but not a green bond."* (Denell, 13.03.2017)

6.2 Price determinants

From the underwriter's perspective, the process of creation of a green bond consists of 5 steps that are defining, selecting, verifying, monitoring and communicating green aspects of a security. This process involves competences that are not required for a regular bond, making a green bond by definition more expensive in issuance. In accordance with Christopher Flensborg, the abovementioned future values for investors associated with a green bond are higher than ones of a non-green security, which means that in term of NPVs, a green bond is actually a better investment than a regular bond.

"*There is an extreme liability to the banks providing green bonds to identify those future values of green bonds, ensuring the discounted factors to allow investors to buy into this investment. If we don't do it, the price needs to be the same. At early stages of the market, when those future values are unknown, it is very difficult to argue for them. So, most of the green bonds historically have been coming at a comparable price. Now we are beginning to see some issuers that can get cheaper funding and we are, with certainty, seeing more investors being interested in the same asset at a more expensive price."* (Flensborg, 13.03.2017)

Discussing the historic patterns of pricing green bonds, Helena Lindahl mentioned that the actual "lesson learned" between the first appearance of green bonds in 2007 and the revival of the market in 2012 was that this market would not grow unless green bond investors earned the same yield as investors in regular bonds. The underlying purpose of such pricing was to facilitate investment into green bonds, to make sure there was no lack of capital for financing low-carbon projects. However, the situation changed when sustainability became a wide-spread trend among investors and the demand for green securities overreached the supply. Helena Lindahl admitted paying a 2-4 basis points price premium while purchasing green bonds, stating that the excess demand for the securities will ensure their exceptional performance (Lindahl, 15.03.2017).

Thomas Nystedt, the Head of Treasury at Vasakronan, commenting on the pricing of green bonds, acknowledged that due to a low demand for the company's regular bonds, they had to offer higher yield to be able to attract investors. With green bonds, however, the situation is quite the opposite: the issuer got cheaper financing because of oversubscription to the bond in the process of issuance (Nystedt, 13.03.2017). Cristopher Flensborg confirmed that the excess demand for green bonds allows the underwriters to place the issue well, and achieve a discount in terms of interest for the companies offering green securities.

"*When you have a new issuance, you have a price range, so you might sell within a certain range. And we see constantly that green bonds come at the lower end, it is a very good execution, so very good funding for the issuer, when other issuers are coming in the middle or maybe at the high end. And that could be a difference of 2 to 5 basis points in execution. It is comparable way of pricing, but it is a better execution because of excess demand."* (Flensborg, 13.03.2017)

Nevertheless, Helena Lindahl pointed out that her first mandate of a fund manager is not to be sustainable, but to provide the investors with a competitive yield in a sustainable manner. These two requirements need to be fulfilled at the same time, meaning there could be no significant sacrifice in terms of price premium for green bonds (Lindahl, 15.03.2017). Mats Andersson, however, stated that in case a green bond is properly designed, long-term investors like pension funds and insurance companies could accept a lower yield in exchange for higher sustainability and lower risk associated with such securities, expressing a hope that in the future sustainability aspects will be taken into account by rating agencies. If this is the case, more sustainable companies will receive a better rating and enjoy lower cost of capital for more fundamental reasons than the excess demand that is driving the market at the moment (Andersson, 14.03.2017).

6.3 Volatility considerations

The increased transparency of green bonds by means of regular reporting on the use of proceeds not only enables the investors to monitor their assets more thoroughly, but also establishes a deeper dialog between investors and issuers. Such a dialog supports the issuers in finding more loyal investors who are likely to adhere to buy-and-hold behavior patterns, making green bonds essentially less volatile in the secondary market, which is highly appreciated by fixed-income investors targeting stable fund performance.

"I expect if we have a severe sell-off like that [like sell-offs in 1998, 2003, 2008 and 2011] in the future, the green bonds will outperform any other asset class. Fund managers see a longer contract with an issuer if they buy green investments and they know what the money is

being used for. I don't have this kind of contract with other issuers: if I don't know what they are going to use the proceeds for, I might as well sell and use the money for my own liquidity." (Lindahl, 15.03.2017)

Christopher Flensborg supported the latter argument that buy-and-hold behavior of green bond investors will lead to significant outperformance of the asset class during the times of turmoil in the financial markets by drawing an example of two highly comparable Korean bonds: during a national conflict initiating a massive sell-off, the green bond issued by one of Korean policy banks outperformed the equivalent bond by 50 basis points.

"Without doubt, green bonds are less volatile than regular bonds. Two South Korean policy banks, KEXIM and KDB, issued two similar five-year benchmark bonds with the maturity in 2018 with the only difference being the "greenness" of KEXIM's bond. Half a year after they issued the bond, there was a conflict between South and North Korea. Whenever there is conflict between South and North Korea, South Korean assets become very volatile. At this moment, KIXEM's green bond outperformed by 50 basis points, because people did not want to sell the assets." (Flensborg, 13.03.2017)

Another rationale behind the buy-and-hold investor behavior is the limited amount of green bonds on the supply side of the market. According to Mats Andersson, due to the aspiration of large institutional investors to signal their "greenness" by reaching and maintaining a predetermined percentage of green assets in the total portfolio, the investors have to compete for new issues and prefer to hold green bonds to maturity (Andersson, 14.03.2017). Christopher Flensborg confirmed that most of the green bonds that are coming to the market are being sold immediately and never appear on the secondary market (Flensborg, 13.03.2017).

6.4 Liquidity

The buy-and-hold behavior of green bond investors and the excess demand for the asset class form a very specific stance of liquidity aspect in the market. On the one hand, as green bonds appearance on the secondary market is very unsystematic and infrequent, the efficient price determination mechanism, which is considered to be an inherent part of a liquid market, is definitely not present in relation to green bonds.

"It is very difficult to determine the secondary market value of a green bond. What we do see in green bonds is lack of material: often green bonds are less traded than non-green bonds. Therefore, there might be a lacking factor or some illiquidity in pricing on the screens, which creates systematic mispricing of green bonds, they are not following the market. The competition for secondary stock, which can drive the secondary market, making dealers more aggressive on pricing, has not appeared yet." (Flensborg, 13.03.2017)

Helena Lindahl expressed a belief that due to the absence of robust price setting mechanism, most of the data on green bonds is potentially misleading. There is only a limited number of green bonds with the amount of issue of more than USD 1 billion that are considered to be benchmark size and traded on a regular basis. Therefore, the conclusions of Bakshi & Preclaw (2015) and the results of the quantitative part of this research are partially explained by this specific form of market illiquidity.

"I think sometimes you can see that green bonds are trading above or with a higher yield than normal bonds. But what is the data on a bond telling you? You have a data point that has no bids and no offers, which is pretty much a mismanaged, dead data point. I think the best way to look at this market if you want to have price disclosure is to look at green bonds that are benchmark size and bonds that are actively traded like French OAT. It is only those bonds you can look at when you do price comparison." (Lindahl, 15.03.2017)

On the other hand, market liquidity is also perceived as the ability of the market to provide a counterparty for a deal in a short period of time and is often measured as the speed of the process of selling an asset. From this perspective, the green bond market may be considered a liquid one: due to the excess demand, it takes almost no time to find a buyer for a green bond once it appears on the secondary market.

"*If I can find small lots of an issue in the market I buy it, and then I can sell 10-15 million only to get a mark on it that somebody sold this one, to get the market going, because I want more people to do it my way. I am doing it to provide a secondary market, because this is my responsibility, too. And if I don't sell, there won't be a secondary market. I think I can sell all my green bond holdings before lunch any given day, because the demand is so strong."* (Lindahl, 15.03.2017)

6.5 Future outlook of the green bond market

Vasakronan was the first company in the world to issue a green bond in 2013 and followed up with a few more issues later on. According to Anna Denell, the additional costs the company incurred in order to issue these bonds were negligible in comparison with the benefits attained from the issue, in particular, diversification of investor base, cheaper debt financing and enhanced business sustainability. Moreover, the issuance of the consecutive bonds required even less of administrative effort. Therefore, the company's representatives claimed that they would definitely work more with green bonds in the future providing a sufficient number of environmental projects to use as an underlying for green securities.

"*There are only benefits for us. Maybe it is more difficult if you haven't worked with sustainability. You have to have systems in place to be able to put up the reporting, but for us it is difficult to find any drawbacks."* (Denell, 13.03.2017)

The learning curve is observed not only for issuers, but for underwriters as well. According to Christopher Flensborg, at the early stages of the market, the process of issuance of a single green bond was extremely time consuming as it required setting up new processes and designing a framework suitable for the asset class. Since then, significant progress has been made: for leading investment banks that have already developed the methodology and ensured the internal standards for the issuance of green securities, it is relatively easy to identify and issue a bond in accordance with the existing guidelines.

"*Right now we can identify green loans and bonds because we have established infrastructure, so it can be easily done now, but before we had procedures and standards in place, it took a while."* (Flensborg, 13.03.2017)

Despite the fact that the demand for green bonds is currently much greater than the supply, experts expressed a belief that not all the market participants have been engaged yet. More specifically, private wealth funds are still expected to complement the demand side of the market. Consequently, the allocation of private capital into green bonds might become the next significant step in the market development.

"*The main part of green bonds was created to fit into what institutional assets owners, pension funds and insurance companies want. Then, when the market started growing, it had become appealing to asset managers. Now we begin to see lots of funds buying into it. We are not seeing, however, many wealth managers buying green bonds, we think it is going to come next. This market has not been engaged, because service providers, banks, that are servicing these clients are not really alert about what is actually important to these clients. We know there is a lot of interest, but this distribution mechanism has not been activated yet."* (Flensborg, 13.03.2017)

Since 2012 the green bond market grew substantially in volume and in the issuers' diversity, but notwithstanding this escalated development, no unified international standards for green bonds have been established. According to Christopher Flensborg, a certain degree of flexibility allowed the market to serve multiple parties involved and enabled its transition to a big market as opposed to a niche market (Flensborg, 13.03.2017). However, Mats Andersson highlighted that now there is an acute need for more rigid controls and standardized methodology for the issuance of green bonds to facilitate further development of the market.

"*We need to find a methodology that is accepted both by issuers and investors and the sooner the better. I think Green Bond Principles are too broad and could be interpreted in too many ways, so we need to take steps further. I think one way to do this is third-party check and I*

think that auditors ought to look into this as they look into other things, check companies on sustainability and how they actually use proceeds from green bonds. I think that we need to have some kind of reporting standards and methodology on how to define a green bond." (Andersson, 14.03.2017)

All in all, based on experts' assessment, it appears almost certain that the green bond market will expand in the future. Christopher Flensborg expressed an opinion that it might take approximately five years for the market to mature (Flensborg, 13.03.2017). Mats Andersson, in turn, stated that such events like the Paris Agreement, the first issue of green bonds in China and the results of G20 meeting indicating the importance of the green bond market were the milestones passed in the market development. However, while the market growth is imminent, the focus should not be shifted from the very essence of the product and its crucial role in the transition to a low-carbon economy.

"You always underestimate a movement like this with the green bonds. I think we moved past a number of tipping points, so there is no way back. My only concern is that if we don't design the product well enough, you might end up with greenwashing, you might end up saying that this product is totally ridiculous – it doesn't solve anything – and then you can kill a product that could be designed in a proper way and could be a solution how to finance green projects." (Andersson, 14.03.2017)

7 Discussion of the qualitative results

Bearing in mind the interviewees' insights into the green bond market discussed in the second part of this research, we arrive at several noteworthy conclusions regarding the nature of the price premium on green bonds identified using the regression analysis. First and foremost, most of the experts agree that the price premium of 36 basis points as suggested by regression coefficients is unrealistic and not existent at this stage of the market development. Due to the limited amount of actively traded green bonds and the buy-and-hold behavior patterns of green bond investors, the market may be considered illiquid, which results in the absence of efficient price determination mechanism attributable to liquid markets. Consequently, the data on the value in the secondary market of a green bond might be potentially misleading and biased towards the higher quoted price of a security, which partially explains the conclusions of Bakshi & Preclaw (2015), and the results of the quantitative part of this research.

Nevertheless, there is empirical evidence that a smaller price premium for green bonds is indeed present on the market. The issuers of green bonds are able to achieve cheaper debt financing by means of a better placement of an issue by investment banks, enabled by the significant oversubscription in the process of issuance. Such a price premium upon issuance facilitated by the excess demand for green securities might account for approximately 2-5 basis points (Flensborg, 13.03.2017). Moreover, on the secondary market investors are also inclined to pay a modest price premium of 2-4 basis points for green bonds, implying that the excess demand for the securities leads to excellent price performance (Lindahl, 15.03.2017).

Apart from the verification of the existence of price premium for green bonds, a few more meaningful resolutions about the functioning of the green bond market may be uncovered. In particular, one of the main drivers of demand for green bonds is the pronounced trend for mitigating the climate change risk by large institutional investors, resulting in an intent of such investors to reach and maintain a certain meaningful proportion of their assets under management in green bonds. Furthermore, we not only discover that pension funds and insurance companies tend to adhere to buy-and-hold behavior in relation to green bonds, but also hypothesize that such behaviour, in cooperation with the limited supply of such assets, creates a very specific form of market illiquidity, namely weak price setting system due to rare green bonds trades accompanied by quick and efficient process of selling such bonds. Finally, we find academic support to the theory that green bonds are less volatile on the secondary market than regular bonds and expected to substantially outperform regular bonds during times of market distress.

8 Limitations

The most influential potential limitation is data availability. Although at the very beginning we obtain 865 green bonds from the Climate Bonds Initiative and another 177 non-overlapping green securities from the Barclays Global Aggregate Bond Index, after accounting for the sample inclusion criteria, we are forced to reduce our final sample from 1042 to 118 bonds. The problem would become even more severe were we to loosen up the rules for including bonds in the final sample due to the insufficient data availability for small issuance bonds. This may affect the robustness of our results as well as create a potential bias striving from the fact that there are less issuers than number of bonds in the final sample, which might prejudice the results towards certain issuers. A possible way to solve this problem is to allow only one observation per issuer by using weighted-average approach. However, this would imply a reduction of the final sample, and we would risk running into robustness issue even more.

Yet another limitation that arises from the insufficiency of data is our inability to use the desired variables and their measurements, which leads to potential omitted variable bias as well as potential bias in the results. We are unable to design a proxy for tax treatment that was found to have a significant influence on the spread formation. Although many researchers abstract from using any proxies for taxes in their structural models, green bonds are more likely to be granted any privileges in the way capital gains are treated by tax authorities, thus, making the variable a far-reaching part of the model.

Another caveat that has to be borne in mind is our inability to use the optimal measure of liquidity due to the paucity of the data. Although in our paper we find that it has a small negative significant effect on the yield spread, the literature suggests that liquidity per se should have a more pronounced impact on the spread. Thus, alternative proxies for capturing liquidity footprint shall be considered, for example, the most widely used being the bid-ask spread. Nevertheless, one could draw on more arduous approaches such as the one introduced by Lesmond et al. (1999) where the authors estimate liquidity based on the occurrence of zero returns.

Finally, the paper might benefit from expanding the time span of the analysis. Currently, the quantitative part examines the bonds at one point in time as of 30.12.2016. Taking into account the early stage of development of the green bond market, it may be useful to see the dynamics of green bonds' advancement.

9 Conclusions

This research paper represents an academic attempt to determine the key characteristics of the green bond market that make it significantly different from the traditional bond market, with the focus on particular features of green bonds that have an effect on their pricing by investors. Given the relative novelty of such financial instrument as a green bond, and the lack of scientific literature on the asset class that is believed to be of an ultimate importance in the process of transition to a low-carbon economy, we made use of the combination of quantitative and qualitative research methods in order to verify the existence of a price premium on green bonds, and provide insights into the nature of this premium.

Using the regression analysis, we distinguish a statistically significant spread difference between green and regular bonds, more specifically, green bonds are found to have a 36 basis points tighter spread. However, the subsequent empirical findings indicate that the biggest portion of this price premium is attributable to the market illiquidity in a form of inefficient price determination mechanism. Nevertheless, we prove the existence of a smaller price premium of on average 3-5 basis points at the placement of a green bond issue, and on the secondary market. In addition, we find arguments in support of the theory suggesting a pronounced tendency of large institutional investors to hold green bonds until maturity, implying lower volatility of green bonds on the secondary market, which might potentially account for their lower yield spread.

The results of this research confirm that green bonds present a viable way to attain cheaper debt financing for the companies engaged in carbon efficiency projects. Green bond investors, in turn, perceive the asset class as an opportunity to mitigate the climate change risk and to earn competitive return on their holdings. However, this work is only an early attempt to describe the main aspects inherent to the green bond market. The experts estimate that it would take approximately 5 years for this market to mature and expect to observe the unified green bond standards by that time. When this process is complete, and the green bond market becomes efficient in price setting, the researches might undertake another attempt to distinguish the statistical difference in pricing of green and regular bond and track the evolution of the market since its emergence to maturity.

10 References

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11 Appendices

11.1 Appendix 1

Variance inflation factor test

Variable	VIF	1/VIF
USD	6.93	0.144357
Equity	5.77	0.173444
Other	3.62	0.276576
NA	1.96	0.511429
OAD	1.32	0.758536
DefaultPro~y	1.29	0.778161
REST	1.27	0.788622
ASIA	1.23	0.812400
GreenDummy	1.02	0.981049
Mean VIF	2.71	

11.2 Appendix 2

Pairwise correlation

	Amount~D	Equity	Defaul~y	OAD	NA	REST	ASIA	USD	Other	GreenD~y
AmountIssu~D	1.0000									
Equity	-0.0118	1.0000								
DefaultPro~y	-0.1064*	0.0685*	1.0000							
OAD	-0.0036	0.0737*	0.5444*	1.0000						
NA	-0.0180	0.4397*	0.0504*	0.1513*	1.0000					
REST	-0.0513*	0.0157	-0.0345*	-0.0654*	-0.3242*	1.0000				
ASIA	-0.0766*	-0.0076	-0.0348*	-0.1000*	-0.2280*	-0.0535*	1.0000			
USD	-0.0058	0.6445*	0.0693*	0.0465*	0.5086*	0.0426*	0.0522*	1.0000		
Other	-0.0291*	0.3305*	-0.0249*	-0.0010	-0.0849*	-0.0133	0.0743*	-0.3965*	1.0000	
GreenDummy	-0.0814*	-0.0487*	-0.0765*	-0.0090	-0.1067*	0.0981*	0.0577*	-0.0530*	0.0113	1.0000

11.3 Appendix 3

Moody's default study, 2016. Probability of default in % by credit rating and years to maturity

Rating	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Aaa	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aa1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Aa2	0.0	0.0	0.1	0.2	0.4	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.9	2.1	2.4	2.6
Aa3	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.6	1.8	2.1	2.4
A1	0.1	0.2	0.4	0.7	0.9	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.5	2.8	3.0	3.3	3.6	3.9	4.0	4.2
A2	0.0	0.2	0.3	0.5	0.8	1.1	1.5	1.9	2.2	2.6	3.0	3.3	3.7	4.1	4.5	5.0	5.6	6.2	6.7	7.1
A3	0.1	0.2	0.4	0.6	0.9	1.1	1.4	1.7	2.1	2.4	2.6	2.9	3.3	3.7	4.2	4.7	5.0	5.6	6.1	6.7
Baa1	0.1	0.4	0.6	0.9	1.2	1.5	1.7	1.9	2.1	2.3	2.7	3.1	3.6	4.1	4.6	5.3	6.0	6.5	6.7	6.9
Baa2	0.2	0.5	0.8	1.2	1.5	1.9	2.3	2.7	3.1	3.6	4.2	4.9	5.5	6.1	6.7	7.1	7.6	8.1	8.8	9.4
Baa3	0.3	0.7	1.1	1.6	2.3	2.9	3.4	4.1	4.7	5.4	5.9	6.4	7.0	7.7	8.3	9.2	10.2	11.2	12.3	12.9
Ba1	0.5	1.5	2.8	4.1	5.5	6.8	7.8	8.6	9.5	10.4	11.3	12.2	13.0	13.7	14.7	15.6	16.4	17.3	18.9	20.3
Ba2	0.8	2.0	3.5	5.0	6.3	7.4	8.4	9.5	10.9	12.3	13.5	14.6	15.4	16.3	17.4	18.2	18.9	19.5	20.4	20.5
Ba3	1.5	4.1	7.3	10.7	13.5	16.2	18.6	20.9	23.0	24.9	26.6	28.3	30.2	32.3	34.2	36.2	38.2	40.0	41.4	42.1
B1	2.2	5.8	9.7	13.5	17.3	20.7	24.2	27.2	29.9	32.0	33.8	35.4	37.2	39.2	40.8	41.9	43.0	44.2	45.5	47.1
B2	3.2	8.2	13.1	17.6	21.5	25.0	28.0	30.4	32.7	34.7	36.3	37.8	39.0	40.2	41.9	43.5	44.9	46.0	46.3	47.0
B3	5.4	11.6	17.9	23.1	28.1	32.4	36.1	39.1	41.4	43.1	44.3	45.2	45.7	46.3	46.4	46.7	47.7	48.1	48.1	48.1
Caa1	5.2	12.0	18.3	23.6	28.2	31.9	35.0	37.6	41.0	44.5	46.8	48.1	48.9	49.2	49.2	49.2	49.2	49.2	49.2	49.2
Caa2	10.8	19.5	27.0	33.7	39.0	43.0	46.5	50.6	54.3	57.0	58.8	59.3	59.3	59.3	60.1	61.6	62.0	62.0	62.0	62.0
Caa3	20.4	32.1	39.9	44.8	49.4	52.5	56.1	59.1	59.7	59.7	59.7	59.7	59.7	59.7	59.7	59.7	59.7	59.7	59.7	59.7
Ca-C	30.0	39.4	46.0	50.4	52.8	53.7	55.1	56.2	56.7	56.7	57.3	58.3	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9

11.4 Appendix 4

Approximate list of questions used for conducting semi-structured interviews:

1) What was your motivation to issue/purchase/serve as an underwriter for a green bond?
2) What is the process of issuance like? How do reporting standards differ in comparison to regular bonds?
3) Are there any additional costs while issuing a green bond compared to a regular bond?
4) In your opinion, what features of green bonds are appreciated by investors the most?
5) Did you observe the excess demand for green bonds during the issuance?
6) From your point of view, what drives the demand for green bonds?
7) Have you observed green bonds being less volatile than regular bonds?
8) Are there any particular patters green bond investors follow?
9) To your mind, what benefits of green bonds may influence investor's decision to overpay for a green bond?
10) Would you issue/purchase a green bond again?