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ARE INVESTORS RATIONAL PROFIT MAXIMISERS OR DO THEY EXHIBIT A GREEN PREFERENCE?

– Evidence from the green bond market

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Abstract

Green bonds are a new debt investment product that has been developed to stimulate green investments. Using a data set of 28 matching pairs of bonds, the spread differentials between green and conventional bonds of the same issuer was explored in order to find out whether investors exhibit a green preference. The results showed no evidence for the existence of a green preference among investors and indicated instead that green bonds were traded at a discount compared to their conventional counterparts. The results indicate that green bonds are unlikely to be a large catalyst for higher green investment rates as long as there are no targeted policies that accompany them.

Keywords: Green preference, Investing, Bonds, Utility, Climate change

JEL: G11, G12, H23

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Terminology

CBI	Climate Bonds Institute
GBP's	Green Bond Principles
GHG	Green House Gas
Green Technology	Technology that mitigates emissions or makes existing technology more energy efficient.
OLS	Ordinary Least Squares (regression methodology)
OTC	Over The Counter, means that a financial instrument is not traded on an open exchange
PPM	Premiepension, a part of the Swedish pension system in which the individual chooses to invest in various mutual funds.
SRI	Socially Responsible Investment
Utility	A set of preferences between different goods or services. The preferences are individual and can change over time.
Use of Proceeds	Voluntary specification by the issuer of what the money borrowed through the bond could be used for.

I. Introduction

One of today's most pressing concerns for policy makers all over the world is the climate change that poses a severe threat to life on earth as it is today. Some people remain sceptical to whether the global warming is due to human activity. For example, as late as in January 2015 the US senate voted regarding this issue in which the majority of senators refused to accept a causal relationship between these two factors (Goldenberg, 2015). However, most climate researchers seem to agree that the current warming is anthropogenic and that this development needs to be halted (Stern, 2006).

In order to stop an increasingly alarming development, it is estimated that € 55-80 billion has to be invested above the business as usual level each year with additional investments needed for developing country adjustments (Stewart et al., 2009). The current rate of global investment in green technology is too low and therefore, it is important to find ways to stimulate the investment rates – a central theme of this thesis.

Since the required investments are so substantial, it is necessary to involve private capital investors. The limited budgets of the public sector are neither likely to be able to sustain increased investment rates nor to find the political support to try to do so. Most of the private risk-willing capital in the world can be found in the capital markets and developing ways to channel capital markets investments to green activities is thus crucial for reaching the necessary levels of green technology investment. However, private investors have different incentives than governments in that they lack responsibility to care for society as a whole.

Financial theory often assumes that investors are rational profit maximisers but experiments have often shown that human beings are in fact not purely rational and care about the welfare of other people (i.e. show altruistic behaviour) as well as social norms (Levitt & List, 2007). The increasing popularity of organic products indicate that people are in fact willing to pay for greener products but the question is whether this is also true when it comes to investment. If investors have a green preference, i.e. if they value the same investment opportunity higher if the investment is green, they would be willing to give up some of their return in order to invest in green projects.

Recently, a new type of debt instrument, called green bonds, has been developed. In short, this is a means of financing where the proceeds of the bond have to be used for green purposes as defined by a set of principles stated at the issuance of the bond. Green bonds are designed to target large institutional investors that usually have a substantial part of their total funds invested in bonds. Since the bond market is currently $ 83 trillion in size (Barclays, 2014) and growing, it has the potential to fund a large part of the investments needed in green technology (Calder et al., 2014).

The market seems to have embraced the new investment product (Barclays, 2014). Nevertheless, assuming that capital markets are relatively efficient, in the long run green bonds are likely to have a relatively limited impact on green investment rates unless investors are willing to lend money cheaper (accept lower returns) to invest in green technology. If investors require the same return for green investments as for conventional ones, green bonds should be accompanied with policy initiatives to create more impact.

i. Purpose

The purpose of this thesis is to investigate whether investors are strictly rational and look for the highest return possible at a certain risk level or if they value contribution to society. In this thesis, the scope of social welfare is limited to the contribution to green development. Practically, if investors do put an additional value in contributing to green development they would exhibit a green preference. This means that for the same risk level, the investors would be willing to accept a lower return on their investment if the investment is considered green. This is only true if investors' utility curves shift downwards when adding greenness as a factor in their respective utility curves.

Most studies on ethical investments investigate a hypothesis that looks at whether ethical investments are costly, i.e. have lower returns due to the constraint of the investment universe. However, the opposite question, whether investors have a green preference and thus accept lower returns, is seldom asked. Yet, if the goal is to increase the green investment rate at a much higher speed than the growth in world GDP or the share of green technology in the capital markets, this is a much more important question.

The first perspective, when the ethicality is seen as a cost, merely answers the question whether ethical investments can be as profitable as the total market. A green preference, on the other hand, would show that green investments might not need to provide the market rate of return and still be acceptable to investors. If this holds true, green corporations have a lower cost of financing for the part of their business that is green which could, in turn, increase the size of the market that is invested in green.

This thesis contributes to the existing literature by introducing the concept of green preference to the literature on capital markets and critically investigates whether green bonds can actually stimulate green investments on their own or not. Additionally, to my knowledge, this is the first academic paper that investigates the green bond market.

ii. Research Question and Hypothesis

Following this, the research question is "Are investors rational profit maximisers or do they show a green preference?"

The tool used for investigating this question is the yield of green bonds compared to their conventional counterparts. A positive spread difference would mean that green bonds are traded at a discount, which would indicate that the value of the bonds is lower than conventional bonds. If the spread difference is negative, it means that green bonds are trading at a premium, which means that the issuer is financing the investment cheaper with green bonds.

The hypothesis is that there are currently no significant differences between the two types of bonds. This is due to previous research indicating that there are no differences in the returns of ethical and conventional investments (see e.g. Statman, 2000). Additionally, the Swedish pension fund AP7 found in a survey that only 25% of the respondents thought that ethicality should be considered even if it led to lower returns (Elsässer, 2014). This is a low number considering that stated and actual preferences normally differ (Friberg & Sanctuary, 2012) which indicates an even lower true preference for investing ethically.

A second hypothesis is that there are no differences in volatility between the bonds. This is important to test since a difference in volatility means that the investment is more risky and could also be an indication of lower liquidity.

The advantage of using green bonds instead of ethical funds (that would have more data available), is that ethical funds tend to be relatively permissive on the type of investment that could be included in such a fund. Not only does it mean that other ethical aspects than the environment are included, the restriction on eligible activities is in general less stringent. Green bonds have the advantage of solely focusing on green investing which is more suitable when investigating green preference.

II. Background

The climate change has been on the global agenda for a few decades but the progress of mitigating emissions and the adaptation of human activity to fit the planets' ecosystems still seems far away. The aggregate effects of the warming and pollution are not certain and are highly dependent on actions taken today but all scenarios pose significant threats to human lives (see Harris & Roach, 2007 p.12 for a good overview of the different scenarios).

There have been many initiatives to take action against the climate change on a global scale but there have been little progress in negotiating solid deals. In recent years, many countries have introduced their own initiatives. For example, today China is the world leader in renewable energy manufacturing and has the highest installed capacity of renewable power generation (REN21, 2014, p.102). These initiatives are extremely important but since global commons (i.e. global resources such as the atmosphere or the ocean) are considerably larger than local commons (Ostrom,

2010) these isolated efforts are not going to be enough and combatting the climate change will require global cooperation.

It is estimated that a total of $53 trillion in green investments (Boulle et al., 2014) are necessary up until 2035 in order to get the world on a 2 degree increase trajectory which is seen as the minimum amount of warming that is possible when taking into account the emissions that have already occurred. The current rate of investment is significantly lower than this, which creates a sense of urgency among governments and other policy makers to increase these investments. If it can be assumed that markets are relatively efficient this problem arises because the optimal individual investment rates in green technology is lower than the social optimal level.

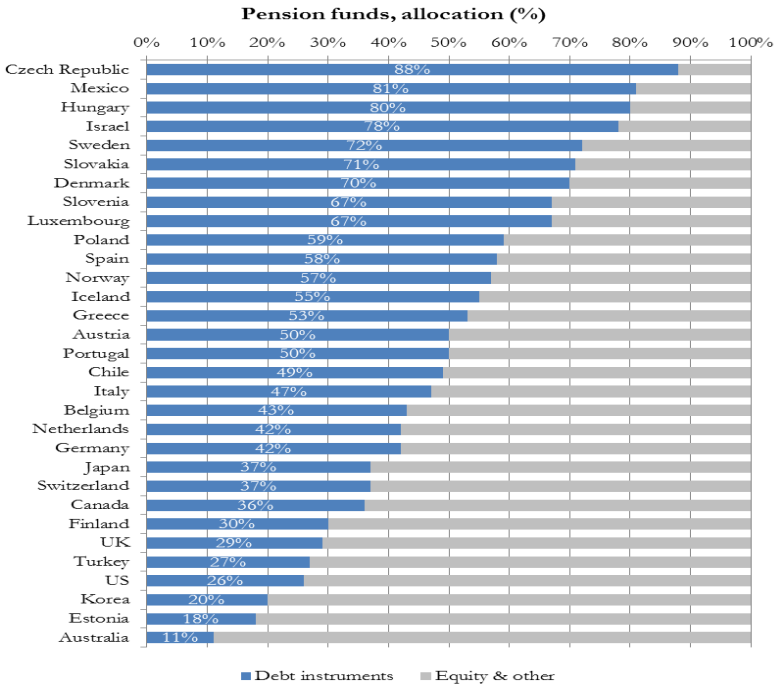
Green technology is a very broad concept and there are many different definitions. However it is important to stress that both mitigation and adaptation activities are included in the concept. There is not only a shift from dirty activities to green activities required but also the allocation of research needs to be shifted in the same direction (Aghion et al., 2009). Furthermore, it is important to find an efficient allocation between more short-term solutions that are focused on adaptation of existing technologies and long-term solutions that mitigate the problems altogether. This means that it is necessary to create various investment opportunities since investors have different needs and they need to be matched with the needs of the corporations that they are supposed to finance.

Investors have seemed to be concerned about the underinvestment in green technology and many of them have expressed that they want to use their investments to stimulate green growth. The earliest examples of this are mutual and pension funds that have specific mandates for investing in sustainable technology. The question is however, whether investors care enough about social welfare to accept lower returns. Researchers have shown that in most cases the return of ethical and conventional investments do not differ significantly. This is puzzling since then, the investors are not really showing any preference for social welfare and it points towards that they are simply maximising their returns under an additional constraint. Investors can only be seen as having a preference for social welfare if they are willing to give up some of their return in order for the investment to be ethical. Furthermore, it is likely that only a preference for social welfare can increase a sub-optimally low investment rate, since if the investments where good enough to return the market rate of return, they would have already been funded.

As mentioned previously, most of the risk-willing private capital is invested on the capital markets. Because of the substantial need for investment, capital markets financing of green growth can only be successful if instruments are designed to attract investors with a considerable asset base such as pension funds, sovereign wealth funds and insurance companies (Reichelt, 2010). This kind of investors often

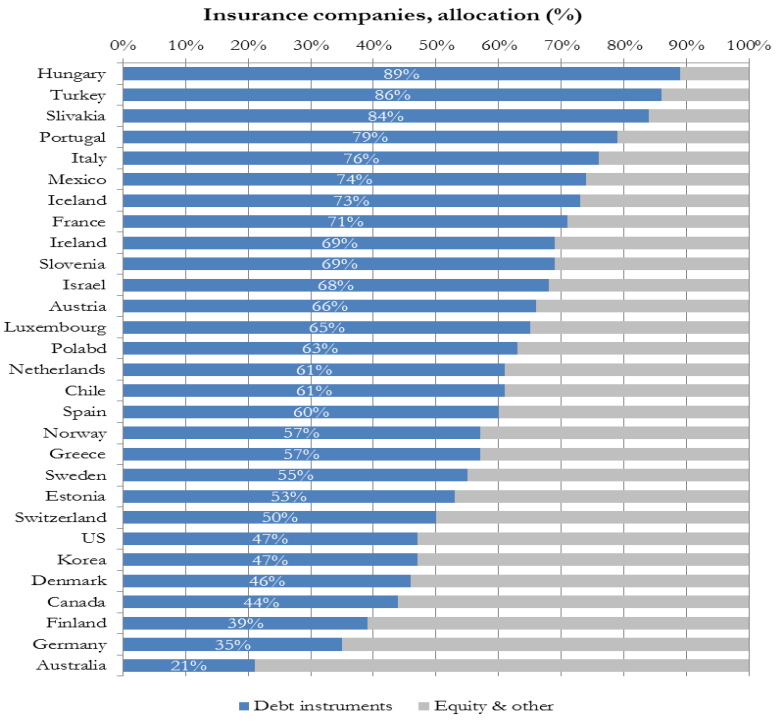
has a large part of their investments in debt instruments (see Graph 2.1 and 2.2 below) which is what makes green bonds particularly interesting.

Graph 2.1 Pension funds' allocation in bills and bonds



Source: Inderst et al., 2012 (own modification)

Graph 2.2 Insurance companies' allocation in bills and bonds



Source: Inderst et al., 2012 (own modification)

i. Behavioural literature

Although it is often assumed in theory that people are completely rational decision makers, there is an extensive body of research that indicate that we are only limitedly so (see Kahneman, 2011 for a good overview of cognitive biases). This irrational tendency has also been observed on the capital markets. For example evidence show that we are unwilling to realize losses and often stick to low-performing stocks instead of taking the loss and invest in something better-performing (Riple, 2013).

Behavioural economics and behavioural finance look at the psychological aspects of the decision making process of economic agents. Some of the evidence indicates that we are both altruistic and willing to incur costs to punish behaviour that we believe is unjust (Bazerman & Moore, 2013). For example, it turns out that we value fairness and reject low bids in ultimatum games (Riple, 2013).

Evidence contradicting the theory that humans are rational profit maximisers can also be found when studying the brain. In an experiment, scientists analysed neural activity in the brain when subjects made mandatory or voluntary transfers to a local charity. They showed that both the pure altruism (taxation) and the "warm glow" (voluntary transfer) type of giving elicited neural activity in parts of the brain that are linked to reward processing (Harbaugh et al., 2007)

If human beings are indeed only limitedly rational, a simple risk-return maximisation does not show the investors true preferences. Instead, we need to look at the investors' utility curves. If investors indeed have a green preference, adding the green label to a bond is going to shift or change the shape of their utility curve.

In economic language this means that an additional factor, which could be seen as a beta of a regression, exist in the utility curve that corresponds to the greenness of the bond. Since green technology is beneficial for society, an investor that values social welfare should see the greenness as a good. The question is thus whether greenness creates additional utility for investors, which would push the utility curve of the investor to the right if the investment is considered green. The existence of a shift in the utility curve is the central question of this thesis. Although this might sound abstract, on an individual level people make these kinds of decisions on an everyday basis.

Let us illustrate this reasoning with a practical example from regular life. Nowadays, we have organic and conventional produce in the grocery store and generally the organic product is more expensive. Sometimes the difference is a few percent but for some products the difference is much higher. According to economic theory, people would only buy organic products at a higher price if they are compensated for this by some other factor that increases their utility.

If we look at a hypothetical example with oranges we have that in terms of price:

1.5 kg oranges (conventional) = 1 kg oranges (organic)

Clearly, 1.5 kg of oranges is more than 1 kg of oranges, so why would anyone buy organic oranges? The answer is of course that there are differences between the oranges. Many people believe that organic products have different quality than conventional products, like tasting better and being healthier (Hoffman et al., 2014) but sometimes they are also perceived as less lasting (Menigo, 2015). The fact is that many people buy organic produce simply because it is better for the environment (Hoffman et al., 2014). This means that whether or not there are differences in quality,

U(1 kg oranges (conventional)) < U(1 kg oranges (organic))

Thus, the consumer is indifferent between conventional and organic oranges when:

U(O(p,q,S)) = U(O(p,q,S)) + U(Green)

Where O=orange
p = price
q= quantity
S= quality (vector of quality determinants)
Green = green preference

The capital markets case is slightly different and more complicated than in the example above because many investors do not maximise their own utility but the utility of the firm that they are employed or the utility of their customers. The idea behind green preference is however the same and this thesis is looking at whether the green bond market can give any evidence of the existence of a U(green) factor on the bond market.

III. The capital markets and the development of green bonds

i. The capital markets

The capital markets are market places that match risk-willing capital (investors) with corporate financing needs. In order to accommodate different types of needs, there are nowadays several different categories of investment products (Berk & DeMarzo, 2007).

The two main divisions within capital markets are the debt markets and the equity markets. The debt market, which mainly consists of bills and bonds, is the largest part of the market estimated at around $80 trillion which corresponds to approximately 75 % of the total market. The typical investors are large institutional investors such as pension funds, insurance companies and mutual funds. Individual investors represent a smaller share of the market compared to the equity market due

to minimum investment limits, called denominations, being relatively high. Another barrier for individual investors is the fact that bonds are traded over the counter (OTC) which requires that you have contact with a broker, either directly or through your bank contact.

ii. Green Bonds

Green bonds are a relatively new phenomenon on the market and were pioneered by the European Investment Bank and the World Bank in 2007/2008 when investors approached them about creating a green investment product. A green bond is a regular bond but has one extra constraint which is that the money raised from the bond (henceforth called the use of proceeds) can only be used for financing green projects and activities.

Due to initial inconsistencies in the utilisation of the term green bonds, The Green Bond Principles (GBPs) were developed by an industry group consisting of various market actors since they realised that the uncertainties lead to a lower credibility of the product. Green use of proceeds were thus defined and divided into eight non-exhaustive categories (ICMA, 2015):

- Renewable energy
- Energy efficiency (including efficient buildings)
- Sustainable waste management
- Sustainable land use (including sustainable forestry and agriculture)
- Biodiversity conservation
- Clean transportation
- Sustainable water management (including clean and/or drinking water)
- Climate change adaptation

The green bond market grew slowly in the beginning but reached $40 billion of new issuance in 2014 and for 2015 the new issuance volume is expected to more than double to reach $100 billion (Barclays, 2014). Furthermore, an encouraging development is that regular corporations have now started to issue green bonds, which was not the case a few years ago when the market was totally dominated by government related entities (Barclays, 2014). One could say that green bonds are starting to become mainstream.

Figure 3.1 Green bond market by sector of issuer, year end 2012

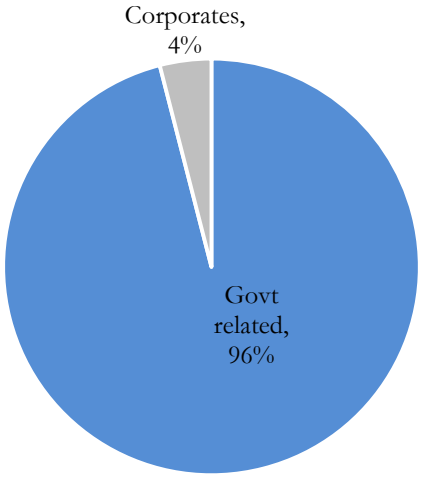
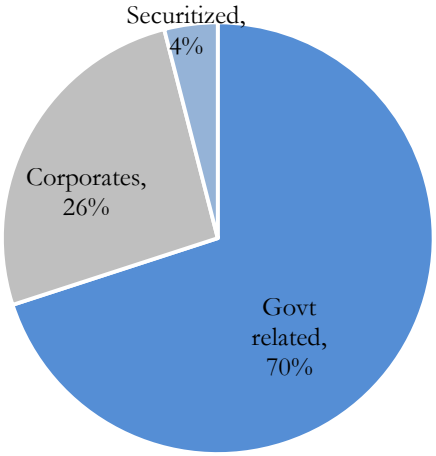


Figure 3.2 Green bond market by sector of issuer, June 2014



Source: Barclays, 2014 (own modification)

The process of issuing a green bond is very similar to regular bond issuances and the investment product has started to become relatively standardised. The additional requirements compared to conventional bonds are:

1. The issuers create guiding principles for their green bond issuance. This is normally a 2-page document that states what type of projects and activities that can be financed with proceeds from the green bond (see Vasakronan (2014) for an example of a standard document of this kind).

2. A ring-fenced account is set up specifically for the green bond(s) so that the financing of projects from the green bond are transparent and can be monitored. This is only necessary for issuers that also have activities that are to be considered non-green. Thus it is very important for commercial banks but not relevant at all for a renewable energy company.

3. A second opinion is created through an independent certifier. The assessment is not standardised but generally consists of a 5-10 page

document where the company's project profile and the industry sector as a whole is analysed. The company's environmental policies and own adaptations to difficulties with standards etc. is also discussed in order to assess the possibility for the company to ensure a high standard on their green activities.

4. A yearly investment letter is created where there are descriptions to the investors what kind of projects that have been financed through the use of proceeds.

It is important to understand that even though the money raised from a green bond can only be used to finance activities that are defined in the green bond principles as green, the money to pay the coupons and the payback of the principal investment at maturity can come from any cash flow of the company. The default risk of the bond is thus identical to a conventional bond of the same issuer (given they have similar strucutral features).

There are some additional costs involved in issuing green bonds (Climate Bonds Initiative, 2014). First, there is a fee to the third-party independent verifier that issues the second opinion about the bond (step 3 in the process above). Second, it is required that the bond is registered by the Climate Bonds Standard Board (CBSB) which costs one tenth of a basis point, i.e. 0.001% of the total bond. None of these costs could be considered to be a significant cost to the issuer. Apart from this, there are some costs associated with regularly providing information to investors and monitoring entities but these are also small and unlikely to discourage from issuing green bonds.

Hence, once the bond has been issued, the additional constraints of a green bond are:

- The limitation of the use of proceeds to green activities
- The creation of yearly information material to investors so that they can monitor their investment.

For investors, green bonds do not create any additional constraints since this is a commitment made solely on the issuers' side. However, if the investor is strict about monitoring the use of proceeds of the green bond, there will be some extra costs since they need to take time to read and analyse the projects that have been funded through the bond.

Incentives and motivation

What is the rationale behind green bonds? In order to understand the potential benefits of green bonds, it is important to define the different incentives and motivations for both issuing and investing in this type of bond. In other words, we

need to understand why this type of product is interesting from the perspective of the market.

The issuers' perspective

For the issuer, the activities or research that could be labelled as green development and financed with a green bond typically already exist in their corporate portfolio. Thus, it is not a major disruption in their usual business but it requires corporations to define what part of their business that could legitimately be considered green.

The motivation of the issuer could principally be divided into two main categories, financial and marketing reasons. The former consist of investor diversification, strategic motivations or if issuing green bonds are a cheaper means of financing. Marketing reasons could for example be to position and promote the company as a socially responsible corporation or a way to provide a service to important investors if they have green investment mandates that they would like to fill.

Most issuers and adviser point out that green bond issuances tend to attract new investors to firms which mean that the investor base is diversified and broadened. This could be beneficial from a cost perspective because it creates a bigger market for the firms bonds. Another way of exploiting a market diversification is to issue green and conventional tranches of bonds in order to find more market depth (i.e. to raise more money).

The investors' perspective

In section II above, some of the behavioural aspects of investing were discussed. However, there are many reasons why investors might choose to invest in a green bond and all of these are of course not irrational. As seen in the table below, there could be pure financial reasons why an investor would prefer to invest in a corporation that issues green bonds, for example, sometimes corporations that put a lot of effort in investing in green development are seen as safer in the long-term perspective because of expected shifts in technology or the possibility of stricter regulations.

Table 3.3 Motivations for green investing

Financial considerations	Extra-financial considerations	Reputational considerations	Compliance and fiduciary duty
Portfolio return criteria	Ecological	Of the investor and the investee companies	Domestic law and regulations
Portfolio risk criteria	Scientific	Pressure by politicians, media, NGOs etc.	International conventions
Portfolio diversification criteria	Ethical/Religious	Intangible asset such as community investing	Voluntary industry codes
Long-term risk considerations	Political/Social	Marketing tool	Disclosure regulation
Internalization of externalities	Other "norm" based		Good governance codes
	Double or triple bottom line		Part of fiduciary obligations

Source: Inderst et al., 2012

Although out of scope for this thesis, it is necessary to understand the idea of why green bonds could make corporations focus more on green activities. If green financing is indeed cheaper, corporations will have the incentive to shift their activities into projects that are green because of their lower cost of financing. Moreover, some green projects that previously had lower return on investment than the cost of financing might be possible to be realised if this cost goes down. Another possible effect that is true whether or not green financing is cheaper, is that green bonds forces corporations to earmark some of their money to green activities which could increase the size of the budget for these products. Last but not least, if commercial or development banks issue green bonds, they have a certain amount of targeted funding for green projects which in turn enhances the chance of getting financed for firms with green activities.

IV. Previous literature

Green bonds are a new phenomenon and despite the fact that several policy papers have been published by investment advisers and sovereign agencies, there have not yet been any academic studies in the subject. However the literature on bond pricing and ethical investments in general is more developed and can be used to find a suitable methodology for investigating green bond yields. This section will summarise

the relevant part of this literature and draw some conclusions regarding the suitable methodology for this thesis.

i. Bond spreads

Modern portfolio theory is a line of theory that attempts to explain asset prices and construct optimal investment portfolios by maximising return at different risk levels. Markowitz (1952) claimed that all investors aim at achieving the highest possible return at a given risk level. Mogdliani and Miller (1961) developed this into the theory of the rational investor. This article assumed perfect information and that all actors where knowledgeable about how to maximise their return. Sharpe (1964) used the same ideas to create the capital asset pricing model (CAPM) which gives a simple relationship between the values of all securities on the capital markets. According to these theories, diversification of assets leads to the elimination of idiosyncratic risk which means that the investors need only to get compensated for the exposure to the systematic (market-wide) risk.

The literature on the drivers of bond spreads is tightly connected to modern portfolio theory and was pioneered by a seminal article regarding the optimal capital structure written by Mogdliani and Miller (1958) in which the authors set up the foundations for the valuation of firms in a world of uncertainty. Optimal leverage structure has been quantitatively investigated by Brennan and Schwartz (1978) and Fama and French (1993) extended this to model common risk factors in the returns of stocks and bonds where they show that some balance sheet measures explain part of credit spread differentials.

However, it has been shown that structural bond pricing models lack accuracy (Eom et al., 2004) This could be due to restricting assumptions that biases the estimation results. For example empirical studies have shown that the traditional Black-Scholes (1973) model and the extension by Merton (1974) underestimates credit spreads due to the assumption that default only occurs when a firm has exhausted all its assets (Longstaff & Schwartz, 1995). However, most models tend to over predict bond spreads on average, especially for bonds from firms with high leverage (Eom et al., 2004).

Corporate bond spreads

Following this, it is clear that there is no real consensus in what the excess spread of corporate bonds compared to government bonds consists of. Default risk (and the expected loss given default) is the most intuitive part of the excess spread and the effect of this factor can be estimated through the credit rating. Nevertheless, the extent to which this parameter explains the bond spread is debated. What all researchers seem to agree upon is that default risk does not explain all of the spread. Other factors that are commonly acknowledged to have explanatory power are:

- Tax effects: government bonds are often taxed differently to corporate bonds and some studies (e.g. Elton et al. (2001)) find that the tax effect is indeed very important in a data set with US bonds.

- Risk premium: corporate bonds are relatively more risky than government bonds and if this risk is systematic rather than diversifiable (as is the conclusion of Elton et al. (2001)) investors will demand an extra premium for holding this risk.

- Liquidity: some researchers argue that liquidity issues are more important than the two factors above (e.g. Chen et al. (2007)) for example since some investors such as asset managers are reluctant or cannot hold illiquid bonds due to requirements of marking their portfolios to market.

Studies that empirically investigate differences in bond spreads normally use OLS estimation with panel data. This is a good methodology if you have large sample size (which is unfortunately not the case when it comes to green bonds). An example of such a model is the one proposed by Chen et al. (2007) that includes a liquidity measure, with the rest of the model building upon bond yield determinants from Elton et al. (2001).

$$
\begin{aligned}
Yield\ Spread_{it} \\
= \alpha + \beta_1 Liquidity_{it} + \beta_2 Maturity_{it} + \beta_3 Amount\ Outstanding_{it} \\
+ \beta_4 Coupon_{it} + \beta_5 Treasury\ Rate_{it} \\
+ \beta_6 10Yr - 2Yr\ Treasury\ Rate_{it} + \beta_7 EuroDollar_{it} \\
+ \beta_8 Volatility_{it} + \beta_9 Bond\ Rating_{it} \\
+ \beta_{10} PreTax\ Coverage\ Dummy_{it} \\
+ \beta_{11} Operating\ Income/Sales_{it} + \beta_{12} Debt/Assets_{it} \\
+ \beta_{13} Debt/Capitalization_{it} + \varepsilon_{it}
\end{aligned}
$$

The advantage of an OLS model is that it is simple, has a large body of research that discusses suitable determinants and if correctly implemented, it could be used to draw general conclusions. Green bonds are very similar to conventional bonds in terms of structure so there is no reason to believe that they differ significantly in terms of explanatory factors but if a green bond dummy is to be included in a standard OLS, it would be extremely important to argue for why they do not correlate with the other determinants and the error term in order for the estimate to be considered unbiased.

Furthermore, there is no solid theory behind the determinants in the equation above and there is also a lack of consensus about the mechanisms behind the effect on yield

spreads that these determinants are assumed to have. This makes it difficult to interpret results and also raises various questions. For example, it is questionable whether some of the determinants included in the regression, like the EuroDollar dummy and the various Treasury rates are equally relevant for bonds with different currency denominations. In the end, this might require that only a single currency is used which is not a suitable strategy if the sample size is limited. Data availability would further decrease the sample size since this method requires access to a large variety of data, of which each represents a risk to biasing the estimates if they are measured incorrectly.

Last but not least, green bonds are a fairly recent phenomenon but since financial data is collected daily, it is possible to obtain quite a few observations. Some of the other terms in the estimation are however only observed on a much more uncommon basis. This is especially true for the three last terms of the expression, derived from the Fama-French (1993) model, which could be observed quarterly at best.

Modelling the yield curve

Another feasible method is using a Monte Carlo simulation in order to forecast the yield curve of conventional bonds and green bonds respectively. This method was pioneered by Nelson and Siegel (1987) (and thus called the Nelson-Siegel model) and was refined by Diebold and Li (2006). The assumption of the model is that the yield curve can be simulated using an equation. The original Nelson-Siegel (1987) proved adequate for estimating the term structure of US Treasury bills. The data utilised consisted of 37 samples of yield and term to maturity observations collected between 1981 and 1983. Since green bonds are very similar in terms of structure, coupon and costs, and as long as the issuers are matched for the respective yield curves, there is no reason to believe that they should have a different representation than for conventional bonds.

The advantage of using a simulation is that unlike OLS it is not necessary to identify parameters that affect bond yields. However, the green bond market is immature and the bonds that have been issued have been mainly issued in the time span between 5-10 years which means that we do not have data for estimating the longer maturity range of the yield curve. Since it is also necessary to have several bonds from the same issuer, it would only be possible to use this method on two of the issuers because of the limited data availability, and even then, the data quality would be relatively poor. The yield curves could also be estimated on the whole market but that would require even better data availability.

Additionally, the issuers that potentially have enough bonds outstanding are supranational agencies and these issuers are very special since they often have high

ratings (AAA-AA) due to government guarantees. Thus, no general conclusions could be drawn if this method were to be used.

ii. Speciality bonds

Speciality bonds are a subgroup of bonds that are tailored to fund a certain type of project such as green bonds, catastrophe bonds and SRI bonds. As mentioned earlier, there are no academic studies performed on green bonds, which is why it is interesting from a methodological perspective to look at research on other speciality bonds to find a suitable empirical strategy.

The most developed type of speciality bond is the sukuk bond which is a sharia compliant investment product that has a very similar payment structure to bonds. They require a principal investment and pays interest during the term of the loan but the difference from conventional bonds is that they consist of partial ownership of assets, that could be physical assets, projects, businesses, debt etc. which means that the interest is not paid on the money (which is prohibited according to sharia law) but on the share of the asset. Although sukuk bonds are conceptually very different from green bonds, the literature within this field is relevant from a methodological perspective.

Ariff et al. (2013) uses matched samples of conventional and sukuk bonds in the Malaysian market and find that the returns of these bonds differ significantly and also find that there is no Granger causality between the two. They thus conclude that despite the structural similarities, sukuk and conventional bonds should be seen as two separate securities and that bond pricing models need to be modified in order to price sukuk bonds correctly.

However Uppal (2014) criticises this study arguing that matching is difficult due to the different structures of the bonds citing "marked difference in the structuring, placement, collateral, issuance costs, liquidity and bankruptcy cost of sukuk and the conventional bonds". The author also criticises the use of Granger causality since the data used is recorded monthly which means that cross-serial correlations cannot be expected since the market should adjust much quicker to new information. Instead, Uppal investigates 49 fixed rate sukuk bonds on a more global scale (12 markets) and compares them to US treasuries with one year constant maturity. Using a Vector Error Correction (VEC) model it is shown that conventional bonds and sukuk bonds are co-integrated and the conclusion is that the market prices both types of bonds similarly.

The structural differences highlighted by Uppal (2014) between sukuk bonds and conventional bonds needs to be addressed if the matching technique is going to be used. When we look at the objections raised against matching sukuk and conventional bonds, we can draw the conclusion that green bonds seem to be much more similar to conventional bonds.

structuring – no difference if matched correctly

placement – unclear what this entails, seems to be geographical location but it does not say whether it is of the investor or the issuer. In any case, it is probably more relevant to sukuk securities because they are mostly issued out of Muslim countries and bought by investors specialised in Islamic finance.

collateral – no difference

issuance costs – green bonds have marginally higher issuance costs

liquidity – might be a difference (could check in data)

bankruptcy cost – no difference

This indicates that the objections should have marginal impact and be unlikely to significantly bias the results when matching conventional and green bonds.

iii. Ethical (mutual) funds

Ethical mutual funds (sometimes called socially responsible investment (SRI) funds) are similar to green bonds for different reason than sukuks, namely they also share the idea of investing in sustainable development. Ethical funds have their origin in the 1960's when the interest for equality, labour and civil rights issues increased due to the political climate. Nowadays, ethical funds have assets of several trillions of dollars and are generally concerned with climate change. Due to the long history of ethical funds, several studies have looked at the difference in the performance of ethical versus conventional mutual funds but most of the studies do not find any significant differences (see e.g. Hamilton et al. ,1993; Statman, 2000).

There have been several matched pairs studies with one example being Kreander et al. (2005) that looked at 60 European mutual funds (30 pairs) that were matched on age, country of investment, size and investment universe. Renneboog et al. (2008) also used the matched pair method, matching on age, size, fees and risk exposure. They find that ethical fund performance is lower than for conventional funds but only significantly so for France, Japan and Sweden.

Bauer et al. (2005) investigates the same issue among ethical mutual funds from the UK, US and Germany. They use a modified version of the matched pairs test where 103 ethical funds are matched with the average of three matching conventional funds each in order to minimise the risk for individual differences. The results showed that ethical funds had a catching up phase when they underperformed but the returns converged to the same level as for conventional mutual funds.

Although green bonds are different from ethical mutual funds, there are several insights to draw for the continuation of this thesis. First, matching seems to be the preferred method for looking at differences in returns because of the unobserved differences that might exist between funds. Second, the results indicate that there might not be any differences in returns and furthermore, that results obtained might be caused by market immaturity which means that the spread differentials could reach a different level (or cease to exist) in the steady state.

V. Empirical strategy

I. Bond valuation

A bond can be structured in several ways but is basically it is a contract where the bond holder lends money to the bond issuer and expects to get the principal (the amount lent) back at a certain date in the future, called the maturity date, and receive interest payments, called coupons, at a fixed frequency (that could be zero) in the meantime.

In its simplest form, bond valuation is an ordinary net present value calculation of the expected cash flows from the bond and the value of the principal at maturity (Berk & DeMarzo, 2007 p. 225):

$$P = \sum_{n=1}^{N} \frac{C}{(1+i)^n} + \frac{M}{(1+i)^n}$$

Where P = bond price
C = the coupon payments which correspond to regular interest payments for bank loans.
i = (required) yield of the investor.
M = the principal investment, which corresponds to the borrowed amount. A bond is normally not amortised so the full amount is repaid at the maturity date.
N = the number of coupon payments

For bonds with fixed coupons, this is a very straightforward calculation. However, in reality, bond pricing is not that simple since the required yield is hard to estimate and varies according to the risks associated with holding the bond. In a world where there are uncertainties about future interest rates and the financial viability of firms these risks could be substantial and translates into credit spread differentials on bonds with similar contractual structures.

Since the coupon and the principal investment are agreed upon in the initial contract, the only factor that changes with time is the required yield, i. If investors indeed have

a green preference this would affect the price of the bond through its effect on i since any green preference in the utility curve would lower the required yield of the investment.

II. Bond yields

Even though the bond price is what the investor pays for the bond, bond prices cannot be used to compare bonds with each other (Berk & DeMarzo, 2007 p.228-229). This is because a bond has fixed coupon payments *C* (or in the case of a floating bond a fixed spread over an index) and a fixed principal amount at maturity *M*. Thus the cash flows from the bond never change and the factor that fluctuates is required yield *i*. The yield corresponds to interest rates on bank loans and is the return that investors demand in order to lend the money to the issuer.

The relationship between bond yields and bond price is inverse and the intuition behind this is that when the price goes down, you pay less for the same pre-determined future cash flows i.e. the yield is higher.

There are several yield measures such as yield to maturity, yield to call and yield to worst. The most commonly used measure is yield to maturity which is the annualized return on the investment assuming that all coupon payments are re-invested at the same rate (Bodie et al., 2011, p.479). The measure assumes that the investor holds the bond until maturity and that all cash flows are paid out on time with no default. The fact that green bonds do not have complicated structural features such as call options etc. makes yield to maturity the most appropriate measure for the value of the bond.

III. Matching

The previous literature on sukuk bonds (e.g. Safari, 2012) and ethical funds (e.g. Renneboog et al., 2008) suggest that matching is the preferred technique when looking at differences between special and conventional types of investment. As explained above, it is an appealing method due to the relatively limited amount of outstanding bonds.

The number one strength of utilising the matching pairs technique is that it accounts for unobserved differences between issuers. Furthermore, if there are unobserved differences in the bond structures (such as differences in legal jurisdiction etc.) they are more likely to differ between issuers than for different bonds by the same issuer. This is because bonds are usually issued from "programmes" that could be seen as contractual frameworks. Additional terms such as green bond principles can just be added to this pre-determined "programme".

Unlike equity, bonds are not completely standardised instruments and there are certain factors that can be varied in order to match issuer and investor needs. These factors can have impact on the price, liquidity and volatility of the bonds. In order to

find suitable matches between green and conventional bonds, it is therefore important to understand the main characteristics of bond structures which are outlined below[1].

Issue size

The issue size is important for both equity and debt investors since small issuances are likely to be less liquid than larger ones. Illiquidity is a problem since prices are likely to be more volatile and because it could lead to delays in getting out of a position in the stock or bond.

Small issuances could also be tailored specifically for certain investors which usually indicates that the bond is for buy-to-hold purposes i.e. the investors that initially buy the bond will hold them until maturity. Then, there is no price data since the bond was not traded. Furthermore, they could be tap issues (additional issuance from an existing bond) that have not yet integrated with the original issuance which means that they eventually will merge with another bond in the data set.

However, the most important reason for eliminating small issuances from the data set is the risk that the price data might be wrong, something that is less of a problem when analysing equity prices. This is because, unlike stocks, bonds are traded OTC, so when you buy a bond you always call your bank or broker and they will then re-check the prices at which the seller is willing to sell. Thus, the seller does not have to commit to the prices shown on the screen as is the case with the stock market which means that bond prices are seldom adjusted unless there is some trading activity going on in the bond.

Credit Rating

The credit rating is an assessment of the default risk usually made by a credit rating agency. Since ratings are costly not just in terms of fees but also in terms of managing the paper work for rating agencies, they are avoided as much as possible. Instead, shadow ratings could be made from the issuers advisor (normally a bank or corporate finance firm) that indicate what the likely rating of the company had there been a formal rating. These ratings are of course less reliable than a formal rating since the shadow ratings are made by the same banks that market that take the bonds to the market and many investment professionals therefore use them with caution.
There is a big divide between bonds that are rated BBB- and lower, called high-yield bonds, and those that are rated between AAA and BBB, investment grade bonds. Since many fund managers do not have mandates to invest in high-yield bonds, the market depth (i.e. the amount of money that could be raised) can be significantly lower if the bond is given a non-investment grade rating. The market for high-yield

[1] This section goes through the fundamentals of bond structures and is loosely based on Berk & DeMarzo, 2007 and Bodie et al., 2011. For a more thorough overview please refer to these books.

bonds is relatively developed in the US but is still immature in many European markets, which leads to higher risks and liquidity issues.

It is important to add that a rating, neither formal nor shadow, is to be considered as a guarantee of the credit quality for the firm or bond, something that became evident in the Global Financial Crisis of the late 00's. In the aftermath of the crisis, several market actors have become sceptical about the methodologies and the incentives of the credit rating agencies but have not changed the fact that ratings are still a very important consideration for institutional investors.

In this thesis, the issuer is one of the matching criteria, which eliminates the possibility of the issuers being of different credit ratings. However, the individual bonds could be of different credit quality which could lead to discrepancies in their ratings. Since most bonds in the data set are not rated, it is important to make an assessment whether this would have been likely. Practically, this is done by matching the collateral type of the bonds (see next page for more about collateral type).

Maturity

A longer the maturity of a bond means that the investment is riskier because it is more likely that the interest rate environment changes and affects the value of the bond. Thus the longer maturity a bond has, the higher the required yield. This means that the maturity date of the bonds is an important matching criterion in the coming analysis in order to ensure that the bonds have the same risk level.

Coupons

The interest payments on bonds are called coupons and are naturally a key component in determining bond yields. Coupons can either be fixed and pay a certain dividend per year or pay a floating dividend, called Floating Rate Notes (FRN). In Europe, FRN means that the coupon payment is fixed at a certain rate over or under the 3-month Libor rate but the benchmark indices vary depending on the geographical market. FRNs are more difficult to analyse since interest rates always fluctuate and many empirical studies exclude FRNs because of this.

Most coupon payments are made semi-annually but the coupon could also be paid with a different time interval. Coupon payments that are due more frequently are considered less risky because there is less chance of default between the payments. Furthermore, the time value of money makes interest payments more valuable if they are frequent because it means that the next payment is due sooner. It is therefore important that bonds are matched with the same coupon type and pay out frequency.

Collateral and Seniority

Bonds can have different seniority in the case of a default, with the most common categories being (senior) unsecured and subordinated. A bond can also have collateral, which means that certain assets are pledged to protect the claim. In the

European market a common form of a bond with collateral is the covered bond, which is a bond that is connected to a certain pool of assets that the bond holders can pledge in the case of a default. Covered bonds are generally seen as very secure investments meaning higher ratings and lower credit spreads but this is naturally dependent on the quality of the assets pledged.

Collateral and seniority are important structural factors that can affect the credit spreads significantly, especially for issuers with lower credit quality. In the case of green bonds, the vast majority of bonds are senior unsecured or unsecured and all other bond types should therefore be eliminated from the analysis to ensure consistency.

VI. Data

The time series data was retrieved from Bloomberg on March 17, 2015. There were then 274 active bonds that were labelled as green on the total market. Since bond data is registered manually, there is a potential risk that some of the entries are incorrect, but a quick cross-check with the list on the Climate Bond Institutes list of green bonds verifies that the data is accurate. None of the papers in the literature review have a detailed specification about the process of how bonds were matched or eliminated from their data sets. Therefore the elimination process below my own based on the structural characteristics of bonds that have been pointed out in the literature as being important to match.

Zero coupon bonds (2 bonds) and other bonds that have irregular or complex coupons (25 bonds) were excluded from the data set because the effect on the bond pricing is unclear. After some consideration, the floating rate bonds (32 bonds) were also eliminated since they have a different yield measure than fixed coupon bonds and the data quality was poor. Furthermore any bonds that include some kind of collateral were excluded as well (2 bonds). No bonds in the sample are subordinated which leaves us with a sample that consists entirely of senior unsecured or unsecured bonds.

The matching of the bonds was done manually by looking at the issue date, coupon type and frequency and most importantly, by matching the maturity date. Naturally, some of the bonds do not have matching pairs which means that they have to be eliminated from the sample. After this procedure, there were 130 matching pairs left of which a few bonds had several different matches. In this case, data for both matching bonds were retrieved and the bond with the best data was chosen. When data availability was good for both bonds, the one with the closest maturity date to the green bond was chosen.

Since many of the remaining bonds were very small in terms of issue size (below USD 10 million), they were eliminated and the data set was reduced to 64 bonds. The limit is somewhat arbitrary since this would be a very small bond in some countries while it would be relatively normal in other jurisdictions. This limitation was necessary due to the reasons explained in section III. Although it seems like a big decrease in the number of bonds, in terms of volume, the reduction was less than 10 %.

The next step was to look at data quality of the time series data in order to assess whether the quality was good enough for a time series regression. The data is again obtained from Bloomberg and consists of daily price and yield (ask and bid) quotes from January, 2011 to March 19, 2015 but most of the bonds were issued later than the start date which means that there are not quotes for the entire time period. There were several bonds that lacked data on the bond yield which meant that a further 25 bonds had to be eliminated.

Each time series needs to have at least a month of data recorded (although the more the better) and this criteria led to the elimination of 10 bonds due to the lack of observations. A further 2 bonds were eliminated due to illiquidity. This left us with a final data set comprised of 28 matching pairs of bonds with time series data. Please refer to Appendix 1 for a list of the bonds accompanied with their Bloomberg identifier.

The sample size is relatively small compared to the initial size of the data set but is in line with Kreander et al. (2005) that looked at 30 pairs of matching funds and Ariff and Safari (2012) that used 49 pairs of sukuk bonds. The data set is however much smaller than the Bauer et al. (2005) data set of 103 pairs of bonds and the sample size is a part of the methodology that could be improved upon once data availability becomes better. However, at this point in time, it is difficult to argue for keeping any of the bonds that have been eliminated according to the criteria above.

VII. Results

The summarized data shows that the mean yield for green bonds seems to be slightly higher than for conventional bonds. The same tendency can be seen for the 95% confidence interval in which green bonds are slightly higher on both sides.

Table 7.1 Summary statistics yield (%), full data set

	Mean	Standard error	Standard deviation	95% Confidence Interval		No of obs
Green	2.8588	0.6284	3.3253	1.5694	4.1483	28
Conventional	2.7814	0.6064	3.2089	1.5371	4.0257	28

In order to investigate the hypothesis of whether a more mature market will tell a different story, a subset consisting of only data from 2015 was also analysed. The summary statistics paints a similar picture as the full data set with the mean yield for green bonds being higher than for conventional bonds. Both of these summary tables give an initial indication that rather than showing the existence of a green preference, it seems like green bonds are actually penalised by the investors and that they give higher yields for the same type of bond.

Table 7.2 Summary statistics yield (%), 2015 subset

	Mean	Standard error	Standard deviation	95% Confidence Interval		No of obs
Green	2.5333	0.6533	3.4572	1.1928	3.8739	28
Conventional	2.4575	0.6450	3.4130	1.1341	3.7810	28

From the hypotheses defined earlier in the thesis, we have that the null hypothesis is that there are no differences in the means of green and conventional bonds. The earlier alternative hypothesis was that the difference is negative due to green preference. In this case, a one-sided alternative hypothesis could be used. However, the summary statistics above indicate that the opposite might in fact be true and thus, the alternative hypothesis is defined as two sided.

$$H_0: Yield_{Green} - Yield_{Conventional} = 0$$

$$H_A: Yield_{Green} - Yield_{Conventional} > 0$$

$$H_A: Yield_{Green} - Yield_{Conventional} < 0$$

In order to investigate whether the differences seen in the summary statistics are significant, matching pairs of bonds were first tested in pair-wise dependent samples t-tests. Since the time series are relatively long, the data was conclusive and the null hypotheses that the differences in the mean yield equalling zero were rejected in all but one case. In 21 cases the yield difference was positive at the 1%-level, which means that green bonds traded at a discount. In the remaining six cases, green bonds were cheaper and traded at a premium (for the results of the individual t-tests, see Appendix II). This was also significant at the 1%-level. Furthermore, testing for differences in volatility showed that the null of equal volatility could not be rejected for any of the matched pairs. The number of observations was good for the individual t-tests apart from one series that only had 24 observations (although this series still gave a significant result). The remaining series had a range of observations between 102 and 739 observations (see Appendix II).

The six pairs that showed significantly lower spreads for green bonds (and thus indicating a green bond premium) consisted of five supranational bonds (83.3%) and one corporate bond (16.7%) from the real estate industry. This corresponds well to the share of corporate bonds in the sample (17.9%). The bonds were mixed in terms of currency with three EUR bonds, one NZD bond, one ZAR bond and one SEK bond. This is not consistent with their respective share in the sample but it is hard to draw any conclusion from this due to the small number.

We then looked at a matching pairs t-test that uses just the means and not the entire time series data. Although this leads to dramatically fewer observations, it reduces the risk of bias due to potential errors in the data. Since the pairs are matched pairs are the dependent sample t-test has to be used.

Table 7.3 Matched t-test results

	Yield		**Volatility**	
	Full data set	2015	Full data set	2015
Mean difference	0.0774	0.0758*	-0.0225	-0.0303
	(0.0539)	(0.0442)	(0.0316)	(0.0287)
Observations	28	28	28	28
Bonds * days	8495	1523	8495	1523

*significant at the 10% level

For the full data set, the results show that there are no significant differences between green and conventional bonds. However, if we look at the data for only 2015, the mean difference is significant at the 10%-level. Again, the result is showing that conventional bonds have lower yields and thus are cheaper than green bonds. Investors thus seem to have a preference for conventional bonds compared to their green counterparts. Given that the mean yield is 2.5% the size of the difference is not substantial but definitely shows that there is no evidence of a green preference.

Thus, the individual t-tests (that is the more correct method in this case) are conclusive, and the small sample show the same tendency which means that we have strong case in favour of conventional bonds. Thus we reject the null and conclude that conventional bonds on average have a lower yield requirement.

We then proceed to the second hypothesis which has a null of no difference in volatility between green and conventional bonds. A matched pairs test was performed on the difference between the standard deviation of the two types of bonds both using the whole data series and the small sample as in the case with the yield differences. The results show that there are no differences in the standard

deviation at any relevant significance level and the results are similar for the individual t-tests, the full data set and the 2015 subset. Thus the null of no differences in volatility cannot be rejected.

To assess the robustness of the results we need to look at the key assumptions that the matching pairs t-tests rely upon (Lund & Lund, 2015):

A. Continuous data variable
B. The independent variable should consist of two categories that are related or matched
C. The sample of pairs is a random sample of the population
D. Differences between the pairs should follow a normal distribution, i.e. no outliers or significant differences in the distribution of data points. This is not as important when the sample size is large since it is rather a question of statistical power rather than one of accuracy.

The first two assumptions are unproblematic since the bond yield data indeed is continuous and as argued for above, conventional and green bonds indeed consist of matching pairs if matched correctly.

The third assumption is somewhat more problematic since the sampling for obvious reasons is not completely random. All bonds that have a suitable match, had a relatively normal issue size and had enough data were included in the data set. This does not necessarily mean that this assumption is violated but for the robustness sake we look at various descriptive characteristics and compare these with the original data set.

The comparison shows that some smaller currencies are lacking from the sample but the percentage of bonds denominated in more commonly used currencies like EUR or USD seems consistent. SEK bonds seem to be slightly overrepresented in the sample. Industry type looks similar although supranational agencies are overrepresented (78% compared to 67%) and financial services are underrepresented (3.5% compared to 15.3%) in terms of number of bonds. However, in terms of volume this is not an issue since this difference is driven by 34 issuances made by Credit Agricole that were eliminated from the data set due to their very small issuance volumes. Eliminating these, financial services corresponded to 3.3% of the bonds issued which is very close to the share in the sample. Credit ratings mainly follow the industry types and thus do not show any significant differences. Thus it looks like there is no indication that the population and the sample differ significantly and thus should be considered sufficiently random.

The last assumption can be checked by searching for outliers and by performing a normality test for the differences of each matching pair. The time series data seem to follow one another smoothly and there is no evidence for outliers. However, when

testing for normality of the differences using the Shapiro Wilks test, the null of a normal distribution of the differences was rejected for all the time series and for all relevant significance levels. Since the result is so strong, I decided to use the Wilcoxon Sign-Rank test that is a better test when the distribution is severely non-normal (McDonald, 2014). However, the results were identical to the matched pairs t-tests done in the first place.

VIII. Discussion/Robustness

i. Data and Methodology

When it comes to a matched pairs t-tests, the difficulty is always to ensure that the matching is adequate. All the bonds in the sample have fixed coupons, the same currency, collateral type, and credit rating and are matched according to issuer but there is always the possibility that unobserved differences exist. What can be said is that there are slight differences in the maturity dates. None of them is larger than six months but this could of course still affect the results. Unfortunately, due to the limited amount of matching bonds, it is impossible to find a perfectly matching pair of bonds.

Other methods could be used to investigate the same hypothesis and the most suitable for further research is modelling the yield curves of green versus conventional bonds for a few specific issuers. A weakness with this method is that the sample is largely going to consist of supranational agencies but it would still be an interesting exercise and would work out the problem with finding perfectly matching pairs. As the green bond market grows, the quality of data will increase for both this and the matched pairs method.

When it comes to evaluating green or social preferences on the capital markets, other approaches are possible such as comparing the returns of industry sectors that are relatively green with typically dirty ones. The main difficulty in this case would be to find comparable instruments.

ii. Other considerations

Green bonds are still a new phenomenon and the market is still immature which means that investors might not be certain at this point on how to trade these instruments. This means that the investors might change their strategies as the market matures which could lead to other results. As the market reaches more of a steady state, the spread differentials might converge to different levels.

There are still many issues remaining with green bonds. First of all, there is no real consensus on what constitutes a green bond. The GBP's are very diverse and does not eliminate the possibility of greenwashing. Secondly, there is no rating system for green bonds and therefore there is no way of assessing the greenness of a specific

bond unless you read the materials provided by the issuer. A rating would reduce the effort of information seeking for individual investors and would also enable a larger variety of green bonds (very green to not so green) and also help to prevent green bond requirement becoming too stringent and thereby stifling the market. These uncertainties and the cost to acquire the relevant information could contribute to the relatively higher returns required for green bonds.

As a side note, there are some questions regarding whether the bond market is actually the best alternative for targeting green technology investment. The bond market is interesting because it represents 75% of capital markets as well as because there are many large institutional investors that are heavily invested in bonds. These investors are more easily monitored and targeted by policies or regulation which creates potential for an implementation of such. Unfortunately, the characteristics' of bonds make them less likely to support new technology start-ups and innovations in companies that do not have other sources of cash flows to rely on. This is because bonds require regular interest payments which make stable cash flows a very important feature for a successful bond issuance. An innovative start-up that might have negative EBITDA are generally not suitable candidates to issue bonds.

With that said, the limitations are of course only true for firms that directly finance their activities through bonds, and development and commercial banks could make up for this by issuing bonds themselves and lend money to the smaller firms. Furthermore, bonds could still be important for adaptation of existing technology, emission reduction initiatives for transports and buildings and for companies that have other cash cow products. The bond market is thus more suitable for large corporations which to some extent will affect the type of green innovation that they can support.

IX. Conclusion

This thesis did not find any evidence of the existence of a green preference and most of the tests performed actually indicated the opposite - that conventional bonds are in fact traded at a premium. There is no evidence of a green preference and this is consistent with previous research on ethical investments. Thus the main conclusion of this thesis has to be that there is no evidence contradicting the theory of the rational return maximising investor – at least not on the green bond market. Furthermore, this difference between the bond types were not stemming for differences in volatility which indicates that the difference is not stemming from differences in risk (assuming that the matching was indeed adequate).

This is consistent with the finding that people on average are not willing to give up money on the pension in order to invest ethically (Elsässer, 2014). This observation is interesting since the willingness pay for ethical alternatives have been found on

various retail markets (see e.g. Bjørner et al., 2004). There are several possible explanations for this, for example in this case the consumer is not making the asset allocation themselves but leaves it to a professional that might have differing incentives. An interesting angle that focuses on the consumer could be the concept of mental accounting (Thaler, 1985). The model explains that people value money and make choices differently according to which mental account the money used booked on. Therefore, it could be the case that when it comes to our consumption account (now) we are happy to pay for green alternatives, but on our pensions account (tomorrow) we might be much more reluctant to do so. The existence of such behaviour could be a topic for further research.

This thesis also gave an indication of the limitations of assuming that creative investment products are going to stimulate investment rates in green technology. Many policy makers seem to believe that a lack of investment vehicles is one of the main reasons to the underinvestment in green projects (see e.g. Croce et al., 2011) and green bonds is said to be a way of solving this problem. Yet, bonds per se are not a new phenomenon and a substantial chunk of financing is therefore unlikely to just lay around waiting for a suitable bond product. If investors have no preference for green bonds, they are not likely to have a significant impact on green investment rates. That is, unless money currently not invested at all is invested or if projects that were previously not funded at all or were funded inefficiently are financed through these bonds. Unfortunately, I have failed to find any studies that look at the amount of such low-hanging fruit. Investigating the existence of such would be an interesting question for further research.

One area that could potentially benefit from green bonds is projects that are financed through development banks. This is because development banks aggregate the funding and a green bond locks the proceeds to be used solely for green projects which could lead to increased lending to these. Since development banks' main goal usually is about stimulating certain industries rather than pure profit green bonds could be a way of actively shifting their financing activities to green projects. However, these actors tend to already have a large focus on environment which renders doubt about the effect of a green bond compared to just issuing a conventional bond from the same development bank.

One point that is important to raise is that the market for green bonds is still immature and the investors' might not yet trust them to be good investment products. Thus there might be future potential for green bonds to become a cheaper funding alternative.

In any case, if the underinvestment in green technology is not a problem caused by the lack of investment vehicles but rather one of investors lacking opportunities giving adequate return, policy and regulations is the key to move forward. The

existence of a green investment product like green bonds makes it easier for governments to create targeted policies.

It is important to distinguish between policies that give direct support to green activities versus creating investment incentives. The problem with incentives is that you always get what you incentivise and because of the inflexibility and the time consuming process of implementing policies and monitoring them, policies can never keep up with technological innovation. This could lead to inefficient technology being incentivised because the technology existed at the time of the policy proposal but is no longer the most efficient solution. Some researchers, such as Milton Friedman argues that government failures are very common because of bureaucracy and less analytical capabilities. Investment is a more flexible target because there are many more actors in the market each with their own analytical capabilities.

If investment incentives are to be implemented, it is important that there is a system in place to monitor the sector and ensure that the risk of greenwashing is low. There are several ways in which governments could incentivise the issuance and investment in green bonds (Calder et al., 2014):

1. Create investment funds that invest all or a certain amount of their money in green bonds. This creates more demand and creates legitimacy for the green bond market, both of which could lead to lower financing costs for green projects (i.e. the bond will price tighter).

2. Provide guarantees (at state or municipal level) to green projects in order to enhance the credit ratings of the bonds issued to finance the project. This would also reduce the financing costs.

3. Create tax incentives for investors by treating green bonds more favourably than conventional bonds. Some tax incentive schemes already exist for example at municipal level in the US and a scheme in the Netherlands that targets individual investors to buy into a specific "Green Fund".

   On a regulatory (coercive) level, it might be possible to require national pension funds and insurance companies to invest at least a certain share of their fund in green projects. For example, in Sweden, this could be a requirement for being eligible as a choice for the PPM programme. Unfortunately most tools available for policy makers are blunt and they will only be efficient if they are implemented consistently and as a package solution. It is however essential that climate policy is addressed both through the stimulation of innovation and of the financing thereof.

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Appendices

Appendix I

List of bonds

AFDB G	EI4132177 Corp	AFRICAN DEVELOPMENT BANK
AfDB C	EJ8217048 Corp	AFRICAN DEVELOPMENT BANK
AFDB G	EJ3356411 Corp	AFRICAN DEVELOPMENT BANK
AfDB C	EK3697704 Corp	AFRICAN DEVELOPMENT BANK
AFDB G	EJ8766135 Corp	AFRICAN DEVELOPMENT BANK
AfDB C	008281BA4 Corp	AFRICAN DEVELOPMENT BANK
Agence FranceG	EK4611688 Corp	AGENCE FRANCAISE DEVELOP
Agence FranceC	EK2903962 Corp	AGENCE FRANCAISE DEVELOP
G?teborg G	EJ8568853 Corp	CITY OF GOTHENBURG
G?teborg C	EJ5888254 Corp	CITY OF GOTHENBURG
EIB G	EK0981200 Corp	EUROPEAN INVESTMENT BANK
EIB C	EJ5097013 Corp	EUROPEAN INVESTMENT BANK
EIB G	EJ1271687 Corp	EUROPEAN INVESTMENT BANK
EIB C	EK0161845 Corp	EUROPEAN INVESTMENT BANK
EIB G	EK4710878 Corp	EUROPEAN INVESTMENT BANK
EIB C	EK0369372 Corp	EUROPEAN INVESTMENT BANK
EIB G	EJ7525862 Corp	EUROPEAN INVESTMENT BANK
EIB C	EI7914977 Corp	EUROPEAN INVESTMENT BANK
IBRD G	EK3354868 Corp	INTL BK RECON & DEVELOP
IBRD C	EK1822395 Corp	INTL BK RECON & DEVELOP
IBRD G	EI7368026 Corp	INTL BK RECON & DEVELOP
IBRD C	EJ9215959 Corp	INTL BK RECON & DEVELOP
IBRD G	EI1567227 Corp	INTL BK RECON & DEVELOP
IBRD C	EJ3049610 Corp	INTL BK RECON & DEVELOP
IBRD G	EI1566864 Corp	INTL BK RECON & DEVELOP
IBRD C	EJ2027518 Corp	INTL BK RECON & DEVELOP
IBRD G	EI1567581 Corp	INTL BK RECON & DEVELOP
IBRD C	EJ1007289 Corp	INTL BK RECON & DEVELOP
IBRD G	EK2735083 Corp	INTL BK RECON & DEVELOP
IBRD C	EK4882107 Corp	INTL BK RECON & DEVELOP
IBRD G	EI1569702 Corp	INTL BK RECON & DEVELOP
IBRD C	EJ3001850 Corp	INTL BK RECON & DEVELOP
IFC G	EJ8740387 Corp	INTL FINANCE CORP
IFC C	EJ6958676 Corp	INTL FINANCE CORP
IFC G	EJ8740320 Corp	INTL FINANCE CORP
IFC C	EJ5818061 Corp	INTL FINANCE CORP
KfW G	EK3739316 Corp	KFW
KfW C	EJ7609716 Corp	KFW
Kommunalbank G	EJ9363940 Corp	KOMMUNALBANKEN AS

Kommunalbank C	EJ8535621 Corp	KOMMUNALBANKEN AS
Nederlandse G	EK3569374 Corp	NEDER WATERSCHAPSBANK
Nederlandse C	EK0370396 Corp	NEDER WATERSCHAPSBANK
NIB G	EJ8486791 Corp	NORDIC INVESTMENT BANK
NIB C	EJ7456704 Corp	NORDIC INVESTMENT BANK
NRW G	EK5698064 Corp	NRW.BANK
NRW C	EK3938470 Corp	NRW.BANK
Rodamco G	EK2966274 Corp	RODAMCO SVERIGE AB
Rodamco C	EJ9721097 Corp	RODAMCO SVERIGE AB
Unibail G	EK0810946 Corp	UNIBAIL-RODAMCO SE
Unibail C	EJ7063583 Corp	UNIBAIL-RODAMCO SE
Unilever G	EK1269761 Corp	UNILEVER PLC
Unilever C	EH8631622 Corp	UNILEVER PLC
Vasakronan G	EK7559421 Corp	VASAKRONAN AB
Vasakronan C	EK7246912 Corp	VASAKRONAN AB
Vasakronan G	EK1272823 Corp	VASAKRONAN AB
Vasakronan C	EK0901711 Corp	VASAKRONAN AB

Appendix II

List of the number of observations used in each of the matched pairs t-tests and the t-values obtained when testing for mean differences for the full time period.

Bond	No of obs	T-test (difference of means)
AfDB 1	388	26.72
AfDB 2	177	67.91
AfDB 3	375	77.41
Agence France	136	-68.46
Göteborg stad	148	78.63
EIB 1	277	14.68
EIB 2	620	29.89
EIB 3	310	29.10
EIB 4	439	55.28
IBRD 1	199	48.82
IBRD 2	356	-38.16
IBRD 3	632	-12.22
IBRD 4	739	7.17
IBRD 5	598	-34.50
IBRD 6	132	25.51
IBRD 7	378	10.52
IFC 1	189	1.42
IFC 2	375	7.16

KfW	177	-17.65
Kommunalbanken AS	349	75.70
Nederlanse Waterschapsbank	190	49.87
NIB	185	60.09
NRW	102	15.27
Rodamco Sverige	206	95.38
Unibail-Rodamco	281	27.32
Unilever	261	118.84
Vasakronan 1	24	-11.27
Vasakronan 2	252	45.17