Green Bonds

Does the greenness of the bond impact on the bond yield?

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ABSTRACT
In this thesis the existence of the yield premium of green bonds is investigated. This paper complies with the instructions that were used in the analysis run by Zerbib (2018). The results of the fixed-effect panel regression confirm the hypothesis on which our paper is based on. We found a negative premium: the yield of the conventional bond is higher than the yield of the green bond.

Furthermore, this paper examines how the definition of the greenness of the bond is specified by various institutions and experts.

KEY WORDS
Green Bonds, Sustainable Finance, Green Bond Premium, Liquidity

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“Climate change is not an environmental challenge. It is a fundamental threat to economic development.”

-Jim Yong Kim- President, The World Bank
# TABLE OF CONTENTS

Abstract..............................................................................................................................................2
Key Words.............................................................................................................................................2
Acknowledgements..............................................................................................................................2

1. Overview ......................................................................................................................................5
   1.1 Aim ........................................................................................................................................... 6
   1.2 Structure .................................................................................................................................. 7

2. Literature Review .............................................................................................................................7

3. Background ...................................................................................................................................10
   3.1 Bonds .....................................................................................................................................11
      3.1.1 Bond’s maturity .................................................................................................................11
      3.1.2 Bond’s coupons ...............................................................................................................11
      3.1.3 Bond rating ....................................................................................................................12
      3.1.4 Bond’s duration ..............................................................................................................12
   3.2 Green bonds ............................................................................................................................12
   3.3 Green bond market ................................................................................................................13
   3.4 Risks ........................................................................................................................................14

4. How can we define “green”? .......................................................................................................15
   4.1 Background ............................................................................................................................16
   4.2 Principle and standards ..........................................................................................................18
      4.2.1 Green Bond Principles ..................................................................................................19
      4.2.3 Climate Bonds Standard .............................................................................................20
   4.3 European commission standards .........................................................................................21

5. Data description and matching method ....................................................................................22

6. Empirical methodology ................................................................................................................24

7. Analysis .......................................................................................................................................26
   7.1 Tests .......................................................................................................................................27

8. Discussion .................................................................................................................................29

9. Conclusion ...................................................................................................................................30

Appendix I .......................................................................................................................................31
Appendix II .......................................................................................................................................32
1. OVERVIEW

In this first part we describe the aim of our study and the structure of the paper. However, we focus on the concept of Green Finance which we are interested in. This is the reason why we decided to study in particular one financial instrument involved in argument: Green Bonds. Moreover, we briefly present the problems and benefits linked to green bonds.

Given the growing impact of a climate change, financing of the sustainable investments is becoming a significant topic, owing to the shortage of public funds. In this regard, the role played by the financial markets is relevant and has to provide ways by which funds can be assigned to investments intending to reduce climate change\(^1\). Nowdays, one of the most important concepts is the existence of the Green Finance which aids the transition to a low-carbon, more resource-efficient and sustainable economy\(^2\).

The Green Finance was born from the direct connection between ecosystem and financial markets through national and international green financial initiatives. One of the most relevant impacts of the connection between ecosystem and financial markets is the development of “green” financial instruments, such as “green bonds”\(^3\).

In 2007, a group of Swedish pension funds looked for a financial solution in which they could invested their savings mitigating the global warming\(^4\). One year later, was created the concept of Green Bond by Skandinaviska Enskilda Banken (SEB) and The World Bank to satisfy the demand of the investors for the climate-related opportunities. It is a financial tool which matches the characteristics of fixed debt securities with climate mitigation supplying to the market climate-related investment opportunities. Under the current problem of climate change, the green bond is an instrument that increases the participation of the industries in sustainable projects, processes and technologies with a level of transparency which permits investors to figure out the targets and diversify the risk\(^5\).

The behaviour of investors on the capital markets changed. Today they care about the goals of the investment which they are supporting. Hence, all issuers have to measure, report and control the social and environmental benefits which derived from the investment. Thus, the requirements for the green bonds, in which are included the definition of eligible projects, party opinion and reporting, are used for the progress of new financial tools, such as social bonds, blue bonds and other debt


\(^{2}\) European Commission

\(^{3}\) Trends in Ecology and Evolution, Galaz et al., October 2015


instrument which are issued for specific purposes. According to Bloomberg, the creation of new financial tools is possible by the increase in the demand of the green bonds on the market in the last years.

The interest of the investors in the social and environmental benefits of the investments represents an important change on the bond market, as consequence the issuer has to provide clear information to investors of the objectives underlying the project. The investors want to create social value and mitigate the risk of their portfolio, in other terms they want to measure their environment contribution. The green investments are attractive because they permit to obtain financial and environmental benefits.

As will be presented later, there is a lack in the regulation of the green bonds. Since there is a deficit in definitions of what “environmentally benefits” mean, different organizations developed standards to attract investors close to the green investments. Organizations tried to cover this problem by providing green label certifications which indicate a correlation to a specific definition of “green”. Institutions are working on the harmonization of the concept “green” to ensure transparency and safety to the investors on the market. Indeed, European Commission, supported by SEB, is going to present a plan in which they issue standards for sustainable concepts, starting with common taxonomy across countries. The meeting is going to take place in June 2019.

The crucial factor that encouraged our decision to analyse green bonds derived from the interest in bonds as an alternative financing way. Simultaneously, the interest that we nourish in the Green Finance derives from the fact that we are able to have a massive impact in the fight against climate change and global warming. The financial initiatives which are developing represent an important step for the future linked to different reasons, such as the evolution of the financial markets and the increase of the environmental benefits. Furthermore, the investors can build their portfolio including green investments which allow to hedge their position from climate risk.

1.1 Aim

The aim of the paper is to demonstrate the impact of the greenness of the bond on the bond’s yield, in other terms we are going to analyse the presence of a green premium. This study is based on the same assumptions as Zerbib (2018), in such a way we will be able to compare our outcomes with his previous study.

This paper aims to provide answers to the following questions:

- Does the greenness of the bond impact on the bond yield?

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• How does the market define “green”?

The hypothesis which we assume is the existence of the green bond premium. In our analysis we build the fixed-effect panel regression model to investigate if there is a green premium, in the following chapter we are going to explain the method used.

The research questions are solved by theoretical and empirical studies.

1.2 Structure

The second chapter is dedicated to the literature review of the topic of interest. The third section will present the background by giving definitions for all the characteristics of the conventional and green bonds, taking into account the risks of the bonds. Additionally, we will analyse the green bond market. In the fourth section we will answer the question of how we can define “green” considering the different principles and standards that are currently available at national and international level. Method, used to collect data on which the study is based is described in the fifth section. In the sixth section, description of the empirical model can be found. In the seventh section, we lay out the explanation of the research questions. The last section will conclude with the summary of our analysis.

2. Literature Review

In this section we analyse the impact of Corporate Social Responsibility on different variable in the literature. We considered this study for our analysis.

We consider all the studies which take into account the environmental management, or better the social responsible policy, how impacts on the cost of financing.

In the beginning, it is relevant to focus on the difference between CSR and CSP. In 1979 Caroll defined the CSR “a conceptual framework that includes the economic, legal, ethical and philanthropic or discretionary expectations that society places on businesses at a given point in time” (Caroll, 1979). The concept of Corporate Social Performance (CSP) is an extension of the concept of CSR, indeed the CSP is the targets that the company reaches by putting in place the CSR (CSR and CSP, Kolb, 2018).

Various authors discussed about the impacts of a corporate social performance (CSP) on the stock returns of the companies, in particular the social actions put in place by companies (Konar and
Cohen\textsuperscript{9}, Kempf and Osthoff\textsuperscript{10}, Semenova and Hassel\textsuperscript{11}, Statman and Glushkov\textsuperscript{12}). These articles did not reach a general opinion, although they suggest that the social actions positively affect the performance of the company. Additionally, other studies suggest that the cost of equity is affected negatively by high CSR (El Ghoul et al.\textsuperscript{13}, Dhaliwal et al.\textsuperscript{14}) or the environmental issues of the companies will influence the decisions of the investors, which implies reduction in cost of equity in relation to a high environmental profile of the firm (Chava (2014)\textsuperscript{15}, Sharfman and Fernando\textsuperscript{16}, Heinkel et al.\textsuperscript{17}). At the same time, Oikonomou\textsuperscript{18} et al. and Ge and Liu\textsuperscript{19} developed empirical studies both focused on the impacts of CSP on the credit rating of the bond and on the yield. They reached analogue results: overall CSR performance is related to a better credit rating and a lower yield spread. Bondholders value CSR performance more likely for the financially healthy firms than for the financially distressed firms and that bondholders are more likely to use CSR performance information to assess the creditworthiness of issuers with weaker corporate governance and worse information environments and those operating in environmentally sensitive industries\textsuperscript{20}. Moreover, Jiraporn et al. underlined that the degree of CSR of a given firm is affected by the average degree of CSR of geographically close firms, higher degree of CSR dues to better credit ratings. Additionally, the study suggests that there are variables such as peer effects, social interactions, and investor clientele that affect the decisions of CSR policies\textsuperscript{21}.

After analysing the effect of CSP on the cost of equity, economists study the impacts of CSP on the cost of debt. However, an equal solution was not reached; the results are different and divergent. Based on the hypothesis of a negative relationship between costs of debt, the firm risk profile and CSP, Magnanelli and Izzo\textsuperscript{22} investigated taking into account 332 worldwide companies during a...
period before the last financial crisis. The result suggests a positive relationship between CSP and cost of debt, opposite to their hypothesis of high CSP are inversely related to the costs of debt. On the contrary, Menz, investigating on the relationship between CSP and costs of debt, found that risk premium for socially and non-socially responsible firms is equal because the information added by the CSP rating does not influence the investor’s decision. His study is based on the European corporates bond market\textsuperscript{23}. Oikonomou\textsuperscript{24} et al. study 3000 bonds related to 742 firms, discovering that CSR irresponsibility are positively correlated to financial risks. Other studies are based on the relationship between corporate governance and costs of debt. Ghouma et al.\textsuperscript{25} investigated the Canadian bond market and discovered a negative relation between a bond spread and corporate governance: higher quality of corporate governance, lower bond spreads. They investigated on each individual component of overall corporate governance: only the structure of the board and the disclosure quality will influence the costs of debt, because these factors are considered relevant for the bondholders. Moreover, another study based on a relationship between the corporate governance and costs of debt, was developed by Klock et al.\textsuperscript{26} in which it was discovered that the US bond market views favourable the quality of corporate governance, firms with strongest antitakeover provisions are associated with a lower cost of debt. Moreover, Ge and Liu investigated on the effects of CSR on bond spreads: better CSR activities are associated with lower cost of debt. They found that bondholders mind more CSR performance of bond issuers that are socially responsible and take into account this information in their bond pricing\textsuperscript{27}. Hasan et al.\textsuperscript{28} (2017) studied the primary market in U.S firms; the results of the analysis suggest that firms located in U.S counties with a higher level of a social capital take advantage from lower at-issue bond spreads. Gross and Roberts examined the relationship between the CSR and a bank loan by using a sample of 3996 loans to US firms: the results underlining the difference in the costs of debt for firms non-socially responsible is higher than with the more responsible ones. Higher CSR difficulties are linked to a greater risk and higher spreads. The outcomes of the study suggest that lenders are more sensitive to CSR concerns when lending on an unsecured basis: banks consider CSR difficulties as the second determinant of the spread\textsuperscript{29}. Li et al. studied the impact of CSR, credit ratings and green bond certification using data of Chinese green bond market. One of the results explains that “certified green bonds with higher credit ratings or higher CSR scores have lower spreads and interest costs”. Moreover, demonstrated a relevant negative effect of higher issuer rating on green bond spreads. Li et al. (2019) argue about the certification of green bonds: after the assessment made by a third-party, green bonds have a low yield


\textsuperscript{24} Oikonomou, I., Brooks, C., and Pavelin, S., “The Effects Of Corporate Social Performance On The Cost Of Corporate Debt And Credit Ratings”, Financial Review 49, no. 1 [2014]: 49-75


\textsuperscript{27} Ge, W., and Liu, M., “Corporate Social Responsibility and The Cost Of Corporate Bonds”, Journal of Accounting and Public Policy 34, no. 6 [2015]: 597-624


spreads, because the certification ensures transparency in the information disclosure in the use of proceeds, potential risks and corporate governance.

So far, studies focused on the impacts of CSR of the issuer on green bond yields. However, it is important to underline the fact that the green bond is strictly linked with the sustainable project underlying. In this regard, we are going to focus on the comparison between a green bond and a vanilla bond of the same issuer. Climate Bonds Initiative (2017) underlines that the behaviour of green bonds is not different from other classes of bonds. Gianfrante and Peri\textsuperscript{30}, demonstrated that an existence of a green bond premium on the primary market is negative and statistically significant. In the study, authors used 121 senior bullet Euro-denominated green bonds issued between 2013 and 2017. Hyun et al. (2018) investigate how greenness is priced in green bond market. The outcomes underline that there is more pressure on the demand of green bonds certified rather than the non-certified ones, because of lower information costs, greater investor confidence and a scarce volume of green bond supplies. Indeed, if the green bond has a CBI certification or an independent review, the green premium is reduced. Furthermore, “EUR-denominated bonds show a negative premium compared with other currencies”. According to other studies, Ehlers and Packer (2017), using a cross-section of 21 green bonds issued between 2014 and 2017 with credit spreads at issuance of conventional bonds of the same issuer and as close as possible maturity, discovered that green bonds have a lower price that correspondent conventional bonds.

3. BACKGROUND

In this section we take two categories of bonds into consideration: corporate and green bonds. Indeed, the analysis of the characteristics of bonds and green bond is developed in line with all the variables that are needed in our empirical analysis. Moreover, there is a paragraph dedicated to the risks that affect bonds.

A green bond is a bond specifically intended to use in climate and environmental projects. These bonds are usually linked to assets and are backed by the issuer's balance sheet, also known as climate bonds. Green bond projects are supported to encourage sustainability. In terms of a climate change, green bond projects foster, for instance, the pollution prevention, sustainable agriculture, energy efficiency, fishery and forestry, protection of the aquatic and terrestrial ecosystems, clean transportation, sustainable water management and the cultivation of environmentally friendly technologies\textsuperscript{31}. Green bonds can be very attractive for investors thanks to tax incentives like tax exemption and tax credits, compared to taxable bonds. Taking into consideration the moral grounds, investors supporting


the social issues such as climate change can be held back and a movement to renewable sources of energy can be activated\textsuperscript{32}.

3.1 BONDS

A bond is defined as the security instrument issued by the governments and corporations to obtain money from investors, of which the latter will receive future payments. A bond is composed by different terms which are indicated in the bond certificate and explained in the following. The maturity date is the final date on which investors get their money back from the issuer. The term of the bond is the time remaining until the maturity date\textsuperscript{33}. Furthermore, there are two ways of payment regarding bonds: On one hand, the agreed interest payments of a bond called coupons; on the other hand, the principal or face value of a bond, the notional amount used to compute the coupons. The coupon rate, which decides the amount of each coupon, can be fixed or floating. Bonds are most commonly issued by the governments (treasury bonds), municipalities and corporations. In addition, bonds can be secured or unsecured. Secured bonds are for instance Mortgage bonds which are secured with property and bonds that are secured with any asset are known as Asset-backed bonds. Notes that have an original maturity less than 10 years and debentures which are a medium to a long-term debt instrument are both examples for unsecured bonds. The present value of all future payments together with the face value stands for the value of the bond\textsuperscript{34}.

3.1.1 BOND’S MATURITY

The maturity of debt securities is fixed at issuance and it is represented at the moment when the creditor receives the principal amount and the coupon. It is possible to distinguish different classes of the maturity short-term, medium-term and long-term. Respectively, in the first case the bond matures in 3 years; medium-term is when bond matures in 4 to 10 years; last class, bond has a maturity higher than 10 years\textsuperscript{35}.

Maturity can be seen as a risk measure. There is a positive relationship between risk and maturity, because a longer maturity displays the investment to uncertainty in the long-term. Indeed, bonds with higher maturity give a higher required yield\textsuperscript{36}.

3.1.2 BOND’S COUPONS

The interest payments provided by bonds are called coupons. The coupons can be paid in two different ways: yearly dividends during the investment period or a floating dividend. The payments can be annual or semi-annual, the latter exposing investors to a lower risk of default of the debtor.

\textsuperscript{32} Ibid.
\textsuperscript{33} Berk & DeMarzo, 2007
\textsuperscript{34} Berk & DeMarzo, 2007
\textsuperscript{35} InCharge debt solution, Bond101: Bond investment Basics, [https://www.incharge.org/financial-literacy/basics-of-bonds-maturity/ ]
\textsuperscript{36} Berk & DeMarzo, 2007
Moreover, short payments are preferred because there are factors such as inflation and variation of exchange rates that can affect coupons\(^{37}\).

3.1.3 BOND RATING

The cash flows of corporate bonds and bonds issued by companies are not known with certainty, thus investors are subjected to default risk. However, several rating agencies assess the creditworthiness of the bonds and provide this information to investors. The ratings give support to investors for the investment decisions and for the liquidity of the market. The most important rating agencies are Standard & Poor’s\(^{38}\) and Moody’s\(^{39}\). The rating table is divided in different classes for each corresponding level of exposure to default risk of the bond: higher rating, lower default risk\(^{40}\). The top grade is AAA and it means that the capacity of the borrower to meet its obligation is strong, the last grade is D which indicates the default: in the middle, there are different classes for each different level of default risk for the creditor\(^{41}\).

3.1.4 BOND’S DURATION

It is important to make a difference between maturity and duration. The former represents the length of time until the final repayment; the latter, on the other hand, is the weighted average time, taking into account the size and timing of interest coupons until the last payment. The duration is an important indicator for investors giving information about sensitivity of the bond in relation to variation of interest rates: with regard to an increase in the yield, the price of the bond will fall by an amount almost equal to the variation in the yield, multiplied by the duration\(^{42}\).

By valuing a bond, it is important to analyze the duration of the investment, because it is useful to compare different bonds. Due to uncertainty in the long-term interest rate, the risk of the investment is higher if the maturity is higher. This affects the value of the bond in a negative way. Nevertheless, the higher risk gives a higher required yield for bonds with a longer maturity.

3.2 GREEN BONDS

Green bonds are seen as a new form of a sustainable investment. Their sole purpose is to finance sustainable friendly projects. By issuing green bonds, issuers raise funds for environmental and social projects, for example in the areas of renewable energies, energy efficiency and water pollution control.

The World Bank, the European Investment Bank and the Swedish Bank SEB issued the first green bonds in the years 2007/2008. They were issued in order to create a green instrument on the debt market, to increase sustainable investing\(^{43}\).

Green bonds are mainly issued by multilateral organisations, but increasingly also by companies. The World Bank’s first green bond received strong market support. It raised awareness of the challenges...
of a climate change and showed institutional investors the potential of supporting climate-intelligent investments with liquid instruments without sacrificing financial returns.\textsuperscript{44}

Green bonds used to fund climate solutions could be of different kind: “use of Proceeds” Bond, “Use of proceeds” Revenue Bond or ABS, Project Bond, Securitization (ABS) Bond, Covered Bond, Loan, Other debt instruments. The most used green bonds are green “used of proceeds” or asset-linked bonds.\textsuperscript{45}

### 3.3 GREEN BOND MARKET

After more than ten years from the issuance of the first green bond, the market has displayed signals of maturity and it has just launched. According to Moody’s and Climate Bond Initiative, the green bond market increased drastically in 2017 and the volume of green bonds issuance reached $162.1 billion. In 2018, the market recorded a solid increase in November and the year evolved pari passu 2017, the volume of total green bond issuance reached at the end of the year was $167.3.\textsuperscript{46}

According to the Climate Bond Initiative, the top 5 countries in 2018 are: USA, China, France, Germany and The Netherlands. USA has a 20% market share of the market with total amount $34 billion; China boasts higher number of issuers than USA, but lower market share at 18% and total amount $31 billion. The last three countries are European: France has a market share at 8%, 12 issuers and total amount of $14 billion; Germany has a market share at 5%, issuers 14 and total amount $7.6 billion; Netherlands has a market share at 4%, issuers 6 and total amount $7.4 billion.\textsuperscript{47}

The expectations for the 2019 by SEB are studied through two different scenarios: organic evolution scenario in which the total cumulative issuance will reach $210 billion; green growth scenario, the issuance will reach $240 billion.\textsuperscript{48}

The growth of the market is driven by the combination of some factors that pull and others that push, such as, respectively demand and the lack in regulation and definition of “green”. According to the growth of the green bond market, the demand has played a key role over the years, because it is increasing over time due to the fact that investors want to diversify their portfolio against the climate risk and to enhance the portfolio’s ESG factors (Environment, Social and Governance). To integrate the ESG factors were launched in 2006 the PRI (Principles for Responsible Investment) which attract investors near to green investments that are in line with the risk/return profile of the investors.\textsuperscript{49}

The current supply is not enough to reach the demand from investors. To explain the reason why the demand for green bonds is high, it is necessary to look at the risks of the green investment. In fact, in the literature, different studies analyse the impact of the greenness of the bond on the bond’s yield. In the following we are going to analyse two of them. According to Zerbib (2017) the results of his study show that the green bonds have a negative premium over their similar conventional bonds.\textsuperscript{50}

\textsuperscript{44} Green Bond Principles, ICMA, 2018
\textsuperscript{45} Explaining Green Bonds, Climate Bonds Initiative
\textsuperscript{46} 2018 Green Bond Market Summary, Climate Bonds Initiative
\textsuperscript{47} Green Bonds: the state of the market 2018, Climate Bonds Initiative
\textsuperscript{48} The study conducted by SEB takes in consideration two different scenarios in which the underlying assumptions differ. The Green Bond: special edition scenario 2019, SEB
\textsuperscript{49} Green Bonds – Ecosystem, Issuance Process and Case Studies, SEB
\textsuperscript{50} Zerbib (2017) analyses the difference in the green bond yield and conventional bond yield. The analysis consists in matching a pair consisting of a green bond and a synthetic conventional bond. The former is built by the interpolation of two conventional bond with equal characteristics of the green bond except in maturity and liquidity.
On the contrary, Karp and Mandel (2017)\textsuperscript{51} found out that the green bonds are traded at lower price and higher yield than conventional bond, which is not in line with the expectations relative to their credit risk profile. The studies underline an important concept which affects the investment decision of the investor: the uncertainty of the investment which investors are exposed to. Indeed, the green characteristics of the investment reassure investors, as it is possible to see from the increase in demand, but also it represents an important factor for the reputation of the issuer in relation to the rating. For this reason, suppliers try to maintain a high level of transparency, reporting and disclosure, to avoid the problem of asymmetric information.

The second problem presented by push factors on the market is the lack in regulation and definition of “green”. Indeed, the issuance of GBP (Green Bond Principles) in 2014 demonstrated how much the regulation is important in the market to ensure transparency, integrity and disclosure. GBP were issued by ICMA as guidelines that represent a key point for the expansion of the green bond market. Moreover, another labelled framework used at the international level is Climate Bond Standards\textsuperscript{52}. The market feels the need for a harmonized regulation that permits the growth of the green bond market and overcomes the current national regulations. To reach this purpose the European Commission is working on this problem. In June 2019 they will present the European Green Bonds Standards to improve the market regulation, in particular introducing standard tax scheme.

The actors who operate on the market are investors and suppliers. In the following chapter, we describe three categories of suppliers: Supranational, sovereign & agency (SSA) issuers that include multilateral and national development banks, regions and cities, sovereign governments and agencies. The role played by these suppliers is crucial for the market because they drive the demand and supply of green bond: increasing liquidity and size of the issuance, developing benchmark yield curves and creating market practises and minimum standards for the next issuances. The non-financial corporate, such as Vasakron the Swedish real estate company, was the first one to issue a green bond. The financial institutions represent the most solid source of funding: in particular bonds are a financial solution for financing and refinancing \textsuperscript{53}.

### 3.4 Risks

Debt securities offer investors defined coupons and a specific future time line for the payment of the principal. During the period in which the investor holds the bond, he/she is exposed to different benefits and risks that derived from different sources, such as variation of interest rates. Benefits and risks are relevant factors that the investor takes into account in the investment decision related to his/her needs and to the investment sustainability. In this section, we are going to examine the major risks at which the bond is exposed and in particular, we are going to analyse the impact of the liquidity risk on green bond, in line with the question research\textsuperscript{54}.

\textsuperscript{51} Does it pay to be green? A comparative Study of the Yield Structure of Green and Brown Bonds in the US Municipal Bonds Market, Karp and Mandel, 2017

\textsuperscript{52} Climate Bond Standards is a labelling framework for bonds issued by Climate Bonds Initiative. This scheme is used at international level by bond issuers, governments, investors and financial markets. The purpose of the standards is to provide clear criteria that allow the assessment of the projects that can be used for the climate bonds and green bonds.

\textsuperscript{53} Green Bonds – Ecosystem, Issuance Process and Case studies, SEB

\textsuperscript{54} FINRA, \url{https://www.finra.org/investors/understanding-bond-risk}
All categories of bonds are subject to risks. Risks can be defined as a financial tool used to assess the investment in terms of return expectations. The most relevant risks which affect bondholders are the following:

- **Inflation risk**: or purchasing power risk, is the risk that the yield of the bond does not move at the same speed of the purchasing power.
- **Interest rate risk**: is referred to the risk associated to a variation (negative or positive) in the interest rate which affects the price of the bond (increase or decrease).
- **Duration risk**: is the risk related to the sensitivity of the price of the bond to a one percent change in interest rates.
- **Credit risk**: represents the inability of the borrower to meet his obligations in a timely manner.
- **Liquidity risk**: is the risk related to the difficulty to find a buyer to sell the bond (trade frequently, more liquid)\(^{55}\).

In our study we take two categories of bonds into account: conventional bond and green bond. The first category is referred to a simply corporate bond and the second category is a particular type of bond which can be exposed to different risks, in respect to the conventional. Indeed, green bonds are exposed to a specific risk that acquires importance in relation to the gap in the regulation and definition of “green”: **reputational risk**. The reputational risk occurs when bonds are defined as green, issued by borrowers that do not show to be socially responsible and the result is an impact on the investor’s trust for the issuer\(^{56}\). In order to avoid the reputational risk, there are criteria at the international level which require the disclosure of the environmental objective pre-issuance and post-issuance. Moreover, the issuer should follow the GBP in launching a green bond, mitigating the credit risk of the bond\(^{57}\). Later we will discuss about the current principles and a standard available.

The risk profile of the green investments is much disputed subject because of its unclear nature. The reason which pushes to this conclusion is the presence of less mature technologies which are not able to assess the risks and benefits of the green investments, thus the technology risk is pricy. This means that the rating agencies and investors value the technology risk by asking the market for a higher return for the green investments\(^{58}\). In conclusion it is possible to underline the strict correlation between the need of an advanced regulation with a greater view of the risk profile of the green bond. The principal research question of this study derives from the level of risk at which the green bond is exposed to and how to figure out if the green component affects the premium.

### 4. HOW CAN WE DEFINE “GREEN”?

*Being one of the most important current problems, this section is concerned about the lack in the definition of “green” and about the development that institutions are putting in place to reach harmonized principles and standards*

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\(^{55}\) Ibid.  
\(^{56}\) UNDP, Global financing solutions for sustainable development, [https://www.sdfinance.undp.org/content/sdfinance/en/home/solutions/green-bonds.html#mst-3](https://www.sdfinance.undp.org/content/sdfinance/en/home/solutions/green-bonds.html#mst-3)  
\(^{57}\) Study on the potential of green bond finance for resource-efficient investments, Report, EC, 2016  
\(^{58}\) Ibid.
Since the first green bond was issued by the European Investment Bank in 2007, the green bond market has grown to 350bn Euros. However, there is still a gap in the definition of green bonds. In fact, anyone can issue a green bond, even if it is not totally green. Previous studies described the first step of a green bond regulation. “There are many environmental and investment experts trying to find good investment opportunities. Any green definitions, standards and codes will therefore need to be adjusted over time.”

As there are masses of definitions for sustainable investments, it would not be useful to compare them. Especially the definition of the “green” differs: “some definitions are very broad and generic; others are more technical and specific.”

In some sectors, a green investment is defined as “the investment necessary to reduce greenhouse gas and air pollutant emissions, without significantly reducing the production and consumption of non-energy goods.”

The environmental organization “Friends of the Earth” (FoE) identified that the energy company Engie listed the Jirau Dam in Brazil as a possible underlying investment for the issuance of Green Bonds, even though it contributes to the deforestation of the Amazon and threatens the habitat of indigenous people.

Additionally, a green bond was issued to construct a hydroelectric power station in Pakistan, with the consequences that 7000 inhabitants must be relocated.

Currently, in the absence of a common regulation across countries, investors and suppliers take into consideration the national rules which give contributions for the definition of the green: also, they refer to principles and standards issued at the international level: Green Bond Principles (GBP) and Climate Bonds Standards (CBS). One limit that emerged in the description of the international standards and principles is that neither the GBP nor the CBI take social impacts into account like human rights violations resulting from Green Bond funding.

In the following, we would like to outline measurements that can help to define the greenness of bonds.

- European Commission Standards
- Climate Bond Standards

The Climate Bonds Initiative (CBI) is a non-profit organization that supports investors in their decision making. Moreover, the initiative has proposed the “Climate Bond Standard and Certification Scheme” with the leading thought of “Developing low carbon industries, technologies and practices that mitigate greenhouse gas (GHG) emissions consistent with avoiding dangerous climate change”

4.1 BACKGROUND

The United Nations Framework Convention on Climate Change (UNFCCC) aims to prevent the dangerous effect of a climate change on the society by fixing targets to reduce the climate change. The Paris Agreement (2015) believes in the Convention and for the first time brings all nations together for a common cause to undertake ambitions efforts to fight the climate change and adapt to its effects, with an enhanced support to assist developing countries to do so too. The fundamental
aim of the Paris Agreement is to strengthen the global response to the threat of the climate change by keeping a global temperature rise in this century well below 2 degree Celsius above pre-industrial levels and to go after efforts to limit the temperature increase even further to 1.5 degrees Celsius. Furthermore, it intends to build up the ability of countries to manage the impacts of climate change. Appropriate financial flows, a new technology framework and an enhanced capacity building framework are significant to achieve these purposes. Moreover, the agreement wants to improve the transparency of action by a new solid transparency structure.\textsuperscript{66}

The Convention, the Kyoto Protocol and the Paris Agreement call for financial assistance from countries with more financial resources, because the capacity to prevent it among countries varies enormously. Climate finance is essential for mitigation, putting in place investments that reduce emissions, and also for adaptation of resources that cut down the climate change.

In accordance with the Paris Agreement 2015 and the UN 2030 Agenda for the Sustainable Development, European union contributes to the global efforts to make the economy more sustainable and it has been at the forefront of efforts to build a financial system that supports the sustainable growth. To reach the EU’S targets of 2030, the European Union estimates an investment gap at 180 billion per year. The EU and the financial sector are playing an important role to attract investors for the green investments.

The High-Level Expert Group on the Sustainable Finance is composed on 20 senior experts from civil society, finance sector, academia and observes from European and International institutions. The HLEG plays an advisory role on how the Commission has to guide the public and private capital flow, identify the risks that affect the financial stability and deploy these policies on a pan-European scale.\textsuperscript{67} In May 2018 the European Commission published three proposals, issued by the HLEG in January 2018, for regulations reflecting the EU’s efforts to connect finance with its own sustainable development agenda. The motion is focused on the creation of the EU sustainable finance taxonomy, disclosures relating to sustainable investments and sustainability risks clearer and low-carbon benchmarks. Additionally, it intends to enhance the transparency duties of the financial intermediaries towards end-investors, with regard to sustainability risks and sustainable investment targets.\textsuperscript{68} Sustainable finance is the supplying of finance to investments taking into account environmental, social and governance considerations.\textsuperscript{69}

Given the growing impact of a climate change, the financing of the sustainable investments is becoming an important topic, because of the shortage of public funds. In this regard, the role played by financial market is relevant, which has to provide ways by which funds can be assigned to investments intending to reduce the climate change.

In 2007/2008 SEB and World Bank developed the concept of the Green Bond as a response to an increased investor demand for engagement in climate-related opportunities. Green Bond integrates the fiduciary element of Fixed Income products with climate mitigation and adaptation awareness, allowing investors access to the climate-related investment projects. In a world where the attention for the climate change is increasing, the Green Bond is a device that increments industry engagement by strengthening investments in sustainable projects, processes and technologies with a transparency that gives the possibility to investors to understand the challenges and thus diversify

\textsuperscript{66} UNFCC, Paris Agreement is Driving Green Bond Surge, 2017
\textsuperscript{67} European commission, High-Level Expert Group on Sustainable Finance
\textsuperscript{68} European Union, Sustainable finance and Disclosure, 2019
\textsuperscript{69} Ibid.
the risks. Simultaneously, Green Bonds provide issuers with an opportunity to have a closer dialogue with the investors and adapt issuance\textsuperscript{70}.

The European Commission promoted the Corporate Social Responsibility (CSR) with the aim to obtain the support of the enterprises to follow international guidelines and principles. In particular, the strategy is focused on the improvement of the visibility of CSR and disseminating good practices, through the integration of CSR into education, training and research. Moreover, the strategy aims to enhance the self and co-regulation process and companies’ disclosure of social and environmental information\textsuperscript{71}.

4.2 PRINCIPLE AND STANDARDS

The lack in a global definition of “green” is a key point that deserves to be taken into account to reach harmonization over different definitions. It is implied that investors are exposed to the uncertainty of the validity of the greenness’ bonds implying impacts on the growth of the green bond market.

As explained before, there are no common definitions of what means “green”, although there are relevant guidelines used at international level:

- **Green Bond Principles (GBP)**: their purpose is to define features and reporting of the green bonds. The limit is the lack in criteria which define Green Projects\textsuperscript{72}.
- **Climate Bond Standards (CBS)**: try to reach a common definition of what is “green”. They indicate which climate-related investments can be associated with the issuance of green bonds\textsuperscript{73}.

However, in some countries guidelines, standards and principles for the green bonds were introduced by the governments. In such green bond market regulated by national authorities, issuers need regulation that specifies the eligible projects and asset categories which comply with the definition of “green”\textsuperscript{74}.

In the central bank of China, Peoples’ Bank of China, issued the Chinese Green Financial Bond Guidelines and Catalogue in 2015. The introduction of the regulation allowed the fast growth of the Chinese green bond market\textsuperscript{75}. Simultaneously, the National Development and Reform Commission which controls the corporate bond market in China, introduced guidelines which were in line with the PBoC’S Catalogue\textsuperscript{76}. In 2017, China introduced innovative guidelines aimed for the listed companies, New China Local Govt green bond policy recommendations. This development in the regulation is bound to the interest of making the market grow\textsuperscript{77}.

In the following paragraphs, we discuss, in particular, about the Green Bond Principles and Climate Bonds Initiative.
4.2.1 *Green Bond Principles*

To ensure transparency, disclosure and reporting of the green bond market, International Capital Market Association (ICMA) issued the Green Bond Principles (GBP) as guidelines that promote integrity. The presence of these guidelines is in the interest of investors and issuers, because they limit the problem of information asymmetry.

Green Bonds Working Group through the collaboration of the ICMA developed the GBP which identify the eligible projects from which environmental benefits are derived, such as: climate change mitigation and adaption; natural resource conservation; biodiversity conservation and pollution prevention and control\(^78\).

However, there is a gap in the regulation of Green Bonds. In principle, anyone can issue a Green Bond, even if it is not green. Therefore, it is important that such bonds are always carefully checked against various criteria. In the case of green real assets, only bonds that offer ethical-ecological added value that can be linked to a real asset are offered.

The Green Bonds Principles recommend transparency and disclosure. They ensure a clear process and disclosure for issuers, that investors, banks, underwriters, placement agents and others may utilise to figure out the features of any given Green Bond. Additionally, they help investors in promoting availability of information necessary to evaluate the environmental impact of their green bond investments and to select the suitable project. The last version of the GBP was in June 2018 by ICMA\(^79\).

The GBP are based on four main elements:

- Use of Proceeds
- Process for Project Evaluation and Selection
- Management of Proceeds
- Reporting

The proceeds are relevant for a Green Bond, because they describe all the features of the Green Project, in particular, they identify the environmental benefits which are derived from the investment. Additionally, the issuers have to specify the share of financing or re-financing and the forecast look-back period for the refinanced Green Projects. GBP underline the eligible Green projects, followed by the list on which they are not limited:

- Renewable energy
- Energy efficiency
- Pollution prevention and control
- Environmentally sustainable management of living natural resource and land use
- Terrestrial and aquatic biodiversity
- Clean transportation
- Sustainable water and wastewater

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\(^78\) Climate Bonds Initiative, *Growing green bond markets: The development of taxonomies to identify green assets*, 2018

\(^79\) ICMA, *Green Bond Principles*, 2018
• Climate change adaptation
• Eco-efficient and/or circular economy adapted products, production technologies and processes
• Green buildings\(^{80}\).

One limit of the GBP is showed by the lack in the standard taxonomy scheme and which is defined at the national level. In that regard, the institutions are developing a standard framework to obtain more harmony across countries.

The second core component requires that the issuers clarify some points:

• The environmental sustainability targets
• The process according to which the issuer considers the project green
• The criteria used to identify the environmental and social risks related to the project.

The issuers should address the ecological sustainability of the projects together with their overriding goals. Furthermore, issuers are encouraged to disclose any green standards or certifications referred to in the project selection process. As the GBP are committed to a high level of transparency, it is recommended that the project evaluation and the selection of an issuer be complemented by an external review\(^{81}\).

The third point, management of proceeds, is recommended so that the management of the proceeds are supplemented by an auditor or other third party to verify the internal tracking method and the allocation of funds from the proceeds of the Green Bond. Accordingly, the net proceeds of the Green Bond should be transferred to a separate account and certified by the issuer in a formal internal process related to the issuer’s lending and investment business for a Green Project\(^{82}\).

At the end, the last key factor the annual report should include is a list of the projects to which Green Bond proceeds have been allocated, as well as a brief description of the projects and the amounts allocated, and their expected impact\(^{83}\).

4.2.3 CLIMATE BONDS STANDARD

The Climate Bonds Standards (CBS) and the Certification Framework established by the Climate Bond Initiative, a non-profit organization, play an important role at the international level. The purpose of the latter is to allow the investors to assess the “low carbon and climate resilient” investments orienting them towards the funds. Moreover, it is possible to find definitions of the eligible projects and assets which must comply with the low carbon and climate resilient economy\(^{84}\).

The CBS provides clear guidelines in line to assess the certain green credentials of the financial instruments and they do not affect the ratings of specific investments. The target is to verify that the

\(^{80}\) ICMA, Green Bond Principles, June 2018
\(^{81}\) Ibid.
\(^{82}\) Ibid.
\(^{83}\) Ibid.
obtained funds are involved in green projects and the assets comply with the delivery of a low carbon and climate resilient economy\textsuperscript{85}.

In the CBS we find the list of projects or assets with environmental contributions:

- Developing low carbon industries, technologies and practices that mitigate greenhouse gas (GHG) emissions consistent with avoiding dangerous climate change
- Essential adaptation the consequences of the climate change\textsuperscript{86}.

The significant characteristics of the CBS & Certification Scheme are the following:

- Full alignment with the last version of the GBP
- Clear mandatory requirements for use of proceeds, tracking, and reporting
- Specific eligibility criteria for low carbon and climate resilient projects and assets
- An assurance framework with independent verifiers and clear procedures
- Certification by an independent Climate Bonds standard Board\textsuperscript{87}.

The CBS do not substitute the financial due diligence, but they are environmental criteria. They help investors on decision-making and the assessment of the credible environmental benefits obtained from the investments. The requirements explained in the CBS are divided into two categories: \textit{pre-issuance}, which the issuer must meet trying to obtain the certification; \textit{post-issuance}, which issuer must achieve to maintain the certification obtained. The last version was uploaded in April 2019\textsuperscript{88}.

4.3 **European Commission Standards**

The European Commission (EC) developed a comprehensive strategy to further connect finance with the sustainability in March 2018. Furthermore, they set up a plan to create standards and labels for green financial products. In June 2018, the technical expert group on sustainable finance was included into the ECs Action Plan. The main scope of duties was to develop in four aspects of the Action Plan: 1) a unified classification system for sustainable economic activities, 2) European Union (EU) Green bond standard, 3) benchmarks for low-carbon investment strategies, and 4) guidance to improve corporate disclosure of climate-related information.

Recommendations:

In the following, we will outline eleven preliminary recommendations which were constructed by the technical expert group on the sustainable finance (TEG). The recommendations were proposed to assist the establishment of a European Green Bond Standard.

- Recommendation #01: “Create a voluntary EU Green Bond Standard.” This means that the EC will adopt proposals to support the EU green bonds, without providing a legal framework. The proposals are to be checked by monitoring the market developments to evaluate the implementation of the EU GBS.

\textsuperscript{85} Ibid.
\textsuperscript{86} Ibid.
\textsuperscript{87} Ibid.
\textsuperscript{88} Ibid.
• Recommendation #02: “Monitor impact and consider further supporting action including possible legislation after an estimated period of 3 years.” After three years, a review of the impact of the EU-GBS will be carried out, with a view to the possible adoption of first laws supporting the implementation of the EU-GBS.

• Recommendation #03: “Develop a legislative proposal for a centralised accreditation regime for external green bond verifiers to be potentially operated by ESMA.” A legislative draft for the authorisation and supervision of external auditors is to be implemented in the future.

• Recommendation #04: “Set up a market-based voluntary Accreditation Committee for external verifiers of green bonds for a transition period.” Furthermore, the TEG proposes to set up an Accreditation Committee in order to establish a transitional system.

• Recommendation #05: “Investors, in particular institutional investors, are encouraged to adopt the requirements of the EU GBS when designing their green fixed-income investment strategies and to communicate their commitment and their expectations to green bond issuers actively as well as to underwriters.” According to the TEG, investors are advised to advertise their green investment strategies in their portfolios.

• Recommendation #06: “Adopt an ambitious disclosures regime for institutional investors.” In addition, a "comply or explain" rule for the obligatory publication of EU green bond holdings is to be revised.

Recommendation #07: “Consider promoting greening the financial system by expressing and implementing a preference for EU Green Bonds.” Accordingly, the European Central Bank should prefer “EU Green Bonds” when buying green bonds in order to promote the greening of the financial system.

• Recommendation #08: “Develop credit enhancement guarantees for sub-investment grade green bonds.” All institutions involved in the investment plan for Europe should conduct measures to make the market for green bonds more attractive. This can take the form of credit guarantees, for example.

• Recommendation #09: “The TEG encourages all types of bond issuers to issue their future green bonds in compliance with the requirements of the EU GBS.”

• Recommendation #10. “The TEG recommends that the European Commission considers setting up a grant scheme to off-set the additional cost of external verification for issuers.” Moreover, the Capacity-building is to be encouraged at EU and international level.

• Recommendation #11: “Promote adoption of the EU Green Bond Standard through the EU eco-label for financial products.” This means that the EC should refer to the EU-GBS when manufacturing financial products bearing the EU Eco-label. This is intended to encourage the adoption of the EU-GBS by bond issuers.

5. DATA DESCRIPTION AND MATCHING METHOD

89 Interim report, European Green Bond Standard, March 2019
This section describes the method applied in our analysis and the collection of data used in the study. The used method derived from the investigation, developed by Zerbib (2018).

The analysis developed in this paper aims to compute the green premium, in other terms we are going to isolate the green bond premium as unobserved factor of the fixed-effect panel regression used. The method selected to compute the synthetic conventional bond is the matching method, in line with the study developed by Zerbib (2018). Scilicet, the matching method consists of matching a pair of securities with the same features except for one characteristic whose effects are interested in\(^90\). In particular, we are going to consider two categories of bonds with the same issuer: green bonds and conventional bonds. Indeed, we will investigate on the yield spread between the green bond and an equivalent synthetic conventional bond. For this purpose, we match a pair consisting of a green bond and a synthetic conventional bond with the same properties except in liquidity, because it is the variable in which we are interested in to estimate the impact of the greenness of the bond on the bond yield\(^91\). In our model we use the Bid-Ask spread as a proxy of liquidity and we define, \(\Delta \text{Liquidity}_{i,t}\), the variable that captures the difference in liquidity. The choice of the Bid-Ask Spread as liquidity measure is justified by the fact that prices include all the information available on the market; it implies that prices reflect immediately the new information available. Fleming\(^92\) showed that the Bid-Ask spread is a useful indicator of liquidity. It has the advantage to be quick and easy to compute in case of available information and additionally it reflects events that affect the prices\(^93\).

The yield spread, \(\Delta \text{Y}_{i,t}\), between the two categories of bonds is defined as the difference between the ask yield of the green bond and the ask yield of the equivalent synthetic bond. We develop the linear interpolation of the two conventional bonds' ask yields to obtain the ask yield of the equivalent synthetic bond which shows same characteristics of the green bond\(^94\).

To build the synthetic conventional bond, we first look for the two conventional bonds with the closest maturity to the green bond’s maturity and same characteristics in terms of: issuer, currency, rating, bond structure and a coupon type. To obtain a more accurate analysis, we will simply use the fixed coupon bonds into our study. By ignoring a floating coupon we do not consider the fluctuation of the interest rate. To prevent outliers, which are extreme data values, we made a restriction for the maturity: the maturity date of the collected conventional bonds must be in a range between either three years shorter or three years longer than the green bonds maturity date.

We collected the data of green and conventional bonds from Thomson Reuters Eikon by using the ISIN-numbers. Firstly, we selected a list of green bonds from the paper “Liquidity risk and yield spreads of green bonds” (Wulandari, Schäfer, Stephan, Sun, 2018) to filter utilisable green bonds which are in line with our restrictions; most of the bonds could not comply with them. Secondly, for each green bond issuer we did a research to find two conventional bonds that have the same characteristics\(^95\) as the green bond.

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\(^{90}\) Zerbib, O. D., “Is There a Green Bond Premium? The yield differential between green and conventional bonds“, [2018]

\(^{91}\) Ibid.

\(^{92}\) Fleming, M. J., “Measuring Treasury Market Liquidity“, [2003]

\(^{93}\) Ibid.

\(^{94}\) Ibid.

\(^{95}\) In terms of issuer, coupon, currency, rating and bond structure.
Our sample consists in 38 labelled green bonds and 76 conventional bonds issued in USD, EUR and SEK. The green bonds in the sample comply with the Green Bond Principles (GBP) and Climate Bonds Standards (CBS) and schemes of certification. We analyse all data and deleted the bonds with missing values or not in line with our assumptions. At the end we obtained 24 triplets of bonds with 2'256 observations. Each triplet is composed by one green bond and two conventional bonds which respect the hypothesis. The collection of the data is made on a period of 5Y (2014-2019) and the frequency selected is daily. The major green bonds present in our sample are just issued for this reason the observations considered start from 10 January 2019 to 24 May 2019.

6. EMPIRICAL METHODOLOGY

The empirical method is explained in this section. We describe the method used to compute the green premium. The matching method that we are going to explain in this section was employed by Zerbib \cite{zerbib} who investigated on the greenness of the bond. In the following, we will explain the method in empirical terms.

The purpose of this is to aim the green premium by a fixed-effect panel regression using STATA. The green premium, $p_i$, is obtained as an unobserved effect in the fixed-effect panel regression of $\Delta y_{i,t}$ on $\Delta \text{Liquidity}_{i,t}$:

$$\Delta y_{i,t} = p_i + \beta \Delta \text{Liquidity}_{i,t} + \epsilon_{i,t}$$

Firstly, we need to estimate the variables that we use in the regression.

In particular, we start with the computation of the difference in the yield spread between the green bond and the synthetic conventional bond. In this step we decided to employ the ask yield for each bond. Firstly, we apply the linear interpolation between the two conventional bonds to obtain the synthetic bond which has the equal characteristics as the green bond except in liquidity. In practical terms, the linear interpolation is a linear function with $a^*$ the slope and $b^*$ the intercept of the function passing through two points: $(Maturity_{CB1}, y_{CB1}^*)$ and $(Maturity_{CB2}, y_{CB2}^*)$.

The yield of the equivalent synthetic conventional bond is:

$$y_{CB}^* = a^* Maturity_{GB} + b^*$$

Then, having the $y_{i,t}^{GB}$ green bond ask yield and the $y_{i,t}^{CB}$ synthetic conventional bond ask yield, we are able to calculate:

$$\Delta y_{i,t} = y_{i,t}^{GB} - y_{i,t}^{CB}$$

\cite{zerbib} Zerbib, O. D., “Is There a Green Bond Premium? The yield differential between green and conventional bonds”, [2018]
Secondly, to compute the residual difference in liquidity between the green bond and the associated synthetic conventional bond, we define a variable that captures the liquidity differential, $\Delta \text{Liquidity}_{t,t}$, as a difference between a green bond and conventional bond’s liquidity indicator:

$$\Delta \text{Liquidity}_{t,t} = \text{Liquidity}^{GB}_{t,t} - \text{Liquidity}^{CB}_{t,t}$$ (4)

According to the analysis developed by Zerbib (2018)\textsuperscript{97}, the synthetic conventional bond, used in the equation above, is based on two closest conventional bonds in terms of maturity. The conventional bond’s bid-ask spread (BA) is defined as the distance-weighted average of CB1’s and CB2’s bid-ask spreads. In empirical terms:

$$d_1 = |\text{Green Bond maturity} - \text{CB1 maturity}|$$

$$d_2 = |\text{Green Bond maturity} - \text{CB2 maturity}|$$

The synthetic conventional bond’s bid-ask spread is defined as follow:

$$BA^{CB}_{t,t} = \frac{d_2}{d_1 + d_2} BA^{CB1}_{t,t} + \frac{d_1}{d_1 + d_2} BA^{CB2}_{t,t}$$

$$\Delta BA_{t,t} = BA^{GB}_{t,t} - BA^{CB}_{t,t}$$ (5)

is the differential liquidity and it is the independent variable used in the equation to estimate the fixed-effect linear panel regression. The maturity green bond and the conventional bond, used in the computation of $d_1$ and $d_2$, is estimated as the difference between the issue date and the maturity date of each bond. The maturity, in this case, is measured in days obtaining a more precise result.

The choice of using the above explained method is in line with the literatures. This method has been used by Kreander et al. (2005)\textsuperscript{98} and Zerbib (2018)\textsuperscript{99}. In particular, we consider the article: “Is There a Green Bond Premium? The yield differential between green and conventional bonds, Zerbib, 2018”.

The reasons for which we chose the matching method are explained in the following. By computing the $p_i$ through the fixed-effect panel regression we do not need to make assumptions on the distribution and to use data of other bonds. Our data shows the features of a specific bond. Furthermore, our data has strict exogeneity holds and the estimator is unbiased and consistent. Our assumption are based on the the article mention above, in this way we are able to compare the results obtained.

\textsuperscript{97} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]

\textsuperscript{98} Evaluating the Performance of Ethical and Non-ethical Funds: A Matched Pair Analysis

\textsuperscript{99} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]
7. Analysis

In this chapter we are going to explain the outcomes obtained from our empirical analysis considering the study run by Zerbib. We will present the results and compare with the previous study. Additionally, are reported all the tests run on our fixed-effect model.

The green bond premium is defined by Zerbib (2018) as a negative yield difference between green bond and the synthetic conventional bond after checking for residual liquidity\textsuperscript{100}. The green bond premium is the time-invariant variable estimated by the fixed-effect model described above. In the model the variable (5) is the independent variable, in the following Table 1 it is represented the spread of the delta Bid-Ask spread over all the sample. The distribution is skewed on right, because the value (-3.371118) is less than zero.

Table 1: Descriptive statistics of ΔBA

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Smallest</th>
<th>Delta BA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>-1.912</td>
<td>-2.1615</td>
</tr>
<tr>
<td>5%</td>
<td>-1.5864485</td>
<td>-2.928</td>
</tr>
<tr>
<td>10%</td>
<td>-2.470</td>
<td>-2.116</td>
</tr>
<tr>
<td>25%</td>
<td>-0.0243945</td>
<td>-2.097</td>
</tr>
<tr>
<td>50%</td>
<td>.01</td>
<td>Mean</td>
</tr>
<tr>
<td>75%</td>
<td>.0924145</td>
<td>Std. Dev</td>
</tr>
<tr>
<td>90%</td>
<td>.127</td>
<td>Variance</td>
</tr>
<tr>
<td>95%</td>
<td>.1679619</td>
<td>Skewness</td>
</tr>
<tr>
<td>99%</td>
<td>.4903560</td>
<td>Kurtosis</td>
</tr>
</tbody>
</table>

We run the fixed-effect panel regression model and we show the results in the Table 2. In our sample we have 2'256 observations and 24 triplets of bonds. To figure out the suitability of the fixed-effect panel regression, the F test was conducted. The null hypothesis in the F test says: “\( H_0 \) all the regression coefficients are equal to zero", it means that the model has not predictive capacity\textsuperscript{101}. In the table below, we reject the null hypothesis of the F test, the \( p\)-value (0.0026) is significant because it is less than 0.05, we accept the alternative hypothesis where all the coefficients are not equal to zero. As consequence, the fixed-effect panel regression model is defined efficient for our analysis. One of the characteristics that distinguishes the fixed-effect from the random-effect model is the correlation between the time-invariant variable and the explanatory variable, in the latter it is assumed equal to zero. In our model, the correlation, \( \text{corr}(u_i, X_b) \), is 0.0812. Furthermore, it is possible to notice from the Table 2 that the value of \( R^2 \) is low at approximately 2%. The probability value of the

\textsuperscript{100} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]

\textsuperscript{101} Complete Dissertation By Statistic Solutions,\textsuperscript{[} https://www.statisticssolutions.com/f-test/ \textsuperscript{]}
**Table 2: Fixed-effect panel regression**

The purpose of this study is to estimate the fixed effects \( (p_i) \). The presence of the green bond premium is tested when the constant in the panel regression is negative and significant. In Table 3 summarises the distribution of the fixed-effects \( p_i \). We can notice that the fixed effects are range between -2.190143 and 0.7462295 with mean \(-1.82e^{-09}\). Large range of the variable indicates that not all the green bonds give the investors a green bond premium. Indeed, in our sample of 24 triplets, just the 20,83% present a negative \( p_i \). From this result we make the assumption that the conventional bond yield is higher than the green bond yield.

**Table 3: Distribution of the fixed effects**

7.1 Tests
In this section, we will explain the conducted tests in our analysis. We performed each of the tests for different reasons which we will discuss later. Each test is composed of the null hypothesis, $H_0$, that scans our model for certain criteria and the alternative hypothesis, $H_a$. The results achieved from the test indicate if we reject or accept the null hypothesis by looking at the $p$-value: If the $p$-value is lower than 0.05 we reject the $H_0$ and accept the $H_a$, and vice versa. In the following, we will check our model with the Hausman test, the Wooldridge test and the Breusch-Pagan test.

To verify if the fixed-effect model fits with our data, we run the Hausman test. The developed Hausman test in the panel data analysis suggests between fixed-effect and random-effect panel regression. The model analyses if there is a correlation between the regressors and the effects. The null hypothesis expresses no correlation and the random-effect model is preferred. If the regressors and the effects are correlated with each other, both the fixed-effect model and the random-effect model are consistent, but the fixed-effect model is inefficient. The alternative hypothesis is based on correlation which means that the fixed-effect model is consistent. Table 4 shows the result of the Hausman test on our sample. The $p$-value (0.6787) is higher than 0.05 which means that we accept the $H_0$. This means that the random-effect model is preferred.

### Table 4: Hausman test

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>(b)</th>
<th>(b-5)</th>
<th>sqrt(diag(V_b-V_5))</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta$</td>
<td>-0.1204</td>
<td>-0.12164</td>
<td>0.0017664</td>
</tr>
</tbody>
</table>

$b = $ consistent under $H_0$ and $H_a$ obtained from $xtreg$

$B = $ inconsistent under $H_0$, efficient under $H_a$, obtained from $xtreg$

**Test**: $H_0$: difference in coefficients not systematic

$\chi^2(1) = (b-5)^\ast[(V_{b-5} - V_5)^\ast(-1)](b-5)$

$= 0.37$

Prob>$\chi^2 = 0.6787$

The Wooldridge test evaluates the presence of the autocorrelation in the sample and it is run generally applied for macro panels with long time series. The $H_0$ affirms no autocorrelation, while the $H_A$ supports the presence of autocorrelation. In Table 5 the Wooldridge test on Stata can be found. By looking at the $p$-value that is lower than 0.05, we reject the null hypothesis and accept the alternative. The presence of autocorrelation is declared. The Wooldridge test is valid under homoscedasticity, in the following we present the test for the presence of heteroscedasticity.

102 Stephanie, [https://www.statisticshowto.datasciencecentral.com/hausman-test/], 2017

103 K. Schmidheiny, Short Guides to Microeconometrics, [https://www.schmidheiny.name/teaching/panel2up.pdf], 2018
Table 5: Wooldridge test

<table>
<thead>
<tr>
<th>Wooldridge test for autocorrelation in panel data</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0: no first-order autocorrelation</td>
</tr>
<tr>
<td>F(1, 23) = 6.423</td>
</tr>
<tr>
<td>Prob &gt; F = 0.0183</td>
</tr>
</tbody>
</table>

The heteroscedasticity is tested by Breusch-Pagan test. The null hypothesis in the model is based on constant variance, in other terms homoscedasticity, while the alternative hypothesis assumes heteroscedasticity, which assumes that the variance changes over time. In Table 6 the result of the test run on our sample is reported. Considering the p-value equal to 0.000, we reject the null hypothesis and accept the alternative, it confirms the presence of the heteroscedasticity.

Table 6: Breusch-Pagan test

<table>
<thead>
<tr>
<th>Breusch-Pagan / Cook-Weisberg test for heteroskedasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0: Constant variance</td>
</tr>
<tr>
<td>Variables: Delta5A</td>
</tr>
<tr>
<td>chi2(1) = 68.34</td>
</tr>
<tr>
<td>Prob &gt; chi2 = 0.0000</td>
</tr>
</tbody>
</table>

In conclusion we want to give a general impression of the results emerged from the tests. In Table 7 we propose a summary.

Table 7: Tests of the model

<table>
<thead>
<tr>
<th>Tests</th>
<th>p-value</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hausman test</td>
<td>0.6787</td>
<td>Random-effect</td>
</tr>
<tr>
<td>Wooldridge test</td>
<td>0.0183</td>
<td>Serial correlation</td>
</tr>
<tr>
<td>Breusch-Pagan test</td>
<td>0.0000</td>
<td>Heteroscedasticity</td>
</tr>
</tbody>
</table>

8. DISCUSSION

This study investigates on the presence of the green bond premium on the market, as aimed by Zerbib (2018). Investors are willing to sacrifice -1.82 basis points of yield, approximately to the -2 basis points green bond premium by Zerbib. Our study is consistent with the study run by Zerbib. Both studies employ the matching method used is based on the same assumption: bonds issued by the same issuer. To capture the liquidity effect, we assess the difference in Bid-Ask spread between the green
bond and synthetic conventional bond. The greenness component was computed by the fixed-effect panel regression.

The negative premium evidences the preference for the green bonds over the conventional bonds\textsuperscript{104}, it justifies the pressure of the demand on the market and a relative low supply\textsuperscript{105}. Zerbib\textsuperscript{106} (2018) defines in his study that the demand of the green bonds is driven by the environmental preferences\textsuperscript{107}. The discovery of our study can be considered as an explanation of how investors assess the risk of the green bond. In other terms, the investors consider the green bonds less risky than similar conventional bonds. The greenness component emerged in the study could be considered as a part of the risk of the bond which could be not caught by the traditional bond pricing model. In the second chapter we discussed about the risks which affect the bonds. In particular we underline that the green bonds are affected by the reputational risk. According to the reputational risk, studies were developed analyzing the rule of the issuer. In particular, Bachelet, Becchetti and Manfredonia (2019) found that the premium requests both the reputation of the issuer and a green certification reducing the asymmetric information on the market giving guarantees to investors\textsuperscript{108}.

Finally, the obtained results from the regression confirm our hypothesis: in which we assume the existence of the green bond premium. This result is consistent with the results reached by Zerbib (2018).

9. CONCLUSION

The green bond is a financial tool which permits to match financial and environmental benefits.

The purpose of this study was to assess the presence green bond premium. To investigate this, we analysed 24 triplets in our sample. Each triplet consists of one green bond and two conventional bonds with the same characteristics in terms of currency, rating, issuer and coupon.

A negative correlation between our independent and dependent variable emerged from our fixed-effect linear regression. We found out that 20,83\% of our bond triplets present a negative green bond premium.

In conclusion, we suggest to investigate on the risks which affect the green bonds and to analyse the determinants of the green bond premium for the next studies.

\textsuperscript{104} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]
\textsuperscript{106} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]
\textsuperscript{107} Zerbib, O. D., "Is There a Green Bond Premium? The yield differential between green and conventional bonds", [2018]
## APPENDIX I

Standard & Poor’s Rating table

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AAA</strong></td>
<td>An obligation rated 'AAA' has the highest rating assigned by S&amp;P Global Ratings. The obligor’s capacity to meet its financial commitments on the obligation is extremely strong.</td>
</tr>
<tr>
<td><strong>AA</strong></td>
<td>An obligation rated 'AA' differs from the highest-rated obligations only to a small degree. The obligor’s capacity to meet its financial commitments on the obligation is very strong.</td>
</tr>
<tr>
<td><strong>A</strong></td>
<td>An obligation rated 'A' is somewhat more susceptible to the adverse effects of changes in circumstances and economic conditions than obligations in higher-rated categories. However, the obligor’s capacity to meet its financial commitments on the obligation is still strong.</td>
</tr>
<tr>
<td><strong>BBB</strong></td>
<td>An obligation rated 'BBB' exhibits adequate protection parameters. However, adverse economic conditions or changing circumstances are more likely to weaken the obligor's capacity to meet its financial commitments on the obligation.</td>
</tr>
<tr>
<td><strong>BB, B, CCC, CC, and C</strong></td>
<td>Obligations rated 'BB', 'B', 'CCC', 'CC', and 'C' are regarded as having significant speculative characteristics. 'BB' indicates the least degree of speculation and 'C' the highest. While such obligations will likely have some quality and protective characteristics, these may be outweighed by large uncertainties or major exposure to adverse conditions.</td>
</tr>
<tr>
<td><strong>BB</strong></td>
<td>An obligation rated 'BB' is less vulnerable to nonpayment than other speculative issues. However, it faces major ongoing uncertainties or exposure to adverse business, financial, or economic conditions that could lead to the obligor's inadequate capacity to meet its financial commitments on the obligation.</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>An obligation rated 'B' is more vulnerable to nonpayment than obligations rated 'BB', but the obligor currently has the capacity to meet its financial commitments on the obligation. Adverse business, financial, or economic conditions will likely impair the obligor’s capacity or willingness to meet its financial commitments on the obligation.</td>
</tr>
<tr>
<td><strong>CCC</strong></td>
<td>An obligation rated 'CCC' is currently vulnerable to nonpayment and is dependent upon favorable business, financial, and economic conditions for the obligor to meet its financial commitments on the obligation. In the event of adverse business, financial, or economic conditions, the obligor is not likely to have the capacity to meet its financial commitments on the obligation.</td>
</tr>
<tr>
<td><strong>CC</strong></td>
<td>An obligation rated 'CC' is currently highly vulnerable to nonpayment. The 'CC' rating is used when a default has not yet occurred but S&amp;P Global Ratings expects default to be a virtual certainty, regardless of the anticipated time to default.</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>An obligation rated 'C' is currently highly vulnerable to nonpayment, and the obligation is expected to have lower relative seniority or lower ultimate recovery compared with obligations that are rated higher.</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>An obligation rated 'D' is in default or in breach of an imputed promise. For non-hybrid capital instruments, the 'D' rating category is used when payments on an obligation are not made on the date due, unless S&amp;P Global Ratings believes that such payments will be made within five business days in the absence of a stated grace period or within the earlier of the stated grace period or 30 calendar days. The 'D' rating also will be used upon the filing of a bankruptcy petition or the taking of similar action and where default on an obligation is a virtual certainty, for example due to automatic stay provisions. A rating on an obligation is lowered to 'D' if it is subject to a distressed exchange offer.</td>
</tr>
</tbody>
</table>
# APPENDIX II

Moody’s Rating table

## Global Long-Term Rating Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaa</td>
<td>Obligations rated Aaa are judged to be of the highest quality, subject to the lowest level of credit risk.</td>
</tr>
<tr>
<td>Aa</td>
<td>Obligations rated Aa are judged to be of high quality and are subject to very low credit risk.</td>
</tr>
<tr>
<td>A</td>
<td>Obligations rated A are judged to be upper-medium grade and are subject to low credit risk.</td>
</tr>
<tr>
<td>Baa</td>
<td>Obligations rated Baa are judged to be medium-grade and subject to moderate credit risk and as such may possess certain speculative characteristics.</td>
</tr>
<tr>
<td>Ba</td>
<td>Obligations rated Ba are judged to be speculative and are subject to substantial credit risk.</td>
</tr>
<tr>
<td>B</td>
<td>Obligations rated B are considered speculative and are subject to high credit risk.</td>
</tr>
<tr>
<td>Caa</td>
<td>Obligations rated Caa are judged to be speculative of poor standing and are subject to very high credit risk.</td>
</tr>
<tr>
<td>Ca</td>
<td>Obligations rated Ca are highly speculative and are likely in, or very near, default, with some prospect of recovery of principal and interest.</td>
</tr>
<tr>
<td>C</td>
<td>Obligations rated C are the lowest rated and are typically in default, with little prospect for recovery of principal or interest.</td>
</tr>
</tbody>
</table>