SONIA STATI

TOWARDS A GREENIFICATION EXPLORING THE GREEN BOND PREMIUM

Fondazione Finanza Etica

LA COLLANA “ANTONIO GENOVESI”

09

Sonia Stati

TOWARDS A GREENIFICATION EXPLORING THE GREEN BOND PREMIUM

Tesi di laurea in MASTER OF SCIENCE IN FINANCE

Università degli Studi di Siena
Corso in Economics and management
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Premio tesi di Laurea sulla Finanza Etica 2021

To my family,

For having believed in me during these years,

To my close friends,

For being part of my life

To Siena,

For making me feel at home all the time

And mostly to Mireya

Without whom everything would have been different

Abstract

This thesis provides an empirical analysis on the existence of a green bond premium on the secondary market, after offering an overview on the green bonds and the literature which turns around them. The EUR-denominated green bonds are studied to determine if they diverge from comparable conventional bonds in terms of yields, during the period from January 2018 to December 2020. Through a matching method, a sample composed of 35 bond couples is obtained. The green bond premium is defined as the yield differential between a green and a comparable brown bond, while controlling for liquidity. On average, we report a negative green bond premium of -3.20 bps within our sample. The greenium differs across the sub-samples, being negative for green bonds issued by financial institutions, for those issued in domestic currency, for those issued by AA- and A-rated issuers, and for those issued by issuers with low or medium ESG risk levels. Finally, a cross-sectional regression is also run to investigate the determinants of the green bond premium. The ESG risk level has been found to be the driver of our negative green bond premium.

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Introduzione

Starting from the Industrial Revolution, the quality of our life has been increasing over the years, due to the unbelievable development of new technologies. Despite the improvements in people's daily lives, there have been also more and more damages to our planet. The continuous growth of world's population, associated with the scarcity of resources, has required an immediate response to the problems associated with the exploitation of the planet and climate change occurring in the last years, before it will be too late. Consequently, a transition towards a "greenification"[1] of our economy has been become a central topic by countries over the world.

In September 2015, all the Member States of the United Nations adopted the 17 Sustainable Development Goals (SDG) to be reached by the year 2030, in order to get benefits for both people worldwide and our planet[2].

In the following December, the first legally-binding global climate change agreement – the Paris Agreement – was adopted by 196 Parties during the 21st Conference of the Parties to the United Nations Framework Convention on Climate (COP21), with the aim of limiting the rise of global mean temperature to 2°C compared to the preindustrial period. More specifically, Article 2 of the Paris Agreement states that (United Nations, 2015):

> "*Parties agreed to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and*

[1] The act of greenify, namely to make something environmentally friendly.
[2] The Global Goals are: eliminate poverty, erase hunger, establish good health and well-being, provide quality education, enforce gender equality, improve clean water and sanitation, grow affordable and clean energy, create decent work and economic growth, increase industry, innovation and infrastructure, reduce inequality, mobilize sustainable cities and communities, influence responsible consumption and production, organize climate action, develop life below water, advance life on land, guarantee peace, justice and strong institutions, build partnerships for the goals.

pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."

To promote this new challenge and to satisfy the ethical intentions of some investors, some financial tools have been used to address capital flow into green projects.

Green bonds may be thought as a suitable financial instrument to promote the transition towards a greener and more sustainable economy. They represent the major instrument within the Sustainable Development Bonds (SDBs) market.

There is not a universal definition of them, but from a financial perspective, they are comparable to conventional bonds. The difference between the two debt instruments lies in the use of the earmarked proceeds. In fact, green bonds build a bridge between the financial system and the environmental goals, using their proceeds to finance green projects.

The green bond market has been developing since 2007, but it is only during the last years that it has been increasing in terms of importance and size. In December 2020, the green bond market has reached its first one trillion (in USD) in global cumulative green issuance since its inception[3]. In order to really promote the transition, by financing green projects, the green bond market must be solid and well-distributed. Consequently, the next one cumulative green trillion must not be reached in a long time, but huge amounts of resources need to be invested in always more and more segments. In other words, green bonds need to be always more fashionable and to offer always more benefits to attract new

[3] https://www.climatebonds.net/2020/12/1trillion-mark-reached-global-cumulative-green-issuance-climate-bonds-data-intelligence

investors.

According to Zerbib (2019), green investors can be motivated by the expectation of a better financial performance of these assets, by lower risk and volatility associated with them, or by non-pecuniary motives.

The will of the investors to support green projects and to contribute to the "greenification" can be represented by the green bond premium, which could evidence their willingness to pay for financing green projects over others.

How much the investors' attitude towards the environment impacts on the bond prices is a central key point in the literature. Comparing the yield of a green bond and the yield of a conventional bond, ceteris paribus, this thesis investigates the existence of a green bond premium on the secondary market.

Hence, a negative green bond premium means that a green bond trades at a lower yield than a comparable conventional bond, pointing out that green investors are receiving less returns. Of course, also the opposite is true.

In order to estimate the yield difference between green and conventional bonds, ceteris paribus, a matching method is applied. To extract the green bond premium, a panel regression with fixed-effects is run, controlling for liquidity differences. Next, the determinants of the green bond premium are identified by running an OLS cross-sectional regression model.

Our analysis is performed on 35 bond-pairs, all EUR-denominated and investment-grade, on the secondary market, taking as period from January 2, 2018, to December 14, 2020.

The results show that, on average, a negative green bond premium of -3.20 bps exists for the EUR-denominated bonds present in our sample on the secondary market. Further, we show that ESG risk

levels are significant drivers of the green bond premium: the negative greenium is greater for low ESG risk level rated bonds.

The rest of this thesis is organised as follows. Section 1 introduces the green bonds. In particular, the different definitions and the several regulatory frameworks are provided to the reader. Moreover, there is also an examination of the evolution of the green bond market, from its birth to the present days, considering all the different types of green bonds and market players. Finally, benefits and limitations are presented to understand which could be the reasons why investors decide to hold this new financial tool.

Section 2 introduces a part of the literature on the green bond premium. In particular, both studies supporting a negative green bond premium and studies supporting the opposite are considered.

Section 3 presents the empirical analysis conducted to assess the green bond premium on the secondary market. In particular, the two datasets are described, the matching method is explained, the methodology is detailed, and finally the results are reported.

Finally, Section 4 summarizes the results and offers some conclusions.

1. Growing Green

This chapter provides a general overview of the green bond market. Describing the common features of the green bonds, we will build a broad definition of them, and place them in the current regulatory framework. Thanks to a quick mention of the evolution of the green bond market, we will be able to understand the current situation in the market. To better draw the green bond field, also the different types of green bonds commonly accepted, the major issuers and investors involved in the market, and the valuation of the potential benefits and limitations of the nascent phenomenon will be briefly analysed. Finally, some challenges will be proposed to scale up the green bond market, including the new proposal of the EU Recovery Fund.

1.1 What is a green bond?

In the last few years, investments in the green economy have become more and more important. The reasons can be different: from the will to reach the United Nations' 17 Sustainable Development Goals within 2030 and to respect the Paris Agreement on climate change to the growing demand for Socially Responsible Investments (SRI)[4] by both retail and institutional investors.

According to the OECD, in order to satisfy the Paris Agreement, investment in infrastructure per year by 2030 should be around USD 6.9 bn (OECD, 2017). Green bonds are considered one of the main financial instruments to perform this objective, and to lead the transition towards a more environmentally sustainable economy.

[4] It is an investment strategy that seeks to consider both financial returns and social good.

Although, even if the green bond market is increasing importance, there is still a great deal of confusion about “what does green mean?”, and particularly about “what is a green bond?”.

Regarding the first question, the Climate Bonds Initiative (CBI) states that the way for growing “green investments” is the development of taxonomies, which will help in the naming of green assets and projects, so that issuers and investors meet each other in a clearer way (Climate Bonds Initiative, 2019). The clarification of green borders, and hence the creation of a common language, may be useful to avoid market fragmentation and to draw a harmonized system, to encourage governments in targeting their climate and infrastructure goals, but most of all, to let investors trust the good intentions of issuers and feel protected against greenwashing (Climate Bonds Initiative, 2019).

In this regard, and as we will see in more detail later, CBI provides a regularly updated taxonomy – Climate Bonds Taxonomy – in which identifies eligible assets and projects in the following sectors: energy, transport, water, buildings, land use & marine resources, industry, waste & pollution control, ICT (Climate Bonds Initiative, 2020).

Unfortunately, also the answer to the second question is difficult to be given, due to the missing of a universal definition of green bonds. In fact, currently, there is no common consensus on the definition, leading actors to misinterpret the potential benefits of the green bond market (Shishlov, Morel, & Cochran, 2016).

In order to try to define this concept in general terms, it might be useful to mention the definitions given by the International Capital Market Association (ICMA) and the Organization for Economic Co-operation and Development (OECD).

According to the "Green Bond Principles" (GBP), re-published in June 2018 and coordinated by ICMA, the green bonds can be defined in the following way:

"*Green Bonds are any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects and which are aligned with the four core components of the GBP.*"

Instead, the OECD in "Mobilising Bond Markets for a Low-Carbon Transition" (2017) states that:

"*Green Bonds are debt instruments used to finance green projects that deliver environmental benefits.*"

By using these two broad definitions, we can affirm that green bonds are innovative debt instruments, issued by financial institutions, governments, or companies to raise funds to finance "green projects or assets". Simply put, green bonds can finance things that would not get financed otherwise. The main goal of them can be summarized in the fight against climate change.

The green bonds are functionally like any other conventional bond. In effect, they share many common features since they are both fixed-income securities (principal, coupon, maturity, yield, rating, pricing, and so on).

As we know, an issuer (or a borrower) sells bonds to raise funds from investors, by promising to pay back at maturity. On the other hand, investors are entitled to future regular payments until maturity. At maturity, the borrower will pay back the principal, as well.

Like any other conventional bond, green bonds are initially issued on the primary market, and then traded on the secondary market, either on various stock exchanges or over the counter (OTC).

The green bond takes the same rating as an issuer's other conventional bond. As we will see later, most of them are recourse-to-the-issuer, and therefore the investors are not exposed solely to the risk of the bond's underlying projects (Rosembuj & Bottio, 2016).

It can be understood that structures, risks, and returns of the two bonds are identical but green bonds differ from the latter in the purpose of their issuance, as the proceeds are only used in "environmentally-friendly investments".

Despite this definition seems to be simple, it is not. In fact, it is not easy to really define which are the "environmentally-friendly investments", for the reasons above mentioned. The lack of taxonomies leads to a lack of universal definition, which in turn, as we will see, leads to a lack of commonly acknowledged standards.

1.2 The regulatory framework

Referring to what was said shortly before, it is right to ask: "*Who regulates what is green?*" Another "big" question that turns around the green field, linked to the lack of harmonised standards!

As the market grew, because of the entry of new issuers, the need for more transparency increased, and hence many guidelines and standards have emerged to avoid any act of greenwashing and to increase transparency. But it is also true to say that, the grown of the market has been linked to the development of regulatory frameworks, which helped issuers and investors to meet each other, and mostly to trust each other.

Nevertheless, even if there are several frameworks and taxonomies, they are non-binding. The punishment, for those who do not respect them, is the loss of credibility on the market, going to increase the lack of confidence in investors, for whom it is difficult to assess the green nature.

Consequently, it becomes clear the reason why the development of global official green bond standards and guidelines assumes relevant importance. Without it, there are too many doubts and misunderstandings, and hence it is difficult to scale up the market and properly fight against the climate change.

The most widespread "international good practices" are the Green Bond Principles and the Climate Bonds Standard and Certification Scheme, which are useful tools for both investors and issuers, even if they are soft. They are dealt with in the following two subparagraphs.

1.2.1 Green Bond Principles

The "Green Bond Principles" (GBP) have been the first set of voluntary guidelines, aiming to promote integrity within the market, by recommending "transparency, disclosure and reporting" (ICMA, 2018). Following these principles, issuers release credible green bonds, and consequently, investors are safeguarded by undesirable situations.

They were developed by ICMA along with thirteen major investment banks[5] in January 2014. The most recent version, the one from which most of the information in this thesis is drawn, was published in June 2018.

[5] Bank of America Corporation, Citigroup, Crédit Agricole CIB, JPMorgan Chase, BNP Paribas, Daiwa, Deutsche Bank, Goldman Sachs, HSBC, Mizuho, Morgan Stanley, Rabobank and SEB.

In order to launch a green bond aligned with the GBP, there exist four pillars, which can be summarized in this sentence (Ehlers & Packer, 2016):

"*Green bonds should use proceeds for environmentally sustainable activities, have a process for determining project eligibility, manage the proceeds in a traceable fashion, and report annually on the use of proceeds*".

1. Use of proceeds

The vital aspect of a green bond lies in the use of its proceeds, otherwise, it would have been a simple conventional bond. In this respect, the GBP declares that, for labelling a bond as green, its proceeds must be used to finance green projects, with evident positive environmental impacts. Moreover, all the information related to the green project should be properly described in the legal document by the issuer.

In addition, the GBP provides a non-detailed list of eligible green projects, from which an issuer should choose for the allocation of proceeds: renewable energy; energy efficiency; pollution prevention & control; sustainable management of living natural resources; terrestrial & aquatic biodiversity conservation; clean transportation; sustainable water management; climate change adaptation; eco-efficient products, production technologies & processes (ICMA, 2018).

2. Process for Project Evaluation and Selection

In the second pillar, the GBP encourages the issuers to plainly delineate the adequacy of the project as green, the related eligibility criteria (considering also the potential risks of the project), and to communicate to investors which are the environmental sustainability goals they want to pursue.

Furthermore, the issuers are invited to maintain a high level of transparency, and the use of external review (to delineate and disclose the project evaluation process) is strongly recommended by the GBP (ICMA, 2018).

3. Management of the proceeds

Regarding the management of the proceeds, the GBP states that they should be "credited to a sub-account, moved to a sub-portfolio or otherwise tracked by the issuer in an appropriate manner" (ICMA, 2018).

Again, a high level of transparency is highly recommended to be maintained, and the use of an auditor (or other third-party) could be judicious to check funds' allocation.

4. Reporting

In order to get full transparency, and so to inform market participants, detailed periodic reports are required to be published by the issuers, in order to give knowledge on the project progress, by inserting qualitative/quantitative indicators to monitor its performance (ICMA, 2018).

In addition to the abovementioned principles, we can also find a section on "External review". Even if it is not a specific principle, the importance of an external review is often mentioned in them and its use is strongly recommended by the GBP, like a good way to validate "greenness". The "external review" topic is better deepened in paragraph 1.6.

1.2.2. Climate Bonds Standard and Certification Scheme

The Climate Bonds Initiative[6] (CBI) has designed the "Climate Bonds Standards and Certification Scheme", which is an international best practice for labelling a bond as green. It is used both by issuers, in ensuring their good green intentions (and so increasing their transparency and credibility on the market), and by investors, in addressing their investment green decisions.

In the "Climate Bonds Standard" (CBS) there are present the requirements to be met by the issuers to launch a credible bond, and so to get the "Climate Bond Certification", structured in two distinct phases (Climate Bonds Initiative, 2019):

- **Pre-issuance requirements**, to be fulfilled in order to get Certification ahead of issuance;
- **Post-issuance requirements**, to be fulfilled within 24 months in order to get Certification after the issuance.

Certification can only be maintained if the issuers make available reports at least annually. The Certification confirms (Climate Bonds Initiative, 2019):

- The full alignment with the GBP;
- The certainty that practice of internal controls, tracking, reporting, and verification are done in the best way, thanks to the assessment of a third-party;
- The allocation of bonds' proceeds to finance green projects.

Differently from the GBP, which only recommends the use of an external reviewer, to get the Climate Bonds Certification, the use of an external reviewer is mandatory.

[6] The Climate Bonds Initiative is an international investor-focused not-for-profit organisation. It was founded in 2010 to promote large-scale investments that will deliver a low-carbon and climate-resilient global economy. For more information, see https://www.climatebonds.net/

In 2019, the cumulative amount of Certified Climate Bond passed the USD 100 bn mark, with the Transport sector be the dominant one (Climate Bonds Initiative, 2019). Currently, the Certified Climate Bonds account for USD 135 bn (approximately).

In support of the CBS, there is the "Climate Bonds Taxonomy", i.e. the list of the eligible projects and assets in line with the goals of the Paris Agreement. It was developed for the first time in 2013 but often updated. It is considered a useful tool for market participants to identify which are the assets and the projects that are making a significant impact on the transition to a greener economy (Climate Bonds Initiative, 2020).

1.2.3. Country-specific regulations

In addition, countries and regional bodies have published their local definition and standards for green investments. Country-specific regulations could better fit the country's environmental priorities but it is also important that they are aligned with global regulations, otherwise, it could generate higher transaction costs and confusion (Berensmann, 2017).

European Union

In March 2018, the European Commission developed the "Action Plan on Financing Sustainable Growth" (Action Plan), aiming to link finance and sustainability, and to make European Union be carbon neutral by 2050. In other words, economic growth should be supported by finance, trying to safeguard the environment.

The Action Plan included ten Actions but we are going to consider only two of them:

Action 1: "*Establishing an EU classification system for sustainable activities*"

On 18th June 2020, the European Parliament adopted the text of the "Sustainable Finance Taxonomy Regulation", which entered into force on 12th July 2020 (Financial Stability, Financial Services and Capital Markets Union, 2020).

The EU Taxonomy is a classification system to help issuers and investors to understand if their investment decisions are as "sustainable" as they appear, and so to safeguard them against the risk of greenwashing.

To be in line with the EU Taxonomy, the EU TEG in the Final Report states that economic activities need to (EU TEG on Sustainable Finance, 2020):

- ✓ Contribute to at least one of six environmental objectives;
- ✓ "Do not significantly harm" any other environmental objectives;
- ✓ Meet minimum safeguards;
- ✓ Comply with technical screening criteria.

The six environmental objectives are: Climate Change Mitigation, Climate Change Adaptation, Water & Marine Resources, Circular Economy Transition, Pollution Prevention & Control, and Biodiversity & Ecosystem Protection.

Action 2: "Creating standards and labels for green financial products"

The "EU Green Bond Standard" (EU GBS) could be one of the main tools to overcome barriers in the green bond market, such as the lack of green definitions, lack of clear economic benefits for issuers, costly procedures for reporting and external review, and so on (EU TEG on Sustainable Finance, 2020).

As reported by the EU TEG, the EU GBS is a voluntary standard, which will help issuers to launch green bonds aligned with the internationally accepted "best practices", such as the GBP.

The EU GBS should regulate the four core components of green bonds:

- **Green Projects**

The TEG states that: "any type of listed or unlisted bond or capital market debt instrument issued by a European or international issuer that is aligned with the EU GBS should qualify as an EU Green Bond" (EU TEG on Sustainable Finance, 2020). In other terms, the alignment with the EU Taxonomy is required.

- **Green Bond Framework**

The publication of a Green Bond Framework is required to confirm the voluntary alignment with the EU GBS and to communicate to investors all the relevant aspects of the projects that will be financed through the EU Green Bond (EU TEG on Sustainable Finance, 2020).

- **Reporting**

Issuers should make two types of mandatory reports: on the use of proceeds (allocation reporting), and on environmental impact (impact reporting) (EU TEG on Sustainable Finance, 2020).

- **Verification**

Green Bond Framework and final allocation report must be verified by an external review (EU TEG on Sustainable Finance, 2020).

China

The green bond market in China is growing fast, gaining ground over the years. China's policy on green finance has been crucial to make this result since many guidelines have been published up to define a comprehensive framework for green finance (Climate Bonds Initiative & SynTao Green Finance, 2020).

China is considered the second-largest issuer country, accounting for USD 31.3 bn of internationally aligned green bonds in 2019. However, a consistent quote of green bonds issued is not aligned with international standards, worth USD 24.2 bn.

Since the end of 2015, many guidelines have been published to favour China's green finance development (Climate Bonds Initiative & SynTao Green Finance, 2020). They are summarized in Figure 1:

Figure 1: Policy measures taken by China to scale up the green bond market

Source 1: Climate Bonds Initiative, 2020 – Personal Elaboration

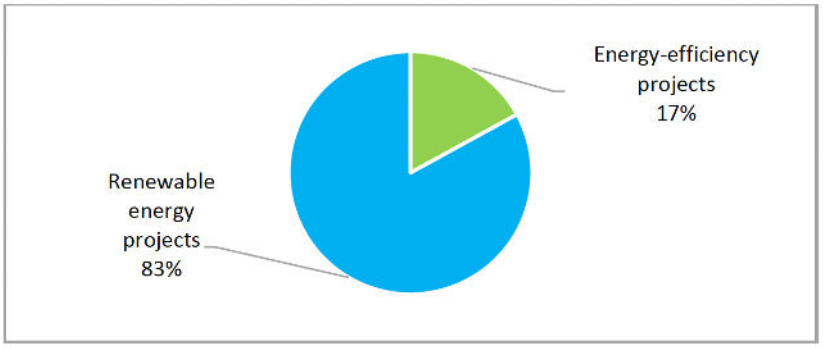
An important turning point has been taken place in 2020, because of the realisation of the draft on "Green Bond Endorsed Project Catalogue (2020 Edition)" (2020 Catalogue) by the People's Bank of China (PBoC), the National Development and Reform Commission (NDRC), and the China Securities Regulatory Commission (CSRC) (Climate Bonds Initiative & SynTao Green Finance, 2020).

The introduction of the 2020 Catalogue can be considered one of the most important developments in the green bond market, both because it has contributed to the harmonisation of domestic guidelines, and mostly because it has contributed to reduce the divergence of China's standard from other generally accepted international market standards, leading to a future global harmonisation (Rui, 2020). According to the latest version, "clean fossil fuels" projects have been removed from the list of eligible projects, in line with international standards.

1.3. The Growth of the Green Bond Market

In July 2007, the European Investment Bank (EIB) inaugurated the green bond market, issuing its first climate-focused bond, i.e. the "Climate Awareness Bond" (CAB)[7], worth EUR 600 million (or USD 0.81 bn), thus relatively small compared to today's numbers. The proceeds were used to finance 14 projects in six different countries between 2007 and 2008 (UniCredit Research, 2017). As shown in Figure 2, 83% of proceeds were used for renewable energy projects, while 17% for energy-efficiency projects.

Figure 2: Allocation of CAB proceeds in 2007 (in %)



Source 2: EIB, UniCredit Research, 2007 – Personal Elaboration

[7] It was a structured bond, with returns linked to an equity index (instead of fixed coupon).

Only one year later (in 2008), the World Bank issued its first green bond denominated in Swedish krona, namely the "World Bank Green Bond", worth SEK 2.325 bn (around USD 400 million). It was developed with Skandinaviska Enskilda Banken (SEB), to respond to a group of Scandinavian pension funds, who were seeking to support "climate-focused projects" (The World Bank - Treasury, 2015).

In the following years, the green bond market was dominated by Multilateral Development Banks[8] (MDBs), such as the International Finance Cooperation (IFC), and other public entities, like governments, agencies, and municipalities (Cochu, Glenting, Hogg, & al., 2016).

As shown in Figure 3, during the first years, the transactions were very small, with the "highest" peak in 2010, worth USD 4 bn.

A shift in the issue size curve can be noticed only from 2013, when corporates started to issue green bonds, and thus joined the green bond market. Vasakronan was one of the first to issue a corporate green bond in 2013, together with EDF and Bank of America.

In general, it was not only the entrance of corporations on the market, which led to an increase in the issue size but also the publication of the first voluntary standards and guidelines, such as the GBP and the CBS.

The expansion has further been encouraged by the entry in the market of emerging countries, such as India and China, which issue a large amount of green bonds, and by the launch of environmental sustainability initiatives, like the Sustainable Development Goals (SDGs).

[8] The Multilateral Development Banks, or MDBs, are supranational institutions set up by sovereign states, which are their shareholders. Their remits reflect the development aid and cooperation policies established by these states. They have the common task of fostering economic and social progress in developing countries by financing projects, supporting investment and generating capital for the benefit of all global citizens. (see EIB: https://www.eib.org/en/about/partners/development_banks/index.htm)

Over the years, the green bonds started to become "fashionable" and to attract always new investors. The volume dimensions are growing hugely, and they are finalized to further grow in the following years, letting the green bond market reach always new peaks.

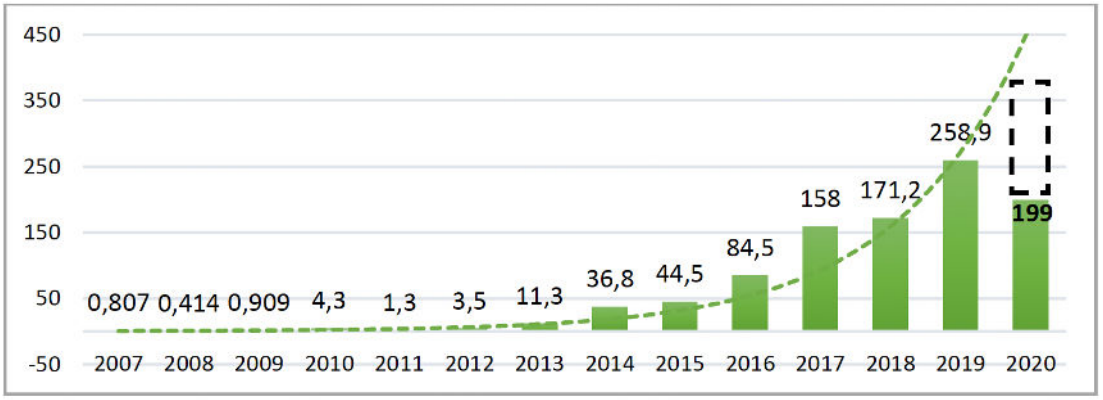
As of H1 2020, there have been around USD 868 bn of cumulative issuance at the global level (Climate Bonds Initiative, 2020).

Before the advent of the pandemic, the green bond market was riding the wave. The total issuance of 2019 was higher than the CBI's forecast, so that also for the year 2020, the CBI's expectations were really encouraging, worth around USD 350 – 400 bn (Chestney, 2020). Unfortunately, as we all know, the year 2020 has been hit by a serious pandemic, which has also had effects on the green bond market, slowing down somewhat its rapid expansion.

Figure 3 reports the historical evolution of the green bond market, over the years. Regarding the year 2020, the data refer up to the first half of November 2020.

In addition, the graph can be used to predict how much issuers should issue by the end of 2020, to be in line with the expectations (around USD 150 bn out of USD 350 bn).

Figure 3: Green Bond issuance since 2007 (in USD bn)



Source 3: Climate Bonds Initiative, 2019 – Personal Elaboration

1.4. The Green Bond Market Today

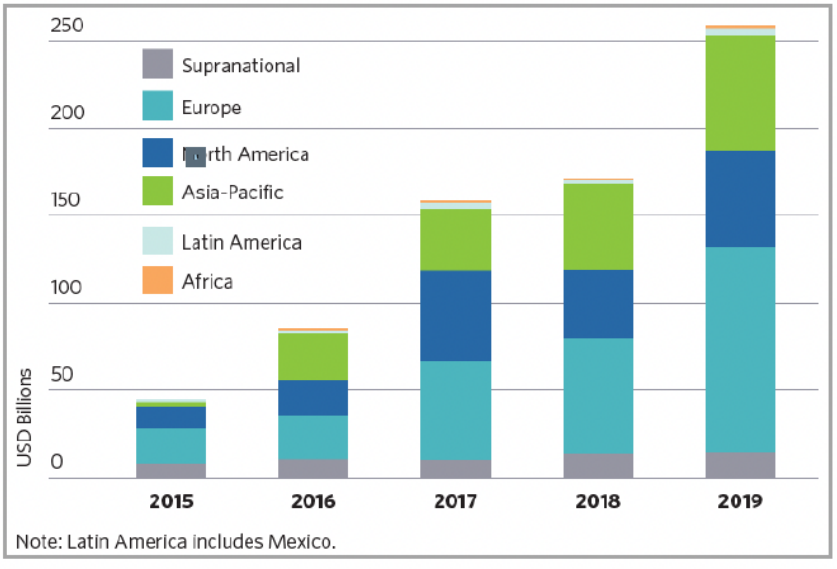
Before analysing the impact of COVID-19 on the green bond market in 2020, it is useful to describe which was the situation last year. In order to do it, we will go to get all the relevant information from the CBI's annual report – Green Bonds Global State of the Market (2019).

In 2019, the green bond market reached the record, moving from USD 171.2 bn to USD 258.9 bn (+ 51.23% vs. 2018).

All regions increased volumes, following the trend of 2016. Among others, the region with the highest amount issued was Europe (accounting for 57% of the global expansion), underlining Europe's devotion to the encouragement of Sustainable Finance development. Although, the largest changes over the previous year were from Latin America (+ 216%) and Africa (+ 495%), despite the much lower amount issued.

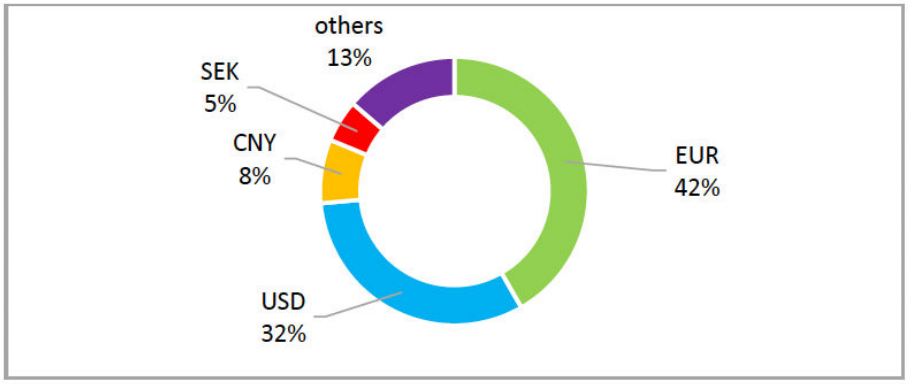
Figure 4 reports the yearly issuance volumes split per region.

Figure 4: Green Bond issuance by region from 2015 to 2019 (in USD bn)



Source 4: Climate Bonds Initiative, 2019

Figure 5 : Green Bond issuance by currency in 2019 (in %)

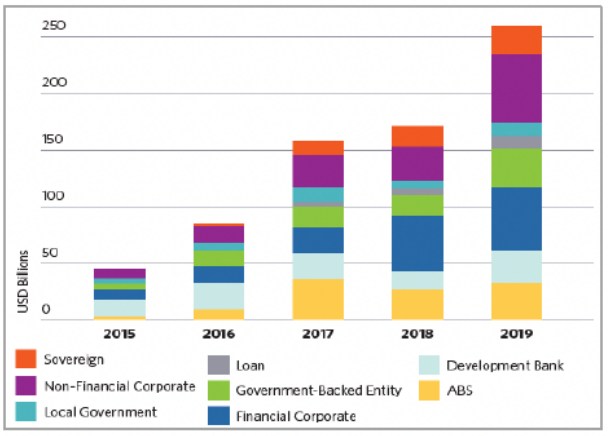


Source 5: Climate Bonds Initiative, 2019 – Personal Elaboration

It can be seen in Figure 6 that, over the years, and particularly from 2015 to 2019, the composition of issuers on the green bond market has considerably changed.

In 2019, the market was dominated by Financial and Non-Financial Corporates, with the latter be the winner for the first time ever of the top position as issuer, rising 101%.

Figure 6: Green Bond issuance by issuer type from 2015 to 2019 (in USD bn)

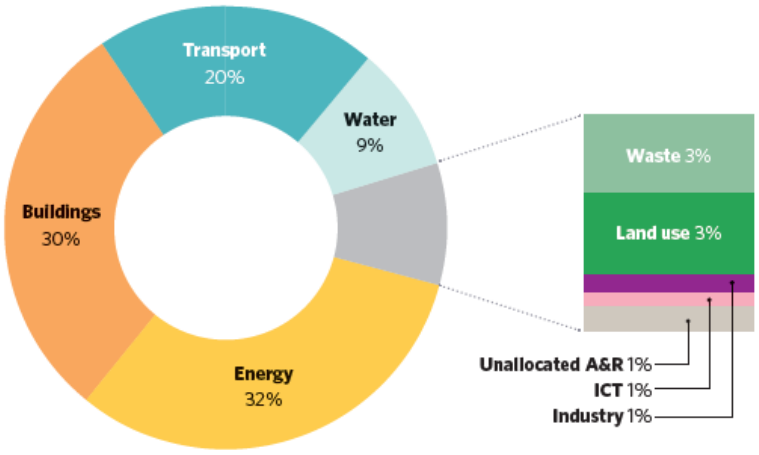


Source 6: Climate Bonds Initiative, 2019

Some considerations on the Use-of-Proceeds of green bonds are useful to be mentioned for this analysis. The categories in which the green bonds have reached the highest results were: Energy, Buildings, and Transport accounting for over 80%.

Figure 7 shows that the Energy sector prevailed with around 32%, showing to be the most attractive category of projects for investors, whilst the Buildings sector accounted for around 30% and the Transport sector for around 20%. Comparing to previous years (2017 and 2018), all categories recorded volume increases.

Figure 7: Green Bonds' use of proceeds in 2019 (in %)



Source 7: Climate Bonds Initiative, 2019

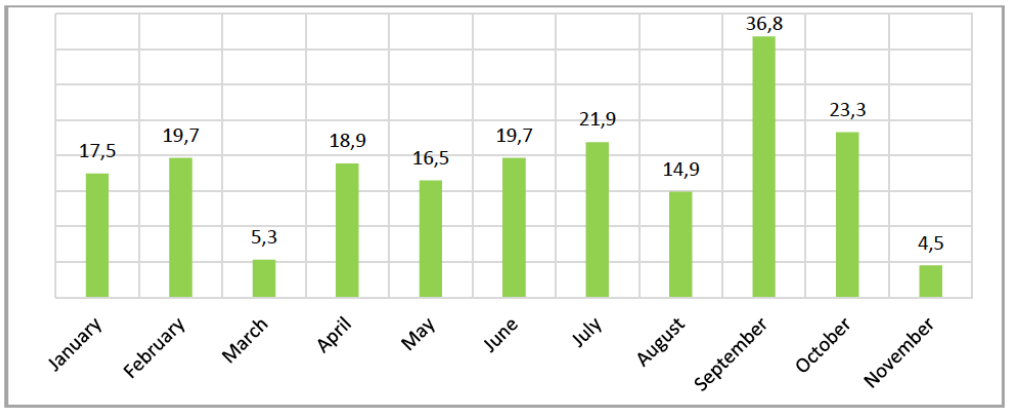
Moreover, it is interesting to investigate which projects are mainly financed by each issuer type. In fact, it is likely that the private sector tends to finance more Energy and Building projects. The reasons given by CBI are different, such as that the benefits of this type of project are easier to be calculated, or that typically it is the private sector that owns these sectors. By contrast, the public sector is more focused on Transport, Water, and Waste projects.

Finally, in 2019, it was possible to notice a significant transformation in the distribution of bond maturity. In fact, it

moved from shorter terms to longer ones, linked to the fact that market volatility decreased, and interest rates remained low[9].

The year 2020 was expected to become another record year, reaching an issuance volume of USD 350 – 400 bn, according to the CBI. In fact, in January and February, the green bond market started well, with a cumulative issuance of around USD 37.2 bn, whilst March amounted to only USD 5.3 bn, starting to reflect the impact of COVID-19 (Climate Bonds Initiative). So far, September was the best month ever in terms of volume issued, accounting for USD 36.8 bn (Climate Bonds Initiative)[10].

Figure 8: Green Bond issuance volume in 2020 (in USD bn)



Source 8: Climate Bonds Initiative, 2020 – Personal Elaboration

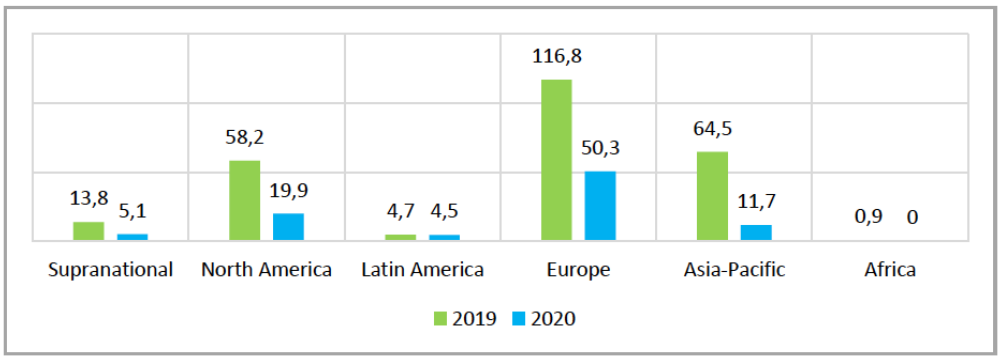
As we can imagine, but also confirmed by CBI in "Sustainable Debt – Global State of the Market H1 2020" in every region issuance went down in H1 2020, placing itself to below half of 2019 levels. Africa has concluded the first half of the year without issuances. The only exception was Latin America, which has almost exceeded 2019 levels (thanks to continued sovereign issuance from Chile).

[9] In 2018, the situation was completely the opposite: higher market volatility and increasing interest rates. Consequently, shorter terms were preferred.
[10] The data refers as of the first half of November 2020.

The weakest region (excluding Africa) was Asia-Pacific, due to the poor performance of China. We should remember that the COVID-19 hit China before others.

Europe performed very well, representing for the first time 55% of the global total.

Figure 9: Comparison between 2019 and H1 2020 in relation to issuance by regions (in USD bn)

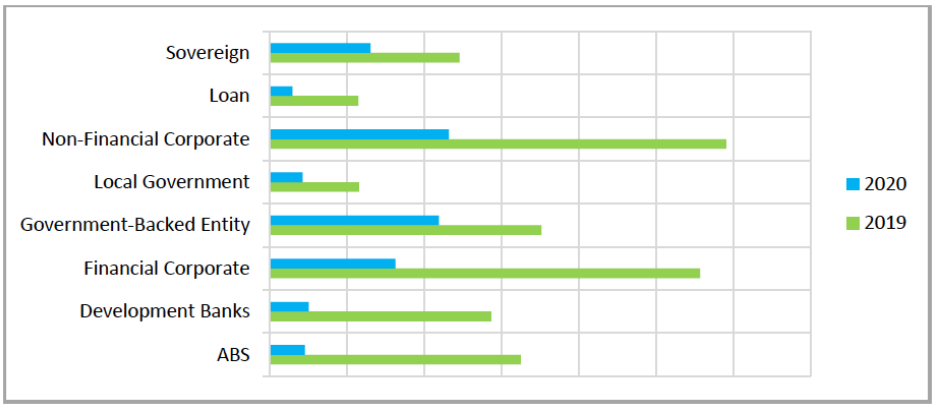


Source 9: Climate Bonds Initiative, H1 2020 – Personal Elaboration

Regarding the issuer types, the private sector has been shaken more than the public sector, due to the fact that investment plans of the private sector are more flexible to be managed than those of the public sector, and moreover, the private sector is more vulnerable to market dynamics, particularly in the short-term (Climate Bonds Initiative, 2020).

Among private-sector issuers, Non-Financial Corporates performed well with respect to Financial ones, maintaining the top position as issuer type.

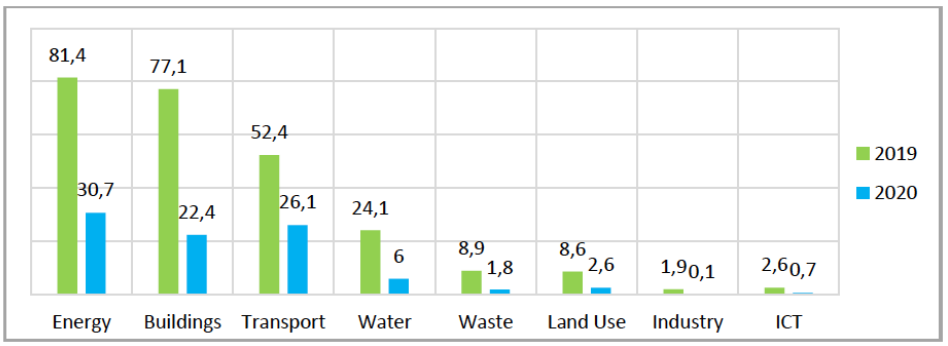
Figure 10: Comparison between 2019 and H1 2020 in relation to issuance by issuer type (in USD bn)



Source 10: Climate Bonds Initiative, H1 2020 – Personal Elaboration

Energy, Buildings and Transport confirmed their top positions of the previous year, rising to a record of 87%. The merit must be assigned to Transport, which reached half of 2019 levels, because of rail investments from Sovereigns and Government-backed entities (Climate Bonds Initiative, 2020). Although, Energy and Buildings dropped by 62% and 71%, respectively.

Figure 11: Comparison between 2019 and H1 2020 in relation to issuance by use of proceeds (in USD bn)



Source 11: Climate Bonds Initiative, H1 2020 – Personal Elaboration

Finally, regarding the currencies, there was an increased volume among the most used currencies, reflecting a preference for "safer"

ones in a time of market uncertainty (Climate Bonds Initiative, 2020).

In conclusion, we can affirm that, even if the pandemic hits all the markets, and thus also the green bond market, the growth momentum has not totally disappeared with the pandemic.

1.5. Types of Green Bonds

Since its inception, the green bond label has been applied by the issuers to a variety of structures. The previously mentioned GBP have classified the green bonds in four different forms, depending on their structure:

- **Standard Green Use of Proceeds Bond**
- **Green Revenue Bond**
- **Green Project Bond**
- **Green Securitised Bond**

The former, i.e. **Green Use of Proceeds Bond**, is the most popular green bond type on the bond market and, consequently, the most interesting for our purposes. Its popularity is because it behaves very similar to conventional debt obligations. The interest payments and principal repayment are ensured by the issuers' assets ("recourse-to-the-issuer") in case of default (Rosembuj & Bottio, 2016). Moreover, they share the same credit rating as the issuer (Deschryver & de Mariz, 2020). The only difference between green and brown lies, of course, in the fact that proceeds raised are earmarked for green projects.

Differently from the previous one, the **Green Revenue Bond** is defined as a "non-recourse-to-the-issuer" debt obligation, which means that the interest payments and principal repayment are

linked to the cash flows generated by the project, whose proceeds may be used in related or unrelated green projects (Rosembuj & Bottio, 2016).

The case in which the investor takes a direct exposure to the risk of the green projects, being able or not to recourse to the issuer, we are talking about **Green Project Bonds**. Obviously, the credit risk is higher since the uncertainty is more. The proceeds are invested in a specific green project (Rosembuj & Bottio, 2016).

Lastly, if the green bond takes the form of a **Green Securitized Bond**, it means that the bond is collateralised by one or more green project(s). This typology includes covered bonds, ABS, MBS, and other structures.

Following the classification of OECD – Mobilizing bond market for a low-carbon transition (2017) – we can state that Corporate bonds and SSA[11] bonds lie in the first category, i.e. Green bond Use of Proceeds. In fact, they share similar features on the "use of proceeds" and the "recourse-to-the-issuer". Indeed, Sovereign bonds and Municipal bonds usually assume the form of Green Revenue bonds.

1.6. Green Players

The main actors in the green bond market are:

Issuers

They are the "borrowers of the money", and include Multilateral Development Banks, such as World Bank, European Investment Bank, International Finance Corporation, banks and financial institutions, such as Bank of America, KfW, Credit Agricole,

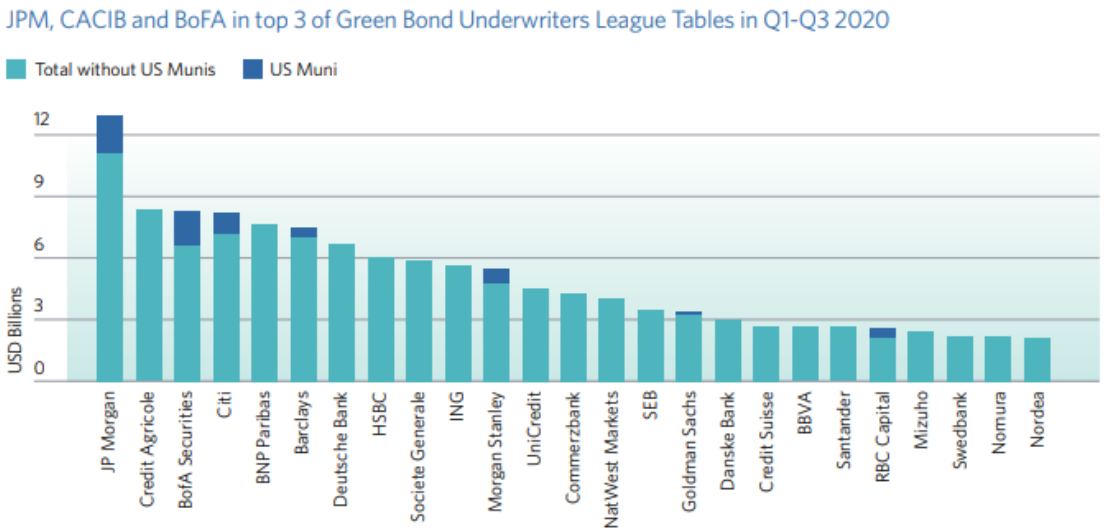
[11] Supranational, sub-sovereign and agency bonds are issued by International Financial Institutions (IFIs), such as World Bank and European Investment Bank.

municipalities, such as City of Gothenburg, City of Johannesburg, State of Massachusetts, and corporations, such as Apple, Toyota (Cochu, Glenting, Hogg, & al., 2016). They define the credit risk[12] of the green bond.

Underwriters

They are financial institutions that specify the terms, definitions, and obligations of the green bond. In the three quarters (Q1 – Q3) of 2020, the top green bond underwriters in terms of volume were JP Morgan, Crédit Agricole, Bank of America Securities, and Citigroup[13]. Among others, UniCredit also appears in the league table.

Figure 12: Green Bond Underwriters League Table



Source 12: Climate Bonds Initiative, 2020

External reviewers

In order to assess the correspondence between green bonds and guidelines, there exist different forms of external review, such as

[12] The likelihood that the investor will be repaid their initial loan.
[13] See https://www.climatebonds.net/resources/league-table

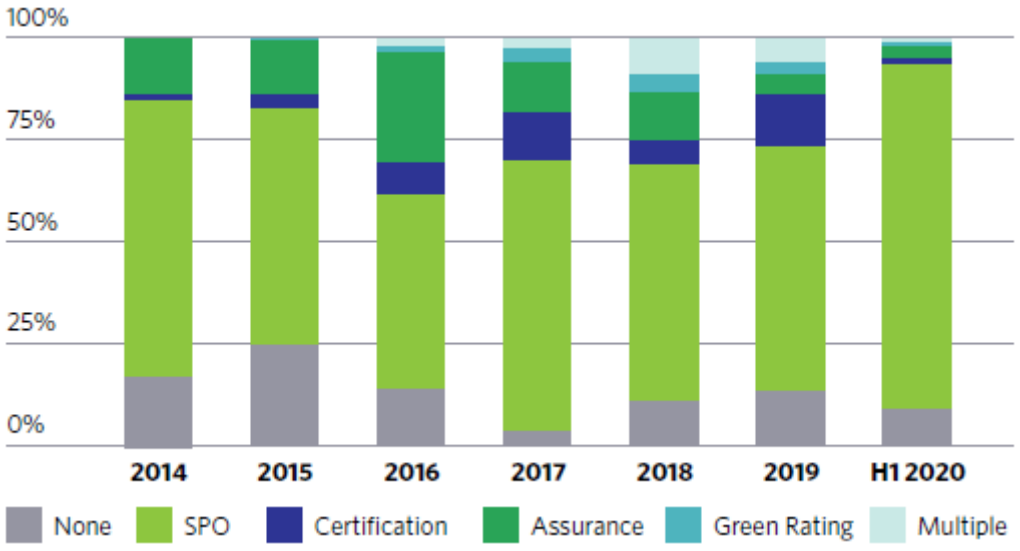
Second Party Opinion, Verification, Certification, or Green Bond Scoring/Rating (ICMA, 2020).

All of the firms providing external reviews should satisfy the following "fundamental ethical and professional principles": integrity, objectivity, professional competence & due care, confidentiality, and professional behaviour (ICMA, 2020).

By looking at the most recent data, the second party opinion confirmed itself as the most preferred external review type, accounting for 83% of issuance in the first half of 2020 (vs. 60% in 2019) (Climate Bonds Initiative, 2020).

At the time of issuance, the issuer can ask for a second opinion on their green bonds. Therefore, the fact that the review can be done only before issuing a green bond and not on an ongoing basis represents a limit, but it may be overcome by certifications and rating agencies, despite they are in an early stage (Ehlers & Packer, 2016).

Figure 13: Types of External Review from 2014 to H1 2020



Source 13: Climate Bonds Initiative, 2020

The impact of COVID-19 was made evident by the increase of issuance without an external review after March (Climate Bonds Initiative, 2020). During the coronavirus pandemic, the fixed income market has been used as "a tool to solve or combat problems, whether climate change or COVID-19" (Environmental Finance, 2020). The lack of external reviews in some cases can be attributed to the emergency period in which they were issued.

The leading global provider of the second opinion is CICERO[14], who also provided the second opinion for the first green bond issued by the World Bank in 2008. By using "Shades of Green" as methodology, they assign three different degrees of green (dark, medium, and light), reflecting the alignment of the green bond with a low-carbon climate-resilient future (CICERO Shades of Green).

The other two are Sustainalytics and Vigeo Eiris.

Currently, certification is only provided by the Climate Bonds Initiative. As we have already seen, issuers who meet pre- and post-issuance requirements receive a certification, allowing them to be more credible on the market. Last year, certification under Climate Bonds Standard has almost doubled in volume, confirming itself as the second-largest external review (Climate Bonds Initiative, 2019).

A green bond rating is typically provided by rating agencies. In 2016, Moody's published "Green Bond Assessments" (GBA) for the assessment of green bonds, considering five broad factors: use of proceeds, ongoing reporting, organization, management of proceeds, and disclosure on the use of proceeds (Shilling, 2016).

The assessment scale assumes different grades from GB1 (excellent) to GB5 (poor).

One year later, in 2017, Standard & Poor's introduced the "Green Evaluation" approach¸ which is a weighted aggregate of

[14] CICERO is a climate research institute based in Oslo.

transparency, governance, and mitigation (or adaptation). The score goes from E1 to E4 (S&P Global Ratings, 2020).

Market intermediaries

Over the years, several stock exchanges have set up dedicated segments for green bonds, supporting the transition to a green economy. They are an important actor, because they can provide not only regulated and transparent markets (increasing the credibility of the green bonds, as they require to meet some standards to be listed in these segments) but also market liquidity (Berensmann, 2017). Moreover, it provided the access to more diversified types of investors.

In addition, over-the-counter trades are other market intermediaries.

Figure 14: Green Bond Segments on Stock Exchanges

Name of Stock Exchange	Type of Dedicated Section	Launch Date
Oslo Stock Exchange	Green bonds	January 2015
Stockholm Stock Exchange	Sustainable Bonds	June 2015
London Stock Exchange	Green bonds	July 2015
Shanghai Stock Exchange	Green bonds	March 2016
Mexico Stock Exchange	Green bonds	August 2016
Luxembourg Stock Exchange	Luxembourg Green Exchange	September 2016
Borsa Italiana	Green and Social bonds	March 2017
Taipei Exchange	Green bonds	May 2017
Johannesburg Stock Exchange	Green bonds	October 2017
Japan Exchange Group	Green and Social bonds	January 2018
Vienna Exchange	Green and Social bonds	March 2018
Nasdaq Helsinki	Sustainable bonds	May 2018
Nasdaq Copenhagen	Sustainable bonds	May 2018
Nasdaq Baltic	Sustainable bonds	May 2018
Swiss Stock Exchange	Green and Sustainability bonds	July 2018
The International Stock Exchange	Green bonds	November 2018
Frankfurt Stock Exchange	Green bonds	November 2018
Santiago Stock Exchange	Green and social bonds	July 2019
Moscow Exchange	Sustainable bonds	August 2019
Euronext	Green bonds	November 2019
Hong Kong Exchange	STAGE, Sustainable and Green Exchange	June 2020
Singapore Stock Exchange	Green, Social and Sustainability bonds	n.a.

Source 14: Climate Bonds Initiative, 2020

Index providers

In order to overcome the problems coming from a lack of universal standardisation and a lack of clear risk and performance data, many financial institutions and credit rating agencies have created indices to support investors in the evaluation of green bonds performance (GBP SBP - Databases & Indices Working Group, 2018). Currently, the green bond indices are:

- Solactive Green Bond Index, the first one to be launched in March 2014 by Solactive;
- S&P Green Bond Index, launched in July 2014, and S&P Green Bond Select Index, launched in February 2017, both by S&P;
- BAML Green Bond Index, launched in October 2014 by Bank of America Merrill Lynch;
- Bloomberg Barclays MSCI Green Bond Index, launched in November 2014 by Barclays MSCI;
- Finally, in 2016 China launched ChinaBond China Green Bond Index and ChinaBond China Green Bond Select Index to capture the performance of China green bond market.

Each of them differs according to different eligibility criteria for inclusion.

Investors

They are those who buy green bonds. Green investors are usually institutional investors, such as insurance companies, mutual funds, pension funds, ETFs, investment banks, international organizations, and governments, but also private investors are present on the market (e.g. commercial banks, household savings). Many of them are focused on environmental targets and are less return-sensitive (Hyun, Park, & Tian, 2018). Many of them tend to

be long-term investors since they want to protect themselves against inflation risk, default risk, and market volatility.

1.7. Benefits And Limitations of Green Bonds

Green bonds can offer various advantages for both issuers and investors, but also the benefits for the environment are evident, as they can raise funds to support environmentally friendly projects, that would otherwise not be supported.

Issuers can count on several benefits by issuing green bonds. As a matter of fact, it is more likely that investors devoted to "green and responsible behaviour" will be attracted to this kind of investment, since they want their portfolios to be, in a certain way, ESG (Sustainable Banking Network (SBN), 2018). Therefore, issuers benefit from the enlargement of the pool of buyers (diversification of investor base).

Moreover, issuers benefit from a strengthening of reputation in the creation of sustainable value, letting them appear more "appetizing" on the market (Sustainable Banking Network (SBN), 2018).

Indeed, even if it is not always in this way, recent evidence suggests that there exist also pricing benefits on their issuance (Sustainable Banking Network (SBN), 2018). In other words, green bonds may be financed less expensively since they could enjoy a higher price and lower yield, compared to conventional bonds (negative green bond premium).

As reported in "Green Bond – Treasurer Survey", published by CBI in 2020, several noteworthy results were:

- Almost every respondent (98%) agreed that their green bonds have attracted new investors;

- Most of them (75%) agreed that the demand for their green bond was higher than that for their vanilla bonds;
- Almost half of them (48%) agreed that the costs of funding a green bond were similar to those of a vanilla equivalent, while another relevant percentage (42%) agreed that the costs were lower.
- The main reasons for issuing resulted to be the reputational benefits and the market signal;

Let us now turn to investors' benefits. As we saw before, green bonds are comparable to conventional bonds. It means that investors benefit from investing in activities with environmental impact, getting comparable financial returns, and hence without renouncing anything (Sustainable Banking Network (SBN), 2018).

Moreover, green bonds are characterized by greater transparency and disclosure into the use of their proceeds, increasing awareness on green issues in the investors, and enabling them to better assess the associated risks (Sustainable Banking Network (SBN), 2018). This feature is not common in conventional bonds, where specific reports on the use of proceeds are not included. In fact, regarding the conventional bonds, the issuer is free to use the proceeds for any purpose.

Finally, green bonds tend to be less volatile than conventional bonds since they are oriented towards long-term institutional investors with a buy-and-hold strategy (Deschryver & de Mariz, 2020).

Obviously, "all that glitters is not green", and there are also risks and barriers.

While the green bond market is growing fast, the main problem in its further growth is the lack of a universal clarification on what a green bond really is, namely a lack of harmonised standards

(Climate Bonds Initiative, 2015). The regulatory framework (at the national and international level) is still fragmented, and mostly it is non-binding.

The evaluation of green credentials is a crucial key point for all market participants. On one hand, issuers (e.g. governments) want to know if they are really doing something positive for the environment by supporting the green bond market. On the other hand, investors need to know if their green investments are really as "genuine" as they think. Simply putting, both of them are subject to the risk of "greenwashing", i.e. the risk that, even if a bond is labelled as green, its proceeds may be allocated to projects with questionable environmental merits (Climate Bonds Initiative, 2015).

Because of the non-binding nature of the current regulatory framework, the punishment, for those issuers who change opinions once received fund, lies only in the reputational field, without any legal consequences.

Moreover, the need for external reviews appears to be essential, in order to verify the green nature of the bonds and to monitor the real allocation of their proceeds; but it is also true that this need requires to support higher transaction costs, both initial and ongoing, which may become a disincentive for issuers (OECD, 2017).

By analysing the CBI's Green Bond - European Investor Survey (2019), some of these issues emerge. Most of the respondents (64%) declared to have a preference for green bonds, when available and competitively priced. Although, a similar percentage of respondents (67%) highlighted unmet demand for green bonds. A lack of suitable assets could be a barrier to entry into the green bond market. Issuers should enter in all the sectors and with all types of green bonds, but mostly by applying transparency and disclosure.

The most attractive investment features resulted, from the survey, to be positive fundamentals and transparency. In fact, most of the respondents (79%) declared that they would not have bought a green bond if, at issuance, the proceeds had not been clearly allocated in green projects. In addition, more than half of them (55%) declared that they would have sold the green bonds if post-issuance reporting had been poor.

Consequently, it is evident that standardisation of green bond definitions, consistency of reporting, and disclosure (pre- and post-issuance) are highly recommended to scale up the green bond market (Climate Bonds Initiative, 2019).

1.8. Green Recovery Measures

Due to the "particular" historical period that we are living in, some considerations on the link between the COVID-19 and green bonds need to be done.

Unfortunately, the COVID-19 pandemic is one of the major threats that both humans and economies worldwide are facing. Yet, something positive could be obtained from this disaster. In fact, it could be a huge opportunity for the transition to a low emission economy. The rationale behind it is not so strange, due to the policy measures to reactivate the economies, that are going to be taken by different countries. One of these policy measures is the EU Recovery Plan, briefly analysed in the following sub-paragraph.

1.8.1. EU Recovery Plan

In order to support the recovery of Member States, in May, the European Commission proposed the "Next Generation EU", worth EUR 750 bn. Recently, Ursula von der Leyen, the president of the European Commission, declared to sell EUR 225 bn of green bonds

as part of the EU Recovery Fund, following the indication of EU Sustainable Finance Taxonomy (Climate Bonds Initiative, 2020). The full success of this policy measure would drastically increase the size of the global green bond market, too.

2. Literature Review

This chapter focuses on the central point of this thesis, namely the existence or not of a green bond premium in the pricing of green bonds. To answer this question, we will begin by looking at several studies conducted on this argument. Most of them are in support of lower yields for green bonds, and hence the existence of a negative green bond premium, others do not. Consequently, we could affirm that there are mixed results on it, mostly depending on the choice of the sample and the method used by each author.

2.1. The Green Bond Premium

Nowadays, most of the literature turns around the analysis of the green bond premium, which regards the pricing and the yield difference between green and conventional bonds, finding contrasting evidence.

Usually, when a new bond is issued, the issuer could bear an additional yield, that is the "new issue premium", to attract new investors. Consequently, the bond is issued at a lower price and higher yield than existing debt. However, also the opposite is true – the "new issue discount" – i.e. when a bond is issued at a higher price and lower yield than existing debt. In this scenario, the issuer benefits from cheaper financing costs (Climate Bonds Initiative, 2020). When we refer to the green bond market, this extra yield is called the green bond premium, or greenium.

As mentioned in the previous chapter, the most typical green bond is the "Standard Green Use-of-Proceed bond", which has been drawn around the concept of "flat pricing", i.e. no additional costs at issuance between standard bonds and green use of proceeds

bonds[15]. This is due to the fact that the credit quality of green bonds is equal to that of other vanilla bonds from the same issuer (Climate Bonds Initiative, 2020).

However, some empirical analyses have shown conflicting results on this topic, discovering the existence of a green bond premium both on primary and secondary markets.

Before starting the review of the literature, it might be useful to define some concepts.

The green bond premium, or greenium, refers to the yield difference between green and conventional bonds, ceteris paribus.

A negative greenium means that the green bond trades at a lower yield relative to an equivalent conventional bond. Because of the inverse relationship between price and yield, it implies that the green bond is priced higher than a comparable conventional bond (traded at a premium), and hence investors have to pay more for the green feature[16].

As stated by Nanayakkara & Colombage (2019), "if green bonds are issued at a premium over conventional bonds and subscribed by investors, this provides an additional inducement for issuers to issue more bonds to the market with a green label".

Of course, the opposite is true in the case in which there exists a positive greenium, and hence green bonds are traded at a discount.

The existence of a negative greenium – a green bond returns less than an equivalent conventional bond – could be useful both for issuers and investors.

Let us assume that a corporation can issue a 10-year bond, with a 5% coupon, at a price of EUR 100. Therefore, that corporation is

[15] Issuers do not take any pricing advantage, and investors do not give up any return.
[16] A green bond premium of -2 bps indicates the yield that investors are willing to give up for financing green investments rather than conventional investments with strictly equal risk.

willing to issue a green bond, with the same financial characteristics, only at a price higher than before (and hence with a lower yield) since the issuance of a green bond requires more external costs[17] and less freedom in the allocation of its proceeds. Consequently, the presence of a negative greenium in the primary market could offset these additional costs, lowering the cost of capital, and hence issuers might ask for cheaper financing.

On the other hand, investors might accept lower financial returns, as they are more interested in environmental returns than financial ones (Alonso, 2020). Moreover, rising prices in the secondary market mean that investors could benefit from an easier selling of the green bonds on at profit (Partridge & Medda, 2020).

In addition, the advantage in the issuance of this "exceptional" financial instrument could lead to an increment in financing green projects and activities, driving the transition to a low-emission economy.

Unfortunately, it is a well-known fact that green bonds and brown bonds share the same financial characteristics, including credit quality[18]. For that reason, one of the arguments against the existence of a negative greenium is that, in case of issuer default, green bonds are treated in the same way – pari-passu – as bonds with the same rating and issuer (Ma, Schoutens, & et al., 2020). Despite the good intentions of the green bonds, they are exposed to the same risks as brown bonds.

Since 2016, Climate Bonds Initiative periodically has been publishing reports on the "Green Bond Pricing in the Primary Market".

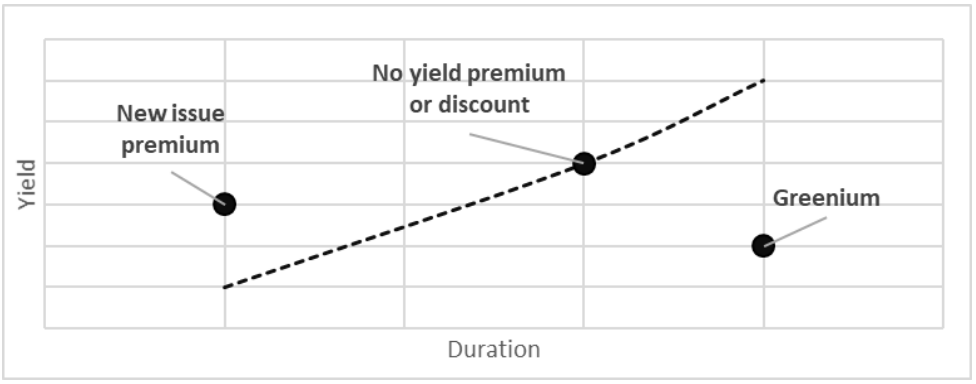
The green allocation is the average percentage of green bonds allocated to investors who defined themselves as green or socially responsible investors; as we can see in Table 1, over the periods

[17] We refer to a second-party opinion, regular reporting, certification, and so on. On average, it is estimated that the external costs for the issuer range around 0.3 and 0.6 bps for a USD 500 million issues. Certification under the Climate Bonds Initiative costs around 0.1 bps.
[18] See 1.1 WHAT IS A GREEN BOND?

considered, the green allocation has ranged around 50 – 55% (Climate Bonds Initiative, 2020).

For the CBI, a greenium exists if the new green bond is plotted below the issuer's yield curve; if it is plotted on the issuer's yield curve, then no yield premium or discount exist; finally, if it is plotted above the issuer's yield curve, a new issue premium exists (see Figure 15). To be included in the sample, green bonds must follow some specifications, regarding announcement date, currency (EUR or USD), benchmark size, consistency with the Climate Bonds Taxonomy, and so on (Climate Bonds Initiative, 2020).

Figure 15: Issuer's Yield Curve



Source 15: Climate Bonds Initiative – Personal Elaboration

By looking at Table 1, we can observe that, among a sample of 111 green bonds, covering a period from 2018 to H1 2020, only 20 green bonds showed a greenium; however, about the performance in the immediate secondary market, most of the green bonds have tightened more than comparable bonds, after 7 and 28 days.

Regarding the period Jan-Jun 2020, the result could be attributed to the advent of the pandemic, and hence to the fact that "investors were more cautious and buying opportunistically, particularly in Europe" (Climate Bonds Initiative, 2020).

Table 1: Main findings on Green Bond Pricing in Primary Market

PERIOD	GREEN INVESTORS	NEW ISSUE PRICING	TIGHTER SPREAD AFTER 7 DAYS	TIGHTER SPREAD AFTER 28 DAYS
JAN – JUN 2018	55%	Greenium: 0 On Curve: 5 Yield Premium: 13	62%	59%
JUL – DEC 2018	53%	Greenium: 2 On Curve: 5 Yield Premium: 14	56%	44%
JAN – JUN 2019	53%	Greenium: 6 On Curve: 15 Yield Premium: 12	46%	61%
JUL – DEC 2019	50%	Greenium: 7 On Curve: 8 Yield Premium: 3	60%	56%
JAN – JUN 2020	55%	Greenium: 5 On Curve: 6 Yield Premium: 10	63%	59%

Source 16: Climate Bonds Initiative - Personal Elaboration

In the following two paragraphs, we will see which authors support the existence of a negative greenium, and which ones do not.

Most of the studies analysed are based on global data and just a few of them on smaller market segments. Moreover, the most used approach is the matching method, i.e. matching green bonds with equivalent conventional bonds, to investigate in the yield differences. When such a difference is obtained, and it is negative, the green nature of the bond is identified as the potential guilty.

2.2. Evidence of a Negative Greenium

Most of the empirical research analysed to conduct this thesis claimed the existence of a negative green bond premium. We should remind that a negative greenium means that investors are willing to give up part of their returns, in order to invest in green

bonds. Usually, they are disposed to do it, whether they believe in the good intention of the issuer. Even though, some studies show that it is not true for highly rated green bonds, since they can be totally assimilated to conventional bonds.

Ehlers & Packer (2017) wondered if the price of a green bond was influenced by the green label. Their analysis was based on the comparison of the credit spreads at issuance of green and conventional bonds of the same issuers. They took a cross-section of 21 green bonds, issued between 2014 and 2017, while for conventional bonds they took those issued by the same issuers at the closest possible issue date of green bonds. Only USD- and EUR-denominated green bonds were treated. The obtained results allowed them to declare that a negative greenium of 18 bps (on average) was present in their sample, reflecting the fact that "green bond issuers on average have borrowed at lower spreads than they have through conventional bonds" (Ehlers & Packer, 2017). By looking at the single green bonds in that sample, issuers of 5 green bonds did not take any advantage. The explanation about the negative greenium given by them was linked to the excess of demand for green bonds over the relative supply. Moreover, once segmented the sample by rating category, they stated that "the green yield difference was greater for riskier borrowers" (Ehlers & Packer, 2017).

Schmitt (2017) concentrated his research on three questions: firstly, he wondered on the existence of a green bond premium; then, in which market or industry it could occur; and finally, whether it could be constant over time. By taking a sample of 160 global labelled green bonds[19], issued between January 2015 and May 2017, he estimated the difference in yield with synthetic conventional bonds, ceteris paribus. Differently from others, he compared each green bond with twenty comparable conventional

[19] They do not necessarily need to comply with the GBP, but they are categorized through the issuer itself.

bonds. Consequently, the existence of a negative green bond premium of 3.2 bps in that sample was found by him; then, he did not notice relevant differences between developed and emerging markets, nor among different industry groups; finally, as expected by him, the premium was not constant over time, but it declined in 2016 and 2017, due to the increased issuance (Schmitt, 2017).

Baker et al. (2018) followed the work of Karpf & Mandel (2018), by conducting their analysis on the US green bond market. They extended the traditional CAPM with preferences for green bonds. They took a sample composed by 2.083 municipal green bonds, issued between 2010 and 2016. Even a sample of 19 corporate green bonds, issued between 2014 and 2016, was taken, but it was not considered too much because of its small number. On the primary market, a negative greenium of 6 bps (on average) emerged in the sample of municipal bonds, and moreover, this premium was found to be more significant for Climate Bonds Certified green bonds (around 26 bps).

Hachenberg & Schiereck (2018) based their research on the belief that the green feature was attractive for investors, leading to an increase in the demand, which would justify the hypothesis that "green bonds trade tighter than conventional bonds, ceteris paribus". To conduct their analysis, each green bond was matched with two equivalent conventional bonds, which should have fulfilled the following criteria: same issuer, ranking, and currency, no structured, either fixed or floating coupons, both secured or unsecured, and minimum issue size of USD 150 million (Hachenberg & Schiereck, 2018). The final sample was composed by 63 green bonds and 126 conventional bonds, issued between October 2015 and March 2016. Once classified the sample into different ratings (AAA, AA, A, BBB), they noticed that, on average, green bonds were traded tighter than equivalent conventional

bonds (-1.18), but highly rating green bonds (AAA) were traded wider (+0.45). In addition, the sample was also classified by type of industry, obtaining the following, and expected, results: green bonds issued by financial institutions and corporations traded tighter, while those issued by government-related issuers traded wider. Finally, they concluded by saying that the differences in pricing were due to industry and ESG rating, and no to issue size, maturity, and currency.

Gianfrate & Peri (2019) researched the convenience to issue green bonds, even taking into account the transaction costs, in the Euro primary market, and then applied the same technique to research it in the secondary market. The comparison between green and equivalent conventional bonds was made through the propensity score matching technique[20]. The sample was composed by 121 EUR-denominated green bonds, issued between 2013 and 2017. Regarding the primary market, the existence of a statistically significant negative greenium of around 18 bps was found. This evidence resulted to be larger for corporate issuers (-21 bps), after having conducted the same analysis on the type of issuers (Corporate and Non-Corporate)[21]. Finally, also in the secondary market, it was found a lower, but still significant, negative green bond premium.

Nanayakkara & Colombage (2019) based their analysis on 7 hypotheses. Among them, the existence of a green bond premium was also proposed. They employed the option-adjusted measure (OAS) to compare the credit spreads of green and conventional bonds. They were the first to use panel data regression with a hybrid model. The sample analysed was composed by 82 global

[20] They refer to "getting the green label" as the treatment, to "Green bonds" as the treatment group, and to "Conventional bonds" as the untreated group. The change in the outcome variable due to the treatment is the treatment effect.

[21] It was allowed by the various types of green bonds present in the sample, e.g. corporates, sovereign states, national and multinational agencies, municipalities, financial institutions.

green bonds, issued between 2016 and 2017. The results obtained allowed them to affirm that a negative greenium of 62.7 bps existed in that sample, and hence the green bonds were traded at a tighter yield than conventional bonds.

Zerbib (2019) wanted to identify the effect of pro-environmental preferences on bond market prices, through the green bond premium. It was taken a sample composed by 110 green bonds and their matched conventional bonds on the secondary market, issued between July 2013 and December 2017. The matching method based on maturity was used to build synthetic bonds, which were compared to green bonds to estimate the difference in yield. A negative, but small, green bond premium of 1.8 bps (on average) emerged from that sample. Furthermore, the author pinpointed that the rating and the sector have behaved like significant drivers of the premium since low-rated bonds and financial bonds presented a more accentuate negative green bond premium. Finally, through robustness tests, he showed that the premium was not a market premium, nor a risk premium. As a result, the author concluded by saying that the pro-environmental preferences had a low effect on bond prices. The small green bond premium would not have been a disincentive for investors to invest in green bonds, but an opportunity for issuers to broaden their bondholder base.

Kapraun & Scheins (2019) structured their analysis on the research of three main topics, regarding: the difference in yields between green and conventional bonds; the variation across markets (primary vs secondary), currencies, issuers (corporates vs governments), and time; the green credibility. For the primary market analysis, they considered 1.520 green bonds and 202.394 conventional bonds in a Fixed Effects regression analysis. For the secondary market analysis, they matched green bonds with conventional bonds of the same issuer, with the same rating,

seniority, currency, and bond type, and with similar issue sizes and maturities (Kapraun & Scheins, 2019). It allowed them to compare 4.609 bond pairs. Finally, they tested the credibility. Regarding the primary market, they obtained a negative green bond premium of 20 – 30 bps, and substantial variation of green bond premium across currencies, issuer types, and over time. Differently, in the secondary market, they obtained a positive green bond premium of 10 bps; the only exceptions were the green bonds issued by governments or supranational institutions, showing the importance of the issuers' credibility. Finally, regarding the green credibility, they obtained a positive green bond premium for green bonds issued by low rated ESG's companies, because of greenwashing effects, and for those issued by very high rated ESG's companies, because of green labelling effects[22].

Partridge & Medda (2020) researched the existence of a green bond premium in the US municipal bond market, considering both primary and secondary markets. Differently from Karpf & Mandel (2018), Baker et al. (2018), and Larcker and Watts (2019) who focused on bonds labelled as "green" by Bloomberg, they relied on bonds declared as "green" by issuers. Their sample was composed by 453 matched pairs of green and vanilla bonds, issued between 2013 and 2018, used to perform a matched pair analysis. They observed a negligible greenium in the primary market, while a negative one in the secondary market of 5 bps.

[22] If an issuer is highly credible for its environmental-friendly purposes, it is treated as a conventional bond issuer, and so it does not benefit from lower yields.

2.3. No Evidence of a Negative Greenium

On the other side, some authors declare that the green bond premium would not exist, or it would be even positive. Differently from before, the following studies end up with green bonds traded at a discount and with higher yields.

Therefore, assuming the existence of a positive greenium means that the green bond is penalized by its "green nature".

Karpf & Mandel (2017) analysed the US green municipal bond market, taking 1.880 green municipal bonds and 36.000 conventional bonds, issued by the same issuers between 2010 and 2016. They focused on the yield term structure differences between green and conventional bonds, from the same issuers. From that sample, on average, a positive spread has emerged. According to the authors, it can be explained by "the difference in the mean characteristics between brown and green bonds" (Karpf & Mandel, 2017). Consequently, the market was penalizing green bonds.

Hyun et al. (2018) wondered how greenness was priced in the green bond market. They collected data from 2010 to 2017 about green bonds in compliance with GBP, obtaining 60 pairs of green and synthetic conventional bonds to be analysed, through the liquidity-adjusted yield premium. They found, on average, no evidence on the green bond premium, neither positive nor negative. However, externally reviewed green bonds and CBI certificated green bonds were shown to enjoy, respectively, a negative greenium of around 6 and 15 bps, compared with other green bonds without this additional greenness information (Hyun, Park, & Tian, 2018).

Bachelet et al. (2019) questioned the impact of the green feature on the green bond pricing, liquidity, and volatility in the secondary

market. In order to compare the yield spreads, they adopted an exact matching method. The green bond and the conventional bond should have had the same issuer, currency, rating, bond structure, coupon type, and they should have been as similar as possible in terms of maturity date, coupon rate, and amount issued (Bachelet, Becchetti, & Manfredonia, 2019). The sample, composed by labelled green bonds and listed on the CBI website, included 89 bond couples, issued from 2013 to 2017. A positive green bond premium, ranging from 2.06 and 5.9 bps, was found from that sample. For an in-depth analysis, the sample was divided into private and institutional issuers. Regarding private issuers, a positive green bond premium of around 2 – 3 bps emerged, and precisely it was much higher for private issuers without third-party verification of around 7.5 bps (on average). Regarding institutional issuers, a negative green bond premium was found of 4 bps (on average).

Larcker & Watts (2020) treated the US municipal green bond market, for three reasons: first because "municipal issuers commonly price multiple tranches of securities, both green and non-green securities, on the same day with similar maturities"; then, because "the credit for municipal green bonds is identical to the credit for their non-green counterparts"; and finally, because "small issues of green municipal securities are very likely to provide powerful test of whether a greenium exists" (Larcker & Watts, 2020). Their research was based on a sample of 640 matched pairs of green and conventional bonds (with the same issuer, issue date, maturity, and rating) allowing them to declare that the greenium was exactly equal to zero (in proxy 85% of matched cases). If the greenium is zero, it means the pricing of a green bond is equivalent to the pricing of an equivalent conventional bond.

2.4. A Summary of the Greenium Studies

Table 2 reports all the authors analysed in the previous paragraphs, trying to give an intuitive pic of the most widespread thoughts about the greenium literature.

In particular, the type of dataset, the market analysed (primary or secondary), the sample size, the timeframe taken, the method applied, and finally the greenium obtained are all reported.

Table 2: Summary of literature review

AUTHOR	DATASET	MARKET	SAMPLE SIZE	TIMEFRAME	METHOD	GREENIUM (BPS)
Ehlers & Packer (2017)	USD- and EUR-denominated	Primary	21	2014 – 2017	Yield comparison	-18
Schmitt (2017)	Global	Secondary	160	2015 –2017	Fixed-Effects Model	-3.2
Baker et al. (2018)	US municipals and US corporates	Primary	2.083 19	2010 – 2016 2014 – 2016	OLS Model	-7.4 to -5.5
Hachenberg & Schiereck (2018)	Global	Secondary	63	2015 – 2016	Panel data regression	-1.18
Gianfrate & Peri (2019)	EUR-denominated	Primary and Secondary	121 70 – 118	2013 – 2017 3 different dates of 2017	Propensity score matching	-18.5 -11 to -5
Nanayakkara & Colombage (2019)	Global	Secondary	82	2016 – 2017	Panel data regression with hybrid model	-62.7
Zerbib (2019)	Global	Secondary	110	2013 – 2017	Fixed-Effects Model	-1.8
Kapraun & Scheins (2019)	Global	Primary and Secondary	1.513 769	2010 – 2018	Fixed-Effects Model	-30 to -20 +10
Partridge & Medda (2020)	US municipals	Primary and secondary	453	2013 – 2018	Yield curve analysis	Negligible -5
Karpf & Mandel (2017)	US municipals	Secondary	1.880	2010 – 2016	Oaxaca-Blinder decomposition method	+7.8
Hyun et al. (2018)	Global	Secondary	60	2010 – 2017	Fixed-Effects GLS Model	0
Bachelet et al. (2019)	Global	Secondary	89	2013 – 2017	OLS model	+2.1 to +5.9
Larcker and Watts (2020)	US municipal	Primary	640	2013 – 2018	Matching and Yield comparison	0

Source 17: Personal Elaboration

3. Empirical Analysis

This chapter is dedicated to the empirical research of the green bond premium on the secondary market. Different hypotheses will be formulated and tested: first, the existence of a green bond premium on the secondary market, within our sample; then, if the green bond premium varies across different sub-samples. Two datasets will be defined, a green one and a brown one, and through the matching method, a bond-pair sample will be created. A panel regression model with fixed effects will be run to estimate the green bond premium. Inspired by previous studies, also the definition of the potential determinants of the green bond premium will be investigated in this analysis, through a cross-sectional regression model.

3.1. Hypothesis Development

In the previous chapter, we reviewed a part of the literature that turns around the green bonds' field. Those studies differ in various elements, but all of them are focused on searching for the existence of a green bond premium on the market.

Thus, also this thesis aims at investigating if the yield difference between green and conventional bond, ceteris paribus, could exist.

A green bond premium is an additional yield that investors demand to invest in green bonds (Zerbib, 2019). Traditionally, risks and returns are the factors which influence the investment decisions. Although, concerning the green bonds, also sustainable preferences could drive the investment decisions. If the greenium is negative, an attitude for green preferences emerges. Investors are not only

interested in the returns, but they could care also about the green intentions of the bond, and hence they would be willing to undertake such kind of investment, receiving a lower yield than investing in comparable conventional bonds. The more is negative, the more the non-pecuniary, or green, motives influence the investors. Otherwise, in the case in which there is a positive or a neglectable green bond premium, it could mean that investors consider as substitutes the two investments, and so it is not necessary to give up a part of returns for green intentions, sometimes asking for a higher yield to hold green bonds. Consequently, researching a greenium on the secondary market is mainly focused on the investors' intentions.

As a starting point, we would like to assess if a green bond is traded at a lower yield than a similar conventional bond on the secondary market, due to the non-pecuniary preferences of the investors, leading to research the following hypothesis:

Hypothesis 1: There exists a negative green bond premium on the secondary market.

Furthermore, the size of the green bond premium could differ across various factors, as we saw in the literature.

In fact, the degree of renunciation of a part of returns by investors could depend on the issuer's sector. As explained by Hachenberg & Schiereck (2018), green bonds issued by government-related trade wider than green bonds issued by financial institutions and corporates. Zerbib (2019) also has found evidence that the green bond premium differs across sectors.

Hypothesis 2: The green bond premium varies across sectors.

Moreover, the non-pecuniary motives of the investors could be correlated to the credit quality of the green bonds. As reported by Hachenberg & Schiereck (2018), green bonds with a high degree of creditworthiness, and hence the lowest risk of default, are traded wider than comparable conventional bonds. The situation could be equal in the case of green bonds with low credit quality. While in the first case the reason could lie in seeing the two kind of bonds as substitutes, in the second case the investors could not feel safe in giving up a part of their returns for investing in a green project with such kind of investments.

Hypothesis 3: The green bond premium varies across credit ratings.

Furthermore, as we will see, our sample will be composed only of EUR-denominated green bonds. It means that there are some entities who issue bonds in domestic currency, and others in foreign currency, to broaden their investor base. It is plausible to question if on the secondary market the two different issuances are perceived in the same way by investors.

Hypothesis 4: The green bond premium varies between domestic and foreign currency.

Finally, the ESG risk level attributed to each issuer could influence the size of the green bond premium. A green bond with a high ESG risk level could not be traded at a lower yield since investors do not feel encouraged by the green intentions of those issuers.

Hypothesis 5: The green bond premium varies across ESG risk levels.

In order to conclude our analysis, the potential determinants of the green bond premium are researched. Previous studies have

identified different determinants, such as the credit ratings, the ESG risk levels, and the issuers' sectors.

3.2. Data Collection

The starting point for the construction of a green dataset consisted of the collection of all the bonds contained in "iShares Global Green Bond ETF"[23], retrieved on December 2, 2020. The initial sample reported 488 active green bonds, excluding cash positions and derivatives such as futures and currency forwards. Therefore, some selection criteria to clean the sample were set:

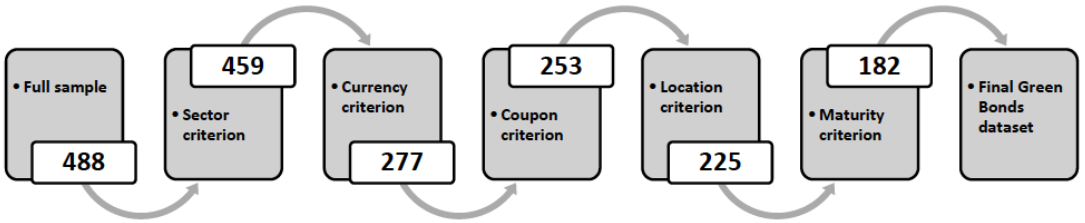
- Sector criterion: among others, only Corporates and Government-related sectors were selected since almost 90% of the full sample was represented by them, while Treasury and Securitized were discarded[24].
- Currency criterion: only EUR-denominated green bonds were selected since more than half of the full sample was represented by them;
- Coupon criterion: coupon rates equal to 0% or higher than 2,50% were excluded from the sample, due to their large concentration in the range 0,10 – 2,50%.
- Location criterion: among others, France, Germany, Supranational, United States, Netherlands, Spain, Canada, Italy, Belgium, China, United Kingdom, Australia, Denmark, Japan, and Sweden were selected, due to their weight in that ETF.
- Maturity criterion: since most of the green bonds were characterized by maturity in 3-5 years or 7-10 years, all the green bonds with a maturity higher than 2030 were excluded.

[23] https://www.ishares.com/us/products/305296/ishares-global-green-bond-etf-fund
[24] The Bloomberg Barclays global classification scheme has been used to classify bonds by issuer type.

After the cleaning process, the remained green dataset was composed of 182 bonds.

Figure 16 reports the sample selection process followed to arrive at the final green bonds sample:

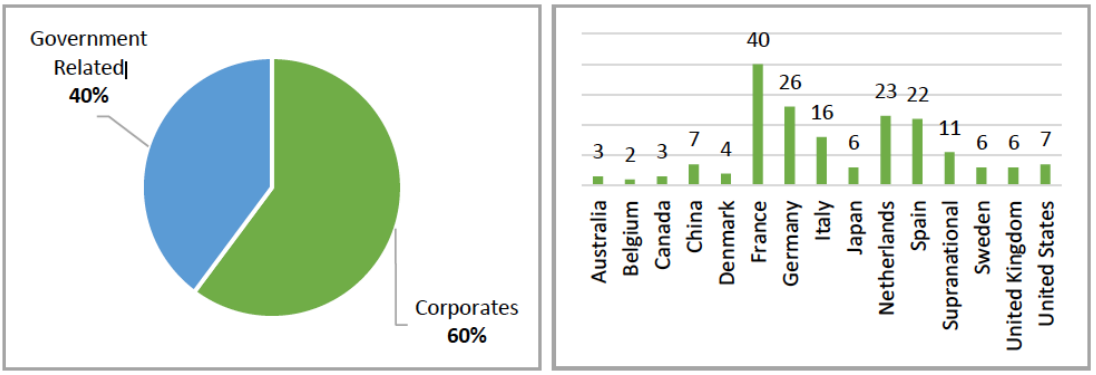
Figure 16: Selection process



Source 18: Personal Elaboration

The obtained green bonds were all EUR-denominated bonds, issued by 103 different issuers in 15 different countries. The majority of the issuers were located in France (19%). Moreover, Corporates[25] represented 60% of the full sample, while Government-related[26] only 40%.

Figure 17: Green bonds dataset composition by Sectors and Locations



[25] Composed of Financial Institutions, Industrial, and Utility.
[26] Composed of Agency and Supranational.

Source 19: Personal Elaboration

The next step consisted of the selection of the brown dataset. All the conventional bonds were retrieved from Datastream Thomson Reuters, access kindly offered by the University of Siena. To be included in the brown sample, bonds must fulfil the following criteria: (1) they must be active; (2) they must be from the same issuers as the green bonds; (3) they must be denominated in EUR as the green bonds; (4) they must have the same ranking as the green bonds; (5) they must have fixed coupon rates as the green bonds; (6) maturity date must be at most 2032; (7) issue date must be at least 2015[27]; (8) coupon rate must be at most 2,75%.

Finally, a conventional bonds database composed of 1.624 bonds was obtained.

3.3. The Matching Method

According to the literature, there exists a difference in yields between green and conventional bonds, ceteris paribus, either positive or negative (and in few cases also no difference). To verify this hypothesis, we follow the matching method, used by some of the previously examined authors. Simply put, we should compare two bonds that are as similar as possible to each other, except for the green nature. If a difference in yield is found, it could be attributed to the green feature. As stated by Stuart (2010), the employment of a matching procedure is useful to reduce bias in the estimation of the treatment effects[28].

[27] The Green Bond Principles were introduced in 2014, then the selection of an issue date at least 2015 is linked to this event.
[28] In statistics, the bias of an estimator is the difference between this estimator's expected value and the true value of the parameter being estimated.

Therefore, we take two groups: a green group (or treated group) that receives the treatment, and a brown group (or control group) that receives the control.

The first step is to determine if an observation is a good match for another one. According to Stuart (2010), to define the "closeness", it is important to first identify which variables to include in the matching process, in order to satisfy the assumption of "ignorable treatment assignment"[29]. Consequently, the distance between the two observations should be defined. Among the four primary ways to define the distance[30], exact matching is considered the ideal one. Unfortunately, it could lead to many observations not being matched. In fact, even if it is possible to match a green with a conventional bond for certain characteristics, it could be difficult, if not impossible, to match them according to others. For this reason, the exact matching has to be combined with other distance measures (Stuart, 2010). After looking for conventional bonds issued by the same green issuer, with the same green rating, country of risk, currency, and bond type, we select a conventional bond with similar characteristics in terms of issue date, maturity, amount issued, and coupon rate. For the issue date, a maximum difference of six years between the issue dates of the green and conventional bonds is allowed (Zerbib, 2019). For maturity, a maximum difference of two years between the maturities of the green and conventional bonds is allowed (Zerbib, 2019). For the amount issued, a maximum difference in the issue amount of 400% between green and conventional bonds is selected (Zerbib, 2019). Finally, for the coupon rate, a maximum difference of 0,25% between the coupon rates of the green and conventional bonds is allowed (Bachelet, Becchetti, & Manfredonia, 2019). All the matching criteria are summarized in the Table 3.

[29] Matching methods rely on ignorability, which assumes that there are no unobserved differences between the treatment and control groups, conditional on the observed covariates (Stuart, 2010, p. 5).
[30] They are exact, mahalanobis, propensity score, and linear propensity score.

Table 3: Matching criteria

CHARACTERISTICS	CRITERIA
Issuer	*Same*
Sector	*Same*
Market of issue	*Same*
Currency	*Same (EUR)*
Credit rating	*Same*
Coupon type	*Same (Fixed rate)*
Issue date	*+/- 6 years*
Maturity	*+/- 2 years*
Amount issued	*+/- 400%*
Coupon rate	*+/- 0.25%*

Source 20: Personal Elaboration

The decisions behind such criteria are consistent with the findings of previous studies, in order to mitigate potential differences between the two bonds, which can emerge in terms of credit risk premium, currency risk premium, maturity risk premium, liquidity risk premium, and interest risk premium.

As stated by Zerbib (2019), the yield difference between green and comparable conventional bonds is "the cumulative effect of the liquidity differential and the green bond premium". As we know, the green bond market and conventional bond market differ in size, and hence the latter is characterised by greater liquidity. In order to control for differences in liquidity, which could lead to bias in the estimation of the green bond premium, previous studies impose restrictions concerning the amount issued and the issue date. Doing in this way, some liquidity risk should be controlled for. However, different researchers suggest also to add a liquidity proxy, as a control variable. We follow Zerbib (2019) in using the difference in the bid-ask spread of the green and the conventional bonds as liquidity proxy.

$$\Delta BidAsk = BidAsk_{i,t}^{GB} - BidAsk_{i,t}^{CB} \quad (1)$$

where $\Delta BidAsk$ is the difference between the Bid-Ask spread of the green bond i at time t ($BidAski,tGB$), and the Bid-Ask spread of the conventional bond i at time t ($BidAski,tCB$).

To compute the bid-ask spread for each bond, we use the closing percent quoted bid-ask spread, defined as the bid-ask spread divided by the average:

$$BidAsk_{i,t} = \frac{Ask\ price_{i,t} - Bid\ price_{i,t}}{Ask\ price_{i,t} + Bid\ price_{i,t}/_2} \quad (2)$$

The next step is to use all the distances before defined in doing the matching. Therefore, a 1:1 match is implemented, namely, each green bond is compared to a conventional bond with the smallest distance from the first one. The matching procedure was successful for 35 of the previous 182 green bonds in the dataset.

3.4. Descriptive Statistics

An important step is to assess the quality of the resulting matched sample, by analysing both qualitative and quantitative variables.

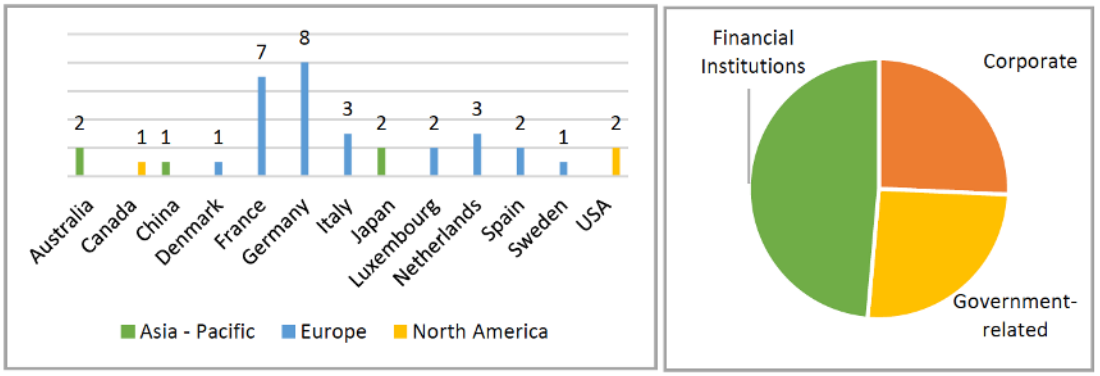
As said before, the final matched sample is composed of 35 couples, and hence 70 bonds.

They are issued by 27 different issuers from 13 different countries. Most of them are from Europe (77%), while the others are from Asia-Pacific (14%) and North America (9%). Among them, 66% of the issuers have issued in their domestic currency, while 34% in foreign currency. Figure 18 reports the sample composition concerning the country of risk and the region.

At the issuer type level, we distinguish among Government-related (Agency and Supranational), Financial Institutions, and Corporates (Industrial and Utility). In Figure 18, the composition of the sample by sector is reported. The financial sector is the most representative

one, accounting for 48,6%, while Corporate and Government-related account both for 25,7%.

Figure 18: Bond-pairs composition by country of risk and region, and by sector



Source 21: Personal Elaboration

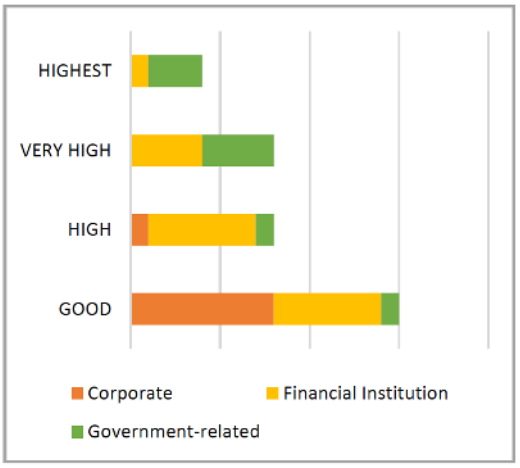
Regarding the ESG ratings, retrieved from Sustainalytics31, most of the issuers have a good reputation in terms of sustainability, showing an average score of 19,24 (out of 100).

Almost all the government-related issuers have shown a negligible ESG risk. Only one financial institution has shown a high ESG risk. Finally, three issuers are not rated by Sustainalytics, and hence considered as “no rated” in the following steps.

Table 5: Bond-pairs composition by Moody's ratings

MOODY'S RATINGS		
HIGHEST	**4**	**11%**
Aaa	4	
VERY HIGH	**8**	**23%**
Aa1	4	
Aa2	1	
Aa3	3	
HIGH	**8**	**23%**
A1	6	
A2	1	
A3	1	
GOOD	**15**	**43%**
Baa1	9	
Baa2	4	
Baa3	2	
	35	

Figure 20: Graphical representation of the bond-pairs by levels of rating and sectors



Source 23: Personal Elaboration

From a quantitative point of view, some descriptive statistics for our green and conventional bonds are provided in Table 6, to evaluate if the matching criteria taken before were correct.

The largest variation between the green and brown samples is related to the issue amount.

Although they are mainly concentrated in the same range, there are two exceptions, i.e. two conventional bonds issued by government-related borrowers, which have larger issue amounts. It leads to an average green issue amount of EUR 742,14 million, and an average brown issue amount of EUR 1.077,86 million. The presence of positive outliers is confirmed by the mean greater than the median. The relationship changes when we compare the 25 and 75 percentiles. However, it should be not a big issue since the liquidity risk is controlled for by also using a liquidity proxy.

The other characteristics are quite similar. In fact, almost all of them have been issued at a discount, with an average of EUR 99,52

for green bonds, and EUR 99,61 for conventional bonds. Among the green bonds, 3 of them have been issued at par. Also among the conventional bonds, 3 of them have been issued at par, but there is also 1 of them that has been issued at a premium, with an issue price of EUR 100,11. The green and brown coupons are concentrated in the same range, with an average of 0,782% for green bonds, and 0,76% for conventional bonds. Finally, also for the maturity there are no differences among them, with an average of 7 years for green bonds, and 7,20 years for conventional bonds.

Table 6: Descriptive statistics of the green and conventional bonds used in the sample

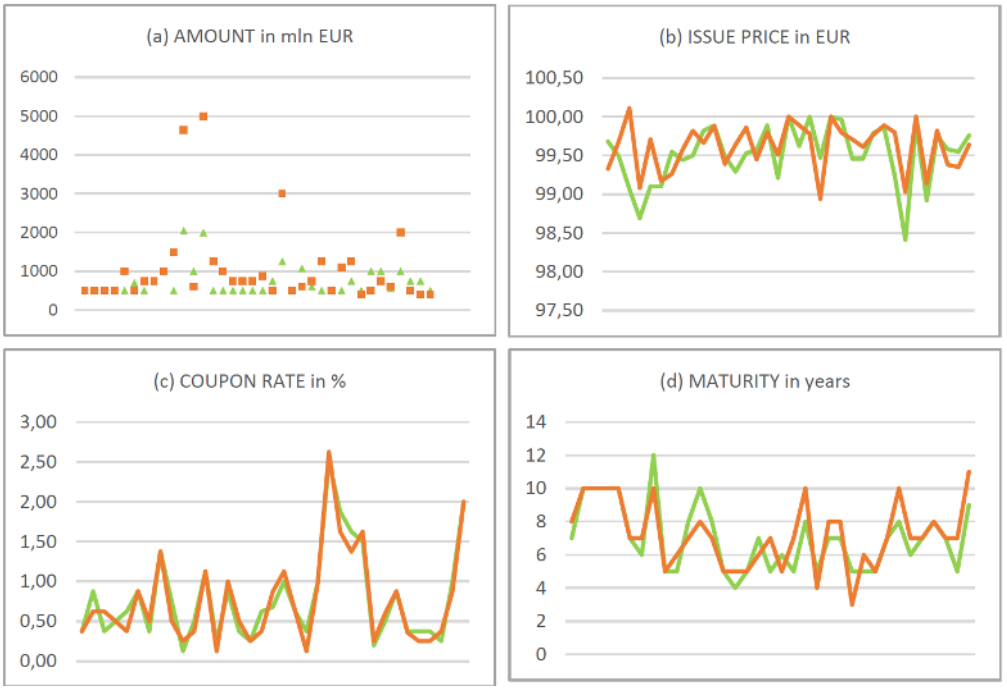
Green bonds	Min.	25%	Median	Mean	75%	Max.	Std. Dev.
Issue Amount (mln EUR)	500	500	500	742,14	937,50	2.050	387,62
Issue Price (EUR)	98,41	99,365	99,55	99,52	99,805	100	0,38
Coupon (%)	0,125	0,375	0,625	0,782	0,99	2,50	0,56
Maturity (years)	4	5	7	7	8	12	2

Conventional bonds	Min.	25%	Median	Mean	75%	Max.	Std. Dev.
Issue Amount (mln EUR)	400	500	750	1.077,86	1.050	5.000	1.067,03
Issue Price (EUR)	98,94	99,385	99,68	99,61	99,82	100,11	0,30
Coupon (%)	0,125	0,375	0,60	0,76	0,989	2,625	0,57
Maturity (Years)	3	6	7	7,2	8	11	2

Source 24: Personal Elaboration

For a more intuitive comprehension, Figure 21 (a-d) shows the differences between the two samples.

Figure 21: Graphical representation of the different green and brown bonds characteristics



Once assessed that the two samples share quite similar characteristics, we proceed by computing the variables of interest for our analysis.

For all the bonds, daily observations of ask prices, bid prices, ask yields, and bid yields from their issue date until December 14, 2020, are retrieved from Bloomberg, access kindly provided by the Supervisor of this thesis.

When a bond in a couple misses a daily yield observation, that line is removed from our panel. The panel data sample consists of 19.810 daily observations for 35 cross-sectional units across a period of 5 years. As a historic timeframe for our analysis, the period from January 2, 2018, to December 14, 2020, is taken. The decision is consistent with the higher concentration of starting days around 2018. Finally, we get panel data composed of 16.825 daily observations for 70 bonds.

The distribution of ask yields is reported for the sample of green bonds and conventional bonds. Moreover, the difference between the ask yield of the green bond and the conventional bond, identified as ΔY, is reported. On average, the ask yield difference is around -2.55 bps, with a median of 3.88 bps. A positive median evidences the presence of outliers, indicating that, in realty, less than 50% of the bond-pairs in the sample have a negative yield difference. The yield difference ranges from -90.52 bps to +25.98 bps, being skewed to the left (-1,2907) and with kurtosis of around 2,846.

Due to extreme values recorded during 2020, the differences between the ask yields of the green and the conventional bonds are winsorized at 0,5 and 0,95 percentile for the full dataset, through Eviews[31]. The new variable is identified as ΔY_wns, and it ranges from -41.3 bps to +31.04 bps, showing a reasonable negative skewness (-0,5794) and kurtosis of around -0,4050. In this case, a green bond trades at a lower yield than a conventional bond of -1.19 bps, on average.

Regarding the liquidity proxy, ΔBidAsk, its distribution is concentrated around zero, with a slightly positive skewness (0,0753) and kurtosis of -0,6319. In general, the chosen liquidity proxy seems to be adequate to control for differences in liquidity.

Table 7: Descriptive statistics of the matched bonds

	Min	25%	Median	Mean	75%	Max	Std. Dev.
No. of trading days	138	269	449	480,91	747,50	755	220,78
Ask Yield GB, Y_{GB}	-0,2998	0,0262	0,1652	0,2617	0,5189	0,9879	0,3286
Ask Yield CB, Y_{CB}	-0,3971	0,0716	0,2560	0,2872	0,5332	1,7957	0,4073
Δy	-0,9052	-0,1486	0,0388	**-0,0255**	0,1184	0,4063	0,2598
Δy_wns	-0,413	-0,1486	0,0388	**-0,0119**	0,1062	0,3104	0,1945
Bid-Ask Spread GB	0,0013	0,0024	0,0031	0,0035	0,0044	0,0071	0,0014
Bid-Ask Spread CB	0,0009	0,0024	0,0034	0,0034	0,0040	0,0071	0,0015
ΔBidAsk	-0,0014	-0,0006	0,0001	0,0001	0,0007	0,0018	0,0008

[31] All the values outside a given interval are converted into the values observed at the interval's maximum and minimum percentiles [-0,413; 0,345].

3.5. Model

In order to conduct our analysis, we follow the model proposed by Zerbib (2019), namely a two-step regression model. First, a green bond premium is identified by estimating a fixed-effect regression model. Second, the potential determinants of the green bond premium are researched, through an OLS regression model.

3.5.1. Estimation of the green bond premium

The fixed-effect panel regression model is the following one:

$$\Delta y_{i,t} = greenium_i + \beta \Delta BidAsk_{i,t} + u_{i,t} \quad (3)$$

where $u_{i,t}$ is the error term, $\Delta BidAsk_{i,t}$ is the liquidity proxy, as defined in Equation (1), and *greeniumi* is the entity-specific time-invariant fixed effect, representing the green bond premium since all the other differences in bonds characteristics are already accounted for.

The dependent variable is $\Delta_{yi,t}$, calculated as the difference between the ask-yield of the i-th green bond and the ask-yield of the comparable i-th conventional bond at time t:

$$\Delta y_{i,t} = y_{i,t}^{GB} - y_{i,t}^{CB} \quad (4)$$

The decision to use the ask-yields is consistent with the findings of Zerbib (2019) since we are focusing on the investors' demand and the issuer's supply of green bonds.

Finally, several tests are performed to validate the use of a fixed-effect regression model. In particular, both the F-test and Breusch-Pagan test are performed to examine the existence of individual effects. In all the two cases, the null hypothesis is rejected at the 1% significance level, concluding with the presence

of individual effects. Consequently, a Hausman test is performed to determine the best method between fixed and random effect models. The null hypothesis that fixed and random effect models are equal is rejected at the 1% significance level, concluding with the preference for a fixed-effect model. Table 8 reports the previously conducted tests, with the respective conclusions.

Table 8: Tests of the regression model for the selection of the best model

Test	H_0	H_1	p-value	Conclusion
F-test	Pooled OLS	Fixed effect model	0,0000	Reject H_0, and hence there is a significant fixed effect.
Breusch-Pagan test	Pooled OLS	Random effect model	0,0000	Reject H_0, and hence there is a significant random effect.
Hausman test	Random effect model	Fixed effect model	0,0000	Reject H_0, and hence the Fixed effect model is preferred.

Source 26: Personal Elaboration

3.5.2. Determinants of the green bond premium

To identify which characteristic of the green bond determines a potential variation in the green bond premium, an OLS regression model is implemented. The model is:

$$\widehat{greenium}_i = \beta_0 + \beta_1 \ln(IssueAmount) + \beta_2 Maturity + \beta_3 Rating + \gamma_1' ESGrisk + \gamma_2' Sector + \varepsilon_i \quad (6)$$

where ε_i is the error term.

The dependent variable $greenium_i$^ is the previously estimated time-invariant green bond premium for each couple i. The characteristics considered are the issue amount, the maturity, the issuer sector, the credit rating, and the ESG risk level. The currency is not considered since all of them are EUR-denominated. Like Zerbib (2019), the Issue amount is assumed to be the natural logarithm of the green bond's issue amount to linearize the values, while the Maturity is the remaining green bond's maturity on

December 14, 2020. For the Rating, an integer number is assigned to the respective credit rating (Aaa, Aa, A, or Baa), based on a scale of 1-4, where 1 represents the lowest credit rating and 4 represents the highest one. The Sector is a vector of dummy variables, representing Government-related, Financial Institutions, and Corporates. The reference group is Government-related. Finally, the ESG risk is a vector of dummy variables, representing No rated/High, Medium, Low, and Negligible. The reference group is No rated/High. All of them are described more deeply in Table 9:

Table 9: Determinants of the green bond premium

Variable	Description
Issue Amount	The issue amount of the green bond denoted in mln EUR.
Maturity	Green bond's remaining maturity in days, as of December 14, 2020.
Rating	It varies from 1 to 4, where 1 indicates Baa and 4 indicates Aaa.
ESG risk	Vector of dummy variables. The sample contains No rated/High, Medium, Low, and Negligible. The reference group is No rated/High
Sector	Vector of dummy variables. The sample contains Government-related, Financial Institutions, and Corporates. The reference group is Government-related.

Source 27: Personal Elaboration

3.6. Results and Discussion

3.6.1. Estimation of the green bond premium

The results for the estimation of the green bond premium are reported for both the dependent variables $\Delta \hat{y}$ and $\Delta \hat{y}\_wns$, as previously defined. In particular, model (a) reports the results considering the ask yield difference without winsorization, while model (b) reports the results considering the ask yield difference with winsorization.

First, tests for heteroskedasticity and serial correlation are implemented. In particular, both the Wald test and the LR test are conducted to detect the presence of heteroskedasticity in the

residuals. Then, the Wooldridge test and the Pesaran's CD test are conducted to detect the presence of serial correlation. These tests show that there are heteroskedasticity and serial correlation in the residuals. Therefore, the estimation of the standard errors needs to be robust to heteroskedasticity and serial correlation. The results are summarized in Table 10.

Table 10: Tests of the regression model for the estimation of the green bond premium

	Test	H_0	p-value	Conclusion
Heteroskedasticity	Wald test LR Test	Residuals are homoscedastic	0,0000	Reject H_0, and hence there is heteroskedasticity
Serial correlation	Wooldridge test	No serial correlation of order one (ρ=0,5)	0,0000	Reject H_0, and hence there is autocorrelation
	Pesaran's CD test	No cross-section dependence in residuals	0,0000	Reject H_0, and hence there is cross-sectional dependence.

Source 28: Personal Elaboration

The estimate for the coefficient of the liquidity proxy, i.e. the difference in the bid-ask spread (ΔBidAsk), is around -12,96 for model (a) and -12,21 for model (b). The results indicate that there is a negative correlation between the difference in yield and the difference in liquidity. A 1 bp increase in the bid-ask spread between green and conventional bonds implies a 12.96 bps (or 12.21 bps) decrease in the yield difference between green and conventional bonds. This result means that green bonds provide lower returns and are simultaneously less liquid than comparable conventional bonds. The result is consistent with Zerbib (2019) findings, even if the magnitude differs for few bps. The coefficient is significant at the 1% level for all the models. Similar to Zerbib (2019), R2 is very low in both models. It means that the liquidity proxies explain only a small percentage of the total variation in the difference in yield. However, it is not a big issue since through the

matching method almost all the differences in yield are already controlled for, except for the green nature. Moreover, the variable of interest in this analysis is the green bond premium.

Table 11: Results of the regression model in model (a) and model (b)

	(a)	(b)
	$\widehat{\Delta y}$	$\widehat{\Delta y}\_wns$
ΔBidAsk	-12,96180***	-12,21232***
	(0,355845)	(0,347955)
within R^2	0,011621	0,033556
F-statistic	3.313,780	6.827,288
p-value (F-statistic)	0,0000	0,0000

Source 29: Personal Elaboration

The green bond premium is isolated and estimated for each of the 35 couples in the sample. It varies in sign and magnitude in a range from -92.34 bps to 42.20 bps for model (a), and from -43.40 bps to 31.01 bps for model (b). On average, there is a green bond premium of -3.20 bps for model (a), and -2.18 bps for model (b). The different signs between mean and median indicate the existence of large outliers in our sample.

Table 12 reports the distribution of the green bond premium for both model (a) and model (b).

Table 12: The distribution of the green bond premium for both model (a) and model (b)

	(a)	(b)
	$\widehat{greenium}$	$\widehat{greenium\_wns}$
Min	-0,9234	-0,4340
25%	-0,1610	-0,1646
Median	0,0346	0,0310
Mean	**-0,0320**	**-0,0218**
75%	0,1123	0,1035
Max	0,4220	0,3101
Skewness	-1,2335	-0,5703
Kurtosis	2,5958	-0,4080

Source 30: Personal Elaboration

At this point, we should test if the mean (or median) of the green bond premium is statistically significant. Before doing it, normality tests must be performed, in order to assess if we should use parametric or non-parametric tests. Both the Jarque-Bera and Shapiro-Wilk tests are performed, rejecting in both cases the null hypothesis of normal distribution.

Consequently, we proceed by using a non-parametric test, i.e. the Wilcoxon signed-rank test, under the null hypothesis that the median of the green bond premium is zero. In both models, we cannot reject the null hypothesis, and hence the green bond premium is not significantly different from zero. Although we found that "there exists a negative green bond premium" in our sample, this hypothesis is not statistically supported.

Table 13 reports the results from the normality tests and non-parametric tests conducted on the estimated green bond premium.

Table 13: Normality tests and Non-parametric test on the estimated green bond premium

	Test	H_0	p-value	Conclusion
Normality test	Jarque-Bera test	Normal distribution	0,0000 (a) 0,0026 (b)	Reject H_0, and hence the distribution is not normal.
	Shapiro-Wilk test		0,0090 (a) 0,0588 (b)	
Non-parametric test	Wilcoxon signed-rank test	Median of premium is zero	0,9543 (a) 0,9678 (b)	Do not reject H_0, and hence the median of premium is not statistically significant.

Source 31: Personal Elaboration

In order to verify the other hypothesis, the matched sample is split into different sub-samples, based on sector, currency, rating, and ESG risk level.

Regarding the sector, green bonds issued by financial institutions show a negative greenium of around -12.26 bps for model (a) and -8.91 bps for model (b). Financial institutions are one of the most active players in the green bond market, and hence they are assumed to have greater intentions in financing green projects, leading investors to accept lower yields for green bonds. Whilst, the green bonds issued by Government-related show a positive greenium of around 2.93 bps for model (a) and 2.58 bps for model (b). According to Hachenberg & Schiereck (2018), the explanation has to be searched by looking at the issuer's perspective. In fact, they declare that being government-related issuers one of the most active in promoting the growth of the green bond market, they may fear that asking investors to give up a part of returns compared to conventional bonds might hurt the market growth (Hachenberg & Schiereck, 2018). Instead, the results for green bonds issued by Corporates are different from what was expected by previous findings. In fact, a positive greenium of around 7.77 bps for model (a) and 5.76 bps for model (b) emerges. A possible explanation

could be searched in the type of issuer considered in this sample. Almost all of them are energy companies, and therefore the investors could not feel the necessity to give up a part of returns to finance a normal activity for them.

Regarding the currency, green bonds issued by countries in their domestic currency are traded at a lower yield than their comparable conventional bonds of around -6.88 bps for model (a) and -5.02 bps for model (b); whilst, those issued by countries in a foreign currency are traded at a higher yield of around 3.85 bps for model (a) and 3.26 bps for model (b). The results could be explained by several reasons, such as the different numerosity of the two sub-samples, the greater willingness of some investors to give up a part of returns for the green intentions of Europe, the higher credibility of a country issuing in its domestic currency, and hence the lower exchange risk associated with them, or just being randomness.

Regarding the rating, Aa- and A-rated green bonds trade at a lower yield of around -8.62 bps and -13.28 bps for model (a) and -7.76 bps and -11.95 bps for model (b). Green bonds issued by more credible entities are expected to be traded at lower yields than their comparable conventional bonds. Consistent with the findings of Hachenberg & Schiereck (2018), the situation is opposite for Aaa-rated green bonds, which trade at a higher yield of around 9.30 bps for model (a) and 8.92 bps for model (b), and for Baa-rated green bonds, which trade at a higher yield of 1.73 bps for model (a) and 3.03 bps for model (b). The reason for the former can be that, within our sample, the high rated green issuers are almost all government-related issuers. Instead, for the second one, the reason could lie in the fact that Baa-rated green bonds might be too close to non-investment grade, and hence investors may not be so confident in giving up part of the returns for the green aspect.

Regarding the issuers' ESG risk level, the green bonds with a negligible ESG risk level show a slightly positive greenium of around 1.93 bps for model (a) and 1.57 bps for model (b). In our

sample, almost all of the green bonds with a negligible ESG risk level, and hence with the highest reputation in terms of sustainability, are issued by government-related. Green bonds with low and medium ESG risk levels show a negative greenium, of around -17.05 bps and -7.52 bps for model (a) and -14.13 bps and -5.63 bps for model (b); then, as proved also by Kapraun & Scheins (2019), green bonds with a high ESG risk level, or without an ESG risk rating, show a positive greenium, of around 29.40 bps and 21.40 bps for model (a) and 28.54 bps and 18.10 bps for model (b). The lower reputation in terms of sustainability leads investors not to trust their green intentions, asking for higher yields.

Table 14: Green bond premium by sub-sample

		(a)		(b)		
Category	**Sub-sample**	**Mean**	**Median**	**Mean**	**Median**	**#couple**
Sector	*Corporate*	0,0777	0,0781	0,0576	0,0747	9
	Financial Institutions	-0,1226	-0,1573	- 0,0891	-0,1606	17
	Government-related	0,0293	0,0254	0,0258	0,0217	9
Currency	*Domestic*	-0,0688	0,0138	-0,0502	0,0107	23
	Foreign	0,0385	0,0565	0,0326	0,0524	12
Rating	*Aaa*	0,0930	0,0703	0,0892	0,0666	4
	Aa	-0,0862	-0,0279	-0,0776	-0,0313	8
	A	-0,1328	-0,1610	-0,1195	-0,1646	8
	Baa	0,0173	0,0781	0,0303	0,0747	15
ESG risk level	*Negligible*	0,0193	0,0195	0,0157	0,0161	8
	Low	-0,1705	-0,1685	-0,1413	-0,1711	5
	Medium	-0,0752	0,0193	-0,0563	0,0158	18
	High	0,2940	0,2940	0,2854	0,2854	1
	No rated	0,2119	0,2059	0,1810	0,2020	3

Source 32: Personal Elaboration

Again, a Shapiro-Wilk test is performed on each sub-sample, with at least 8 bond pairs, to verify the null hypothesis of the normal distribution. For all of them, the null hypothesis of normality cannot be rejected, except for domestic currency and Baa rating in model (a).

Consequently, a Wilcoxon signed-rank test and a t-test are performed on each sub-sample, under the null hypothesis that the

mean/median is equal to zero. None of the null hypotheses is rejected, meaning that none of the average green bond premia in the sub-samples is found to be significantly different from zero.

Finally, the previous results confirm our hypothesis that the green bond premium varies across different sub-samples, but again this conclusion is not statistically supported.

3.6.2. Determinants of the green bond premium

The different characteristics of the green bond are considered to assess which one could be a potential determinant of the green bond premium. By varying the independent variables, different specifications are implemented:

1) Issue amount, Maturity, and Rating

$$\widehat{greenium}_i = \beta_0 + \beta_1 \ln(IssueAmount) + \beta_2 Maturity + \beta_3 Rating + \varepsilon_i \quad (6)$$

2) Issue Amount, Maturity, and ESG risk level

$$\widehat{greenium}_i = \beta_0 + \beta_1 \ln(IssueAmount) + \beta_2 Maturity + \gamma_1' ESG\ risk + \varepsilon_i \quad (7)$$

3) Issue Amount, Maturity, and Sector

$$\widehat{greenium}_i = \beta_0 + \beta_1 \ln(IssueAmount) + \beta_2 Maturity + \gamma_1' Sector + \varepsilon_i \quad (8)$$

4) Issue Amount, Maturity, Sector, Rating, and ESG risk level

$$\widehat{greenium}_i = \beta_0 + \beta_1 \ln(IssueAmount) + \beta_2 Maturity + \beta_3 Rating + \gamma_1' ESGrisk + \gamma_2' Sector + \varepsilon_i \quad (9)$$

Assuming as a dependent variable the estimated green bond premium for each couple means that we are dealing with cross-sectional data. In order to verify if the assumption of homoskedasticity is satisfied, the Breusch-Pagan test is implemented for each specification and for both model (a) and model (b), as defined so far. Regarding model (a), the assumption

of homoskedasticity is satisfied only by specification (2), at the 10% level. Regarding model (b), it is satisfied by all, but specification (2), at the 10 % level. Consequently, White robust standard errors are applied in those specifications where the assumption of homoskedasticity is not satisfied.

Since several explanatory variables are included in the model, to investigate for multicollinearity problems, the Variance Inflation Factors (VIF) are computed for each of them. None of them shows a value greater than 10, therefore there are no multicollinearity problems.

Table 15: Tests for heteroskedasticity

			(1)	(2)	(3)	(4)
	Test	**H_0**	**p-value**	**p-value**	**p-value**	**p-value**
Heteroskedasticity	Breusch-Pagan test	Homoskedasticity	0,0781 0,1859	0,1283 0,0928	0,0624 0,1101	0,0416 0,4744
		Variable	(1)	(2)	(3)	(4)
Multicollinearity	VIF	*Issue Amount*	1,180	1,088	1,056	1,336
		Maturity	1,022	1,151	1,164	1,850
		Fin. Institutions			1,590	4,331
		Corporates			1,539	6,745
		Rating	1,159			2,454
		Negligible		2,498		4,758
		Low		1,999		2,021
		Medium		2,699		3,550

Source 33: Personal Elaboration

All the results from the specification (1), (2), and (3) both with ***greeniumñ*** for model (a), and ***greeniumñ_wns*** for model (b) as dependent variables, are presented in Table 16 and Table 17. In order not to confuse ourselves and not to be redundant, only results from model (a) are deeply commented; the reason is that the results from model (b) appear to be similar. Moreover, we should not forget that model (b) is based on an artificial dataset.

By looking at the sign of each estimate, we could define which has a positive or negative impact on the green bond premium. Assuming that our green bond premium is negative, a positive impact means less negative green bond premium, while a negative impact means more negative green bond premium.

The results show that the issue amount of the green bond and the green bond premium are positively related. In particular, a more significant issue amount decreases the negative green bond premium, in absolute terms. This result is not consistent with Zerbib (2019), who finds a negative linkage between them. In our sample, green bonds issued by government-related are those with higher issue amount, which trade at positive greenium, providing support for the results. The estimate of the issue amount is significant at the 5% level in specification (1) and at the 10% level in specification (3).

As for Zerbib (2019), the magnitude of the estimate of maturity is nearly equal to zero, meaning that a longer maturity in the green bonds do not increase/decrease the green bond premium. Differently from Zerbib (2019), it is significant at the 5% level in specification (1) and at 10% level in the other specifications.

The credit quality characteristic is not statistically significant in defining the green bond premium. However, a 1-level increase in the bond rating (higher credit quality) leads to a decrease of 3.51 bps in the green bond premium. Therefore, green bonds with higher credit quality increase more the negative green bond premium. The result is consistent with Zerbib (2019) and Karpf & Mandel (2017).

A green bond with a negligible ESG risk level decreases by 30.94 bps the green bond premium level, compared to a no rated/high risk level green bond, meaning that it becomes more negative. Similar results are obtained for low ESG risk level and medium

ESG risk level. The estimates are all significant in both specification (2) and specification (4).

A green bond issued by a corporate increases of only 3.44 bps the green bond premium, compared to a green bond issued by a government-related, meaning that it becomes less negative. The result supports our previous findings, knowing that both corporate and government-related green bonds are traded wider. A green bond issued by a financial institution decrease by 10.41 bps the green bond premium, compared to a green bond issued by a government-related, meaning that it becomes more negative. Again, it is consistent with our previous finding, knowing that only financial institutions are found to trade tighter.

Finally, the ESG reputation has a statistically significant impact in determining the negative green bond premium, differently from the credit quality and the sector.

The R^2 ranges from 16,36% to 40,13%, while the adjusted R2 ranges from 8,26% to 21,70%. It means that only a little variation in the green bond premium is explained by the characteristics considered.

Table 16: Determinants of the green bond premium: model (a)

	(1.a)	(2.a)	(3.a)	(4.a)
		$\widetilde{greenium}$		
Constant	-1.3666***	-0.7499	-0.9844*	-0.5212
	(0.5237)	(0.7086)	(0.5732)	(0.4705)
Issue Amount	**0.1898****	0.1223	**0.1341***	0.1199
	(0.0764)	(0.1065)	(0.0806)	(0.0749)
Maturity	**0.0001****	**0.0001***	**7.22E-05***	**8.95E-05***
	(4.22E-05)	(6.16E-05)	(4.28E-05)	(4.84E-05)
Corporates			0.0344	0.0216
			(0.0673)	(0.2306)
Financial Institutions			-0.1041	-0.1376
			(0.0876)	(0.1347)
Rating	-0.0351			-0.0298
	(0.0356)			(0.0616)
Negligible		**-0.3094***		**-0.3346*****
		(0.1526)		(0.1244)
Low		**-0.4188****		**-0.4447*****
		(0.1638)		(0.1161)
Medium		**-0.3035****		**-0.3490*****
		(0.1333)		(0.1216)
R^2	0.1636	0.3156	0.1938	0.4013
R^2-adjusted	0.0826	0.1976	0.0863	0.2170
F-statistic	3.1471	2.6746	2.4075	5.6845
p-value	0.0389	0.0417	0.0713	0,0003

*Note: * p<0,10; **p<0,05; ***p<0,01*

Source 34: Personal elaboration

The results from model (b) confirm the significative role of ESG risk level in determining the green bond premium, without finding anyone else.

Table 17: Determinants of the green bond premium: model (b)

	(1.b)	(2.b)	(3.b)	(4.b)
		$\widehat{greenium\_wns}$		
Constant	**-1.0402***	-0.4994	-0.7316	-0.3830
	(0.5516)	(0.3688)	(0.5609)	(0.5272)
Issue Amount	0.1447	0.0846	0.0975	0.0966
	(0.0885)	(0.0535)	(0.0843)	(0.0826)
Maturity	**8.48E-05***	**0.0001*****	6.44E-05	8.69E-05
	(4.63E-05)	(3.23E-05)	(4.98E-05)	(5.46E-05)
Corporates			0.0179	-0.0355
			(0.0925)	(0.1685)
Financial Institutions			-0.0766	-0.1257
			(0.0822)	(0.1181)
Rating	-0.0324			-0.0373
	(0.0330)			(0.0421)
Negligible		**-0.2705*****		**-0.2916***
		(0.0574)		(0.1445)
Low		**-0.3656*****		**-0.3838*****
		(0.1144)		(0.1152)
Medium		**-0.2620*****		**-0.2824****
		(0.0634)		(0.1069)
R^2	0.1846	0.3834	0.1997	0.4746
R^2-adjusted	0.1057	0.2772	0.0930	0.3129
F-statistic	2.3406	5.4457	1.8717	2.9358
p-value	0.0925	0.0011	0.1413	0.0177

Note: p<0,10; **p<0,05; ***p<0,01*

Source 35: Personal Elaboration

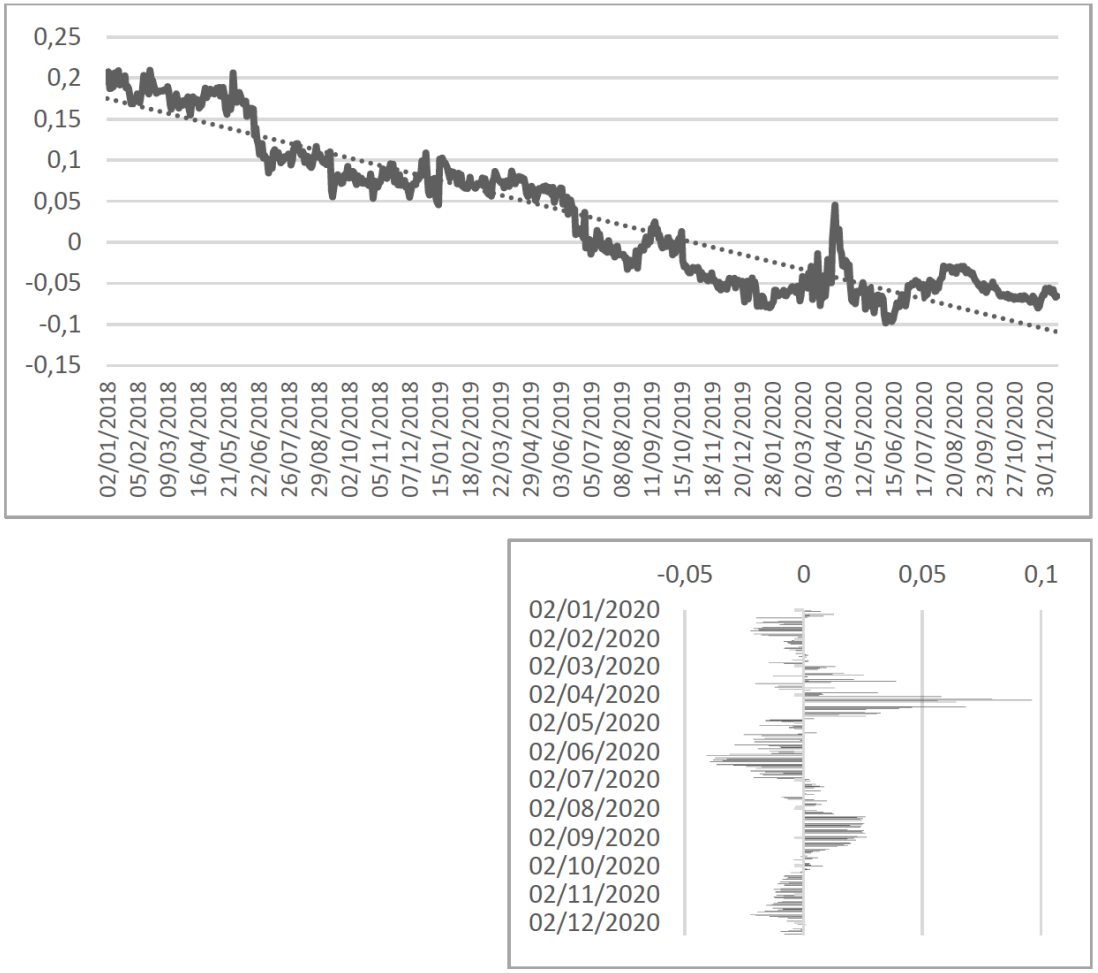
3.6.3. Green bond premium during COVID-19

Figure 23 reports the evolution of the greenium across the three periods examined. We could notice that the average green bond premium moved from 5 bps to 21 bps in 2018, keeping itself always positive. Then, it moved from -7 bps to 10 bps in 2019, and from -10 bps to 5 bps in 2020. As the green bond market has been growing, the green bond premium seems to move downward, highlighting the willingness of the investors to pay a premium for financing green projects and a higher knowledge about such kind of investment. Since the second half of 2019, it has remained negative in our sample. The always sustainable efforts of European

policymakers towards a "greenification" could affect the negative green bond premium for a long time.

Unfortunately, the COVID-19 pandemic has impacted the world's economy, affecting demand and supply on both green and conventional bond markets. Looking at Figure 23, we can see that there was an unstable trend, particularly in April 2020. Therefore, our results (in terms of magnitude) could have been affected by the presence of these outliers.

Figure 22: Evolution of the green bond premium



Source 36: Personal Elaboration

CONCLUSION

Climate change and global warming represent an increasing threat to economies around the world. Hence, there is an urgent need for environmentally friendly projects. In 2007, we saw the emergence of an innovative financial tool to address resources into sustainable projects, namely the green bonds.

The idea behind this thesis is to assess if the growing class of green investors is willing to pay a premium, i.e. accept lower yields, to invest in climate-friendly projects through green bonds compared to an otherwise identical conventional bond.

As we saw, in the literature there is an ongoing debate about the argument, leading to mixed results. Some studies report that green bonds trade at lower yields, or at a premium, than their comparable conventional bonds; whilst, other studies report no significant differences or even higher yields for green bonds.

Our empirical analysis can be summarized in the formulation of three questions: i) does a green bond trade at a lower yield than a comparable conventional bond?; ii) does the green bond premium vary across bonds' characteristics?; and, iii) is the good sustainable reputation of the bond issuer a driver for determining a negative greenium?

We analysed if the EUR-denominated green bonds trade at a lower yield than comparable conventional bonds on the secondary market, during the period from January 2018 to December 2020.

On average, green bonds trade 3.20 bps (or 2.18 bps with winsorization) tighter than their comparable conventional bonds on the secondary market in our sample. Unfortunately, the results are not statistically significant[32]. The existence of a negative greenium of just few bps is not a big challenge for this asset class,

[32] There are also other studies with insignificant results.

leading the green bonds to be still attractive as much as conventional bonds.

Although the evidence of a negative green bond premium in our sample, only 43% of our green bonds trade tighter (i.e. 15 out of 35). Consequently, the results could be influenced by the main presence of green bonds issued by financial institutions (i.e. 10 out of 15) and by issuers located in Europe (i.e. 12 out of 15), which benefit from higher credibility in the green bond market.

The negative greenium may be explained by different factors. The first one is a possible mismatch between supply and demand. As we saw, the market for green bonds is in full development, and it is destined to grow more and more since always more issuers, such as companies, governments, and multinationals, are seeking to raise funds to carry out environmentally friendly projects, and, moreover, always more investors are attracted to these assets. Despite its remarkable growth, the size of the green bond market represents only a small percentage of the overall bond market, being also concentrated in a small perimeter. For example, green bonds are mainly rated with good credit qualities, limiting some investors' risk profiles. Therefore, the growing demand for sustainable investments is satisfied by a limited number of green bond issues. The second one turns around the investors' preferences, who could prefer to sacrifice few bps for non-pecuniary motives. Since the green bonds are addressed to help the environment, these good intentions could offset the lower cash flows received. Finally, green bonds are less risky or volatile than comparable conventional bonds. Consequently, they tend to be more stable during periods of risk aversion, such as the current pandemic. Hence, investors could accept to receive lower yields due to the compensation for lower volatility.

Furthermore, the green bond premium has been analysed across different sub-samples, finding that it varies within each segment. Green bonds issued by financial institutions trade, on average, tighter than their comparable conventional bonds, while those issued by corporates and government-related trade, on average, wider. Regarding the currency, we distinguished between bonds denominated both in domestic and foreign currencies. The obtained results are opposite, namely the green bonds issued by the former trade tighter, while the others trade wider than their comparable conventional bonds. Then, a positive greenium has been found for Aaa- and Baa- rated green bonds, while a negative one for Aa- and A-rated green bonds. Finally, the largest gap between the max and min green bond premium has been found within the ESG risk level sub-sample (around 46.50 bps). Green bonds with a low ESG risk level show the largest negative greenium. Green bonds with medium ESG risk level show negative greenium, too. Whilst, the other two show a positive greenium.

In conclusion, the ESG risk level has been found to be the only one statistically significant driver of the negative green bond premium. Specifically, a good sustainable reputation can be considered as a significant determinant for a negative green bond premium.

The comparisons of these results with studies previously examined is not properly correct. Even if the idea outstanding the various studies is similar, they differ from each other for several reasons, such as the type of issuers examined, the sample size, the method used, the matching criteria proposed, the characteristics assessed, and so on, leading to always different interpretations. A possible future analysis could be to start from the same bond-pairs used in this thesis and evaluate possible different results in the following years, especially considering the upcoming EU Recovery Fund.

In conclusion, our model presents some limitations, which could explain the insignificant results of our analysis: small sample size, which should be increased by setting less stringent matching criteria; underrepresented categories, leading to a disparity among the sub-samples' numerosity; some bonds have been issued recently, carrying only few days with available data on yields; finally, this thesis has been written during the COVID-19 pandemic, which may have affected the results.

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