UNIVERSITY OF LJUBLJANA

SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

FINANCIAL PERFORMANCE OF GREEN BONDS VS. CONVENTIONAL BONDS: A MULTIFACTOR APPROACH

Ljubljana, 11th of May, 2021 MARTIN NOVAK

AUTHORSHIP STATEMENT

The undersigned Martin Novak, student at the University of Ljubljana, School of Economics and Business (hereafter: SEB-LU), author of this written final work of studies with the title: Financial Performance of Green Bonds vs. Conventional Bonds: A Multifactor Approach, prepared under the supervision of prof. dr. Vasja Rant PhD, DECLARE:

1. this written final work of studies to be based on the results of my research;
2. the printed form of this written final work of studies to be identical to its electronic form;
3. the text of this written final work of studies to be language-edited and technically in adherence with the SEB-LU's Technical Guidelines for Written Works, which means that I cited and/or quoted works and opinions of other authors in this written final work of studies following the SEB-LU's Technical Guidelines for Written Works;
4. to be aware of the fact that plagiarism (in written or graphical form) is a criminal offence and can be prosecuted in accordance with the Criminal Code of the Republic of Slovenia;
5. to be aware of the consequences a proven plagiarism charge based on the this written final work could have for my status at the SEB-LU in accordance with the relevant SEB-LU Rules;
6. to have obtained all the necessary permits to use the data and works of other authors which are (in written or graphical form) referred to in this written final work of studies and to have clearly marked them;
7. to have acted in accordance with ethical principles during the preparation of this written final work of studies and to have, where necessary, obtained the permission of the Ethics Committee;
8. my consent to use the electronic form of this written final work of studies for the detection of content similarity with other written works, using similarity detection software that is connected with the SEB-LU Study Information System;
9. to transfer to the University of Ljubljana free of charge, non-exclusively, geographically and time-wise unlimited the right of saving this written final work of studies in the electronic form, the right of its reproduction, as well as the right of making this written final work of studies available to the public on the World Wide Web via the Repository of the University of Ljubljana;
10. my consent to the publication of my personal data that are included in this written final work of studies and in this declaration, when this written final work of studies is published.

Ljubljana, 11th of May, 2021 Author's signature:_________________________

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEA – Annual Emission Allocation

CAPM – Capital Asset Pricing Model

EAP – Environmental Action Program

EEA – European Economic Area

EIB – European Investment Bank

ESD – Effort Sharing Decision

ESG – Environmental, Social and Governance

EU – European Union

EUAs – European Union Allowances

EU-ETS – European Emission Trading System

EUR – Euro

GBP – British Pound

GBPs – Green Bond Principles

GDP – Gross Domestic Product

GHG – Greenhouse Gasses

ICMA – International Capital Market Association

IPCC – Intergovernmental Panel on Climate Change

S&P – Standard and Poor's Rating Agency

SDGs – Sustainable Development Goals

SRI – Sustainable and Responsible Investment

UNFCCC – The United Nations Framework Convention on Climate Change

UoP – Use of Proceeds

US – United States of America

USD – United States Dollar

YTM – Yield to Maturity

INTRODUCTION

For ages, the consideration of ethical values, such as environmental sustainability, has been seen as a potential drain on profits in the financial world. However, recent alarming climate trends and policy changes due to the increased climate commitments of the Paris Agreement have made investors much more attentive to the environmental externalities of business activities. As a consequence, mainstream attitudes have changed dramatically and a considerable proportion of stakeholders, ranging from consumers to investors, now not only encourage but demand higher levels of transparency and compliance with ethical standards. In this respect, environmental, social and governance (ESG) criteria are becoming increasingly important when considering and executing a business strategy. Nowadays, many companies, especially those based in Europe that deal with polluting activities, deeply consider their production plans before they are executed. This has certainly been encouraged by EU climate regulations and standards, but also by a renewed business environment that is beginning to consider climate-friendly products and projects seriously (Ehlers & Packer, 2017).

The financial sector, long criticised for unethical and climate-indifferent behaviour, particularly at the outbreak and in the aftermath of the last financial crisis, is increasingly introducing ESG and other sustainability criteria into investment decision-making processes. Of course, the financial sector does not propose and sell ethical green investments "per se", but it aims to finance them in a profitable way - short or long term. It is recognised today that ethics "sells" and unethical behaviour is punished through investor activism and the loss of shareholder image. This is certainly true for many green projects that continue to emerge and for climate-related activism that wastes no time to protest and punish brown activities (The World Bank, 2020).

Whereas action against climate change has not always been a priority of ethical investors, the business world has been increasingly willing to act in-depth to address climate issues lately. For this reason, the world is looking for new financing possibilities and a readjustment of finance that can allow further development of the green sector. A new type of instrument that has come to light in the context of Sustainable Finance in recent years are green bonds. They are defined as “fixed-rate, liquid financial instruments used to raise funds for climate change mitigation, adaptation and other environmentally friendly projects”. (The World Bank, 2020).

The evolution of green bonds can be traced back to 2007, when the European Investment Bank (EIB) issued the world's first so-called climate-responsible bond, which was soon followed by the first true green bond issued by the World Bank a year later, in 2008. In 2019, the green bond market reached a new peak with total yearly issuance of USD 250 billion and an exceptional total global exposure of over USD 600 billion. While the initial green bonds were mainly issued by development banks and municipalities, the share of commercial bank and other corporate issuance is increasing. In general, any company that can raise a conventional bond can also be eligible to issue a green bond. This means that a company engaged in brown operations may theoretically also be able to release a green bond if the standards of the issue comply with the standards and legislation governing the emission of green bonds (The World Bank, 2020; Tett, Temple-West, & Nauman, 2019).

Despite extensive research on the need for and impact of green finance and green bonds, the market so far offers relatively substantially less empirical evidence of the financial performance of these green financial instruments compared to their conventional counterparts. For years, investors have regarded them as a "charitable investment", with concerns about returns and a lack of transparency. Sometimes people say that they want to recognise a premium for this type of investment - a premium to be environmentally friendly, which translates into lower overall returns and (perhaps) lower financing costs for the issuer. However, there is still a lack of solid evidence of "green premiums". Furthermore, an important assessment of green instruments still needs to be made, namely the risk-adjusted financial return. This is very important for investors who are willing to have a clear view of the overall risk-return offered by this segment, especially for long-term investors such as pension funds, which are subject to strict regulation that prevents them from taking too much risk in the market. Recent fears point in the opposite direction, namely that although the market for "green" bonds is more difficult to manage due to its regulation and lack of transparency, it could be subject to over-optimism with the consequent risk of bubbles and implosion. Nevertheless, there is still little scientific evidence to support or deny this quote (The World Bank, 2020; Asgari, 2019).

The present study conducts a comparative analysis of the emergence of the global green and conventional bonds. The results, therefore, help to provide a good overview, also of the financial characteristics, which will allow more empirical insights into the development of sustainable finance, more specifically green bonds. The following research will explain whether the "green" label implies a different financial performance of green bonds compared to conventional bonds or not. The only feature that distinguishes green bonds from conventional bonds is the Use of Proceeds (UoP) and as a result, investors investing in green bonds should not expect any meaningful differences in returns compared to traditional bond investments. Nevertheless, an environmental image could eventually lead to extra value and hence green bonds could be considered a better choice as an investment overall. The thesis hypothesis is based on these arguments.

The study is carried out using an extended Fama-French approach, which considers various equity and bond factors that capture most of the underlying fundamentals of the bond market. These factors have been researched and used in previous studies, all of which can also relate to the bond market. This thesis tries to replicate this approach in the field of green bonds. These so-called Fama-French factors str the market risk premium, size and value premium and the Carhart factor and a proxy for the maturity structure and the probability of default, and other additional factors appositely constructed for research in the bond market (Fama & French, 1993; Carhart, 1997).

In addition to the Introduction, the remainder of the master's thesis is organized as follows. Section two gives an overview of the problem of climate change which justifies the need for any kind of intervention. Furthermore, section three explains the current situation in the green financial market in detail to give the reader a clear understanding of the current happenings and future trends. Following the presentation of the current situation, the thesis turns to the purely empirical issues, explaining in detail how the model was created, how the data was collected and prepared and then presenting the results of the analysis. Finally, the paper concludes with a discussion of the results obtained and a conclusion that summarizes the entire work and the results.

This study provides a good theoretical background by reviewing and updating the literature dealing with the role of green bonds. To illustrate, the thesis focuses purely on the financial performance of such bonds, while other factors, such as behavioural considerations or other factors not found at financial, which could potentially affect overall performance, are not considered in the research for the time being. In any case, these may provide a sound basis for further theoretical research.

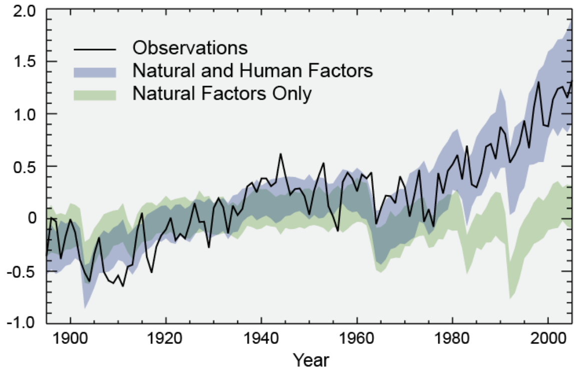
1 CLIMATE AND ENVIRONMENTAL POLICIES AND FINANCING NEEDS

Climate change has brought with it several critical consequences, the most important of which are rising weather and ocean temperatures, rising sea levels and falling ice on land. Many of these phenomena seem unprecedented over decades and millennia. For example, the first two decades of the 21st century were the warmest since 1850 in terms of atmospheric temperature. According to the Intergovernmental Panel on Climate Change (IPCC) study, the average temperature on the planet has risen by almost 1°C since the beginning of the 20th century and the sea level has risen by an average of 19 cm. Besides, the concentration of carbon dioxide in the atmosphere has increased by more than 20% since 1958 and by about 40% since 1750. Anthropogenic activities are one of the main causes of these phenomena; for example, the use of fossil fuels and deforestation have been responsible for more than half of the observed temperature increases (IPCC, 2020a).

According to the study, human activities such as greenhouse gas emissions, aerosols and changes in land use are "very likely" to be the main cause of the global warming observed since 1950, estimated to account for 95 per cent of the total. Also, the probability has been assessed at a very high confidence level, exceeding 90 per cent. In addition, future projections based on mathematical models indicate a further increase in temperatures, with temperatures well above the target of an additional 1.5°C by 2050. The worst predictions are for a staggering +4.5°C by the end of this century, something which is certainly scary. However, the task of the IPCC is to provide governments and other supranational actors (with the EU as a major stakeholder) with a comprehensive and more up-to-date assessment of the scientific, technical and socio-economic knowledge of climate change based on different scenarios. Policymakers are then empowered to make tough decisions based on empirical evidence rather than guesswork (IPCC, 2020a).

The IPCC is just one of several organisations studying the effects of climate change. Figure number 1 below shows the results of the US Global Research Program (2021), which confirms the previous findings' trend by disentangling the effects of anthropogenic and natural factors that contribute to global temperature increases. The study finds that natural factors have little effect or virtually no effect on the increase in global average temperature, while human factors show a clear upward trend over the decades. It is therefore not difficult to understand how anthropogenic greenhouse gas emissions and other factors are triggering the situation we now face (U.S. Global Change Research Program, 2021).

Figure 1: Average Global Temperatures over the Last Century

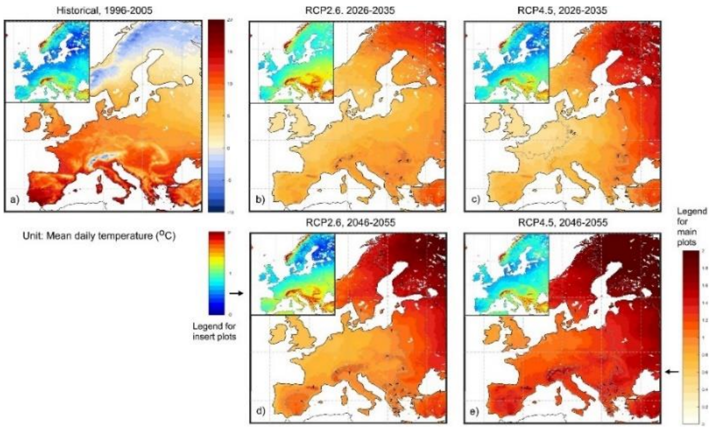


Source: U. S. Global Change Research Program (2021).

1.1 Implications of climate and environmental trends

The economics of climate change deals with the financial consequences of abnormal weather conditions that can affect the smooth functioning of productivity in a given sector. Rising temperatures, as displayed by figure 2, cause abnormal conditions that can have a significant impact on the economy, both directly and indirectly. Although significant macroeconomic effects may occur in the long term, some of them are already being felt. Serious effects in terms of overall lower labour productivity are not yet apparent, but unusual climatic conditions have already affected more sensitive sectors such as agriculture, fisheries and energy production. Moreover, a possible slowdown in productivity and thus in overall GDP growth could certainly put the assets of individuals and institutions at risk (OECD, 2018).

Figure 2: Absolute Mean Change in Temperatures from Historical (°C)



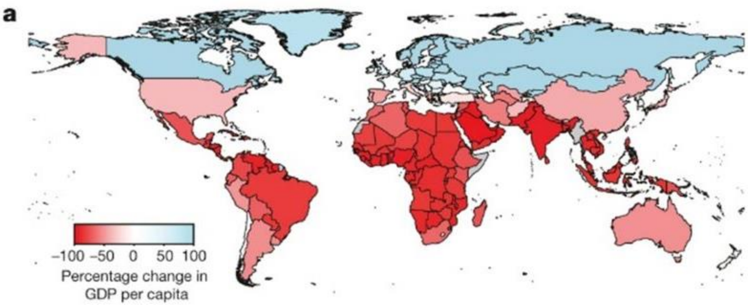
Source: Larsen, Petrović, Radoszynski, Kenna, & Balyk (2020).

Recent econometric studies written by Matsumoto (2019), Nordhaus (2019), Tavoni (2020) and a study by Dellink, Lanzi, and Chateau (2019) predict enormous damage to global production due to the global rise in temperature. Assuming that temperatures will rise by 3°C - which is likely given current trends and in the absence of appropriate measures - the economic loss of world GDP by 2100 will be in the range of 15-60% compared to what could be possible at that time. This would certainly be catastrophic, which is why policies aimed at mitigating climate change have become such a hot topic today. However, these figures only take into account the current working methodology, which means that the outcome would probably be different because of the adaptation options based on future technological development. In particular, the study by Tavoni (2020) remains very important to provide an initial assessment of the potential severity of the problem if it is not adequately mitigated.

Again, a study by Giuzio et al. (2019) is based on the hypothesis that sustainable investments are (or will be) already less risky than non-sustainable investments. Therefore, the transition to a more sustainable economy is crucial for both the real economy and the financial sector, which is why central banks are now also reflecting on how they can play a central role in putting the economy on a more sustainable path by exploiting the monetary, regulatory and supervisory policy in this area.

The data confirm that the trend is worryingly upward. Action must be taken without serious economic consequences endangering a large part of potential economic activity worldwide. Moreover, a loss of economic activity would, all other things being equal, certainly lead to a dramatic increase in global inequality. This would be due to the negative effects of climate change. As the map in figure 3 shows, the southern countries, which are poorer on average, will tend to bear the greatest burden. Therefore, the increase in income and life disparities as a result of climate change is another process that must be avoided (Reedtz, 2019).

Figure 3: Economic Impacts of Climate Change



Source: Faiella (2019).

One example of these changes is the rising sea levels, which raise serious concerns about whether coastal cities, such as Venice, can continue to thrive in the future. Although tidal floods in Venice are natural, their intensity has increased steadily over the last decades, indicating that climate change is already having an impact on the economy of this great and rich city in terms of culture and tourism. Likewise, Italy is also one of the countries that will suffer the most from the deterioration of the river-related flooding processes if they are not adequately mitigated (Faiella, 2019).

Contrary to problems with excess water, climate-related problems have also led to problems with water availability. This phenomenon has a significant impact on agriculture and also on part of energy production. Water scarcity has a direct impact on the current agricultural system, either at a higher cost or with lower product quality. Reduced water availability also reduces hydropower production, which in turn complicates the clean energy production process. Again, Southern European regions are facing and are likely to continue to face increasing water scarcity. A good example is 2017, which, with low rainfall, was a year of one of the lowest levels of hydropower generation in decades. This event is on the rise throughout the hemisphere, which is normally rich in water. In the southern parts of the world, however, the risk of severe droughts and resulting land and forest fires is even greater. According to the study, "human mortality from heatwaves will rise sharply". It is of primary concern, therefore this phenomenon must be taken seriously (Faiella, 2019).

Other studies in the medical field show how temperatures above 32°C can reduce productivity by up to 14%. This is expected to lead to an increase in work-related heat stress, thereby increasing the risk of accidents with job losses and decreasing production capacity. This is because at higher temperatures the risk of contracting infections from external vectors could increase the number of accidents at work. Here, the study found that the most vulnerable sectors are agriculture and construction (Faiella, 2019).

Other obvious consequences related to climate change concern energy consumption. At present, the main concern of policymakers is how to reduce energy consumption and/or how to produce it sustainably. Rising temperatures can have "positive" effects on reducing energy consumption in cold periods (energy consumption for heating services). However, this trend of lower energy consumption is likely to be offset by the opposite problem, namely energy for cooling during hot periods, which are eventually expected to last longer and have higher peaks - something that will severely affect energy supply. Also, this trend of increased demand for cooling energy will be particularly pronounced in countries where temperatures are historically lower, confirming that climate change and global emissions have a serious impact on the climate with a higher expected temperature over the years. For this reason, there is an urgent need to think about how to reverse the negative effects of climate change (Larsen, Petrović, Radoszynski, Kenna, & Balyk, 2020).

1.2 Two types of climate policies

Climate change is ongoing and is caused by a large amount of greenhouse gases in the atmosphere. From this perspective, there is only one way to react: eliminate the causes and, at the same time, prepare to manage the effects. In other words, we must reduce the amount of greenhouse gases in the atmosphere and take the necessary measures to deal with an already changing climate. The two go hand in hand, because the more global warming increases, the more difficult it will be to deal with the problem. Therefore, usually, the terms used to describe these two actions are "mitigation" and "adaptation". Mitigation to undertake actions to reduce global pollution, and adaptation, which means that we are currently adapting to the results already happening (IPCC, 2020a).

1.2.1 Mitigation: emitting fewer greenhouse gases

The term "mitigation" includes all actions that aim to reduce the amount of greenhouse gases in the atmosphere. A mitigation action is essential because it is through the emission of excessive amounts of these gases, whose concentrations in the atmosphere are higher than ever before, that climate change occurs. The Earth's average temperature has already risen by about one degree Celsius, which is already having serious consequences in some respects. So far, the only effective prescription for reducing the concentration of greenhouse gases in the atmosphere is to emit less of them. However, this solution is as simple to find as it is difficult to implement because greenhouse gas emissions - CO2 in particular - are the basis for almost all human activities. That's why measures such as those proposed by the EU are needed - measures that aim to alleviate this serious problem without hindering economic growth. Ultimately, this is one of the main problems facing European policymakers today (European Environment Agency, 2020).

In this context, we are talking about individual and collective (macroeconomic) measures. At the individual level, mitigation could perhaps mean a reduction in water consumption when washing, a reduction in heating consumption by lowering the temperature, etc. However, all depend on energy to function, and energy is still massively derived from polluting sources. Therefore, at a collective level, two types of actions can be undertaken.

Eventually, energy consumption can be reduced by investing in energy efficiency, so that less and less energy is needed to run the washing machine. This can be done, for example, by modernising electricity networks in households or by providing incentives for appliances that consume less energy. In this way, less energy is used in general and greenhouse gas emissions are reduced. At the same time, a plan to replace fossil fuels with "clean" energy sources is needed. These include renewable energy sources, such as solar panels or wind power, like the sun and wind, but also river flow and wave movement. The search for renewable energy, currently relegated to a secondary role, means producing energy without emitting greenhouse gases and thus "mitigating" global emissions.

However, at present, the technology is still in its infancy, so large-scale clean energy production is not economically feasible. Perhaps when nuclear fusion technology is further developed, this idea could become a reality. In any case, for the time being, it is crucial to modernize the technology that will eventually reduce energy consumption. Indeed, better technology, developed mainly by private companies, requires a functioning large-scale market to sell its products and make a profit - which is then reinvested. This is certainly a virtuous cycle from which humanity could never escape. That's why the plans proposed by the EU today are moving in that direction to promote a stronger and more developed free market, with incentives to move towards a sustainable future, which is the only possible way to achieve the desired results.

1.2.2 Adaptation: adjusting to a changing environment

This process refers to the adaptation of natural or human systems in response to current or future pressures and impacts of climate change. It, therefore, aims to reduce and mitigate potential damage and exploit opportunities, covering all preventive interventions implemented to mitigate the effects of an unavoidable change in Earth's climate. The main examples of adaptation interventions could be: the construction of hydraulic safeguards to defend the coasts (such as currently present in the Netherlands or Venice), water resource management, prevention of the health effects of heatwaves, diversification of the tourism offer, strengthening civil protection, etc (European Commission, 2020b).

For the EU, adaptation is a priority: in fact, several adaptation measures need to be taken because they yield short-term results, despite the uncertainty of forecasts, or just because they are beneficial for both mitigation and adaptation to climate change. The main recommendation in this optic is to:

- avoid the development and construction of infrastructure in high-risk areas when settling or relocating;
- design of infrastructure and buildings to minimise water and energy consumption and improve water storage and cooling capacity in urban areas;

- coastal and flood management, including the creation or restoration of floodplains or salt marshes, which improve the capacity to manage floods and sea-level rise and contribute to the achievement of biodiversity and habitat protection objectives;
- improving preparedness and contingency planning to deal with risks (including climate-related risks).

Mitigation and adaptation measures are complementary rather than alternative, although in some cases they may overlap and act in synergy. For example, the planting of a tree is both an adaptation measure to prevent soil erosion and a mitigation measure (afforestation), which captures CO2. Another example is that saving water (adaptation) also leads to saving energy (mitigation). In a sense, energy-saving, and energy diversification are both adaptation and mitigation measures.

However, although both mitigation and adaptation are needed today, the less mitigation there is today, the more adaptation is needed later – a process that will become less and less effective and costly, especially in the case of developing or third world countries. Therefore, the moral of the story is that humanity needs to solve the problem by mitigating greenhouse gas emissions as quickly as possible (IPCC, 2020b).

1.3 International climate and environmental policies

It was only from 1990 that the world began to treat global warming as a serious issue, and regular international negotiations and agreements aim to set limits on greenhouse gas emissions by the signatory countries. Below I shortly introduce the main international accords which permitted the world to tackle the problem seriously (IPCC, 2020c).

UNFCCC - Rio de Janeiro (1992):

The United Nations Framework Convention on Climate Change (UNFCCC) is the first and most important international agreement to reduce greenhouse gas emissions. It was signed in 1992 at the Earth Summit in Rio de Janeiro. This agreement is not legally binding in the sense that it does not impose binding limits on greenhouse gas emissions on individual signatory countries.

The Kyoto Protocol (1997):

This is the first international document to impose an obligation to reduce emissions on the most developed countries: -5% (based on 1990 emissions) in the first compliance period between 2008 and 2012, with the European Union (EU) setting a further reduction target of -8%. The second commitment period under the Kyoto Protocol started in 2013 and ends in 2020 when the signatory countries committed themselves to reduce emissions by at least -18% below 1990 levels. The EU also committed itself to further reducing emissions by -20% below 1990 levels.

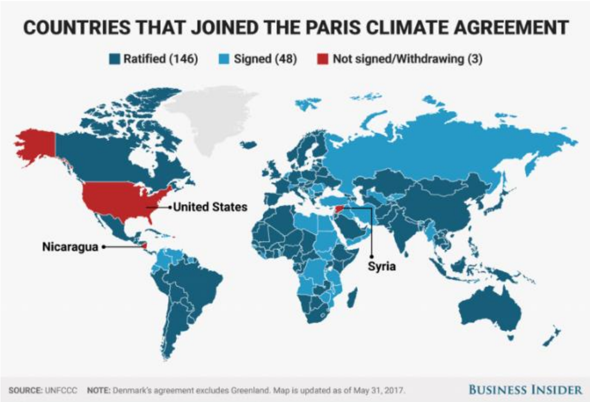
The United States has never signed the Kyoto Protocol. Canada withdrew before the end of the first commitment period. Russia, Japan and New Zealand are not in the second commitment period. This means that the Kyoto agreement currently only applies to around 14% of global emissions.

Paris Agreement (2015):

With 40.000 participants, this was the most media-rich summit since Copenhagen (2009), which resulted in the first universal text with a goal to limit global warming to well below 2, and preferably to 1.5 degrees Celsius, compared to pre-industrial levels. (i.e. 2.900 billion tonnes of Co2, a reduction of 40-70% of emissions by 2050). The targets are reviewed every 5 years in the framework of the National Designated Commitments (INDC) to make them even more ambitious. The countries that have signed the Paris Agreement are shown in figure 4 and represent the situation in 2017.[1]

The Paris Agreement entered into force in 2016 when at least 55 countries representing at least 55% of global greenhouse gas emissions meet the conditions for ratification. As a matter of fact, all EU countries ratified the agreement. The agreement signed in Paris had the advantage of being the first binding and global agreement on combating climate change.

Figure 4: Paris Agreement – Signatory Countries



Source: Harrington & Gould (2017).

The cornerstone of the entire agreement is the goal of limiting the temperature rise to well below 2 C° compared to pre-industrial levels, with a commitment to limit the rise to 1.5 degrees. The other main points are: to peak greenhouse gas emissions as soon as possible, to start with continuous reductions until a balance is found between emissions and cuts in the second half of the century; all countries have communicated their commitments at the national level, with improved adjustments to be made at regular intervals (every five

[1] The United States rejoined the agreement under the new Biden administration after a formal completion of withdrawal in late 2020 under the Trump administration..

years); funds are earmarked for the most vulnerable and susceptible countries to climate change, which are in some way unable to adapt. Another part is funding to assist developing countries: the roadmap aims to create a fund of USD 100 billion a year by 2020, with a commitment to increase funding for adaptation and international cooperation from time to time. Besides, there is the issue of transparency and flexibility, so that everyone can contribute according to their capabilities.

The Paris Agreement was signed on 22 April 2016, World Earth Day, at the United Nations headquarters in New York by 175 countries. The rules for its entry into force (4 November 2016) required its ratification by at least 55 countries representing at least 55% of greenhouse gas emissions. Italy ratified it on 27 October, just in time for the launch of Cop22 in Morocco.

Therefore, the five key points include:

- The agreement commits signatory countries to stop global warming within 2 degrees C° to pre-industrial levels, and within 1.5 degrees if possible.
- Governments will have to set and implement targets for reducing man-made greenhouse gases (primarily carbon dioxide, but also methane and HFC refrigerants).
- Commitment reviews are planned every five years, starting in 2023.
- The richest countries will have to help the poorest financially through a $100 billion "Green Climate Fund" to be set up by 2020.

Since 1995, the UNFCC has held an annual Conference of the Parties (COP) among its members. This is where the global warming situation in individual countries is discussed and action is decided. The political novelty of the Paris Agreement was the accession of the largest producers of greenhouse gases, the United States and China, which had previously refused to join the Kyoto Protocol so as not to hamper their economic growth.

Unfortunately, the agreements made in Paris failed to reduce emissions on a short-term basis, which ultimately increased from 50 to 55 billion tonnes in 2019. However, while short-term results do not appear to be sufficient, there is empirical evidence to suggest that long-term environmental trends have indeed improved. Before the 2015 Paris summit, global emissions were projected to increase global temperature by 3.5°C by 2100, but now, according to estimates from Climate Action Tracker, that trajectory has decreased to 2.9°C. This shift is the result of a combination of technological, economic and political changes. Among them, for example, the cost of renewable energy technologies such as solar power, which has fallen dramatically; economic growth that has slowed; heavier regulations, especially within the European Union. Ultimately, by 2019, Europe's emissions were 24% below 1990 levels. Moreover, EU leaders agreed on a more ambitious plan to cut emissions by 55% by 2030 (Climate Action Tracker, 2020).

To improve emissions targets in the short-term, a greater shift to cleaner technologies is needed. Anyhow, the biggest step forward in this direction is likely to be a combination of market incentives and financial investment in these technologies, rather than some kind of international agreements that only theoretically binding. In this perspective, one of the main developments is indeed the market for sustainable finance with all its aspects, which is discussed in detail in this thesis.

Sustainable Development Goals (2016):

In January 2016, the Global Agenda for Sustainable Development and the associated Sustainable Development Goals (SDGs), entered into force internationally. The UN member states have committed to achieving them by 2030. This Agenda makes a clear judgement that the existing development model has become unsustainable, not only from an environmental point of view but also from an economic and social one. The Agenda, therefore, moves beyond the idea that sustainability is only an environmental issue and reaffirms an integrated vision of different dimensions of development. In this case, all countries, whether developed, emerging or developing, are called upon to contribute to the efforts needed to put the world on a sustainable path. Each country must therefore commit itself to define its own national sustainable development strategy (NSSD) that will enable it to achieve its objectives and report on its achievements in a process coordinated by the United Nations. The implementation of the Agenda requires the active participation of all sectors of society, from business to the public sector, from civil society to philanthropic organisations, from universities and research centres to cultural and information operators, which means that implementation takes place at 360 degrees. The Global Agenda for Sustainable development and Sustainable Development goals, therefore, represent the broadest context of international climate and environmental policies (United Nations - Inter-agency Task Force on Financing for Development, 2020).

Despite all the above-mentioned initiatives, data shows that countries are not meeting the 2015 targets of the Paris Climate Agreement. This is confirmed by a study published by Climate Transparency, which analyses countries' performance against 80 different indicators and does so with the support of 14 research organisations. It shows that G20 countries' emissions increased in 2019 in all sectors, particularly in the construction sector. This means that the 2030 targets are slowly fading on the horizon unless new measures are implemented to increase climate ambition. The fight against global warming is therefore becoming crucial, especially as 20 countries are responsible for about 80% of global greenhouse gas emissions. In theory, this group should reduce its emissions by 45% by 2030 and achieve climate neutrality or zero emissions by 2050, but these goals seem utopic with current technology and dedication.

The 2020 Covid-19 pandemic shortly reduced emissions, which are going back "on track" as economic activity starts to recover. However, the Pandemic has also pushed institutions to invest more, and a good piece of it will be directed towards a more sustainable future.

Clearly, we are talking here about the European Union with its "Next Generation EU" plan, which promises over a trillion euros of new investment. In addition, once again in these months, EU officials have increased the greenhouse gas emissions reduction target to 55%, which was previously set at an already ambitious 40% reduction compared to emissions in 2005. Moreover, with the new presidency, the US seems to be looking at the climate issue differently; and China is also taking the issue seriously, but projects to peak its greenhouse gas emissions only by 2030.

Therefore, much more needs to be done, but more importantly, real penalties for those not following the rules must be applied. But who is enforcing them globally? In theory, the organisation that promotes international climate agreements, in practice none. Is it like trying to enforce the ban on using deadly weapons in wars; where again, who enforces it? Again, none. The only option is always either to go to "war" against the non-obeyers or simply to try to force the market to go in the direction of a more sustainable and resilient future - something that is happening now.

1.4 European Union's climate and environmental policies

1.4.1 The EU Environmental Action Programme (EAP)

The basis for all environmental aspects of the EU is contained in the Environmental Action Programme (EAP), which has existed in the EU since 1970. However, this programme changes over time and is of paramount importance as it represents a direction in which environmental policy should move. The current EAP, the seventh in a row, was adopted in 2013 and ends in 2020, setting out six priority objectives with complimentary advice on measures to be taken to achieve them by the end of the year (European Commission, 2020c, 2021).

These six objectives aim at:

- achieving the 2030 greenhouse gas emission reduction target and climate neutrality by 2050;
- enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change;
- advancing towards a regenerative growth model, decoupling economic growth from resource use and environmental degradation, and accelerating the transition to a circular economy;
- pursuing a zero-pollution ambition, including for air, water and soil and protecting the health and well-being of Europeans;
- protecting, preserving and restoring biodiversity, and enhancing natural capital (notably air, water, soil, and forest, freshwater, wetland and marine ecosystems);

- reducing environmental and climate pressures related to production and consumption (particularly in the areas of energy, industrial development, buildings and infrastructure, mobility and the food system);

By basing their strategies on the EAP, the EU strategies all have multiple targets but are divided into periods in which different targets are to be achieved in different timeframes. The longest-term strategy is 2050 and deals with an effective reduction in greenhouse gas emissions over all years. It foresees a climate-neutral future through the European Commission, i.e. just like the Paris agreement to keep the rise in global temperature below 2°C, but with the ambition of keeping it at 1.5°C. However, more concrete targets can be observed in the 2020 climate and energy package and the 2030 climate and energy framework (European Commission, 2020c).

The 2020 package consists of various binding rules designed to guarantee that the EU achieves its climate and energy targets by 2020. Within the package, there are three main targets, usually referred to as 20/20/20, which refer to a 20% reduction in greenhouse gas emissions, the contribution of renewable energy to 20% of EU energy and a 20% increase in energy efficiency. On the other hand, the 2030 framework for the period 2021-2030 implied targets of 40/32/32.5, with the figures having the same meaning as for the 20/20/20 targets. In 2020, the greenhouse gas emissions reduction target 2030 has been further increased from 40% to 55%. The main benefits of the 2030 framework are to ensure affordable energy for all consumers, increase the security of energy supply and thus reduce dependence on energy imports, develop new opportunities for jobs and growth and, lastly, the benefits for health and the environment (European Commission, 2021).

1.4.2 The European Green Deal

The Green New Deal is a total European response (with concrete measures) to the climate change emergency, a strategy that includes new legislation and investment, to be implemented over the next 30 years. For the first time, a law binding on all EU countries has enshrined the achievement of carbon neutrality by 2050. This will unite the actions of individual citizens, cities and regions and help businesses become global leaders in clean technologies, by creating new jobs and facilitating the transition to a circular and sustainable economy to ultimately achieve zero emissions by the set target (European Commission, 2020a, 2020h).

The legislation aims to promote a fair and equitable transition to a sustainable, carbon-neutral economy in all member states. The focus will be on achieving a balanced transformation that leaves no citizen or region of the EU bloc behind.

Specifically, the Deal aims to decarbonise the energy sector, which accounts for 75% of polluting emissions. Therefore, the transformation will also affect the entire industrial production system and help it become a world leader in the green economy. Certainly, mobility will also have to be rethought in terms of sustainability, since transport is responsible for 25% of the continent's pollutant emissions.

The first milestone set for achieving climate neutrality is a 55% reduction in emissions (compared to 1990 levels) by 2030. Following the principle of no-one is left behind, the Commission will open negotiations with the Member States and all neighbouring countries and, through an assessment of the social, economic and climate impacts and the different capacities of each country, a mechanism for financial support of disadvantaged regions will be set up.

Initial discussions of the Green Deal suggested that it would be financed by large amounts of public and private money. About EUR 1 trillion, or about EUR 100 billion per year, will be mobilised in the first 10 years. With the adoption of the new budget, EUR 1 074 trillion will now go to the multi-annual financial framework for 2021-2027 and as much as EUR 750 billion to the next generation of the EU, supporting citizens, businesses and the regions worst hit by the crown crisis. According to the plans, the climate agenda will eventually account for around 30% of the total amount available. However, it is interesting to note that for the NextGeneration-EU to become operational, the European Commission must have the legal ability to borrow from the markets and distribute the amounts where they are most needed. To this end, the EU Member States still need to ratify the own resources decision following their constitutional requirements.

This epoch-making strategy focuses on cleaner energy generation, sustainable agriculture and industry, promotes biodiversity, a better way of life and aims to improve many other areas of interest. The main concern, of course, is to drastically reduce pollution to prevent a climate catastrophe.

In this optic, energy production, which is currently responsible for 75% of the EU's greenhouse gas emissions, is a major concern. This means above all promoting the spread of renewable energies and stopping the continued use of fossil fuels. To date, the differences in the introduction of clean technologies between West and East remain large; for example, Poland still gets 80% of its electricity from coal, while the share of its neighbour Germany is much lower at 36%. Moreover, Poland remains the only European country that has not yet formally agreed to zero net emissions by 2050. Unlike in Western Europe, all Eastern countries have hardly built any solar or wind power plants or thoroughly modernised nuclear power plants (European Commission, 2020a).

The environmental ambitions of the Green Deal will not be realised if Europe acts alone. The drivers of climate change and biodiversity loss are global and do not stop at national borders. The EU can use its influence, expertise and financial resources to mobilise its neighbours and partners to make common progress towards sustainable development. The EU will continue to play a leading role in this field and seek to build alliances with likeminded actors, recognising the need to preserve its security of supply and competitiveness, even when others are not ready to act.

Another important objective will be to make the use of human resources that cause excessive pollution more sustainable. This means adopting new laws across Europe for the construction or renovation of houses and industries that reduce pollution from production processes, facilitate public transport and rail transport, thus promoting a circular economy and creating more jobs for sustainable development.

1.4.3 EU regulative instruments

1.4.3.1 EU climate law

Based on the latest news, it seems that for the first time in Europe, there will be a legal framework for climate change. The European Commission proposed the EU climate law in 2020 and the corresponding regulation is expected to be adopted in 2021. The law will help formalise the EU intention to achieve zero net emissions across the Union by 2050, making this objective legally binding and setting specific medium-term targets. According to the European Commission, the new regulative environment will also establish a series of basic principles which could form as the basis for all future EU measures, especially in the framework of governance. These principles will relate to the well-being of citizens, the welfare of society, economic competitiveness, energy efficiency, security, health and protection of vulnerable consumers, solidarity and a scientific approach to future measures (European Commission, 2020a).

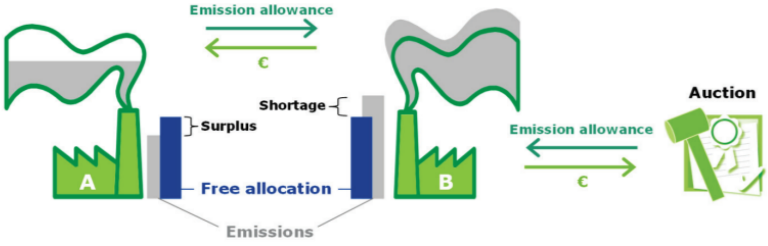
1.4.3.2 European Emission Trading System (EU-ETS)

The EU-ETS, established in 2005, is one of the main instruments of EU climate change policy. It is the first, largest, international and most important carbon market in the world. It operates in all EU Member States and includes Liechtenstein, Norway and Iceland (European Commission, 2020g).

The EU-ETS effectively reduces emissions from energy-intensive installations such as power stations and industrial plants, as well as air transport between these countries. Its effectiveness is proven, as 45% of all EU greenhouse gas emissions are covered by the scheme (European Commission, 2020g).

The EU-ETS is also known as the "cap and trade" system. A cap is a limit on the number of greenhouse gases emitted by plants. Over time, the cap should be lowered to reduce overall emissions. From 2013, the cap will be reduced by 1.74% per year and an even faster rate of reduction is envisaged since 2021. Given the level of the cap, companies earn and/or buy emission allowances that can be traded. A cap gives a company the right to emit greenhouse gas emissions of one tonne of carbon dioxide. There is also the possibility of buying international credits, albeit in limited quantities. The latter is due to the global reduction in emissions. The reason for the limited quantity is to guarantee the value of the allowances, therefore, trading allows emissions to be reduced in the cheapest way for companies, with a carbon market price, while supporting investment in low-carbon technologies. Figure 5 quite clearly and concisely illustrates how this mechanism works in practice (European Commission, 2015).

Figure 5: EU Emission Trading System – Illustrative Scheme



Source: European Commission (2015).

The EU-ETS can be classified according to trading phases. To date, we count three distinct phases which all carry important differences among each other (Glowacki, 2020).

Phase 1 – 2005-2007:

The first round of the EU-ETS was a testing phase in which the Member States were given the freedom to decide on the total number of allowances to be allocated, which were ultimately granted free of charge based on historical factors. According to the analysis made by the EU Commission, around 200 million tonnes of CO2, or 3% of all verified emissions, were reduced by the EU-ETS to nominal transaction costs. However, problems came after the first year of operation, when it became clear that too many European Union Allowances (EUAs) had been allocated to companies, leading to an excess of EUAs and a resulting fall in prices to zero by the end of the period.

Phase 2 - 2008-2012:

The second phase coincided with tighter emission allowances, with the total EU volume decreasing by 6.5% compared to 2005. During this phase, Iceland, Norway and Liechtenstein became part of the EU-ETS and the scope was modified to include other toxic substances. Besides, Member States could have auctioned up to 10% surcharges instead of free allocation. However, the extra credits and the economic crisis in 2008, which limited emissions by EU companies, led to a large surplus in the EU-ETS agreements and brought the allowance price down from €30 to less than €7 - a problem the European Commission has been working to solve.

Phase 3 - 2013-2020:

During the previous period, a series of problems have had to be faced, three of which are important. The main one was the collapse of the EU allowances, which weakened the credibility of the process, then the reduction in total emissions was not as high as expected, and finally, the total cost of this green transformation did not appear to be very effective and it was also subject to many frauds - not a great success. To remedy the inherent weaknesses of the system, the reforms introduced at this stage include an emissions cap applied evenly across the EU in order to achieve the greenhouse gas reduction target more effectively. This cap is reduced by 1.74% per year in order to achieve a 23% reduction in emissions in 2020 compared to 2005. The Commission has therefore adopted a further directive which specifies that auctions must meet criteria such as predictability, cost-effectiveness, fair access to the auction and simultaneous access to relevant information for all operators. The main policy challenge for the third trading period is the large surplus of allowances carried over from the second to the third trading period, which resulted in a price of only 3 to 7 euros. Once again, the EU decided to defer the auctioning of 900 million EU allowances until the end of the trading period, which was only adopted after a long and controversial political process.

Participation in the EU-ETS is mandatory for companies within the following sectors producing:

- carbon dioxide (CO_2) coming from electricity and heat production, energy-intensive industries like oil refineries, ore processing, chemicals, etc. as well as those involved in commercial and civic aviation
- nitrous oxide (N_2O) resulting from the production of nitric, adipic and glyoxylic acid and glyoxal
- perfluorocarbons (PFCs) deriving from aluminium production.

While participation in the EU-ETS is binding for companies operating in these sectors, some exceptions do apply, for example in some sectors where only companies above a certain size are included, or where public authorities implement fiscal or other measures that reduce their emissions by an equivalent amount, and finally in the aviation sector for flights within the European Economic Area (EEA), until 31 December 2023.

The current phase differs in some respects from earlier phases. First, there is only one emission limit value for all EU Member States instead of national limits. Secondly, additional gases and sectors are included. Thirdly, auctioning is the most important way to allocate allowances with the consistency of the allocation rules to free allowances. Finally, to provide funds for the use of innovative renewable energy, carbon sinks and storage technologies, 300 million allowances have been set aside in the reserve for new entrants. This is done through a special programme called NER-300, which is a funding programme for projects that provide innovative low-carbon energy presentations (Investors' Corner Team, 2020).

As regards the fourth phase, the key elements had already been agreed upon for the period 2021-2030. This current phase started on 1st January 2021, where the European Commission now intends to carry out a complete review of the EU-ETS Directive by 2026 in order to bring it more into line with the current economic sphere and the different objectives set during the Pandemic. At this stage, we should see the greatest results in terms of the transition to a more sustainable economy as well as a major leap forward towards a greater degree of unity in the European market. A key element of the current phase is the faster annual decline in the limit compared to the previous period, by increasing the pace of annual reductions in allowances to 2.2% in 2021, which will permit to achieve higher GHG reduction sooner (this pace will have to be further hastened given the higher, 55%, GHG reduction target for 2030). The EU is committed to reducing emissions at a level commensurate with the EU's contribution to the 2015 Paris agreement and the 2030 climate and energy framework. It should also stimulate investment in innovation, strengthen the Market Stability Reserve (MSR), maintain a free allocation of allowances to protect the international competitiveness of the sectors concerned and help the industry to cope with the challenges of the transition to a low carbon economy (European Commission, 2020g).

Moreover, the benefits of the cap-and-trade structure are numerous. It is a structure that makes it possible to aim for emission reductions at the lowest cost to the people involved and to the economy. Compared to other possible structures and forms of emission reduction, cap and trade are the most effective. Companies within the EU-ETS program are free to choose how they will reduce emissions and, if they are very successful, they can even earn some extra money through the sale of excess emissions coupons. However, companies involved in this Cap and Trade System may also opt for slower restructuring (more emissions), but it is costly because they need more coupons to buy on the market. This market mechanism (price) should move companies in the desired green direction. Furthermore, the tax is not a viable option in the EU, as the reduction targets may not be met and the carbon price would be difficult to determine as the several Member States would want a different price (European Commission, 2020g).

Because of the measurable results, the important benefits are highlighted. Starting with the first advantage: cost-benefit, which is the flexibility of trading in terms of carbon pricing, and since it is a whole market, everyone has the same price and those who can reduce emissions at the lowest cost can benefit. Secondly, there is certainty about the amount of emissions that the EU will allow in a given period, and compliance with these limits will positively support the achievement of environmental objectives and commitments. Thirdly, revenue raised by governments through emissions auctions, and fourthly, certainty about the quantity that minimises the budgetary risk for the Member States as regards the plausibility of the need to buy additional international units to meet the Kyoto Protocol commitments. This is because the EU-ETS contributes around 50% of emissions (European Commission, 2020g).

The revenue generated by auctioning these allowances is allocated to the Member States based on certain criteria relating to the number of emissions. This contributes to 88% of all auctioned allowances. A further 10% will be distributed to the less prosperous Member States to help them reduce greenhouse gas emissions and climate change. The final 2% is known as the Kyoto bonus, which is allocated to nine Member States that have reduced their emissions by 20% or more compared to 2005. It should be noted, however, that its allocation is only valid for the period 2013-2020. Now, 90% of the allowances auctioned will be allocated as 88% of the allowances before and 10% to the least prosperous Member States, as is already the case in the current period. In addition, 50% or more of the auctioned revenues must be used for energy and climate change purposes (European Commission, 2020g).

1.4.3.3 Effort Sharing Decision (ESD)

The Effort-Sharing Decision (ESD) is a binding part of the legislation in the EU's climate and energy package to ensure that climate and energy targets are met. Unlike the EU-ETS, the ESD deals with the reduction of non-traded greenhouse gas emissions, such as buildings, waste, agriculture, and transport, except for aviation, which accounts for up to 60% of all emissions. However, emissions from land use and forestry are not subject to the ESD (Carbon Market Watch, 2019).

From the current period from 2013 to 2020, the ESD requires all Member States combined to reduce emissions by 10% by 2020 compared to 2005 levels. For the period 2021-2030, the combined emission reduction is set at 32.5%, again compared to 2005 levels. This reduction will have to be further revised upwards because of the higher, 55%, GHG reduction target for 2030. In the new period, the effort sharing legislation takes the form of regulation instead of a decision. Within this legislation, a specific emission reduction target is calculated for each Member State, as each Member State should have sufficient freedom to choose which sector could potentially require the largest reduction (the so-called Annual Emission Allocation – AEA). The emission reduction target for an individual Member State is calculated based on the economic capacity of its relative wealth, measuring GDP per capita in 2005 (European Commission, 2020e).

However, implementing policies and commitments to meet their GHG targets may place a burden on AEA for some Member States. Therefore, ESD itself helps with the availability of various flexibility instruments. For example, a Member State with higher GHG emissions in one year of its AEA can borrow 5% of AEA from another Member State, borrow from the next year or use credits from international projects. If there is a surplus of AEA in one year, the country can transfer it to the other Member States or use it within the commitment period. Each member state is obliged to report on its annual development or deterioration of greenhouse gas emissions. In the event of non-compliance, corrective measures and sanctions are applied.

Further adjustments will now be made for the period 2021-30, with the Commission reviewing all climate and energy laws to bring them into line with the higher standards of a 55% reduction in greenhouse gas emissions set a few months ago. To reach the new 55% target, the EU will need to further improve energy efficiency and increase the share of renewable energy - which is currently set at 32.5% by 2030.

As said, both targets will be increased during the revision process of these two pieces of legislation and the Commission has launched an ad hoc public consultation on how to align them with the Green Deal targets. In light of the new 2030 target and the new renewable energy target, this is expected to rise to 38-40%.

1.4.3.4 EU Green Bond Standard and sustainable finance taxonomy

In March 2018, the European Commission presented the Sustainable Finance Action Plan, an action programme that builds on the recommendations of the EU High-Level Expert Group on Sustainable Finance. The ultimate goal was to strengthen the role of finance in the transition to a sustainable economy, building on the success story of the EU-ETS (EU Green Bond Standard Working Group, 2019).

The plan starts by creating a common framework or "taxonomy" for sustainable finance to define what is sustainable for the environment. This is the so-called "EU Taxonomy of Sustainability", which is to be developed for the European market, with a tendency to become the leading international framework in this area due to its affordability and resulting accessibility. As a result, the European Commission is committed to creating common standards and EU quality certificates for the green bond market that correspond to the same taxonomy, to promote the credibility of the financial product and increase investor confidence (European Commission, 2020d).

Besides, the Sustainable Finance Expert Group published a report in 2019 on potential European standards for green bonds. According to this report, any type of bond instrument that complies with the following rules can be classified as “green”:

- The proceeds will be used exclusively to finance or refinance, in whole or in part, new or existing environmental projects under the future European taxonomy. This means that projects or activities financed by green bonds should fall within the categories defined by this classification system.
- The green bond issue must be accompanied by documentation confirming its compliance with European standards.
- Compliance with the above standards must be verified by an independent, accredited external auditor.

Any issuer wishing to use the term "EU Green Bond" must ensure that these three requirements are met and constantly updated (EU Green Bond Standard Working Group, 2019).

However, like the standards set by Green Bond Principles (GBPs) framework, the European Green Bond framework is structured in a similar way being divided into four main elements covering the nature of the:

- Green Bond Project:
  For a project to be recognised as green, it only has to comply with European legislation - principles. In this way, issuers and investors can rely on a common definition of "green" to avoid confusion about which assets can be financed by green bonds. In this way, reputational risks due to an unclear picture of whether such bonds finance green projects are completely avoided thanks to a common and clear framework that defines what green is.
- Framework for green bonds:
  This is the document to be issued and provides detailed information on the main aspects, such as the environmental objectives to be achieved by the green bond, the process that led the issuer to identify green projects and income management.
- Impact Reporting:
  The reporting standards are set at a very high level, so compliance ensures a transparent overview of the situation around reporting. The documents must show how and why a particular project is in line with the green bond, the geographical distribution of revenues and the green bond ratio, which indicates the amount of debt of the green bond concerning the total debt of the issuing company.
- Verification:
  This phase must be assigned to an external (independent) and recognised expert. The current market situation offers us a wide range of appraisers, which can increase uncertainty. To alleviate this problem, the EU framework introduces the figure of an accredited assessor.

The similarity and relation to the four basic components of the GBPs are obvious. Due to the success of GBPs as reference guidelines at the international level, the expert group commissioned by the European Commission has decided to use it as a starting point for the development of future European standards. At the same time, the European-level upgrade attempts to clarify some aspects that may increase the ambiguity among which we see the confusion regarding the "green" definition of projects, the lack of information on environmental impacts, the quality of some external auditors and verification controls (European Commission, 2020d; International Capital Market Association, 2018).

However, there is a fundamental difference between these two standards. While the guidelines issued by the International Capital Market Association (ICMA) are a set of non-binding recommendations for the issuer, compliance with the requirements of the

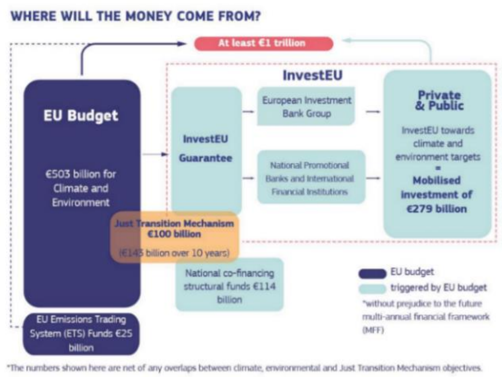
European standards becomes essential for the issuance of a green bond. The aim is to create a more restrictive regime to which all issuers must adhere to avoid uncertainties and discontinuities in the market, as the lack of clearly defined rules and a standardised market is currently a common concern of players in the green bond market.

1.4.4 EU financial instruments

1.4.4.1 EU Investment Funds

In addition to climate targets and regulatory instruments, mobilization of sufficient financial resources to support the investment needed for the green transition is the other crucial ingredient that will determine the success or failure of the European Green Deal. In this respect, the European Commission envisages a combination of public and private financial resources to finance over a trillion initiatives over the next decade. This trillion will not all come from the EU budget but could be "mobilised" from the private financial sector as well as the national (member state) level. This implies a growing market of green finance in the future (European Commission, 2020f).

Figure 6: European Green Deal – Financing Scheme



Source: European Commission (2020f).

As Figure 6 clearly shows, the number of €1 trillion can be achieved by reserving some quotas for sustainable initiatives in the existing EU budget programmes and new initiatives (such as the Just Transition Mechanism), using the EU budget as a guarantee to attract additional private funds, and extrapolating the amount from seven to ten years while recognising that the plans could only be revised upwards. This results in just over €1 trillion for the coming decade. The strategy, therefore, consists of a few individual parts, which together provide the amount shown.

Some of the money that the European Commission wants to use to finance the European Green Deal is available in the EU's long-term budget, the "Multiannual Financial Framework" (2021-27) at €1.074 billion, whereas another significant part comes exclusively from a newly established financing mechanism, the Next Generation EU, which amounts for €750 billion (€390 billion in grants and €360 billion in loans). The part relating to the Multiannual Framework, extrapolated from seven to ten years, will result in over €500 billion. Besides, the European Commission plans that its member states will provide around €114 billion for climate and environment projects during this period (European Commission, 2020f).

Another part is the "Invest EU" initiative, which aims, among other things, to create a "sustainable infrastructure". Overall, it plans to attract €279 billion of sustainable public and private investment by 2027, according to the Commission's forecasts, and therefore, expand the market for sustainable finance. The EIB will also increase the share reserved for sustainable projects from 25% to 50% of the total number of projects.

The Just Transition Fund will be used to finance sustainable initiatives in the regions that are expected to be adversely affected by job losses in the green transition process. As in any product cycle, the transition from an economy based on heavy industry and fossil fuels to a more sustainable and, in the short term, less labour-intensive economy, remains a heavy financial burden. For this reason, the fund policy will promote the economic convergence of economically disadvantaged regions due to the transition process. Also, under the rules of the Fund, for every euro paid out by the EU to each country, national governments must agree to co-finance projects between 1.50 and 3 euros and duly inform the Commission of how the money is spent. In this scenario, the Just Transition Mechanism will mobilise investments of at least €100 billion yearly over the period 2021-2027, financed by the EU budget, Member States, InvestEU and the European Investment Bank (EIB). If this amount is extrapolated over ten years, it should amount to around €143 billion.

Finally, the remainder of the planned investment should come from the "Innovation and Modernisation Fund", which is formally not a part of the EU budget but is financed from the revenues of the auctioning of emission allowances under the EU Emissions Trading Scheme, which is expected to provide some € 25 billion for the EU's transition to climate neutrality, again with a special focus on low-income Member States (European Commission, 2020f).

Figure 6 does not include the resources of the Next Generation EU, which will come on top of the above initiatives and are also supposed to be closely aligned with the objectives of the European Green Deal. A substantial share (roughly 35%) of these resources, in particular under the so-called Recovery and Resilience Instrument, will be dedicated to the green transition, which adds another €260 billion (€375 billion over ten years) to the figures above, so overall green finance mobilisation over the next ten years may be closer to €1.5 trillion.

However, the Commission cannot do everything alone. It needs the cooperation of other European institutions and nation-states, especially when it comes to drawing up multi-annual budgets. For the Green Deal to be effective, it must also be implemented by the private sector. Two steps must also be taken to ensure the correct dissemination of positive policy effects. Depending on the policy pursued: the more secure, clear and supportive legal environment you offer to investors, the more leverage private investment can guarantee - and this is where green bonds (or Green Finance in general) come in - the subject of the next chapter and the main topic of thesis in general.

Some of the measures taken in the past are now explained to help the reader understand how empirically effective EU policies have been. With these results in mind, the hope for the success of future policies could be much greater and more solid.

1.4.4.2 Private investments

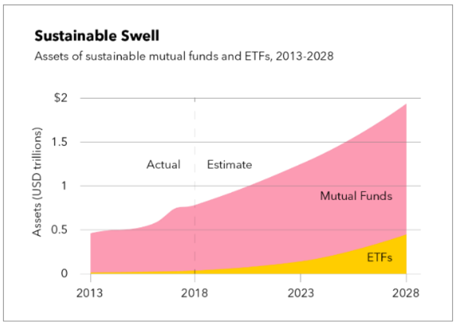
The European Union’s main objective is to attract as many private investments as possible, knowing that public funds can’t suffice. In fact, the Commission has calculated that 180 billion euros a year are needed for climate and energy to complete the energy transition and meet the Paris Agreement. Public finance is clearly not enough and a systemic change in investment culture is needed to engage the private sector in this effort. A change that the Commission intends to set out in its Sustainable Finance Action Plan. Reallocating private capital to more sustainable investments requires a complete rethink of how the entire financial system works. One of the key elements is the establishment of a rating system to better explain to the markets what "sustainable" means while developing a checklist of investments and financial activities considered "green". This list is used by regulators to facilitate capital requirements for bank lending to sustainable projects (Morgado & Lasfargues, 2018).

It is possible to expect a real explosion of green investments in the years to come, thanks to better regulation and standards, and a truly decisive shift towards a more sustainable future made by public authorities steering private capital consequently. The world's largest hedge fund, BlackRock, projects that total assets of sustainable mutual funds will reach about $2 trillion by 2028, as shown in figure 7 (BlackRock, 2020).

In short, the green economy has gradually become a standard, with more and more companies adopting principles based on a more sustainable way of doing business. Certainly, this is good news, since a zero-emissions future is only possible with the support of private capital. This shift has started to develop a model focused on the quality of life, environmental protection, and sustainable development to reduce the environmental and ecological risks linked to the intensive exploitation of the planet's resources. Moreover, companies compliant with such a technology are also among the most innovative and can exploit the process to gain market share or, at least, massively reduce waste and other expenses. According to the researchers, the transition to a clean economy also leads to a structural change in employment: the green economy is a net source of quality jobs, decent wages, secure working conditions, job stability, employment, decent careers and workers' rights (Kruse, Dellink, Chateau, & Agrawala, 2017).

The time is therefore ripe not only for green investments, but the injection of capital into this sector is a real necessity for the fate of our planet, particularly in Europe, and for the competitiveness of the companies on the horizon, which sometimes struggle in terms of innovation compared to the major tech companies in the US or China. As said, the benefits of private investments are twofold, first pollution and other environmental impacts are avoided, and secondly, the ability of these green solutions to get off the ground, with private investments increasing the multiplier effect of the public spending.

Figure 7: Assets of Sustainable Mutual Funds (2013-28)



Source: BlackRock (2020).

Eventually, private financing through green finance is becoming more and more active and can take on the role that everyone expects as an irreplaceable process in achieving the climate targets endorsed in Paris in 2015. Anyhow, several aspects are still under question such as uniform standards and certification criteria, for which the EU is currently standing for their proper definition. Certainly, credibility is key, since investors need proper transparency in the destination of funds to correctly assess the real impact of each financing and thus avoid the risk of greenwashing, which is still present in today's green financing.

2 OVERVIEW OF GREEN FINANCE

Green bonds are among the most popular bond instruments for impact investing. Like any other type of bond, green bonds are debt instruments with coupons, duration and maturity, with the issue price directly determined by supply and demand. They are characterised by the purpose for which they are issued: These bonds are defined as “plain vanilla” and the capital invested in them is used exclusively to finance activities that have a positive impact on the environment. Projects financed through the issuance of green bonds can concern energy efficiency, renewable energy, sustainable waste management, ecological transport, but also initiatives that do not directly reduce emissions of greenhouse gases - for example, water management, biodiversity conservation or adaptation to climate change such as the construction of dams. Such a broad and general definition of "green" leads to several difficulties in identifying projects that can generate environmental benefits and thus fall within the scope of green bonds, and in delimiting non-compliant projects (LuxFLAG, 2021; Ehlers & Packer, 2017).

This financial segment received a major boost in 2009 with the Copenhagen Agreement, which stipulated that the financial markets must play a central role in the fight against climate change by mobilising private investment in mitigation and adaptation projects. On this occasion, following the EU-ETS strategy, the major economies agreed that the most effective strategy for attracting more investment, which is largely necessary to reduce GHG emissions and thus the global temperature rise, is to create and promote financial products based on market principles, whether or not they follow a purely profit-driven approach. From this perspective, green bonds are very effective because of their standard and long-established financial characteristics combined with their commitment to the environment, a mix designed to attract as many investments as possible. This can make them desirable for a wide range of investors, from socially conscious investors to institutional investors with their asset class for climate-oriented investments (EU Green Bond Standard Working Group, 2019).

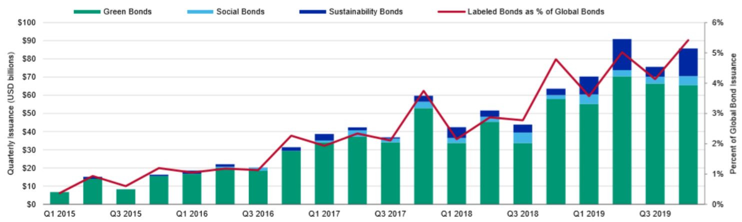
Green bonds have also been considered to produce several benefits for issuance. These may consist of making diversification more focused on longer-term benefits for the investor base, more attractive to a younger investor base, more attractive to those who are recognised as having a more positive opinion on climate change measures and increased visibility by sending proactive messages on environmental sustainability to the outstanding and potential shareholder base. Developments have shown that issuers can strengthen and broaden their investor base by promoting climate (environmentally) oriented financial products.

From this point of view, companies increasingly understand that the management of environmental engagement can improve their economic performance to follow recent market developments which suggest that more stringent environmental requirements and profit maximisation go hand in hand.

2.1 Green Bonds in the Global and European Bond Market

Green bonds represent a minority share of the global bond market, but they are growing very strongly considering that the first issue was only a little over ten years ago and that the global market still needs specific regulations and standards for issuing green bonds. According to the latest study by Moody's Investor Services, green bonds accounted for more than 2% of total global bond issuance in the last two years, reaching about 4% in the last quarter of 2019 (Kuchtyak et al., 2020).

Figure 8: Green Bonds Issuance Worldwide (Percentage of Total Bond Issuance)



Source: Kuchtyak et al. (2020).

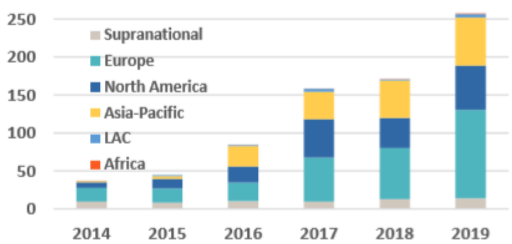
Figure 8 shows how the share of green bonds in total bonds issued has doubled in just two years. At the international level, this report shows that the European bond market is the one where green bonds have been the most successful, underlining once again Europe's commitment to promoting the development of sustainable finance. In 2018, green bond issues accounted for 5.3% of the European bond market, excluding government bonds, which accounted for a striking share of total issues.

2.2 Issuers and Investors

The main global issuers of green bonds are private companies (financial and non-financial), supranational institutions (mainly development banks) and the public sector (national and local governments). These bonds are mainly issued in dollars and euros (about 80% of the world's issuers) and have an average maturity of 5-10 years (Roboredo, 2018).

On the credit side, there is a significant number of institutional investors and organisations in the insurance and banking world that are equipping themselves with instruments to integrate the effects of climate change into medium and long-term strategies. Climate change brings with it a range of risks - physical, reputational, legal, technological and social. The latter is important for companies and institutions and, consequently, for investors themselves. These risks, if not managed effectively, can cause significant financial damage, which investors should therefore consider for reasons other than environmental and ethical, but also economic and financial (Bank of England, 2019).

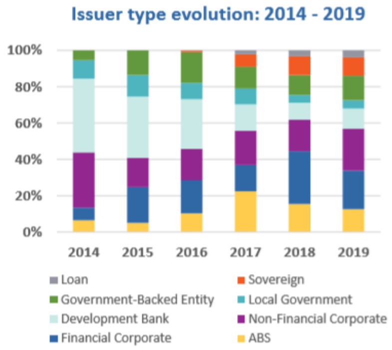
Figure 9: Global Green Bond Market (in billions)



Source: Climate Bonds Initiative (2020).

As Figure 9 shows, the global green bond market has been largely dominated by Europe, North America and Asia have come into play only in very recent years. European countries continue to position themselves as market leaders, accounting for 45% of total global green bond issuance, compared to 40% in 2018. The European Commission, as explained above, is seeking to further increase the volume by including measures to support the credibility of the green bond market and boost investor confidence in the Sustainable Finance Action Plan, aimed at promoting better and more consistent regulation across the European Union. Whereas it is interesting to recognise that the biggest growth contributor to the green bond market is Europe where cumulative issuance reached $120 billion, up from $85 billion in 2018, it is on the other hand also interesting to note that the green bond market is growing substantially in the United States, where policymakers have not been seriously considering the climate issue during the Trump Presidency. This shows that even countries deliberately denying climate change will eventually need to move to cleaner technologies due to market forces. One of these market forces under scrutiny is of course Sustainable Finance - Green Bonds (Climate Bonds Initiative, 2020; EU Green Bond Standard Working Group, 2019).

Figure 10: Green Bond Worldwide Issuance by Type



Source: Climate Bonds Initiative (2020).

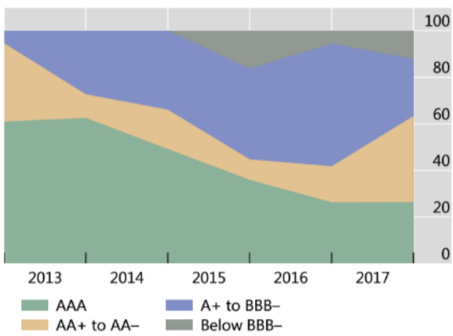
Figure 10 shows that the composition of issuers on the global market for green bonds has changed considerably over the years. The considerable attention paid to environmental sustainability by supranational institutions led to the global green bond market being dominated by development banks in the beginning. Over time, however, development bank issuance has declined significantly, while private companies - mainly financial institutions and large corporations - have become the main players in the global green bond market. Financial companies include Fannie Mae (USA) and the Industrial Bank of China (China), which are the two largest green bond issuers in the world. Among the top three non-financial companies, on the other hand, we are registering mainly energy companies that want to defuse their polluting businesses by issuing bonds that then finance their move towards clean energy. Also, national governments have started issuing green bonds from 2016 onwards. So far, the main issuers of government bonds are France, Belgium and Ireland. By issuing green bonds, these countries report on their efforts and commitment to achieving sustainable development goals - the so-called Sustainable Development Goals (SDGs) - in terms of climate and environment (Climate Bonds Initiative, 2020).

2.3 Green Bonds Types

Bonds used to be classified according to the type of issuer (government bonds, corporate bonds, etc.). The Climate Bond Initiative, an international organisation promoting green financial products, then identifies different types of green bonds according to their guarantee level. The most widespread type of green bonds on the bond markets refers to green bonds through their UoP. Green bonds are so-called because the use of proceeds is intended to finance green projects. Apart from this aspect, which is common to all different types of green bonds, they are ordinary bonds where repayment of the capital is guaranteed by the assets of the company or corporation that issued the bond. In this way, the credit risk associated with these bonds is equivalent to that of other bonds issued by the same issuer. Similarly to traditional bonds, a certain degree of repayment uncertainty is inherent in the issue of green bonds. For this reason, independent ratings assess the default or credit risk of bond issuers and publish ratings of their creditworthiness, which helps investors to make informed choices when purchasing individual bonds. Of course, the green bond market follows the same logic as the conventional bond market. A highly rated issuer will end up paying lower interest rates than a lower credit-rated issuer, while riskier bonds guarantee higher yields, but at the expense of a higher risk of default (Climate Bonds Initiative, 2020).

Figure 11 shows the distribution of green bond credit ratings from Standard & Poor's, Moody's and Fitch. The graph shows that most green bonds in the bond market tend to be positively rated from AAA, which is the highest rating implying the lowest level of risk, to BBB-, which indicates medium to low-quality debt. Only a fraction of issued bonds are below investment grade, i.e. all issues up to BBB-. Although this study was carried out in 2017, it remains an important reference for further development in this area of interest (Ehlers & Packer, 2017).

Figure 11: Green Bonds Risk Assessment



Source: Ehlers & Packer (2017).

Generally, the repayment of green bonds does not depend on the performance of the projects financed, i.e. investors do not assume the risks associated with the success of the individual project, but more generally on the credit risk linked to the issuing institution itself.

Additionally, the Climate Bond Initiative also recognises the existence of a green bond type through which the investor assumes direct credit risk for a green project: the green bond project ("Project Green Bond"). Given the initial uncertainty of a new investment that is redirected to a green project, this naturally implies a higher credit risk. This category of bonds should therefore be more attractive to investors seeking higher yields (Ehlers & Packer, 2017; Climate Bonds Initiative, 2020; The World Bank, 2020).

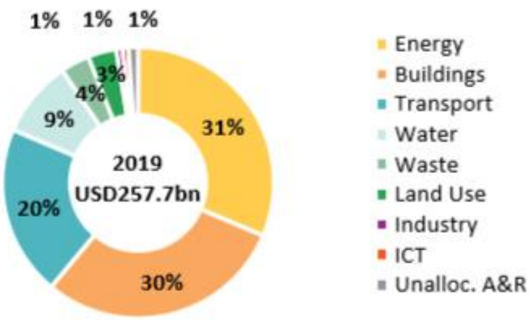
The same conclusion applies to green revenue bonds, i.e. bonds where the repayment of capital is less certain and depends on the cash flows generated by the financing of a particular project. For example, transport revenue securities are issued to finance local public transport projects such as buses, metro, toll roads and airport systems, where they can be redeemed using the revenue generated by the transport system. However, some bonds are redeemed by taxes generated in the area served by the system or by some other commitment. If the revenue collected, either by the municipal agency (through the revenue) or any other public authority (with collected taxes), is below expectations or zero, bond investors will not receive the full amount due. Therefore, the rate of return on these particular bonds is higher than for normal bonds (Environmental Finance, 2020).

Finally, according to Environmental Finance, there are also green securitised bonds (securitised bonds) whose first source of repayment is generally the cash flows of the underlying assets, with the same logic as the very well-known Asset-Backed Securities. Several green projects with different levels of risk are packaged into the same security, which is then sold on the market at a certain price. They can be a vehicle for combining different assets that cannot be sold separately. In any case, this phenomenon is relatively limited in the world of green bonds. For example, the SolarCity Corporation, the largest US company installing photovoltaic modules, has entered the green bond market by issuing bonds backed by the rental business for solar panels under an agreement with customers (Environmental Finance, 2020).

2.4 Use of Financing

As far as the selection of green bond association projects is concerned, European issuers have always used a substantial part of the proceeds from green bonds in the energy sector. However, the share of energy in the overall mix has decreased in recent years as the amounts flowing into buildings and transport have increased.

Figure 12: Financing Use by Sector



Source: Climate Bonds Initiative (2020).

The data and figure 12 show that to date more than 80% of all funds have been used for improvements in the energy, property (buildings) and transport sectors. These data reflect the fact that the abovementioned sectors are the ones where the greatest effort is needed, as they're among the largest contributors to GHG emissions. In addition, a report of the Climate Bonds Initiative states that there is a high positive correlation between the interest in investing in a particular sector and its greenhouse gas emissions. According to the same report, there is also a discrepancy between the allocation of funds and actual needs. Some sectors, such as industry and agriculture, are underfunded, while other sectors, such as the real estate sector, have a high overcapacity of attracting funds compared to their emissions - and therefore a need for investment. At the same time, however, Europe is again the best performer in magnitude, with funding (in percent) close to the trend in real emissions. Conversely, Asia and the US show larger discrepancies. In this case, stronger political regulation by the respective governments will be beneficial in managing a correct allocation of resources and with this, the European Union can become a flagship in this area as well (Climate Bonds Initiative, 2020).

2.5 The Main Green Bond Indices

Like other securities, green bonds are represented in specific market indices that aim to replicate the movements that the global green bond market follows. This allows investors to assess the risk and return of a green bond compared to other investments based on four global indices, as figure 13 displays. The oldest and therefore most relevant indices are the following (Roboredo, 2018).

- Barclays MSCI Green Bond Index
- S&P Dow Jones Green Bond Index
- Solactive Green Bond Index
- Bank of America Merrill Lynch Green Bond Index

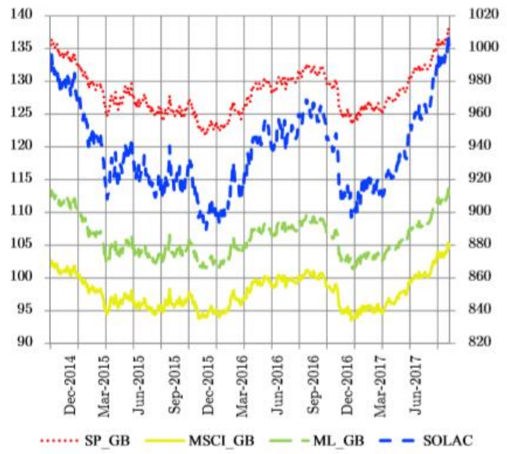
The first was first released in November 2014 and is the result of a collaboration between Bloomberg and MSCI Inc. It is an index that analyzes green bonds issued by companies, governments, the state and special purpose vehicles. They are defined as green according to the categories issued by MSCI (which are consistent with international principles), namely alternative energy, renewable energy, environmental protection and prevention, water sector, sustainable construction and climate change adaptation. An index can be considered a green bond index if 90% of the proceeds from the bond are to be allocated to one of the above categories. To be included in the index, these bonds must necessarily exceed a certain threshold, which varies depending on the currency used but must necessarily be above 200,000 units. The issuer must pay a fixed coupon and the investor buying the green bond may not sell the bond before its maturity, which must be more than one year. Each month the index is revalued with the introduction of new green bonds or the exclusion of bonds that are no longer eligible (GBP Databases & Indices Working Group, 2017).

The second index was created instead by S&P Dow Jones Indices in June 2014. This index is used to track bonds issued by companies and governments, bonds that are considered green under the taxonomies of the Climate Bonds Initiative. The interest rate on the coupons payable can be of various types: fixed, floating or zero-coupon. It is a multi-currency index that is recalculated monthly. Also, all bonds maturing in the month following the recalculation are excluded from the performance assessment (GBP Databases & Indices Working Group, 2017).

Another index was published again, for the first time in March 2014 by a German company, Solactive AG. It contains all green bonds that correspond to the taxonomies of the Climate Bonds Initiative, except for some types such as green convertible bonds, municipal and inflation-linked bonds. This index aims to cover larger bonds with an issue value and maturity of at least $100 million or at least six months. Besides, this index uses only 5% of the value of the bond and is recalculated monthly.

The final index was first published by Bank of America Merrill Lynch in October 2014. It is an index that analyses green bonds issued by companies and governments but excludes bonds with securitisation principles. Furthermore, the UoP in this index should only come from bonds that finance environmental and climate projects. The issue value of the green bond must have a minimum threshold that varies depending on the currency in which the green bond is issued, similar to the Barclays MSCI Green Bond Index. The coupons payable are fixed and the maturity of the bond must be at least 18 months, with the recalculation period being determined every month (GBP Databases & Indices Working Group, 2017).

Figure 13: Green Bond Indexes Price Trends



Legend: SP_GB: S&P Dow Jones Green Bond Index, MSCI_GB: Barclays MSCI Green Bond Index, ML_GB: Bank of America Merrill Lynch Green Bond Index, SOLAC: Solactive Green Bond Index.

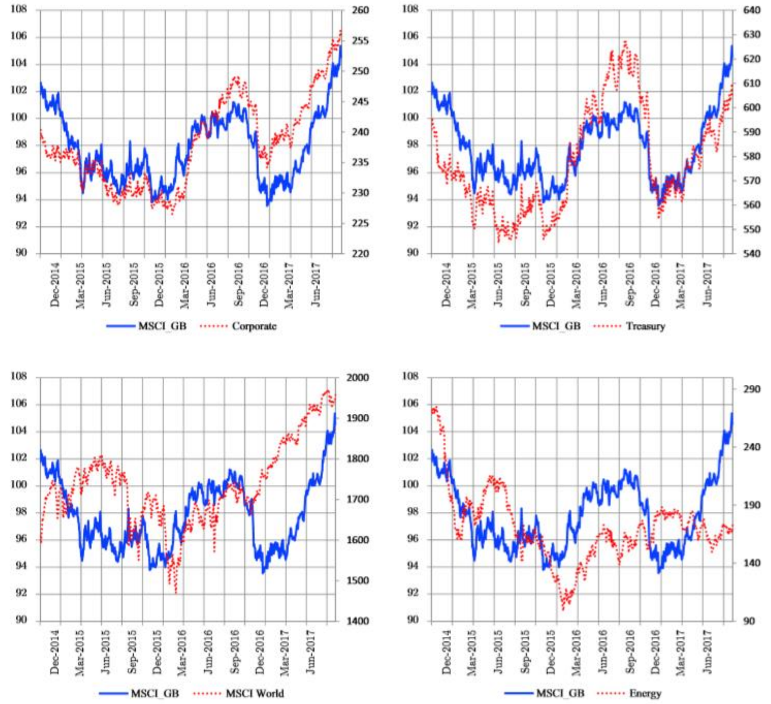
Source: Roboredo (2018).

In addition, the paper by Roboredo (2018), presents in a single set of graphs the trend of the four indices listed above (figure 13). The data have been collected by Bloomberg and cover the period from 2014 to 2017. As expected, the four indices show similar trends, show also a high movement correlation but have different values due to their construction.

The study then continues with a single focus on the Barclays MSCI Green Bond Index to find a possible correlation between green bonds with the corporate and government bond markets, the global equity market and the energy sector index (figure 14). According to the survey, the main findings show a positive and significant correlation between green bond prices and corporate and government bond prices. Moreover, the green bond market appears to be less volatile than the corporate bond market.

At the same time, there is no significant correlation between MSCI Green Bond and the MSCI World index, as well as between MSCI Green Bond and an energy-based index. Moreover, the volatility measured in the green bond market appears to be lower than that observed in both the MSCI index and the energy market.

Figure 14: Green Bond vs Other Indexes Price Trends



Source: Roboredo (2018).

The results seem to indicate that an investor investing in the corporate or government bond market, regardless of the number of green bonds making up the portfolio, would not benefit from risk diversification if he were to include a green bond in his portfolio. Instead, he considers them as substitute bonds. For investors active in the equity markets and the energy sector, the result changes significantly: the benefits of diversification would be significant in this case, with a corresponding risk reduction.

2.6 Green Bonds Financial Risks and Potential Bubbles

Sustainable bonds, like any other corporate counterpart, require an external evaluation to obtain approval for market issuance. The lowest investment grade rating is BBB, while there are also bonds that fall well below this critical level. Of course, bonds with a higher rating are more likely to be an attractive investment for long-term oriented companies, which ultimately have to pursue a low-risk strategy. The knowledge that better ratings have a lower risk profile and the recognition that most investors are larger organisations (with a low-risk profile) means that low-risk, low-yield bonds are often oversubscribed. It should also be noted that such large oversubscription may also be a factor of the relatively small size of the issuing company, combined with a larger investor base compared to regular vanilla bonds. A diversified investor base also offers more stability in volatile times and can therefore contribute to its popularity. Green bonds, like other types of bonds, are also very liquid, which is a positive sign for the development of this segment (EU Green Bond Standard Working Group, 2019).

Other relevant risks include the potential for "greenwashing", which shows that companies have the potential to become "green" just to get a positive opinion about their operations. In this case, these companies try to control a negative opinion about their business by pretending to be green. Negative opinions can, however, be different. It may well be that the company itself is sustainable, but financially poorly positioned. The same is very likely to happen if a company that is considered to be environmentally friendly reassures its customer base by issuing green bonds. Economically, the first phenomenon is more relevant as it poses a potential threat to the financial sustainability of the investment and a potential misallocation of resources. In this case, recognising that the green bond market has a larger investor base - and a growing market hype for this type of product - a company can benefit from greater financing opportunities than it would deserve under normal conditions. So, if the world (and in particular the EU) moves towards binding standards, the risk of greenwashing will be reduced. This explains the growing importance of clear and harmonised standards (Quinson, 2020).

Given that the main purpose of issuing green bonds is to finance the environmental transition, an appropriate mix between financial and clear environmental sustainability objectives is therefore necessary. In this perspective, as described before, there is still confusion at the global level about the correct labelling of green bond products. For this reason, this segment, which is crucial for financing the ecological transition, remains vulnerable to pure financial bubbles that could undermine its effectiveness in the future.

To counter these threats, financial regulators should rapidly develop adequate and enforceable standards, which will also rapidly become global. Only then will this market segment experience steady and healthy growth. In the light of these considerations, it can be said with certainty that the European Union is moving steadily in the right direction, with the full adoption of a stringent regulation in the following years, which is expected to make the green financial sector even more attractive.

3 EMPIRICAL ESTIMATION OF GREEN BOND YIELDS

In general, the literature on bond pricing has been much less studied than the literature focusing on equities. This is because of the fascinating ability of the stock markets, where the possibility of winning bets is much more pronounced than in the bond market. In any case, both financial markets, although different, have common methods for estimating their returns. In this section, we will delve deeper into the literature to find out which econometric methods are most commonly used and try to answer the question of whether negative or positive returns on green bonds have been found in the literature currently available.

3.1 Literature Overview

The most commonly used method is the one-factor CAPM (Capital Asset Pricing Model) invented by two famous economists in two separate works, namely Sharpe (1964) and Lintner (1965), which serves as the first explanatory model to study both stock and bond markets. However, given the rather poor explanatory power of this model, the research carried out by Fama and French (1992) has identified a possibility of improvements and created the so-called three-factor model. This model is another important milestone in financial theory as it can reduce the price error present in the original model. This model then contained additional information, namely the size and value of the listed companies in addition to the market premium (risk), which ultimately led to a significant improvement in their results. Also, the same authors wrote a further improvement the following year, Fama and French (1993), which adds two more factors to the previous model, related to interest rate and credit risk. These two factors, namely $TERM$ (interest rate risk factor) and DEF (insolvency risk) both contain risk factors for equities but can also be used in general for research on the bond market, which also improved the general regression results.

In addition to the initial use of market, size and value factors, the additional two proxy variables aim to capture the risk in bond yields from unexpected interest rate movements and credit risk, captured by the probability of default of the corresponding firm. The importance of the default factor was seen in a study by Merton (1973), which identified it as an important factor in bond pricing. Another study carried out by two Italian researchers, Gabbi and Sironi (2005), confirmed the importance of this factor but indicated that liquidity is a relevant factor. In this perspective, there’s another important study by Grinblatt, Titman and Wermers (1995) and Carhart (1997), which call for a momentum factor to capture the variability of the outcome. In addition, the quality of a multi-factor approach to study bonds’ returns was also confirmed by Johansson and Lundgren (2012) following the procedure proposed by Fama and French (1993) for the process of pricing bonds.

Eventually, the method revolved around a diverse type of regression, called the Fama-Macbeth type, being considered a reference approach for testing asset pricing models. This methodology was first used in the paper written by Fama and Macbeth in 1973 (Fama & Macbeth, 1973).

Although less extensive than the literature on equities, research on fixed-income securities has provided interesting results on the so-called and hypothetical "green bond premium". In this perspective, it is very important to mention the work done by Zerbib (2018), which analysed the performance between green bonds and an equivalent synthetic bond. For the sample of interest, which includes only investment-grade securities, the author found a significant negative average premium on European and US green bonds compared to conventional bonds. On average, the premium calculated in their paper is negative by two to nine basis points for the entire sample as well as for EUR and USD bonds separately. They also showed that the main determinants of the premium are the rating and the type of issuer, where negative premiums are more pronounced for financial bonds and low rated bonds.

There is still a general uncertainty as to whether the relationship between environmental performance (or in other cases sustainability) and return is sustainable. Research shows different results, ranging from positive to negative, with no clear consensus for this market segment. The issue must also be seen in a dynamic perspective: with all the changes in legislation and, last but not least, the ongoing climate change, "brown" activities will become less and less financially attractive over time, to the extent that they may cause losses. From this point of view, a focus on green finance may prove to be the only financially sustainable strategy in the long term, even if in the short term past data and studies do not yet bear this out, precisely because the field is relatively new, but will grow faster in the future. Clarity and consensus are likely to come as more and more data become available in the future. Another paper by Karpf and Mandel (2017) examined the US bond market and sought to identify the differences within the green market segment. The study clarifies that green bonds on average have negative returns compared to their traditional counterparts, but this range can be explained to a large extent by the characteristics of the respective issuer and the bond. However, this study also has a more limited sample of securities for comparison, as the market itself has tripled in the last three years.

Besides all these studies, Bachelet, Becchetti and Manfredonia (2019), conducted another important study on the situation in the global green bond market. This paper not only compares the two interest rate categories but also compares the differences between green bonds issued by private companies and those issued by public institutions. The authors found that green bonds issued by private companies had better results in terms of market premiums compared to institutional bonds, while they were less actively traded and therefore more illiquid. According to the study, green bonds issued by private companies have positive returns compared to traditional bonds, while those issued by institutions have slightly negative returns. It is also important to stress that the positive results in terms of premiums disappear as soon as the bonds comply with a full certification scheme rather than a partial one.

Another important study was conducted in 2020, which tried to summarize all the findings in the field of green bonds by considering the empirical results of the studies conducted so far. According to their work, there is a consensus on the negative green premium ranging from 56% of primary and 70% of secondary market studies. They find that the negative green premium varies widely in the primary market, while in the secondary market an average green premium of -1 to -9 basis points is observed in the available literature (MacAskill, Roca, Stewart, Liu, & Sahin, 2021).

Finally, the study on the performance of the US corporate bond market conducted by Bektić, Wenzler, Wegener, Schiereck and Spielmann (2017) confirms the quality of an extended multi-factor model based on the Fama-French method but adds that not all factors used in this traditional regression can be very relevant. They point out that the original equity-based factors proposed in 1992 ($MKTRF$, SMB and HML) do not add much value, while the other two (DEF and $TERM$), which are by nature bond market based, seem to provide better information for a bond market analysis. Similarly, Fama and French (2015) argue that the new factors proposed in the 2015 study (RMW - Robust Minus Weak, which takes into account the difference in returns between companies with robust and low profitability) and (CMA - Conservative Minus Aggressive, taking into account the difference in returns between companies with a low and high investment policy) added to the previous equity-based factors are also particularly relevant for the bond market. Actually, this study can provide another good basis for comparing the results of this research. A similar result was also found by Israel, Palhares and Richardson (2017) when they investigated returns over a long period and in cross-section with over 10,000 bonds available in their study. However, the most important information is that, regardless of the factors used, a multifactor approach is an appropriate methodology for the research in this thesis.

The Sustainable and Responsible Investment (SRI) market, similar to green bonds, is also experiencing positive momentum, with important and handy literature emerging. Sustainable investing, also known as socially responsible investing, is the process of incorporating Environmental, Social and Governance (ESG) factors into investment decisions. It may or may not be linked to the issue of green bonds, where it is only in recent years that this market has attracted attention in the financial markets, which explains the deficits in the quantity of available literature (Chen, 2020)

About a decade ago, a relevant study was carried out by Xiao, Faff, Gharghori and Lee (2013) which could not find any significant impact of sustainability investments on global equity returns. Again, Gil-Bazo, Ruiz-Verdú, and Santos (2010) instead provided relevant evidence that US SRI funds show a positive performance before and after fees compared to their conventional competitors. Additionally, Manescu (2010) conducted a study that looked at environmental, social and governance (ESG) attributes across a wide range of data on US companies. The results showed that the differences in returns of companies without ESG attributes, whether positive or negative, are most likely due to incorrect pricing. The implications are that certain ESG attributes are relevant to value, but they have not been reflected in stock prices as efficiently. In this context, an article by Flammer (2018) provides evidence that the issuance of green corporate bonds has become increasingly important over time, most notably in industries where the natural environment is economically and financially important. Also, the study states that green bonds offer positive returns at the time of the announcement, relevant improvements both within long-term values, operating performance and overall environmental performance.

Green bond issuance then also increases the company's green innovation and encourages longer-term ownership, mainly due to a larger pool of shareholders interested in green development.

Finally, an important study, which is very close to the idea of research in this thesis, was conducted by Ibikunle and Steffen (2015). Although the study focused more on the stock market than on bonds, it provides a very good basis for the methodology used in this thesis. The thesis takes a similar approach to evaluate and compare performance between conventional bonds and bonds that classify themselves as green.

The research in this thesis is conducted using a multi-factor model, i.e. an extended CAPM. To perform the analysis between these two bond categories, a dummy variable that sorted these categories in a way that allowed their correct comparison is introduced. In this case, the dummy variable referred to the class of the fund that was investing in either conventional (no precise label), green (green finance) or black (fossil energy and natural resource). According to the study by Ibikunle and Steffen (2015), green mutual funds underperformed conventional funds over the entire reference period. Further evidence suggests that green funds are beginning to significantly outperform their black counterparts, particularly in the 2012-2014 investment window.

The work will follow a similar procedure to the relevant methods described above, trying to identify any difference between the performance of the two categories in question, conventional and green bonds. The successful results achieved so far in both the equity and bond markets provide a strong incentive to apply such a methodology in the context of this research. It is considered as an important step to update the literature dealing with the performance of green bonds, because over time, but also due to new emerging regulations, the importance of a clear performance picture becomes greater than ever.

3.2 Estimation Method

The estimation method in this thesis will follow one of the milestones of financial theory, namely the Fama-Macbeth method developed in 1973, on which additional factors will be built, as proposed in 1992 by Fama-French and other subsequent studies.

3.2.1 The Capital Asset Pricing Model

The CAPM was developed by William Sharpe and John Lintner and is based on the Markowitz portfolio choice model. In his work, he assumes that investors are risk-averse, while at the same time considering the investment as a probability distribution of the outcome. In this case, however, the model has only two individual parameters that form the actual basis for the investor's portfolio choice:

$$U = f(E_w, \sigma_w) \qquad (1)$$

where the part relative to E_w concerns expected future wealth, while σ_w is the estimated standard deviation relating to the discrepancy that may exist between actual and expected future wealth as proposed by Sharpe (1964). Therefore, all portfolios with efficient mean-variance represent a combination that looks for the tangent between the portfolio and the risk-free assets (Fama & French, 2004).

The well-known formula for the CAPM used in this research has the form:

$$r_t = rf_t + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \epsilon_t \tag{2}$$

where r_{ft} is the risk-free interest rate and $r_{Mt} - r_{ft}$ is the weighted excess return of the market portfolio, calculated by subtracting the risk-free interest rate from a global market portfolio exposure. Besides, β_{iM} is used to measure the degree of correlation between the equity return and the excess return of the market portfolio. In this formula, we recognise r_{ft} as a risk-free asset that is not correlated with the market and therefore takes the name of a "Zero Beta Asset".

3.2.2 An Extended Capital Asset Pricing Model

Although the original model is a good start in estimating expected returns, it has relatively little explanatory power within the bond or equity market. Consequently, it needs something more specific to be used. Therefore, the econometric methodology used in this paper is based on the three-factor model developed by Fama and French in 1992.

In their paper, Fama and French have shown that their extension is capable of capturing the common risk factors even in the case of a bond market, which is why the thesis is based on this approximation of the expected returns on the market under consideration.

The authors established the basic Fama-French three-factor model as follows:

$$r_t = rf_t + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \beta_{i,SMB}SMB_t + \beta_{i,HML}HML_t + \epsilon_{i,t} \tag{3}$$

wherein this case, the first part remains identical to the previous equation, while new variables, namely the SMB_t and HML_t got introduced. They represent the difference in returns of small-cap vs. big-cap companies (SMB_t) and the difference in returns between high and low book-to-market companies (HML_t). Their respective betas are $\beta_{i,SMB}$ and $\beta_{i,HML}$, with the $\beta_{i,SMB}$ measuring the small firm effect on bond returns and $\beta_{i,HML}$ accounting for the value premium.

This evolution of the model with premiums in terms of size and value is based on the idea that larger firms have, on average, lower returns than smaller counterparties, while being better positioned in terms of liquidity risk. The difference in returns between a portfolio of large companies and a portfolio of small companies is considered as a factor that considers the size risk, which corresponds to a premium for small companies based on the size required by investors. The same intuition applies to the value premium, which reflects the difference in risk between growth and value companies, where value companies are expected to earn premium returns (Petkova, 2009).

In the case of the following study, which compares two categories of bonds, Fama-French's original three-factor model is extended to include a new factor variable that takes into account the dynamics from a global market perspective. This is introduced following work by both Carhart (1997) and Grinblatt, Titman and Wermers (1995) who found that investment strategies that rely on dynamics perform significantly better than those that neglect this factor.

Therefore, the so-called Carhart Four-Factor Model is structured as follows:

$$r_t = rf_t + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \beta_{i,SMB}SMB_t \tag{4}$$

$$+ \beta_{i,HML}HML_t + \beta_{i,MOM}MOM_t + \epsilon_{i,t}$$

with MOM_t (monthly momentum) the factor is considered as the difference between a portfolio of 12 months winning and 12-months losing stocks at time t. At the same time, the $\beta_{i,MOM}$ shows the effects of the momentum factor on the returns.

The success of the first paper prompted Fama and French to conduct additional research in this area, and so Fama and French (1993) demonstrated the relevance of their equity risk factors to the bond market. They also extended their model to include two specific factors which are relevant in a fixed income securities environment. In this case, they have added two new relevant factors to the model which allow the result to be more precise and thus show higher quality.

Considering this, the whole regression becomes:

$$r_t = rf_t + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \beta_{i,SMB}SMB_t + \beta_{i,HML}HML_t \tag{5}$$

$$+ \beta_{i,MOM}MOM_t + \beta_{i,TERM}TERM_t + \beta_{i,DEF}DEF_t + \epsilon_{i,t}$$

This model is based on two additional factors, namely $TERM_t$ and DEF_t. The first one, $TERM_t$, aims to capture unexpected changes in interest rates. This factor attempts to show the degree of deviation from expected changes of yields in the case of long-term bonds due to a shift in short-term interest rates.

The second factor, DEF_t, on the other hand, captures the standard credit risk spread. This means that it considers the probability of default of a company. This variable is calculated simply as the difference between long-term government bonds and a given portfolio of long-term corporate bonds. Ultimately, this factor has been found to have high explanatory power for the pricing of the default premium.

However, to capture the difference between the two categories of bonds (conventional vs. green), the study is carried out by using a so-called dummy variable, which appropriately selects either green or conventional bonds and determines their relative performance. For the sake of completeness, this approach follows the approach used by Ibinkule and Steffen (2015) in their paper.

Therefore, the final regression model will be of the form:

$$r_t = rf_t + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \beta_{i,SMB}SMB_t \tag{6}$$
$$+ \beta_{i,HML}HML_t + \beta_{i,MOM}MOM_t + \beta_{i,TERM}TERM_t$$
$$+ \beta_{i,DEF}DEF_t + \delta_{i,GREEN}GREEN_t + \epsilon_{i,t}$$

Where $\delta_{i,GREEN}$ translates the effect of the performance of the green in the case that the factor $GREEN_t$ indicates the value 1, which represents the presence of a green bond. This term does not cover any additional explanatory power in the case of conventional bonds marked 0.

The final model used to perform the second pass of the Fama-Macbeth regression procedure follows the specification:

$$r_t - rf_t = \alpha_{i,t} + \beta_{iM}\left[r_{Mt} - r_{ft}\right] + \beta_{i,SMB}SMB_t \tag{7}$$
$$+ \beta_{i,HML}HML_t + \beta_{i,MOM}MOM_t + \beta_{i,TERM}TERM_t$$
$$+ \beta_{i,DEF}DEF_t + \delta_{i,GREEN}GREEN_t + \epsilon_{i,t}$$

Equation (7) is a slight modification of (6) in that it shifts the r_{ft} to the left side of the equation and therefore introduces an $\alpha_{i,t}$ on the right side as a pricing error. This error represents the part of the return, unexplained by the model's regressors, where indeed, a low value of $\alpha_{i,t}$ is another indicator of the quality of the model. Obviously, the same logic applies to previous equations as well, where an $\alpha_{i,t}$ appears at that point.

A serious concern when trying to quantify the green bond premium or any other effect of sustainability is that the influence of other determinants cannot be isolated. As discussed just before, not controlling for these determinants means that the presence of a premium for green bonds will be hidden. By including relevant factors in the analysis, the relevancy of the model should be much higher.

3.2.3 The Fama-Macbeth Procedure

The Fama-McBeth two-step regression is a common way to test how the above-presented factors describe the performance of a portfolio (or an asset). However, this methodology is mainly used in the academic world, as there are now many other, more advanced[2], and modern methodologies in the literature. The procedure aims to calculate the premium from the exposure to the factors of interest (depending on the length of the equation).

In the first step, the return of each portfolio (or asset) is regressed on the time series of one or more factors to determine the exposure of returns to each factor (also called the "factor exposures"). These regressions are carried out on a rolling basis, with the window fixed to 60 periods to generate a time series of factor exposures for each portfolio (or asset). Of course, the results will differ depending on the number of factors added (Cochrane, 2009).

In the second step, a cross-section of portfolio (asset) returns is regressed on the previously estimated factor exposures at each time-period to produce a time series of risk premium coefficients for each factor. Finally, these coefficients are averaged over the time-period for each factor, and the expected premium for a unit exposure to each risk factor is retrieved.

3.2.3.1 First Pass

In the form of an equation, for a portfolio of n asset returns and m factors, the first step obtains the factor exposures (βs) by calculating n regressions of returns, each on m factors (each equation in the following represents a regression):

$$r_{1,t} - rf_{1t} = \alpha_1 + \beta_{1,F_1} F_{1,t} + \beta_{1,F_2} F_{2,t} + \cdots + \beta_{1,F_m} F_{m,t} + \epsilon_{1,t} \tag{8}$$

$$r_{2,t} - rf_{2t} = \alpha_2 + \beta_{2,F_1} F_{1,t} + \beta_{2,F_2} F_{2,t} + \cdots + \beta_{2,F_m} F_{m,t} + \epsilon_{2,t}$$

$$\vdots$$

$$r_{n,t} - rf_{nt} = \alpha_n + \beta_{n,F_1} F_{1,t} + \beta_{n,F_2} F_{2,t} + \cdots + \beta_{n,F_m} F_{m,t} + \epsilon_{n,t}$$

where $r_{1,t}$ is the return of portfolio or asset i (n in total) at time t, $F_{j,t}$ is the factor j (m in total) at time t, β_{i,F_m} are the factor exposures, or loadings, that describe how returns are exposed to the factors, where t goes from 1 through T. Clearly, each regression uses the same factors F, because the purpose is to determine the exposure of each asset's return to a given set of factors.

[2] It is worth mentioning that the Fama-Macbeth regressions only produce standard errors corrected for cross-correlation, while it does not remove time series autocorrelation. Alternative methods involve using the standard error of time-series correction and examining the cross-correlation of the error term with years and double clustering. Examples include the Fama-Macbeth - Cluster-Robust standard error method (by firm and by time).

This procedure will produce as many betas as there are factors available, multiplied by the number of securities available in the sample over the whole period excluding the initial window - in this case, 60 days (Sylvain, 2012).

3.2.3.2 Second Pass

Following the first pass, with the betas obtained, the second step is to calculate T cross-sectional regressions of portfolio or asset returns on the m estimates of βs (later called $\hat{\beta}$) calculated from step first. In this case, the regression uses the βs obtained in the first step, because now the objective is finding the exposure of n returns to m-factor loadings over time.

$$r_{i,1} - rf_{i,1} = \lambda_{1,0} + \lambda_{1,1}\hat{\beta}_{i,F_1} + \lambda_{1,2}\hat{\beta}_{i,F_2} + \cdots + \lambda_{1,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,1} \quad (9)$$

$$r_{i,2} - rf_{i,2} = \lambda_{2,0} + \lambda_{2,1}\hat{\beta}_{i,F_1} + \lambda_{2,2}\hat{\beta}_{i,F_2} + \cdots + \lambda_{2,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,2}$$

$$\vdots$$

$$r_{i,T} - rf_{i,T} = \lambda_{T,0} + \lambda_{T,1}\hat{\beta}_{i,F_1} + \lambda_{T,2}\hat{\beta}_{i,F_2} + \cdots + \lambda_{T,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,T}$$

where the returns r are the same as in equation (8), λ are regression coefficients which are then used to calculate the risk premium for each factor, where, in each regression, i goes from 1 to n.

In practice, in the second step, the cross-sectional analysis, we observe many assets at once in time as Stock and Watson (2012) suggest. In exactly this case we can observe many conventional bonds together with green bonds, with the ultimate intention of testing different factors across these different bonds.

Finally, there are $m + 1$ series λ for each factor, each of length T. Moreover, if ε is assumed to be i.i.d. (independent and identically distributed), it is then possible to calculate the risk premium λ_m for the factor F_m by averaging the m-th λ over T:

$$\bar{\lambda} = \frac{1}{T}\sum_{t=1}^{T}\hat{\lambda}_t \quad (10)$$

Clearly, in a similar manner, it is also possible to obtain standard deviations and t-statistics. It is common practice to derive the sample mean of a sample series x_t from the sample variance of the sample by looking at the time-varying sample x_t. Under the Fama-Macbeth assumptions, the (squared) sampling error of the sample $\bar{\lambda}$ is as follows:

$$\sigma^2(\bar{\lambda}) = \frac{1}{T^2}\sum_{t=1}^{T}(\hat{\lambda}_t - \bar{\lambda})^2 \tag{11}$$

While the standard error SE is then:

$$SE(\bar{\lambda}) = \sqrt{\sigma^2(\bar{\lambda})} \tag{12}$$

And so, test the statistical significance of the estimated factor under the null hypothesis $\bar{\lambda} = 0$ the test statistic is:

$$\tau_{score} = \frac{\bar{\lambda}}{SE(\bar{\lambda})} \sim \tau_k \tag{13}$$

Finally, a complete, all-explanatory model should explain all cross-sectional differences in expected returns due to the so-called "risk premia". These should have an R^2 that is as close as possible to 1.

This statistic is calculated by:

$$R^2 = 1 - \frac{\sum_{i=1}^{N} e_t^2}{\sum_{i=1}^{N}\left(\hat{\lambda}_t - \bar{\lambda}\right)^2} \tag{14}$$

in this case, containing e_t, which is the cross-sectional regression error.

On the other hand, we also have instead of the R^2_{adj}, which corrects the calculation for the independent variables and penalises the inclusion of an additional variable if it does not provide enough additional explanatory power.

In this case, this statistic is calculated below:

$$R^2_{adj} = 1 - \frac{(1 - R^2)(n - 1)}{n - p - 1} \tag{15}$$

Here n symbolises the size of the sample, while p stands for the number of predictors used in the model of interest.

To be fair, the t-statistic in equation (13), proposed by Fama and MacBeth (1973), assumes that the error terms in the equation are independent and identically distributed. This assumption, however, can be violated by errors in the variables, a problem inherited in the two-pass estimation method. The actual factor loadings are not observable and must therefore be estimated in the first pass regression. As a result, the explanatory variables in the second run regression are measured with some degree of error. Also, given the probability of correlations in the measurement error, the t-ratios proposed by Fama and MacBeth (1973) should be interpreted with care. In particular, as pointed out by Shanken (1992), standard errors are underestimated, which leads to an overestimation of the t-statistic in equation number (13).

Fama and MacBeth (1973) suggest then using portfolios instead of individual assets as dependent variables. They assert that the ensuing diversification effect will improve the reliability of the beta estimates and thus alleviate the problem of errors in the variables. the beta estimates and thus alleviate the problem of errors in the variables. Lo and MacKinlay (1990) argue that this approach can conceivably reduce the problem of errors in variables, but sorting portfolios based on common asset properties could significantly bias the model results. Alternatively, an approach is introduced by Shanken (1992), who suggests directly adjusting the standard errors in the second-pass regression for the bias of errors in variables. Finally, an easier to implement approach is advised by Petersen (2009), who indicates that in order to estimate standard errors, the Newey-West adjustment (Newey-West robust standard errors) should be used to control for autocorrelation.

3.3 Dataset Description

This section illustrates the process of data collection for the two categories of bonds (conventional and green bonds) as well as the benchmarks and the Fama-French factors used for the empirical analysis. The data section also provides detailed evidence of how both $TERM$ and DEF factors are constructed. Finally, it also provides information on the procedures that deal with data protection processes.

It is well known that most investors, such as pension funds, pursue strategies that follow their nature of low-risk, long-term investment, so returns are here proxied by the "Yield-to-Maturity" approach, which is then analysed using an extended Fama-French method. In this way, the thesis takes into account coupon income and cash flow dates, assuming a holding period until maturity - thus replicating the long-term approach highlighted above.

This method is based on work by Houweling, Mentink and Vorst (2005), who claim that it has a clear advantage over a method with realised returns. They find that the Yield-to-Maturity approach is more appropriate than realised returns because it considers market expectations of the bond's yield to maturity. Finally, following the same study, this thesis assumes that each coupon payment received is properly reinvested in the bond at the time of the calculated yield to maturity. Certainly, this may not be the best approach for all investors in the world of bonds, but as most players are long-term oriented, this method remains a good approximation to reality.

3.3.1 The Dataset for Bonds

The data on which this thesis is based consists of 301 different bonds issued between 01.01.2010 and 31.12.2018, a period of nine years. The choice of this period is to examine each bond issued in euros that could fall into this "green" category based on their UoP, as well as conventional bonds that per se have similar financial characteristics to those issued for environmental purposes and based on a class of “project finance” and “investment”. Also, it was relevant for the analysis to eliminate distortive effects due to currency fluctuations, which is why the criteria are limited to a single currency (EUR).

The data on bond yields are taken from the Eikon-Reuters remote terminal, where the issuing currency is expressed in EUR for reasons of comparability, to avoid problems with the exchange rate and inflation fluctuations. Table 1 describes the basic characteristics of the dataset.

Table 1: Bonds Dataset – Key Statistics

	Green Bonds	**Conventional Bonds**
Number of Bonds	163	138
AAA	*55*	*99*
A/AA	*58*	*22*
BBB	*50*	*17*
Average YTM	1.85%	1.91%
AAA	*1.72%*	*1.89%*
A/AA	*1.89%*	*1.83%*
BBB	*1.96%*	*2.10%*
Average days since the issue date	860	1,025
Time-period (from-to)	01/01/2010 - 31/12/2018	

Source: Own Work.

3.3.1.1 Green Bonds

The green bond data set consists of 163 green bonds filtered using the "green bond" tag available in the Eikon-Reuters terminal. This tag ensures that bonds can be filtered according to some "green" principles, which allows for correct data collection. According to Bloomberg, these bonds are: "fixed income instruments or those whose proceeds are used for projects or activities that promote climate protection or adaptation to climate change or other environmental sustainability purposes". This label, therefore, excludes all bonds that are not clearly categorised by the issuer according to this definition or, also, do not contain clear documentation about their "green" character.

As mentioned above, the quality of the data will reflect the situation that has shaped the development of this market over the years. Although the first institutional green bond was issued in 2007, the market started to take adequate account of this segment only years later, when a large number of public institutions and companies started to issue green bonds to finance their activities. This is certainly something quite normal, as the market first recognises the validity of the operation and only then considers focusing on it.

Finally, the data set is further narrowed down to maintain a higher level of data quality by removing duplicates and excluding short-term bonds (with a maturity of less than one year) - according to the long-term principle based on this analysis.

3.3.1.2 Conventional Bonds

Again, the data set containing all the conventional bonds used to carry out this analysis is taken from the Bloomberg terminal, which makes it easier to find, filter and extrapolate different bonds based on their defining characteristics. The sample is of course the same length as the sample of green bonds. To be comparable to the green bond selection process, conventional bonds are also selected according to a value principle, with only those with "investment" or "project financing" being included in the final data set. In order to become even more comparable, the thesis focuses only on those with an S&P investment grade, excluding currencies other than the EUR. Consequently, the data set under this approach includes a total of 138 conventional bonds.

3.3.2 Factors

The factors used to explain bond returns are a crucial part of this analysis. They are either taken directly from Kenneth's French website or artificially constructed following previous studies using original Fama-French, Extended Fama-French and other bond-specific factors.

3.3.2.1 Risk-free rate and the Fama-French Factors

The three basic Fama-French factors, market risk premium, size premium and value premium, are collected on the same website that is needed to obtain the risk-free rate. The data can be easily accessed from Kenneth's French website at Dartmouth School, which now includes factors and the risk-free rate that come directly from the European stock market, something which will prove very useful. Both the size and value premiums were formed from 6 value-weighted portfolios, which were created according to size and book-to-market ratio. According to Fama and French (1993), these factors have good explanatory power for both the equity and bond markets. These factors are based on a book-to-market (BE/ME) approach, which can capture most of the cross-section of returns and can significantly increase the explanatory power of the model.

- $\text{Risk} - \text{Free Asset}\ (\text{R}_\text{f})$: Building on the work of Fama and French (1992), this study could also consider the US T-bill as a proxy for the risk-free interest rate. However, there are other risk-free proxies around the financial markets, such as the German 31-day Bund, which would be more appropriate for this study. Since the analysis is based on the European market, it is indeed better to use a general European risk-free interest rate when carrying out the analysis. As mentioned above, Kenneth's French dataset already contains a European risk-free rate.
- MKTRF: The market risk factor is only a difference between the market return and the return of the risk-free interest rate.
- SMB: The size factor, namely "small-minus-big", is simply constructed by averaging the returns of the biggest portfolios and subtracting them from the average returns of the smallest portfolios in terms of market capitalization. The main rationale behind this factor is that, in the long-term, small-cap companies tend to see higher returns than large-cap companies.
- HML: The "high-minus-low" value factor is calculated according to a similar logic as the previous factor, by taking the mean value and then subtracting the returns of the low-value portfolio from the high-value one. In this case, this factor considers the book-to-market value ratio instead of market capitalization. Moreover, the HML factor reveals that, in the long-term, value stocks (high book-to-market ratio) enjoy higher returns than growth stocks (low book-to-market ratio).

3.3.2.2 Carhart Factors

- MOM: Momentum is defined as the rate of acceleration of the price or volume of a security or index, i.e. the speed at which the price changes. More specifically, the momentum factor refers to the tendency of winning stocks to remain strong in the short term. The momentum factor is classified as a "persistence" factor, meaning that it tends to benefit from the ongoing trend of the market. Momentum factors have typically outperformed in macro environments that are characterised by long cycles of underlying market trends, as many studies have confirmed this surprising phenomenon.

Momentum-based trading is a popular strategy within asset management that signals traders to take a long or short position in a stock in the expectation that its momentum will continue in either an upward or downward direction as share prices, earnings and revenues accelerate or decelerate. Therefore, many studies of asset returns, either equities or fixed-income securities, have included momentum as a relevant factor. this component is also collected from the same database but is based on the work of Grinblatt, Titman and Wermers from 1995.

3.3.2.3 Bond Specific Factors

These components follow the logic proposed by Fama and the French in 1993.

- TERM: This is defined as the difference between the monthly long-term government bond yield and the respective T-Bill yield, interpreted as the risk-free interest rate. The long-term government bond is the "ten-year constant maturity" available in Bloomberg. To be consistent with the data in this paper, it is retrieved daily.
- DEF: Finally, the last factor, according to Fama and French, is simply the difference between long-term government and corporate bonds. This reflects the risk appetite (reflected in the spread) between government bonds, which are supposed to be a much safer investment, and the corporate sector, which is usually seen as a riskier investment. The long-term government bond is the same as that used to construct the "maturity" component, while the long-term corporate bond is proxied by the Bloomberg Barclays Long US Corporate Total Return Index. Again, for the sake of completeness and comparison, they are retrieved and calculated daily.

Besides, it is suggested to try to capture the general volatility of fixed income securities by constructing a more specific factor than a classical MKTRF which is constructed based on overall stock market return differentials. Therefore, a new factor is presented.

- MKTRF_bond: The last factor attempts to identify bond-based market fluctuations. This modification may prove useful in the one-factor model, since the factor mentioned above is specific only to the stock market, as claimed by Elton, Gruber and Blake (1995) in their research paper. It is constructed using the MSCI World Bond Index based on daily returns. The logic is virtually identical to that of the classic MKRTF factor, with the difference that this factor is constructed to follow developments in the bond market entirely, rather than the overall market.

4 RESULTS AND DISCUSSION

In the fourth section, the results of empirical research with the relevant regression tables are presented and then discussed in comparison with the previous literature. Also, useful interpretations are made to facilitate the understanding of the results of the work.

4.1 Results of the main model

This section is divided into several parts in which the results of each model are presented and analysed separately. The procedure is the same for each model, except for some minor modifications based on the number of variables used, as discussed in detail in the previous section. Therefore, we also want to demonstrate the validity of the Fama-Macbeth procedure by introducing some type of modifications that could impact the model's relevance. Modifications are made based on time, the nature of the variables or their ratings to show how sensitive the regression is to different classification scenarios. This means that the analysis will also focus on introducing or substituting different factors to discover something specific to the bond market. It will also try to understand the influence of time on the quality of the results, as the process of issuing green bonds has become increasingly important in recent years.

Table 2: Fama-Macbeth Regression Results – from One to Six-Factor Model

	1-Factor Model	3-Factor Model	4-Factor Model	6-Factor Model
$\boldsymbol{\alpha}$	0.328	0.199	0.192	0.174
Standard error	0.073	0.060	0.064	0.065
$\mathrm{T-value}$	4.49	3.30	2.97	2.68
	***	***	**	**
$\boldsymbol{\lambda\ MKTRF}$	0.952	-0.024	-0.171	-0.175
Standard error	1.295	0.096	0.068	0.062
$\mathrm{T-value}$	0.74	-0.25	-2.51	-2.82
			*	**
$\boldsymbol{\lambda\ HML}$		0.731	0.297	0.319
Standard error		0.102	0.105	0.114
$\mathrm{T-value}$		7.17	2.83	2.80
		***	**	**
$\boldsymbol{\lambda\ SMB}$		-0.183	-0.276	-0.195
Standard error		0.057	0.058	0.083
$\mathrm{T-value}$		-3.21	-4.76	-2.35
		**	***	*
$\boldsymbol{\lambda\ MOM}$			0.524	0.002
Standard error			0.067	0.001
$\mathrm{T-value}$			7.82	1.90
			***	
$\boldsymbol{\lambda\ DEF}$				0.002
Standard error				0.003
$\mathrm{T-value}$				0.67
$\boldsymbol{\lambda\ TERM}$				0.466
Standard error				0.075
$\mathrm{T-value}$				6.21
				***
$\boldsymbol{\delta\ GREEN}$	-0.315	-0.216	-0.197	-0.176
Standard error	0.112	0.066	0.067	0.051
$\mathrm{T-value}$	-2.81	-3.27	-2.94	-3.45
	**	**	**	***
$\boldsymbol{R^2}$	0.21	0.44	0.50	0.59
$\boldsymbol{R^2_{adj}}$	0.04	0.38	0.43	0.52

The standard errors are reported in the second line, while Pearson values of individual factors are displayed by asterisks, where * stands for 95% (0.05), ** for 99% (0.01) and *** for 99.9% (0.001) significance level.

Source: Own Work.

Table 2 summarizes the results of the second step Fama-Macbeth regressions using four different models of increasing complexity based on the factors considered to explain bond returns. All models contain the $GREEN$ dummy variable to differentiate between green and conventional bonds ($GREEN$ = 1 for green and 0 for conventional bonds).

4.1.1 Single-Factor Model (CAPM)

This model, estimated based on equation (2), is the simplest and shows a negative and significant $GREEN$ dummy, which represents a rather high underperformance of green bonds compared to conventional bonds. Initially, one can expect a lower factor, one closer to parity (0). However, this difference (-0.315) can also be partly explained by the simplicity of this model, which ultimately requires additional relevant variables to best explain the situation in the financial markets. This hypothesis is confirmed both regarding α and to other regression statistics, which do not conform to the best practices of this method. In this case, the "alpha" remains quite high and significant at 0.328, which means that the error is still high. The only true variable in the model is the $MKTRF$ which is insignificant and displays a value of 0.952. The poor performance of this model is also confirmed by the regression statistics, which show low values for both R^2 and R^2_{adj}. For the reasons just explained, it is best to add other relevant factors in this analysis, which should theoretically limit this bias and give better overall results than the simple "one-factor model".

4.1.2 Three-Factor Model (Extended CAPM)

The second Three-Factor Model, estimated according to equation (3), shows that the $GREEN$ factor is lower than previously indicated. In this case, the factor loading is still high but much closer to zero than in the previous model; the value is now -0.216 compared to -0.315 before. In addition, this model now confirms earlier findings by displaying better results in terms of the alpha coefficient, which is now lower at 0.199. The two statistics, namely HML and SMB, show values of 0.731 and -0.183, both significant. The negative sign before SMB suggests that high-cap companies still grow at a faster rate compared to low(er) capitalized ones. More correctly, it suggests that the excess return was generated because the firm was large. On the other hand, those with a high book-to-market (value stocks) performed better than those with a lower book-to-market (growth stocks), something reflected in the positive sign before HML. Likewise, a positive coefficient for the HML factor indicates that the excess return is driven by the high book-to-market value of the company issuing the bond. Eventually, this model is much better in its general validity with a much higher R^2_{adj} than before.

4.1.3 Four-Factor Model (Carhart)

This model, estimated according to equation (4), differs only slightly from the previous model, namely by the addition of the momentum factor MOM, which is constructed from the difference between the securities with the best and worst performance. This factor formed the basis for a very important trading strategy that has worked very well over the last decades. Fortunately, the addition of the 4th factor improved the overall result, which was then reflected in a lower pricing error of (0.192). As for the variable differentiating green bonds is concerned, a negative but closer to zero coefficient is obtained (-0.197). It is also interesting to note that the $MKTRF$, a factor specific to market conditions, has finally become significant with a value of -0.171. Moreover, the factors HML and SMB remain in line with the previous model in terms of the sign, though with a different magnitude which is now either 0.297 or -0.276. Finally, as said, the MOM, with a value of 0.524 also contributed to improving the quality/validity of the regression, with both R^2 and R^2_{adj} now again higher than in the model with three factors.

4.1.4 Six-Factor Model (Complete Model)

As theoretically justified and therefore expected, the six-factor model, estimated based on equation (5), provides the best results in all areas. This is certainly due to the inclusion of other relevant factors that can better model uncertainty in financial markets. In precisely this case, both the $GREEN$ dummy, which is again more in line with expectations (-0.176) and the α at 0.174, the lowest value ever recorded in this analysis, though high and significant, should be mentioned. It is also interesting to note that these two incremental factors did "force" the MOM factor to become insignificant, while still having a positive effect on the overall regression. Furthermore, the factors HML and SMB were displaying a positive 0.319 and a negative -0.195 again in line with the previous models. Finally, two new factors were introduced DEF and $TERM$ showing a 0.002 and 0.466 respectively, where only the latter is statistically significant, which contradicts the initial expectation that they should both be statistically relevant to the study because directly related to the bond market. Eventually, the $TERM$ seems to capture all the variation concerned with these factors. Ultimately, the six-factor model also outperforms other models in terms of model quality. In this case, both the R^2 and R^2_{adj} show the highest values compared to the other models, something being in line with expectations.

4.2 Modifications

In this sub-section, the analysis aims to discover some different results compared to the classical methodology presented earlier. Therefore, slight modifications are made to the main models, which should lead to some improvements in the overall picture of the quality of the model.

In this section, three main modifications are made, namely the change in the type of variable, the subset that either reduces the length of the sample or divides the sample according to the ratings of the bonds. However, these modifications are only applied to the complete six-factor model, estimated according to equation (5).

4.2.1 Substitution of market risk factor and restriction of the time-period to recent years

Two modifications relative to the earlier analysis are provided in this section as a completion of the analysis. The results are presented in Table 3.

Table 3: Factor Substitution and Period Restriction - Six-Factor Model

	Substitution of Market Risk Factor (6-Factor Model)	**Period Restriction to Recent Years (6-Factor Model)**
$\boldsymbol{\alpha}$	0.184	0.256
Standard error	0.064	0.083
$\mathrm{T-value}$	2.88	3.08
	**	**
$\boldsymbol{\lambda\ MKTRF}$		-0.098
Standard error		0.045
$\mathrm{T-value}$		-2.18
		*
$\boldsymbol{\lambda\ MKTRF\_bond}$	-0.087	
Standard error	0.067	
$\mathrm{T-value}$	-1.30	
$\boldsymbol{\lambda\ HML}$	-0.145	-0.123
Standard error	0.087	0.049
$\mathrm{T-value}$	-1.67	-2.51
		*
$\boldsymbol{\lambda\ SMB}$	0.332	0.387
Standard error	0.111	0.205
$\mathrm{T-value}$	2.99	1.89
	**	
$\boldsymbol{\lambda\ MOM}$	0.002	0.003
Standard error	0.007	0.005
$\mathrm{T-value}$	0.27	0.59
$\boldsymbol{\lambda\ DEF}$	-0.001	-0.001
Standard error	0.004	0.002
$\mathrm{T-value}$	-0.28	-0.42

(table continues)

Table 3: Substitution of Market Risk Factor and Period Restriction to Recent Years - Six-Factor Model

(continued)

	Substitution of Market Risk Factor (6-Factor Model)	**Period Restriction to Recent Years (6-Factor Model)**
$\boldsymbol{\lambda\, TERM}$	0.004	0.01
Standard error	0.001	0.004
$\mathrm{T-value}$	2.86	2.38
	**	*
$\boldsymbol{\delta\, GREEN}$	-0.184	-0.212
Standard error	0.062	0.077
$\mathrm{T-value}$	-2.97	-2.75
	**	**
$\boldsymbol{R^2}$	0.59	0.49
$\boldsymbol{R^2_{adj}}$	0.52	0.45

The standard errors are reported in the second line, while Pearson values of individual factors are displayed by asterisks, where * stands for 95% (0.05), ** for 99% (0.01) and *** for 99.9% (0.001) significance level.

Source: Own Work.

First, the $MKRTF$ variable, which captures fluctuations in the whole market, is replaced with a more specific bond-based variable. This is now called $MKRTF\_bond$ and is displayed instead of the former. Applying a minor modification to the model with the highest number of factors does not produce the expected results. As described in the table above, the results are slightly worse than in the previous model, with the α, $GREEN$ and R^2, at 0.184, -0.184 and 0.59, respectively. It is particularly interesting to notice, that this model makes almost all factors have a lower significance than before, which is not consistent with the initial considerations, which would lead to the results being better in terms of significance considering the factor being specific for the green fixed-income market. This means that the broader market factor $MRKTF$ is more suitable to explain bond returns than $MKRTF\_bond$, a bond specific one., at least based on these data.

Second, the observation period is changed so as to only includes bonds issued after the year 2015. This is done to understand if there is an important difference in the results from 2015 to the final year. The model with the highest number of factors also shows similar results, with the $GREEN$ dummy remaining quite high and negative at -0.212, while showing a high pricing error α of 0.256. Unfortunately, the overall explanatory power of this regression is lower compared to the model with the full sample size (0.49 to 0.59), as well as many regressors now become less significant than before.

4.2.2 Estimation by bond rating class

In this last section, all bonds are divided into sub-groups based on their financial rating class. The bonds are therefore divided into three categories: AAA rating, A/AA and BBB. As already indicated in the methodology section, the positive or negative rating outlook (for example both A+ or A- are considered as an A rating to avoiding excessive fragmentation). The main model is then re-estimated for each rating sub-group to provide a more detailed picture of the market.

Table 4: Estimation by Bond Rating Class - Six-Factor Model

	AAA	**A/AA**	**BBB**
$\boldsymbol{\alpha}$	0.455	0.363	0.375
Standard error	0.118	0.124	0.085
$\mathrm{T-value}$	3.86	2.93	4.41
	***	**	***
$\boldsymbol{\lambda\ MKTRF}$	-0.02	-0.02	-0.13
Standard error	0.008	0.007	0.039
$\mathrm{T-value}$	-2.12	-2.29	-3.38
	*	*	***
$\boldsymbol{\lambda\ HML}$	0.081	0.304	0.145
Standard error	0.061	0.094	0.018
$\mathrm{T-value}$	1.32	3.23	8.10
		**	***
$\boldsymbol{\lambda\ SMB}$	-0.193	-0.081	-0.381
Standard error	0.082	0.129	0.224
$\mathrm{T-value}$	-2.35	-0.63	-1.70
	*		
$\boldsymbol{\lambda\ MOM}$	0.002	0.006	-0.004
Standard error	0.002	0.003	0.003
$\mathrm{T-value}$	0.90	2.33	-1.19
		*	
$\boldsymbol{\lambda\ DEF}$	-0.0012	-0.0156	-0.002
Standard error	0.001	0.014	0.001
$\mathrm{T-value}$	-1.20	-1.12	-2.22
			*

(table continues)

Table 4: Estimation by bond rating class - Six-Factor Model

(continued)

	AAA	A/AA	BBB
$\boldsymbol{\lambda\,TERM}$	0.223	0.399	0.493
Standard error	0.143	0.204	0.401
$\mathrm{T-value}$	1.55	1.96	1.23
$\boldsymbol{\delta\,GREEN}$	0.045	0.014	-0.195
Standard error	0.010	0.006	0.025
$\mathrm{T-value}$	4.62	2.28	-7.70
	***	*	***
$\boldsymbol{R^2}$	0.60	0.56	0.53
$\boldsymbol{Adj.\ R^2}$	0.48	0.46	0.43

The standard errors are reported in the second line, while Pearson values of individual factors are displayed by asterisks, where * stands for 95% (0.05), ** for 99% (0.01) and *** for 99.9% (0.001) significance level.

Source: Own Work.

The first scenario depicted just above in table 4, built upon highly secure AAA bonds, shows an α higher than usually expected from a Complete Model (0.455), accompanied now with a positive $GREEN$ dummy (0.045). It's also interesting to see, that all variables are now statistically significant, confirming that there's a difference when analysing the same situation from a different perspective. However, this Complete Model shows poorer results in terms of quality than the traditional Six-Factor one, with many variables not reaching significance, something different compared to the model using the complete dataset.

The second scenario based on A/AA-rated bonds, instead also shows a higher than expected α (0.363), but much lower than in the first securities' segment (AAA). In this case, as well, the $GREEN$ dummy remains positive and even higher compared to the first model (0.014), showing quite a discrepancy with the model where all different bonds are pooled together. Moreover, similarly, as before, many variables are not significant, but the model's quality remains satisfactory, but lower compared to the pooled Six-Factor Model.

Finally, the model-based only on BBB-rated bonds, contrary to the other bond segments, shows a $GREEN$ dummy of (-0.195), the lowest of all three models, as well as the only one negative. Moreover, the alpha remains still too high (0.375), confirming that also this sample's partitioning provokes some type of bias. Ultimately, the factors remain statistically insignificant in many cases, while showing a coefficient of determination being in somewhat line with the other two models featuring AAA and AA/A bonds.

Theory suggests that grouping securities into portfolios based on a common rule should lead to better results. In many cases, the test is performed by grouping stocks according to the industry in which they operate. In this case, however, the regression was performed by grouping them into three different portfolios according to their rating class. In the end, the results should be better than in the original (polled) sample, but the result seems to be of lower quality when considering the remaining pricing error, which is higher than before. On the other hand, it produced a slightly better regression fit in one particular group, demonstrating that this procedure is still relevant.

Partitioning the dataset according to the bond's quality (ratings) opens the possibility of interesting and differentiated results. In this case, however, the downside is a higher pricing error as well as other issues. Probably, partitioning has reduced the representativeness of the sample, as too little data was available and the sample was not very well divided between green and conventional bonds, with some categories having too many or too few observations of each in their sample. This may also be due to a problem known as sample-selection bias, since a certain degree of randomness that characterized the pooled sample now partially disappeared, making it difficult to specify the analysis correctly. However, the results also indicate that this type of analysis conducted under such conditions still led to interesting results which show how the negative gap between the two interest categories increases as the bonds become riskier. According to the sample, investors seem to reward green bonds that fall below a certain quality threshold, namely those with a label below A, more than their conventional counterparts, requiring a lower yield overall. If the results were sufficiently robust, this would raise an important question as to whether investors perceive risk differently under the same rating categories but with different UoP (Heckman, 2005).

4.2 Discussion

This thesis focused on the analysis of green vs. conventional bond returns. The main objective was to understand whether there is any statistically significant difference between the two, against the null hypothesis of no difference. Over the period of interest, the empirical analysis documents a significant and negative premium on green bonds of -0.176 reached in the model with the highest number of variables, which means that investors are willing to sacrifice an average of 17.6 basis points of their yield on green bonds compared to conventional bonds. The study thus finds that green bonds are trading at lower yields than their identical conventional counterparts, which underlines a strong interest of investors in green bonds. Since green bonds contribute to the financing of climate and environmentally friendly investments, this result reaffirms the policy ambitions and recommendations of the authorities linked to financial climate change actors. In this optic, the findings of this thesis are also consistent with a variety of previous research on green bond market returns, which also documented negative premiums, albeit at a lower level compared to the level found in this thesis. More specifically, the result is about 8 basis points more negative than the results of a recent article that summarised the main findings of the literature in this field. This article written by, MacAskill, Roca, Stewart, Liu and Sahin (2021) explained that the negative premium on green bonds is, on average, in the range of -1 to -9 basis points, with a few studies pointing at even higher negative premiums. However, the divergence is not severely higher and could be explained using other more sophisticated models with different specifications and/or variables of interest or with different sample length and periods.

The lack of green bond issuance relative to high investment demand could be caused by several factors. On the issuer side, green bond issues seem to depend on the existence of green projects and are subject to disclosure, monitoring and reporting requirements on the use of proceeds. On the investor side, interest in green bonds is being stimulated by public and private initiatives to redirect investment towards low-carbon assets. So, if the supply of green bonds grows faster than demand, the negative premium may fall. On the other hand, growing demand could drive up the absolute value of negative premiums, thereby reducing the cost of capital and favouring green projects (Zerbib, 2018).

Indeed, this leads to diverging interests between bond issuers and investors. While the negative premium favours the issuance of green bonds, it may reduce the interest of investors who are not obliged to diversify their portfolios by investing in sustainable bonds. If the equivalent conventional bond yields higher returns, the green bonds will be redeemed by investors who do not need to meet the requirements for green investment bonds. However, problems arise because the negative premium would not only reduce the financing of low-carbon projects but also increase the concentration of risk among the few existing green investors, potentially increasing systemic risk.

To maintain incentives for investors and redirect large capital flows towards green transformation, the authorities could use three levers: changing prudential rules, implementing supportive fiscal policies and adopting stringent and standardization rules. Lowering the cost of capital to support green corporate bonds would create incentives for institutional investors to offset the negative premium of green bonds by creating excess solvency. The second option would be a subsidy in the form of a tax advantage, which would increase the net return to investors on green bonds accordingly. The third is to stimulate the rate of green bond issuance with a greater degree of policy standardization, which would bring negative premiums closer to zero, due to the simple rules of supply and demand. This triple measure, in terms of the net cost of debt for issuers and the net return for investors, could result in a positive cycle of increasing financial flows towards the issuance of additional and perhaps even larger green bonds. Furthermore, there is a widespread need for a widely accessible secondary market for investors to either trade or invest. At present, there's only a limited number of green bond mutual funds and green bond ETFs, so opening up the menu of green bond mutual funds and ETFs is key to widening the investor pool, support the primary market and vice versa. These positive spillover effects are likely to lead to a larger and more efficient green bond market (Fatica, Panzica, & Rancan, 2019).

While the thesis focuses on the green bond factor, it does not neglect the results of other specific and financially important factors impacting bond returns, such as HML, SMB and MOM. In this case, the intention to explain bond yields may seem impractical at first glance because they are based on equity principles, but the literature shows that such factors can contribute to some extent to explaining bond yields. Concerning these factors, the initial expectation was that the same factors across different models would share the same sign, perhaps with different numbers, something which did happen almost every time. There were also some differences, but a possible explanation could be that the explanatory power of one variable was captured by some others that were added later. This is common in such models and was probably also the case in this thesis. The other three factors, namely MOM, DEF and $TERM$ did not seem to be very much in line with initial expectations, as it turned out that when all three were pooled together, only one of them was statistically significant. The theory also suggested that at least both (DEF and $TERM$) were, as they were quite relevant to the fixed-income market. Moreover, when such a phenomenon occurs, it is expected that one of the previous factors, being "replaced" by others, will become insignificant or much less significant than before. This phenomenon occurred, and specifically for the last three factors, it is possible to recognise that the insignificance of one or two factors was due to the explanatory power that was already captured by the other similar factor. However, overall, the results were quite in line with expectations.

Nevertheless, the relevance of more complete models with additional variables is also confirmed by the R_{adj}^2, which continued to increase with the addition of further variables, with the highest value being just over 52%. One possible intuitive explanation for the relevance of equity factors in a world of fixed income securities is that bond issuers are generally large companies and most likely the same as in the equity world. As a result, the two markets are to some extent interlinked. However, it is difficult to compare the magnitude of these results with those in other papers because other studies have used different variables and methodologies to find differences between these two types of bonds. For this reason, the current results on other explanatory power of the regressions themselves are difficult to put into a broader perspective, something that was a bit easier in the case of the green premium.

This negative green bond premium remains the same, even in different model specifications. The analysis should show how the relevant specification changes affect the regression result. In the first case, a bond-specific factor - $MRKTF\_bond$ - was introduced to replace the stock market-specific factor $MKTRF$. This modification showed only a very limited difference between the green bonus in the model with the largest number of variables while creating inferior results in other terms. In the second case, by changing the length of the dataset, we find only a small difference in returns between the two categories of interest in the six-factor model, compared to the classical method used in the first case. However, the overall regression significance is now quite lower than before.

Finally, it was also interesting to understand how the different classifications (ratings) affected the results of the variables of interest. However, unfortunately, the initial expectations of better results were not really met, as one would expect an even higher R^2 and a lower α. Also, the results seem odd, since two rating-based regressions for higher-rated bonds showed a positive coefficient for green bonds, whereas only BBB-based bonds showed a negative regression coefficient of the $GREEN$ dummy. These results could be misleading because a hardly unbalanced panel is observed, which leads to too many green bonds in one data set and too few in the other data sets, something critical for a correct evaluation of any type of analysis. However, on top of all, the results have some economic rationale behind them. Perhaps such an analysis with a larger data set would have produced a more robust result, but overall, it is still satisfactory enough, at least for the procedure itself.

The last consideration relates to the type of analysis carried out in this paper. Although the procedure in this paper follows the typical Fama-Macbeth regression type, several upgrades could improve the overall results. This paper focuses exclusively on a financial perspective, but other factors, perhaps based on behavioural aspects, could give a different overall picture. Another approach to analysing performance would be paired-based, comparing green and conventional bonds from the same issuer. They are assumed to have the same inherent risk characteristics and the difference in performance should be due solely to the factor associated with the issue of a green bond and not due to other unobserved drivers. Besides, the inclusion of a class of black bonds whose proceeds are specifically earmarked for fossil fuel and non-renewable energy projects could be of additional interest to the sector. Furthermore, liquidity could be another factor that should be used to further enhance its explanatory power. In general, there is much scope for further (yet different) investigation which should provide other insights into the green bond market.

CONCLUSION

The thesis aimed to examine the perception of investors to sacrifice part of their profits to finance the green transformation. The objective was to understand if there is a significant difference in investing in green compared to conventional bonds. This analysis shows that there is evidence, based on a sample of bonds issued in EUR, that investors are willing to sacrifice a part of their expected return to finance sustainable projects. These results contradict initial expectations that there are no differences in yields between green and conventional bonds where investors can finance the green switch without losing anything in terms of expected yields. The nature of the negative green bond premium is not yet clear but is indicative of a high influx of sustainable finance investment that may also be due to the financial sector's portfolio diversification strategy, which aims to become a bastion of green finance.

To find reliable results and determine which of the most common factor models is best suited to determine bond yields, several common models have been tested, showing which of these helps to explain the volatility of bond yields the best, using the Fama-Macbeth approach. As illustrated in the results section, the explanatory power of the models increases as more factors are added. The empirical results confirm that models that include more factors work better than the simpler ones, underlining the relevance of the variables added. To be able to compare the quality of the models with varying number of factors is good practice to show the R^2_{adj} instead of the normal R^2. The simpler CAPM model alone can explain 4% of the model's variation, which simply not enough even for such a simple model. Continuing with the Fama-French three-factor model, the overall quality is improved massively, and the model can now explain 38% of the variation. Also, the Carhart model is run to see if the stock market's momentum helps to explain bond yields by adding a momentum factor. In this case, the explanatory power is greater with a 5-pp increase in R^2_{adj}, reaching a good 43%. Finally, the six-factor model, with an overall significance of 52%, shows that a skilful combination of stock and bond specific factors together can significantly improve the overall significance and explanatory power.

It turns out that the pricing error in all models in this analysis is statistically significant and is fairly high, in the range of 17 to 33 basis points. Looking instead at the "green dummy", the variable of interest in this regression, it is clear that the coefficients remain statistically significantly negative and different from zero for all six models, indicating that it is meaningful whether the bond is green or not, at least for the issues denominated in EUR. On the other hand, the main 6-factor model remains only partially consistent after changing the dataset to show the most recent issues and after changing the market to a bond-based variable. Besides, interesting, but perhaps not robust enough, results are observed when bonds were grouped according to their rating, where the negative premium appears to be very pronounced for BBB rated green bonds rather than for safer bonds, where, instead, a positive sign is observed before the green dummy.

Finally, it is also worth noting that the green bond market has only been around for about a decade, so it would certainly be interesting to continue to carry out similar studies in the years to come. Of course, it is now possible to carry out further research using only sector-, country- or company-specific data and approaches, which would make it possible to discover even more novel developments in the field of sustainable finance. At the same time, further research could also be carried out on the impact of the benefits of sustainability labelling of these intangible assets, which would further contribute to creating added value in the field of sustainable development and thus stimulate further academic advances in this field.

REFERENCES

1. Asgari, N. (2019, July 03). *World's top pension fund warns against risk of green-bond 'fad'*. Retrieved November 12, 2020, from url: https://www.ft.com/content/f844f1c2-998e-11e9-8cfb-30c211dcd229

2. Bachelet, M. J., Becchetti, L., & Manfredonia, S. (2019). *The Green Bonds Premium Puzzle: The Role of Issuer Characteristics and Third-Party Verification.* Rome: University of Rome - Tor Vergata. Retrieved August 21, 2020, from url: https://www.mdpi.com/2071-1050/11/4/1098/htm

3. Bank of England. (2019). *Climate change: what are the risks to financial stability?* Retrieved August 26, 2020, from url: https://www.bankofengland.co.uk/knowledgebank/climate-change-what-are-the-risks-to-financial-stability

4. Bektić, D., Wenzler, J.-S., Wegener, M., Schiereck, D., & Spielmann, T. (2017). Extending Fama–French Factors to Corporate Bond Markets. *The Journal of Portfolio Management, 45*(3), 141-158. doi:http://dx.doi.org/10.2139/ssrn.2715727

5. BlackRock. (2020). *Growth of sustainable investing*. Retrieved December 28, 2020, from url: https://www.blackrock.com/institutions/en-ch/solutions/sustainable-investing

6. Carbon Market Watch. (2019, March). *EU Climate Leader Board – Where countries stand on the Effort Sharing Regulation.* Brussels: Carbon Market Watch. Retrieved November 18, 2020, from url: https://carbonmarketwatch.org/publications/eu-climate-leader-board-where-countries-stand-on-the-effort-sharing-regulation/

7. Carhart, M. (1997). On persistence in mutual fund performance. *Journal of Finance, 52(1)*, 57-82. doi:https://doi.org/10.1111/j.1540-6261.1997.tb03808.x

8. Chen, J. (2020, November 3). *Socially Responsible Investment (SRI)*. Retrieved December 02, 2020, from url: https://www.investopedia.com/terms/s/sri.asp

9. Climate Action Tracker. (2020). *Temperatures - Addressing global warming*. Retrieved December 15, 2020, from url: https://climateactiontracker.org/global/temperatures/

10. Climate Bonds Initiative. (2020). *Green Bond Market Summary - 2019.* London: Climate Bonds Initiative. Retrieved April 03, 2020, from url: https://www.climatebonds.net/system/tdf/reports/2019_annual_highlights-final.pdf?file=1&type=node&id=46731&force=0

11. Cochrane, J. (2006). Asset Pricing (Revised Edition). *Journal of Economic Behavior & Organization, 60(4)*, 603-608. doi:https://doi.org/10.1016/j.jebo.2005.08.001

12. Dellink, R., Lanzi, E., & Chateau, J. (2019). The Sectoral and Regional Economic Consequences of Climate Change to 2060. *Environmental and Resource Economics, 72,* 309–363. doi:https://doi.org/10.1007/s10640-017-0197-5

13. Ehlers, T., & Packer, F. (2017). *Green Bond Finance and Certification.* Basel: BIS Quarterly Review. Retrieved August 21, 2021, from url: https://ssrn.com/abstract=3042378

14. Elton, E., Gruber, M., & Blake, C. (1995). Fundamental Economic Variables, Expected Returns, and Bond Fund Performance. *The Journal of Finance, 50(4)*, 1229-1256. doi:https://doi.org/10.2307/2329350

15. Environmental Finance. (2020). *Sustainable Bonds Insight - 2019.* London: Environmental Finance. Retrieved April 23, 2020, from url: https://www.environmental-finance.com/assets/files/SUS%20BONDS%20INSIGHT%20FINAL-final.pdf

16. EU Green Bond Standard Working Group. (2019). *Report on EU Green Bond Standard.* Luxemburg: Publication Office of the EU. Retrieved May 09, 2020, from url: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-green-bond-standard_en.pdf

17. European Commission. (2015). *EU-ETS Handbook.* Brussels: Pubblication Office of the EU. Retrieved July 01, 2020, from url: https://ec.europa.eu/clima/sites/default/files/docs/ets_handbook_en.pdf

18. European Commission. (2020a). *A European Green Deal*. Retrieved October 19, 2020, from url: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

19. European Commission. (2020b). *Adaptation to climate change*. Retrieved December 19, 2020, from url: https://ec.europa.eu/clima/policies/adaptation_en

20. European Commission. (2020c). *Climate Action*. Retrieved December 20, 2020, from url: https://ec.europa.eu/clima/policies/international/cooperation/india_en

21. European Commission. (2020d). *Ecofriendly investment – EU standard for 'green bonds'*. Retrieved December 23, 2020, from url: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12447-EU-Standard-for-Green-Bond-

22. European Commission. (2020e). *Effort sharing: Member States' emission targets*. Retrieved July 5, 2020, from url: https://ec.europa.eu/clima/policies/effort_en

23. European Commission. (2020f). *The European Green Deal Investment Plan and Just Transition Mechanism Explained*. Retrieved December 19, 2020, from url: https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_24

24. European Commission. (2020g). *EU Emissions Trading System (EU-ETS)*. Retrieved May 04, 2020, from url: https://ec.europa.eu/clima/policies/ets_en

25. European Commission. (2021). *Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people.* Retrieved January 31, 2021, from url: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562

26. European Environment Agency. (2020, November 23). *Climate change mitigation*. Retrieved December 16, 2020, from url: https://www.eea.europa.eu/themes/climate/intro#:~:text=Climate%20change%20mit

27. Faiella, I. (2019, November 18). *Gli impatti climatici sull'economia reale*. Retrieved November 28, 2020, from url: https://www.rivistaenergia.it/2019/11/gli-impatti-dei-cambiamenti-climatici-sulleconomia-reale/

28. Fama, E., & French, K. (1992). The Cross-Section of Expected Stock Returns. *Journal of Finance, 47(2)*, 427–465. doi:https://doi.org/10.2307/2329112

29. Fama, E., & French, K. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33(1)*, 3-56. doi:https://doi.org/10.1016/0304-405X(93)90023-5

30. Fama, E., & French, K. (2004). The Capital Asset Pricing Model: Theory and Evidence. *Journal of Economic Perspectives, 18(3)*, 25-46. doi:http://dx.doi.org/10.2139/ssrn.440920

31. Fama, E., & Macbeth, J. (1973). Risk, return and equilibrium: Empirical tests. *Journal of Political Economy, 81(3)*, 607-636. doi:https://www.jstor.org/stable/1831028

32. Fatica, S., Panzica, R., & Rancan, M. (2019). *The pricing of green bonds: are financial institutions special?* Brussels: JRC Working Papers in Economics and Finance. Retrieved November 28, 2020, from url: http://dx.doi.org/10.2139/ssrn.3623146

33. Flammer, C. (2018). *Corporate Green Bonds.* Boston, Massachusetts, U.S.A.: Questrom School of Business. Retrieved November 28, 2020, from url: http://dx.doi.org/10.2139/ssrn.3125518

34. Gabbi, G., & Sironi, A. (2005). Which factors affect corporate bonds pricing? empirical evidence from eurobonds primary market spreads. *The European Journal of Finance, 11(1)*, 59-74. doi:https://doi.org/10.1080/1351847032000143422

35. GBP Databases & Indices Working Group. (2017). *Summary of Green Fixed Income Indices Providers.* Zurich: ICMA. Retrieved April 10, 2020, from url: https://www.cbd.int/financial/greenbonds/icma-indices2017.pdf

36. Gil-Bazo, J., Ruiz-Verdú, P., & Santos, A. A. (2010). The performance of socially responsible mutual funds: The role of fees and management companies. *Journal of Business Ethics, 94*, 243–263. doi:https://doi.org/10.1007/s10551-009-0260-4

37. Giuzio, M., Krusec, D., Levels, A., Melo, A. S., Mikkonen, K., & Radulova, P. (2019, May 29). *Climate Change and Financial Stability*. Retrieved June 04, 2020, from url: https://www.ecb.europa.eu/pub/financial-stability/fsr/special/html/ecb.fsrart201905_1~47cf778cc1.en.html#toc6

38. Glowacki, M. (2020). *Phases (trading periods) of the EU ETS*. Retrieved January 05, 2021, from url: https://www.emissions-euets.com/carbon-market-glossary/878-phases-trading-periods-eu-ets

39. Grinblatt, M., Titman, S., & Wermers, R. (1995). Momentum Investment Strategies, Portfolio Performance, and Herding: A Study of Mutual Fund Behavior. *The American Economic Review, 85*(5), 1088-1105. doi:https://www.jstor.org/stable/2950976

40. Harrington, R., & Gould, S. (2017, June 01). *The US will join Syria and Nicaragua as the only nations that aren't part of the Paris agreement*. Retrieved December 08, 2020, from url: https://www.businessinsider.com/195-countries-that-signed-paris-climate-agreement-accord-deal-2017-5?IR=T

41. Heckman, J. (2005). Selection Bias. *Encyclopedia of Social Measurement, 12*(1), 463-468. doi:https://doi.org/10.1016/B0-12-369398-5/00115-8

42. Houweling, P., Mentink, A., & Vorst, T. (2005). Comparing possible proxies of corporate bond liquidity. *Journal of Banking and Finance*, *29*(6), 1331-1358. doi:https://doi.org/10.1016/j.jbankfin.2004.04.007

43. Ibikunle, G., & Steffen, T. (2015). European Green Mutual Fund Performance: A Comparative Analysis with their Conventional and Black Peers. *Journal of Business Ethics*(145), 337–355. doi:https://doi.org/10.1007/s10551-015-2850-7

44. International Capital Market Association. (2018). *Green Bond Principles Voluntary Process Guidelines for Issuing Green Bonds.* Zurich: ICMA. Retrieved from url: https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/Green-Bonds-Principles-June-2018-270520.pdf

45. Investors' Corner Team. (2020, February 2). *Climate action 101 – The EU Emissions Trading System*. Retrieved November 23, 2020, from url: https://investors-corner.bnpparibas-am.com/economics/climate-action-101-the-eu-emissions-trading-system/

46. IPCC. (2020a). *Global Warming of 1.5°C.* Geneva: IPCC. Retrieved September 03, 2020, from url: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

47. IPCC. (2020b). *International Cooperation: Agreements & Instruments.* London: Intergovernmental Panel on Climate Change. Retrieved December 21, 2020, from url: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter13.pdf

48. IPCC. (2020c). *Adaptation and Mitigation.* Retrieved December 12, 2020, from url: https://ar5-syr.ipcc.ch/topic_adaptation.php

49. Israel, R., Palhares, D., & Richardson, S. (2017). *Common Factors in Corporate Bond Returns.* London: Forthcoming in the Journal of Investment Management. doi:http://dx.doi.org/10.2139/ssrn.2576784

50. Johansson, D., & Lundgren, T. (2012). *A study of corporate bond returns using Sharpe-Lintner CAPM and Fama-French.* Stockholm: Master's thesis, Stockholm School of Economics. Retrieved November 15, 2020, from url: http://arc.hhs.se/download.aspx?MediumId=1740

51. Karpf, A., & Mandel, A. (2017). *Does it pay to be green? A Comparative Study of the Yield Term Structure of Green and Brown Bonds in the US Municipal Bonds Market.* Paris: University Panthéon-Sorbonne. doi:http://dx.doi.org/10.2139/ssrn.2923484

52. Kruse, T., Dellink, R., Chateau, J., & Agrawala, S. (2017). *Employment Implications of Green Growth: Linking jobs, growth, and green policies.* Paris: OECD. Retrieved January 21, 2021, from url: https://www.oecd.org/environment/Employment-Implications-of-Green-Growth-OECD-Report-G7-Environment-Ministers.pdf

53. Kuchtyak, M., Zubets, A., Conner, S., Ghosh, R., Davison, A., & Cahill, B. (2020). *Green, social and sustainability bond issuance to hit record $400 billion in 2020.* New York: Moody's Investors Service. Retrieved August 18, 2020, from url: https://www.eticanews.it/wp-content/uploads/2020/02/Sector-In-Depth-Sustainable-Finance-Global-03Feb20.pdf

54. Larsen, M. A., Petrović, S., Radoszynski, A. M., Kenna, R. M., & Balyk, O. (2020). Climate change impacts on trends and extremes in future heating and cooling demands over Europe. *Energy and Buildings, 226*, 59-75. doi:https://doi.org/10.1016/j.enbuild.2020.110397

55. Lintner, J. (1965). The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *The Review of Economics and Statistics, 47*(1), 13-37. doi:https://doi.org/10.2307/1924119

56. Lo, A. W., & MacKinlay, A. C. (1990). Data-Snooping Biases in Tests of Financial Asset Pricing Models. *The Review of Financial Studies, 3*(3), 431-467. doi:https://doi.org/10.1093/rfs/3.3.431

57. LuxFLAG. (2021). *Activity Report 2020.* Luxebourg: LuxFLAG. Retrieved July 21, 2020, from url: https://www.luxflag.org/media/pdf/annual_report/AnnualActivityReport_2020_FINAL.pdf

58. MacAskill, S., Roca, E., Stewart, R. A., Liu, B., & Sahin, O. (2021). Is there a green premium in the green bond market? Systematic literature review revealing premium determinants. *Journal of Cleaner Production, 280*(2), 37-49. doi:https://doi.org/10.1016/j.jclepro.2020.124491

59. Manescu, C. (2010). *Stock returns in relation to environmental, social, and governance performance: Mispricing or compensation for risk?* Gothenburg: University of Gothenburg. Retrieved April 21, 2020, from url: https://doi.org/10.1002/sd.510

60. Matsumoto, K. (2019). Climate change impacts on socioeconomic activities through labor productivity changes considering interactions between socioeconomic and climate systems.

Journal of Cleaner Production, 2016, 528-541. doi:https://doi.org/10.1016/j.jclepro.2018.12.127

61. Merton, R. C. (1973). An Intertemporal Capital Asset Pricing Model. *Econometrica, 41*(5), 867-887. doi:https://doi.org/10.2307/1913811

62. Morgado, C., & Lasfargues, B. (2018). *Engaging the Private Sector for Green Growth and Climate Action: An Overview of Development Co-Operation Efforts.* Paris: OECD. Retrieved December 05, 2020, from url: https://www.cbd.int/financial/2017docs/oecd-private2017.pdf

63. Nordhaus, W. (2019). Climate Change: The Ultimate Challenge for Economics. *American Economic Review, 109*(6), 1991-2014. doi:https://doi.org/10.1257/aer.109.6.1991

64. OECD. (2018). *Financing Climate Futures: Rethinking Infrastructure Policy Highlights.* Paris: OECD Publication Office. Retrieved November 19, 2020, from url: https://www.oecd.org/environment/cc/climate-futures/policy-highlights-financing-climate-futures.pdf

65. Petersen, M. A. (2009). Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches. *The Review of Financial Studies, 22*(1), 435–480. doi:https://doi.org/10.1093/rfs/hhn053

66. Petkova, R. (2009). *The Cross-Section of Stock Returns and the Fama-French Three Factor Model.* New York: Springer. Retrieved December 23, 2020, from url: https://doi.org/10.1007/978-0-387-30440-3_203

67. Quinson, T. (2020, October 10). *ESG Market Record Is Causing Bubble Anxiety*. Retrieved December 23, 2020, from url: https://www.bloombergquint.com/business/esg-market-record-is-causing-some-bubble-anxiety-green-insight

68. Reedtz, P. M. (2019). *Rischi climatici, finanza e banche centrali.* Rome: Bank of Italy. Retrieved June 03, 2020, from url: https://www.bancaditalia.it/pubblicazioni/interventi-vari/int-var-2019/Reedtz-28112019-ICMA-p.pdf

69. Roboredo, J. (2018). Green bond and financial markets: Co-movement, diversification and price spillover effects. *Energy Economics, 74*, 38-50. doi:https://doi.org/10.1016/j.eneco.2018.05.030

70. Shanken, J. (1992). On the Estimation of Beta-Pricing Models. *The Review of Financial Studies, 5*(1), 1–33. doi:https://doi.org/10.1093/rfs/5.1.1

71. Sharpe, W. F. (1964). Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *Journal of Finance, 19*(3), 425–442. doi:https://doi.org/10.2307/2977928

72. Stock, J., & Watson, M. (2012). *Introduction to Econometrics.* New York: Pearson Education. Retrieved November 12, 2020, from url:

https://econometricsweb.files.wordpress.com/2016/11/stock-watson-econometrics-3rd-edition-ilovepdf-compressed.pdf

73. Sylvain, S. (2013). *Fama-MacBeth 1973: Replication and Extension.* Chicago: University of Chicago. Retrieved April 06, 2020, from url: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.1706&rep=rep1&type=pdf

74. Tavoni, M. (2020, March 25). *The impact of climate change on economic growth*. Retrieved January 23, 2021, from url: https://www.som.polimi.it/en/the-impact-of-climate-change-on-economic-growth/#:~:text=The%20latest%20IPCC%20report%20on,the%20end%20of%20the%20century.&text=Projected%20economic%20impacts%20of%20climate%20change.

75. Tett, G., Temple-West, P., & Nauman, B. (2019, October 23). *Green bonds hit $1tn amid growing pains*. Retrieved November 14, 2020, from url: https://www.ft.com/content/f9baa3b8-f51d-11e9-b018-3ef8794b17c6

76. The World Bank. (2019). *Green Bond Impact Report 2019.* Washington: The World Bank Group. Retrieved August 13, 2020, from url: https://pubdocs.worldbank.org/en/790081576615720375/IBRD-Green-Bond-Impact-Report-FY-2019.pdf

77. U.S. Global Change Research Program. (2021). *National Climate Assessment.* Retrieved January 09, 2021, from url: https://nca2014.globalchange.gov/report#menu-report

78. United Nations - Inter-agency Task Force on Financing for Development. (2020). *Financing for Sustainable Development Report 2020.* New York: United Nations. Retrieved September 12, 2020, from url: https://developmentfi nance.un.org/fsdr2020

79. Xiao, Y., Faff, R., Gharghori, P., & Lee, D. (2013). An Empirical Study of the World Price of Sustainability. *Journal of Business Ethics, 114*, 297–310. doi:https://doi.org/10.1007/s10551-012-1342-2

80. Zerbib, O. D. (2018). Is There a Green Bond Premium? The Yield Differential Between Green and Conventional Bonds. *Journal of Banking and Finance, 98*, 39-60. doi:https://dx.doi.org/10.2139/ssrn.2889690

APPENDICES

Appendix 1: Povzetek v slovenščini

Upoštevanje etičnih vrednot, kot je okoljska trajnost, je v finančnem svetu že od nekdaj veljalo za potencialno izgubo dobičkonosnosti. Vendar so zaradi nedavnih zaskrbljujočih podnebnih trendov in sprememb politike, ki so posledica večjih podnebnih zavez iz Pariškega sporazuma, vlagatelji postali veliko bolj pozorni na okoljske zunanje učinke poslovnih dejavnosti. Posledično se je prevladujoči odnos močno spremenil in precejšen delež deležnikov, od potrošnikov do vlagateljev, zdaj ne le spodbuja, temveč zahteva višjo raven preglednosti in skladnosti z etičnimi standardi. V zvezi s tem postajajo okoljska, družbena in upravljavska merila (angl. ESG) vse pomembnejša pri proučevanju in izvajanju vsakršne poslovne strategije. Danes mnoga podjetja, zlasti tista s sedežem v Evropi, ki se ukvarjajo z dejavnostmi, ki so okolju nevarne, temeljito preučijo svoje proizvodne načrte, preden jih bi sploh izvedeli. K temu zagotovo pripomorajo podnebni predpisi in standardi EU, pa tudi prenovljeno poslovno okolje, ki je začelo resno upoštevati podnebju prijazne izdelke in projekte.

V okviru te magistrke naloge je bila opravljena primerjalna analiza pojava globalnih zelenih in konvencionalnih obveznic. Rezultati zato prinašajo dober pregled, tudi finančnih značilnosti, kar omogoča podrobnejši empirični vpogled v razvoj trajnostnega financiranja, natančneje zelenih obveznic. Naslednja raziskava prikazuje, ali oznaka "zelena" pomeni drugačno finančno uspešnost zelenih obveznic v primerjavi s konvencionalnimi obveznicami ali ne. Pri zelenih obveznicah je edina značilnost, ki jih razlikuje od običajnih obveznic, uporaba prihodkov (angl. Use of Proceeds), zato vlagatelji zelenih obveznic, ne bi smeli pričakovati bistvenih razlik v donosnosti v primerjavi s tradicionalnimi naložbami v navadne obveznice. Kljub temu bi lahko okoljska podoba sčasoma prinesla dodatno vrednost, zato bi lahko zelene obveznice veljale za boljšo izbiro kot naložba na splošno. Hipoteza teze temelji na teh argumentih.

Študija je zarati tega izvedena z uporabo razširjenega Fama-Frenchovega pristopa, upoštevajoč različne lastniške in obvezniške dejavnike, ki zajemajo večino temeljnih značilnosti trga obveznic. Ti dejavniki so bili raziskani in uporabljeni v prejšnjih študijah delniškega trga, se pa lahko nanašajo tudi na trg obveznic. Tako imenovani Fama-Frenchovi faktorji predstavljajo premijo za tržno tveganje, premijo za velikost in vrednost ter Carhartov faktor in proxy za strukturo zapadlosti in verjetnost neplačila ter drugi dodatni faktorji, primerno konstruirani za analize na trgu obveznic.

Rezultati te analize kažejo, da na podlagi vzorca obveznic, izdanih v EUR, obstajajo statistična dokazila, da so vlagatelji pripravljeni žrtvovati del svojega pričakovanega donosa za financiranje trajnostnih projektov. Ti rezultati so v nasprotju s prvotnimi pričakovanji, da ni razlik v donosnosti med zelenimi in običajnimi obveznicami, pri katerih naj bi vlagatelji financirali prehod na okolju prijazne projekte, ne da bi pri tem izgubili kar koli v smislu pričakovanega donosa. Narava negativne premije za zelene obveznice še ni jasna, vendar kaže na velik priliv naložb v trajnostno financiranje, ki je lahko tudi posledica strategije diverzifikacije portfelja finančnega sektorja, ki si prizadeva postati vodilna sila zelenega vlaganja.

Za pridobitev zanesljivih rezultatov in določitev, kateri od najpogostejših faktorskih modelov je najprimernejši za določanje donosnosti obveznic, je bilo preizkušenih več najbolj razširjenih modelov, pri čemer je bilo z uporabo pristopa Fama-Macbeth prikazano, kateri od njih najbolje pomaga pojasniti variabilnost donosnosti obveznic. Pri tem, kot je prikazano v razdelku o glavnih rezultatih analize, se pojasnjevalna moč modelov povečuje z dodajanjem večjega števila pojasnjevalnih spremenjlivk. Empirični rezultati pa tudi potrjujejo, da modeli, ki vključujejo več spremenljivk, delujejo bolje kot enostavnejši, kar poudarja pomembnost vključenih spremenljivk. Da bi bilo mogoče primerjati kakovost modelov z različnim številom dejavnikov, je dobra praksa namesto običajnega R^2 prikazati R^2_{adj}. Študija prikazuje, da enostavnejši model CAPM lahko sam pojasni le 4% variance modela, kar je preprosto premalo tudi pri tako preprostem modelu. Če nadaljujemo s trifaktorskim modelom Fama-French, se je splošna kakovost močno izboljšala in model lahko zdaj pojasnjuje dobrih 38% variabilnosti. Dodatno, Carhartov štirifaktorski model, z dodajanjem faktorja dinamike finančnega trga (angl. momentum factor) je pomemben zato, da se ugotovi, ali zagon delniškega trga na splošno pomaga pri pojasnjevanju tega študije obvezniškega tržišča. V tem primeru je pojasnjevalna moč še večja, saj se R^2_{adj} poveča za 5 odstotnih točk in doseže sedaj dobrih 43%. Nazadnje, šestfaktorski model s skupno vrednostjo 52% kaže, da lahko spretna kombinacija dejavnikov, značilnih za svet delniškega in obvezniškega trga, znatno izboljša skupno veljavnost in pojasnjevalno moč in torej relevantnost analize.

Vseeno, izkazalo se je, da je cenovna napaka (angl. pricing error) v vseh modelih v tej analizi statistično značilna in precej visoka, v okviru 17 do 33 bazičnih točk. Istočasno je pa zanimivo zaznati, da se značilnost te napake zmanjšuje s povečanjem števila relevantnih spremenljivk in torej kakovosti modela. Na drugi strani, če namesto tega pogledamo "zeleno dummy", spremenljivko, ki nas najbolj zanima v tej analizi, je jasno, da koeficienti ostajajo statistično značilno negativni in različni od nič pri vseh modelih, kar kaže, da je pomembno, ali je obveznica zelena ali ne, vsaj za izdajanja, denominirana v eurih. Negativni koeficient se statistično značilno razlikuje od nič in dosega najmanj negativnih -17 bazičnih točk, kar prikazuje precejšnje zanimanje vlagateljev za segment trajnostnih obveznic. Z druge strani pa glavni šestfaktorski model ostane le delno konsistenten po spremembi nabora podatkov, tako da prikazuje novejše izdaje in enako po spremembi spremenljivke ki zajema in prikazuje uspešnost delniškega tga, v tako ki temelji le na uspešnost obvezniškega trga. Poleg tega se opažajo zanimivi rezultati, vendar morda ne dovolj robustni, ko so bile obveznice razvrščene v skupine po njihovi bonitetni oceni, pri čemer se zdi, da je negativna premija zelo izrazita pri zelenih obveznicah z oceno BBB in ne pri varnejših obveznicah, kjer je namesto tega opazen pozitiven znak pred zelenim dummyjem. V primeru, da bi bili rezultati dovolj zanesljivi, bi se postavilo pomembno vprašanje, ali vlagatelji različno zaznavajo tveganje pri istih bonitetnih kategorijah, vendar z različno uporabo pridobljenih sredstev namenjenih financiranju zelene transformacije.

Nazadnje je pa tudi primerno priznati, da trg zelenih obveznic obstaja šele približno desetletje, zato bi bilo vsekakor zanimivo nadaljevati z izvajanjem podobnih študij tudi v prihodnjih letih. Seveda, je sedaj mogoče izvesti nadaljnje raziskave lahko samo s podatki in pristopom, specifičnim za posamezen sektor, državo ali podjetje, kar bi omogoča odkrivanje še novejših dosežkov na področju trajnostnega financiranja. Ob tem, se lahko nadaljnje raziskave opravijo tudi na področju učinkov koristi trajnostnega označevanja teh neopredmetenih sredstev, kar bi dodatno prispevalo k ustvarjanju dodane vrednosti na področju trajnostnega razvoja in s tem spodbudilo nadaljnji akademski razvoj na tem področju.

Appendix 2: Other Descriptive Statistics of the Bond Dataset

Table 5: Other Descriptive Statistics of the Bond Dataset

Type	**Amount Issued (in EUR)**				**Issue Date**		**Maturity Date**	
Green Bond	**Mean**	**Std. Deviation**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
NO	595,230,769.23	346,718,053.01	1,500,000,000.00	5,000,000.00	**12/28/2018**	**3/11/2015**	**10/5/2029**	**11/3/2020**
Agency	600,000,000.00	212,692,489.85	1,000,000,000.00	50,000,000.00	11/26/2018	4/20/2015	11/26/2025	11/3/2020
Corporate	661,969,696.97	312,971,920.98	1,250,000,000.00	15,000,000.00	12/28/2018	9/22/2015	10/5/2029	2/5/2021
Other Gov/Supra	385,909,090.91	522,410,576.00	1,500,000,000.00	5,000,000.00	5/24/2018	3/11/2015	5/24/2028	11/21/2024
YES	751,839,323.53	541,518,110.18	5,000,000,000.00	15,000,000.00	**12/10/2018**	**8/20/2013**	**11/26/2029**	**6/9/2020**
Agency	888,448,275.86	749,640,262.52	4,000,000,000.00	15,000,000.00	11/30/2018	8/20/2013	11/30/2028	8/20/2020
Corporate	640,217,391.30	249,383,929.00	1,500,000,000.00	100,000,000.00	10/11/2018	2/26/2014	11/26/2029	6/9/2020
Govt/Treasury/ Central Bank	1,717,447,500.00	1,515,574,146.30	5,000,000,000.00	500,000,000.00	2/7/2018	12/20/2016	8/7/2026	12/20/2021
Non-US Munis	300,000,000.00	-	300,000,000.00	300,000,000.00	12/10/2018	9/10/2014	11/22/2027	9/19/2022
Other Gov/Supra	937,789,473.68	469,646,628.52	2,050,000,000.00	18,000,000.00	**12/28/2018**	**8/20/2013**	**11/26/2029**	**6/9/2020**

Source: Own Work.

Appendix 3: Descriptive Statistics of the Regressors

Table 6: Descriptive Statistics of the Regressors

	Mean	Median	Standard Deviation	Kurtosis	Skewness	Range	Minimum	Maximum	Observations
RF	0.0021	0.0000	0.0041	0.0757	1.4407	0.0100	0.0000	0.0100	2516
$MKTRF$	0.0532	0.0750	0.9585	4.3861	-0.4227	12.0300	-6.9700	5.0600	2516
$MKTRF\_bond$	0.0004	0.0008	0.0082	3.4406	-0.5009	0.0972	-0.0590	0.0383	2516
SMB	-0.0017	-0.0100	0.5168	1.5983	0.1891	5.6100	-1.9900	3.6200	2516
HML	-0.0100	-0.0300	0.5031	1.9024	0.3553	5.0200	-1.9400	3.0800	2516
RMW	0.0060	0.0000	0.3405	1.5520	0.0266	3.2900	-1.6300	1.6600	2516
CMA	0.0009	-0.0100	0.3007	1.9647	0.3505	3.2800	-1.3200	1.9600	2516
MOM	0.0190	0.0500	0.7024	2.0453	-0.3155	7.4500	-3.8100	3.6400	2516
DEF	0.0001	0.0001	0.0044	1.3320	0.1105	0.0436	-0.0194	0.0242	2516
$TERM$	-0.0142	0.0010	0.9420	53.5208	-1.0665	23.6660	-13.3395	10.3265	2516

Source: Own Work.

Appendix 4: Correlation Matrix of the Regressors

Table 7: Correlation Matrix of the Regressors

	RF	$MKTRF$	$MKTRF\_bond$	SMB	HML	RMW	CMA	MOM	DEF	$TERM$
RF	1.0000									
$MKTRF$	-0.0056	1.0000								
$MKTRF\_bond$	0.0031	0.8166	1.0000							
SMB	-0.0086	0.3375	0.2221	1.0000						
HML	-0.0229	0.1070	0.0897	0.0595	1.0000					
RMW	-0.0058	-0.4196	-0.3167	-0.3412	-0.1742	1.0000				
CMA	-0.0041	-0.1289	-0.1158	-0.0020	0.5901	-0.0105	1.0000			
MOM	0.0005	0.0029	0.0029	-0.1105	-0.3582	0.0092	-0.1425	1.0000		
DEF	0.0003	-0.0545	-0.2042	-0.0200	-0.0897	0.0413	0.0083	-0.0013	1.0000	
$TERM$	0.0075	-0.0242	-0.0030	-0.0259	-0.0199	0.0633	0.0039	0.0100	0.0249	1.0000

Source: Own Work.