Universidade do Minho
Escola de Economia e Gestão

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Green Bonds, Conventional Bonds and their "Black Peers": a PortfolioPerformance Comparison.

July 2021

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UMinho | 2021

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Dissertação de Mestrado
Mestrado em Finanças

Trabalho efetuado sob a orientação da
Professora Doutora Florinda Cerejeira Campos Silva

Julho de 2021

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ACKNOWLEDGEMENTS...

This has been a great journey, filled with obstacles and challenges that overall contributed to my growth, not only regarding finance, but also in other areas, such learning additional languages other than Stata or R, since "SQL" was probably the most important tool that I had to deal with in order to proceed with this work. I feel like I gained value, and that is the best feeling.

I am thankful to my parents, my mom and dad had an immense role in all of this, giving me the opportunity to pursue this education, always being there for me and the most important part, cheering me up when things did not go that well. Without them, this would not be possible.

I would also like to thank Professor Florinda Silva, my supervisor, for all the time spent on reunions, all the emails, all the information shared and her opinions. Especially on those moments when I found myself stuck.

Also, I am thankful to my friends, that helped me through all this process, staying there for me during the hard times, checking up on me, and most importantly, being part of this journey.

At last, I want to thank all the professors that in some way impacted my path, stimulating my curiosity about everything, showing and passing into me their passions.

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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RESUMO

Foi nestes últimos anos que as campanhas ambientais têm sido mais expressivas e eficientes, fazendo com que as pessoas estejam mais sensíveis em relação à atual situação ambiental. O objetivo desta dissertação é analisar e comparar a performance financeira de Obrigações Verdes, Obrigações Convencionais e Obrigações "Black" emitidas no mercado internacional de obrigações, para ver se as obrigações verdes conseguem ser um bom ativo financeiro de renda fixa, como elas podem ter um papel fulcral em financiar as mudanças necessárias para resolver os atuais e futuros desafios ambientais que o mundo enfrenta. Usando uma amostra composta por 1118 obrigações verdes, 91939 obrigações convencionais e 560 obrigações "Black", emitidas entre Janeiro de 2010 a Março de 2021, que depois de um processo de "matching", são incluídas em 4 carteiras diferentes. Uma carteira de obrigações verdes com 302 obrigações, que faz "match" com uma carteira de obrigações convencionais com 302 obrigações, e uma carteira de obrigações verdes com 273 obrigações que fazem "match" com uma carteira de obrigações "Black" com 273 obrigações.

A análise da performance destas carteiras é efetuada usando um modelo de quatro fatores, para o período de Janeiro de 2015 até Março de 2021. Os resultados sugerem que existe um fraco desempenho da carteira de obrigações "All Black" no período analisado, e na carteira de obrigações "Matched Black" no subperíodo de 2017 a 2019. Também existe um fraco desempenho estatisticamente significativo a 10% quando comparando o retorno da carteira "Matched Green" e "Matched Convencional" durante o período de Janeiro de 2015 a Março de 2021, e um fraco desempenho por parte das carteiras de obrigações Verdes em comparação com a carteira de obrigações "Matched Convencional" nos subperíodos de 2016 até 2018, 2017 até 2019 e 2018 até 2021, quando o Índice de Mercado de Obrigações Convencional é utilizado. Quando se considera o Índice de Mercado de Obrigações Verdes, os resultados sugerem que não existe rendibilidade anormal para nenhuma das carteiras, e que não há diferenças ao nível do desempenho das carteiras de obrigações Verdes, "Black" ou Convencionais. Em ambos os cenários, a nível dos fatores de risco, obrigações "Black" têm uma maior exposição ao fator de risco de incumprimento, evidenciando que são obrigações mais arriscadas quando comparadas com obrigações Verdes.

PALAVRAS-CHAVE: combustíveis fósseis; meio ambiente; obrigações black; obrigações convencionais; obrigações verdes;

ABSTRACT

It was on the last couple of years that the recent environmental agenda has been more expressive and effective, making people more sensitive to the current environmental situation. The aim of this dissertation is to analyse and compare the financial performance of Green Bonds, Conventional Bonds and "Black" Bonds issued on the international bond market, to see if green bonds can be a good fixed-income financial asset for investors, as they can have a major role on financing the necessary changes to solve some of the current and future environmental challenges that the world faces. We use a dataset composed by 1118 green bonds, 91939 conventional bonds and 560 black bonds, issued between January 2010 to March 2021, that after a matching process, turns into four different portfolios: A green bond portfolio with 302 bonds, that matches with a conventional bond portfolio with 302 bonds, and a green bond portfolio with 273 bonds that matches with a black bond portfolio with 273 bonds.

The performance of these portfolios is evaluated using a four-factor model, for the period of January 2015 to March 2021. The results suggest that there is an underperformance of the All Black bonds portfolio from January 2015 to March 2021, and the Matched Black bonds portfolio on the sub-period of 2017 to 2019. There is also a small and statistically significant (at 10% level) underperformance of the Matched Green and Matched Conventional portfolio during that same period, and an underperformance from the Green bond portfolios when compared to the Matched Conventional bond portfolio on the sub-periods of 2016 to 2018, 2017 to 2019 and 2018 to 2021, when using the Conventional Bond Market Index. When considering the Green Bond Market Index, the results suggest that there is no abnormal performance for none of the portfolios, and there are no differences regarding the performance of Green, Black or Conventional bond portfolios. On both scenarios, in terms of risk, black bonds have a higher exposure to the default risk factor, showing to be riskier bonds when compared to green bonds.

KEYWORDS: black bonds; conventional bonds; environment; fossil fuel; green bonds

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1. INTRODUCTION

Sustainability and the environment have been now more than ever, relevant subjects on the daily life of the population. Nowadays, people are more aware about the current environmental problems, and therefore, they take this into consideration when it comes to their consumption, activities and overall decision making, in order to preserve that same sustainability and the future of the next generations.

As any other person, investors can also have an impact and adopt these changes, but are they aware of it? Investors can have a part on this pursue for sustainability and environmentally friendly practices, by taking into consideration the issuer purposes and procedures, filtering out the investments that do not benefit these kinds of environmental practices.

One way to do it, is to invest on financial assets whose purposes are to finance these environmentally friendly projects, and that is when green bonds enter in the scenario.

At the moment, a general definition or standard for a green bond or what make a bond green is not available, although it can be seen as a fixed-income financial instrument used to gather capital to finance green projects, as these projects are meant to create environmental and climate benefits.

To this extent, green bonds can play a major role in the process of changing the usage of fossil resources, and by that create more environmentally friendly projects in order to help reducing the environmental problems that the world faces, as the futures challenges for sustainability and the environment.

The first green bond was issued in 2007 by multilateral institutions European Investment Bank (EIB) and World Bank, with an AAA-rating. Since then, the amount of green bonds issued has increased a lot. Just to have an idea, according to Chestney (2020, 16 January), the global green bond and loan issuance almost reached the value of 255 billion Dollars in 2019, which at the time, represented an increase of almost 50% of the value reached in 2018, which was around 171.4 billion Dollars. On that same article, it was stated that according to the values reached in 2019 and the estimates for 2020, the milestone for 2021/2022 was to reach the 1 trillion Dollars mark on green investments. According to Jones (2021, 24 January), the record for green issuance was broken again, with a total of 269.5 billion Dollars for 2020, in a year that with the pandemic it was expected to slow down the growth, but the third quarter of the year showed a record-breaking increase that compensated for the slow second quarter.

Statistics show that specially since 2014, the market growth increased drastically to the point that the green bond market reaches new highs in terms of issuance at the end of each year, even on a

slow year as 2020 was. Even though this market is still rather small when compared to the conventional bond market, it shows great potential, especially during these times when the population itself is faced with the current problems and is educated with the existent environmental campaign.

These types of bonds can be issued by both private or public institutions. In fact, various city governments decided to use this type of asset to finance projects related to more ecological transports, or some other types of energy sources.

As Fatica and Panzica (2021) suggested, these green bonds really do have an impact on the reduction of carbon emissions by the issuer, especially if it is the case of a first emission, the bonds had an external review or if those bonds were issued after the Paris Agreement. The Paris Agreement, that was established in 2015, according to Glavas (2018) turned investors' attention, especially equity market investors, into the green bond scenario.

An important question is if investors are willing to filter their portfolios, in order to incorporate these green bonds, and to which point that could in some way decrease their returns. If investors have a "Rational Behaviour", as it was stated by Miller and Modigliani (1961), they will always prefer more wealth than less, either in form of cash or creation of value on their holdings. Therefore, if green bonds did not present at least the same level of returns or better, the usual "rational" investor would not even consider it.

The main objective of this dissertation revolves around this topic. The main questions that this research will try to answer are the following. Are green bonds a good alternative type of fixed-income investment for investors that are more conscious about the impact of their decision regarding investments? Investing on portfolios composed by green bonds can be appealing to investors that do not care about socially responsible investments, and their only objective is to maximize wealth? If green bonds do not have a similar performance or return to other types of bonds, these types of investors will not consider them as a viable option.

A similar study was conducted by Ibikunle and Steffen (2017), where in their case, they focused on green mutual funds, conventional funds and their "black peers", for a period between 1991 and 2014.

In order to draw accurate conclusions, we analyse and compare the performance of portfolios composed only by green bonds with portfolios composed of conventional bonds, and at last, portfolios only composed of what is going to be called "Black" bonds. These Black bonds are bonds issued by companies that are directly or indirectly connected with fossil fuel extraction, transformation, and transportation (type of activities that prejudice the environment), in the same way that bonds issued by financial institutions with the aim of financing these activities will also be taken into consideration as black

bonds. What these different types of bonds share all in common, is the fact that they were all issued on the international market.

By analysing and comparing their performance, it might be possible to see if there is any type of outperformance when compared to each other, and perhaps reach some conclusions that could benefit the green bond investments in the investor's perspective, or simply show if fossil fuel divestment is something that investors should do in order to increase their returns.

This is a relevant topic in the way that, considering the current situation that the world faces in terms of all the environmental problems that are being dealt with, and the ones that are about to come, it is indeed necessary to take into consideration sustainability and the impact of our actions as investors and citizens. Therefore, by analysing and comparing the performance of these three types of bonds, it might be possible to discover if green bonds can be a good investment not only on their environmental impact, but also financially, gathering more attention from investors, and perhaps divest from fossil fuels bonds to channel that capital to the green bond market, which creates beneficial impact on the environment, and perhaps positive impacts return wise. To the best of my knowledge, this is the first research that evaluates the financial performance of green bond portfolios, but also compares them with conventional bonds and black bonds (bonds linked to companies or institutions whose activities are related to fossil fuel).

The data used is gathered using Refinitiv Eikon Datastream, regarding bonds issued on the international bond market during the time period of January 2010 to March 2021. Those bonds had certain characteristics that permitted to identify them has green, conventional or black, and after that, in order to build comparable portfolios, a matching process that matched green bonds with conventional bonds, and green bonds with black bonds is performed, respecting some standards and making the best possible match between a green bond and a conventional bond, or in the other case, a green bond with a black bond.

The methodology used to assess portfolio performance is based on the multi-index model proposed by Elton et al. (1995). Two alternative versions of the model are considered, one using a conventional bond market index as the benchmark, and another one using a green bond index, to see if that would have any impact on the results. Value-weighted portfolios are analysed during the time frame of January 2015 and March 2021.

This dissertation is divided on a total of 6 chapters, starting with the current introduction, which mentions why this topic is important, and how the research will evolve. Secondly the literature review, which is organized by topics in different sections. Thirdly, the methodology, which shows how the portfolio

returns were calculated, and the performance model used. Then the fourth chapter, focused on explaining the data gathering process, the matching procedure, and some descriptive data on the portfolios. The fifth chapter, that shows the results for both the conventional and green bond market index. And at last, the sixth chapter, about the conclusions of this dissertation, and possible research to be done in the future.

2. LITERATURE REVIEW

This chapter of the dissertation introduces a small part of the existent literature on the subject of green bonds.

As it was stated before, green bonds are somewhat a recent type of financial asset, considering that the first issuance of a green bond happened in 2007, by the European Investment Bank, labelled as a Climate Awareness Bond, and the first official green bond was issued in 2009, by the World Bank in a value of $157 billion. Therefore, even though there is growing number of studies on the subject, since they are so relatively new, the time period of the data analysed is rather short when compared to studies on other types of bonds, and most research are focused on their pricing/yield spread rather than other areas.

The literature review is divided into different areas or types of research. Some of them strictly on green bonds, and others related to Environmental, Social and Corporate Governance (ESG) or Corporate Social Responsibility (CSR).

2.1. Green Bond definition and Greenwashing

One of the main topics that is mentioned in the green bond literature is the lack of a specific or general definition, or eligibility criteria for green bonds. Some of the existent green bond literature, such as Reboredo et al. (2020), state that the issuance of green bonds is one of the possible methods that issuers have in order to gather capital for environmentally friendly projects. The only problem is that this vague definition opens up the opportunity to some issuers to launch their bonds entitled as green bonds to attract investors that go with the current environmental trend, when in reality the capital is not used properly for friendly environmental projects. This type of practice, where the issuer does not apply the proceeds in the friendly environmental way that they originally stated is called greenwashing.

This is somewhat problematic, since some investors might stay away from this type of asset, because even though they are interested on going for an environmentally friendly investments, they are not sure if the issuer they are financing is indeed going to use the capital as they initially specified that they were (Fatica et al., 2021).

For Ntsama et al. (2021), the nonexistence of a specific criteria that defines what is considered a green bond, may lead some issuers to be afraid of launching bonds into the market and be accused of greenwashing. Or even another scenario, like the one mentioned by Parguel et al. (2011), where some

corporate brands or companies, that are well known for their good corporate socially responsible practices, took advantage of their own reputation and decided to stop their responsible practices while still communicating into the press or other reports that they still follow those socially responsible principles.

In order to surpass this type of problem, where the investors do not trust the companies because they do not have an already established reputation, the issuer can verify their bonds with a third-party certification. Bachelet et al. (2019) show that issuers that do have an already established reputation or have their green bonds certificated by third-party institutions are able to get a negative premium due to investors' disposition to pay for environmentally friendly bonds or because since they are certified or issuers have enough good reputation, investors do not have to worry about the greenwashing problem. Along the same subject, Baker et al. (2018) also conclude that green bonds that have external reviews or certifications and that are publicly registered on the Climate Bond Initiative database, when compared to self-labelled green bonds, can benefit from higher premiums. Fatica et al. (2021), not only conclude the same as the others, but also find that in terms of the reputation of the issuer, entities that have issued more than one green bond benefit from an extra premium when compared to those that are issuing green bonds for the first time. More research on this topic of the impact of external certification on the green bond price will be covered on the next section of this chapter.

Therefore, it is possible to conclude that, as Baker et al. (2018) or even Baldacci and Possamaï (2021) said, there is a necessity for a specific definition or standard regarding green bonds, to improve the transparency of the market or even standardize what green bonds are to improve or simplify the certification process. Not forgetting that this type of certification also translates into an extra cost for the issuer, which could be reduced or eliminated with a universal definition.

2.2. Green Bond Pricing/Yield

As mentioned on the introduction to this section, the topic of Green Bond Pricing or Yield has been the main research focus on this type of financial asset. The main conclusion that can be drawn from several studies on this topic is that there is indeed a difference on the pricing and yield of green bonds when compared to conventional bonds, but it is not possible to conclude the same thing regarding "Black bonds", because to our best knowledge, such a comparison has not been done yet.

According to Hachenberg and Schiereck (2018), green bonds are priced differently from conventional bonds. The authors approached this question by comparing the price differentials from green bonds and conventional bonds, concluding that green bonds do not trade significantly tighter than conventional bonds. However, when looking into it with more detail, it was possible to see that other specific factors ended up having an impact and creating this differential between those two types of bonds. For example, single A-rated green bonds trade significantly tighter when compared to conventional bonds, and even though it was not statistically relevant, AA and BBB rated green bonds also traded economically tighter. And regarding the certification or a second opinion of green bonds, even though they can be expensive, for bonds with ratings of AA, A, BBB, the difference on price can compensate the expenses on such external certification.

Hachenberg and Schiereck (2018) are not the only authors that confirm this effect of an external certification or an external opinion on the green bond prices and yields. Actually Hyun et al. (2020), Bachelet et al. (2019), Fatica et al. (2021), Baker et al. (2018) and Löffler et al. (2021) are some of the many others that draw the same conclusion.

Hyun et al. (2020) measure the so-called green bond premium as the liquidity-adjusted ask yield spread between a green bond and its synthetical counterpart. The level of greenness information, corresponding to how transparent they were with the capital gathered and their external certification, had significant effect on the level of the green bond premium. In fact, an external reviewed green bond with a certificate by the "Climate Bonds Initiative" had a 15-basis points discount, when compared to green bonds without certification, or in case the bond is certified by another institution, then they had a 6-basis points discount. The reason behind it would be that investors require a lower yield on this type of certified green bonds because they are exposed to lower information cost. They also find that other factors such as the issue size of the issue end up having an impact on the green bond premium, and that a term premium exists on the green bond market.

For Bachelet et al. (2019), institutional green bonds displayed negative premium and were more liquid, but at the same time, when compared to similar brown bonds, private green bonds showed a positive premium and were more liquid than their brown matches. This positive premium effect was even stronger for green bonds that did not have a certification. At the end, they conclude that green bonds can indeed have a negative premium and with that, issuers can raise money at a discount, but for that to happen, the issuer has to be already well established, with a good public reputation or they need that external certification, because as Hyun et al. (2020) argue, it reduces asymmetric information, making it

more transparent, and it takes all the doubts that the investor could have regarding greenwashing. These factors help investors to pay a bit more for these types of bonds, since some of them are willing to pay for environmental sustainability, and with such information, they are less exposed to stakeholder risk on green investments.

Fatica et al. (2021), also analyse the impact of the certification and reputation on the pricing of the bond. When comparing green bonds with external certification, and self-labelled green bonds, they conclude that the ones with external review gained a bigger premium, and that issuers that were not issuing green bonds for the first time, benefited as well from a larger premium due to the reputation effect. When only considering supranational institutions and non-financial corporate green bond issuers, they found that they benefited from a premium when compared to ordinary bonds. Another interesting finding was that green bonds issued by financial institutions did not benefit in terms of price when compared to conventional bonds, but at the same time, these financial green bond issuers reduced their lending to sectors with higher emission intensities, showing an increase on the greenness of the banks' balance sheet.

To add to it, Baker et al. (2018), other than showing the positive effect of certification on green bonds, also conclude that green bonds were issued at a premium, with lower yields, when compared to similar ordinary bonds. And in particular, green bonds with small par value or those that are almost riskless, were more closely held by investors than ordinary bonds.

Also addressing the subject of the external certification effect on prices, Löffler et al. (2021) also show that having what they call as "Green Label", makes investors pay a bit more for bonds that do not have it. The authors also concluded that green bonds are more likely to be senior unsecure debt, the amount issued is usually bigger than those of conventional bonds, and the yield of green bonds was lower than conventional bonds by an expressive amount of 15 basis points or 20 basis points, depending on if they were in the primary market or secondary market, and at last, that green bonds usually have a lower underlying risk.

One of the most recognized papers on green bond pricing is Zerbib (2019), who finds a small negative premium, meaning a lower yield for green bonds when compared to conventional bonds. The premium was on average -2 basis points. At the time of the research, whose sample of bonds covered July 2013 to December 2017, the author concludes that there was a low impact of investors pro-environmental preferences on bond prices, which means that investors do not have a disincentive to support green bonds and their market.

Another interesting approach was the one by Febi et al. (2018), since they analysed the difference on yields of green bonds and conventional bonds from the liquidity risk perspective. From 2014 to 2016, green bonds were on average, more liquid than the matched conventional bonds. When using the LOT liquidity measure, which was named after the authors (Lesmond et al., 1999), and the bid-ask measure it showed that both types of measure were positively related to the yield spread. As on the fixed-effects of their model, only the LOT liquidity measure appeared to be relevant for green bonds. Also, on the most recent years of the research, the liquidity risk on the yield spread of green bonds was insignificant.

Comparing the results of the research analysed on this topic, it is possible to conclude that green bonds indeed benefit from a premium, with lower yields when compared to conventional bonds. The results are even more expressive when it is taken into consideration the existence of green bond certification, or if it is not the first time that the issuer decides to issue green bonds and there were no problems associated with it. What might explain this type of results is the investor willingness to spend a bit more for greenness, since green bonds are usually associated with better ratings and less risks, and at the same time, the idea that such investment is having a positive impact on the environment.

2.3. Green Bond Issuance Impact on the Issuer

In this section, we focus on studies that aim to show the impacts that the issuance of green bonds ends up having on the issuer itself. The impact could be on the stock and firm's value, the ability of lowering the cost of capital, the issuer image to the public, the improvement of the issuer environmental impact, and many others.

Flammer (2021) finds that by issuing green bonds, the companies show some signs of environmental commitment, that would later translate to a positive reaction on the firm stocks. Also, the companies that issue green bonds improved their environmental and financial performances and became more appealing to investors that are sensitive to the environment.

Similar results are obtained by Zhou and Cui (2019), since they find that announcements of green bonds issuance had a positive impact on the stock prices of the issuer. Not only that, but green bond issuance also had an impact in improving the company's profitability, their operational performance and improved their capacity for innovation. These green bonds also produced significant economic and environmental benefits, along with a natural increase on the companies CSR activities. Glavas (2018)

also finds that the issuance of green bonds had a positive impact on the stock prices of the issuer, and another interesting finding was that the Paris Agreement brought the attention of equity investors into the green bond scenario.

Also supporting the idea that green bond issuance had a positive impact on the stock prices, Tang and Zhang (2020) confirmed that with such a positive impact on the stock prices, the issuance of green bonds ended up being also favourable to shareholders since it would drive them into net profit, and that in terms of the public image of the issuer, green bonds were able to attract media exposure and investors with environmental criteria.

Zhang et al. (2021) show that after issuing green bonds, the issuer benefits from a stock liquidity improvement, a reduction of their perceived risk, also a decrease in terms of information asymmetry and creation of corporate value. Another interesting conclusion was that since green bonds have a lower yield when compared to non-green bonds, then the issuers of green bonds were able to reduce the cost of debt. Li et al. (2020) reaches a similar conclusion, since they show that green bonds have indeed a lower interest cost, which would translate into a lower cost of capital. Also, the authors argue that green bonds certification could act like some type of credit rating for the bond.

Similar conclusion was reached by Gianfrate and Peri (2019), in the way that the authors show that green bonds reduce the cost of capital for organizations or issuers that needed to finance or even re-finance green projects.

And at last, Nanayakkara and Colombage (2019), that not only show that the reason behind the green bonds' premium was mostly due to lower risk, but they also argued that issuers could take advantage of the current demand of investors for green bonds. According to them, the green label incentives issuers to raise funds through green bonds, and those investors can use those bonds as an opportunity to diversify their investments. Another interesting topic that is covered on this study is regarding the external certification of green bonds, as some issuers do not want to improve the credibility of their bonds because of the high cost associated with the external certification. Even though the external review effect could cover that same cost, if there was a standard definition or regulation for this type of bonds, such costs could decrease or disappear. Also, to attract more investors, the institutions should issue green bonds on the local currency, since that would attract more investors as they would escape from the foreign exchange risk, and that there is an issuer effect related to the issuer reputation or public image.

Considering these studies, it is possible to conclude that there are several benefits for institutions to issue green bonds, especially if they are externally reviewed or certified. Green bonds are a good source of financing, since they present a lower cost of debt when compared to conventional bonds, and even with the extra cost of a possible certification, the cost of debt can be even lower. Green bonds can improve the financial performance of the issuer and create value for shareholders, due to the positive impact that their issuance has on stock prices. It does not only benefit the issuer's financial performance, but naturally improves the environmental performance of the company, improving their innovation capacity. And with such commitment towards the environment, the issuers become more attractive for certain types of investors that are more sensitive to the environment, and that take into account the impact that their investments have on the world, as green bond issuance can impact the reputation of the issuer.

2.4. Performance of Portfolios/Funds with ESG Criteria and Impact on the Issuer

This section of the literature focuses on the research regarding the performance of portfolios or funds that take into consideration ESG or CSR criteria. Most of the existent studies focus on the financial performance of Socially Responsible Investing (SRI) equity mutual funds, not in portfolios of bond funds. According to Rudd (1981), by using any type of social responsibility criteria on portfolios with stocks or bonds, it would increase the investment risk, except on some rare circumstances. Therefore, at that time, using ESG or CSR criteria was seen as a risk, and perhaps not worth it, because they would miss out on some other rentable investment opportunities. But since then, the market has changed, and new research shows positive results for bond portfolios with ESG criteria, and positive effect for issuers with CSR activities, similar to the conclusions shown on the green bond section.

For example, Pereira et al. (2019), conclude that investors can take into account ESG criteria when selecting bonds for their portfolio without renouncing on financial performance, although high-rated portfolios based on environmental and ESG scores were significantly more exposed to the default factor.

On the other hand, Harjoto et al. (2020) show that bond portfolios that did not take into account CSR concerns had a higher mean annualized excess return than the ones that did consider them. Actually, they find that bonds from companies without CSR concerns present a better reward-to-risk ratio in bonds. Furthermore, bond portfolios with CSR concerns had a negative abnormal return, while the ones without CSR concerns had a positive abnormal return. According to the authors, bondholders see CSR investments as a risk shifting tactic by the shareholders.

Henke (2016), using a sample covering the period of 2001 to 2014 conclude that socially responsible bond funds did outperform by one-half of one percent annually. This outperformance was directly related to the relief of ESG risks, risk that decreased because of the elimination of corporate bond issuers that had poor CSR activities, and it was most likely to occur during recessions or bear market periods. Another interesting finding was that fund managers of these types of funds seemed to exclude bond issuers with the highest ESG risks, using as indication the lowest ESG ratings. This type of "worst-in-class" exclusion instead of a "best-in-class" inclusion screening was exclusive to SRI fixed income investments. Therefore, there was no empirical evidence suggesting that ESG screening could cause a trade-off between the financial and non-financial investment objectives. For this type of responsible investors, the ESG rating for fund portfolios seemed to be necessary to identify truly social investments, or at least know to which extent of ESG integration was there on different funds.

Now looking more into the perspective of the pricing, according to Menz (2010), from July 2004 to August 2007, it was not obvious that CSR had an actual impact on the pricing of the bonds. Actually, the data showed that investment grade corporate bonds for socially responsible corporations had a higher risk premium, *ceteris paribus*, than non-socially responsible corporations.

For the issuer, Schröder (2014) shows that companies that had a "good" CSR rating had on average a lower financing cost, and that this financing cost seemed to be directly related with the ethical or unethical behaviour of the companies, and therefore their CSR ratings.

Finally, Salvi et al. (2020) demonstrate that more responsible firms were able to benefit from lower bond spread and it also improved their rating. On the other hand, in case there was a superior level of CSR-related controversies, those firms would be penalized on both dimensions. Corporate social performance strengths were also associated with lower credit spread and better credit quality, while controversies had the opposite effect. As a matter of fact, the authors state that rating agencies are inclined into considering and incorporating corporate social performance in the ratings given to financial securities.

To summarize, even though traditional finance argues that while screening or adding a criteria to portfolio selection could naturally result on a lower financial performance, and that investors would be exposing themselves to extra risk, more recent research points out that it is possible for investors to take into consideration ESG criteria without penalizing their financial performance. Also, when taking into account the benefits for the issuer, rating agencies seem to take into consideration the degree of CSR of the issuers which can later translate into better credit quality and lower costs of debt.

2.5. Fossil Fuel Divestment

Considering that one of the objectives of this research is to see if green bonds are a good financial asset to replace the allocation of capital on fossil fuel, this section of the literature review focuses on the effects of a divestment from fossil fuel related securities. Even though fossil fuel divestment is a growing topic of interest, most of the available research that considers the financial point of view, are mostly for the equity market. Recent studies such as Stephens et al. (2018) argue that especially Canadian and American colleges and universities, have been impacted by this fossil divestment movement, since students, alumni and professors defend that these educational institutions should align their investment practices with the current social values that they defend.

Trinks et al. (2018) conclude that fossil fuel divestment did not seem to affect the performance of US common stock portfolios during the period of 1927 to 2016. Actually, from 2011 to 2016, fossil fuel stocks underperformed mostly due to the negative evolution of oil prices.

Henriques and Sadorsky (2018), also find that it was possible to divest from fossil fuel and utilities while still getting a higher risk-adjusted return by channelling those investments to clean energy stocks. Also, investors averse to risk were willing to pay a fee to make that switch from fossil fuel stocks to clean energy stocks.

It was also shown by Hunt and Weber (2019) that the divestment of fossil fuel can increase the risk-adjusted return. Not only that, but by divesting from fossil fuel the investors would naturally reduce the carbon exposure of investment and being a member of the fossil fuel industry was correlated with a higher financial risk.

As with a more neutral results, Plantinga and Scholtens (2020) do not find performance differences between portfolios with fossil fuel stocks and portfolios without it, since the results were statistically insignificant, which means that that fossil fuel divestment would not harm the investors' financial performance.

In conclusion, considering the analysed research, what seems to prevail is that it is possible for investors to divest from fossil fuel portfolios/funds or simply stocks without having to deal with a negative impact on their financial results. It could actually be the opposite since fossil fuel investments are directly related to the oil prices and present a higher financial risk.

2.6. Green Bonds to Diversify Risk

On this final section, the objective is to analyse the existent literature that evaluates how green bonds can be used as an asset to diversify risk and hedge portfolios, for both equity and fixed-income investors.

Firstly, Reboredo et al. (2020) conclude that green bonds were indeed good for portfolio hedging and risk diversification over different investments views, in case those portfolios are constituted by stocks, high-yield corporate bonds and energy stocks. Also, green bonds act as a unique asset class, and their price is influenced mostly by treasury and corporate bond prices.

Along with the same theme from the last section, Jin et al. (2020) state that the performance on the carbon market is highly unstable, and therefore, a green bond index is effective as a hedging instrument for this carbon risk.

For Arif et al. (2021), green bond indexes could be used as a diversified asset for medium and long-term equity investors. Also, it could be used as a hedging asset and "safe-haven" instrument for currency and commodity investments. With green bonds, investors could reduce investment risk and develop investments in low-carbon assets and both issuers and holders could not only accomplish low-carbon investment objectives, but they can also escape extreme financial market turbulence. It is even mentioned that the resilience of green bonds during the COVID-19 pandemic indicates that they could be used as a sustainable instrument to start up again the global economy.

Not focused on green bonds, but on a broader subject, Duanmu et al. (2019) concluded that there was no statistically significant difference between the performance of hedge funds that had high rated CSR investments compared to those with low rated CSR investments. As a matter of fact, hedged funds with higher weighted CSR scores showed significantly lower risk factors, when compared to the ones with lower weighted CSR scores, which goes accordingly with another of their findings, which was that hedge funds exposure to high rated CSR investments increased during the analysed period, particularly during post-financial crisis.

So, in conclusion, the existent research on green bonds and their role on diversifying risk mostly agrees that this fixed-income asset is indeed capable of decreasing the funds exposure to risk, especially when the fund is composed by stocks and high-yield corporate bonds. At the same time, green bonds apparently act as an unique asset class, and during this pandemic period, they maintained they were a "safe-haven" instruments.

3. METHODOLOGY

This chapter of the dissertation has the objective of showing all the steps regarding the calculation of the returns of the constructed portfolios, and the financial performance evaluation model chosen to conduct this research.

3.1. Portfolio Construction

Regarding the construction of the bond portfolios for this analysis, there were two possible scenarios that were taken into consideration which was if the portfolios would be equal-weighted or value-weighted. The final decision was to go with the value-weighted approach. We chose this approach since research shows that there is a higher systematic risk associated with the equal-weighted approach (Pae and Sabbaghi, 2015), and value-weighted portfolios control better for the size. In an equally-weighted approach, a small size bond has the same impact as a bond with a bigger size.

With this in mind, it was necessary to gather data on the total return of each one of the bonds. According to Refinitiv Eikon Datastream, the source of all the data, the calculation of the Total Return (RI) of the bonds is given by the following equation:

$$RI_t = \frac{RI_{t-1} \times P_t + A_t + NC_t + CP_t}{P_{t-1} + A_{t-1} + NC_{t-1}} \qquad (1)$$

In this equation, RI stands for Total Return, P for clean price, A for Accrued Interest, NC for next coupon and at last, CP is the value of any coupon received on time t or since $t-1$, while t refers to the time period. With this Total Return (RI), it is possible to calculate the monthly return rate of each bond, that is required to calculate the monthly return rate for the portfolios and to evaluate their performance. The equation for the calculation of the monthly return rate is:

$$r_t = \frac{RI_t - RI_{t-1}}{RI_{t-1}} \qquad (2)$$

Where r_t refers to the monthly return rate of the bond at time t, RI_t refers to the Total Return of the bond at time t and RI_{t-1} is the Total Return of the bond at time $t-1$.

With the monthly return rate of each one of the bonds, it is then possible to calculate the value-weighted monthly return rate of the portfolios as follows.

$$r_{p,t} = \sum_{b=1}^{N} \left(\frac{MV_{b,t}}{MV_{p,t}} \times r_{b,t} \right) \qquad (3)$$

Where $r_{p,t}$ is the monthly return of the portfolio p at time t, $MV_{b,t}$ is the market value of the bond b at time t, $MV_{p,t}$ is the total market value of the portfolio p at time t, and $r_{b,t}$ is the monthly return of the bond b at the time t.

3.2. Performance Evaluation Model

Even though performance evaluation models such as the CAPM, developed by Sharpe (1964), Lintner (1975) and Mossin (1966) are widely used, the fact that it is a single-index model makes it highly debatable since only considering one risk factor could result on incorrect results. Several researches showed that multi-factor models present a better explanatory power of financial asset returns (Fama & French, 1992; Fama & French, 2013; Fama & French, 2015).

Therefore, the model chosen to evaluate the performance of bond portfolios is the one proposed by Elton et al. (1995), since it is a well known model used in several studies. It is a multi-factor model with four risk factors, being those a bond market factor, which was the main used factor until then on single-index models, a default spread, an option factor and at last a stock market factor. This unconditional model can be defined by the following equation:

$$r_{p,t} = \alpha_{p,t} + \beta_{1p} Bond_t + \beta_{2p} Default_t + \beta_{3p} Option_t + \beta_{4p} Equity_t + \varepsilon_{p,t} \quad (4)$$

On this equation, $r_{p,t}$ represents the excess return of the portfolio p at time t; α_p represents the abnormal excess return of the portfolio p at time t; $Bond_t$ is the bond market factor calculated as the difference between the return on a Bond Market Index and the risk-free rate at time t; $Default_t$ is the return spread between a High-Yield Bond Index (High risk) and a Government Bond Index (Lower risk)

at time t; $Option_t$ is the return spread between a Mortgage-Backed Security (MBS) Index and a Government Bond Index at time t; $Equity_t$ is the excess return of the Stock Market Index at time t; and at last, $\varepsilon_{p,t}$ which is the error term.

According to Elton et al. (1995), the bond market factor is used to capture the exposure to investment grade bonds; the equity market factor is used as a measure of expectations about general economic conditions; the default risk factor affects aims to capture the higher risk of default associated with corporate issuers; and at last, the option risk factor, aims to capture the differences in returns associated with embedded options.

For the purpose of analysing the possible impact on the portfolio performances of different proxies for the Bond Market index, both a conventional international Bond Market index, and an international Green Bond Market index are used.

In addition, we analyse long-short investment portfolios, resulting from going long in Green bond portfolios and short on Conventional or Black portfolios. The returns on these portfolios are the difference in returns between Green bond portfolios and Conventional or Black bond portfolios. The alphas (α) for these long-short portfolios measure the performance difference between Green bond portfolios and Conventional or Black bond portfolios.

Moreover, we analyse the alphas (α) for all the bond portfolios, being the entire sample of Green and Black bonds, the matched portfolios, or the long-short portfolios in sub-periods, to have a better understanding of the monthly abnormal returns along the years. It is only used for the Conventional Bond Market Index, since in this case, the objective is to see their performances in the context of a conventional market.

When necessary, the results are corrected for heteroskedasticity and autocorrelation utilizing the Newey and West (1987) method, since it is suggested by Hoechle (2007) that this is the best approach to deal with this type of data.

4. DATA

This chapter covers all the data gathering process, namely the construction of the sample, the matching process for building comparable portfolios, and at last, descriptive data about the portfolios and index characteristics, such as maturity, issued amount, returns, and others.

4.1. Sample Construction

All the required data was gathered using Refinitiv Eikon Datastream. Considering that the objective is to evaluate and compare the performance of portfolios composed of only green bonds, conventional bonds, and "black" bonds from several countries, all the bonds had to be issued on the international market.

First of all, one of the general requirements was that regarding the period of the data, all the bonds had to be issued between January 2010 and March 2021.

Regarding green bonds, in order to gather them, we used the Datastream "Constituent Lists" filter, searching for the key words "International Green". From there, the list with the code "INGBI" was chosen, and respecting the time span mentioned before, it was possible to gather 1118 green bonds, which were confirmed to be green by the "Green Bond Indicator" (GBI) available on Datastream. Data related to the bonds issue date, maturity, issued amount (in dollars), currency in which the bond was issued and the country of the issuer is also obtained, in order to make the matching process that is going to be explained later. Information regarding the bond Total Return (RI) and Market Value (MV) to compute the portfolio's return was also collected.

For the black bonds, while using Datastream's filter, instead of applying the "Constituent Lists" filter as before, the chosen filter was "Bonds and Convertibles". From there, the keywords "Petrol; Petroleum; Oil; Gas; Natural Gas; Fossil Fuel" were used on the search engine, once again only gathering information about bonds issued on the international market. Since some of the keywords could result on some bonds that did not fit the criteria, the next step was to download and use the information about the issuers industry to filter out any bond that could be placed on the list of black bonds by mistake, and to make sure that there were no green bonds among the list, it was used the same "Green Bond Indicator" that was used to identify the green bonds. The final result was a list of 560 black bonds, whose issuer were directly related with oil or gas extraction, transformation and transportation. Once again, after having the final list of black bonds, the data referring to the bond issue date, maturity, issued amount (in dollars),

currency, country of the issuer, total return and market value was downloaded, considering that the data about their industry was already available.

As for the conventional bonds, a combination of Datastream's "Constituent Lists" and "Bond and Convertibles" filters was used. Since during the matching process between green bonds and conventional bonds the country of the issuer is going to be one of the criteria, then one way of narrowing down the vast number of existent conventional bonds issued on the international market was to search for "Constituent Lists" from each one of the green bond issuer's countries, and in some cases, it was necessary to use the "Bond and Convertibles" filters in order to gather bonds for some countries that did not have constituent lists or a reasonable number of bonds. The final list was composed of 91939 conventional bonds. For those bonds, data related to the bonds issue date, maturity, issued amount (in dollars), the currency of the issuer, the country of the issuer, their industry, total return and market value was downloaded.

Further information regarding the issuer country is displayed on Appendix A, with the number of bonds issued per country.

It is also important to state that all the three lists were compared, eliminating any duplicate bond or any green bond without a "Green Bond Indicator".

At last, it was necessary to find available data that fitted the Elton et al. (1995) model criteria, respecting that the indexes had to be for the international market.

For the Bond Market Index, the chosen index for the conventional bond market index was the Financial Times Stock Exchange World Broad Investment-Grade Bond Index (FTSE WorldBIG), while for the green bond market index it was the S&P Green Bond Index, which tracks the global green bond market. For the risk-free rate, it was the 4 weeks US T-Bill Market rate, since the data on the returns was all converted to dollars. For the Equity Market Index, it was used the Morgan Stanley Capital International All Country World Index (MSCI AC World). Considering the Default risk factor, for the High Yield Bond index, it was used the International Exchange Bank of America Global High Yield Index (ICE BofA Global High Yield Index), while for the Government Bond Index it was used the Financial Times Stock Exchange World Government Bond Index (FTSE World Government Bond Index). At last, regarding the Option risk factor, for the mortgage-backed security Index, it was used the Financial Times Stock Exchange World Broad Investment-Grade Mortgage-Backed Securities Index (FTSE WorldBIG MBS), while the Government Bond Index was the same one used for the Default risk factor.

4.2. Matching Process

In order to make the portfolios comparable, it was necessary to implement a matching process. These portfolios had to follow certain standards to make them comparable. It is also important to state that every single match corresponded to a pair of bonds with those similar particularities. For example, it would not be possible to make a match between a green bond and two conventional bonds, or the other way around, it had to be one green bonds for one conventional or black bond.

Starting with the matching between green bonds and conventional bonds, the criteria that they had to follow were:

1. The maximum difference between the issue date of the two bonds is 2 years. For example, if the green bond was issued in January 2018, the conventional bond had to be issued between January 2016 and January 2020.
2. The maximum difference between the maturity of the two bonds is 1 year. For example, if the green bond had a maturity of 1.5 years, then the conventional bond should have a maturity between 0.5 and 2.5 years.
3. The amount issued of the conventional bond could be between the double of the value of the green bond, and half of it. For example, if the green bond issue amount was 100 million dollars, then the conventional bond issued amount had to be between 50 million dollars and 200 million dollars.
4. The two bonds had to be issued by entities from the same country. For example, if the green bond was issued by a French company, the conventional bond would also have to be issued by a French company.
5. The two bonds had to be issued on the same currency. For example, if the green bond was issued in Euros, the conventional bond had to be issued in Euros as well.
6. The two bonds had to be issued by entities from the same type of industry. For example, if the green bond was issued by an entity whose SIC code is 6029 (Commercial Banks, Not Elsewhere Classified), the conventional bond had to be issued by an entity that also operated on that same industry.

To match a green bond with a black bond, the standards where similar to the ones stated before. The biggest difference would be that since what makes a bond black is the industry that they operate in, it would be impossible to pair them considering the industry. At the same time, characteristics such as

the country of the issuer and the currency cannot be used as well, in order to preserve the pairing process. For this reason, the standards for the matching between these two types of bonds had to be:

1. The maximum difference between the issued date of the two bonds is 2 years. For example, if the green bond was issued in January 2018, the black bond had to be issued between January 2016 and January 2020.
2. The maximum difference between the maturity of the two bonds was 1 year. For example, if the green bond had a maturity of 1.5 years, then the black bond should have a maturity between 0.5 and 2.5 years.
3. The amount issued of the black bond could be between the double of the value of the green bond, and half of it. For example, if the green bond issue amount was 100 million dollars, then the black bond issued amount had to be between 50 million dollars and 200 million dollars.

These were the standards necessary for two bonds to be considered similar, and able to match. Although, the actual matching process was more complex. In order to get the actual pairs of matches, it was necessary to use the software "SQL". With that same software, it was possible to automatically find every single one of the possible matches between green bonds, and the other two types of bonds (black and conventional).

After calculating all the possible matches by coding, a problem occurred, since several green bonds had more than one match, or the other way around, and since the objective of the match was to find the best pair between all the possible matches, it was necessary to create an extra standard for those situations to decide which match was the best or the most accurate. It was decided that the best pair, was the one with the smallest difference regarding their issue date, if it was not enough, then it would be taken into account the smallest difference between their maturity, and only then, if necessary, it would be taken into account the smallest difference in terms of the issue amount.

With this process, and after taking off all the pairs for which at least one of the bonds did not have the necessary data related to the Total Return (RI) and Market Value (MV), the final dataset resulted on 273 pairs of green bonds matched with black bonds, and 302 pairs of green bonds matched with conventional bonds.

4.3. Descriptive Statistics

This section presents some descriptive statistics of the bonds included in the final dataset, and the different portfolios before and after the matching process. For the monthly analysis of the portfolios performance, the period considered was between January 2015 and March 2021, therefore the monthly excess returns presented on Table 9 and 10 refer to that period.

Table 1 reports descriptive statistics concerning the maturity and the issued amount when considering all the green bonds.

Table 1. Descriptive statistics of entire Green Bonds Sample

	Maturity	Amount Issued (in thousands $US)
Mean	23.976	478000
Standard Deviation	121.476	558000
Median	7	371077.8
Minimum	0.997	500
Maximum	999	7150000
P1	1.999	1095.703
P99	999	2340000
Skewness	7.871	4.474
Kurtosis	63.225	43.843
Observations	1118	1118

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the entire Green Bond Sample, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and were registered as Green Bonds on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis, and the number of observations.

Looking at Table 1 it is shown that the mean on the maturity of green bonds is approximately 24 years, with a difference of roughly 10 years more than the average of the conventional bonds sample (Table 2), and 10 years less than the black bonds average (Table 3).

For the issued amount of the green bond sample, the mean value was somewhat similar to the one by black bonds (Table 3), which can be explained by the considerable difference in terms of observations when compared to the conventional bonds sample (Table 2).

Both the maturity and amount issued on green bonds are highly skewed.

On Table 2, it is displayed information on the maturity and amount issued for the entire conventional bonds sample.

Table 2. Descriptive Statistics of entire Conventional Bonds Sample

	Maturity	**Amount Issued (in thousands $US)**
Mean	15.229	115000
Standard Deviation	89.734	407000
Median	5	2203.202
Minimum	0.077	0.00471
Maximum	999	20501710
P1	0.256	100
P99	50.25	1750000
Skewness	10.779	10.083
Kurtosis	118.166	221.929
Observations	91939	91939

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the entire Conventional Bond Sample, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and did not have a Green Bond Indicator or an Industry that belonged to the Black Bond criteria on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Looking at Table 2, the first thing that comes to mind is the fact that the average maturity and issued amount is clearly smaller. As it was stated before, one of the possible reasons behind it is the

massive difference in terms of the number of observations. The level of Kurtosis on the data shows how extreme the difference in the values can be, therefore somewhat proving the severe disparity in terms of the percentile 1, and percentile 99, on both variables. In this case, the maturity and amount issued show that they are both highly skewed as well.

Table 3 reports the information regarding the maturity and amount issued for the entire black bonds sample.

Table 3.Descriptive Statistics of entire Black Bonds Sample

	Maturity	Amount Issued (in thousands $US)
Mean	35.441	527000
Standard Deviation	154.685	438000
Median	8.51945	500000
Minimum	0.744	128
Maximum	999	3000000
P1	1.369	19400
P99	999	2270292
Skewness	6.054	2.419
Kurtosis	37.777	12.013
Observations	560	560

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the entire Black Bond Sample, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and did not have a Green Bond Indicator and had an Industry that belonged to the Black Bond criteria on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

On Table 3, when considering the issued amount, it is possible to conclude that the average issued amount for black bonds was somewhat similar to the one present on the green bond sample. It

also displays a lower level of Kurtosis when compared to the green bonds sample. In terms of maturity, when comparing the black bonds with green bonds, it displays a similar difference as the one between the green and conventional bonds samples. Also, the values regarding skewness and kurtosis are comparable to some extent, showing that there is a similar distribution regarding the maturity of these two bonds, being once again highly skewed.

Tables 4 and 5 display descriptive statistics on the green bond and black bonds after the matching process, which means that these descriptive statistics refer to the final portfolios.

Table 4. Descriptive Statistics of Green Bonds matched with Black Bonds

	Maturity	**Amount Issued (in thousands $US)**
Mean	24.215	676000
Standard Deviation	119.274	463000
Median	8.5014	606664.5
Minimum	0.997	10000
Maximum	999	3000000
P1	2.494	32782.663
P99	999	2318357
Skewness	8.04	1.637
Kurtosis	65.847	6.817
Observations	273	273

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the Green Bond Sample that matched with Black Bonds, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and were registered as Green Bonds on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Table 5. Descriptive Statistics of Black Bonds matched with Green Bonds

	Maturity	Amount Issued (in thousands $US)
Mean	24.179	605000
Standard Deviation	119.276	472000
Median	8.5	500000
Minimum	1.5	13811
Maximum	999	3000000
P1	2.014	39915.914
P99	999	3000000
Skewness	8.04	2.701
Kurtosis	65.853	12.611
Observations	273	273

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the Black Bond Sample that matched with Green Bonds, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and did not have a Green Bond Indicator and had an Industry that belonged to the Black Bond criteria on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

From Tables 4 and 5, it is possible to see that for both maturity and issued amount, both portfolios are balanced and comparable. When focusing on maturity, the matching process resulted on two portfolios with very similar statistics, even in terms of the distribution of values, they are almost the same. In terms of the issued amount, it is normal that the values have a slightly bigger difference, since the parameters for a match were a bit wider than for maturity. The most obvious difference would be for their skewness and kurtosis.

As for Tables 6 and 7, they present the descriptive statistics for the Matched Green and Conventional bond portfolios.

Table 6. Descriptive Statistics of Green Bonds matched with Conventional Bonds

	Maturity	Amount Issued (in thousands $US)
Mean	20.166	573000
Standard Deviation	113.696	463000
Median	5.9993	589272.8
Minimum	1.999	550
Maximum	999	4000000
P1	2.999	11982.802
P99	999	2000000
Skewness	8.492	2.185
Kurtosis	73.248	13.576
Observations	302	302

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the Green Bond Sample that matched with Conventional Bonds, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and were registered as Green Bonds on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Table 7. Descriptive Statistics of Conventional Bonds matched with Green Bonds

	Maturity	Amount Issued (in thousands $US)
Mean	20.069	629000
Standard Deviation	113.707	497000
Median	5.0124	606664.5
Minimum	1.001	1000
Maximum	999	4000000
P1	2.002	9340
P99	999	2120000
Skewness	8.492	1.836
Kurtosis	73.247	11.13
Observations	302	302

This table presents descriptive statistics regarding the maturity and amount issued (in thousands $US) of the Conventional Bond Sample that matched with Green Bonds, gathered from Refinitiv Eikon Datastream. All the bonds were issued between January 2010 and March 2021 on the International Bond Market and did not have a Green Bond Indicator or an Industry that belonged to the Black Bond criteria on Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Tables 6 and 7 show that in this sample, after the matching process, both variables present balanced values for the matched portfolios. The statistics displayed for the maturity are identical, even presenting a similar distribution of values when looking at the skewness, which is the same, and kurtosis, with a minimal difference. As for the issued amount, it also shows similar statistics, especially regarding the skewness and kurtosis, which when compared with the green and black matched portfolios, shows a smaller difference, meaning that they share a very similar distribution.

Table 8 reports the main descriptive statistics of monthly excess returns for the entire sample of green and black bonds, while for the conventional bonds it is the excess return from the portfolio that matched with the green bonds.

Table 8. Descriptive Statistics on the Monthly Excess Return for each type of Bond

	All Green Bonds	All Black Bonds	Matched Conventional Bonds
Mean	0.2%	0.3%	0.1%
Standard Deviation	1.8%	2.5%	1.6%
Median	0.3%	0.1%	0.3%
Minimum	-6%	-12.6%	-5.2%
Maximum	4.5%	10.8%	4.1%
P1	-6%	-12.6%	-5.2%
P99	4.5%	10.8%	4.1%
Skewness	-0.531	-0.581	-0.6
Kurtosis	4.871	14.482	4.5
Observations	75	75	75

This table presents descriptive statistics regarding the monthly excess return for the entire sample of Green and Black bonds, and the Matched Conventional bond portfolio, during the period of January 2015 until March 2021. It was calculated using the total return (RI) and market value (MV) data, gathered from Refinitiv Eikon Datastream, utilizing the value-weighted approach. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Table 8 results show that, from the three different types of bond portfolios, the black bonds portfolio presents the highest average and maximum monthly excess return. At the same time, it has the lower minimum value and the highest standard deviation. What might explain such values on return is the relation between fossil fuel investments and oil prices, as stated by Trinks et al. (2018). For the other two types of bonds, the monthly excess returns statistics show similar results, which can somehow be

explained by the fact that the conventional portfolio was built to match the green bond sample, therefore they share similar characteristics.

Table 9 displays the descriptive statistics on the monthly excess return for all the matched portfolios.

Table 9. Descriptive Statistics on the Monthly Excess Return for each Portfolio

	Matched Green (Black)	Matched Black (Green)	Matched Green (Conventional)	Matched Conventional (Green)
Mean	0.2%	0.3%	0.1%	0.1%
Standard Deviation	1.7%	3.2%	1.6%	1.6%
Median	0.4%	0.1%	0.3%	0.3%
Minimum	-5.6%	-14.6%	-4.8%	-5.2%
Maximum	4.5%	12.6%	4.7%	4.1%
P1	-5.6%	-14.6%	-4.8%	-5.2%
P99	4.5%	12.6%	4.7%	4.1%
Skewness	-0.521	-0.434	-0.301	-0.6
Kurtosis	4.398	11.372	4.355	4.5
Observations	75	75	75	75

This table presents descriptive statistics regarding the monthly excess return for each one of the matched portfolios, during the period of January 2015 until March 2021. It was calculated using the total return (RI) and market value (MV) data, gathered from Refinitiv Eikon Datastream, utilizing the value-weighted approach. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

Since Table 9 reports the descriptive data on the monthly excess return of the portfolios that matched with each other, they could have similar characteristics.

When comparing the portfolios composed of the Matched Green and Black Bonds, it is possible to see that the Matched Black (Green) bond portfolios has a higher monthly excess return than the one shown by the Matched Green (Black) portfolio. However, both the standard deviation, maximum and minimum values, and, Kurtosis, show that the Matched Black (Green) portfolio monthly excess return does suffer from a more intense variance of returns.

As for the Matched Green (Conventional) and Matched Conventional (Green) portfolios, they present approximately the same value of monthly average excess return, and standard deviation. Not only that, but also display similar values of maximum and minimum monthly excess return, and their distribution of values as well (comparable skewness and kurtosis).

Table 10 reports the descriptive statistics regarding the monthly excess return of the risk factors used on the performance evaluation model.

Table 10. Descriptive Statistics on Monthly Excess Return on the Risk Factors

	Bond (Conventional)	Bond (Green)	Default	Option	Equity
Mean	0.2%	0.1%	0.3%	0%	0.9%
Standard Deviation	0.9%	1.5%	2.5%	0.7%	4.6%
Median	0.20%	0.23%	0.60%	0.02%	1.0%
Minimum	-2.1%	-5.7%	-13.7%	-1.8%	-19.1%
Maximum	2.1%	4.0%	5.3%	1.4%	12.5%
P1	-2.1%	-5.7%	-13.7%	-1.8%	-19.1%
P99	2.1%	4.0%	5.3%	1.4%	12.5%
Skewness	-0.01	-0.564	-2.082	-0.358	-0.924
Kurtosis	2.828	5.058	13.402	3.113	7.211
Observations	75	75	75	75	75

This table presents descriptive statistics regarding the monthly excess return for each one of the risk factors used on the performance evaluation model, during the period of January 2015 until March 2021. It was calculated using the total return (RI), gathered from Refinitiv Eikon Datastream. It is shown the mean, standard deviation, median, minimum, maximum, percentile 1, percentile 99, skewness, kurtosis and the number of observations.

There is a slight difference regarding the mean monthly excess return of the Bond Market (Green and Conventional) factor, Default and Option factor, since their average returns are 0.1%, 0.2%, 0.3% and 0%, respectively. The Equity factor is the one that registered the biggest mean monthly return with a value of 0.9%. At the same time, it is the risk factor with the largest standard deviation, and the biggest

amplitude between the maximum monthly excess return and the minimum. Also, the Default risk factor shows a naturally highly negative skewness and presents a level of Kurtosis fairly higher when compared to the other factors.

5. EMPIRICAL RESULTS

This chapter presents the results on the performance of the different portfolios using the unconditional model proposed by Elton et al. (1995). The period of analysis is, January 2015 to March 2021. The first part of the chapter focuses on the results obtained using the Conventional Bond Market Index as the bond market benchmark, while the second part of the chapter focuses on the results obtained using a Green Bond Market Index as the bond market benchmark.

5.1. Results with the Conventional Bond Market Index

In this first section we present the results of the performance evaluation model using the excess returns on the FTSE WorldBIG index (a conventional bond market) as the bond risk factor.

Table 11 reports the results on the financial performance of the matched portfolios and portfolios composed of the entire sample of green and black bonds available, and Table 12 presents the results on the financial performance of the differences portfolios, the difference between the matched portfolios, the entire green and black bonds sample, and the entire green bonds sample and the matched conventional bonds portfolios, to compare the performance and risk of the different portfolios, and at last, Table 13 reports the monthly abnormal returns (α) for the different matched portfolios and portfolios composed of the entire sample of green and black bond portfolios, and for the Long-Short strategy portfolios, measuring the financial performance during different sub-periods.

Table 11. Financial Performance of the Portfolios with the Conventional Bond Market Index

	All Green	All Black	Matched Conventional	Matched Green (Conventional)	Matched Green (Black)	Matched Black
Bond Market	1.600***	1.550***	1.272***	1.371***	1.564***	1.669***
	(0.350)	(0.187)	(0.337)	(0.358)	(0.342)	(0.225)
Equity Market	0.096	0.046	0.091	0.0960	0.0746	0.042
	(0.067)	(0.072)	(0.0651)	(0.065)	(0.067)	(0.100)
Default	0.160*	0.750***	0.140	0.106	0.178*	0.963***
	(0.095)	(0.098)	(0.095)	(0.092)	(0.093)	(0.182)
Option	0.628	0.069	0.706*	0.623	0.681*	-0.036
	(0.380)	(0.205)	(0.383)	(0.397)	(0.367)	(0.333)
α	-0.21%	-0.21%**	-0.22%	-0.21%	-0.20%	-0.26%
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Adjusted R^2	0.56	0.83	0.43	0.44	0.51	0.77
N	75	75	75	75	75	75

This table presents the regression results of the four-factor model for each of the bond portfolios. Monthly abnormal returns (α), the risk-factors coefficients (β), the explanatory power ($\text{Adjusted } R^2$), and the number of observations, for the 75 months analysed (from January 2015 to March 2021), are reported. Bond Market is the difference between the return on the FTSE WorldBIG (Bond Market Index) and the 4 weeks US T-Bill Market rate (risk-free rate). Equity Market is the difference between the return on the MSCI AC World (Equity Market Index) and the 4 weeks US T-Bill Market rate. Default is the return difference between the ICE BofA Global High Yield Index (High Yield Bond Index) and the FTSE World Government Bond Index (Government Bond Index). Option is the return difference between the FTSE WorldBIG MBS (Mortgage-Backed Security Index) and the FTSE World Government Bond Index (Government Bond Index). The standard errors are reported between parenthesis, and the statistical significance is shown by *, **, and *** for 10%, 5% and 1% levels, respectively. These results are corrected for heteroskedasticity and autocorrelation, when necessary.

When considering the results presented on Table 11, it is possible to see that all of the portfolios show a negative alpha (α), being statistically not significant for all portfolios except for the All Black portfolio (at 5% level of significance), meaning that it is underperforming the bond market, during the period under analysis (January 2015 to March 2021). To be more precise, All Green, All Black, and Matched Conventional portfolios exhibit monthly alphas of about -0.21%, while the Matched Conventional, Matched Green (Black) and Matched Black presents a monthly alpha of -0.22%, -0.20% and -0.26%, respectively.

Analysing the coefficients of the different risk factors, the Bond Market risk factor presents positive coefficients for all the portfolios, being statistically significant in all the portfolios (at 1% level), being as it was expected, the main factor explaining the bond portfolio returns. As for the Equity Market risk factor, it has a positive coefficient for all the portfolios, although it is not statistically significant.

For the default risk factor, all the portfolios present positive coefficients, but it is statistically significant (at 1% level) for the All Black and Matched Black portfolios, and for the All Green and Matched Green (Black) portfolio (at 10%). As it was mentioned in the literature review, activities related with the fossil fuel industry have more financial risk (Hunt and Weber, 2019) and since black bonds are mostly corporate bonds, they end up having a higher risk than a public issuer would have, as it can be seen on Appendix B. The All Green and Matched Green (Black) bond portfolios also have a statistically significant coefficient, but it is not as expressive as the one presented on Black bond portfolios.

As for the option risk factor, all the portfolios except the Matched Black portfolio present positive coefficients. As a matter of fact, the All Black portfolio presents a coefficient closer to zero, confirming the tendency on the Matched Black portfolio. The option risk factor was statistically significant at 10% level on the Matched Conventional and Matched Green (Black) portfolios.

Regarding the explanatory power of the analysis (Adjusted R^2), this four-factor model presents a higher explanatory power on the excess returns from the Black bond portfolios than the Green and Conventional bond portfolios.

Table 12.Financial Performance Differential of the Long-Short Portfolios with the Conventional Bond Market Index

	Match Green -Match Black	**Match Green -Match Conventional**	**All Green - All Black**	**All Green -Matched Conventional**
Bond Market	-0.118	0.086	0.037	0.315***
	(0.385)	(0.054)	(0.335)	(0.070)
Equity Market	0.033	0.0058	0.051	0.006
	(0.128)	(0.010)	(0.098)	(0.010)
Default	-0.785***	-0.033	-0.590***	0.021
	(0.212)	(0.024)	(0.137)	(0.027)
Option	0.709	-0.091	0.550	-0.086
	(0.472)	(0.067)	(0.367)	(0.103)
α	-0.02%	-0.06%*	-0.07%	-0.06%
	(0.003)	(0.000)	(0.002)	(0.000)
Adjusted R^2	0.47	0.18	0.44	0.28
N	75	75	75	75

This table presents the regression results of the four-factor model for the differences portfolios (long-short portfolios). Monthly abnormal returns (α), the risk-factors coefficients (β), the explanatory power ($\text{Adjusted } R^2$) and the number of observations, for the 75 months analysed (From January 2015 to March 2021). Bond Market is the difference between the return on the FTSE WorldBIG (Bond Market Index) and the 4 weeks US T-Bill Market rate (risk-free rate). Equity Market is the difference between the return on the MSCI AC World (Equity Market Index) and the 4 weeks US T-Bill Market rate. Default is the return difference between the ICE BofA Global High Yield Index (High Yield Bond Index) and the FTSE World Government Bond Index (Government Bond Index). Option is the return difference between the FTSE WorldBIG MBS (Mortgage-Backed Security Index) and the FTSE World Government Bond Index (Government Bond Index). The standard errors are reported between parenthesis, and the statistical significance is shown by *, **, and *** for 10%, 5% and 1% levels, respectively. These results are corrected for heteroskedasticity and autocorrelation, when necessary.

Table 12 shows the results regarding the differences portfolios, calculated as the difference of monthly excess returns between the different portfolios, using the excess return on the conventional bond market index as the bond market factor.

From this perspective, most of the differences portfolios present no statistically significant alphas, meaning that the green bond portfolios perform similarly to the black bond portfolios, considering the entire sample or only the matched sample, and also when it is compared the All Green sample with the matched sample of conventional bonds. However, in this case, the difference between the Match Green portfolio and the Match Conventional portfolio shows a statistically significant (at 10% level) negative alpha, meaning that the matched green bond portfolio underperforms at approximately -0.06% when compared to the matched conventional bond portfolio.

Regarding the exposition to the different risk factors, the results shows that the Bond Market risk factor presents a positive statistically significant coefficient at 1% level for the comparison between the All Green portfolio and the Matched Conventional portfolio, showing that the All Green portfolio presents a higher exposure to the bond market factor. Also, it shows that the coefficient for the default risk factor on the comparisons between Match Green (Black) portfolio and the Match Black portfolio, and the comparison between the All Green and All Black bond portfolios is negative and statistically significant at 1% level, meaning that the Green bond portfolios are less exposed to the default risk factor, when compared to the Black bond portfolios.

Table 13. Financial Performance of Portfolios for Rolling Windows with the Conventional Bond Market Index

			All Green	All Black	Matched Green (Conventional)	Matched Conventional	Matched Green (Black)	Matched Black	All Green – All Black	All Green – Matched Conventional	Matched Green – Matched Black	Matched Green – Matched Conventional
2015	**-**	**2017**	-0.19%	-0.22%	-0.22%	-0.20%	-0.20%	-0.41%	-0.00%	-0.02%	0.18%	-0.05%
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)	(0.000)
2016	**-**	**2018**	-0.00%	-0.16%	0.04%	0.00%	0.01%	-0.35%	0.07%	-0.09%***	0.29%	-0.05%
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.000)	(0.005)	(0.000)
2017	**-**	**2019**	–0.05%	-0.09%	-0.08%	-0.08%	-0.04%	-0.18%**	-0.09%	-0.13%***	0.00%	-0.11%***
			(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.002)	(0.000)
2018	**-**	**2021**	-0.13%	-0.22%	-0.13%	-0.14%	-0.13%	-0.24%	-0.02%	-0.10%***	-0.00%	-0.10%***
			(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.000)	(0.002)	(0.000)

This table presents the monthly abnormal returns (α), obtained from the four-factor model for each of the bond portfolios and the Long-Short portfolios when considering different sub-periods. The standard errors are reported between parenthesis, and the statistical significance is shown by *, **, and *** for 10%, 5% and 1% levels, respectively. These results are corrected for heteroskedasticity and autocorrelation, when necessary.

Table 13 presents the monthly abnormal returns (α) on different sub-periods, for the existent portfolios, including the long-short portfolios mentioned before. The results show that there is a statistically significant (at 5% level) underperformance of the Matched Black bond portfolio, during the sub-period of 2017 to 2019. A similar result was obtained on Table 11, that also shows an underperformance of these type of bonds, in that case it was the All Black bond portfolio.

As for the long-short portfolios, it presents statistically significant alphas on the comparison between Green bond portfolios and the Matched Conventional bond portfolio. To be more precise, when considering the comparison between the matched portfolios, it shows negative statistically significant alphas (at 1% level), for the sub-periods of 2016 until 2018, 2017 until 2019 and 2018 until 2021. For the comparison between the All Green bond portfolio and the Matched Conventional bond portfolio, it shows similar results with the same statistical significance (at 1% level), for the sub-periods of 2017 until 2019 and 2018 until 2021. This means that the Green bond portfolios underperformed when compared to the Matched Conventional bond portfolio, during the stated sub-periods. On Table 12, when comparing the Matched Green bond portfolio and the Matched Conventional bond portfolio it was possible to achieve a similar conclusion.

5.2. Results with the Green Bond Market Index

This section presents the results on the financial performance of the bond portfolios using the excess returns on the S&P Green Bond Index as the bond risk factor.

Table 14 shows the results regarding the financial performance of the matched portfolios, and the portfolios with the entire sample of Green and Black bonds, while Table 15 reports the results related to the financial performance of the differences portfolios, the difference between the Matched Green and Matched Black portfolios, the Matched Green and Matched Conventional portfolios, the All Green and All Black portfolios, and the All Green and Matched Conventional portfolios.

The objective is to conclude if the different bond portfolios perform differently and if they show different exposition to the different risk factors.

Table 14. Financial Performance of the Portfolios with the Green Bond Market Index

	All Green	All Black	Matched Conventional	Matched Green (Black)	Matched Black	Matched Green (Conventional)
Green Bond Market	1.074***	0.490***	0.996***	1.114***	0.404***	1.035***
	(0.044)	(0.102)	(0.065)	(0.032)	(0.150)	(0.054)
Equity Market	0.052*	0.076	0.037	0.023	0.091	0.043
	(0.027)	(0.092)	(0.030)	(0.022)	(0.123)	(0.030)
Default	-0.122**	0.540***	-0.100*	-0.105**	0.751***	-0.148**
	(0.054)	(0.109)	(0.058)	(0.044)	(0.183)	(0.058)
Option	-0.200*	-1.068***	0.133	-0.089	-1.335***	-0.017
	(0.113)	(0.167)	(0.152)	(0.067)	(0.299)	(0.147)
α	0.04%	0.03%	-0.02%	0.04%	-0.01%	0.00%
	(0.000)	(0.001)	(0.001)	(0.000)	(0.002)	(0.001)
Adjusted R^2	0.92	0.78	0.87	0.94	0.71	0.87
N	75	75	75	75	75	75

This table presents the regression results of the four-factor model for each of the bond portfolios. Monthly abnormal returns (α), the risk-factors coefficients (β), the explanatory power ($\text{Adjusted } R^2$), and the number of observations, for the 75 months analysed (from January 2015 to March 2021), are reported. Bond Market is the difference between the return on the S&P Green Bond Index (Green Bond Market Index) and the 4 weeks US T-Bill Market rate (risk-free rate). Equity Market is the difference between the return on the MSCI AC World (Equity Market Index) and the 4 weeks US T-Bill Market rate. Default is the return difference between the ICE BofA Global High Yield Index (High Yield Bond Index) and the FTSE World Government Bond Index (Government Bond Index). Option is the return difference between the FTSE WorldBIG MBS (Mortgage-Backed Security Index) and the FTSE World Government Bond Index (Government Bond Index). The standard errors are reported between parenthesis, and the statistical significance is shown by *, **, and *** for 10%, 5% and 1% levels, respectively. These results are corrected for heteroskedasticity and autocorrelation, when necessary.

By analysing Table 14, it is possible to see that this model using the excess returns on the Green Bond Market index as the bond market factor clearly shows a higher explanatory power than the one using the excess returns on the Conventional Bond Market index for the green bond and conventional bond portfolios, while at the same time, it shows a small decrease on the explanatory problem on black bond portfolios.

Regarding abnormal excess returns the results are similar, as the alphas are not statistically significant for any portfolio. The alphas presented are positive for the All Green, All Black, Matched Green (Black) and Matched Green (conventional), at approximately 0.04%, 0.03%, 0.04% and 0.00%, respectively. As for the Matched Conventional, and Matched Black, they are approximately -0.02% and -0.01%, respectively.

As for the risk factors, starting by the Market risk factors, it shows that the Bond Market risk factor is once again the risk factor that explains the most the returns of all portfolios, presenting positive coefficients for all bond portfolios that are statistically significant at 1% level, coefficients that are especially higher for the green bond sample, as it was expected. The Equity Market risk factor also presents positive coefficients for all the portfolios, but now it is statistically significant (at 10% level) for the All Green bond portfolio.

For the default risk factor, it presents significant different results, in the sense that it shows statistically significant coefficients on all portfolios. The All Green, Matched Conventional, Matched Green (Black), and Matched Green (Conventional) bond portfolios present a negative statistically significant coefficient, meaning that Green bond portfolios and Conventional bond portfolios are less exposed to the default risk factor. As for the All Black and Matched Black portfolio, they show a positive statistically significant (at 1% level) coefficient, meaning that the returns of Black bond portfolios are more exposed to the default risk factor, as it was stated on the last section, this can be explained by the higher level of exposure to financial risk on companies involved on the fossil fuel industry and their exposure to shocks on oil prices (Hunt and Weber, 2019). Also, it is known that Green bonds are issued mostly by financial, sovereign, sub-sovereign, and supranational entities (Appendix B), while at the same time, this green bond dataset is composed by bonds with a green bond indicator, naturally presenting a lower risk for the bondholder.

By analysing the option risk factor, it shows that the All Green, All Black, Matched Green (Black), Matched Black and Matched Green (Conventional) bond portfolios all present a negative coefficient. As a matter of fact, the negative coefficient is statistically significant for the All Green portfolio at 10% level, for

the All Black portfolio at 1% level, and for the Matched Black portfolio at 1% level. Such results suggest that these types of bond portfolios returns are significantly less exposed to the option risk factor.

Table 15. Financial Performance Differential of the Long-Short Portfolios with the Green Bond Market Index

	Match Green -Match Black	Match Green -Match Conventional	All Green - All Black	All Green -Matched Conventional
Green Bond Market	0.705***	0.035	0.579***	0.074
	(0.144)	(0.037)	(0.087)	(0.077)
Equity Market	-0.067	0.006	-0.023	0.016
	(0.113)	(0.010)	(0.086)	(0.018)
Default	-0.853***	-0.045**	-0.659***	-0.019
	(0.185)	(0.021)	(0.119)	(0.028)
Option	1.247***	-0.149**	0.869***	-0.333*
	(0.298)	(0.072)	(0.164)	(0.177)
α	-0.03%	-0.05%	-0.06%	-0.01%
	(0.002)	(0.000)	(0.001)	(0.001)
Adjusted R^2	0.58	0.17	0.59	0.22
N	75	75	75	75

This table presents the regression results of the four-factor model for the differences portfolios (long-short portfolios). Monthly abnormal returns (α), the risk-factors coefficients (β), the explanatory power ($\text{Adjusted } R^2$) and the number of observations, for the 75 months analysed (From January 2015 to March 2021). Bond Market is the difference between the return on the S&P Green Bond Index (Green Bond Market Index) and the 4 weeks US T-Bill Market rate (risk-free rate). Equity Market is the difference between the return on the MSCI AC World (Equity Market Index) and the 4 weeks US T-Bill Market rate. Default is the return difference between the ICE BofA Global High Yield Index (High Yield Bond Index) and the FTSE World Government Bond Index (Government Bond Index). Option is the return difference between the FTSE WorldBIG MBS (Mortgage-Backed Security Index) and the FTSE World Government Bond Index (Government Bond Index). The standard errors are reported between parenthesis, and the statistical significance is shown by *, **, and *** for 10%, 5% and 1% levels, respectively. These results are corrected for heteroskedasticity and autocorrelation, when necessary.

Table 15 reports the results regarding the differences portfolios, calculated as the difference between the monthly excess returns of green bond portfolios and the others different types of portfolios, in this case using the excess return on the Green Bond Market index as the bond market factor.

None of the differences portfolios presents statistically significant alphas, meaning that the green bond portfolios perform similarly to the black bond portfolios, considering the entire sample or only the matched sample, and also to the matched conventional bond portfolio, which is a different result when compared to the ones that the conventional bond market index present.

As for the different risk factors, the results show that exists a higher exposure to the Bond Market risk factor on the portfolios composed of Green bonds, when compared to the black bond portfolios, being statistically significant at 1% level. As for the default risk factor, the results show that the higher exposure to the default factor by the Black bond portfolios when compared with the Green bond portfolio still holds, being statistically significant at 1% level on both analyses. We also find a lower exposure to the default risk factor for the Match Green bond portfolio, when compared with the Match Conventional bond portfolio, being statistically significant at 5% level. As to the option risk factor, the results show that there is a higher exposure of the Green bond portfolios to that risk factor, when compared with the Black bond portfolios, being statistically significant at 1% level. Also, the results show that there is a lower exposure to the option risk factor when comparing the Green bond portfolios to the Matched Conventional portfolio, showing negative coefficients that are statistically significant at 10% level.

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6. Conclusions

Nowadays, the environmental agenda is something that is starting to be implemented into the mind of individuals, influencing how they should act, how they should think, and which changes they should implement in their life.

The impact felt on the daily life of individuals, has also affected when it comes to investments, especially with the 2015 Paris Agreement, opening the eyes of some investors into the importance of their role, and the need for going green. But as expected, investors that were not willing to consider the impact of their investments on the environment, do not feel the necessity to incorporate green bonds on their portfolios, especially if they did not present a similar return, or even better.

Looking at the previous research, it was possible to see that green bond issuance can be beneficial for both the issuer and investors (on the stock market). Since green bond issuance can create value for a company, therefore increasing the value of their shares (beneficial to shareholders) (Flammer, 2021; Zhou and Chui, 2019; Glavas, 2018; Tang and Zhang, 2020), and also for the company, it can be a good way to gather capital at a lower cost (Zhang et al., 2021; Li et al., 2020; Gianfrate and Peri, 2019), since green bonds seem to have lower yields and are usually priced higher (Hyun et al., 2020; Bachelet et al., 2019; Fatica et al., 2021; Baker et al., 2018; Löffler et al., 2021). Also, investigation regarding fossil fuel divestment suggests that it is possible to divest from fossil fuels without suffering negative impacts on the financial performance, since other types of investments do have similar risk-adjusted returns or even better (Trinks et al., 2018; Henrique and Sadorsky, 2018; Plantinga and Scholtens, 2020). It is also argued that Green bonds can be used as hedging or risk diversification tools, since they act as a unique asset class (Reboredo et al., 2020; Jin et al., 2020; Arif et al., 2021).

The data used on this dissertation is composed of a total of 93617 bonds, of which 1118 are green bonds, 560 black bonds and 91939 conventional bonds, issued between January 2010 to March 2021. All of them were issued on the international bond market. Since this is a big number of bonds, with a variety in terms of their characteristics, it was necessary to do a matching process, which narrowed down the number of bonds analysed, and at the same time, made the portfolios have similar characteristics so they are indeed comparable. The final sample of analysed portfolios comprises a green bond portfolio with 302 bonds, that was similar and comparable to a conventional bond portfolio with 302 bonds, and another green bond portfolio with 273 bonds that matched with a black bond portfolio with 273 bonds.

Then using the four-factor model proposed by Elton et al. (1995), the returns of these portfolios were analysed, during the period of January 2015 to March 2021. We use two alternative bond market benchmarks to compute the bond market factor, a conventional bond market index and a green bond market index. Additionally, we also analyse difference portfolios.

According to the results of the performance evaluation model, when utilizing the conventional bond market index, we conclude that there is no abnormal excess return for any of the portfolios other than the All Black bond portfolio (statistically significant at 5% level), which had an alpha of -0.21%, meaning that the All Black bond portfolio was underperforming the market. A similar result is presented later, when considering the monthly abnormal returns on different sub-periods, since the Matched Black bonds portfolio shows an underperformance during the sub-period of 2017 until 2019. The rest of the portfolios had statistically insignificant alphas. Also, the risk factor that explains the returns the most is the bond market factor, being statistically significant at 1% level for each one of the portfolios. It is also shown that the default risk factor had statistically significant coefficients for both portfolios composed of Black bonds (at 1% level), and the All Green and Matched Green (Black) portfolios (at 10% level), meaning that these four portfolios are exposed to the default risk factor. According to the literature, activities related with the fossil fuel industry have more financial risk (Hunt and Weber, 2019), and their performance can be affected by shocks on oil prices (Trinks et al.,2018), which can translate into this exposure to the default risk. As for the option risk factor, there were positive and statistically significant (at 10% level) coefficients for the Matched Conventional and the Matched Green (Black) bond portfolios. When looking at the financial performance differential of the Long-Short Portfolios, results show that the Matched Green (Conventional) bond portfolio underperforms at approximately -0.06% when compared to the Matched Conventional bond portfolio, at a significance level of 10%. This result is reinforced by the analysis on sub-periods, since it presents negative statistically significant alphas on the comparison between Green bond portfolios, and Conventional bond portfolios on the sub-periods from 2016 until 2021. The rest of the bond portfolios did not show statistically significant differences in performance compared to other bond portfolios. Regarding the exposition to the different risk factors, the results show that there is a higher exposure to the bond market factor (at 1% level) by the All Green bond portfolio when compared to the Matched Conventional bond portfolio. Regarding the default risk factor, the results show that both comparisons between the Green bond portfolios and the Black bond portfolios present statistically significant (at 1% level) coefficients, meaning that Green bond portfolios are less exposed to the default risk factor, when compared to Black bond portfolios. This result can be explained once again by Hunt and Weber (2019) and Trinks et al. (2018), and by the difference in terms of the type of issuer of Green and

Black bonds, since the Black bonds on the matched portfolio are mostly issued by corporate entities (Appendix B).

As for the results obtained while using the green bond market index, they show that there are no abnormal excess returns for any bond portfolios, as all alphas are statistically not significant. For the risk factors, results show that the Bond Market risk factor is once again the one that explains the most the returns of all portfolios, being statistically significant at 1% for all the bond portfolios. The equity market risk factor shows a positive and statistically significant (at 10% level) coefficient only for the All Green bond portfolio. Probably the most significant difference between the results presented with the Conventional Bond Market Index and the Green Bond Market Index is the exposure to the default risk factor, since now the coefficients are statistically significant for all the bond portfolios, being negative for the Matched Conventional bond portfolio and all the Green bond portfolios, which means that these bond portfolios are less exposed to the default risk factor. In turn, for the Black bond portfolios, the coefficients are positive and statistically significant at 1% level, meaning that bond portfolios with this type of bonds are more exposed to the default factor, as it was presented on the conventional bond market index analysis. For the option risk factor, it shows negative and statistically significant coefficients for the All Green (at 10% level), All Black and Matched Black bond portfolios (at 1% level), meaning that these type of bonds portfolios are less exposed to the option risk factor. When considering the financial performance of the differentials of the Long-Short portfolios, the results show no statistically significant alphas, meaning that these bond portfolios have a similar performance. For the risk factors, the results show a higher exposure from the Green bond portfolios to the bond market risk factor, when compared with the Black bond portfolios, being statistically significant at 1%. Once again, the black bond portfolios show a higher exposure to the default factor when compared to the Green bond portfolios (statistically significant at 1%) which can be explained by the reasons mentioned above. Also regarding the default risk factor, the results show that the Matched Green bond portfolio is less exposed to the default risk factor when compared with the Matched Conventional bond portfolio, being statistically significant at 5%. As for the option risk factor, the results show a higher exposure of Green bond portfolios to the option risk factor, when compared with Black bond portfolios (statistically significant at 1%), but when comparing the Green bond portfolios with the Matched Conventional bond portfolio, it shows that Green bond portfolios are less exposed to the option risk factor than the latest.

In general, the model that used the Green Bond Market Index presented a higher explanatory power on the return of these portfolios, with the only exception being the bond portfolios composed of Black bonds.

With these results, it is possible to conclude that the All Black bond portfolio underperformed at -0.21%, that is proven to be accurate on the Matched Black bond portfolio on the sub-period financial performance. There was also an underperformance of approximately -0.06% when comparing the Matched Green and Matched Conventional bond portfolios, that was later supported on the analysis of the financial performance in sub-periods, when using the Conventional Bond Market Index. Other than this scenario, the bonds show similar performance and no abnormal excess returns that are statistically significant. Therefore, investors can take into consideration the environmental impact and purposes of the projects that they are financing, without expecting a loss or underperformance if they divest from Black bonds, while at the same time experiencing a decrease on their exposure to the default risk that was associated with that type of bond. The same cannot be said about Conventional bonds, since results show that there is an underperformance of the Green bond portfolios when compared to the Matched Conventional bond portfolio on the sub-periods of 2016 until 2018, 2017 until 2019 and 2018 until 2021, when using the Conventional Bond Market Index.

Such conclusions are important, as they can be seen as an incentive for fossil fuel investors to go green on their portfolios, and therefore have an overall better impact on environment without penalizing their returns.

Since green bonds are somehow a still recent market in constant growth, there are different topics still unexplored. Future research could analyse the performance of these types of bonds, during moments of oil prices shocks, to see the impact that they could have on black bonds returns, and how returns of green and conventional bonds hold up. Also, when possible, it would be interesting to expand the period of analysis, since a longer period could provide more accurate answers, and since this is a case of such an emerging market breaking issuance records every single year, it is important to keep a close track on how it evolves and performs. Another interesting approach would be to compare their performance on three different periods, pre-pandemic, during the pandemic and after the pandemic, to see the influence that it had on bonds returns, and perhaps discover if any type of bond were able to outperform the others, since as Arif et al. (2021) argue, green bonds could be an important asset on fomenting the world economy.

It is also important to point out that, many studies complain about the same thing, being that there is a need for the creation of standards to classify a bond as a green bond, since with such standards that those bonds have to meet, there would be a reduction of the cost of green bond issuance, since there would be no need to look for an external certification, and with such a close regulation of the market, it would be important to analyse it effects on the performance and price of those bonds.

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APPENDICES

APPENDIX A. NUMBER OF BONDS ISSUED PER COUNTRY FOR EACH TYPE OF BOND

This appendix shows information regarding the number of bonds issued per country, for the Green Bond sample, Conventional Bond sample, and the Black Bond sample. All the bonds were issued on the International Bond Market from January 2010 until March 2021.

1.List of Green Bonds issued per Country on the Sample

	Number of bonds		Number of bonds		Number of bonds
United Arabic Emirates	4	France	76	Mauritius	7
Argentina	2	United Kingdom of Great Britain and Northern Ireland	72	Mexico	5
Austria	10	Georgia	1	Netherlands	100
Australia	6	Guernsey	4	Norway	14
Belgium	3	Greece	1	Peru	2
Bermuda	5	Hong Kong	30	Philippines	28
Brazil	3	Honduras	1	Poland	5
Canada	19	Hungary	1	Portugal	4
Switzerland	8	Ireland	4	Seychelles	1

Côte d'Ivoire	3	India	10	Sweden	134
Chile	10	Iceland	1	Singapore	13
China	9	Italy	31	Slovenia	1
Costa Rica	1	Japan	23	Turkey	4
Germany	51	Korea	26	United States of America	192
Denmark	11	Cayman Islands	33	Venezuela	3
Egypt	1	Lithuania	2	Virgin Islands	15
Spain	45	Luxembourg	49	South Africa	1
Finland	29	Macao	4	Total	1,118

This table presents the number of Green Bonds issued per country during the period of January 2010 until March 2021.

2.List of Conventional Bonds issued per Country on the Sample

	Number of bonds		Number of bonds		Number of bonds		Number of bonds
United Arabic Emirates	22	Egypt	25	Japan	7,406	Peru	5
Argentina	82	Spain	520	Korea	721	Philippines	153
Austria	352	Finland	617	Cayman Islands	2,137	Poland	38
Australia	1,766	France	9,735	Kazakhstan	1	Portugal	33
Barbados	1	United Kingdom of Great Britain and Northern Ireland	11,823	Liberia	2	Serbia	1
Belgium	305	Georgia	2	Lithuania	11	Russian Federation	1
Burundi	2	Guernsey	213	Luxembourg	11,758	Seychelles	1
Bermuda	281	Greece	71	Marshall Islands	4	Sweden	1,503
Brazil	80	Hong Kong	6,744	Macao	14	Singapore	9,923
Canada	4,966	Honduras	15	Mauritius	8	Togo	2
Switzerland	75	Croatia	2	Mexico	231	Turkey	125
Côte d'Ivoire	45	Hungary	17	Malaysia	9	Taiwan	4

Chile	172	Ireland	2,446	NA	19	United States of America	6,742
China	340	Israel	1	Nigeria	5	Venezuela	41
Costa Rica	24	India	135	Netherlands	5,182	Virgin Islands	15
Curaçao	24	Iceland	19	Norway	454	Vietnam	1
Germany	3,158	Italy	814	New Zealand	8	South Africa	82
Denmark	367	Jersey	32	Panama	6	Total	91,939

This table presents the number of Conventional Bonds issued per country during the period of January 2010 until March 2021.

3.List of Black Bonds issued per Country on the Sample

	Number of Bonds		Number of Bonds
United Arabic Emirates	2	Cayman Islands	1
Argentina	1	Luxembourg	9
Azerbaijan	2	NA	136
Bahrain	4	Nigeria	5
Bermuda	7	Netherlands	9
Brazil	1	Panama	1
Canada	4	Peru	3
Germany	6	Portugal	1
United Kingdom of Great Britain and Northern Ireland	23	Saudi Arabia	20
Guernsey	1	Sweden	2
Greece	1	Singapore	1
Indonesia	1	Thailand	2
Ireland	3	Turkey	1
India	12	Trinidad and Tobago	1
Italy	6	United States of America	225
Jersey	2	Virgin Islands	3
Korea	64	Total	560

This table presents the number of Black Bonds issued per country during the period of January 2010 until March 2021.

APPENDIX B. NUMBER OF BONDS ON THE MATCHED BOND PORTFOLIOS PER TYPE OF ISSUER

This Appendix shows information regarding the number of bonds issued per type of issuer for the Matched Green (with Black) portfolio and the Matched Black (with Green), and for the Matched Green (with Conventional) and the Matched Conventional (with Green).

1.Number of bonds on the Matched Green and Black portfolios per type of issuer

	Green	Black
Agency	27	9
Corporate	82	210
Financial	103	28
Sovereign	7	-
Sub-Sovereign	6	-
Supranational	48	9
NA	-	17
Total	273	273

This table presents the number of bonds from each type of issuer on the Matched Green and Matched Black bond portfolios.

2.Number of bonds on the Matched Green and Conventional portfolios per type of issuer

	Green	Conventional
Agency	36	43
Corporate	42	42
Financial	174	169
Sovereign	4	4
Sub-Sovereign	20	20
Supranational	26	24
Total	302	302

This table presents the number of bonds from each type of issuer on the Matched Green and Matched Conventional bond portfolios.