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A study of the green bond premium and the effect of the coronavirus

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Abstract

This paper analyzes the difference in yields between green and conventional bonds. To compare the yields of the green and conventional bonds, a matching method is used where bonds are matched based on the same characteristics, which resulted in a dataset of 222 matches. After the matches were formed, a fixed-effect regression has been run to extract the green bond premium by controlling for the residual liquidity difference. The daily yields have been compared for 116 trading days, resulting in a panel dataset of 25752 observations. An average significant green bond discount of 6.3 basis points was found, indicating a higher average yield for green bonds compared to conventional bonds. This positive yield difference can be contributed to the corporate bonds, with a discount of 8.3 basis points, whereas the supranational bonds showed a premium of 6.7 basis points. Another remarkable finding was the relationship between the Coronavirus and the green bond premium. A small discount was given before Corona, followed by a period of 20 days with very volatile values. After the first hectic of the Coronavirus, a small premium of 2.32 basis point was found. This indicates that the willingness to invest in green bonds has increased since the start of the Coronavirus.

Keywords: Green bond premium; yield difference; Coronavirus; ESG scores

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1. Introduction

With the rising level of carbon dioxide and climate change that has become an important issue, firms are searching for other ways to decrease the carbon dioxide level. As the industry is responsible for 29% of worldwide energy consumption (Nejat et al., 2015), making the industry sector more energy efficient would make a significant difference in the reduction of worldwide energy consumption. Aside from the environmental problems that climate change is giving, it will also pose a serious threat to the economy.

First, according to (World bank, 2020), climate change will trigger wider disruptions for households and firms costing at least $390 billion a year. Moreover, the impact of extreme natural disasters is equivalent to a global $520 billion loss in annual consumption. Next to the costs that this is giving to the firms due to a threat to the economy, the costs of carbon emission will rise significantly in the future. Currently, the prices are already at an 11-year high (Financial Times, 2020), with a price of 25 Euro per tonne. Where the emission allowance price is 25 Euro per tonne in 2020, the forecast is that the allowance price will rise to above 40 Euro per tonne in 2025 (SDG resources, 2020). This makes that it will be crucial for firms to make the switch to less carbon-intensive production methods.

The changes that must be made require a substantial amount of capital. A substantial amount of capital is required to make the switch to less carbon-intensive production methods.

An investment of $110 trillion in the period 2016-2050 is required to achieve the goal of restricting the temperature to rise a maximum of 1.5 degrees (Investment Needs, 2020). The majority of this capital must come from the income market, with a debt to equity ratio of 8.52 at the end of 2019 (S&P Global Debt to Equity Ratio 2006-2019 | SPGI, 2019). At the end of 2018, there was an amount of $188 trillion of debt outstanding worldwide, corresponding to 226% of the GDP (IMF, 2019).

Green bonds can contribute to this in several ways. (Ehlers et al., 2017) has asserted that a mix of lump-sum taxes and subsidies, with regulations to establish constant prices, is the best solution for closing the gap between the private and social costs of pollution. Green finance can contribute to this by increasing the flow of capital to environmentally beneficial projects. According to Ehlers, green finance aims to “internalize environmental externalities and adjust risk perceptions for the sake of increasing environmentally-friendly investments”. Green bonds are an important fundamental of this green finance.

The current status green bond market

Currently, the top three issuers of green bonds are the USA, China, and France (ICMA, 2018). Financial institutions were accountable for the biggest market share, with commercial banks as the most active of all financial institutions. Moreover, the Euro was the preferred currency in 2018, representing 40% of the annual market by volume. The bond type that was issued the most was a senior unsecured bond, with 59% of issue volume. The green bond proceeds have been allocated primarily to finance renewable energy, with 52% of the total proceeds going to renewable energy. Moreover, the majority of the issuers of green bonds tend to be highly rated, with only small friction below investment-grade. (Ehlers et al. 2017).

Despite the rapid growth of the green bond market in recent years, with a growth rate of 26% in the first half of 2019 compared with 2018 (Refinitiv Perspectives", 2019), the market for green bonds is still tiny compared with the global bond market. In 2016, the green bonds only accounted for 1.6% of the global debt issuance. (Ehlers et al. 2017)

The low share of green bonds in the global bond market can either be due to low demand or due to low supply. According to (Zerbib,2016), banks are not prone to expand their balance sheets for the financing of sustainable assets. However, Institutional investors have been taking an interest in the possibility of including sustainable environmental investments in their assets, especially as many of them regard climate change as a threat to long-term economic growth. (Zerbib, 2016)

Also, the national governments are supporting the issuance of green bonds. In Poland, all the proceeds of the green bonds are set aside in an allocated account to fund specific projects with a green bond label (World Bank, 2018). France is also allocating the proceeds of the green bond market to green projects. Thus, both institutional investors and national governments are willing to make investments in green projects.

As the projected cost of the sustainable energy structure decreases, then the cost of financing will become the major factor on which the long-term cost of energy depends (Zerbib, 2016). However, Zerbib has argued that this also results in a lower yield for the investors. This lower yield might discourage investors that are not obliged to invest in green projects.

To study the willingness of investors to finance green projects, the yield difference between green and normal ‘conventional’ bonds can be examined. The yield difference between green and conventional bonds can give an insight into the relation between demand and supply on the green bond market. With a negative yield difference, there would be a higher demand relative to supply in the case of green bonds compared to conventional bonds.

So, a negative yield difference would indicate that investors believe that green bonds are a good investment (Ehlers et al., 2017). In the remainder of the paper, a positive yield difference between green bonds and conventional bonds will be seen as a green bond discount, while a negative yield difference will be seen as a green bond premium.

As there exists a negative relationship between the yield of a bond and the price of a bond, a higher yield for green bonds compared with conventional bonds indicates that green bonds are trading on a lower price than conventional bonds and vice versa, if green bonds are trading on a lower yield, this indicates that they are trading for a higher price than conventional bonds.

The yield curve gives a snapshot of the performance of the green bonds at a specific point of time. So, this yield curve can show whether the bonds are trading at a discount (falling above the yield curve, since prices are inversely proportional to yields), and which ones are selling at a premium (falling below the yield curve) (Partridge & Medda, 2018).

To increase the share of green bonds in the worldwide bond market, it is important to identify whether green bonds are significantly trading for either a higher or a lower price compared to 'normal' conventional bonds. Therefore, this paper tries to answer the following question*: Do green bonds trade at a premium compared with conventional bonds?* So, is the yield for green bonds on average significantly lower than for conventional bonds, which results in a price for green bonds that is significantly higher than for conventional bonds?

To answer this question, a matching method is used, where matches are made between green and conventional bonds. For every green bond in the dataset, a conventional bond with the same characteristics is searched. The only residual difference between the matched green and conventional bonds is a small difference in liquidity. This residual liquidity difference will be controlled for to extract the green bond premium. This will be done through a fixed-effect regression.

The green bond premium is represented by the yield difference given after controlling for the difference in liquidity. This way, there are no estimators in the regression that bias the estimation (Zerbib, 2016).

This paper has contributed to the existing literature in several ways. First, as the green bond market is a fast-growing market, the dataset of 222 bonds is larger than the one of comparable papers. This increases the accuracy of the model.

Secondly, the composition of the green bond premium has been examined further. We find that there exists a large difference in the green bond premium between different issuer types. Moreover, the green bond premium differs significantly between investment-grade and non-investment-grade bonds.

Lastly, the effect of the Corona crisis on the green bond premium has been examined. The daily averages of the green bond premium show a very volatile pattern since the start of the Coronavirus. The difference in the premium before and after the Corona crisis has been inspected further.

The paper is structured as following: in section two, the existing literature will be explored to form a good hypothesis. Then in section three, the dataset will be described. In section four, the methodology of the paper will be explained, whereas in section five the results of the research are given. In section six, several robustness checks will be done, and the effect of the coronavirus will be examined. The paper will be closed by a discussion on the results and a conclusion in sections seven and eight.

2. Literature review

The literature review is structured as follows. The first part of the literature review will analyze what the opportunities are in the green bond market for both the issuers and the investors. The second part of the literature will focus on the current barriers in the green bond market and the role that financing can play overcoming these barriers to contribute to the development of the green bond market. The third part of the literature will focus on the green bond premium.

2.1 opportunities in the green bond market

Issuer perspective

Green bonds can be an interesting option for issuers as they profit from the reputational gains the disclosure requirements of green bonds come along with. Besides, the use of green bonds will align financial and sustainability guidelines. *(Schmitt, 2017).* Furthermore, higher prices and lower yields at the time of issue translate to lower costs of capital for issuers, thereby offsetting some or all the additional expenses of the disclosure. (Partridge & Medda, 2018).

Next to a lower cost of debt, proactive environmental risk management may also increase the credit rating. Furthermore, good environmental management might lower the probability of future clean-up costs, due to the strengthening of environmental regulations as mentioned by (Schmitt, 2017).

(Zerbib, 2016) has found that a company's stock reacts positively to a green bond issue. Zerbib has studied the effects of Corporate Social Responsibility (CSR), especially those of good environmental performances, on companies' stock prices and performances. Firms with better corporate social performance or a more favorable environmental impact benefit from a lower cost of capital.

However, Zerbib mentioned that these findings are not necessarily transferable to the debt market for several reasons. Firstly, the payoff profile of a debtholder differs from that of a stockholder. Since bondholders have little upside available, they must analyze and assess all the downside risks, including environmental hazards. Secondly, bonds generally account for a larger share of companies' balance sheets than equities. Thirdly, firms are more sensitive to the pressure exerted by green investors as they refinance themselves more frequently via the debt market than they increase their capital.

Ultimately, Zerbib came to two conflicting thoughts about the effect of environmental performances on the cost of capital. The first theory is the stakeholder theory, according to which a better environmental performance decreases the cost of capital via a three-fold process. Firstly, they have a positive impact on the company's revenue, which reduces litigation, sanctions, and boycott risks and increases customer activities and government support. Secondly, it reduces the information asymmetry with the lender and thus prevents adverse selection processes and especially environmental hazard risks. Thirdly, good environmental performances increase the size of the bondholder base, which exerts downward pressure on bond yields. (Zerbib, 2016).

The other theory is called the shareholder theory. According to this theory, environmental expenditure is an inefficient use of resources liable to reduce profits and the ability to pay interests, which increases the cost of capital and the bond credit spread. This can be confirmed by Graham and Maher (2006), who relate environmental liabilities or scandals with decreasing bond ratings and increasing yields. Thus, despite the lower yield of green bonds, due to the market inefficiency, the effect of environmental expenditures on the cost of capital for issuers is still ambiguous.

Investor perspective

Additionally, green bonds can be an interesting opportunity for investors. Despite that on the investor side, a green premium may reduce the yields for the bondholder, the rising prices in the secondary market suggest that the investors can sell the green bonds even at a profit in the secondary market (Partridge & Medda, 2018).

Moreover, the green label makes the green bond an interesting investment opportunity for two reasons. Firstly, because investors aspire to be part of the energy transition. These investors are willing to pay a premium for the green label if they value sustainability and are willing to pay for non-monetary reasons (Kapraun & Scheins, 2019).

Secondly, green bonds can be an interesting investment opportunity as the associated risk of such bonds are perceived to be lower than the risks of conventional bonds provided that there is no greenwashing, as stated by (Nanayakkara & Colombage, 2019).

Besides, by adding green bonds to their portfolio, investors get the opportunity to diversify their investment returns. The environmentally friendly investment options make that investors can better balance their portfolio's. Both (Ehlers et al., 2017) and (Schmitt, 2017) mention in their papers that green bonds give a lower exposure to environmental risk compared to non-environmental issuances. Green bonds can hedge against environmentally related financial risks**.**

Environmentally related financial risks can consist of both physical risks and transition risks. The physical risks can be droughts and floods or natural disasters, such as wildfires. According to (Oxfam International, 2020), the number of climate-related disasters has tripled over the last 30 years. Moreover, they have stated that adapting to climate change and coping with damages will cost developing countries $140-300 billion per year by 2030.

The transition risk is the risk of changes in environmental regulations. To decrease the amount of carbon dioxide emission, higher carbon prices can be of great benefit. (Zakeri et al., 2015) has found that there is a significant positive relationship between the carbon price and the reduction in carbon emission. Due to the Paris agreement, regulators will put stricter rules on the production process of firms. One of these rules will likely be a higher carbon emission price. The credit rating agencies will also notice this presumable change in the carbon price and therefore take these financial risks into account by their rating process. (Chabowski, Chiang, Deng & Sun, 2019). Therefore, high-polluting issuers will receive generally lower credit ratings than low-polluting issuers.

(Ehlers et al., 2017) has examined whether green bonds can provide an instrument for investors to hedge against these environmentally related financial risks. To the extent that issuers of green bonds are better shielded against large revaluations, they could serve as an efficient risk management instrument.

However, according to Ehlers, this does not need to be the case. He argues that green bonds generally comprise investor claims on an entity's overall operations. A large and diversified energy company may invest a considerable amount in green projects. However, other parts of its business, such as coal power plants, are exposed to environmentally related credit risks like changes in carbon regulations. There may also be green bonds whose income stream is vulnerable to climate change quite apart from transition risk. For instance, wind farms are subject to flood risk. In the case of almost all green bonds, the exposure to environmentally related credit risks is a function of the entire company's business. Only a few green bonds are project bonds, where claims are on the cash flows of the financed green project itself.

Besides, (Ehlers et al., 2017) indicate that total returns in US dollars on unhedged green bond indices, however, have exhibited higher volatility than those of broad-based bond indices. This is because green bonds are way more diverse. The green bonds have higher currency risk, which increases the volatility of the bond. Therefore, it is no foregone conclusion that green bonds can serve as a hedge against environmental financial risk.

2.2 Current barriers

To increase the share of green bonds on the worldwide bond market, the current barriers for both investors and issuers to participate in the green bond market must be investigated first. Therefore, the next section will contain the current barriers of the green bond market and how green financing can play a role in increasing the share of green debt on the total amount of worldwide debt.

Firstly, suggesting a premium of the green bond, this indicates that bonds are traded at lower yields than comparable conventional bonds. For issuers, this would be beneficial as they must pay a lower yield and receive a higher price. However, investors that are not obliged to assign part of their balance sheet to the purchase of green assets, will choose for conventional bonds as they give a greater yield. Besides, a premium would increase the concentration of green bond risks among the few existing green investors and thus, potentially boost the level of systematic risk *(Zerbib, 2016)*

According to (Zerbib, 2016), there are two kinds of barriers to the development of green projects. On the one hand, some barriers restrict the attractiveness of green projects to investors. These barriers are related to the fiscal incentives for making green investments, consisting of too low carbon pricing and uncertainty regarding the evolution of the feed-in tariffs. Furthermore, large companies undergo difficulties in shifting their strategy to low-environmental-impact problems.

On the other hand, some barriers restrain the number of issues. First, there is a lack of awareness about the benefits of issuing green bonds at the moment. Moreover, there are higher legal and reputational costs if commitments are not achieved coming with green bonds compared with conventional bonds. These barriers also include the higher costs associated with monitoring the use of proceeds. This has been confirmed by (Zerbib, 2016), who indicates that on the issuer's side, the emission of green bonds depends on the existence of green projects and is subject to the obligation of disclosing, tracking, and reporting the use of proceeds. Zerbib states that these restraints are more binding than those governing regular bond emissions and may reduce the volumes issued.

The higher costs associated with the use of proceeds makes that there is a lack of generally accepted green definitions. This together with inadequate policies, standards and regulations result in low creditability for the green bonds *(Nanayakkara & Colombage, 2019).* The low creditability of the green bonds makes the investor more skeptical about the green credentials of the bond. Investors do not trust green labels without additional verification *(Kapraun & Scheins, 2019).*

Investors cannot be sure that the proceeds of green bonds are invested in an environmentally friendly way and not merely "green-washed" to give the appearance thereof (Ehlers et al. 2017).

Possible solutions

The measures that must be made to increase the share of green bonds in the worldwide bond market, given by literature, can be divided into two categories. The first category focuses on the regulatory measures and states that the regulations should be better coordinated between organizations. Moreover, there should be more consistency in the green bond standards. The second category focuses on the financial measures and studies how the cost can be decreased for both the issuer and the investor.

The low share of bonds can be partly attributed to the low creditability of green bonds. The costs associated with the standardization process harm the creditability of the bonds (Nanayakkara & Colombage, 2019). Standardization would lead to lower costs of second opinion providers, which will result in a higher supply of bonds with a green label.

(Nanayakkara & Colombage, 2019) also noted that it is important that local regulations are harmonized with international guidelines. These regulations must be streamlined in line with investor and issuer needs. (Ehlers et al., 2017) stated that despite the various existing definitions and labels for green bonds, there is more and more consistency noticeable in the green market.

However, they suggest that more ongoing monitoring by “second opinion” providers, rating agencies, or other forms of continuous third-party verification may be needed. Even if asset managers utilize the green label simply to signal to ultimate investors their fulfillment of green mandates, the information value of those labels can depreciate over time as technology evolves or policies of the issuer change. As mentioned before, it is important to know that green bonds are safe for environmental financial risks. Therefore, Ehlers has suggested enhancement of the green bond standards to highlight the degree of financial risks to further encourage investors to manage these risks effectively.

These investors are more likely to pay the premium when it is certified as such by a third party or when the bond is listed on an exchange with a dedicated Green bond segment and tight listing requirements. (Kapraun & Scheins, 2019)

Credit rating agencies can play a role in this by very extensively rating the green bonds to reflect the issuer’s reputation. Nanayakkara has stressed that also development banks can play an important role in creating more consistency. The close examination of GB issuing countries around the world reveals that market entry remains minimal in developing countries, particularly the companies that have not raised funds from the GB market. Therefore, development banks can promote public awareness of green financial products to scale up the GB market to meet the global requirements for green investments.

(Ehlers et al., 2017) has suggested that more bonds with claims on the cash flows of an individual project could help diversify issuers and credit risks as individual projects have higher credit risk since issuers of green bonds tend to be highly rated, with only a small fraction rated below investment-grade. (Zerbib, 2016) recommends national and supranational authorities to draw up a precisely defined framework for green bond requirements and streamline the approval process to increase the flow of low-carbon projects.

Consequently, external certification is required to increase the creditability of the bonds. This external certification allows asset managers to show beneficiaries that they are indeed investing in green bonds when requested to do so and might be more cost-effective. (Ehlers et al, 2017) has classified several kinds of bond certification.

First, there are the ICMA green bond principles, outlining general criteria that most certification schemes follow. It provides issuers with guidance on the key components of green bond issuance, namely: (i) the use of proceeds for environmentally sustainable activities; (ii) a process for determining project eligibility; (iii) management of the proceeds in a transparent fashion that can be tracked and verified; and (iv) annual reporting on the use of proceeds.

Secondly, there is the CBI climate bond certification, which establishes sector-specific qualification criteria to judge an asset's low carbon value and sustainability. There is an external verification that the bond meets environmental standards and that the issuer has the proper controls and assets in place. Then, the assets are eligible for climate bond certification. Limitations of the CBI certification are that it does not mandate verification on an ongoing basis and their binary nature: a bond is either green or not green. There is no degree of environmental benefits.

Thirdly, there are green bond indices that identify specific bonds as green via a stated methodology and allow investors to invest in a portfolio of green bonds to diversify risks. To this extent, the green bond index providers also effectively act as institutions of certification. A limitation of these indices is that it does not contain concrete inclusion criteria and it is not sure how long the index providers can monitor such environmental criteria on an ongoing basis.

Fourthly, external reviews can be used. In 2018, 89% of the green bonds issued, received at least one external review with second party opinions as to the preferred option (ICMA, 2018). Examples of external reviews are *CICERO*, which reflects the bonds loyalty to a long-term vision for a low-carbon, "environmentally resilient" society or *MOODY'S GREEN BOND ASSESSMENT (*Green Bond Assessments (GBAs), which are intended to "assess the relative likelihood that bond proceeds will be invested to support environmentally friendly projects) or *Standard & Poor's Green Evaluations* (The focus of these ratings is broader than that of GBAs, as they include a technical environmental impact assessment component, along with governance and transparency components).

Beside the measures to increase the creditability of the issuer, several fiscal measures can be taken to ensure that the cost of green bonds will decrease to make it more attractive for investors and issuers. (Nanayakkara & Colombage, 2019) has recommended the government to provide subsidies and tax incentives to both issuers and investors to mobilize private funds to the GB market. Besides, this paper has suggested that financial institutions can provide guarantees to encourage issuing risk-mitigating green debt instruments. According to (Zerbib, 2016), Tax support measures must be weighed up against traditional climate support facilities and they could be improved by reducing the present tax exemptions for those promoting fossil energies.

To decrease the level of risk, (Zerbib, 2016) has suggested to promote risk pooling, and especially via asset-backed securities. This might also enable smaller players to enter the market and thus decrease the systematic risk in the market. Public institutions can play a role by improving the risk profile through credit enhancement.

Finally, the central bank and other monetary authorities could support the development of green projects by prioritizing the purchase of green bonds in their quantitative easing programs, whereas the amount of green lending should determine the banks' reserve requirements.

2.3 The green bond premium

To assess the willingness to invest in green bonds, the yields of green bonds are compared with the yields of conventional bonds. Literature has been explored to form a hypothesis on the existence of a yield difference and whether this holds a green bond premium or a green bond discount. The majority of the reviewed literature has found a green bond premium, indicating that green bonds are trading, on average, on a lower yield than conventional bonds. However, according to these papers, this premium can differ significantly.

First of all, there is the difference in premium between the primary and the secondary market. A premium in the primary market, indicating a premium paid by the investors, does not necessarily translate into a noticeable underperformance for investors in the secondary market. Investors in the secondary market may well price in a different premium from primary market investors. (Ehlers et al., 2017). Ehlers indicated that the performance of green bonds and conventional bonds were similar over time in de secondary market. Thus, according to Ehlers, over a longer period, there does not exist a green bond premium in the secondary market.

(Zerbib, 2016) has found that the secondary market structure has the potential for increasing the green bond issuance and offering a primary yield which is slightly lower than that observed on the conventional bond curve. According to (Partridge & Medda, 2018), there exists a relationship between the green bond premium in the primary market and the green bond premium in the secondary market. This paper argues that the presence of a green bond premium in the secondary market could lend pressure to primary market prices since secondary market prices are an indicator of what the market will bear. According to this paper, the primary market trends seem to lag behind the secondary market trends by two years. (Kapraun & Scheins, 2019) has found that the green bond premium that existed in the primary market, disappeared in the secondary market.

In addition to the difference between the primary and the secondary market, also the composition of the green bond premium shows interesting values as there exists a significant difference in premium between particular types of bonds.(Nanayakkara & Colombage, 2019) has found that there is a greater premium for riskier bonds. So, bonds with a lower rating than AAA generally have a higher premium, which has been confirmed by (Zerbib, 2016). Zerbib has added that there also exists a difference in premium for bonds with a small and bonds with a large issued amount. According to him, bonds with a lower issued amount give a lower premium.

Moreover, Zerbib found that also USD bonds give a greater premium than EUR bonds. (Kapraun & Scheins, 2019) has also found a difference in premium between different types of bonds. They detected a difference in premium between the issuer types. They found a premium for official entities such as governments and supranational organizations. However, for corporate bonds, a discount was given in the secondary market.

Next to the green bond premium that exists due to the difference in yields, also a liquidity premium must be incorporated according to existing literature. (Beber et al., 2009) has found that there exists a negative relationship between the liquidity of a bond and the credit spread. Therefore, lower liquidity results in a higher credit spread. Moreover, (Friewald et al., 2012) have found that the change in the credit spread can be accounted for 14% on the liquidity premium. Therefore, it is important to control for the liquidity premium in the regression.

To determine if positive external reviews result in lower yields, the relationship between the bonds' sustainability scores and the yield differences of the bonds is examined. A negative relationship between the yield differences and the sustainability scores of the green bonds would indicate that investors are willing to accept a lower yield if the issuers have better external ratings.

The following questions will be investigated:

1. *Do green bonds trade at a premium or a discount compared to conventional bonds?*
2. *What is the effect of the corona crisis on the green bond premium?*
3. *What is the relationship between the yield differences and the sustainability scores?*

The reviewed literature has resulted in the following hypotheses:

Hypothesis 1: Green bonds do trade at a premium compared to conventional bonds

Hypothesis 2: The corona crisis results in a larger premium

Hypothesis 3: There exists a negative relationship between the yield differences and the sustainability scores

3.Data

Matching

In order to find the yield difference between green and conventional bonds, a matching method has been used. Bonds have been matched on identical characteristics. The only difference between the bonds is a small residual difference in liquidity. Therefore, the difference in liquidity is controlled for through a liquidity proxy. The yield difference that is left is the green bond premium.

The analysis is performed as follows. At first, a dataset from Thomson Reuters has been collected. This dataset consists of 1749 bonds with a green label and over two million conventional bonds. The dataset of green bonds consists of bonds from different issuer types, such as supranational, sovereign, and corporate bonds. The best option to compare the green with the conventional bonds would be to find identical 'twins' for the green bonds. This holds bonds from the same issuer, with the same issue date and maturity date and the same coupon value. However, as the green bond dataset is relatively small, it is unfortunately not possible to find identical 'twins'.

To match the green and conventional bonds, several bonds are removed from the green bond dataset. Only plain vanilla fixed coupon bonds are selected. Moreover, all the bonds in the sample must be active. The next step was to remove bonds from currencies with a small number of bonds available. This resulted in a dataset with bonds that were traded in US $, AU $, Euro, CH Y, JP Y, SEK, or MYR. This led to a dataset of 802 green bonds. Then, we tried to find conventional bonds that match these green bonds as precisely as possible.

Suggestions from other literature have been considered to match the green and conventional bonds. (Partridge & Medda, 2018) has focused on the US municipal bond market since it is possible to obtain data from identical green and conventional bonds on this market. So, bonds with the same issuer, same time to maturity and same format, also priced on the same day.

Furthermore, this paper indicated that it is important to find bonds with the same tax status. This is because tax advantages are frequently given in muni bond issuances. Thus, the issuer type of bonds must be the same.

Moreover, suggestions of (Zerbib, 2016) have been followed to match conventional bonds that have a maturity within two years of the green bond. This means that the conventional bond can mature either a maximum two years before or after the green bond matures. This has limited the difference in maturity. Zerbib also suggests limiting the difference in liquidity by inspecting the issue date and issue amount as a large difference in the issue amount and issue date can have a significant impact on the yield level.

All the factors that influence the yield level, except for the green bond label, must be controlled for. Zerbib indicated that the issued amount of the conventional bond could be at least 25% of the issued amount of the green bond and a maximum of 400% of the issued amount of the green bond. Besides, conventional bonds cannot be issued six years before or after the green bond is issued.

These recommendations have been considered and groups of bonds with the same characteristics have been formed. The green bond dataset has been divided into groups of maturity with a range of two years. Furthermore, groups have been formed based on the issue date. As there is a large number of conventional bonds available, we have chosen to reduce the difference in year of issue to a maximum of three years. In order to do so, just as with maturity, the dataset has been divided into subgroups. The same method has been used for the issued amount.

The three groups have been combined, to make different subgroups of the green bond dataset. Conventional bonds were searched that are in the same groups of bonds. Moreover, the credit rating and the currency of the conventional bonds must match with the credit rating and currency of the green bond.

As the dataset only consists of bonds that are active and are plain vanilla fixed bonds, this makes that the matches have the same coupon type, same activity, same issuer type, same credit rating, and same currency. Furthermore, the differences in issue amount, issue date, and maturity date have been limited. Despite that the matches are not identical 'twins', the green bonds could be matched with comparable bonds to find the yield difference between the green and conventional bonds.

This resulted in a sample of 222 matches. The descriptive statistics of these matches are presented in Table 1. Looking at the frequency distribution of the credit ratings, one can observe that 30 bonds have the highest rating of AAA. Moreover, 17 bonds are high yield, with the other 205 bonds being investment-grade bonds.

The majority of the bonds are corporate bonds, while there are 29 supranational bonds in the dataset and only 3 sovereign and 3 sub-sovereign bonds in the sample. Moreover, the larger part of the sample consists of bonds that are issued in either Euro or US$. This was partly due to the unavailability of credit ratings for bonds of certain currencies, such as the Chinese Yuan.

Table 1: descriptive statistics of the bond pairs.

	Frequency		Frequency
Rating		**Issuer type**	
Aaa	30	CORP	187
Aa1	3	SOV	3
Aa2	12	SSOV	3
Aa3	10	SUPR	29
A1	23	*Total*	222
A2	20	**Currency**	
A3	30	A$	3
Baa1	42	E	130
Baa2	23	U$	88
Baa3	12	Y	1
Ba1	5	*Total*	222
Ba2	6	**Inv. grade**	
Ba3	2	no	17
B3	4	yes	205
Total	222	*Total*	222

Yield difference

After the matches have been formed, the yield data is subtracted for the green and conventional bonds. If the yields are analyzed on an annual basis, much of the intraday pricing movements and trends are missed. (Partridge & Medda, 2018). Therefore, yield data of the bonds have been obtained on a daily basis. The yield to maturity has been obtained from the 1st of January 2020 till June 11th, 2020, resulting in 116 days of yield data for the matched bond pairs. This recent yield data will give a good insight into the status of the green bond market.

As the yield data is obtained from the 1st of January 2020 till June 11th, 2020 and we are comparing yields in the secondary market, including bonds that are issued during the aforementioned period will give primary issuance effects. Therefore, none of the bonds in the dataset are issued in 2020.

All the bonds with missing yield data are removed from the sample. Accordingly, all the bonds in the sample have full yield data for the whole period. Yield data for both the green and the conventional bonds have been subtracted. To study the existence of a green bond premium, the yield of comparable green and conventional bonds must be analyzed. Therefore, the yield difference between green and conventional bonds will be the dependent variable of the following regression:

$$\Delta y_{I,t} = \rho_I + \beta\Delta \text{ Liquidity}_{I,t} + \varepsilon_{I,t}.$$

At first, the daily green and conventional yield data are obtained from Thomson Reuters Datastream. Then the yield difference is calculated by the following formula:

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

This yield difference is obtained for every day for every match. A positive yield difference means that the green bond is trading on a higher yield than its matched conventional bond. Then, the green bond is trading at a discount, as the investors receive a higher yield for a green bond than for a comparable conventional bond. The yield to maturity is used because it can compare bonds with different maturities. As mentioned in the matching part, the maturities of the matched bonds are comparable, and the difference is limited. However, there still exists a difference and as the yield to maturity expresses the value of different bonds in the same terms, the yield to maturity is used as the dependent variable in the regression.

With the matching method, the differences between green and conventional bonds are limited as much as possible to minimize the maturity bias and the liquidity bias. To check if this matching method was efficient, the liquidity and maturity of the green and conventional bonds were compared by looking at the descriptive statistics of the dataset. In Tables 2 and 3, the descriptive statistics of the duration, maturity, and age are shown for the green and conventional bond dataset.

As one can see, the means for both duration, maturity, and age are quite comparable for the green and conventional datasets. The mean value of duration is slightly higher for the green bond dataset than for the conventional bond dataset. However, this difference is only 4 basis points.

For maturity, the mean of the green bonds is slightly higher, indicating that the green bonds, on average, mature a few months later than the matched conventional bonds. This illustrates a small maturity bias towards green bonds. However, the median value is somewhat higher for the green bonds.

For age, the mean of the conventional bonds is a little higher, indicating that the conventional bonds are on average a few months older than the green bonds. A reason for this can be that the green bond market is relatively young.

Altogether, the differences between the green and conventional bond datasets are very small, which is an indication that the matching method was efficient in limiting the liquidity and maturity bias for the regression.

Table 2: duration, maturity, and age green bonds

	mean	*sd*	*median*	*min*	*max*
duration	4.883403	(2.879891)	4.70195	.2297	16.6905
maturity	5.251514	(3.218421)	4.8904	.2472	19.0246
age	2.494682	(1.544647)	2.23425	.4889	8.211
N	222				

Table 3: duration, maturity, and age conventional bonds

	mean	*sd*	*median*	*min*	*max*
duration	4.8437	(2.83514)	4.75555	.07405	16.239
maturity	5.240593	(3.221845)	4.9548	.09041	19.0548
age	2.736063	(1.610395)	2.3421	.5472	8.2109
N	222				

To analyze the differences in liquidity, the issued amounts of the green and conventional bond datasets were compared. However, as the issued amounts were given in the currency of the bonds, the amounts must be converted to US$. In order to do so, the live market exchange rates were used. ("XE - The World's Trusted Currency Authority: Money Transfers & Free Exchange Rate Tools", 2020).

The following conversion rates were given:

Au $ => US $ = 0.690521

Euro => US $ = 1.13767

JPY => US $ = 0.00936396

Then, the total issued amounts and the frequencies were given for the different currencies. As can be seen in Table 4, the issued amounts were larger for the conventional bond dataset. Hence, the difference in liquidity still needs to be controlled for, despite the small differences in the duration, maturity, and age. An explanation for the difference in issued amounts can be that the green bond market is still relatively small compared to the total bond market. Moreover, the conventional bond issued amount could be between 25% and 400% of the green bond issued amount, which is a large range.

Table 4: issued amounts for every currency

Issued amount green bonds by currency

Currency	N	mean
A$	3	184,138,933
E	130	753,099,778
U$	88	581,556,818
Y	1	280,918,800
Total	222	675,285,166

Issued amount conventional bonds by currency

Currency	N	mean
A$	3	201,401,958
E	130	850,182,708
U$	88	712,919,386
Y	1	187,279,200
Total	222	784,018,662

Accordingly, a liquidity proxy must be chosen and added to the regression of the yield difference. In the regression used for the model: $\Delta y_{I,t} = \rho_I + \beta\Delta \text{ Liquidity}_{I,t} + \varepsilon_{I,t}$, the liquidity proxy is represented by $\beta\Delta \text{ Liquidity}_{I,t}$.

The daily bid and ask prices are obtained by Thomson Reuters Datastream. All the bonds for which not all the daily bid or ask prices were available are removed from the dataset. This resulted in a panel dataset with 222 matched bonds and 25752 observations.

To test the effect of the sustainability score of bonds on the green bond premia, the ESG scores are subtracted from the Thomson Reuters database. Datastream has defined the ESG score as "an overall company score based on the self-reported information in the environmental, social and corporate governance pillar"

The ESG scores could not be obtained for all the bonds. Eventually, the ESG scores could be obtained for 49 bonds. For those bonds, the green bond premia were analyzed to see if bonds with a high ESG score show a larger green bond premium.

4. Methodology

To extract the green bond premium from the dataset, a suitable liquidity proxy must be chosen. (Zerbib, 2016) has mentioned that the liquidity proxy is subject to three different constraints. The first is that it is not possible to use day-to-day data and therefore intraday liquidity measures cannot be used. The second constraint is that no information about daily trading volumes is available. The third constraint is that a liquidity proxy must change over time. Therefore, proxies such as the issued amount or issue date cannot be used.

(Langedijk, Monokroussos & Papanagiotou, 2018) has benchmarked different liquidity proxies and found that the bid-ask spread is the best performing proxy across different frequencies. The bid-ask spread is also used by (Zerbib, 2016) as a liquidity proxy.

The bid-ask spread is defined by the following regression:

$$BAS_{i,t} = ASK_{i,t} - BID_{i,t}$$

Thus, the bid-ask spread is calculated for every green and conventional bond on a daily basis. Then, the liquidity proxy is defined by the following equation:

$$\Delta \text{ Liquidity}_{\text{I,t}} = BAS_{i,t}^{GB} - BAS_{i,t}^{CB}$$

The descriptive statistics of the bid-ask difference are shown in Table 5. The descriptive statistics show an average value for the bid-ask difference of 0.02.

Table 5: bid-ask spread descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
BAS	25752	.024	.366	-9.654	4.552

This liquidity proxy is used in the regression $\Delta y_{\text{I,t}} = \rho_{\text{I}} + \beta\Delta \text{ Liquidity}_{\text{I,t}} + \varepsilon_{\text{I,t}}$. After controlling for the liquidity proxy, the green bond premium can be extracted from the regression. The green bond premium is represented by ρ_{I} , while $\varepsilon_{\text{I,t}}$ represents the error term in the equation.

The next step is to decide whether a fixed-effect or random-effect model fits better with our model. Suggestions of (Schmitt, 2018) are followed and a Hausman test is conducted. The null hypothesis of the model is that a random-effect model is appropriate, while the alternative hypothesis is that the fixed-effect model is the better option. In this case, the null hypothesis is rejected and therefore a fixed-effect model has been chosen. The result of the Hausman test can be found in the Appendix.

Fixed-effect regression gives the bond-specific time-invariant unobserved effect without giving any information about the other bonds (Zerbib, 2016). Moreover, unbiasedness and consistency of the estimator are assured with fixed-effect regression.

Moreover, heteroskedasticity could be present in the dataset. There is heteroskedasticity if the variability of the error term of the independent variable is not equally distributed within the sample. (Van Keppel, 2019). Also, the serial correlation must be tested. This is when the error terms are correlated over time to a certain degree.

To test for the presence of heteroskedasticity, a modified Walt test has been conducted. A probability of 0.0000 shows that heteroskedasticity is present in the sample. As an extra test, also a Breusch-Pagan test has been conducted. The Breusch-Pagan test confirms the presence of heteroskedasticity in the sample. The results of both tests can be found in the appendix.

To allow for this heteroskedasticity and serial correlation, clustered standard errors are used. There has been controlled for the liquidity difference in two ways. By matching the bonds on comparable issue date and issue amount, the difference in liquidity is reduced significantly already. The remaining difference is controlled for in the regression. After controlling for this difference, the green premium can be extracted. This green premium reveals what part of the yield difference is due to the green bond label when all the other differences between the bonds are controlled for.

The green bond premium has been subtracted for a sample of 222 bonds with 25752 observations. The results are presented in the next section.

5. Results

The following section presents the results of the regressions that have been run. Firstly, the effectiveness of the liquidity proxies has been tested. Secondly, the yield difference between the green and conventional bonds has been analyzed, with correspondingly the green bond premium which is extracted from the regression $\Delta y_{I,t} = \rho_I + \beta\Delta \text{ Liquidity}_{I,t} + \varepsilon_{I,t}$. Then, the determinants of the green bond premium will be analyzed. This will be followed by an investigation on the effect of the coronavirus on the green bond premium. Consequently, the relationship between the issuers' ESG scores and the yield differences is inspected.

5.1 Liquidity proxy

At first, the efficiency of the liquidity proxy has been tested for both the fixed effect regression and the fixed effect regression with clustered standard errors . The results are given in Table 6. The R-squared indicates what part of the variation of the dependent variable can be explained by the variance of the independent variable. As can be seen in the Table, the R-squared gives a low value of 0.000178. This R-squared is the within R-squared of the model, which represents the ordinary R-squared from OLS on the transformed data.

To test the significance of the R-squared, an additional F-test can be performed. As can be observed in Table 5, the F-test shows significance even at the 99.9% confidence level. Therefore, we can say with 99.9% certainty that we reject the null hypothesis that no variation of the dependent variable is explained by the independent variable. This indicates that part of the variation of the yield difference is explained by the bid-ask difference. Hence, the bid-ask difference can be considered as a competent liquidity proxy.

Furthermore, a T-test has been conducted for the bid-ask difference. The null hypothesis of this test is that the bid-ask difference does not affect the yield difference. As can be seen in Table 6, the bid-ask difference is significant on a 95% confidence level and therefore the null hypothesis can be rejected on a 95% confidence level. Therefore, we can say with 95% certainty that the bid-ask difference affects the yield difference between green and conventional bonds. As the coefficient in the output model is negative for the bid-ask difference, it means that the bid-ask difference has a negative effect on the yield difference. A 1% increase in the bid-ask difference results in a 0.052% decrease in the yield difference.

Table 6: regression results bid-ask spread

	(1)	(2)
	FE	FE clustered
BAS	-0.0520*	-0.0520
	(0.0244)	(0.121)
F Statistic	4.553***	0.186
R2	0.000178	0.000178
N	25752	25752

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As mentioned in the methodology part, clustered standard errors are used to allow for heteroskedasticity and serial correlation. Therefore, the efficiency of the bid-ask difference as a liquidity proxy has also been tested for a fixed effect regression with clustered standard errors. As can be seen in Table 6, the coefficients are the same for the standard fixed effect regression and the one with clustered standard errors. Also, the R-squared is the same for the fixed effect regression with clustered standard errors.

However, both the F-test and the T-test do not show significant values for the bid-ask difference. Thus, for the fixed effect regression with clustered standard errors, the null-hypothesis that the bid-ask difference cannot explain differences in the yield difference is accepted. Hence, according to the model, the bid-ask difference does not add power to the model. As the bid-ask difference was used as an extra liquidity proxy to check for existing differences in liquidity, this means that if clustered standard errors are used, the bid-ask difference does not add value.

Therefore, the measures taken at the matching method in combination with the clustered standard errors were strong enough to sufficiently reduce the difference in liquidity between the green and conventional bonds. This can be confirmed by the fact that the difference in liquidity was very small as can be seen in Table 4. The average bid-ask difference has a mean value of 0.02, which is very small and shows the effectiveness of the measures taken to minimize the liquidity bias at the matching method.

5.2 Yield difference

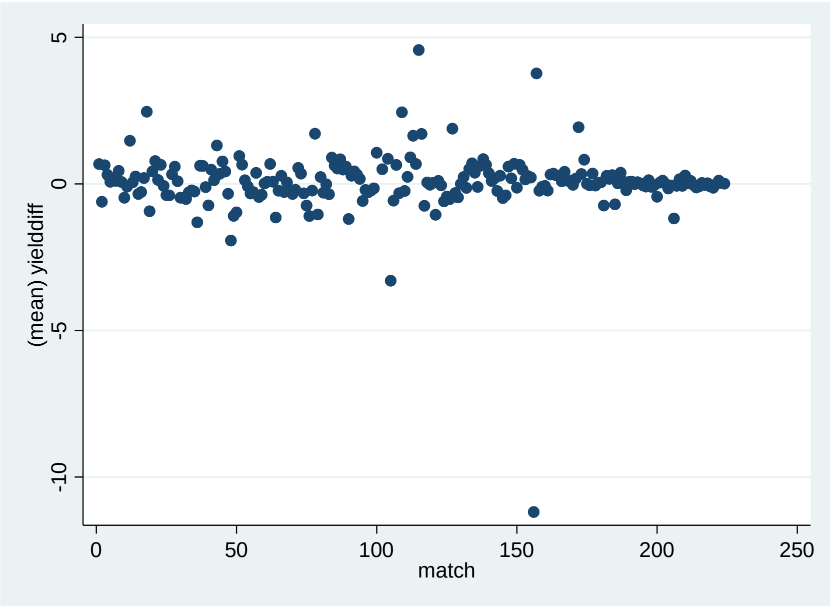
After the effectiveness of the bid-ask difference as a liquidity proxy has been tested for both the standard fixed effect regression and the fixed effect regression with clustered standard errors, the results of the regression for the difference in yield between green and conventional bonds are investigated.

At first, the time-series averages of the yield difference are calculated for every matched bond pair. The descriptive statistics of the yield differences are presented in Table 7. As can be observed, the mean of the yield differences is 0.06, while the standard deviation gives a value of 1.59. The median yield difference in our sample is 0.0275. The positive mean value indicates that the average green bond is trading at a higher yield than its comparable conventional bond.

Table 7: descriptive statistics yield difference

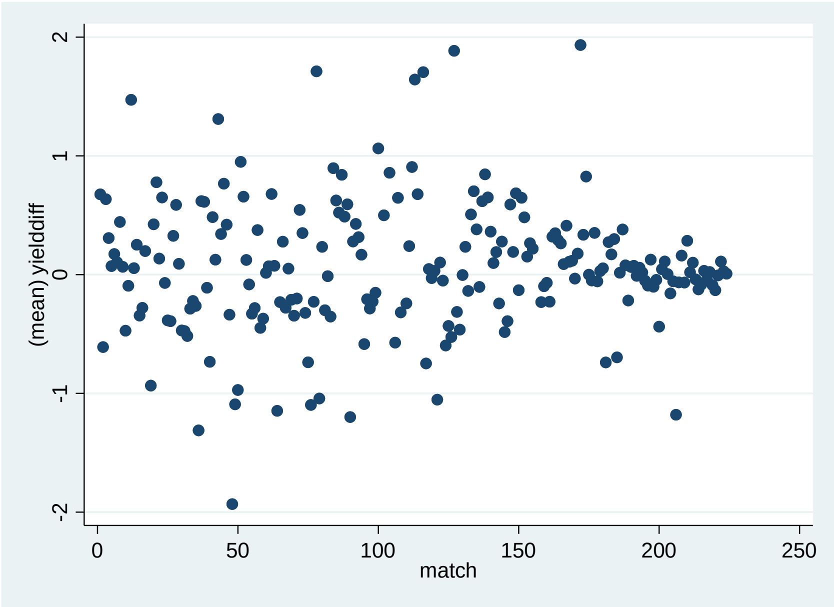
	mean	*sd*	*median*	*min*	*max*
Yield difference	.061796	1.585407	0.0275	-34.3947	35.3421
N	25752				

Figure 1: distribution yield differences



The distribution of the yield difference between the green and conventional bonds is shown in figure 1. As can be seen in the figure, the sample contains a few outliers. However, the majority of the yield differences are concentrated around zero. To illustrate this, the bond matches with average yield differences that were < -2 or > 2, were removed from the sample. In total, six bonds were removed from the sample. Four bonds that had an average yield difference that was > 2 and two bonds that had an average yield difference that was < -2 were removed. Then, the following distribution of the yield differences is given. As can be seen, the majority of the yield differences have a value that lays between -1 and 1.

Figure 2: distribution yield differences without outliers



5.3 Regression

As mentioned before, the following regression has been run:

$$\Delta y_{i,t} = \rho_i + \beta\Delta \text{ Liquidity}_{i,t} + \varepsilon_{i,t}.$$

Table 8: descriptive statistics green bond premium

	mean	*sd*	*median*	*min*	*max*
GB premium	.0630325	1.587285	.0277752	-34.3947	35.3421
N	25752				

The descriptive statistics of the green bond premium can be found in Table 8. A green bond discount of 0.063 has been found for the fixed effect regression. So, after controlling for liquidity differences, the yield of green bonds is on average still 6.3 basis points higher than the yield of conventional bonds. For the fixed effect regression with clustered standard errors, the same green bond discount of 0.063 is given. Therefore, one can say that, on average, investors are receiving a 6.3 basis points higher yield for their investment. Accordingly, green bonds are trading on a discount compared to the conventional bonds.

In Table 9, the average yield difference without controlling for the liquidity difference, and the green bond premium are compared. Without controlling for the liquidity differences, the yield difference between green and conventional bonds was 0.061. Therefore, adding the bid-ask difference as a liquidity proxy makes a small difference in the green bond discount.

Table 9: the effect of the liquidity proxy

	mean	*sd*	*p50*	*min*	*max*
GB premium	.0630325	1.587285	.0277752	-34.3947	35.3421
Yield difference	.061796	1.585407	.0275	-34.3947	35.3421
N	25752				

5.4 Determinants of the green bond premium

In the next section, the determinants of the green bond premium are examined. At first, the differences in the green bond premium between bonds with a small issue size and bonds with a big issue size are analyzed. To do so, the dataset has been divided into bonds with an issued amount below $600 million and bonds with an issued amount of $600 million or higher.

Table 10: green bond premium by issued amount groups

Green bond premium by amount issued

Amount	N	mean
<600M	15080	.114
>600M	10672	-.008

As can be seen in Table 10, bonds with a small issued amount show a significantly higher green bond discount than bonds with a big issued amount. This indicates that green bonds with a small issued amount trade on average at a yield that is 11.4 basis points higher than their comparable conventional bond after controlling for the liquidity difference. However, for bonds with a big issued amount, a green bond premium of 0.8 basis points is shown. This implies that green bonds with a big issued amount trade on slightly lower yields than their comparable conventional bonds.

Next, the green bond premium of bonds with an investment-grade credit rating is compared with the green bond premium of the speculative bonds. As can be seen in Table 11, bonds that are not investment-grade show a higher green bond discount. The average discount for non-investment-grade bonds is 15.9 basis points, while the average discount for investment-grade bonds is 5.5 basis points. It must be noted that the investment-grade bonds have 23,780 observations, while the non-investment-grade bonds have only 1,972 observations.

Table 11: green bond premium by credit rating

Green bond premium by rating group

Rating group	N	mean
speculative	1972	.159
Investment-grade	23780	.055

Also, the sample has been divided into all the currencies. As can be seen in Table 12, the majority of the bonds are in Euro or US$. There does not exist a large difference in the green bond premium between US$ and Euro bonds. For both groups there exist a small green bond discount.

Table 12: green bond premium by currency

Green bond premium by currency

Currency	N	mean
A$	348	.047
E	15080	.051
U$	10208	.085
Y	116	-.224

To further investigate the composition of the green bond premium, the currencies are further decomposed in the different issuer types. An interesting result is the green bond discount that is given for corporate US$ bonds. Controlling for the liquidity difference, green corporate US$ bonds give a yield that is on average 13.2 basis points higher than its matched conventional bond.

Table 13: green bond premium by currency and issuer type

Green bond premium corporate bonds by currency

Currency	N	mean
A$	348	.046
E	13108	.057
U$	8120	.132
Y	116	-.223

Green bond premium supranational bonds by currency

Currency	N	mean
E	1276	-.025
U$	2088	-.094

Lastly, the green bond premium of different issuer types is compared. The results can be found in Table 14. As can be seen in the Table, the supranational bonds show a green bond premium of 6.7 basis points. This while the other issuer types show a green bond discount. It must be acknowledged that the number of observations for both the sovereign and the sub-sovereign bonds is quite low with both only 348 observations.

Table 14: green bond premium by issuer type

Green bond premium by issuer type

Issuer type	N	mean
CORP	21692	.083
SOV	348	.117
SSOV	348	.029
SUPR	3364	-.067

As can be seen in Table 15, a regression has been run on both the supranational bond and the corporate bond dataset. It can be observed that the green bond premium shows significance at a confidence level of 99.9% for both the supranational and the corporate bonds. However, the F-statistic does not show significance for the supranational bonds and is significant on a 95% confidence level for the corporate bonds. The same results can be found for the T-test on the bid-ask difference as a liquidity proxy. The bid-ask difference has an effect on the yield difference on a 95% confidence level for the corporate bonds.

However, it cannot be concluded that the bid-ask difference has an effect on the yield difference for the supranational bonds, which does not come as a surprise as a very small coefficient is found for the bid-ask difference at the supranational bond regression.

Table 15: GB premium by issuer type

	(1) supranational	(2) corporate
BAS	-0.000262	-0.0706^{*}
	(-0.03)	(-2.31)
_cons	-0.0675^{***}	0.0834^{***}
	(-39.37)	(9.46)
F Statistic	0.000926	5.316^{*}
R2	0.000000278	0.000247
N	3364	21692

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.5 ESG score

In order to test what the effect of the ESG score is on the yield difference between green and conventional bonds, a regression has been run on the bonds with an ESG score available. A fixed-effect regression could not be run as the ESG score does not vary over time. Instead, a normal linear regression has been run and the results are shown in Table 16. A small coefficient is found for the ESG scores and the ESG does not show significance. Therefore, it can be concluded that the ESG score does not add value to the model for the available bonds.

Table 16: regression with ESG scores

	(1) yielddiff
ESG	0.00162
	(1.37)
BAS	0.238***
	(5.33)
_cons	-0.00132
	(-0.01)
F Statistic	14.19***
R2	0.00497

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To confirm that there is no positive relationship between the ESG scores and the green bond premium a scatterplot has been run between the green bond premium and the ESG scores. The scatterplot is presented in Figure 3 and does not show an upward curve.

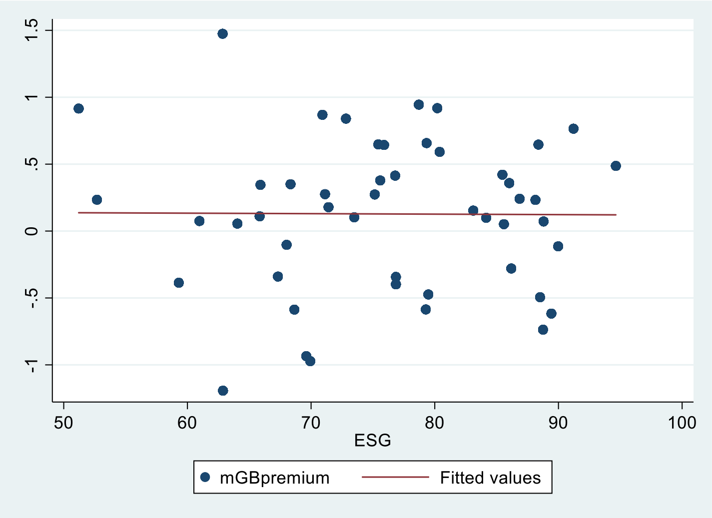


Figure 3: scatterplot GB premium on ESG scores

6. Robustness check

Subsequently, the model will undergo some robustness checks. To test for the robustness, suggestions of (Zerbib, 2016) have been followed and a two-way fixed effect regression is conducted to detect if the green bond premium is stable over time. To do so, a fixed time effect is added to the individual effect.

As can be seen in Table 17, the coefficient of the bid-ask difference is -0.028, while it was -0.052 for the individual fixed effect regression. Moreover, comparing the F-test and the T-test gives a puzzling result. On the one hand, the F-test appears to be highly significant, even at a confidence level of 99.9%.

On the other hand, the T-test shows that the bid-ask difference is not significant, not even on a 95% confidence level. This may happen in time-series analysis, where multicollinearity plays a big role. This is reasonable as the daily yield value for an individual bond is highly dependent on the yield value of the days before.

Therefore, the T-test shows a high P-value as the individual predictors do not have left much to explain after allowing for the effect of the other predictors. This also explains why the individual time effect is only significant during a small part of the days. However, the 0.0000 probability level shows that the predictors together are very strong in explaining the variance in the dependent variable.

Table 17: two-way fixed effect

	(1)
	yielddiff
BAS	-0.0280
	(-1.15)
F Statistic	2.851***
R2	0.0128
N	25752

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

To test the stability of the green bond premium across the whole sample, the average premium of the bonds across the days of the sample period has been illustrated. As can be seen in Figure 4, the green bond premium does not show a stable pattern. However, from day 1 to day 50, a stable small discount of the green bonds can be observed. However, from day 50 on in the sample period, large both positive and negative changes in the premium can be found.

From day 50, a large increase in the average yield difference was followed by a large decrease in the yield difference. This indicates that the average yields of green bonds compared to its matched conventional bonds were rising at first and then the yields of the green bonds compared to the matched conventional bonds were declining very fast.

Figure 4: Gb premium distribution over the days

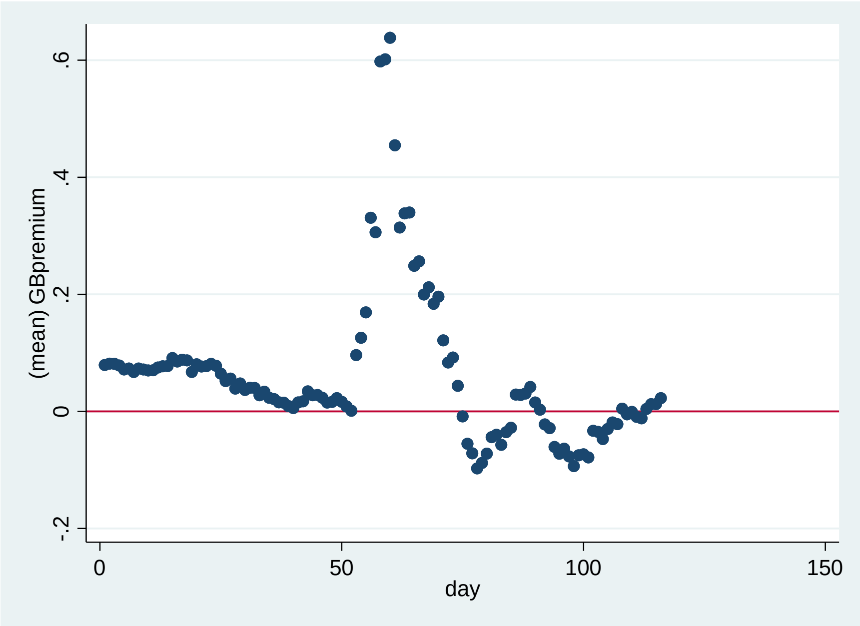


Table 18: green bond premium from day 70 on

	(1) FE	(2) FEclustered
BAS	0.0260	0.0260
	(0.85)	(0.39)
_cons	-0.0232**	-0.0232***
	(-3.04)	(-7.81)
F Statistic	0.726	0.149
R2	0.0000727	0.0000727
N	10212	10212

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To examine if the green bond discount turned into a premium after the corona crisis, a regression on the yield difference has been run from day 70 on. As can be seen in Figure 4, after a big increase and decrease in the period day 50- 70, a more constant value can be observed since day 70.

Both a fixed-effect regression and a fixed-effect regression with clustered standard errors have been run on this sample. As can be observed in Table 18, for both regressions a green bond premium of 2.32 basis points is found.

This green bond premium is significant on a 99.9% confidence level for the FE clustered standard error regression and is significant on a 99% confidence level for the FE regression. Moreover, for both regressions, the bid-ask difference did not show significance, which holds that the bid-ask difference does not add value to the regression in this sample. This can be confirmed by the non-significance of the F-statistic for both regressions. Therefore, none of the variation of the yield difference can be explained by the bid-ask difference in this sample.

In Table 19, the composition of the green bond premium can be found for the sample that starts at day 70. In this sample, the corporate bonds show an average premium, and also the US$ bonds show an average premium. This is a striking result, as both the corporate and the US$ bonds showed the highest discounts in the whole sample. Where the green bond discount of the Euro bonds in this sample is comparable with the discount found over the whole sample, the difference in premium between the samples comes mainly from the US$ corporate bonds.

Table 19: Green bond premium by issuer type and currency sample day 70-116

Green bond premium by issuer type

Issuer type	N	mean
CORP	8602	-.017
SOV	138	.207
SSOV	138	.005
SUPR	1334	-.091

Green bond premium by currency

Currency	N	mean
A$	138	.04
E	5980	.011
U$	4048	-.073
Y	46	-.23

Green bond premium corporate bonds

Currency	N	mean
A$	138	.04
E	5198	.008
U$	3220	-.057
Y	46	-.23

Green bond premium supranational bonds

Currency	N	mean
E	506	-.015
U$	828	-.137

The US$ corporate bonds showed an average green bond discount of 13 basis points over the whole sample and in the sample that starts at day 70, an average green bond premium of 5.7 basis points was found.

Moreover, to test the robustness of the GB premium over time, a comparable regression has been conducted for the same matched bonds during 2019. The bonds with missing yield or bid-ask data for this period were removed from the sample. What followed was a sample of 130 bonds. A fixed-effect regression has been run. The output of the regression can be found in Table 20.

Surprisingly, an even bigger GB discount for green bonds is found. Green bonds trade on a discount of 9.1 basis points. However, looking at the descriptive statistics in Table 21, a median value of 3 basis points can be observed. The fixed effect regression is significant for both the F-test and the T-test on a 99.9% confidence level. Therefore, also for this sample, the bid-ask difference adds value to the model and can be seen as a good liquidity-proxy.

Table 20: regression results data 2019

	(1) FE	(2) FEclustered
BAS	-0.0334***	-0.0334
	(-5.11)	(-0.77)
GBpremium	0.0916***	0.0916***
	(99.73)	(150.84)
F Statistic	26.16***	0.594
R2	0.000781	0.000781
N	33584	33584

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 21: descriptive statistics GB premium 2019

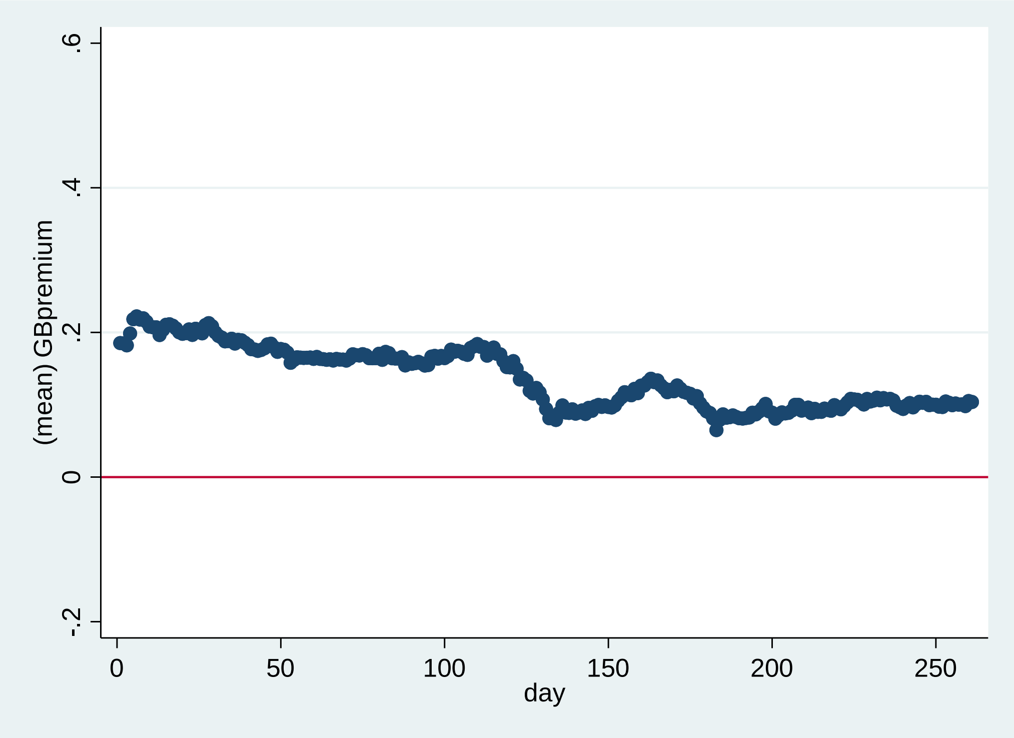
	mean	*sd*	*median*	*min*	*max*
Yield difference	.0920719	.4141387	.033	-1.9234	1.9986
GB premium	.0916037	.4158397	.0322487	-1.930626	2.018684
N	33584				

Moreover, also a fixed effect regression with clustered standard errors has been examined. The output can be found in Table 20. Again, the F-test and T-test show insignificance for the bid-ask difference with clustered standard errors. Thus, with clustered standard errors, the bid-ask difference does not have any explanatory power left.

Accordingly, the bid-ask difference has shown robustness as a liquidity-proxy. To find the time-effect of the green bond premium, the daily average green bond premiums have been scattered for the year 2019. The results are presented in Figure 5. To compare the variance in the daily averages, the same ranges for the scatterplot have been used as in Figure 4. As can be seen, the daily average green bond discount shows a constant value between 0 and 0.2

Consequently, the green bond discount has shown a constant value over time and the bid-ask difference has shown its significance as a liquidity proxy, also over a longer and different period.

Figure 5: GB premium distribution over the days 2019



7. Discussion

As can be observed in the results section, this study has found a positive yield difference between green and conventional bonds across the sample. After controlling for the liquidity difference, a green bond discount is found. This indicates that, on average, investors receive higher yields for green bonds than investors receive for conventional bonds. As there exists a negative relationship between the bond yield and the bond price, this means that green bonds are traded at a lower price than comparable conventional bonds.

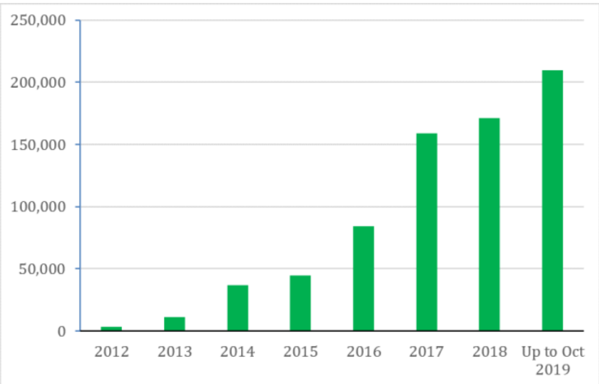
The majority of the existing literature has found a green bond premium. Therefore, the green bond discount found in this study might come as a surprising result. The total issued amount of green bonds in the sample is approximately 150 billion US$. This while the total cumulative issued amount of green bonds worldwide is 810 billion US$ (Climate Bonds, 2020). Therefore, the sample used for this study consists of approximately 18.5% of the total issuance of green bonds.

Moreover, the green and conventional bonds have been matched on the same characteristics. The small difference in liquidity that was left is controlled for. However, this only resulted in a small difference in the green bond premium, which indicates that the matching method was effective.

Also, the robustness of the study has been tested. The same regression has been run on the daily yield data of 2019. Despite that not all the bonds had daily yield data available for 2019 and only 130 bonds were left in the sample, a small green bond discount of 9 basis points was found. Besides, a two-way fixed effect regression has been run to test whether the discount is stable over time. Both robustness tests have shown that there is a stable green bond discount over time.

So, what can be an explanation for the green bond discount, while the majority of the literature suggests a green bond premium? First, there exists a difference in the green bond premium between the primary and the secondary market. According to (Kapraun & Scheins, 2019), the green label in the secondary market seems to be less attractive in the secondary market than in the primary market. Possible reasons given for this are that investors have lower demand for green investments, have additional requirements on the issuer, or do not trust the green label at all. Besides, (Kapraun & Scheins, 2019) argued that the most attractive green bonds do not trade on the secondary market at all, which results in a secondary market with only less attractive green bonds and therefore higher yields. The relatively small share on the bond market might also indicate lower liquidity for the green bonds.

Figure 3: total green bond issuance by year (Investors corner, 2019)



Another reason for the green bond discount might be the increase in the supply of green bonds over the last years. As can be seen in Figure 6, the yearly issued amount has risen from approximately 50 billion US$ to over 200 billion US$ in the first 10 months of 2019. Assuming a stable demand, an increase in supply results in a lower price. As mentioned before, there exists a negative relationship between the bond price and the bond yield. Therefore, an increase in the green bond supply results in higher yields, keeping demand constant.

By investigating the components of the green bond premium, it came out that there existed a large difference in the green bond premium between corporate bonds and supranational bonds. Where the corporate bonds show an average green bond discount of 8.28 basis points, the supranational bonds show an average green bond premium of 6.68 basis points. This finding is supported by (Kapraun, 2019), who also found a green bond discount for corporate issuers and a premium for supranational issuers in the secondary market.

This indicates that in the green bond market, the creditability of the issuer is seen as a crucial aspect, which can be confirmed by the fact that the green bond discount has a larger value for non-investment-grade bonds. The higher discount for issuers with a lower credit rating might indicate that investors still fear green-washing effects. However, running the regression with the ESG scores showed that in our sample, the ESG scores did not affect the yield difference between green and conventional bonds. It must be acknowledged that due to the small availability of the ESG scores, the dataset is reduced to 49 bonds.

The most interesting result is the daily evolution of the green bond premium. Where a constant discount was found for the first 50 days of the sample, a large variance was found for the days 50-115. At first, the green bond discount took a big rise, while the discount declined rapidly 10-15 days later. The first day of the sample was the 1st of January. As not all the days are trading days, this means that the yield data is not given for every day. The 50th trading day of the sample is 10 March 2020. The World Health Organization has declared the coronavirus as a pandemic on the 11th of march. (BBC, 2020). Remarkably, from this moment the green bond discount started increasing rapidly. This showed the panic going on in the bond market.

However, the significant green bond premium indicates that after the chaos at the start of the coronavirus, where high volatility was shown, the average yield difference between green and conventional bonds turned negative, where a positive difference was found before the start of the coronavirus. This demonstrates that investors were willing to accept a lower yield for their green bonds than for comparable conventional bonds after the start of the coronavirus.

However, after the first panic of the coronavirus disappeared, the green bonds showed better performance and the yield difference between green and conventional bonds started declining. By regressing the green bond premium starting at day 70 of the sample, after the first hectic of the coronavirus, we found a premium of 2 basis points.

Part of the good performance of green bonds can be explained by the sector effect. Green bonds generally have lower weight in cyclical industries such as oil and gas or consumer-driven sectors. (SCMP, 2019). The oil prices have decreased significantly due to the price war between Russia and Saudi Arabia and the decrease in consumer use due to corona.

(SCMP, 2019) also indicated that the global solidarity shown during the crisis must be used in the fight against global warming. Therefore, this feeling of solidarity to fight global warming might make investors more willing to choose for green bonds instead of conventional bonds.

Accordingly, an average discount was found for green bonds, indicating higher average yields for green bonds compared with the conventional bond dataset. However, supranational bonds were showing a negative yield difference, indicating that investors are willing to accept a lower yield for green bonds if they are from a supranational organization. Moreover, since the start of the Corona crisis, the green bond premium has shown to be very volatile. Ultimately, the discount of the green bonds has turned into a premium.

8. Conclusion

In this paper, the green bond premium between green and conventional bonds is studied to investigate if investors are willing to accept a lower yield for a green bond than they would for a comparable conventional bond. For this purpose, a matching method between the green and conventional bonds is used, where the bonds are matched based on credit rating, issuer type, coupon type, issued amount, issue date, and maturity. Consequently, the differences are limited as much as possible. A fixed-effect regression has been run after doing a Hausman test for the choice between a fixed effect or a random effect model. The residual liquidity difference that exists has been controlled for by running the following fixed-effect regression:

$$\Delta y_{i,t} = \rho_i + \beta \Delta \text{ Liquidity}_{i,t} + \varepsilon_{i,t}.$$

The liquidity proxy that is used is the difference in bid-ask spread between green and conventional bonds. After controlling for the residual liquidity difference, the green bond premium has been extracted from the formula. An average yield difference of 6.2 basis points is given and after controlling for the liquidity difference, a green bond discount of 6.3 basis points has been found. This indicates that, on average, green bonds trade at a 6.3 basis point higher yield than its comparable conventional bond.

This might be a surprising result as the majority of the literature has found a green bond premium, implying that investors are willing to accept a lower yield for bonds with a green label. However, the green bond premium was found mainly in the primary bond market. For the secondary market, both positive and negative yield differences between green and conventional bonds were found. This study is also conducted in the secondary market.

Looking at the determinants of the green bond premium shows us that there exists a large difference in the premium for the different issuer types. Whereas a discount of 8.3 basis points is found for the corporate bonds, a premium of 6.7 basis points is found for the supranational bonds.

Another interesting result is the difference in the green bond premium between investment-grade and speculative bonds. Where speculative bonds show an average green bond discount of 15.9 basis points, the investment-grade bonds show an average discount of 5.5 basis points. Both results indicate that the creditability of the issuer is a crucial aspect of the green bond premium. However, the effect of the ESG scores on the yield differences has been studied. The regression showed that the ESG scores did not add value to our model, taking the small dataset of 49 bonds into account.

Besides, the daily average green bond premia show an interesting pattern. Whereas the green bond discount was quite constant at the first 50 days of the sample, a very volatile pattern was found from day 51 and on. The 50th day from the sample period was the 10th of march. On the 11th of march, the coronavirus was called a pandemic by the World Health Organization. From that day, the green bond discount became very volatile and first took a big rise, followed by a strong decline in the green bond discount. After this volatile period, an additional regression was run on the green bond premium, giving a premium of 2 basis points for this sample. This shows that the investors were willing to accept a lower yield after the first hectic of the coronavirus disappeared.

To test for heteroskedasticity and serial correlation, a modified Walt test and a Breusch-Pagan test have been conducted. Both tests showed that heteroskedasticity and serial correlation were present in the sample and to allow for this, clustered standard errors are used. Thus, next to the standard fixed effect regression, also a fixed effect regression with clustered standard errors is run.

To detect if the green bond discount is stable over time, a two-way fixed effect regression has been run by adding a fixed time effect to the individual effect. For this regression, the F-test and the T-test showed a conflicting conclusion, which is due to the multicollinearity present in the sample. This can be explained by the fact that the daily yield values are highly dependent on the values of the days before. Moreover, to test for the constancy over time, the same FE and FE (clustered) regressions have been run over all the trading days of 2019. For this period, a constant small green bond discount was found, with daily averages between 0 and 0.2.

The main limitation of this study is the quality of the data. The relatively small amount of green bonds resulted in a rather small dataset. As the matching criteria were strict, not all the green bonds had an 'identical' twin conventional bond. Especially the availability of the credit ratings was low. Moreover, the yield, bid, and ask data were not available for all the bonds on a daily basis. This resulted in a dataset of 222 matched bonds. Especially, looking at the composition of the green bond premium was more complicated as the subsamples of the bonds were quite small. Therefore, if the sample size can be increased, this will improve the accuracy of the model.

Consequently, to improve the accuracy of the model, further research could use a larger dataset of green bonds. As a large difference in premium was found between corporate and supranational bonds, also the difference between corporate bonds and supranational bonds can be examined further. Moreover, the relationship between the green bond premium in the primary and the secondary market can be explored further.

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Appendices

Appendix A: Hausman test

```
. hausman fe re

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe           re          Difference          S.E.
-------------+----------------------------------------------------------------
  bidaskdiff |  -.0515086    -.0438585       -.0076501        .0016485
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       21.54
                Prob>chi2 =      0.0000
```

Appendix B: Breusch-Pagan test

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of yielddiff

         chi2(1)      =     8.10
         Prob > chi2  =   0.0044
```

Appendix C: Modified Wald test

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (224)   =   2.0e+10
Prob>chi2 =       0.0000
```

Appendix D: Green bond premium per bond

ISIN	Green bond premium	ISIN	Green bond premium
AU3CB0226090	.08	XS1422841202	.103
AU3CB0262533	-.617	XS1431730388	.036
BE0002602804	-.934	XS1432384409	-.416
DE000BHY0GA7	.505	XS1432384664	-.092
DE000BHY0GB5	.641	XS1434560642	.049
DE000BHY0GH2	-.132	XS1435056426	.393
DE000BHY0GS9	.654	XS1437622977	-.12
DE000BHY0GU5	.448	XS1453462076	.056
DE000CZ40NG4	.658	XS1490726590	-.474
DE000GRN0008	.642	XS1500338618	-.044
DE000GRN0016	.304	XS1509084775	.178
DE000LB1M214	.309	XS1527753187	-.008
DE000LB2CHW4	.617	XS1527758145	-.532
DE000LB2CLH7	.681	XS1536786939	.165
FR0011225325	.009	XS1550149204	-.269
FR0011858323	.117	XS1567475303	-.103
FR0011911247	-.248	XS1575444622	-.279
FR0012685691	-.04	XS1575474371	.233
FR0013067170	.175	XS1577956789	.624
FR0013245859	.099	XS1587035996	.648
FR0013245867	.242	XS1632897762	-.48
FR0013284247	.066	XS1632897929	-.038
FR0013284254	-.294	XS1636000561	.259
FR0013405537	.487	XS1676952481	-.218
FR0013428489	-1.144	XS1679505070	.439
FR0013428513	-.21	XS1682538183	-.464
FR0013455813	.28	XS1684812255	.113
LV0000801777	-.331	XS1685589027	-.454

US015271AM12	.414	XS1691909920	.84
US015271AP43	.349	XS1694219780	.643
US037833BU32	.153	XS1702729275	-.359
US037833CX61	-.033	XS1713473947	.234
US045167CY77	.019	XS1713474168	2.487
US045167DR18	.129	XS1718393439	-1.321
US045167EB56	-.444	XS1721760541	-.342
US045167EC30	.048	XS1722859532	.359
US045167EJ82	-1.167	XS1725553066	.604
US05351WAA18	.358	XS1733877762	-.05
US05351WAB90	-.73	XS1743657683	-.587
US05502JAA88	.285	XS1750986744	-.223
US064159QD10	.242	XS1758752635	.51
US10112RBA14	.273	XS1766612672	-.072
US18539UAC99	-.435	XS1775946285	-3.294
US20848FAA84	.352	XS1789176846	.531
US25389JAL08	-.242	XS1808338542	.119
US26441YBC03	.319	XS1808739459	.101
US26442CAW47	-.234	XS1811852109	-.054
US26442CAX20	.03	XS1815070633	.028
US26442UAH77	.053	XS1820037270	.421
US26444HAH49	.013	XS1828037827	-.497
US26884ABK88	-.057	XS1828046570	-.087
US298785GQ39	-.01	XS1843433639	.257
US298785HD17	-.094	XS1843437036	.541
US298785HM16	-.045	XS1847692636	-.225
US29878TDB70	-.164	XS1852213930	-.215
US373334KE00	.038	XS1854893291	-.124
US39530LAB62	4.612	XS1856795510	.915
US39530LAC46	-.305	XS1858912915	-.068
US41135WAA99	-.1	XS1867412006	.608
US44107TAY29	1.884	XS1875284702	-.34
US44920UAG31	1.06	XS1890709774	.694

US45905UG408	-.101	XS1891174341	.349
US45905ULF92	.065	XS1893621026	-1.953
US45905URL07	.06	XS1899011784	-.224
US45905UX338	-.065	XS1900101046	.281
US45950VHX73	-.048	XS1904690341	.432
US45950VLH77	.009	XS1909186451	.151
US461070AP91	-.685	XS1912495691	-.003
US461070AQ74	.008	XS1917957687	-.232
US46128MAJ09	-1.051	XS1937665955	-.33
US49427RAN26	-.296	XS1939355753	-.28
US50064YAN31	-.069	XS1946004451	-1.096
US501955AA67	.11	XS1956022716	.191
US501955AB41	.178	XS1960260021	1.31
US595620AQ82	-.031	XS1963849440	-.972
US606822AH76	.489	XS1968711876	.591
US63254ABA51	.328	XS1972557737	.78
US64009VAA61	-11.21	XS1972559352	.136
US65562QAW50	.077	XS1973696716	.111
US67021CAN74	-.049	XS1979446843	.945
US690742AJ00	-.495	XS1980270810	-.326
US75884RAT05	.687	XS1982037696	.014
US843646AM23	.293	XS1982690858	.378
US865622BY94	.59	XS1986632716	-.564
US89114QBT40	.646	XS1989375412	-.114
US95040QAK04	.827	XS1989704843	.265
US95709TAN00	-.749	XS2002017361	-.737
USN3700LAB10	1.743	XS2002491863	-.294
USN3700LAC92	2.466	XS2003499386	.051
USP58072AL66	.116	XS2009861480	.327
USU1851TAB71	-.533	XS2009891479	-.244
USV00027AA65	.24	XS2013745703	-1.094
USV3855GAB69	1.934	XS2014454933	.092
USV6277KAA26	3.749	XS2020608548	-.226

USY3815NAV39	.501	XS2021462440	.838
USY52758AC63	.118	XS2026150313	-1.193
USY52758AD47	.384	XS2028900087	.918
XS1057055060	-.106	XS2047500926	-.586
XS1084043451	-.398	XS2051032444	.075
XS1107718279	-.128	XS2052503872	-.739
XS1140300663	-.386	XS2053052895	-1.031
XS1241581096	.134	XS2055627538	.276
XS1241581179	.069	XS2055786763	.027
XS1242327325	1.474	XS2057887353	.676
XS1280834992	-.084	XS2063247915	.072
XS1303791336	.188	XS2067135421	.345
XS1325600994	-.173	XS2068071641	.006
XS1398476793	-.297	XS2068969067	-.287
XS1400167133	-.353	XS2069318686	1.647
XS1410341389	.869	XS2069407786	1.714
XS1412748136	.735	XS2089368596	.765

Appendix E: descriptive statistics green bonds

Green bonds						
ISIN	rating	amount	life	age	type	currency
XS2057887353	A1	100,000,000	4.3041	0.6973	CORP	A$
AU3CB026253	Baa2	400,000,000	3.863	1.137	CORP	A$
DE000GRN000	A2	500,000,000	0.989	4.011	CORP	E
DE000LB1M21	A2	750,000,000	1.5041	2.4959	CORP	E
XS1241581179	A3	500,000,000	0.9781	5.0246	CORP	E
FR0013067170	A1	300,000,000	2.5068	4.4959	CORP	E
XS1422841202	A1	500,000,000	1.9671	4.0329	CORP	E
DE000BHY0GU	A2	500,000,000	3.2904	3.7096	CORP	E
FR0013284247	A3	500,000,000	2.7151	2.7041	CORP	E
XS1685589027	A3	300,000,000	2.2712	2.7288	CORP	E
XS1567475303	Aa2	500,000,000	1.6849	3.3151	CORP	E
XS1242327325	Ba2	500,000,000	1.9753	5.0274	CORP	E
XS1434560642	Baa1	600,000,000	2.0219	3.9781	CORP	E
XS1636000561	Baa1	500,000,000	2.0411	2.9589	CORP	E
LV0000801777	Baa2	100,000,000	1.9945	5.0082	CORP	E
XS1939355753	A3	1,000,000,000	1.6329	1.3671	CORP	E
XS1713473947	B3	275,000,000	2.6361	2.3611	CORP	E
XS1713474168	B3	275,000,000	2.6361	2.3611	CORP	E
BE0002602804	Baa1	500,000,000	3.0411	1.9589	CORP	E

XS1679505070	Baa1	400,000,000	2.0274	2.2247	CORP	E
XS1972557737	Baa1	500,000,000	2.8411	1.1616	CORP	E
XS1972559352	Baa1	500,000,000	2.8411	1.1616	CORP	E
DE000CZ40NG	Baa2	500,000,000	3.3644	1.6356	CORP	E
XS1858912915	Baa2	1,000,000,000	3.1123	1.8877	CORP	E
XS1140300663	A3	500,000,000	4.4411	5.5589	CORP	E
XS1084043451	Baa2	500,000,000	4.0603	5.9397	CORP	E
DE000GRN001	A2	500,000,000	4.2904	2.7096	CORP	E
XS1725553066	A2	500,000,000	4.4986	2.5014	CORP	E
FR0013245859	A3	700,000,000	3.789	3.211	CORP	E
XS1632897762	A3	500,000,000	5.0384	2.9616	CORP	E
XS1490726590	Baa1	700,000,000	5.2603	3.7397	CORP	E
XS1527758145	Baa1	750,000,000	3.7342	3.5124	CORP	E
XS1575444622	Baa1	1,000,000,000	4.7342	3.2658	CORP	E
XS1676952481	Baa1	600,000,000	5.2356	2.7644	CORP	E
XS1550149204	Baa2	1,250,000,000	4.263	3.4028	CORP	E
XS1718393439	Baa2	800,000,000	4.9233	2.5726	CORP	E
DE000LB2CHW	A2	750,000,000	3.9479	1.0548	CORP	E
XS1867412006	A2	500,000,000	5.2493	1.7507	CORP	E
XS1989375412	A2	500,000,000	3.8877	1.115	CORP	E
XS2052503872	A3	500,000,000	4.263	0.7397	CORP	E
FR0013405537	Baa1	750,000,000	4.211	1.2849	CORP	E
XS1808338542	Baa1	500,000,000	3.8466	2.1534	CORP	E
XS1960260021	Baa1	500,000,000	3.7342	1.2685	CORP	E
XS2067135421	Baa1	1,000,000,000	5.3589	0.6438	CORP	E
XS2089368596	Baa1	750,000,000	4.4795	0.5232	CORP	E
XS1820037270	Baa2	1,000,000,000	4.9205	2.0795	CORP	E
XS1937665955	Baa2	1,000,000,000	5.1068	1.3891	CORP	E
XS1893621026	Baa3	600,000,000	5.337	1.6657	CORP	E
XS1946004451	Baa3	1,000,000,000	3.6521	1.3479	CORP	E
XS1963849440	Baa3	500,000,000	3.7562	1.2465	CORP	E
XS1979446843	Baa3	500,000,000	3.8274	1.1753	CORP	E
DE000BHY0GS	A2	500,000,000	7.3699	2.6328	CORP	E
XS1241581096	A3	500,000,000	6.9781	5.0246	CORP	E
XS1432384664	A3	500,000,000	6.0027	3.9973	CORP	E
XS1400167133	Aa2	300,000,000	5.8603	4.1397	CORP	E
XS1398476793	Baa1	1,000,000,000	5.8575	4.1425	CORP	E
XS1435056426	Baa1	500,000,000	6.0219	3.9781	CORP	E
XS1682538183	Baa1	750,000,000	7.2548	2.7452	CORP	E
XS1702729275	Baa2	850,000,000	7.3534	2.6466	CORP	E
XS1982037696	A1	750,000,000	5.8411	1.1616	CORP	E
XS2051032444	A1	500,000,000	6.2493	0.7534	CORP	E
DE000LB2CLH7	A2	500,000,000	6.1288	0.8739	CORP	E
XS2063247915	A2	1,000,000,000	6.3123	0.6904	CORP	E
FR0013428489	A3	750,000,000	7.0247	0.978	CORP	E
XS2009891479	A3	500,000,000	6.0329	0.9671	CORP	E
XS2055627538	A3	750,000,000	6.2877	0.715	CORP	E
XS2068969067	A3	750,000,000	6.3836	0.6191	CORP	E
XS2003499386	Aa3	750,000,000	5.9589	1.0438	CORP	E

XS1847692636	Baa1	750,000,000	6.3781	1.9561	CORP	E
XS1875284702	Baa1	650,000,000	7.2301	1.7699	CORP	E
XS1750986744	Baa2	1,250,000,000	6.263	2.4028	CORP	E
XS1843437036	Baa2	500,000,000	6.9472	1.0528	CORP	E
XS1891174341	Baa2	1,075,000,000	5.5973	1.4027	CORP	E
XS1980270810	Baa2	500,000,000	5.8274	1.1753	CORP	E
XS2002017361	Baa2	750,000,000	6.4521	1.052	CORP	E
XS2013745703	Baa2	1,000,000,000	6.0247	0.978	CORP	E
XS2020608548	Baa2	500,000,000	7.063	0.9397	CORP	E
XS2069407786	Baa2	750,000,000	6.863	0.6247	CORP	E
XS2053052895	Baa3	600,000,000	6.263	0.7397	CORP	E
FR0013245867	A3	800,000,000	7.789	3.211	CORP	E
FR0013284254	A3	750,000,000	8.7151	2.7041	CORP	E
XS1632897929	A3	500,000,000	9.0384	2.9616	CORP	E
XS1721760541	Baa1	750,000,000	9.4575	2.548	CORP	E
XS2028900087	A1	500,000,000	9.1014	0.9013	CORP	E
DE000BHY0GB	A2	500,000,000	7.8493	2.1534	CORP	E
XS1789176846	A3	300,000,000	7.7562	2.2438	CORP	E
XS2021462440	A3	450,000,000	9.074	0.9287	CORP	E
DE000BHY0GA	Aa2	500,000,000	9.4	0.6055	CORP	E
XS1968711876	Baa1	138,000,000	8.7726	1.2301	CORP	E
XS2026150313	Baa2	400,000,000	9.0932	0.9095	CORP	E
FR0013455813	A3	900,000,000	10.367	0.6356	CORP	E
XS1904690341	A3	300,000,000	10.425	1.5753	CORP	E
XS2009861480	A3	500,000,000	9.9973	1.0054	CORP	E
XS1909186451	Baa1	1,500,000,000	10.427	1.5726	CORP	E
XS2047500926	Baa2	750,000,000	9.7151	0.789	CORP	E
FR0013428513	A3	750,000,000	19.025	0.9781	CORP	E
XS2002491863	A3	750,000,000	18.975	1.0274	CORP	E
XS1899011784	A1	30,000,000,000	1.4639	1.5361	CORP	Y
XS1325600994	Ba2	350,000,000	0.4667	4.5333	CORP	U$
US44920UAG3	Baa1	500,000,000	0.7611	4.2389	CORP	U$
USY3815NAV3	Baa1	500,000,000	0.7611	4.2389	CORP	U$
XS1410341389	Baa3	500,000,000	0.9694	4.0306	CORP	U$
XS1775946285	B3	350,000,000	0.7306	2.2694	CORP	U$
XS1986632716	B3	300,000,000	1.3694	1.1306	CORP	U$
XS1587035996	Aa3	587,000,000	1.8	3.2	CORP	U$
US39530LAC46	Ba1	350,000,000	2.1167	2.8833	CORP	U$
USN3700LAC9	Ba1	350,000,000	2.1167	2.8833	CORP	U$
US25389JAL08	Baa2	500,000,000	2.0528	4.9694	CORP	U$
US064159QD1	A2	500,000,000	2.6	0.9	CORP	U$
XS1856795510	Baa3	650,000,000	3.2944	1.7056	CORP	U$
XS2069318686	Baa3	300,000,000	2.4806	0.5194	CORP	U$
US75884RAT0	Baa1	250,000,000	4.0083	6.0723	CORP	U$
US39530LAB62	Ba1	650,000,000	4.1167	2.8833	CORP	U$
USN3700LAB1	Ba1	650,000,000	4.1167	2.8833	CORP	U$
US95709TAN0	A2	350,000,000	6.0528	3.9777	CORP	U$
XS1453462076	A2	500,000,000	6.1083	3.8917	CORP	U$
US595620AQ8	Aa2	375,000,000	6.8861	3.3639	CORP	U$

US373334KE00	Baa1	325,000,000	5.8028	4.2611	CORP	U$
US46128MAJ0	Baa3	500,000,000	6.8111	3.1889	CORP	U$
USP58072AL66	Baa3	500,000,000	6.8111	3.1889	CORP	U$
XS1733877762	Baa3	500,000,000	7.5028	2.4972	CORP	U$
XS1743657683	A2	500,000,000	7.5778	2.4222	CORP	U$
US18539UAC9	Ba2	850,000,000	7.7583	0.5028	CORP	U$
USU1851TAB7	Ba2	600,000,000	7.7583	0.5028	CORP	U$
US44107TAY29	Baa2	650,000,000	9.5083	0.7111	CORP	U$
US49427RAN2	Baa2	400,000,000	8.5083	1.5361	CORP	U$
US690742AJ00	Baa3	450,000,000	9.175	0.8333	CORP	U$
XS1527753187	Aa3	500,000,000	1.9699	3.5287	CORP	E
XS1575474371	Aa3	500,000,000	2.2384	3.2657	CORP	E
DE000BHY0GH	Aaa	500,000,000	3.3644	2.9945	CORP	E
XS1758752635	A1	500,000,000	2.6247	2.3753	CORP	E
XS1890709774	A1	500,000,000	3.326	1.674	CORP	E
XS1982690858	A1	500,000,000	1.8685	1.1342	CORP	E
XS1057055060	Baa1	750,000,000	2.3671	6.1343	CORP	E
XS1577956789	A1	650,000,000	4.0247	2.9753	CORP	E
XS1691909920	A1	500,000,000	4.3452	2.6548	CORP	E
XS1694219780	A1	500,000,000	4.3315	2.6685	CORP	E
XS1722859532	Aa3	500,000,000	4.4466	2.5534	CORP	E
XS1808739459	A1	750,000,000	4.8603	2.1507	CORP	E
XS1956022716	Aa3	500,000,000	3.7096	1.2904	CORP	E
FR0011911247	A3	1,300,000,000	5.9342	6.0658	CORP	E
XS1900101046	A1	500,000,000	10.4	1.6	CORP	E
XS1828037827	A3	750,000,000	13.981	2.0192	CORP	E
XS1432384409	A3	500,000,000	16.003	3.9973	CORP	E
US865622BY94	A1	500,000,000	0.3556	4.6444	CORP	U$
XS1303791336	A1	500,000,000	0.3556	4.6444	CORP	U$
XS1412748136	A1	400,000,000	0.9556	4.0444	CORP	U$
XS1437622977	A1	1,000,000,000	1.0833	3.9167	CORP	U$
US89114QBT4	Aa1	1,000,000,000	0.2472	2.75	CORP	U$
US606822AH7	A1	500,000,000	3.2528	3.7472	CORP	U$
US037833BU3	Aa1	1,500,000,000	2.6972	4.3028	CORP	U$
US05502JAA88	Ba2	500,000,000	2.3917	2.8583	CORP	U$
USV00027AA6	Ba2	500,000,000	2.3917	2.8583	CORP	U$
US64009VAA6	Ba3	475,000,000	1.6694	3.3306	CORP	U$
USV6277KAA2	Ba3	475,000,000	1.6694	3.3306	CORP	U$
US26442CAW4	Aa2	350,000,000	1.925	1.5944	CORP	U$
US41135WAA9	Aa2	300,000,000	2.1333	0.8667	CORP	U$
US50064YAN3	Aa2	600,000,000	3.1194	1.8806	CORP	U$
XS1917957687	Aa2	300,000,000	1.6111	1.3889	CORP	U$
US63254ABA5	Aa3	750,000,000	3.0222	1.9778	CORP	U$
US05351WAA1	Baa1	600,000,000	4.4694	2.5584	CORP	U$
US843646AM2	Baa1	500,000,000	5.4694	4.5695	CORP	U$
XS1989704843	A2	500,000,000	3.9417	1.0583	CORP	U$
XS2014454933	A2	600,000,000	4.0556	0.9444	CORP	U$
US015271AM1	Baa1	650,000,000	3.5917	1.975	CORP	U$
US501955AA6	Baa1	500,000,000	4.3417	1.1583	CORP	U$

USY52758AC6	Baa1	500,000,000	4.3417	1.1583	CORP	U$
US037833CX61	Aa1	1,000,000,000	7.0222	2.9778	CORP	U$
XS1509084775	Aa3	600,000,000	6.3889	3.6111	CORP	U$
USV3855GAB6	Ba1	535,000,000	6.1306	0.8694	CORP	U$
US015271AP4	Baa1	350,000,000	5.8417	1.225	CORP	U$
US95040QAK0	Baa1	500,000,000	6.675	0.4889	CORP	U$
US26444HAH4	A1	700,000,000	9.4694	0.5445	CORP	U$
US67021CAN7	A1	400,000,000	8.925	1.0694	CORP	U$
US20848FAA8	A3	150,000,000	9.5083	0.7111	CORP	U$
US26884ABK8	A3	400,000,000	8.4694	1.5334	CORP	U$
US26442CAX2	Aa2	650,000,000	8.425	1.5944	CORP	U$
US26442UAH7	Aa3	600,000,000	8.7583	1.2639	CORP	U$
US05351WAB9	Baa1	750,000,000	8.9694	1.0723	CORP	U$
US10112RBA1	Baa1	1,000,000,000	8.4694	1.5389	CORP	U$
US501955AB4	Baa1	500,000,000	8.8417	1.1583	CORP	U$
US26441YBC03	Baa1	400,000,000	9.425	0.575	CORP	U$
US461070AP9	Baa1	500,000,000	8.2889	1.7111	CORP	U$
US461070AQ7	Baa1	300,000,000	8.8028	1.1972	CORP	U$
USY52758AD4	Baa1	500,000,000	8.8417	1.1583	CORP	U$
AU3CB022609	Aa3	300,000,000	1.5123	5.4877	CORP	A$
XS1852213930	A3	500,000,000	1.063	1.937	CORP	E
US45905ULF92	Aaa	5,000,000	2.0833	7.9167	SUPR	U$
US65562QAW	Aaa	500,000,000	1.3	5.7	SUPR	U$
US298785GQ3	Aaa	1,000,000,000	4.3417	5.6583	SUPR	U$
US45905URL0	Aaa	700,000,000	4.725	5.275	SUPR	U$
US045167CY77	Aaa	500,000,000	4.7694	5.2306	SUPR	U$
US45950VHX7	Aaa	1,200,000,000	5.8194	4.1806	SUPR	U$
US298785HD1	Aaa	1,500,000,000	5.8361	4.1639	SUPR	U$
US045167DR1	Aaa	500,000,000	6.1722	3.8222	SUPR	U$
US45905UG40	Aaa	300,000,000	1.8333	3.1667	SUPR	U$
US298785HM1	Aaa	1,500,000,000	6.95	3.05	SUPR	U$
US045167EB56	Aaa	750,000,000	2.1611	2.8389	SUPR	U$
US045167EC30	Aaa	500,000,000	7.1611	2.8389	SUPR	U$
XS1684812255	Aaa	150,000,000	1.2917	2.7083	SUPR	U$
US45950VLH7	Aaa	1,000,000,000	2.3667	2.6333	SUPR	U$
US29878TDB7	Aaa	1,500,000,000	5.0028	2.1305	SUPR	U$
XS1811852109	Aaa	1,500,000,000	5.0028	2.1305	SUPR	U$
US045167EJ82	Aaa	750,000,000	8.2889	1.7111	SUPR	U$
US45905UX33	Aaa	200,000,000	0.3028	1.6916	SUPR	U$
XS1536786939	A2	750,000,000	1.5233	3.4767	SOV	E
XS1766612672	A2	1,000,000,000	6.1534	2.3425	SOV	E
XS1843433639	A1	1,554,685,000	11.055	0.9454	SOV	E
FR0011225325	Aa2	375,000,000	3.789	8.211	SSOV	E
FR0011858323	Aa2	600,000,000	5.8658	6.1342	SSOV	E
FR0012685691	Aa2	500,000,000	6.863	5.1397	SSOV	E
XS1107718279	Aaa	1,800,000,000	6.4219	5.7534	SUPR	E
XS1280834992	Aaa	2,050,000,000	3.4274	4.7918	SUPR	E
XS1431730388	Aaa	1,000,000,000	3.9945	4.0055	SUPR	E
XS1500338618	Aaa	1,250,000,000	17.422	3.6849	SUPR	E

XS1815070633	Aaa	500,000,000	5.3945	2.1096	SUPR	E
XS1828046570	Aaa	1,000,000,000	12.427	2.0384	SUPR	E
XS1854893291	Aaa	600,000,000	5.0932	1.9068	SUPR	E
XS1912495691	Aaa	850,000,000	7.4466	1.5589	SUPR	E
XS1973696716	Aaa	113,000,000	4.8055	1.1972	SUPR	E
XS2055786763	Aaa	500,000,000	6.2877	0.715	SUPR	E
XS2068071641	Aaa	750,000,000	9.3671	0.6356	SUPR	E