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Are Green Bonds Different From Ordinary Bonds? A Statistical and Quantitative Point of View

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Abstract

A green bond is a type of fixed-income security that raises money to invest in predetermined climate and environmental projects, in contrast to conventional debt instruments, where the use of proceeds is not specified in the terms. The difference in yield between a green bond and an otherwise identical non-green bond of the same issuer and with the same terms is called the *greenium*. In this paper, we investigate this yield differential between green and conventional bonds. We estimate the greenium on the basis of the bond's asset swap spread (ASW) to investigate whether, consistent with a non-pecuniary motive for holding green assets, green labels are associated with a negative or positive yield gap with respect to ordinary bonds. We calculate and compare several descriptive statistics of green bonds and conventional bonds. Then, several statistical tests are implemented to analyze potential statistical differences between their return distributions. In our analysis, synthetic non-green bonds are constructed via interpolation of the ASW curve of non-green bonds. There are several findings: (1) From a statistical point of view, no difference between the overall distribution, the mean or median of ASW changes is detected on individual bond pairs. However, our estimation of an overall greenium exhibits a level fluctuating near zero over time with an overall average around -7 bps. (2) In addition, we see indications that the volatility of some green-bonds is lower than their non-green counterparts. (3) We see a lagging effect between the greenium and stress in financial markets. This could indicate that sustainable investments like green bonds are potentially more immune to systemic crises.

Keywords: Green bond, Greenium, Return Distribution, Fat Tails, Non-normal Distribution

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1. Preliminary

Climate change has a large impact on our society, especially in the long term. It will lead to natural disasters occurring more frequently, causing enormous human and material damage. For example, rising sea levels will have an impact on ongoing and future infrastructure development, and generate climate refugees.

According to the European Academies Science Advisory Council (EASAC), a body comprising of scientific academies from 27 nations, the past three and a half decades were marked by increasingly frequent heavy rainfall, floods, heatwaves, and wildfires. The data shows an alarming global quadrupling of the number of hydrological events since 1980 and a doubling since the year 2004. Moreover, since the year 1980, climatological and meteorological events have at least doubled (EASAC, 2018). The societal consequences of climate change are very uncertain and may have tremendous impacts. Possible measures for sustainability (such as taxes on kerosene, European Union Emission Trading Scheme, ...) will also have severe economic consequences (e.g. potentially drastically reducing tourism income). However, the full impact on our society and economy is unknown.

The adoption of the Paris Agreement on climate change and the UN 2030 Agenda for Sustainable Development marks a historical international commitment to the objective of a more sustainable economy and society. In this context, the financial system has a key role to play. Re-orienting finance towards more sustainable investments could help in achieving climate and other environmental and societal policy goals. Currently, the impact of climate change on our society and economy is not well understood and is not adequately quantified. Financial risks stemming from climate change need to be appropriately managed. The modelling of the impact of these climate risks is essential for developing a sustainable policy.

The Organization for Economic Co-operation and Development (OECD) has estimated that the required investment in infrastructure per year by 2030 should equal USD 6.9 trillion to comply with the Paris agreement [1]. To accomplish this objective, many governments have began to issue green bonds to raise funds to finance environmentally sustainable projects, such as pollution prevention, sustainable agriculture and renewable energy. Green bonds are fixed-income securities that are identical to non-green bonds, except that the proceeds are used for projects with an environmental or climate-related focus. The first green bonds were issued in 2007 by AAA-rated multilateral institutions such as the European Investment Bank (EIB) and the World Bank. The green bond market has rapidly expanded since its inception in 2007, notwithstanding the absence of a commonly agreed definition of "greenness". Green bond's annual issuance rose from about USD 3 billion in 2012 to USD 257 billion in 2019. This total is 51% higher than the final 2018 figure of USD 170.6 billion [2]. It is estimated that issuance will reach around USD 300 billion in 2020 according to Moody's report [3]. In addition, as in the case for all global markets and indices, several different data providers track the growth and constituents of the green bond market. These market developments underline the practical relevance of green bonds within financial markets.

Green bonds are self-labeled, an issuer only has to declare it as "green" for it to fall into this category. To avoid the risk of "greenwashing", several agencies and governments have looked to alleviate these concerns by creating more robust and standardized classifications. Also, many third-party verifications provide an independent review of green credentials of the bond. It should be noted that the interest and principal payments on the bond are generally paid using the company's overall cash flows, and not by the specific green project.

Despite the rapid growth in the green bond market, there is still an on-going debate between researchers about the (in)credibility of green bonds and the (in)willingness of capital providers to accept a different yield for green bonds by means of paying a different price compared with the conventional bonds. It could indeed be the case that a green bond is issued with a different yield compared to an otherwise identical non-green bond of the same issuer and with the same term, seniority, and currency. This difference is termed as the greenium. Currently, there seems to be no consensus among researchers about the existence and direction of the greenium.

Since green bonds raise funds for environmentally friendly projects, they have a green label and such investments currently have quite a high attraction from a particular set of investors. Hence, the issuer of green bonds can take advantage of this non-pecuniary motive to achieve cheaper financing than via conventional bonds [4], provided he can identify how the proceeds are invested and that these investments are qualified as green. However, compared with conventional bonds, the issuance of green bonds has more limitations. These environmentally friendly projects have to been verified by a third party to get "certified" as a green bond, which increases the cost of issuance [5]. Extra costs may mean that these issuers are unwilling to issue an equivalent green bond instead of a non-green bond. Furthermore, it is speculated that many investors have a longer-term "buy-and-hold" perspective on green bonds because of their green credentials, which would lead to lower volatility in market sell-offs.

Researchers [6–9] concluding the greenium is negative are more numerous than those concluding that the green premium is positive or non-existent. For example, Preclaw [6] demonstrated by regression analysis that investors paid a premium of around 17 basis points (bps) to acquire green bonds in the secondary market. Febi [7] investigated the effects of the liquidity premium on the green bond yield spread, finding a negative premium in green bonds. Tang [8] found that green bonds are issued at a yield spread that is 6.94 bps lower than corporate bonds issued by similar firms, demonstrating the greenium is negative. Zerbib [9] performed a matching method to estimate the yield differential between a green bond and a counterfactual conventional bond using datum from July 2013 to December 2017, concluding that the greenium is -2 bps for the entire sample. Finally, Karpf [10] concluded a quantitative analysis about green bonds and conventional bonds from the US municipal bond market by building yield curves and running regression analysis, and pointed out that the greenium has turned positive in recent years.

On the other hand, several arguments dispute that a greenium should exist. Fixed-income investors always compare attractiveness by accessing the underlying credit risk and the risk premium offered by the bond. As we mentioned before, the coupon payments and notional repayment on the bond are covered by the issuer, not by the relevant green project. When the issuer defaults, the green bonds will be treated in the same way as non-green bonds. Thus, they have the same credit risk and they are ranked pari-pasu, i.e., there is no difference in the risk that is carried by a green bond or an otherwise identical non-green bond. Thus, from this quantitative viewpoint, no greenium exists. Larcker [11] investigated whether investors were willing to trade off wealth for societal benefits based on the municipal securities market, and concluded the greenium is essentially zero. Partridge [12] concluded that there is no conclusive evidence for the presence of greenium in the primary market by investigating the performance of US green municipal bonds and general municipal bonds. Also, Fatica [13] demonstrated that there is no greenium for financial institutions. However, for green bonds issued by supranational institutions and corporates, a greenium exists.

In this paper, we study and analyze the difference between the green bond and conventional bond based on the asset swap spread (ASW) values. Firstly, we compare the difference between green bonds and conventional bonds through several basic descriptive statistics. In our analysis, synthetic non-green bonds are constructed via interpolation of the ASW curve of non-green bonds. According to i.a. the QQ-plots, we can observe that the ASW distribution exhibit a fatter tail than the tail of a normal distribution. In addition, analysis of tail index estimates shows that green bonds have in general a similar tail behaviour as non-green bonds. Further, several hypothesis tests are implemented to analyze the median and mean. These tests indicate that there is no evidence to assume that the median and mean of the return distribution of green bonds is different than a comparable conventional bond. Further, the Kolmogorov-Smirnov test is performed for the ASW values to determine whether or not green bonds and conventional bonds have the same distribution. According to the results, in general, we have no clear evidence that green bonds follow significantly different dynamics than non-green comparables.

In terms of the greenium, we have no evidence of a significant greenium. However, the point estimates of the *greenium* has an overall average around -7.07 bps. We observe that over the recent years, the greenium turned from slightly positive to negative. Particularly, the greenium dropped sharply in February 2020 and increased gradually from May 2020. This could be related to the COVID-19 stress on financial market during that time.

The rest of this paper is organized as follows. Section 2 overviews some literature on green bonds. Section 3 introduces the bond data we will use. In section 4, we depict the stylized feature of bonds with several descriptive statistics, QQ-plots, and Hill estimators. In section 5, we make several hypothesis tests to compare the mean, median, variance, and distribution of ASW difference between green bonds and conventional bonds. Section 6 studies the greenium. We conclude this paper in section 7.

2. Introduction to Green Bonds

Green bonds are identical to non-green bonds, except that the proceeds are used for “green” projects, that is for projects with an environmental focus. This “use of proceeds” approach represents a change from traditional bond investing, where investors generally focus on overall company characteristics and credit metrics, rather than on how the money raised is subsequently deployed. Green bonds therefore provide additional information, both on use of proceeds and on impact reporting, allowing investors to get more closely involved in the environmental efforts that these companies are engaging in.

It is important to note that the interest and principal payments on the bond are generally paid using the company’s overall cash flows, and not by the specific green project. This means that green bonds rank pari-passu to non-green bonds. The credit (default) risk is therefore dependent on the credit risk of the overall company, and not on the credit risk of the individual project. Hence, credit ratings as well as probability of default and loss given default will be identical for green and non-green bonds.

The issuance of a green bond has no reflection on the overall activities of company itself, which may or may not be green. Hence, companies from traditionally non-green sectors such as transportation or energy, have issued green bonds. It therefore should not be confused with ESG (environmental, social and governance) company ratings or "best-in-class" mandates, which focus on the company as a whole.

2.1. Classification of Green Bonds

Green bonds are self-labelled. Clearly this leads to risk of "greenwashing" (declaring something to be green when it is in fact not) and also leads to many different interpretations of what constituents a green bond. Several agencies and governments have looked to alleviate these concerns through creating more robust and standardised classifications. A majority of issuers have used third-party verifications to provide an independent review of the green credentials of the bond. These include major rating agencies Moody's and S&P, auditors such as KPMG or Deloitte or ESG specialist companies such as Sustainalytics or Oekom. In January 2014 the Green Bond Principles (GBP) were established by the International Capital Market Association (ICMA). These are voluntary process guidelines that "recommend transparency and disclosure and promote integrity in the development of the Green Bond market". This allows both companies and investors to develop a more standardised framework for issuance and analysis of green bonds. The GBP focus on four components: use of proceeds, process for project evaluation and selection, management of proceeds, and reporting. The list of eligible green projects includes (though is not limited to) renewable energy, energy efficiency, pollution preventions and control, environmentally sustainable management of living natural resources and land use, terrestrial and aquatic biodiversity conservation, clean transportation, sustainable water and wastewater management, climate change adaption, eco-efficient/circular economy adapted products, green buildings.

The European Commission was also concerned by the lack of regulation and consistency concerning the issuance of green bonds, and in July 2018 established a Technical Expert Group on sustainable finance. Their results were published in June 2019: a "Report on EU Green Bond Standard" (GBS), which proposed creating a voluntary non-legislative EU green bond standard. The requirements here are more vigorous compared to the ICMA GBP. In particular it brings alignment with EU-taxonomy, so that bond issuance proceeds contribute substantially to one of the six environmental objectives of the EU Taxonomy Regulation, without harming the other objectives. This taxonomy aims to translate EU policy commitments, including the Paris Agreement and the UN Sustainable Development Goals, for use in capital markets. The six objectives are climate change mitigation, climate change adaption, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. Bond issuance should also comply with minimum social safeguards, and the GBS also sets requirements for allocation and impact reporting as well as for external verification. A usability guide for EU Green Bond Standard was subsequently published in March 2020, which provided more specific details for issuers, verifiers and investors. A final decision on whether a legislative approach is indeed required is expected towards the end of 2020.

Looking to other regions, we see that green bond framework guidelines in Asia are generally aligned across the different nations, with similar requirements for use of proceeds across Japan, India, Taiwan and the Association of Southeast Asian Nations. China differs in that it allows clean coal to be eligible, and green bonds issued from China are therefore often not included in global indices if proceeds have been used in this regard.

As these standards are developing, a typical framework has been established for green bond issuers. This begins with defining a green bond framework based on four pillars — use of proceeds, project selection, management of proceeds and reporting impact. Generally a third party opinion is then sought to evaluate the framework, which is then confirmed by auditors. Alternatively rating agencies may be used. Both the framework and the approved third counterparties have been defined in more detail by the EU GBS. Once these steps are completed the green bond framework is published and the bond can be issued.

2.2. The Green Bond Market

The first green bond was issued by the European Investment Bank in 2007, but it took a number of years for issuance to really pick up. By the end of 2013 less than 10 billion Euros of green bonds had been brought to the market. It was not until 2014 where issuance really started picking up, and increased in each subsequent year. 2019 saw record issuance of green bonds of over 200 billion Euros, an increase of over 70% versus 2018 issuance. In total, over 500 billion of bonds are now classified as green.

Issuance of green bonds is now prevalent across multiples sectors, geographies and currencies. This includes issuance by sovereigns, local governments, agencies, corporates, financial institutions, as well as covered bonds, Asset Backed Securities (ABS) and Mortgage Backed Securities (MBS). The market has grown as both investors and issuers have given ESG considerations greater importance in their investment decisions, and as political and regulatory focus has also moved in this direction, in particular through the EU Taxonomy.

As is the case for all global markets and indices, there are several different data providers which track the growth and constituents of the green bond market. One of the most commonly observed is the Bloomberg Barclays MSCI Global Green Bond Index, which aims to emulate the four components laid out in the Green Bond Principles from ICMA. This index's market value has grown three times between launch in 2014 and the end of 2019, to 391 billion EUR as of June 2020, as shown in Figure 2.1. It includes 506 bonds from 219 different issuers. This is a green bond subset of the much larger Bloomberg Barclays Global Aggregate Index, and excludes high yield green bonds, tax exempt green bonds and domestic self-labelled green bonds from China, as well as certain green bonds which do not meet MSCI's eligibility criteria.

Despite the rapid growth, we can observe that this is still an extremely small market compared to the overall Global Aggregate, which has a market value of 53 trillion EUR, and hence this index only represents 0.7% of the overall global bond market. If we consider just corporate bonds, which make up 52% of the Global Green Bond Index or 203 billion EUR, it represents just 1.5% of the 13.5 trillion global credit market. In terms of new issuance, this rose to 3.6% of the total corporate bond issuance in 2019.

Looking at the breakdown of this index in Figure 2.2, we see that the non-corporate issuance is dominated by sovereigns and supranationals (with the French sovereign and the European Investment Bank alone making up over 14% of the index), while corporate issuance is dominated by utilities and banks. The first sovereign bond was issued by Poland in 2016, and since then 11 other countries have followed suit, the most recent being

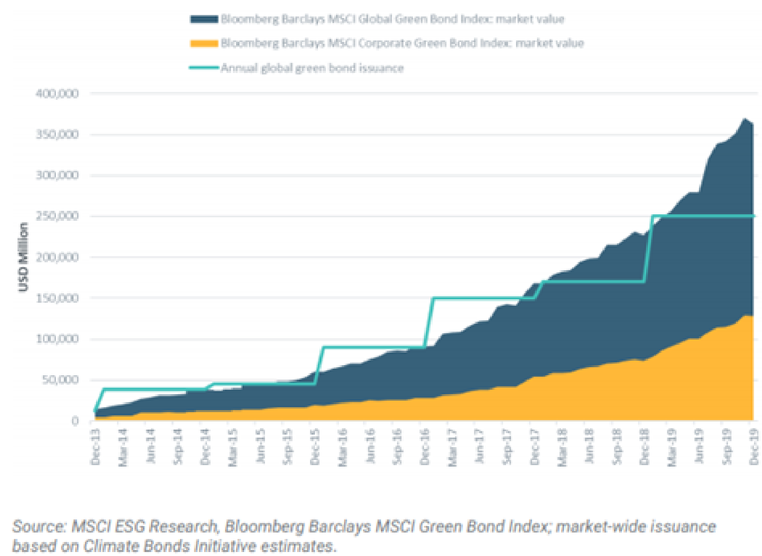


Figure 2.1: Growth in green bond issuance and market value.

Germany who issued 6.5bn EUR in September 2020. From a country perspective, France represents the largest issuer, making up 22% of the index, followed by supranationals at 12% and the USA at 11%. Emerging Market issuance makes up just 8% of the index. Across currencies, EUR denominated bonds make up 66% of the index, USD 23% with the remainder split across 11 further currencies.

Thanks to the additional transparency provided by these bonds, we can also classify how the proceeds have been used. Alternative energy projects continue to be the most common use of funds, followed by green building, shown in Figure 2.3. Sustainable transport has seen the largest proportional increase since 2015. As mentioned above, certain bonds classified as green have failed to meet the eligibility inclusion for this index. MSCI considers a bond as eligible if 90% of the proceeds are allocated to the eligible categories. For example a 2019 green bond issued by Italian gas utility Snam was used to fund equipment upgrades to reduce greenhouse gas emissions and improve maintenance standards of gas based pipelines. The bond was ineligible as the index is not intended to fund fossil fuel projects. Likewise, a 2019 issue from Pepsi, which aimed to purchase recycled or bio-based plastic, did not meet criteria as they could not ensure that the plastic actually gets recycled or composted.

2.3. Criticisms of Green Bonds

As we have eluded to above, the asset class is not without its criticisms. Some of the key objections and difficulties are:

- Green bonds may be issued by companies which have an overall non-green or negative ESG profile. This leads to difficulties for those ESG investors who do invest based only on use of proceeds but rather on the ESG profile of the company as a whole.

- The lack of a single green classification, as well as the phenomenon of self-labelling, can lead to accusations of greenwashing. Furthermore, there are no requirements for green bond issuance proceeds to be kept in a

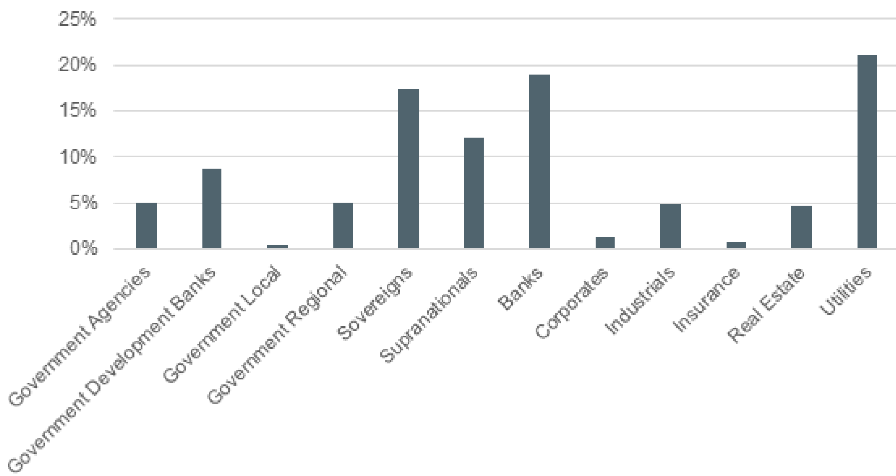


Figure 2.2: MSCI Global Green Bond Index.

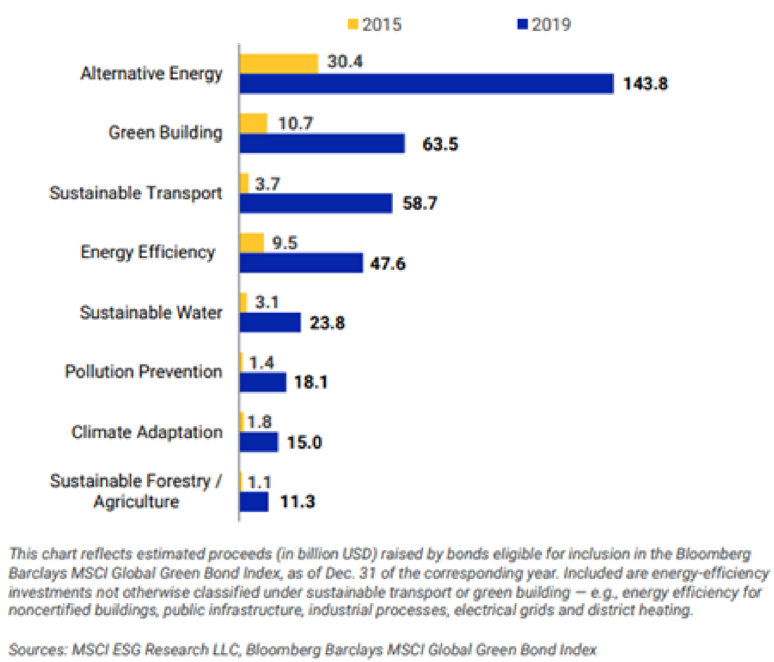


Figure 2.3: Green Bond funding has increased for a variety of purposes (USD bn).

single account at the issuing company, which means in theory that green bond issuance is fungible with non-green bond issuance.

- There have been cases where green bonds have not met the standards of investors or agencies, such as the examples from MSCI above, or the case of Chinese clean coal green bonds.
- In some cases, green bond proceeds are not distributed for many months or years, due to delays in the projects. In this case the green bond issuance is just funding an increase in company cash.
- The lack of consistent reporting requirements.
- The fact that the majority of corporate issuance comes from banks and utilities means it is difficult to create a diversified mandate in this space, which limits demand for dedicated green bond funds.

It is hoped that the EU's Green Bond Standard should help to alleviate many of these issues. However, many of the aforementioned problematic bonds will continue to be labelled as green until they mature.

2.4. The existence of a Greenium

The Greenium of a green bond is defined as the additional spread a green bond pays when compared with an equivalent non-green bond of matching maturity, seniority and currency.

There is some debate as to whether a greenium exists. The key qualitative arguments in favour of a negative greenium (i.e. a green bond should yield less than an equivalent non-green bond) are as follows:

1) Investors receive additional positive benefits from purchasing green bonds, through the positive environmental impact and the corresponding psychological benefits. Hence, these additional benefits should be priced correctly.

2) As interest in green bond and ESG focused investments grows, the demand for these bonds should outstrip the supply, which as we have shown, represents only a minor part of the overall fixed income market. Green bonds can act as a tool for investors to improve the overall ESG credentials of their funds, particularly as the instruments are generally externally verified as being green. In March 2020 a study by Climate Bond Initiatives (CBI) found that green bonds attracted a larger book cover on new issuance compared to non-green bonds, 2.8x compared to 2.0x respectively. A November 2019 CBI investor survey also showed a shortage of green bonds compared to investor appetite.

3) As well as providing additional transparency and visibility on impact, a key aim of green bonds is to allow green projects to be financed at a lower cost than would be usually associated with bond issuance, and hence encourage more green projects to be taken on by corporations. This should help to transition away from projects which are less environmentally friendly. Hence, in this case one would expect a negative greenium.

4) Green investors should have a longer term "buy-and-hold" perspective, as investments have been made with a multi-year view due to their green credentials. This should also lead to lower volatility in market sell-offs.

5) There are considerably more cost involved for an issuer to bring a green bond as opposed to a non-green bond. These are in the form of third party verification at issuance, greater disclosure requirements and reporting over the life-time of the bond. These extra costs suggest the issuer would be unwilling to issue an equivalent coupon when compared to a non-green bond.

On the other hand, there are several arguments which dispute that a greenium should exist. Firstly, the argument regarding positive technicals may not be as strong as, for example, the CBI survey suggests. So far the growth of green bonds has far outstripped the growth of dedicated green bond funds. Goldman Sachs estimates less than 8bn EUR in dedicated funds per the end of 2019. Several billion are invested in ESG focused mandates, but these mandates will not necessarily add green bonds indiscriminately, focusing more on the overall issuer profile. This indicates that many green bonds are held by non-dedicated investors, and that green bond investors have a more limited influence on the pricing of these instruments in secondary markets. This may change as the EU GBS come into play and as investor interest in ESG and green mandates continues to increase.

Secondly, as mentioned above, the quantitative perspective cannot be ignored. Fixed income investors are accustomed to comparing attractiveness based on an assessment of the underlying credit risk and the risk premium offered by the bond. In a scenario where an issuer defaults, the green bonds will be treated in exactly the same way as non-green bonds. The bonds are pari-passu, i.e. of equal claim in default. Furthermore, as we have already mentioned, the coupon payments and notional repayment on the bond are covered by the issuer, not by the relevant green project. Hence, purely examining from a quantitative viewpoint will always point to no greenium existing.

3. The Data

This study is performed on the daily ASW data of corporate bonds, including green bonds and conventional bonds. We have only involved issuers who have issued both types of bonds: green bonds and non-green bonds. This study focuses on EUR denominated bonds. Perpetual bonds and longer-term bonds, like with maturities over 50 years, were not included in our study. The sample contains 521 corporate bonds from 58 companies, as shown in Table A.1(in Appendix A).

4. Stylized Features

In this part, we firstly investigate the distribution of the ASW returns of all bonds in our data as in Table A.1. We calculate several descriptive statistics to understand their distribution. Then, the QQ-plots of the ASW returns are presented to study whether or not they obey a normal distribution. Also, we investigate the correlation between green bonds and non-green bonds through similar QQ-plots. Last, we compare the tail indexes of green bonds and non-green bonds using the Hill estimator.

4.1. Descriptive Statistics

Several descriptive statistics of the ASW return distribution are estimated for the comparison of the green bonds and their non-green counterparts. We focus first on the empirical mean, standard deviation, skewness, and kurtosis. We show these statistics for some bonds in Table 4.1 as an illustration.

Table 4.1: The descriptive statistics of the ASW changes of these bonds. 'Y' and 'N' in the brackets represent green bond and non-green bond, respectively.

Company	Bond Code	Mean	Standard deviation	Skewness	Kurtosis
	XS1422841202 (Y)	-0.0186	2.0864	3.4372	64.7071
	XS1808739459 (Y)	0.0303	2.7282	4.6110	60.8360
	XS1982037696 (Y)	0.0103	3.4452	4.3736	47.2720
	XS1935139995 (N)	-0.0785	3.1197	4.5757	55.7239
	XS1856791873 (N)	0.0042	2.7854	3.7760	52.6930
	XS0765299572 (N)	-0.0287	2.1116	4.1888	72.3798
ABNANV	XS1218821756 (N)	-0.0213	2.1405	5.3403	95.1212
	XS1917577931 (N)	-0.0045	2.5562	2.9219	28.9388
	XS1917574755 (N)	-0.0242	2.4913	4.3970	36.2698
	XS0937858271 (N)	-0.0274	2.1600	4.7456	84.5115
	NL0009980945 (N)	-0.0539	2.3816	2.4811	57.1245
	XS1935134095 (N)	-0.0198	2.3041	2.3708	23.6842
	XS0997342562 (N)	-0.0392	1.6234	2.1217	20.9651
	XS1716820029 (Y)	0.0924	4.9845	1.8968	36.8641
	XS2082324364 (N)	0.4184	9.8924	0.0247	11.5387
	XS1116480697 (N)	-0.0017	4.4293	2.7570	46.2796
BACR	XS1531174388 (N)	-0.0397	4.5396	1.8138	42.2392
	XS1385051112 (N)	-0.0929	3.6104	2.2097	42.6990
	XS1873982745 (N)	-0.0376	5.8842	1.1966	27.1238
	XS1757394322 (N)	0.1236	5.8489	0.1498	21.4586
	DE000CZ40NG4 (Y)	0.1193	5.2633	4.8960	56.6132
	DE000CZ302M3 (N)	0.0073	2.6736	7.2308	123.1759
	DE000CZ40K07 (N)	0.0372	3.3116	6.7466	125.5656
	DE000CZ40LR5 (N)	0.0817	3.5068	6.8286	115.5381
	DE000CZ40L63 (N)	0.0938	3.8363	6.4359	101.4218
CMZB	DE000CZ45VB7 (N)	0.3740	7.0146	3.2144	25.6437

	DE000CZ40MC5 (N)	0.1290	3.8711	5.1043	73.6566
	DE000CZ40N46 (N)	0.1877	6.2161	2.5898	28.7949
	DE000CZ45VM4 (N)	0.7089	9.5086	1.5061	10.1977
	DE000CZ40MM4 (N)	0.1441	4.2567	3.3346	63.1160
DANBNK	XS1963849440 (Y)	-0.0714	4.9426	3.5376	43.4217
	XS1957541953 (N)	-0.0894	4.9606	4.1546	47.6705
	XS2046595836 (N)	0.1290	6.1767	2.6310	26.0264
	XS1799061558 (N)	0.1283	4.1134	3.6183	44.7894
ENBW	XS1901055472 (Y)	0.0030	2.2477	1.6768	13.4789
	XS0438844093 (N)	-0.0254	2.2030	2.3209	27.7329
	XS1074208270 (N)	-0.0383	1.5011	1.1111	22.6494
	XS0207320242 (N)	-0.0411	1.5738	1.8190	33.2709
IBESM	XS1398476793 (Y)	-0.0045	1.9263	2.6490	30.4505
	XS1490726590 (Y)	0.0217	1.7943	2.6312	30.1801
	XS1527758145 (Y)	-0.0111	1.7897	3.0487	37.2501
	XS1575444622 (Y)	-0.0087	1.8222	3.3392	38.2315
	XS1682538183 (Y)	-0.0008	2.1828	3.5381	41.5720
	XS1847692636 (Y)	-0.0146	2.2321	2.9548	31.8551
	XS1171541813 (N)	-0.0188	1.8383	1.8958	33.2227
	XS0879869187 (N)	-0.0231	1.5557	0.3750	14.9349
	XS1726152108 (N)	0.0082	2.0928	2.1074	20.0110
	XS0940711947 (N)	-0.0267	1.5192	0.2175	11.0864
	XS1116408235 (N)	-0.0197	1.9001	1.4512	28.8111
	XS0990109240 (N)	-0.0190	1.7178	2.2258	35.4208
	XS1291004270 (N)	-0.0188	1.8725	1.8371	33.8383
SEB	XS1567475303 (Y)	0.0258	1.8707	3.3700	46.4563
	XS2020568734 (N)	0.0545	2.7973	3.2347	25.2794
	XS1788951090 (N)	0.0510	2.0120	3.3896	41.2617
	XS1370669639 (N)	-0.0387	1.6738	2.4147	25.6886
	XS1291152624 (N)	-0.0322	1.5004	4.4197	105.2375
	XS1033940740 (N)	-0.0317	1.6316	1.5312	18.4210

Based on these descriptive statistics in Table 4.1, we can see that, with a few exceptions, that most of the time the green bond and a comparable non-green bond of the same issuer have approximately the same values for our statistics. It is the first indication that the return-distributions are very similar.

4.2. The Distribution of ASW Change

In this section, QQ-plots are presented to analyze whether or not the ASW returns of these bonds obey a Normal distribution. We show in Figure 4.1 some representative cases of green and non-green bonds and note that for all other bonds the results are of the same nature. We observe an 'S'-shaped QQ-plot, indicating that ASW returns exhibit fatter tails than the normal distribution, both for negative and positive returns. Note that, there is hardly any difference between the quantile plots for the green bond and their non-green counterparts, again indicating that both are driven by a similar distribution.

4.3. Two-sample QQ-plots of Green Bond against Non-Green Bond

Figure 4.2 presents the two-sample QQ-plots plotting the quantiles of the green bond returns against the corresponding quantiles of the non-green bond issued by the same company. These allow to analyze potential differences between their distributions in more detail without any specific distributional assumptions. The QQ-plots exhibit quite a straight line in the main central parts of the returns in almost all sub-figures, suggesting that the green bond and non-green bond from one company follow the same underlying distribution of ASW returns. However in several cases, some deviations can be observed at the extreme negative returns. For instance in cases (a), (b), (e), (g) and (h) the size of the most extreme negative green bond returns is less extreme than the corresponding non-green bond returns.

4.4. Extreme Value Index Estimation

The negative tail of green bonds and non-green bonds can be discussed according to the Hill statistics [14]

$$\hat{\gamma}_k = \frac{1}{k}\sum_{i=0}^{k-1}\left(\log(X_{n-i,n}) - \log(X_{n-k,n})\right), \tag{1}$$

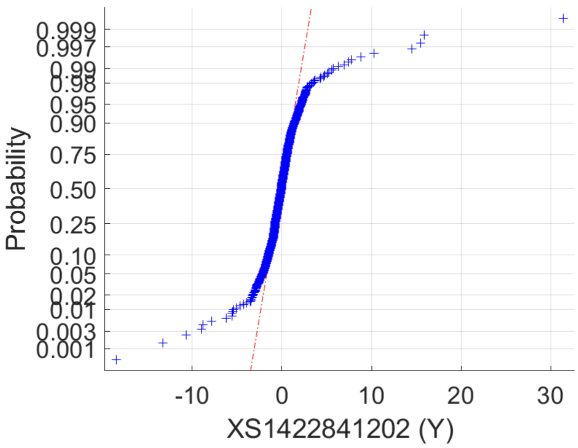
which measure the heaviness of the negative tail. Here k is the number of upper order statistics and $X_{1,n} \leq \ldots \leq X_{n,n}$ denote the ordered absolute values of the negative returns. These results are shown in Figure 4.3. From these figures, we observe that these curves of $\hat{\gamma}_k$ as a function of k for the green bonds and non-green bonds are very close. That is, the bond pairs have a similar type of tail heaviness, while in the cases (a), (b), (e), (g) and (h) discussed in subsection 4.3, the tail index is somewhat lower for the green bonds.

5. Statistical Testing

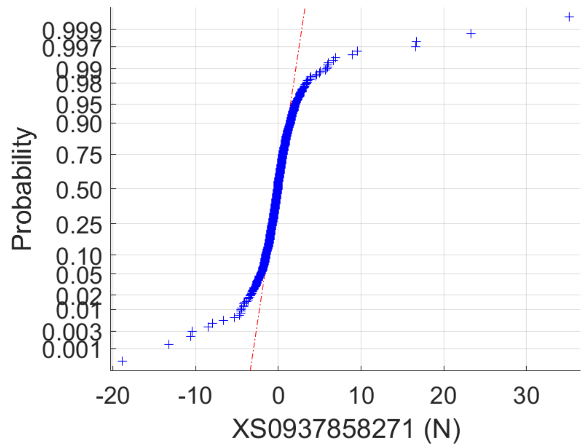
In this part, we perform several hypothesis tests to gain further insight into the potential difference in the return distribution of green and non-green bonds, based on the daily and weekly ASW values.

5.1. Hypothesis Tests for Means and Medians

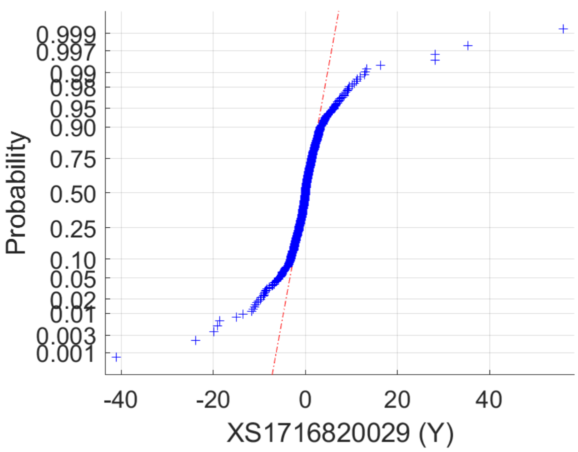
Firstly, we perform several one-to-one two-sample T-tests for each bond pair based on the daily and weekly ASW change which is presented in Table 5.1 and Table 5.2. The null hypothesis of the first T-test is that the green bond and the non-green bond are from populations with equal mean. The proportion of $p_1 < 0.05$ is 0,



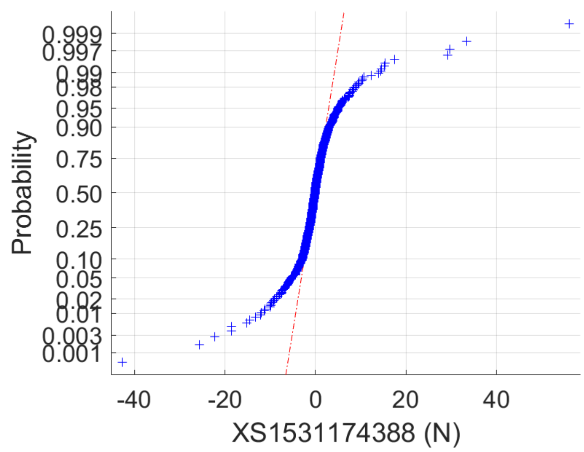
(a) ABNANV (Green)



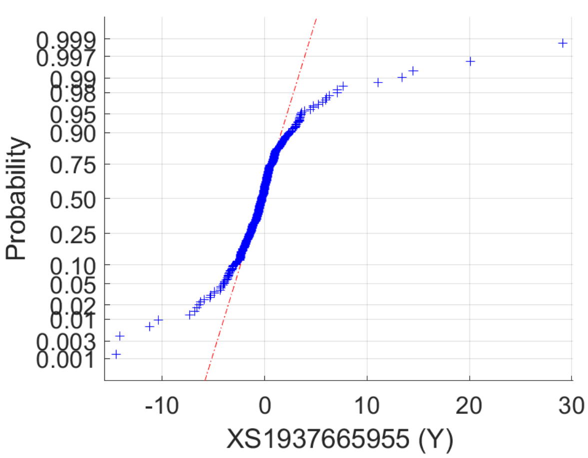
(b) ABNANV (Non)



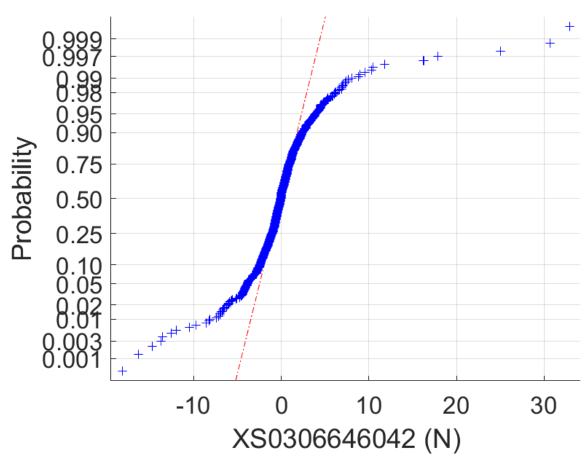
(c) BACR (Green)



(d) BACR (Non)

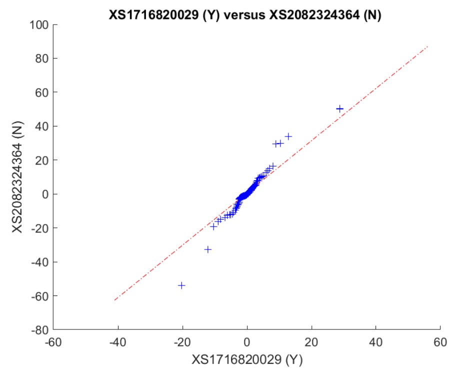


(e) ENELIM (Green)

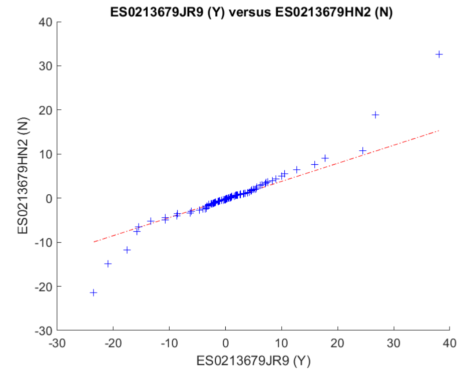


(f) ENELIM (Non)

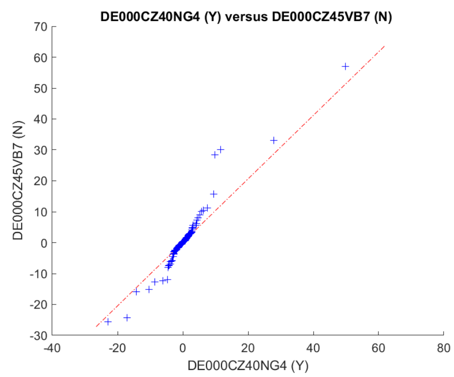
Figure 4.1: The QQ-plots between ASW returns of green bonds and Normal distribution.



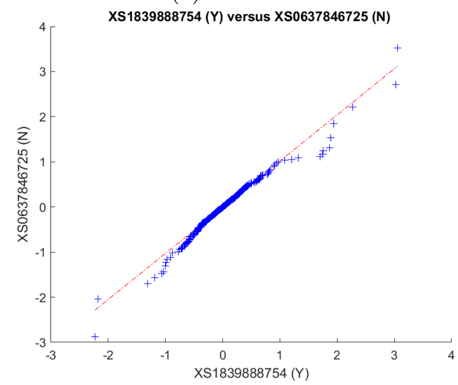
(a) BACR



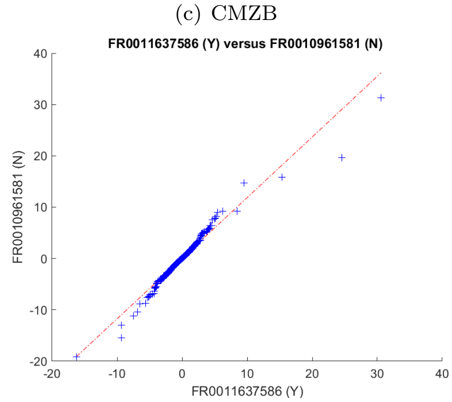
(b) BKTSM



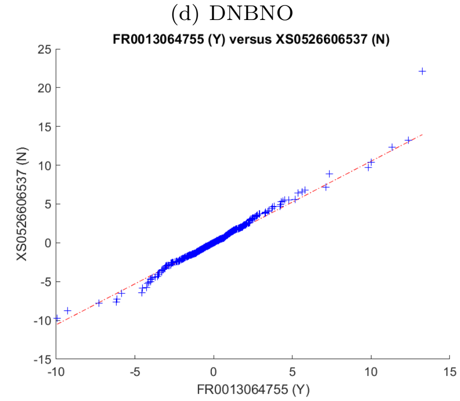
(c) CMZB



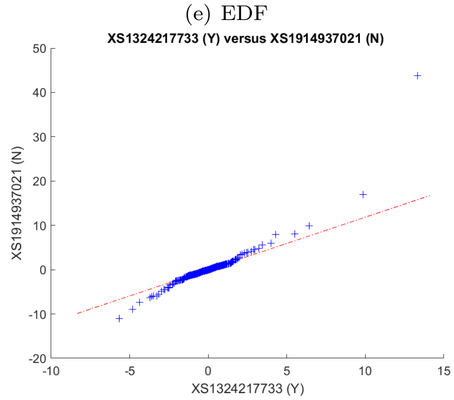
(d) DNBNO



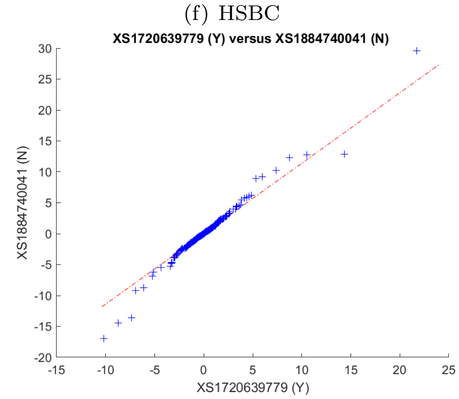
(e) EDF



(f) HSBC



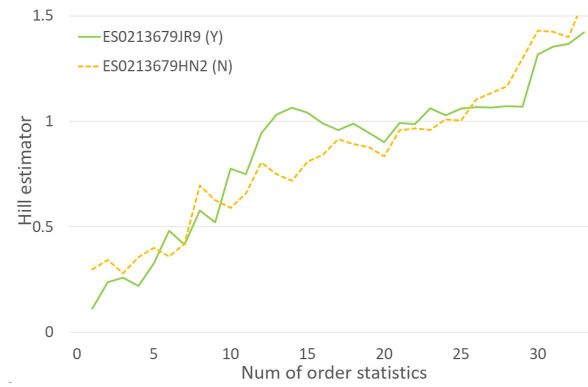
(g) INTNED



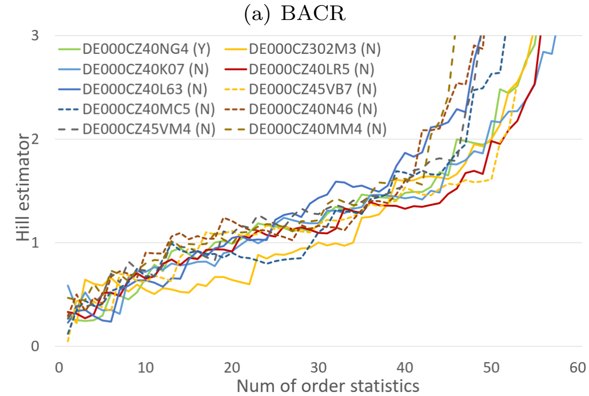
(h) TOYOTA

Figure 4.2: The two-sample QQ-plots of ASW return between the green bond and the non-green bond. 'Y' and 'N' represent green bond and non-green bond, respectively.

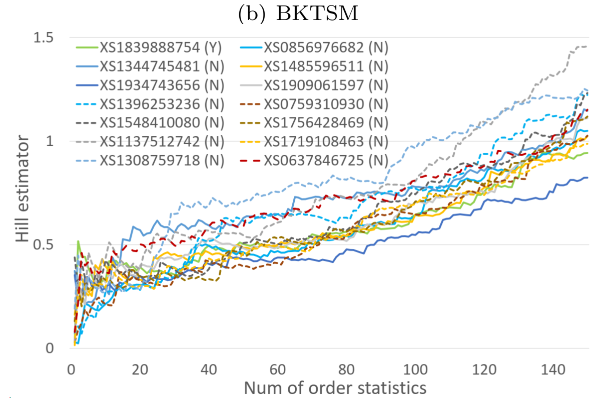
(a) BACR



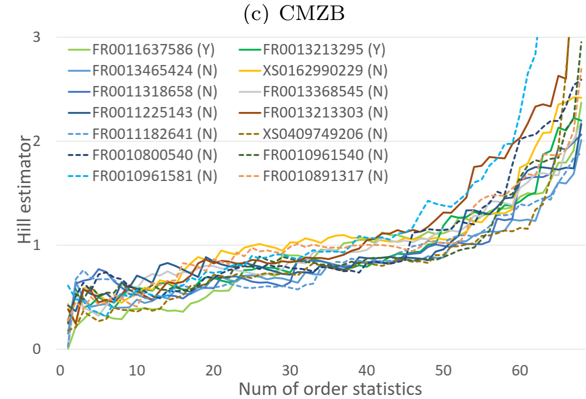
(b) BKTSM



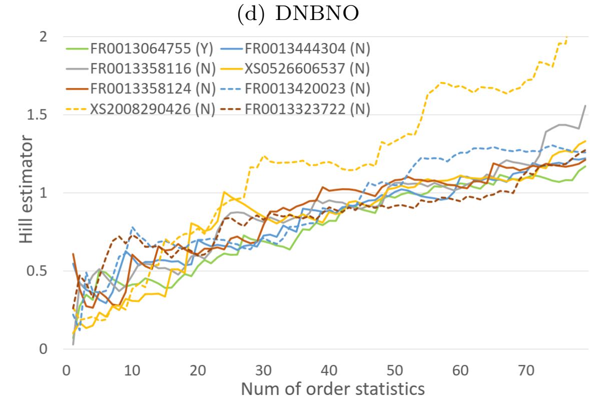
(c) CMZB



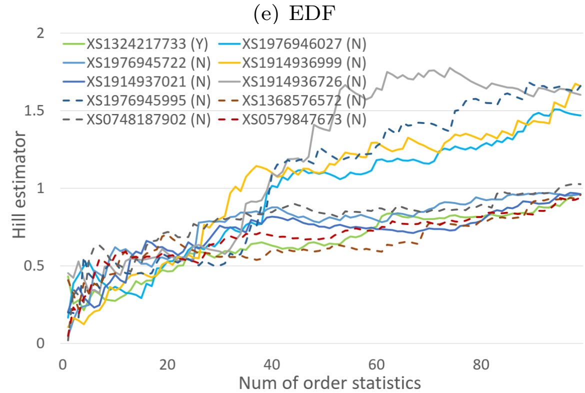
(d) DNBNO



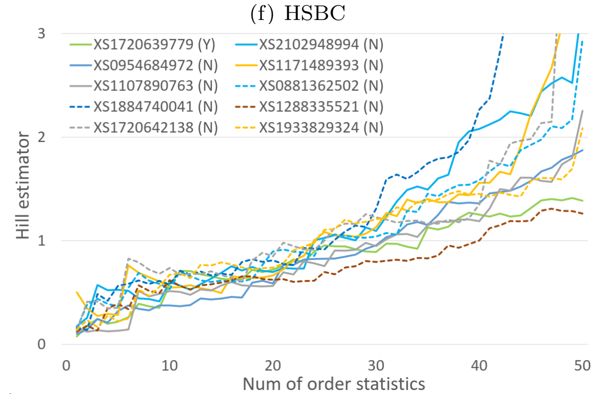
(e) EDF



(f) HSBC



(g) INTNED



(h) TOYOTA

Figure 4.3: The Hill estimator value γ.

which means that none of the null hypotheses can be rejected at the 5% level. Lines h_2 and h_3 are the results of the other two T-tests, with null hypotheses that the mean of the green bond is greater or smaller than the non-green bond, respectively. According to the results of the two tables, we can see that all bond pairs pass the T-tests, that is, for all tested bond-pairs the p-values are always higher than the level of significance of 5%, indicating that the null hypothesis cannot be rejected at the 5% level.

Further, the results of the Wilcoxon rank-sum test [15] (Table 5.1) indicate at line h_6 only 0.56% of bond pairs fail the hypothesis test for the daily ASW changes, which means that the null hypothesis holds and two samples are from continuous distributions with equal medians. Also, we implemented the Wilcoxon rank-sum test in the weekly ASW change, as shown in Table 5.2. The results of weekly ASW values are similar to the daily results. Thus, combined with the previous results, there is no significant difference in the mean and median of ASW return distribution between the green bonds and non-green bonds from one company.

5.2. Hypothesis Tests concerning the Variances

We firstly implement a two-sample F-test, whose null hypothesis is that green bonds and non-green bonds come from the normal distribution with the same variance, referred to h_4 in Table 5.1. We are aware that we have just argued that returns are non-normally distributed and hence the following results should be considered with some precondition. From the Table 5.1, we can see that 43.65% of bond pairs failed the F-test. In addition, we made another two-sample F-test, whose alternative hypothesis is that the variance of a green bond is greater than that of a non-green bond. Only 27.89% of bond pairs reject the null hypothesis, that is, only about a quarter of bond pairs indicate the variance of the green bond is greater than that of the non-green bond. The variance of the green bond is less than that of the non-green bond in most cases, which means the return of a green bond is more stable than a non-green bond. The similar results on weekly ASW values are shown in Table 5.2.

Table 5.1: The summary of all hypothesis tests for the daily ASW changes of all bond pairs. There are 717 bond pairs in total.

Hypothesis tests		The proportion of $p < 0.05$
T-tests	h_1	0
	h_2	0
	h_3	0
F-tests	h_4	43.65%
	h_5	27.89%
Wilcoxon rank-sum test	h_6	0.56%
Kolmogorov-Smirnov test	h_7	12.55%

5.3. Hypothesis Tests for the Distribution

In this part, we firstly investigate whether or not the bonds issued by one company (green and non-green) have the same distribution by the Kruskal-Wallis (KW) test [16] according to the daily and weekly ASW values,

Table 5.2: The summary of all hypothesis tests for the weekly ASW changes of all bond pairs. There are 717 bond pairs in total.

Hypothesis tests		The proportion of $p < 0.05$
T-tests	h_1	0
	h_2	0
	h_3	0
F-tests	h_4	20.22%
	h_5	16.04%
Wilcoxon rank-sum test	h_6	0
Kolmogorov-Smirnov test	h_7	4.46%

as shown in Tables 5.3, 5.4. The null hypothesis of the KW test is that all bonds come from the same distribution. If $p > 0.05$, the null hypothesis is not rejected. Note, "ACAFP1" and "ACAFP2" are shown in the two tables, since bonds from ACAFP company have two credit ratings: A+ and A- (due to differing seniority). The bonds with different credit ratings need to be processed separately.

According to the daily results, we can see that almost all p-values are greater than 0.05, and only one p-value is smaller than 0.05. All p-values are greater than 0.05 in the weekly results. Hence, there is no statistical evidence that the bonds of one company do not follow the same distribution, that is, there is no significant difference between the ASW returns of green bond and non-green bond. Further, we make a two-sample Kolmogorov-Smirnov test [17] for the bond pairs to test whether or not each green bond and non-green bond have the same continuous distribution. $h_7 = 0$ in Tables 5.1, 5.2 means the two bonds of the bond pair have the same continuous distribution. According to the table, about 12.55% of all bond pairs can't pass the KW test in the daily results, and only 4.46% of bond pairs failed the KW test in the weekly results.

Therefore, significant differences between the distributions of green bonds and non-green bonds cannot be inferred in most cases.

6. Greenium of Green Bond

Firstly, we construct a synthetic non-green bond for each green bond via linear interpolation, which has the same maturity as the green bonds. More precisely, we interpolate the ASW term structure of the non-green bonds at the green-bonds' maturity to obtain the ASW of a synthetic non-green bond with the same maturity as the green bond. The ASW values of the synthetic bonds and original bonds are shown in Figure 6.2. From these figures, we can see that the ASW values of the synthetic bonds are very close to the corresponding green bonds, indicating again that there is no real significant difference between green bonds and conventional bonds.

6.1. Hypothesis Tests for Green Bonds and Synthetic Bonds

We performed a statistical test for the green bond and synthetic bonds with the same maturities which are constructed by interpolation based on the ASW values of non-green bonds, as shown in Table 6.1. From the figure,

Table 5.3: The p-values of the Kruskal-Wallis test for the daily ASW values of each company. $p > 0.05$ means that significant differences between bonds from one company cannot be concluded.

Companies	p values	Companies	p values	Companies	p values
ABNANV	0.9975	ACACB	1.0000	ACAFP1	0.9698
ACAFP2	0.8059	AEMSPA	0.5204	ALDFP	0.6673
BACR	0.9910	BBVASM	0.8892	BKTSM	0.7983
BNP1	1.0000	BNP2	1.0000	BPCEGP	1.0000
C	1.0000	CMZB	0.9845	DANBNK	0.9904
DEVOBA	0.6137	DLR	0.6845	DNBNO	0.9970
EDF	0.9993	EDPPL	0.9990	ENBW	0.9447
ENELIM	0.9867	ENGIFP	1.0000	EOANGR	1.0000
ESBIRE	0.9935	FERROV	0.8091	FRLBP	0.8943
FRPTT	0.9354	HERIM	0.7897	HSBC1	0.9943
HSBC2	0.5969	IBESM	0.9618	IGYGY	0.9945
INTNED1	0.9072	INTNED2	1.0000	ISPIM	0.7940
KBCBB	0.9999	LBBW	0.9914	LPTY	0.6990
MIZUHO	0.6922	MUFG	0.8143	NDASS	0.9996
NTGYSM	0.9952	OPBANK	0.9978	ORSTED	0.0731
PLD	0.9963	RABOBK1	0.9833	RABOBK2	0.9998
REESM	0.9937	RY	0.5439	SANTAN	0.9736
SEB	0.4842	SHBASS	0.9995	SOCGEN	0.9636
SOCSFH	0.9923	SSELN	0.8506	SUMIBK	0.9906
SWEDA	0.0374	TENN	0.9900	TOYOTA	0.9939
UBIIM	0.9371	VATFAL	0.8400		

we can see there is no difference in the mean and median of green bonds and synthetic bonds. Half of the bond pairs have similar variances. All synthetic bonds have similar distributions with the corresponding green bonds, which further illustrates that these synthetic bonds are statistically reasonable and can be used to calculate the greenium.

6.2. Greenium

In this part, we analyze the greenium. We quantize the overall difference of ASW values between green bonds and synthetic non-green bonds on our sample. This difference can be regarded as an estimate of the *greenium* taken by green bonds:

$$Greenium = the\ ASW\ of\ green\ bond - the\ ASW\ of\ synthetic\ bond.$$

Table 5.4: The p-values of the Kruskal-Wallis test for the weekly ASW values of each company. $p > 0.05$ means that significant differences between bonds from one company cannot be concluded.

Companies	p values	Companies	p values	Companies	p values
ABNANV	1.0000	ACACB	1.0000	ACAFP1	0.8824
ACAFP2	0.9800	AEMSPA	0.9533	ALDFP	0.6443
BACR	0.9992	BBVASM	0.9662	BKTSM	0.9186
BNP1	1.0000	BNP2	1.0000	BPCEGP	1.0000
C	1.0000	CMZB	0.9985	DANBNK	0.9679
DEVOBA	0.6756	DLR	0.9960	DNBNO	0.9998
EDF	1.0000	EDPPL	0.9997	ENBW	0.8915
ENELIM	1.0000	ENGIFP	1.0000	EOANGR	1.0000
ESBIRE	0.9995	FERROV	0.8941	FRLBP	0.9874
FRPTT	0.9936	HERIM	0.8036	HSBC1	0.9998
HSBC2	0.9962	IBESM	1.0000	IGYGY	0.9997
INTNED1	0.9988	INTNED2	1.0000	ISPIM	–
KBCBB	0.9999	LBBW	0.9989	LPTY	0.9636
MIZUHO	0.9725	MUFG	0.9834	NDASS	1.0000
NTGYSM	0.9996	OPBANK	1.0000	ORSTED	0.2997
PLD	1.0000	RABOBK1	0.9592	RABOBK2	1.0000
REESM	0.9994	RY	0.7261	SANTAN	0.9914
SEB	0.9380	SHBASS	0.9991	SOCGEN	1.0000
SOCSFH	1.0000	SSELN	0.9683	SUMIBK	0.9999
SWEDA	0.9760	TENN	1.0000	TOYOTA	0.9999
UBIIM	0.9234	VATFAL	0.9982		

Estimates over time are graphed in Figure 6.3. From that figure, we observe that the greenium value changes over time and fluctuates around zero. The average greenium of the whole sample is around -7.07 bps, that is, the ASW value of green bonds is 7.07 bps lower than the conventional bonds. Further, we can see that the greenium changes from positive to negative in recent years.

6.3. Extreme Value Index Estimation

In this part, we analyze and compare the extreme value indexes of green bond and its corresponding synthetic bond, shown in Figure 6.1. From the cases (a), (e), (f), (g) and (h), the tail index for the green bonds is lower than that of their corresponding synthetic bonds. And the tail index for the green bonds is higher than that of their corresponding synthetic bonds. Table B.1 (in Appendix B) shows the tail indexes of all green bonds and synthetic bonds. There are a total of 98 green bonds, of which 45 pairs of bonds have the γ value of green bond greater than that of synthetic bond. Therefore, there is no obvious difference in tail index between green bond

Table 6.1: The summary of all hypothesis tests for the ASW changes of the green bonds and the corresponding synthetic bonds. There are 98 bond pairs in total.

Hypothesis tests		The proportion of $p < 0.05$
T-tests	h_1	0
	h_2	0
	h_3	0
F-tests	h_4	50.00%
	h_5	26.63%
Wilcoxon rank-sum test	h_6	0
Kolmogorov-Smirnov test	h_7	20.41%

and synthetic bond.

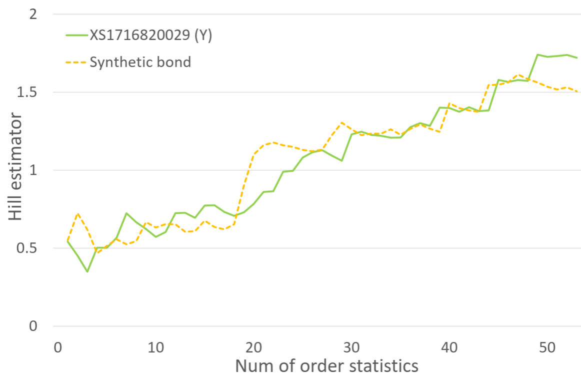
6.4. Greenium during COVID-19

The COVID-19 crises broke out globally in the beginning of 2020 and started affecting financial markets by end of February 2020. In Figure 4(a), we observe the start of a sharp drop of the greenium in March 2020 almost at the moment the VIX, a good measure for the general fear in financial markets, reaches its maximum level. The greenium seems to be robust in an initial phase of a distressed market; we observe a lag of about 17 trading days compared with the VIX index from Figure 4(b). The lag is estimated as the number of days for which there is the most negative correlation between the lagged VIX and the greenium data-series. The most negative correlation is -0.8952 at a lag of 17 days.

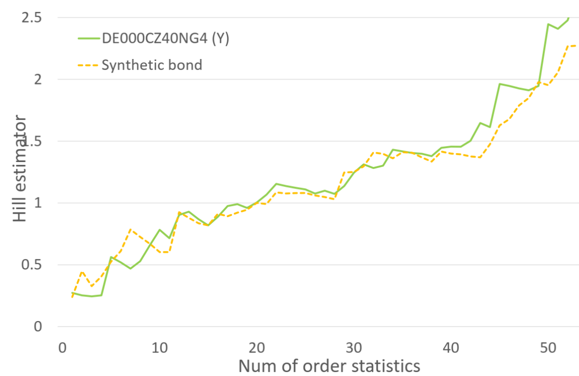
A potential explanation, which needs more research, is that green bonds are proportionally more held in buy-and-hold long-term strategies and hence are less part of a global selling wave than their non-green counterparts. This could be due to these investors focusing on non-pecuniary (environmental) factors when investing in green bonds, which have a longer-term perspective, and are not affected by market volatility. Another potential explanation is that although global financial markets saw large net outflows during the crisis, ESG focused strategies continued to see net inflows. This may have led to proportionally more flows into green bonds compared to non-green bonds, and hence increased demand on a relative basis. Rising spreads of the ordinary bonds in distressed markets, due to selling pressure and a flight to cash, could cause the greenium to become more negative. Sustainable investments like green bonds seem to be hence more robust in systemic crises.

7. Conclusions

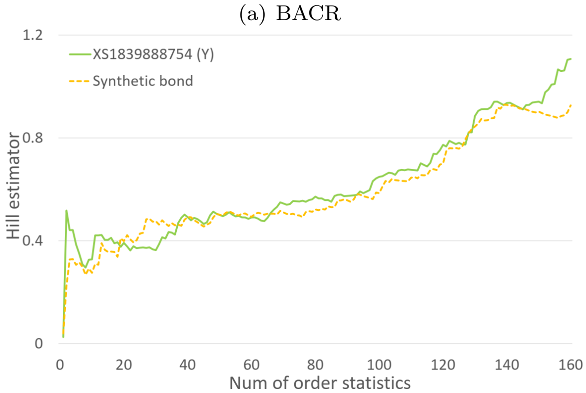
In this paper, we analyzed the potential differences between green bonds and conventional bonds quantitatively and qualitatively. Based on the results of hypothesis tests, we can conclude there is no significant difference in the mean and median of ASW change between green bonds and conventional bonds. Furthermore, most green bonds follow the same distributions of ASW change as their conventional counterparts.



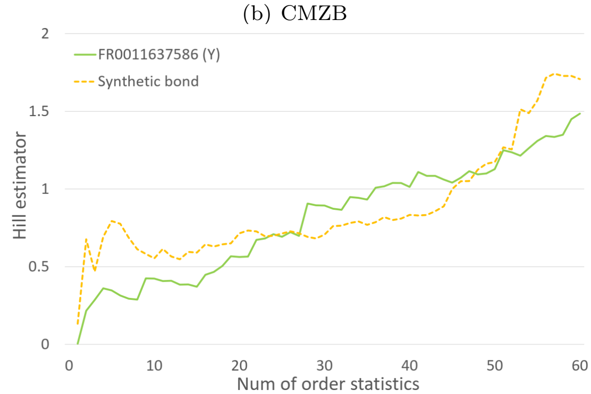
(a) BACR



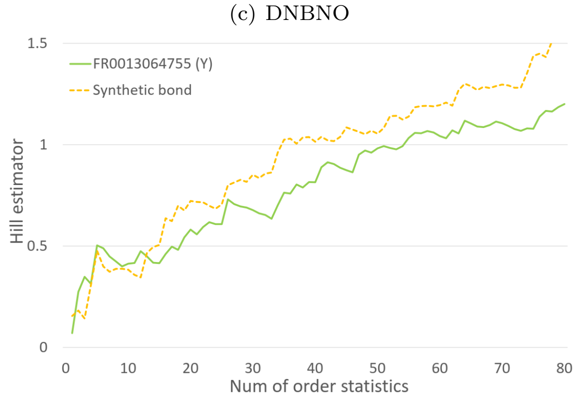
(b) CMZB



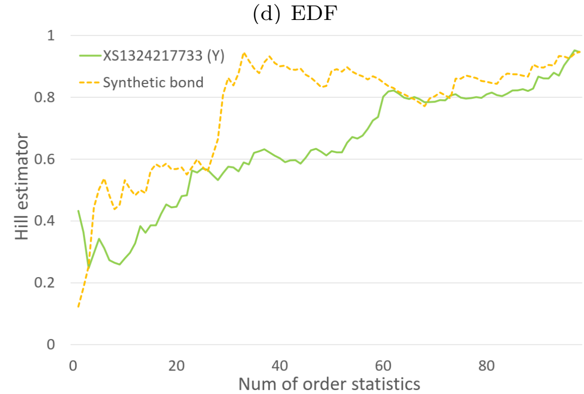
(c) DNBNO



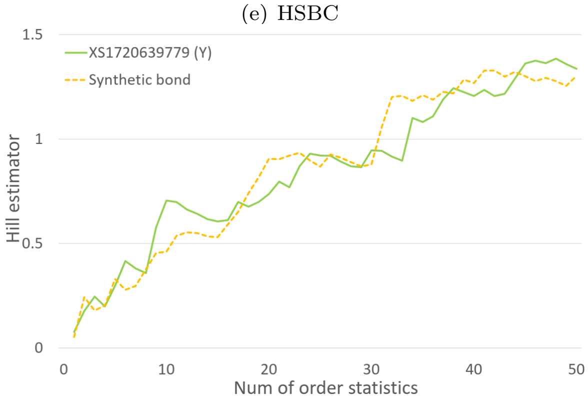
(d) EDF



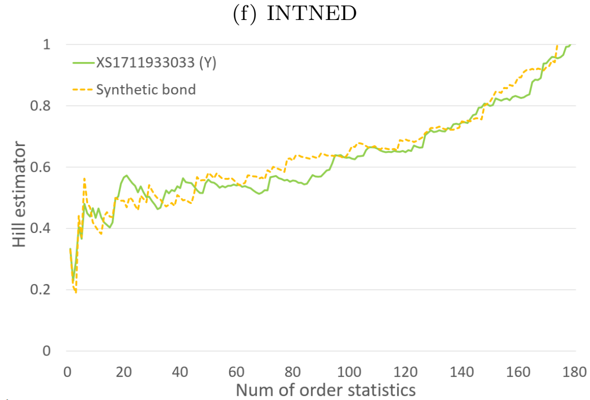
(e) HSBC



(f) INTNED

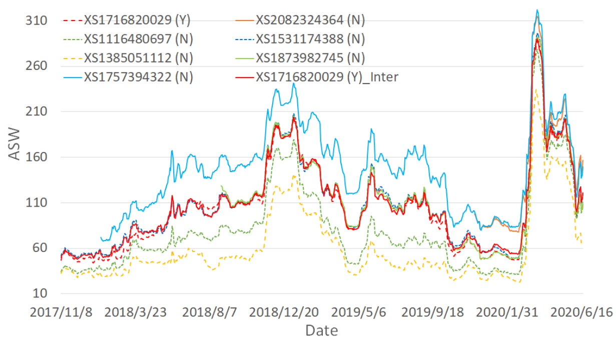


(g) TOYOTA

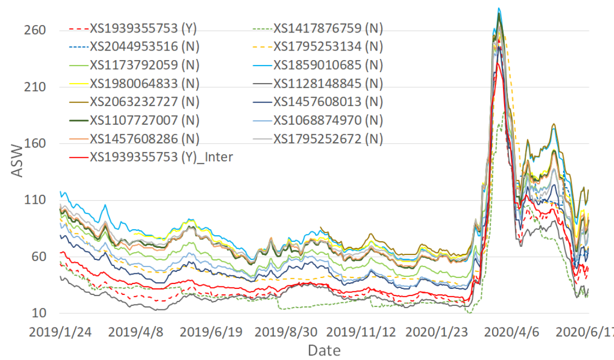


(h) SWEDA

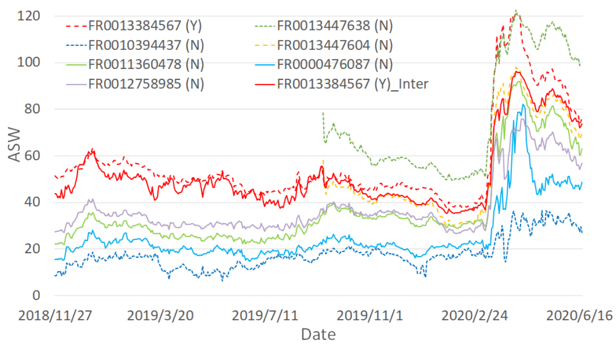
Figure 6.1: The Hill estimator value γ of green bond and the corresponding synthetic bond.



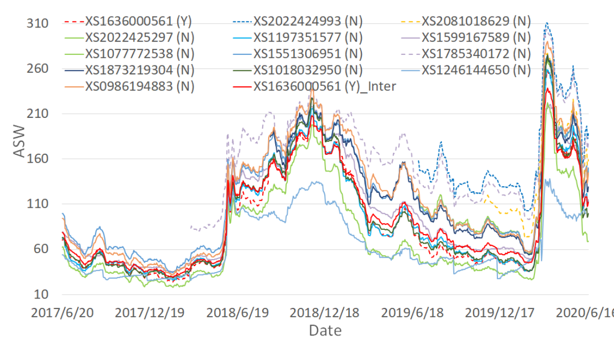
(a) BACR



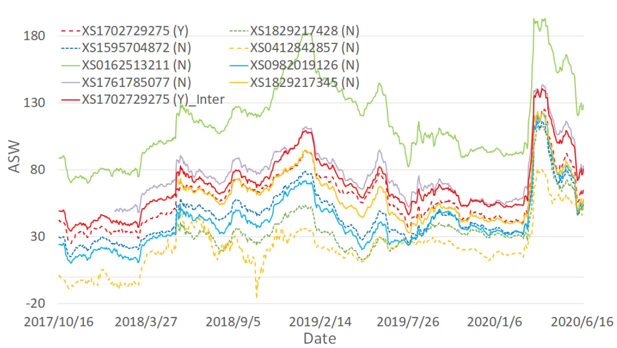
(b) C



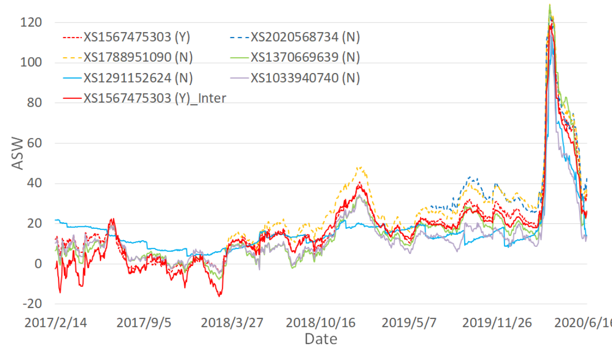
(c) FRPTT



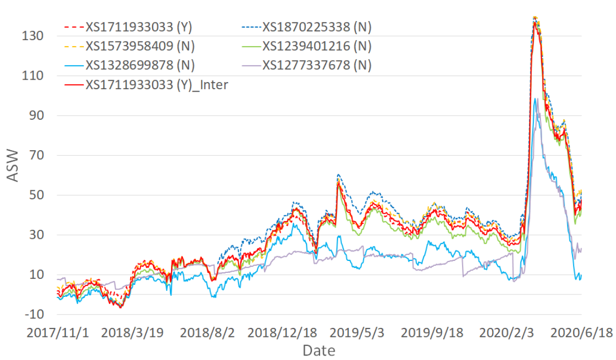
(d) ISPIM



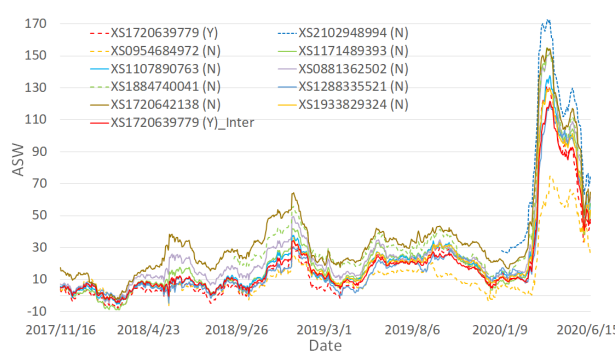
(e) IGYGY



(f) SEB



(g) SWEDA



(h) TOYOTA

Figure 6.2: The ASW values of green bond and synthetic non-green bonds.

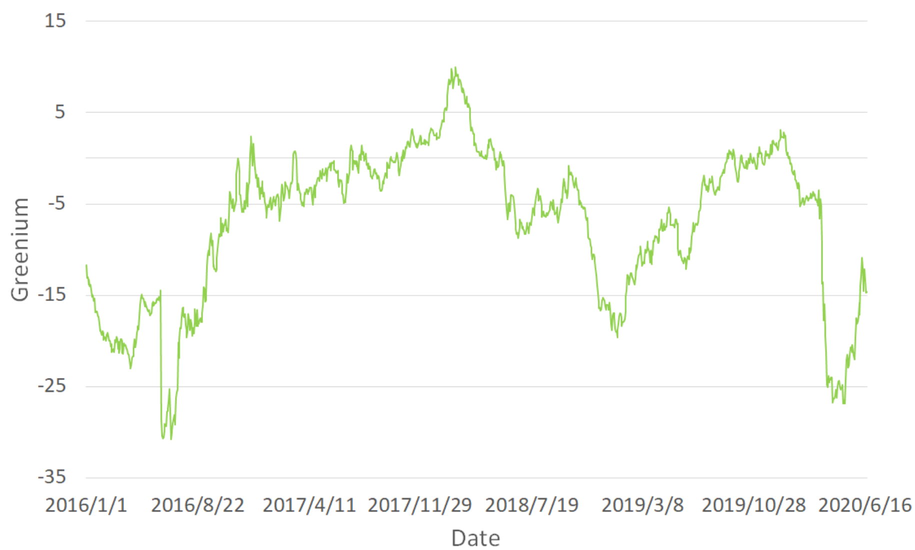
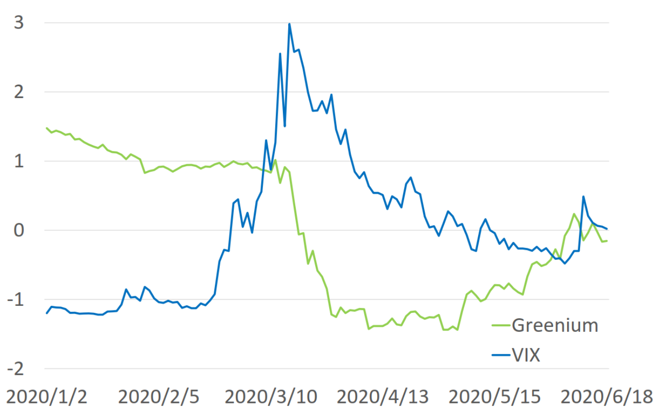
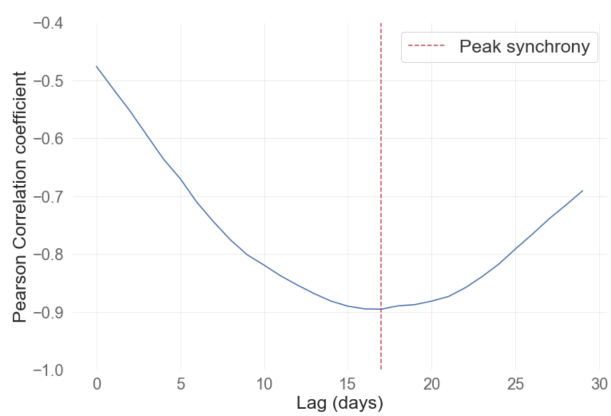


Figure 6.3: The greenium taken by green bonds. The curve is the average of the greenium overall all green bonds.



(a) The relationship between Greenium and VIX.



(b) The pearson correlation between Greenium and VIX.

Figure 6.4: Greenium and VIX during 2020. In the right figure, the horizontal axis is the lag (trading days) of greenium with VIX.

In addition, we used interpolation to construct several synthetic non-green bonds with the same maturities as green bonds to investigate the *greenium* potential present in green bonds. We have no evidence of a significant greenium. The point estimates of the *greenium* fluctuate near zero over time; with an overall average around -7.07 bps. We observe evidence that the greenium becomes more negative in times of financial market stress. These findings could have important consequences for construction of fixed income corporate bond portfolios.

Appendix A. Dataset

Table A.1: The dataset.

Company	Time Range	Nums of Green Bond	Nums of Non-Green Bond	Total Number
ABNANV	2016/1/1-2020/6/18	3	10	13
ACACB	2016/1/1-2020/6/18	1	22	23
ACAFP	2016/1/1-2020/6/18	2	21	23
AEMSPA	2016/1/1-2020/6/18	1	1	2
ALDFP	2017/7/12-2020/6/18	1	1	2
BACR	2016/1/1-2020/6/18	1	6	7
BBVASM	2016/1/1-2020/6/18	2	5	7
BKTSM	2016/1/1-2020/6/18	1	1	2
BNP	2016/1/1-2020/6/18	4	26	30
BPCEGP	2016/1/1-2020/6/18	2	12	14
C	2016/1/1-2020/6/18	1	13	14
CMZB	2016/1/1-2020/6/18	1	9	10
DANBNK	2016/1/1-2020/6/18	1	3	4
DEVOBA	2016/1/1-2020/6/18	1	2	3
DLR	2016/4/12-2020/6/18	3	2	5
DNBNO	2016/1/1-2020/6/18	1	13	14
EDF	2016/1/1-2020/6/18	2	12	14
EDPPL	2016/1/1-2020/6/18	2	8	10
ENBW	2016/1/1-2020/6/18	1	3	4
ENELIM	2016/1/1-2020/6/18	3	10	13
ENGIFP	2016/1/1-2020/6/18	7	9	16
EOANGR	2017/5/17-2020/6/18	3	9	12
ESBIRE	2016/1/1-2020/6/18	1	4	5
FERROV	2016/1/1-2020/6/18	1	3	4
FRLBP	2017/10/6-2020/6/18	1	1	2

FRPTT	2016/1/1-2020/6/18	1	6	7
HERIM	2016/1/1-2020/6/18	2	1	3
HSBC	2016/1/1-2020/6/18	2	13	15
IBESM	2016/1/1-2020/6/18	6	7	13
IGYGY	2016/1/1-2020/6/18	1	7	8
INTNED	2016/1/1-2020/6/18	2	17	19
ISPIM	2016/1/1-2020/6/18	1	12	13
KBCBB	2016/4/21-2020/6/18	1	7	8
LBBW	2016/1/1-2020/6/18	3	3	6
LPTY	2016/5/19-2020/6/18	1	7	8
MIZUHO	2016/10/12-2020/6/18	1	7	8
MUFG	2016/1/1-2020/6/18	3	2	5
NDASS	2016/1/1-2020/6/18	2	8	10
NTGYSM	2016/1/1-2020/6/18	1	6	7
OPBANK	2016/1/1-2020/6/18	1	7	8
ORSTED	2016/1/1-2020/6/18	1	1	2
PLD	2016/1/1-2020/6/18	1	8	9
RABOBK	2016/1/1-2020/6/18	2	12	14
REESM	2016/1/1-2020/6/18	1	3	4
RY	2016/1/1-2020/6/18	1	2	3
SANTAN	2016/1/1-2020/6/18	1	3	4
SEB	2016/1/1-2020/6/18	1	5	6
SHBASS	2016/1/1-2020/6/18	1	7	8
SOCGEN	2016/1/1-2020/6/18	2	9	11
SOCSFH	2016/1/1-2020/6/18	2	14	16
SSELN	2016/1/1-2020/6/18	2	3	5
SUMIBK	2016/1/1-2020/6/18	2	10	12
SWEDA	2016/1/1-2020/6/18	1	5	6
TENN	2016/1/1-2020/6/18	11	3	14
TOYOTA	2016/1/1-2020/6/18	1	9	10
UBIIM	2016/1/1-2020/6/18	1	2	3
VATFAL	2016/1/1-2020/6/18	1	2	3
Total	—	107	414	521

Appendix B. The Hill estimator value γ of green bond and its correponding bond

Table B.1: The Hill estimator value γ of green bond and its correponding bond.

Company	Green Bond Code	Green bond	Synthetic bond
ABNANV	XS1422841202	0.6812	0.4880
	XS1808739459	0.5258	0.5978
	XS1982037696	0.5597	0.6649
ACACB	FR0013465010	0.33511	0.52762
ACAFP	XS2067135421	0.5760	0.6244
	FR0013385515	0.3662	0.1585
BACR	XS1716820029	0.72402	0.52499
BBVASM	XS1820037270	0.2768	0.3719
	XS2013745703	0.3596	0.3161
BNP	XS1808338542	0.5196	0.4511
	FR0013405537	0.5418	0.4620
	FR0013465358	0.6008	0.5095
	XS1527753187	0.5133	0.4845
BPCEGP	FR0013067170	0.6548	0.4348
	FR0013464930	0.4902	0.4530
CMZB	DE000CZ40NG4	0.5200	0.6109
C	XS1939355753	0.1699	0.3854
DANBNK	XS1963849440	0.7241	0.7804
DLR	XS2100663579	0.2574	0.3455
	XS1891174341	0.3303	0.3334
	XS2100664114	0.3919	0.2798
DNBNO	XS1839888754	0.3781	0.4223
EDF	FR0011637586	0.2944	0.6869
	FR0013213295	0.4891	0.5958
EDPPL	XS1893621026	0.5200	0.6309
	XS2053052895	0.6132	0.6421
ENBW	XS1901055472	0.3631	0.4174
ENELIM	XS1550149204	0.6206	0.6088
	XS1750986744	0.6190	0.6570
	XS1937665955	0.6568	0.6523
	FR0013284247	0.5161	0.5653

ENGIFP

	FR0013284254	0.5693	0.6533
	FR0013428489	0.5151	0.6385
	FR0013428513	0.3933	0.4556
	FR0013455813	0.5493	0.6039
	FR0013245867	0.6498	0.7150
	FR0013245859	0.6547	0.6253
EOANGR	XS2047500926	0.4777	0.4974
	XS2047500769	0.4414	0.5533
	XS2103014291	0.3429	0.4097
ESBIRE	XS2009861480	0.4614	0.4141
FERROV	XS1732400319	0.4478	0.3916
FRPTT	FR0013384567	0.6718	0.5560
HSBC	FR0013064755	0.4169	0.3579
	XS1917601582	0.4524	0.6438
IBESM	XS1398476793	0.3469	0.3616
	XS1490726590	0.4354	0.3492
	XS1527758145	0.3705	0.3614
	XS1575444622	0.3977	0.3266
	XS1682538183	0.5336	0.4044
	XS1847692636	0.4945	0.3719
IGYGY	XS1702729275	0.5061	0.3343
INTNED	XS1324217733	0.4228	0.5733
	XS1909186451	0.5259	0.4942
ISPIM	XS1636000561	0.7159	0.7202
KBCBB	BE0002602804	0.4529	0.4318
LBBW	DE000LB1M214	0.2685	0.3989
	DE000LB2CHW4	0.3674	0.4161
	DE000LB2CLH7	0.3479	0.3326
LPTY	XS1960260021	0.8102	0.6039
MIZUHO	XS1691909920	0.3575	0.4571
MUFG	XS1758752635	0.7582	0.5369
	XS1890709774	0.7735	0.5653
	XS2028900087	0.6041	0.4144
NDASS	XS1640493372	0.4603	0.4141
	XS2003499386	0.4910	0.5897

NTGYSM	XS1718393439	0.4768	0.5231
OPBANK	XS1956022716	0.5162	0.5049
PLD	XS2112475509	0.2317	0.3713
RABOBK	XS2068969067	0.6358	0.6819
RABOBK	XS1502438820	0.5383	0.4636
REESM	XS2103013210	0.4715	0.4653
RY	XS1989375412	0.4065	0.5652
SANTAN	XS2063247915	0.4473	0.5206
SEB	XS1567475303	0.4901	0.5014
SHBASS	XS1848875172	0.5062	0.5762
SOCGEN	XS1324923520	0.3775	0.3902
	XS1500337644	0.5140	0.3846
	FR0013434321	0.2558	0.5083
	FR0013481207	0.7191	0.4593
SSELN	XS1676952481	0.3231	0.6561
	XS1875284702	0.3489	0.7250
SUMIBK	XS1694219780	0.6102	0.4664
	XS1998025008	0.7607	0.4702
SWEDA	XS1711933033	0.5177	0.4595
TENN	XS1241581179	0.4804	0.2561
	XS1241581096	0.3134	0.5058
	XS1432384664	0.4317	0.5213
	XS1432384409	0.3491	0.3680
	XS1505568136	0.4576	0.4030
	XS1632897929	0.3787	0.4983
	XS1632897762	0.3975	0.4712
	XS1828037827	0.3733	0.3935
	XS1828037587	0.4213	0.4807
	XS2002491780	0.3435	0.4769
	XS2002491863	0.4216	0.3414
TOYOTA	XS1720639779	0.4163	0.2781
VATFAL	XS2009891479	0.5414	0.3672

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