MSc. Thesis U.S.E.

A Renewed Investigation of the Greenium for Green Bonds and Sustainability-Linked Bonds

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Preface

First and foremost, I would like to acknowledge the help from my supervisor dr. Lisa Sheenan, my gratitude for the guidance and feedback during my thesis process. Also, I want to point out the help with brainstorming and knowledge sharing with my peer students that wrote their thesis on similar topics. Finally, I would like to thank my girlfriend for her mental support, and for always listening to my considerations during the writing process of this thesis. During this process, I have learned a lot about how research on financial markets is done, about the concept of climate bonds, sustainable finance and legislation issues regarding this topic. It was a very educational and rewarding experience and at the same time marks the end of my MSc. Financial Management.

Content

List of abbreviations

Table 1 - Abbreviations

Abbreviation	Meaning
CBs	Conventional Bonds
CO2	Carbon dioxide
ESG	Environmental, Social and corporate Governance
EUGBS	European Green Bond Standards
FE	Fixed Effects
GBs	Green Bonds
GBPs	Green Bond Principles
H1, H2	Hypotheses 1 & 2
KPI	Key Performance Indicators
OLS	Ordinary Least Squares
QQ	Quantile to Quantile
RESET	Ramsey Regression Equation Specification Error Test
SDGs	Sustainable Development Goals
SI	Sustainable Investment
SLBs	Sustainability-Linked Bonds
SLBPs	Sustainability-Linked Bonds Principles
SPTs	Sustainability Performance Targets
SRI	Socially Responsible Investing
VIF	Variance Inflation Factor

Abstract

This thesis investigates whether there is a greenium for Green Bonds (GBs) and Sustainability-Linked Bonds (SLBs), by using a conceptual framework of behavioural economics theory. A sample of 396 GBs, 208 SLBs, and 641 CBs was analysed using four ordinary least squares and four fixed effects regressions. Results show no significant indication of a greenium for GBs but do show evidence for the presence of a greenium for SLBs. This indicates that the greenium for GBs has potentially decayed. On the other hand, the results suggest that because of pro-environmental behaviour or irrational heuristics, investors are accepting a lower yield for SLBs compared to CBs. Due to limitations in both the sampling process and model specification, these results should be interpreted with caution. Further research on the noneconomic motives for investors to invest in GBs and SLBs is necessary to get a better understanding of the causes of these results.

Introduction

This thesis will investigate whether there is a greenium for Green Bonds (GBs) and Sustainability-Linked Bonds (SLBs) relative to Conventional Bonds (CBs). It is necessary to expand on the current literature regarding the potential costs and benefits of using these bonds for investors and issuers to contribute to the improvement of these tools for financing sustainable projects and operations.

In late-2007 a group of Swedish pension funds expressed an interest in investing in climate-related projects. They were inspired by new insights from the 'AR4' report of the Intergovernmental Panel on Climate Change (IPCC) (2007), which directly linked climate change to human action. In 2008, The World Bank issued its first GB (World Bank Group, 2021). Parallel to this, the European Investment Bank had already issued the first 'Climate Awareness Bond' in 2007, which is viewed as the first GB by some sources (Climate Bonds Initiative, 2021; Gianfrate & Peri, 2019; European Investment Bank, 2022). Since their origin, GBs are used as financial debt instruments of which the proceeds must be used for financing projects that promote environmentally sustainable activities.

In the years 2013 and 2014, the GB market grew rapidly, from less than USD5 billion issued in 2012 to more than USD36 billion issued in 2014 (Climate Bonds Initiative, 2015). During this period, corporate and municipal bond issuers started to join development banks in the issuance of GBs. The market expansion of GBs was caused by new developments in the market which brought more attention to investors in three ways. Firstly, World Bank Group President Jim Yong Kim called for a big expansion of the GB market due to United Nations climate summits and negotiations in 2014 and 2015. Secondly, a GB issue of EUR1.4 billion by the French company EDF showed investors the potential of GBs for corporate financing. Thirdly, the Green Bond Principles (GBPs) were introduced by the International Capital Markets Association at this time which were expected to encourage more investors to enter the GB market (World Bank Group, 2014). These principles are a voluntary framework to promote environmental sustainability through global debt capital markets. The GBPs consist of four core components. First of all, the use of proceeds must support a listed category, such as renewable energy or the prevention of pollution. Secondly, the issuer should follow a process of project evaluation and selection to communicate the risk and impacts, but also the eligibility, context, and alignment with green project categories. Thirdly, the issuer must manage the net proceeds of the GB and match them with allocations to eligible green projects while the bond is outstanding. Lastly, the issuers should have updated and readily available information on the use of proceeds reported. As these principles are voluntary, external reviews are recommended to assess the issuers' alignment with the core components (ICMA, 2021). In addition to the GB Principles, also voluntary process guidelines for Social Bonds and Sustainability Bonds were developed by the ICMA. Social Bonds are labelled bonds similar to GBs but the proceeds of these bonds must be used for social outcomes. Sustainability Bonds cover bonds with proceeds directed to a mix of both green and social projects (Climate Bonds Initiative, 2022a). An overview of these four most commonly used labelled bonds is presented in table 2. In this present study, both Social- and Sustainability Bonds will not be included due to scope and time considerations.

Bond label	Green	Social	Sustainability	Sustainability-Linked
Total size of market (cumulative)	USD2.2tn	USD653.6bn	USD682.0bn	USD204.2bn
Description	Dedicated to environmental benefits	Dedicated to social benefits	Green and social benefits combined into one instrument	Changes in coupon (almost always step-ups) linked to performance against entity-level sustainability performance targets (SPTs)

Table 2 - Overview of labelled bonds (Climate Bonds Initiative, 2023)

Further driving the growth of the GB market, were national development banks such as Germany's KfW, France's AFD and the Dutch NWB Bank entering the GB market in 2015 (Climate Bonds Initiative, 2015). Each year since, the market has closed at record all-time highs, except for 2022 in which the volume of GBs dropped by 16% (Climate Bonds Initiative, 2023). This drop was caused by the tightening of the market by the central bank to combat rising inflation, but the market is expected to recover in 2023 (Binnie, 2023).

The Sustainable Development Goals (SDGs), introduced by the UN in 2015, form the basis of a shift towards a more equal and sustainable world. Seventeen goals including the reduction of poverty and hunger, access to medical care and education and the rise of green energy sources are set to be achieved by 2030 (United Nations, 2022). Sustainable investment (SI), a term that indicates sustainable and responsible investment, socially responsible investing (SRI), or environmental, social and corporate governance (ESG) investment, is the fastest-growing area in the mutual fund industry (Utz et al., 2015). Kölbel et al., (2020) suggest that SI is increasingly useful for achieving the SDGs, through shareholder engagement, capital allocation and potentially through other indirect impacts. However, according to the authors, further studies need to investigate the indirect effects of capital allocation and other indirect impact mechanisms as this lacks empirical support.
In addition to the SDGs, the implementation of the 2015 Paris Agreement aims at reducing climate change and requires economic and social transformation. The agreement, adopted by 196 parties at the UN Climate Change Conference in 2015, is a legally binding aim to limit global warming to stay within a 2°C range compared to 'pre-industrial' levels (United Nations, n.d.). To achieve the Paris Agreement, carbon dioxide (CO_2) emissions must decline, thus, increased climate financing towards renewable energy is the least that is needed to avert the worst scenarios of climate change (United Nations, 2022). Fatica & Panzica (2021) suggest that GBs issued after the Paris Agreement lead to a larger reduction in emissions, because of a compelling perception of the need to accelerate the low-carbon transition.

To further understand the demand of investors and benefit for issuers, price and yield premia can be observed to indicate whether GBs are priced differently compared to CBs. Pricing of labelled bonds such as GBs can be observed in both the primary- and secondary markets. In the primary market, the bonds are offered by the issuer to the first buyer, and in the secondary market, investors can trade existing bonds with other investors. According to Zerbib (2019) a small greenium (-2 basis points) for GBs, observed in secondary market data between 2013 and 2017, is not a disincentive for investors to keep investing in GBs because of their pro-environmental preferences. Nanayakkara & Colombage (2019) observe a much larger greenium of -63 basis points in secondary market data from 2016-2017, stating that incentives for both issuers (lower cost of capital) and investors stimulated the growth of the GB market. A commitment to GBs can also be observed in the sustainable debt report by the Climate Bond Initiative (2022) which shows an increasing amount of money being invested in climate bonds up until 2022. At the end of 2021, over USD2.5 trillion of green, social, sustainable, sustainable-linked and transition bonds combined were issued, of which USD1.1 trillion was issued in 2021 itself (a 46% increase compared to 2020). This however, still only represents 3.5% of overall bond issuance, and therefore the GB market needs to grow further in order to achieve the targets in the Paris Agreement (Spinaci, 2022).

Although the GBPs are in place, there is still evidence of issuers abusing GBs for their benefit. Both regulators and investors face "greenwashing" concerns, which is the concept of falsely signalling environmental claims for raising money without a real commitment to sustainability (Flood, 2022). An example of this is the use of GBs for financing a runway at Hong Kong Airport, which raised serious climate- and biodiversity-related risks (Reclaim Finance, 2022). Greenwashing practices have led to doubts about whether the current voluntary principles and guidelines under which GBs can be issued are appropriate. Mittmann and Gao (2022) empirically show that greenwashing is a function of the GBs greenium, stating that if greenwashing exists, GBs have no added value to investors. This is because investors are only willing to pay higher prices for GBs when these can be seen as a valuable signal of a

firm's environmental commitment (Flammer, 2021). In addition, as more awareness is raised regarding greenwashing, more and more companies now tend to keep their climate and sustainability goals undisclosed. This trend of 'green-hushing' was introduced in 2022 by South Pole in their net zero report (2022). The report stated that nearly a quarter of the questioned firms indicated that their sustainability targets were not publicly available. This is a concerning trend as undisclosed sustainability targets are not critically being assessed by the public and if these firms were to issue GBs, they may not comply with the guidelines. Schmittmann and Gao (2022) stress the importance of greenwashing becoming costly by applying strong guidelines, disclosures, fines for false information and validation and screening processes before and after issuance. An article by Mundy in The Financial Times (2022) explains a trend towards enhanced sustainability disclosures and explains the need for standardized sustainability measuring. In the article, the International Sustainability Standards Board (ISSB) expresses their development of a new regulatory system in the form of mandatory climate disclosure, similar to the financial accounting standards. To add, on March 1st 2023, the European Parliament and European Council announced an agreement on the creation of European GB Standards (EUGBS) which ensures that issuers follow strict transparency criteria (Segal, 2023). Although these standards potentially prevent greenwashing, many concerns are raised about whether the standards will be implemented correctly and improve the market size of GBs. One of the stakeholders of these EUGBS who raises concerns is the ICMA, as they argue that due to project complexities or other factors, the European Parliamentary Research Service may not be able to roll out the screen criteria which may hinder the uptake of EUGBS. However, the European Parliament responses to these concerns by stating that the final aim is to incentivise investment in, and further issuance of EUGBs, and takes measures to stimulate deep and liquid market (Spinaci, 2022).

In 2019 the first SLBs were introduced. These bonds are less mature in corporate debt markets compared to GBs and are used for financing predetermined, ambitious sustainability objectives. These objectives are measured using key performance indicators (KPIs) which allow for monitoring the impact of the issuer on themes such as natural capital, energy, climate and biodiversity (Flugge et al, 2021). These impacts are quantified by certain sustainability performance targets (SPTs), which are set by the issuer. According to the voluntary guidelines of the ICMA, the KPIs and SPTs must follow the Sustainability-Linked Bonds Principles (SLBPs). These principles consist of five core components, namely the careful selection of KPIs, well-calibrated and benchmarked SPTs, variable bond characteristics based on the achievement of targets, easily available and clear reporting, and independent and external verification (ICMA, 2020). Although the performance-based structure and SLBPs are put in place to prevent greenwashing, there are concerns about loopholes which issuers of SLBs may abuse. Webb (2022) raises the concern of a potential 'free lunch' as, according to investigations by the Climate Bond Initiative (2022b), the pricing benefits are larger than the step-up penalties in the primary market. This is in line with the findings of Kölbel and Lambillon (2022), who also empirically identify a free lunch as an SLB issue that creates savings averagely higher than the penalties for not achieving sustainability targets. According to Binnie (2023) these loopholes have led to an increased relative appeal for GBs and a decline in SLB issuance in 2022.

Research questions

Studies using data from the secondary market have shown the existence of a greenium in 70% of the studies and an average greenium of -1 to -9 basis points is observed in the past (MacAskill et al., 2021). To address whether issues like greenwashing, green-hushing or other factors have caused the greenium to disappear, this study will follow the question of whether in recent secondary-market data, a greenium exists. Furthermore, this study asks the question of whether a greenium exists for SLBs in the secondary market, as due to the novelty of SLBs this has yet to be studied. The data collection will be specified towards corporate issuers, to narrow down the scope of this topic and to improve comparability with other studies investigating the greenium of corporate issuers in the past (Nanayakkara & Colombage 2019; Flammer, 2021; Immel et al., 2021). Also, the literature review of Cortellini and Panetta (2021) highlights gaps in the literature such as a lack of attention to the US corporate Green Bond market, and a

lack of studies in the Chinese secondary Green Bond market. This study can assist in filling these gaps by using global corporate bond data from the secondary market. Another reason for specifying the scope of this study towards corporate issuers is because of the assumption that corporate issuers are more likely to exploit GBs for greenwashing practises. This assumption is based on the idea that public sector entities have longer investment horizons and have to do good for the public, which makes them less likely to exploit greenwashing practises (Baker McKenzie & IFLR, 2019). To further expand the scarcely available literature on SLBs, this study also aims to explore potential explanations for the difference in the greenium between GBs and SLBs.

Does a greenium exist for green bonds in the secondary market for corporate issuers in recent data?
Does a greenium exist for SLBs in the secondary market for corporate issuers?

Insights gained from this study can inform policymakers, issuers, investors and other stakeholders about the potential benefits and drawbacks of using GBs and SLBs. Policymakers can use insights gained from this thesis to develop preventive measures regarding greenwashing practices and further assess the usefulness of GBs and SLBs for achieving the SDGs and reducing CO2 emissions. Chang et al., (2022) stress the importance of authorities paying close attention when implementing green finance such as GBs, as the relationship between green finance and environmental quality varies across countries.

By observing whether a greenium for GBs and SLBs is present in recent data, issuers can utilize this information when choosing a financing method for sustainable projects. Likewise as described by Nanayakkara & Colombage, (2019) the presence of a greenium for GBs or SLBs allows for a lower cost of capital for issuers when compared to CBs. Moreover, further exploring the field of GBs can benefit society as a whole, because of potential positive environmental or climate effects. More specifically, the proceeds of these bonds help mitigate climate change through a reduction in CO2 emissions and an increase in environmentally friendly activities (Fatica & Panzica, 2021).

For investors, it is relevant to be aware of whether GBs and SLBs are traded at a higher price compared to CBs in recent years. This information can inform them when choosing between different financial instruments. Investors may prefer CBs if a greenium for GBs is still present, or may choose to buy SLBs if the greenium for SLBs is not significantly higher than for GBs. Furthermore, according to Tang & Zhang (2020), impact investors become attracted to buying stocks of companies after they have announced GB issuance. Announcements generally lead to positive stock returns and improved liquidity, positive media exposure and increased institutional ownership. Thus, knowing whether GBs and SLBs allow for a lower cost of capital (in the case of a greenium) may incentivize investors to buy stocks of companies which are likely to issue such bonds.

This study contributes to the existing literature by further investigating whether the greenium that investors are willing to pay for GBs (greenium) persists in recent market data and whether this phenomenon can also be observed for SLBs. Furthermore, this thesis will compare the two types of bonds in terms of their guidelines, legislation and greenwashing practices. This thesis continues with the conceptual framework, which consists of a combination of traditional financial theory and behavioural economics theory and attempts to conceptualise rational and irrational incentives for investors to invest in GBs and SLBs. The literature review further describes the existing literature on the greenium and finds a consensus of a greenium, but also highlights greenwashing practises and potential loopholes exploited by SLB issuers. The literature review is followed by the methodology for the empirical analysis which describes how the data was obtained and analysed. The results section will present the outcomes of the analysis, showing that for GBs no significant greenium was found and that for SLBs a large significant greenium was found, when clustering currencies using a fixed effect method. The results are further addressed and discussed in the discussion and limitation sections, which highlight the limitations caused by sampling and model specification errors and biases. This study will end by explaining the implications and conclusion of this research.

Literature

Conceptual framework

If a greenium exists for GBs and SLBs, this would indicate that the traditional models like the Capital Asset Pricing Model (CAPM) and the Modern Portfolio Theory (MPT), with the assumption of rational investors and maximized returns, break down. The CAPM model is a model used to calculate the expected rate of return based on a linear relationship between risk and return. The MPT is a theory used to select an optimally diversified portfolio in order to maximize returns. Both CAPM and MPT assume that investors behave rational, are risk-averse and seek satisfaction from maximized return on investment (Kenton, 2023; Markowitz, 1952). The CAPM could indicate that for certain risk levels, GBs will give a certain rate of returns, and the MPT could indicate that GBs can be used to diversify portfolios. The CAPM and MPT will however not be used, as the assumptions for those models do not hold in the case of a greenium.

If there is a greenium, the price that investors are willing to pay for the same risk is higher for these bonds when compared to otherwise identical CBs. As this study builds on the general consensus found by MacAskill et al. (2021) that a greenium exists, the behavioural economics theory will be used. Behavioural economics theory is preferred in the case of a greenium, as it indicates non-self-interested investments or investments made with bounded rationality. The theory will be used to indicate investors' decision-making process as irrational or outside of their individual interests. To build a framework using this theory, the concept of irrational heuristics caused by errors and biases in decision-making is used. This theory by Kahneman and Tversky (1981) considers emotive factors to affect decision behaviour, and therefore cause irrational decisions. One of the key elements influencing these emotive factors is the framing effect, which causes individuals to choose positively framed options over negatively framed options. Also, herding bias causes individuals to make irrational decisions. This bias suggests that individuals tend to mimic others, even if others are also making irrational decisions (Altman, 2012). In the context of GBs and SLBs, the framing and herding effect can cause these instruments to be irrationally chosen over CBs. This is because GBs and SLBs are positively presented to benefit the environment, and therefore framed positively. Although framed positively, in the case of greenwashing there is no direct benefit to the environment. Herding behaviour can also cause investors to make irrational decisions, as mimicking other investors that buy GBs or SLBs does not mean that this is the preferred choice from a self-interested perspective. Furthermore, as suggested by Zerbib (2019) a greenium for GBs would indicate the pro-environmental preferences of investors. Although potentially driven by underlying factors, pro-environmental behaviour will be used as a concept to indicate investors are consciously willing to pay a greenium for assets benefitting the environment. In this case, the choice for paying a greenium is rational, as investing in environmentally friendly assets would benefit the investor in the long term. Rationally choosing to pay a higher price for GBs or SLBs only holds under the assumption of no greenwashing. MacAskill et al., (2021) reflect critically on the theory used in the existing literature on the greenium and suggest the approach of adding environmental preferences as an addition over conventional pricing theory. This should be done by considering noneconomic motives such as environmental preferences for investors and socially responsible investing. These can be considered important driving factors for rationalised purchasing decisions, even at greater costs. MacAskill et al., (2021) therefore suggest that academia should consider these noneconomic motives of investors when explaining the existence of a greenium. In case of the absence of a greenium, investors are assumed to behave rationally according to the classical theories and have become aware of greenwashing practices. An overview of the conceptual framework is presented in Figure 1.

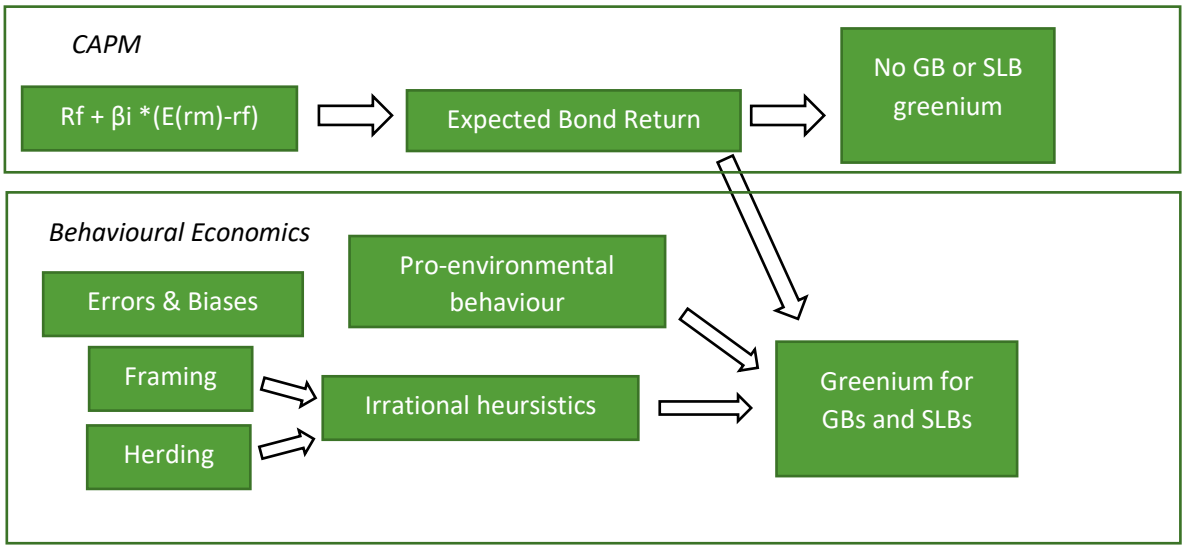

Figure 1 - Conceptual framework

Literature review

According to Gianfrate & Peri (2019), GBs are widely assumed to be one of the key instruments to finance projects and activities that contribute to the temperature goal of the Paris Agreement. This assumption has been assessed by Fatica & Panzica (2021) and Chang et al., (2022). Fatica & Panzica (2021) investigate the association between GB issuances and companies' environmental performance by matching bond data with issuer data. Results show that GB issuers display decreased carbon intensity of their assets. When bonds used for refinancing were excluded, these results were more pronounced, indicating a direct effect of climate-friendly activities reducing CO2 emissions by issuing GBs. In addition, a larger reduction of emissions was found for GBs which have been externally reviewed. Chang et al., (2022) assess the effect of green finance on green technology innovation using a Quantile-on-Quantile method in 10 European countries. This method allows time-series investigation in each selected nation individually, to observe the country-specific and global effect of the variables. Results show that green financing improves environmental quality in 8 out of 10 selected economies. Besides the key role in financing sustainable development for issuers, the issuance of a GB is also beneficial for the firm's shareholders. An empirical study on the announcement return and real effects of GB issuance between 2007 and 2017 shows positive stock returns for existing shareholders (Tang & Zhang, 2020).

An incentive for issuers to issue GBs is the greenium, which allows for cheaper financing than CBs if this greenium is higher than the extra transaction cost for issuing a GB. Several studies investigate the motives for SI, and the effect of pro-environmental preferences and socially responsible investing on the greenium in recent years (Bachelet et al., 2019; Zerbib, 2019; Gianfrate & Peri, 2019; Larcker & Watts, 2020; Kanamura,2020; Diaz & Escribano, 2021; Flammer, 2021; Fatica et al., 2021; Immel et al., 2021). Some of them find evidence for a greenium, while others find controversial results or no evidence. A literature review by Cortellini and Panetta (2021), which summarizes 14 articles aiming to identify a greenium conducted between 2016 and 2020, shows that 63.3% of the studies conducted in the secondary market segment show evidence for a greenium.

The most common method for estimating the greenium in the past is the matching method. This method compares the yield of GBs to otherwise identically (synthetic) CBs. Bachelet et al. (2019) use this method by matching GBs and CBs from the same issuer, and by creating synthetic bonds by linearly combining two other unmatched bonds. They find that GBs may only enjoy a negative greenium in the case of institutional issuers or green verification, highlighting the importance of reducing the information asymmetry between issuers and investors. By matching data from 110 GBs issued between July 2013 and

December 2017 to otherwise identical CBs, Zerbib (2019) estimate the difference in yield returns of these bonds. The results suggest evidence for an averagely lower yield for GBs, namely -2 basis points, but a greater negative greenium for financial and low-rated bonds. By also matching GBs to similar CBs in the same period, Flammer (2021) suggests evidence for the effectiveness of issuing corporate GBs. The article uses a conceptual framework to address potential rationales for issuing corporate GBs and investigates the stock price reaction as a result of the announcement of the issuance of a GB. As CB issue announcements show no significant reactions on the stock markets, stock market reaction after the announcement of issuing a GB is likely resulting from the company's signal of commitment to the environment, as similarly suggested by Tang & Zhang (2020).
An empirical study on the pricing of GBs by Fatica et al., (2021) shows that only some GBs contain a greenium and that for financial institutions this greenium is absent. This is suggested to be caused by investors not being able to identify a clear link between GB issuance by a financial institution and specific green investment projects. To add, Diaz & Escribano (2021) describe the sustainability greenium in energy bonds by comparing green energy companies' bonds against non-green energy bonds, which is 77 basis points on average. This is observed from data from the US Corporate bond market between 2005 and 2014. The study also shows that high-rated bonds have a lower greenium than low-rated risky bonds.

With the rapid growth of the GBs market over the last few years and the potentially lower cost of capital due to the greenium, further growth of the market could be assumed. However, there are also studies showing evidence that this greenium is not present or decaying over time. In contrast to other studies, Larcker & Watts, (2020) suggest that there is no strong evidence for a greenium. This empirical method uses matched green and non-green municipal bonds. It may indicate the difference between markets, as the municipal securities market is considered institutionally different from other asset classes. The article further suggests that greenwashing is not considered a potential cause for the absence of a greenium. A study by Gianfrate & Peri, (2019) on European bonds issued between 2013 and 2017 indicates savings for issuers of 15-21 basis points due to the strong demand of investors for GBs. However, this study also shows a convergence in yield towards similar CB due to a surging supply of GBs, indicating a decaying of the greenium. In addition, Kanamura (2020) examines the performance of GBs over CBs, looking at the expected return, risk and performance ratio of GB premia. The results show that although the investment performance of GBs is superior over CBs, this effect is decaying over time. How the greenium has developed in recent years remains unclear in current literature, as the most recent study that was found analyses market data up until the beginning of 2021 (Baldi & Pandimiglio, 2022).

With the issuance of GBs receiving superior demand from investors, the practice of "greenwashing" (making unsubstantiated or misleading claims about the company's environmental commitment) is a risk (Flammer, 2021). Baldi & Pandimiglio (2022) empirically show that the return on GBs is influenced by the easiness of greenwashing practices. Therefore, likewise to Schmittmann & Gao (2022) and Mundy (2022), Baldi & Pandimiglio suggest that information asymmetry between investors and issuers should be diminished and that policymakers should put more effort into detecting greenwashing practices.

Because of the novelty of SLBs, academic research on this instrument is still scarce. Vulturius et al. (2022) describe the instrument as a new performance-based model to complement the GB's use-of-proceeds model. SLBs are different from other labelled debt instruments because the proceeds are not required to be invested in sustainability projects, but the cost of capital changes according to sustainable performance. Depending on whether sustainability targets are achieved, adjustments in the bond characteristics can take place such as coupon ratchets or increased redemption prices. Furthermore, Vulturius et al. (2022) describe that although SLBs have the potential to encourage investments in zero-emission activities, multiple issues should be concerned for. These issues consist of the credibility and shared understanding of climate targets and whether issuers receive a lower cost of capital when issuing SLBs.

Two other papers on SLBs, published by the Swiss Finance Institute, investigate the performance structure and pricing of SLBs. The first study develops a framework for the incentive structure and pricing of SLBs and proposes a measure of mispricing which allows for studying wealth transfers with SLB issuance. Using this measure and the conceptual framework, the study finds that the industry generally overstates the benefit of yield discount for SLB issuers (Berrada et al., 2022). The second study by Kölbel and Lambillon (2022) empirically investigates whether SLBs are priced at a greenium compared to CBs. In total, 145 bonds were matched with data up until June 2022 which shows a statistically significant greenium of -21.5 basis points when controlling for differences in credit risk and interest rates. For 2021, the unconditional greenium for SLBs was -31 basis points, but for 2022 no significant greenium was found, indicating variation over time. Also, this study conducts a cost-benefit analysis which suggests that the average SLB issue creates savings of USD7.1 million, and the average penalty for failing to reach the target is USD4.1 million resulting in a 'free lunch' of USD3 million regardless of whether sustainability targets are achieved. Because this greenium is observed in the primary market, Kölbel and Lambillon suggest future research to also observe price movements in the secondary market.

Haq and Doumbia (2022) criticize SLBs by identifying two other loopholes. The structure of existing SLBs allows issuers to weaken the link between sustainability and financial outcomes, which expands on the 'free lunch' loophole as described by Kölbel and Lambillon (2022). According to the working paper, issuers minimize potential penalties in SLBs with a 'coupon step-up' structure by choosing late target dates. In this way, the amount of interest payments that will be increased in value due to the step-up is minimized. Also, issuers exploit call options to potentially minimize penalties by setting the first call date close to the target date. Because of this, the credibility of SLBs is threatened, which may result in a reduced demand of investors and thus a low or non-present greenium. The working paper suggests further research is needed to document the pricing response to various structural aspects of SLBs.

A multitude of literature already investigates the existence of a greenium, and a consensus on a greenium in various timeframes and markets is identified by the literature review of MacAskill et al. (2021) and Cortellini and Panetta (2021). However, the concept of the greenium is time-varying and dependent on multiple factors. These factors include; the method used to calculate the greenium, the way the greenium is defined (size-effect type) and whether data from the primary or the secondary market is used. This raises the necessity to continuously update the status of the GB greenium across markets and to identify the most effective methodologies and definitions for the greenium. Furthermore, some studies use complex analysing methods, use different methods of data sampling or observe the greenium in different markets or time frames, which causes methodological heterogeneity across studies (MacAskill et al., 2021). Due to this heterogeneity of the literature, not all studies are easily interpretable and comparable. Existing studies also vary in terms of what factors are defined for driving the demand for GBs, and how they attach and frame financial and behavioural economic theory to the existence of a GB greenium. Therefore, this study aims to investigate the driving factors which have been proposed in the past, and attach them to the behavioural economic theory of Kahneman and Tversky (1981). The general conclusion of the literature reviews of MacAskill et al. (2021) and Cortellini and Panetta (2021) is the consensus of a greenium in the market between 2007 and 2021 for both the primary and the secondary market, of which the latter is more pronounced. Also, although a multitude of research has investigated the greenium, multiple research gaps remain regarding understudied market segments and further identification of the greenium determinants.

This study aims to add new insights to the existing literature by investigating whether the greenium persists in more recent data, or if this greenium decays as the GB market is maturing. Due to the rapidly evolving nature of the GB market, and the contradicting results of past studies, re-estimating the greenium is highly relevant. Because of the methodological heterogeneity in existing literature, this study aims to further reveal the benefits and pitfalls of using an OLS regression method for estimating the GB and SLB greenium. Also, the greenium will be conceptualized based on noneconomic drivers such as

environmental preferences and social factors in the context of behavioural economics theory as proposed by the literature review of MacAskill et al. (2021). Because of the still scarcely present academic literature on SLBs, this study will add to it by empirically analysing their greenium compared to CBs on the secondary market. Finally, by assessing the yield difference of both GBs and SLBs this study aims to investigate how the greenium differs between GBs and SLBs and discuss what could be potential causes based on the conceptual framework.

Hypotheses

The first hypothesis of this study is that the greenium has broken down in recent years (between 2020 and 2023). As suggested by Schmittmann & Gao (2022), Mundy (2022), and Baldi & Pandimiglio (2022), the lack of a strict regulatory system will cause greenwashing to remain unpunished which potentially leads investors to not be convinced of the environmental commitment of the issuer. This may result in GBs having no additional value to investors, and thus no existence of a greenium. Reasons other than greenwashing practises may also influence the absence of a greenium. Since the volume of GBs issued in 2022 dropped by 16%, excess supply is not likely to cause the disappearance of the greenium in this timeframe (Climate Bonds Initiative, 2023).

H1: There is no significant existence of a greenium on the secondary market in recent data.

The second hypothesis for this study is that for SLBs in the secondary market, no greenium exists. This is argued as the loopholes as described by Haq and Doumbia (2022) and the 'free lunch' as described by Kölbel and Lambillon (2022) will cause a loss in investor demand. This hypothesis assumes that investors are fully informed and not influenced by errors and biases. Furthermore, Kölbel and Lambillon showed no significant greenium for SLBs issued in 2022 on the primary market, indicating that in the most recent analysed data, investors are not willing to pay a higher price for SLBs compared to CBs. This is also in line with suggestions made by a Reuters news post which states that investors are doubting the immaterial KPI targets and small penalties for not achieving the targets (Binnie, 2023).

H2: There is no significant existence of a greenium for SLBs on the secondary market.

Methodology

Data

Bond-level data from corporate issuers on the secondary market was acquired from FactSet, for which limited access was granted via Utrecht University. The population of bonds was reduced to secondary market data of GB transactions from January 2020 until May 2023, as this is an understudied timeframe for the greenium. To uniformly identify the greenium in SLBs the sample for these bonds was drawn from the same population of corporate bonds in the secondary market. A sample size of at least 60 bonds of each type was needed, as in past literature this was the lowest amount of bonds used to significantly estimate a greenium (Cortellini and Panetta, 2021). Filters were put in place to create a dataset with complete and relevant information. This was done by dropping bonds which have unusual characteristics or missing data, similar to the method used by Immel et al. (2021), resulting in a sufficiently large dataset of n=1,269 bonds. The selection process is further explained in Appendix 1 and step by step presented in Table 7 in Appendix 1.

Empirical strategy

After the data was acquired and reduced to a sample size of n=1,269, the dataset was analysed using Stata/IC 16.1, in order to get estimates for the greenium of GBs and SLBs. For this, ordinary least squares (OLS) regressions, various robustness tests and Fixed Effect (FE) regression were run.

In the majority of existing literature on the GB greenium, bond-level data is analysed using a matching technique, which matches GBs with otherwise identical CBs (Zerbib, 2019; Bachelet et al. 2019; Flammer, 2021). This study, however, will make use of an OLS regression similar to Immel et al. (2021) and Preclaw & Bakshi (2015). These studies which have used OLS regressions to estimate the greenium in the past, have only done so for different timeframes and markets and were able to get significant results. Using an OLS regression, confounding variables for variation in the spread to U.S. treasury and yield to maturity can be identified and controlled for, resulting in an interpretable estimate for a greenium as an effect of the GB or SLB label. By applying the OLS method in this study, it can be further explored as a tool to estimate the GB and SLB greenium in the future, and outcomes can be compared with premia estimated using the OLS method in the past. Furthermore, by using the bond spread to U.S. treasury yield in basis points, and the yield to maturity in percentage as dependent variables in multivariate regression models, these two outcome measures can be evaluated to describe the greenium for the secondary market for corporate bonds. Another reason for choosing an OLS regression over the matching technique is the time restriction of this thesis.

The models that were used for the OLS regression to estimate the greenium consist of two models which compare GBs to CBs and two models which compare SLBs to CBs. When running models 1 and 2, the SLB observations were dropped, and vice versa for models 3 and 4. To observe the greenium in two different ways, both the yield spread (models 1 and 3) and the credit spread (models 2 and 4) were analysed. For the yield spread, yield to maturity in percentage was used as the dependent variable and for the credit spread, the spread compared to the U.S. treasury yield in basis points was used. A dummy variable which takes on the value 1 if a bond is a GB or SLB, and the value 0 if the bond is a CB, was added as the main independent variable. Observing its coefficient and p-value indicates the size and significance of the greenium. Control variables for bond characteristics were included in the regressions, which are listed in Table 3. Figure 2 in Appendix 2 shows the plotted histograms to check whether the variables were normally distributed. The amount outstanding and years to maturity showed positively skewed distributions, as these variables cannot take negative values. Therefore, “amount out” and “years to maturity” were transformed to a logarithmic scale to give them a more symmetric normal distribution.

MODEL 1:

$$YieldtoMaturity_i = \beta_0 + \beta_1 GreenBondFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 Forreigncurrency_i + \beta_6 CallFlag_i + \beta_7 Creditrating_i + e_i$$

MODEL 2:

$$SpreadTSYBP_i = \beta_0 + \beta_1 GreenBondFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 Forreigncurrency_i + \beta_6 CallFlag_i + \beta_7 Creditrating_i + e_i$$

MODEL 3:

$$YieldtoMaturity_i = \beta_0 + \beta_1 SustainabilityLinkedFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 Forreigncurrency_i + \beta_6 CallFlag_i + \beta_7 Creditrating_i + e_i$$

MODEL 4:

$$SpreadTSYBP_i = \beta_0 + \beta_1 SustainabilityLinkedFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 Forreigncurrency_i + \beta_6 CallFlag_i + \beta_7 Creditrating_i + e_i$$

To verify whether the coefficients of these multivariate models show unbiased estimates, the assumptions of the OLS model were tested using various statistical tests. To test for heteroskedasticity, a Breusch Pagan test was performed. To account for multicollinearity, the correlation between the independent variables was measured using a variance inflation factor (VIF) analysis. To test whether the residuals are normally distributed they were visually inspected using QQ-plots and histograms. After the OLS regressions, the residuals are plotted against each independent variable using scatter plots, to check the linearity of the model. Finally, to test whether the model is specified correctly, a Ramsey Regression Equation Specification Error Test (RESET) was run. To deal with potentially missing confounding variables, FE regressions were run to re-estimate the models. Since the dataset consists of one wave of cross-

sectional data, the FE regression models must make use of a group variable to make clusters. Currency was used as a group variable to cluster the observations into 11 groups. In this way, the variation within the clusters was estimated. Using currency clusters, unavailable variables such as the difference in market conditions between currencies were controlled for. The control dummy variable foreign currency flag was excluded in the FE regression as by clustering the currencies this was already controlled for. Models 5 to 8 show the FE regression models. The estimator u_i was added as a within-cluster error term. The β coefficients estimate the common effect across currencies controlling for the currency heterogeneity.

MODEL 5:

$$YieldtoMaturityi = \beta_0 + \beta_1 GreenBondFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 CallFlag_i + \beta_6 Creditrating_i + u_i + e_i$$

MODEL 6:

$$SpreadTSYBPi = \beta_0 + \beta_1 GreenBondFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + + \beta_5 CallFlag_i + \beta_6 Creditrating_i + u_i + e_i$$

MODEL 7:

$$YieldtoMaturityi = \beta_0 + \beta_1 SustainabilityLinkedFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 CallFlag_i + \beta_6 Creditrating_i + u_i + e_i$$

MODEL 8:

$$SpreadTSYBPi = \beta_0 + \beta_1 SustainabilityLinkedFlag_i + \beta_2\, ln(AmountOut)_i + \beta_3 Ln(yearstoMaturity)_i + \beta_4 Coupon_i + \beta_5 CallFlag_i + \beta_6 Creditrating_i + u_i + e_i$$

Variable name	Stata abbreviation	Value options	Description
Amount outstanding	AmountOut	Amount of million USD	Current amount outstanding as of 19/05/2023
Years to maturity	YearstoMaturity	Amount of years	Amount of years to maturity as of 19/05/2023
Yield to maturity	YieldtoMaturity	Percentage of yield	Yield to maturity as of 19/05/2023
Coupon	Coupon	Coupon rate	Coupon rate as a percentage of original issue size
Foreign currency	ForCurrFlag	1 = Foreign 0 = USD	Dummy variable indicating a currency other than USD
Callable	CallFlag	1 = Callable 0 = not	Dummy variable indicating whether a Bond is callable
Spread to U.S. treasury	SpreadTSYBP	Amount of basis points	Spread to U.S. Treasury in basis points
Credit rating	CRating_num	1 = AAA, 2 = AA+, 3 = AA, 4 = AA-, etc.	S&P Credit Rating
GBs	GreenBondFlag	1 = GB 0 = other	Dummy variable indicating Green Bonds
SLBs	SustainabilityLinkedFlag	1 = SLB 0 = other	Dummy variable indicating Sustainability-Linked Bonds
ESG Label	ESGFlag	1 = SLB or GB 0 = CB	Dummy variable indicating ESG labelled Bonds

Table 3 - Variable description

Empirical results

Descriptive statistics

Table 4 gives an overview of the mean value or proportion for the variables that are included in the regression models. On average, SLBs have a higher amount outstanding than GBs and CBs and are callable in 95% of the observations. GBs have a slightly lower average amount outstanding, spread to U.S. treasury and yield to maturity than SLBs and CBs.

	GBs (n=396)	SLBs (n=208)	CBs (n=641)
Amount outstanding (per 1 million USD)	581.4 (335.8)	711.7 (341.8)	627.4 (513.9)
Years to maturity	8.1 (8.7)	7.2 (4.3)	7.2 (7.8)
Yield to maturity (%)	5.0 (2.2)	5.9 (2.3)	6.4 (4.5)
Coupon (%)	2.7 (1.9)	3.5 (2.2)	3.6 (2.3)
Spread to treasury (BPS)	193.2 (196.8)	290.9 (207.5)	306.0 (436.0)
Foreign currency*	239/396 (60.4%)	104/208 (50.0%)	206/641 (32.1%)
Callable*	269/396 (67.9%)	198/208 (95.2%)	517/641 (80.7%)

Table 4 - Descriptives table

*Values are mean (sd) unless otherwise indicated. *Values indicated in frequency and %.*

Figure 2 in Appendix 2 shows the distribution of credit ratings and the currency for each bond separately. For each bond type, the most common credit rating is BBB+, but both low-rated 'junk bonds', as well as highly creditworthy AAA-rated bonds, are represented in the data. For SLBs, the credit ratings are slightly more centred toward an average rating, showing no rating higher than AA or lower than B-. GBs, SLBs and CBs all are mainly denominated in USD and EUR, and about 15% of each bond type is denominated in multiple other currencies.

Robustness

After the OLS regressions were run (table 11, Appendix 6), the Breusch Pagan test was used to test for heteroskedasticity. Results showed that the constant variance was under the 1% significance level (P=0.0000) for all four models (Table 8, Appendix 4). Therefore, robust standard errors are used. The VIF factor does not show evidence of multicollinearity, as the mean VIF is close to 1 for all models (Table 9, Appendix 4). The QQ plots show a fat-tailed distribution, a skewness/kurtosis test rejects the null hypothesis of normality and indicates a skewed distribution. Although the assumption of normality in the residuals is violated, normality is not a strict assumption when the sample is large enough, and is therefore ignored. Transformation of the dependent variable to improve normality is not chosen as this does not show significant improvement, causes the interpretation of the coefficients to be more complex and potentially may even bias the estimates (Schmidt & Finan, 2017). In addition, fat-tailed distributions are a common phenomenon in financial market returns, and therefore it is universally accepted that the Bell-shaped Gaussian distribution is too light-tailed to be an appropriate model for market returns (Haas & Pigorsch, 2009). To test whether extreme values heavily influence the estimates, the outliers and values with high leverage are identified using Cook's distance. After the identification of these values, they are dropped from the dataset and the observations are regressed to get more robust estimates. The inter-quartile range test by Lawrence C. Hamilton (2012), executed for both the regression with and without extreme values shows that removing values with a Cooks distance higher than the 4/n cut-off point does not drastically reduce the number of severe outliers and does not improve normality (Appendix 5). The extreme values are considered natural variations in the data, and thus not considered invalid due to measurement errors or irrelevant for other reasons. Therefore, the estimates of the regression including

extreme values will be interpreted in the following sections. After visual inspection of the scatterplots (Appendix 5) between the residuals and the independent variables for all four models, apart from the fat tails, no clear indication of departure from linearity was found. Finally, a RESET test is conducted to help indicate whether any confounding variables have been omitted. The results of the RESET test show that for each model, there is strong evidence of omitted variables, which indicates a bias in the estimates (Table 10, Appendix 4). The possible omitted variables and their influence will be further discussed in the limitations of this study.

OLS with Robust std. err.	(1) GB Yield to Maturity	(2) GB Spread TSY BP	(3) SLB Yield to Maturity	(4) SLB Spread TSY BP
Green Bond Flag	-0.195 (0.154)	-38.49* (14.98)		
Sustainability Linked Flag			-0.883*** (0.222)	-82.89*** (22.11)
Ln(Amountout)	0.0143 (0.0388)	3.718 (3.797)	0.0202 (0.0419)	3.771 (4.160)
Ln(YearstoMaturity)	-0.332*** (0.0831)	-24.64** (8.324)	-0.336*** (0.0947)	-20.97* (9.942)
Coupon	0.436*** (0.0651)	36.12*** (6.533)	0.339*** (0.0727)	28.53*** (7.345)
Foreign currency Flag	-0.674*** (0.188)	56.00** (18.74)	-0.554* (0.227)	70.41** (22.76)
Call Flag	0.167 (0.170)	2.441 (16.60)	-0.0116 (0.224)	-14.93 (23.02)
Credit rating	0.536*** (0.0662)	56.15*** (6.556)	0.664*** (0.0779)	68.22*** (7.793)
Constant	0.541 (0.490)	-329.7*** (48.80)	-0.191 (0.564)	-407.4*** (56.26)
N	1035	1035	849	849
R^2	0.4520	0.4177	0.4978	0.4627

Table 5 - Regression estimates with robust std. errors for models 1-4

Standard errors presented in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In order to deal with the omitted variable bias, a FE regression for models 5-8 was run in which currency is used as a cluster. In this way, the outcomes are controlled for the difference between currencies (Wooldridge, 2015). Potential confounding variables influenced by the market conditions of different countries are partly controlled for, resulting in less biased results.

Fixed effects (within) Group variable: Currency	(5) GB Yield to Maturity	(6) GB Spread TSY BP	(7) SLB Yield to Maturity	(8) SLB Spread TSY BP
Green Bond Flag	-0.278(0.251)	-41.15(26.15)		
Sustainability Linked Flag			-0.875** (0.206)	-84.92**(23.56)
Ln(Amountout)	0.0224(0.0138)	4.413***(0.717)	0.0354(0.0207)	5.184(2.441)
Ln(YearstoMaturity)	-0.314**(0.0736)	-23.46***(4.122)	-0.303**(0.0933)	-20.96**(5.537)
Coupon	0.380***(0.0594)	36.28***(6.275)	0.315**(0.0894)	29.93**(8.929)
Call Flag	-0.0586(0.289)	-2.131(30.89)	-0.0965(0.232)	-4.444(29.59)
Credit rating	0.560***(0.0497)	56.75***(5.006)	0.675***(0.0510)	68.42***(4.434)
Constant	0.349(0.291)	-312.8***(29.93)	-0.478(0.517)	-405.3***(44.37)
N	1035	1035	849	849
R^2 (within)	0.4077	0.4100	0.4545	0.4555
R^2 (between)	0.5735	0.6632	0.5907	0.5140
R^2 (overall)	0.4419	0.4124	0.4930	0.4551
Model test p-value	0.0000	0.0000	0.0000	0.0000

Table 6 - Regression estimates with currency clusters for models 5-8

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Interpretation

The regression coefficients in Table 5 show that there is no evidence of a greenium in the secondary market data for GBs when estimated using the yield to maturity outcome. For the spread to U.S. treasury (model 2), there is an estimated -38.49 bps greenium with a significance level of 5%. For the SLB models, there is strong evidence of a greenium for both yield to maturity and spread to U.S. treasury, ceteris paribus. For the yield to maturity (model 3), there is a negative greenium of -88.3 basis points, with a significance level of 0.1 %, and similarly a -82.89 bps greenium (0.1% significance) for the spread to U.S. Treasury compared to CBs (model 4), ceteris paribus. However, when interpreting the regression results of the four OLS models with robust standard errors, the model specification error caused by omitted variables and the non-linearity in the residuals which is likely causing biased estimates are ignored. Because of these biases, the interpretations of the regression estimates cannot be assumed to be precise and trustworthy.

Table 6 shows the estimates of the FE regression models. Models 5 and 6 for GBs show no significant indication of a greenium. Models 7 and 8 for SLBs do show significant negative estimates, with a confidence level of 1%, indicating a greenium in the secondary market for corporate issuers of SLBs. Holding all other confounding variables constant, the yield to maturity is 0.875 percentage points (87.5 basis points) lower for SLBs compared to CBs from the same currency, ceteris paribus. The spread to U.S. treasury is 84.9 basis points lower for SLBs than for CBs from the same currency, ceteris paribus. The model test p-value shows the result of an F-test for the whole model. The p-value being lower than 0.001 indicates that all the coefficients in the regression are jointly significantly different from zero, for a 0.1% significance level. This indicates that no greenium was found for GBs but a greenium was found for corporate SLBs in the secondary market in this data. This result may be caused by a reduced interest of investors in GBs, causing the greenium to have broken down in recent data. For SLBs, a greenium is potentially caused by pro-environmental behaviour or irrational heuristics of investors, but this will be further discussed in the concluding remarks of this thesis.

Apart from the effect of the bond being Green or Sustainability Linked, other notable confounding variables show significant estimates for yield to maturity and spread to U.S. treasury in the regression models. The first confounding variable is the coupon payment rate, which shows a strong positive effect for all four models. Secondly, whether a bond is denoted in a foreign currency (other than US Dollar) has a significant negative effect on yield to maturity, but a positive effect on spread to U.S. treasury. Finally, the credit rating shows a significant positive effect on both yield to maturity and spread to U.S. Treasury, meaning that the higher the risk, the higher the yield to maturity and spread to U.S. treasury, holding the other variables constant. Whether a bond is callable and the amount outstanding does not show significant estimates for influencing the yield to maturity or spread to U.S. treasury.

Discussion and Conclusion

Discussion

This study aimed to re-estimate the consensus of a greenium for GBs and SLBs for corporate issuers in the secondary market by looking at data between the 1st of January 2020 and the 19th of May 2023. Results show that whether investors are willing to pay a greenium to invest in GBs remains uncertain, but investors are willing to pay a significant greenium for investment in SLBs compared to CBs.
Compared to the literature reviews of MacAskill et al. (2021) & Cortellini and Panetta, (2021), which both identify a consensus on a greenium in the secondary market, this greenium for GBs was not identified in this study. The results do show estimates in a negative direction similar to the consensus for a GB greenium as identified by MacAskill et al. (2021). However, for GBs, both the OLS and the fixed effects regression do not show significant estimates, meaning there is no convincing evidence for a greenium.

Only for model 2, with the outcome variable spread to U.S. treasury, the estimates that were found show a greenium of 38.5 basis points with a 5% confidence level. However, this outcome estimate is likely to be biased because of the lack of normality and omitted variable bias. Therefore, this study is in line with 18% of the studies analysed by MacAskill et al. (2021) which find no statistically significant greenium for GBs. One of these studies (Flammer, 2021), also investigated the greenium for global corporate issuers in the timeframe 2013 until 2018. This study found no statistically significant indication of a pricing difference for 152 GBs compared to 152 matched CBs. This indicates that potentially, at that time, the greenium was not present for corporate issuers and that this has remained the same in recent times. In case there was a greenium in the GB market prior to 2020, there is an indication that this greenium is decaying, which is in line with the conclusions of Gianfrate & Peri (2019) and Kanamura (2020). This decay is potentially caused by the increased supply of GBs or a loss of interest from investors (Gianfrate & Peri, 2019; Kanamura, 2020).

Compared to Immel et al. (2021), which used a similar method to estimate the greenium, also identify the negative relationship of a bond being labelled as green on the yield. However, the results found by Immel et al. (2021) show a statistical significance (1%) for the greenium of -8 to -13 basis points corporate issuers between 2007 and 2019. This comparison is similar to other studies which found evidence for a greenium. Zerbib et al. (2019), estimated the greenium in a timeframe of 2013-2017 using a matching method and finds a significant greenium of -2 basis points. Besides the greenium, they identify the effect of pro-environmental preferences on the yield differential. The absence of evidence of a greenium for GBs in this study could implicate that in more recent data, this pro-environmental preference has decayed or shifted to other instruments such as SLBs.

The results of the regressions for SLBs, show evidence of a greenium. For both the OLS regressions and the fixed effects regressions, a significant negative yield to maturity and negative spread to U.S. treasury for SLBs compared to CBs is observed. This indicates that investors are accepting lower returns for SLBs compared to CBs. The size of the greenium is 88 basis points for the outcome of yield to maturity and between 83 and 85 basis points for spread to U.S. treasury. This result is in line with the statements made by Berrada et al. (2022) concerning the mispricing of SLBs leading to abnormal price premiums. Furthermore, this study is in line with the evidence of the presence of a greenium for SLBs found by Kölbel and Lambillon (2022). The estimated average greenium of -9 basis points for SLBs found by Kölbel and Lambillon (2022) is however smaller than the greenium of -88 basis points for yield to maturity estimated by this study. The indication of this large greenium for SLBs is remarkable and unexpected when considering the literature concerning the structural loopholes of SLBs. The penalties for not achieving the targets linked to the SLB can be minimized by setting later target dates and having call options prior to the penalties (Haq & Doumbia, 2022). In the sample used for this study, 95% of the SLBs contain a call option, indicating the potential abuse of this loophole. Therefore, a greenium for SLBs indicates that investors are behaving irrationally in case they invest to achieve maximum yield but potentially also in case they invest for environmental benefits. This is possibly due to the concept of irrational heuristics, driven by errors and biases such as the framing and herding effect, as composed by Kahneman and Tversky (1981).

Suggestions for future research

To further investigate the current state of the greenium and provide more evidence of the noneconomic motives for investors to accept a lower yield for GBs and SLBs, both quantitative and qualitative studies are needed. Further quantitative research must re-estimate the GB and SLB greenium in the timeframe of 2020-2023, by making use of other empirical methods, larger datasets and including more explanatory variables. Including interaction terms can be used in future models to see whether differently rated bonds or the change of other bond characteristics have an impact on the relationship between bond yield and the Green or Sustainability-Linked label, likewise to Zerbib (2019) and Diaz & Escribano (2021). Moreover, the method of matching GBs or SLBs with CBs, a more commonly used method to estimate the greenium

in the past, may give more robust results for the size and significance of the greenium in the secondary market for corporate issuers.

Future qualitative studies should attempt to measure the level of awareness of greenwashing practices in the GB and SLB markets and the motives of investors to invest in GBs and SLBs. This could be done by conducting surveys among investors. In this way, the need for certification and credibility of labelled bonds can be highlighted and the noneconomic motives for investing in GBs and SLBs can be further explored.

Implications

First of all, this study was not able to find significant evidence for a greenium for GBs in recent years but did find evidence that a greenium for SLBs exists. This implies that issuers may benefit from a reduced cost of capital when issuing SLBs, but not when issuing GBs. For investors, the absence of a greenium for GBs indicates that GBs are not valued differently compared to CBs and similar yields can be expected. Due to the greenium for SLBs, investors must be willing to accept lower yields when investing in SLBs. Secondly, this study sheds new light on the OLS method of estimating the greenium for green-labelled bonds. A potential benefit of using an OLS or FE regression is that it is a method for which the GBs and SLBs don't have to be matched to (synthetic) CBs. Thirdly, this study makes use of two unconventional outcome variables in which the greenium can be expressed. By using yield to maturity and spread to U.S. treasury as outcome variables, these ways of determining and expressing the greenium for GBs and SLBs compared to CBs can be used in future studies. Also, this study builds on theoretical reasoning as mentioned by MacAskill and colleagues (2022), by applying a behavioural economics theory to conceptualize noneconomic motives and irrational behaviours of investors to explain the greenium phenomenon. Finally, by investigating and identifying the presence of the SLB greenium, this study can inform issuers, regulators and investors of the pricing of this relatively new instrument. The presence of this greenium highlights the benefit for issuers, the price that investors are paying for their environmentally friendly investments and the need for regulation to enhance credibility and reduce the loopholes for issuers to abuse this instrument.

Limitations

This study contains several limitations, which cause reduced comparability with existing literature and which potentially cause biased or faulty results. Firstly, there are several limitations to the data sampling process, which was partly caused by the lack of full access to FactSet databases. During the sampling process, bonds without relevant information available were dropped from the sample. This potentially caused a sampling bias, as observations with missing information were not randomly dropped which could have had a meaningful impact on the outcomes. Also, during the sampling process, the S&P credit rating and currency were manually added to the observations, potentially causing errors to occur. Secondly, there were limitations to the empirical method used to estimate the results of this study. The non-normality of the data and the residuals of the regressions caused one of the assumptions of the OLS method to be violated. Removing outliers and transforming the data to a logarithmic or hyperbolic inverse sinus scale did not solve the issue of normality in most cases. Because of the fat-tailed distribution, as more often seen in financial market data, a one-on-one matching method would be more suited to estimate the greenium (Haas & Pigorsch, 2009). Another limiting factor for comparing this study to other literature is the use of yield to maturity and spread to U.S. treasury instead of more commonly used outcome variables such as current yield. Although this study addresses the research gap in using these outcome variables to determine the greenium, this reduces the comparability of the acquired outcomes with existing estimations for the greenium in the secondary corporate bond market. A further error in the model specification was the absence of certain confounding variables. The absence of potential confounders such as liquidity, volatility, payment rank, certifications and original amount issued caused the estimates to be unreliable. After using a fixed effects regression to control for the differences

between currencies, part of the bias is resolved, however, some of the confounding variables were still missing in the regression. Lastly, a limitation of this study is not taking into account coupon step-up or step-down penalties of SLBs. The consequences of issuers achieving their sustainability targets influence the payoff for investors and therefore may influence the results of the SLB greenium outcome.

Conclusion

In order to achieve the Paris Agreement target of limiting climate change to stay within a 2°C range of pre-industrial levels, GBs and SLBs should be used as key instruments for investment in projects reducing CO2 emissions. This study investigated whether investors are willing to pay a greenium for GBs and SLBs when compared to CBs. Since GBs were first issued in 2007, many studies have investigated the existence and size of the greenium, and although results are mixed, a consensus on the existence of a greenium was found for data up until the beginning of 2021 (MacAskill et al. 2021; Cortellini & Panetta, 2021). Also during the rise of GBs, more and more concerns were raised about the credibility of the instruments due to greenwashing and, more recently, green-hushing practices (Flood, 2022; Mundy, 2022; Southpole, 2022). Following the success of GBs, three other labelled bonds were introduced, being social bonds, sustainability bonds and SLBs. SLBs were also analysed in this study as due to the novelty of this instrument, the greenium for SLB was still an understudied topic in the literature.

Does a greenium exist for green bonds in the secondary market for corporate issuers in recent data?
Results show no significant evidence of a greenium in the secondary corporate bonds market in recent data, indicating that investors are not receiving lower yields for GBs compared to CBs. The absence of a greenium may be a result of the decay of the greenium that was mentioned in earlier studies by Gianfrate & Peri (2019) and Kanamura (2020). A possible explanation is the breaking down of noneconomic motives to buy GBs, as investors are possibly becoming more aware of greenwashing practices.

Does a greenium exist for SLBs in the secondary market for corporate issuers?
For SLBs, a significant greenium was observed in the secondary market for corporate issuers. This indicates a preference of investors for SLBs over CBs, as they are accepting a lower yield for their SLB investments. Corporate firms can benefit from this greenium by receiving a lower cost of capital when issuing SLBs (Haq & Doumbia, 2022). The greenium for SLBs is an indication that investors are behaving irrationally by investing in SLBs because of herding or framing effects or are behaving out of environmental-friendly behaviour and have not yet come aware of the 'free-lunch' issuers of SLBs are possibly abusing.

The two hypotheses for this study were as follows:

H1: There is no significant existence of a greenium on the secondary market in recent data.

H2: There is no significant existence of a greenium for SLBs on the secondary market.

The results of this empirical study show outcomes in line with H1, as there is no significant indication found for the existence of a greenium for GBs in the secondary market for corporate issuers in recent years. As the volume of GBs issued in 2022 dropped compared to 2021, the disappearance of a greenium is most likely due to a decrease in demand, which might be caused by investors becoming aware of greenwashing practices. Further research will have to investigate the noneconomic incentives for investors influencing the greenium. According to the presented results, the second hypothesis suggesting the absence of a greenium for SLBs is rejected. The results show significant evidence for the presence of a greenium for both yield to maturity and spread to U.S. treasury of SLBs when compared to CBs. This indicates that investors are accepting a lower yield for their investments. This outcome suggests that investors behave irrationally because of errors and biases such as the framing and herding effect. Also,

there is the possibility of information asymmetry causing investors to behave out of their own interests. Because of several limitations in the sampling and model specification process, these conclusions are prone to errors and should therefore be interpreted with caution.

A possible explanation for the difference in the greenium of GBs and SLBs is that for GBs, investors have become more aware of greenwashing and green-hushing practices. This could have caused investors who are seeking to invest in environmentally friendly instruments to switch their investments to SLBs. This potentially led to an increased demand for this new instrument, which in turn led to a greenium for SLBs. With this greenium for SLBs, investors are paying a higher price for SLBs because of environmental reasons or irrational heuristics.

With the disrupting consequences of climate change caused by humans, solutions to reduce CO2 emissions and global warming need to be put in place (IPCC, 2007). To achieve the targets set in the Paris Agreement, SI needs to dramatically increase (Spinaci, 2022). A rising tool for both institutional and corporate issuers is the use of climate-labelled bonds, such as GBs and SLBs. Using these tools, issuers can benefit from a reduced cost of capital (in the case of a greenium) and in turn can finance sustainable projects. This study has indicated that there is no significant evidence of the existence of a greenium for GBs, but there is evidence indicating the existence of a greenium for SLBs. Further legislation and certification measures on a global scale are suggested to increase the credibility of these instruments and prevent greenwashing practices for both GBs and SLBs in the future. For this, the EUGBS is the first step in the right direction.

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Appendix

Appendix 1 – Sampling process

Using the screening tool for debt instruments in FactSet, bond-level data from the secondary market was acquired. In the screening tool, selection criteria were used to narrow the initial sample of n=162,283 bonds to the appropriate timeframe and bonds which contain complete information for the relevant variables. In FactSet, "flags" such as the "Green Bond Flag" and "Social Flag" were added as dummy variables which allowed filtering out non-relevant bonds and identifying GBs, CBs and SLBs in the data. First, all the bonds issued by non-corporate issuers were dropped. After this, bonds issued before 01/01/2020 were dropped as well as bonds which had no value for the ESG flag, which indicates that it is uncertain whether it is a conventional bond or an ESG-labelled bond such as GBs and SLBs. After this, the bonds with the issue symbol "@NA" were dropped as these were considered less likely to have an S&P credit rating available and to further reduce the sample size. Also, observations with an unknown outstanding amount or an outstanding amount lower than 1 million or higher than 5 billion USD were removed. As the S&P credit rating could not be added automatically in FactSet due to access restrictions, this was done manually. Therefore, by randomly assigning numbers to each GB and CB observation in Excel, a large portion of the observations was removed. For the sample of n=2,518 that remained, the S&P credit rating was manually added. During this process, the observations with no S&P rating available were removed. The final sample that remained for the empirical analysis was n=1,269, of which 24 observations were removed in Stata due to missing values.

Sample selection	Number of Bonds
Initial amount of Bonds, no filters	162,283
Drop non-corporate issuers	-35,668
Drop Bonds issued before 01/01/2020	-48,109
Drop observation with missing ESG value	-33,911
Drop observations without issue symbol	-8,520
Drop observations with invalid outstanding amount	-10,342
Randomly drop GB and CB observations	-23,218
Drop observations without credit rating available	-1,249
Drop missing obs. and Sustainability bonds in Stata	-24
Final Sample n=1243	208 SLBs
	394 GBs
	641 CBs

Table 7 - Sample selection

Appendix 2 – Descriptives

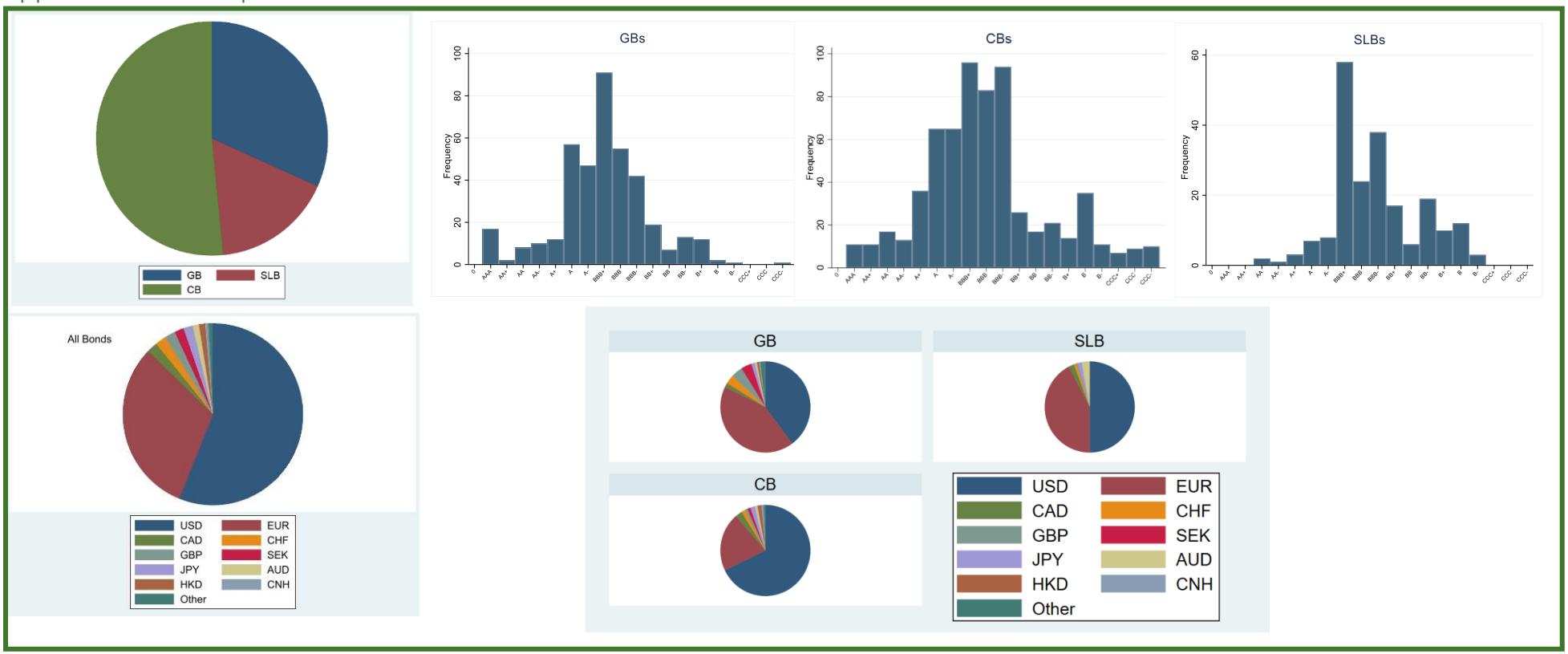


Figure 2 - Descriptives pie graphs and histograms

Appendix 3 – Model specification

Amount outstanding and years to maturity were added to control for the variation in yield to maturity and spread caused by the outstanding amount and time till maturity. The coupon percentage, a dummy for whether the bond is issued in a foreign currency and a dummy for whether the bond is callable were added to account for their influence on the yield and credit spread of a bond. Finally, the S&P credit rating was added to account for the risk level of the bond, and translated to take on ordinal numerical values similar to Immel et al., (2021).

Appendix 4 - Tables robustness tests

Model Ho: Constant variance	1 (GB) Fitted values of YieldtoMaturity	2 (GB) Fitted values of SpreadTSYBP	3 (SLB) Fitted values of YieldtoMaturity	4 (SLB) Fitted values of SpreadTSYBP
chi2(1)	1583.52	2052.05	1339.33	1590.92
Prob > chi2	0.0000	0.0000	0.0000	0.0000

Table 8 - Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

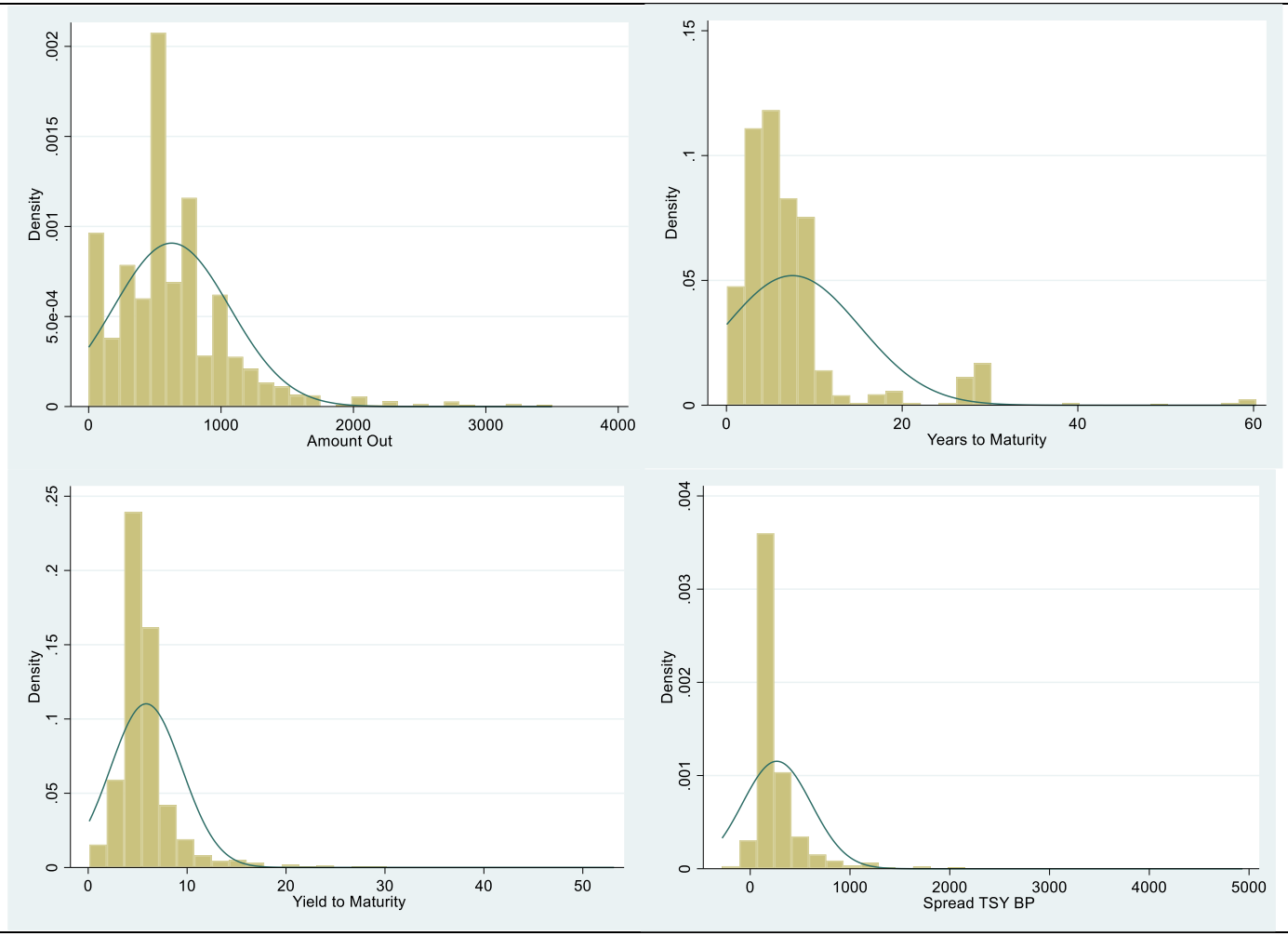
Model	1 (GB)	2 (GB)	3 (SLB)	4 (SLB)
Mean VIF	1.25	1.25	1.28	1.28

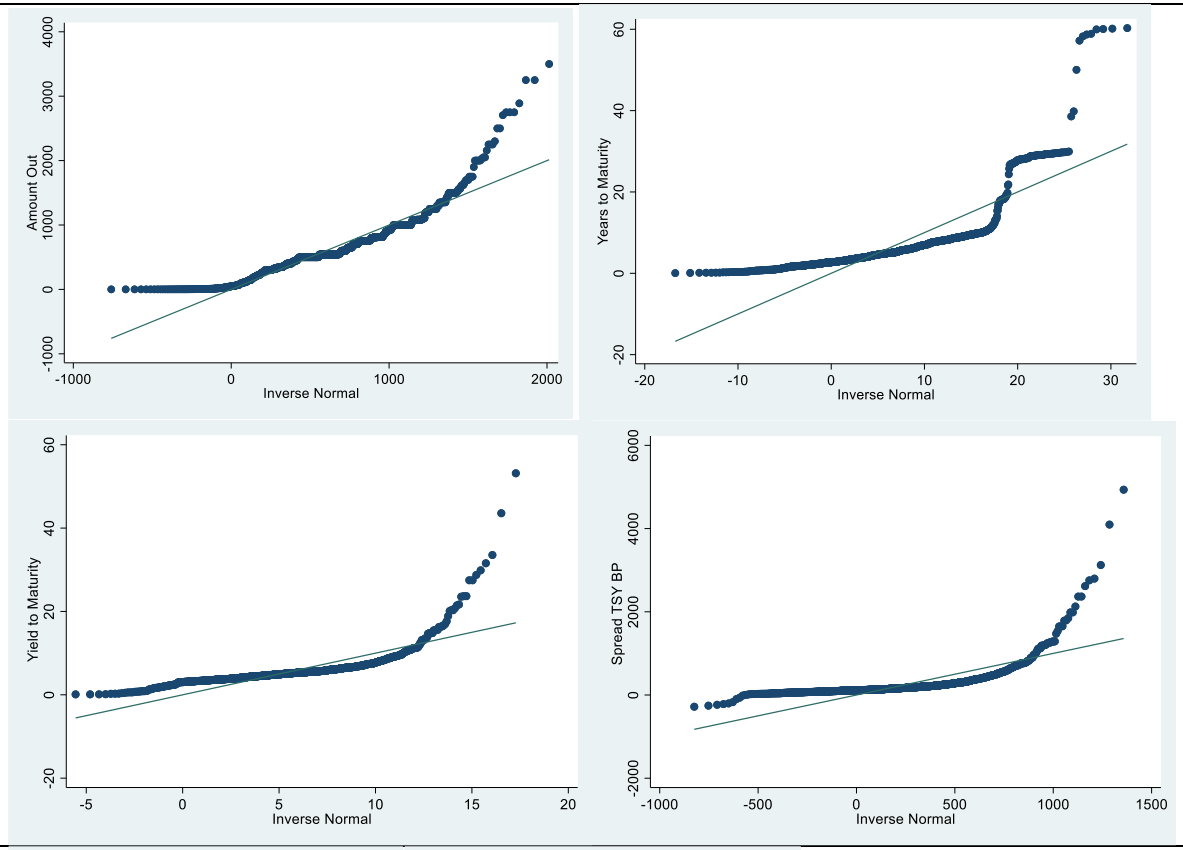
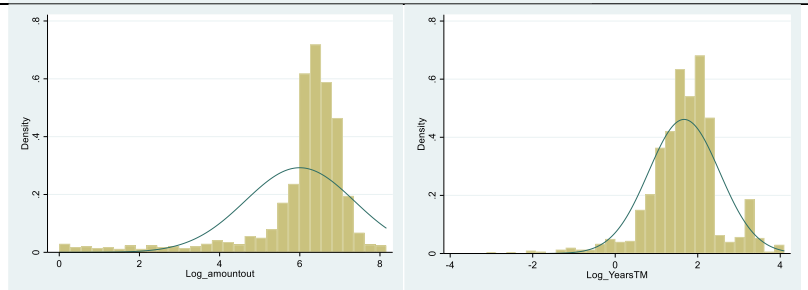
Table 9 - VIF test

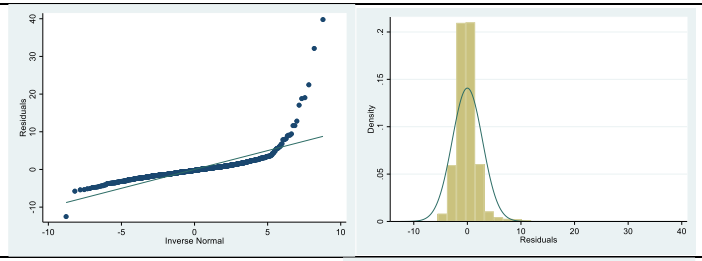
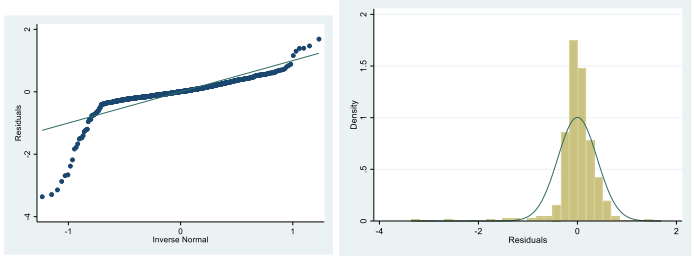
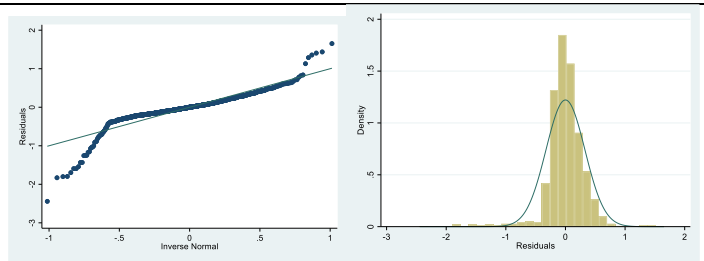
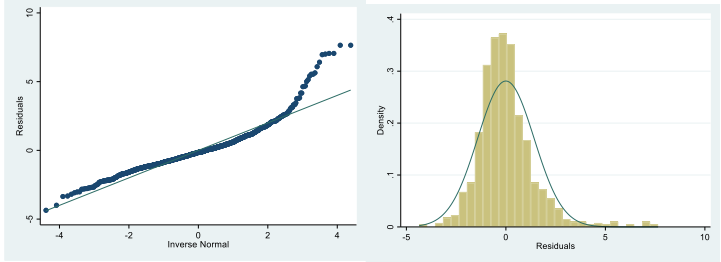
Model Ho: Model has no omitted variables	1 (GB) Fitted values of YieldtoMaturity	2 (GB) Fitted values of SpreadTSYBP	3 (SLB) Fitted values of YieldtoMaturity	4 (SLB) Fitted values of SpreadTSYBP
F(3, 1024)	96.00	158.59		
F(3, 838)			86.35	140.97
Prob > F	0.0000	0.0000	0.0000	0.0000

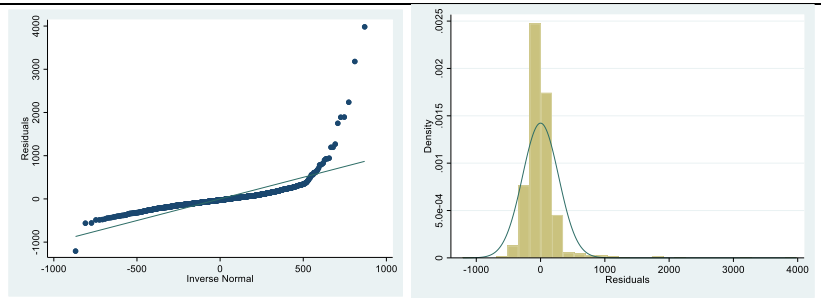
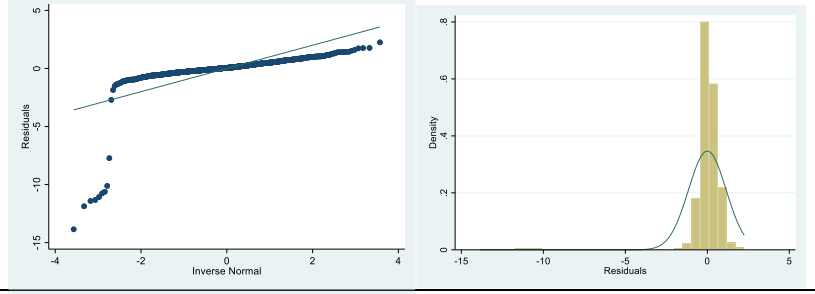
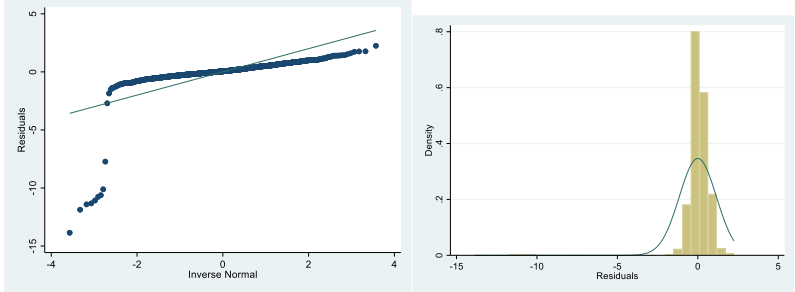
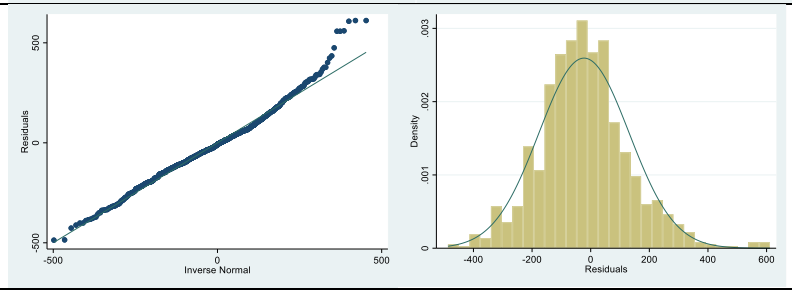
Table 10 - RESET test for model specification errors

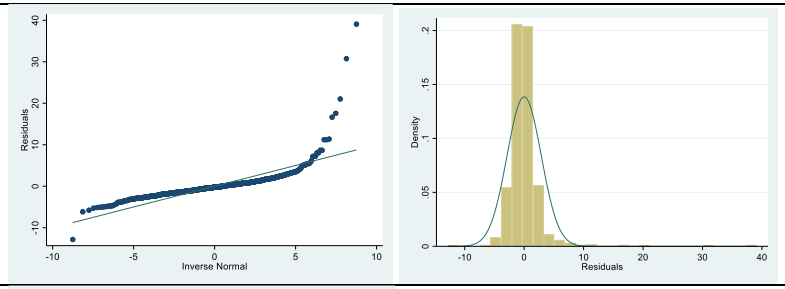
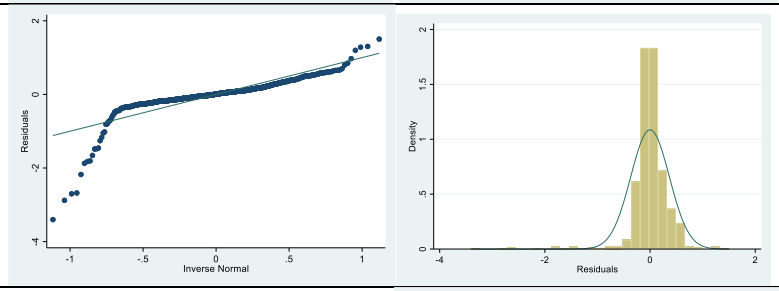
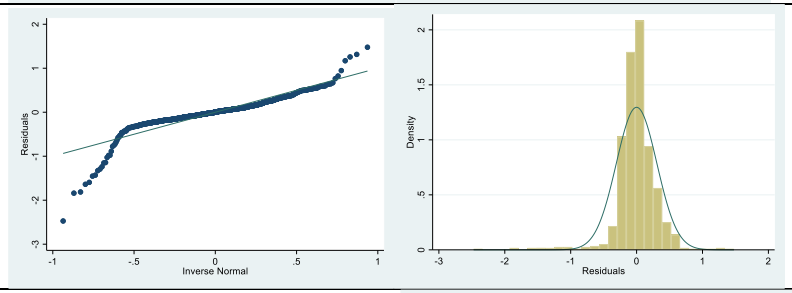
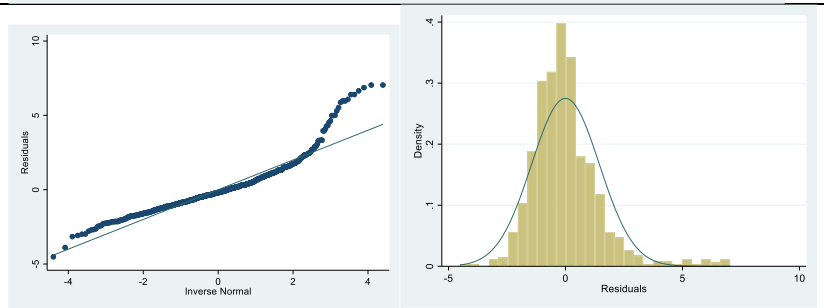
Appendix 5 – Transformations

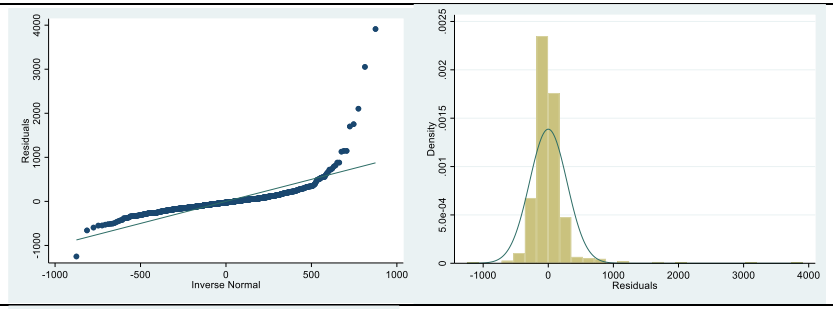
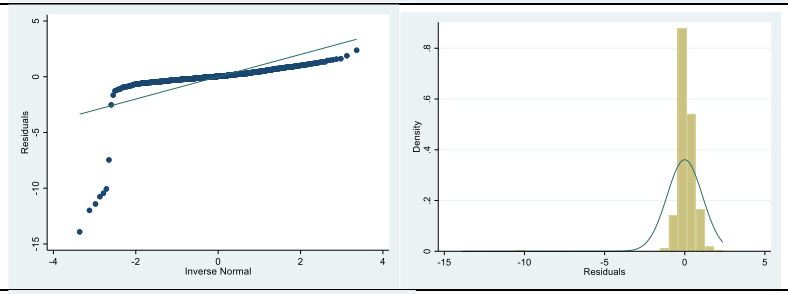
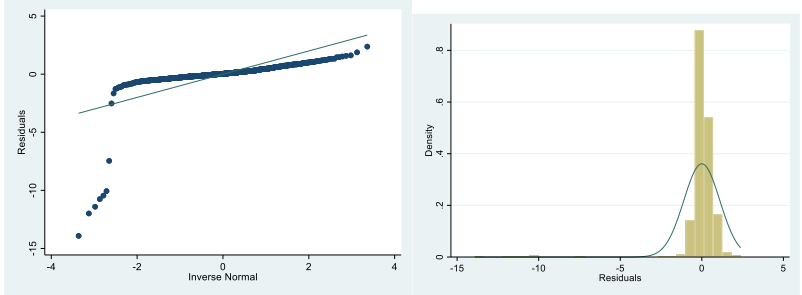
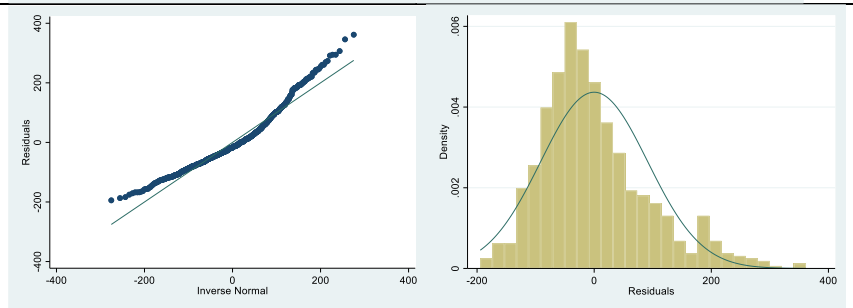
Histograms without transformation	

QQ Plots without transformation	
Amount out and years to maturity after Log transformation	

QQ plot and histogram of residuals of model 1	
QQ plot and histogram of residuals of model 1 – after Log transformation	
QQ plot and histogram of residuals of model 1 – after Hyperbolic inverse sin transformation	
QQ plot and histogram of residuals of model 1 – after removing extreme values	

QQ plot and histogram of residuals of model 2	
QQ plot and histogram of residuals of model 2 – after Log transformation	
QQ plot and histogram of residuals of model 2 – after Hyperbolic inverse sin transformation	
QQ plot and histogram of residuals of model 2 – after removing extreme values	

QQ plot and histogram of residuals of model 3	
QQ plot and histogram of residuals of model 3 – after Log transformation	
QQ plot and histogram of residuals of model 3 – after Hyperbolic inverse sin transformation	
QQ plot and histogram of residuals of model 3 – after removing extreme values	

QQ plot and histogram of residuals of model 4	
QQ plot and histogram of residuals of model 4 – after Log transformation	
QQ plot and histogram of residuals of model 4 – after Hyperbolic inverse sin transformation	
QQ plot and histogram of residuals of model 4 – after removing extreme values	

Model Ho: Residuals normally distributed	1 (GB) Residuals of YieldtoMaturity	2 (GB) Residuals of SpreadTSYBP	3 (SLB) Residuals of YieldtoMaturity	4 (SLB) Residuals of SpreadTSYBP
Observations	1002	1002	821	821
PR(Skewness)	0.0000	0.0000	0.0000	0.0000
Pr(Kurtosis)	0.0000	0.0000	0.0001	0.0000
Joint: Prob > chi2	0.0000	0.0000	0.0000	0.0000

Table 11 - Skewness/Kurtosis test for Normality for regression with extreme values removed

Appendix 6 – Other regression outputs

Model	1 (GB)	2 (GB)	3 (SLB)	4 (SLB)
	Yield to Maturity	Spread TSY BP	Yield to Maturity	Spread TSY BP
Green Bond Flag	-0.195 (0.194)	-38.49* (19.19)		
Sustainability Linked Flag			-0.883*** (0.244)	-82.89*** (24.34)
Ln(Amountout)	0.0143 (0.0628)	3.718 (6.209)	0.0202 (0.0686)	3.771 (6.850)
Ln(YearstoMaturity)	-0.332** (0.104)	-24.64* (10.24)	-0.336** (0.120)	-20.97 (12.03)
Coupon	0.436*** (0.0491)	36.12*** (4.860)	0.339*** (0.0552)	28.53*** (5.511)
Foreign currency Flag	-0.674*** (0.200)	56.00** (19.76)	-0.554* (0.231)	70.41** (23.03)
Call Flag	0.167 (0.234)	2.441 (23.18)	-0.0116 (0.309)	-14.93 (30.88)
Credit rating	0.536*** (0.0303)	56.15*** (3.002)	0.664*** (0.0352)	68.22*** (3.521)
Constant	0.541 (0.453)	-329.7*** (44.78)	-0.191 (0.505)	-407.4*** (50.50)
N	1035	1035	849	849
Adjusted R^2	0.4483	0.4137	0.4936	0.4582

Table 12 - Regression estimates with heteroskadistic std. errors for models 1-4

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$