ON GREENWHASHING RISK/RETURN TRADEOFF IN GREEN BONDS' INVESTMENTS: A GLOBAL EMPIRICAL EVIDENCE

by

Francesco Baldi

Department of Management, University of Turin

Department of Economics and Finance, LUISS Guido Carli University

Email: francesco.baldi@unito.it, fbaldi@luiss.it

Alessandro Pandimiglio

University of Chieti-Pescara

CASMEF, LUISS Guido Carli University

Email: alessandro.pandimiglio@unich.it

Abstract

Green bonds (GBs) are a relatively new asset class that in the recent past has seen a significant growth in demand from investors, who are very sensitive to sustainability issues, and in supply from various types of issuers operating both in the private sector (corporates) and in the public sector (sovereigns, local governments, supranational entities - SNATs - including multilateral development banks). Based on a sample of 199 GBs issued by public sector entities and a sample of 199 GBs issued by corporates, we run simple but effective OLS regressions to investigate the determinants of yields demanded for by investors and, more interestingly, the trade-off between return and greenwashing risk across international markets. Our dataset includes over 92% of GBs' issuances made in Europe (70%), North America (14,3%), and Asia (8.1%). Our empirical analysis conveys that GBs' return is not only determined by rating and volatility as suggested by standard theory, but is also influenced by the degree of the ESG dimension of the underlying infrastructure and the easiness of greenwashing practices. Interestingly, corporate opportunities for engaging in greenwashing may exist and their effects are tied to the type of sector of the issuer. Issuers in the manufacturing and financial services' sectors can more easily engage in greenwashing activities as related monitoring by investors is more complicated. More importantly, risk premia and related yields to maturity required by investors are strongly driven by the level of sustainability (measured by the ESG score) of the project being financed through the issuance of GBs.

Keywords: Green Bonds; Yield to Maturity; Greenwashing; Green Premium.

1. Introduction

In recent decades, continuous climatic and environmental changes have highlighted the need to implement a transformation of the traditional infrastructure network in the sense of greater sustainability. The investment plan for the European Green Deal, announced by the European Commission in December 2019, represents, in this perspective, a concrete response to the climate emergency of our planet. It is a common strategy aimed at converting the economic and industrial system into a zero-pollution green economy. However, the climate and environmental emergency is only one of the issues that needs to be addressed. For instance, the urban population will increase by more than 2 billion people by mid-century, with emerging and developing countries (particularly China, India, and Nigeria) contributing around 35% to this growth. Such a sustained demographic trend will undoubtedly require the modernization, and in some countries the construction, of major infrastructure works. Furthermore, the pandemic explosion linked to Covid-19 has made even more evident the need to invest into resilient assets, capable of absorbing the increasingly frequent exogenous shocks.

Soon, society will require increasing efforts to accelerate the transition to sustainable development, and the financial sector is responding to this new challenge with the promotion of what is now known as "sustainable finance," an entirely new segment dedicated to supporting the green transition. The transition towards a low-carbon society (where global warming is limited to 2°C and gas emissions are strongly reduced) requires significant investment of financial resources in ecologically sustainable development.

In order to better channel financial resources towards sustainable projects, innovative instruments have been recently created. In 2007, debt securities labeled as green (or climate) bonds (GBs) were introduced into the market.[1] These bonds differ from traditional ones as their proceeds are exclusively aimed at financing (or re-financing) new and/or existing environmentally and socially sustainable projects.

GBs are a new asset class that in the recent past has seen a significant growth in demand from investors who are very sensitive to sustainability issues and in supply from various types of issuers operating both in the private sector (corporates) and in the public sector (sovereigns, local governments, supranational entities - SNATs - including multilateral development banks).

[1] The world's first Green Bond, the Climate Awareness Bond, was issued in 2007 by the European Investment Bank (EIB).

Although there are still no binding standards in the issuance of GBs, the International Capital Market Association (ICMA) was the first, at the international level, to indicate the characteristics of GBs by releasing the so called Green Bond Principles in 2014[2]: selection of the project to be financed or refinanced, restriction of the destination of the proceeds to the selected project and tracking of the money by the issuer, reporting at least annually on the use of the proceeds and opinion entrusted to an external auditor (second party opinion provider). In fact, the verification of the use of the proceeds is carried out by third party companies that are called upon to certify as "green" the bonds issued to finance projects that generate benefits in environmental terms.

The growing interest in this new asset class has led to the development of a new "ecosystem", made up of different players that contribute to the functioning of the market. Potential issuers of GBs that intend to organize the placement of a Green Bond must first prepare a Green Bond Framework.[3] The issuer must also request the intervention of an independent specialized auditor whose task is to certify the compliance of such a framework with the above standards.[4] Before issuing a GB, the issuer often obtains a green evaluation from a rating agency. The green impact score is typically expressed on a scale of 0-100 and converted into a synthetic (alphanumeric) judgment.[5] Once the above requirements have been satisfied, GBs are placed on select markets (e.g., Luxembourg Stock Exchange, Euronext Paris, London Stock Exchange).

GBs are beneficial to both issuers and investors. From the issuers' perspective, the benefits of GBs are: 1. reputational (the so-called Green Label Effect); 2. signaling; 3. value-driven; 4. financially-wise.

First, issuers of GBs increase their reputation about the attention they decide to pay to the theme of environmental sustainability, translating it into investment projects that allow for its concrete implementation. In this way, issuers obtain what has been defined as the Green Label Effect,

[2] GB Principles are updated periodically. The most recent version was released in 2021. These are voluntary standards promoted by issuers, investors and intermediaries participating in the GBs market and aimed at minimizing the risks of self-reporting, as well as establishing requirements for periodic reporting to the financial community.

[3] The GB Framework is a document in which it is explained which infrastructure investments the proceeds collected with the issue will be used to finance, indicating the sectors of reference. The Green Bond Framework must be composed by the issuer in accordance with the Green Bond Principles (ICMA, 2021).

[4] The auditor must verify: (a) the sustainability characteristics of the issuance concerning the use of capital resources raised; (b) the issuer's ability to fulfill its commitments related to the implementation of investment projects; (c) the compliance of projects with the Sustainable Development Goals (SDGs) declared by the issuer.

[5] Such a green evaluation is different from the conventional credit rating as it is rather a green, "point-in-time" impact score. The quality of the GB issuance is linked to the actual environmental impact of the underlying infrastructure on the target territory.

which is typically associated with the first issue of GBs rather than with subsequent issues. This effect produces the beneficial expansion of the investor base attracted to the debt securities of companies issuing GBs, extending it to those capital market players particularly committed to environmental sustainability. An increase in shareholders represented by long-term institutional investors oriented to ESG investment policies has been observed for GBs issues by private companies (Flammer, 2021).

Second, through the issuance of GBs, issuers signal to the market their capacity for financial innovation and their commitment to Corporate Social Responsibility (CSR) issues (Xiaoguang and Yadi, 2019). In this regard, evidence from the recent literature shows that companies issuing GBs improve their environmental performance and their propensity to innovate in the ecological field (Flammer, 2021).

Third, some prior studies show that, following the announcement of GBs issuances, there may be a raise in the share price (and traded volumes of stocks) of the issuing companies. The effect of a GBs issue can thus favor the shareholders of the issuing companies, leading to a long-term corporate value increase (Tang, and Zhang, 2020).

Fourth, issuers of GBs incur a lower cost of debt than issuers of traditional bonds, as it has been observed that on average the interest paid annually on GBs is about 18 basis points lower, regardless of the type of issuer (corporate or public).

From the investors' standpoint, GBs may offer three types of advantages: 1. reduction of information asymmetries between issuers and investors; 2. greater solvency; 3. resilience.

First, the underwriting of GBs, when they are certified by specialized third parties, reduces the information asymmetries that exist between issuers and investors regarding the use that the former intends to make of the debt capital raised through the issue (Zhiyong et al 2019). In the case of GBs, investors have the possibility of identifying the sustainable projects that will be financed by the issue; assess their cash flows and monitor the implementation of such investment projects on a periodic basis; be informed about the impacts of such projects in terms of sustainability through the periodic reports that the GB guidelines suggest issuers prepare.

Second, the development and assignment of sustainability "ratings" - such as the ESG (Environmental, Social, Governance) score - by specialized companies, provide the market with additional information regarding the ability of issuers to support the debt assumed. Indeed, it has been observed that, on average, the risk premium associated with GBs is 2 basis points lower than that of conventional bonds, which translates into lower returns for investors. The greater soundness of the issuers of GBs, proven by these new types of scores, offers greater security to the allocation choices of investors and therefore, even in the presence of

comparatively lower economic benefits, has favored the growth of the market for these bonds (Zerbid, 2019).

Third, a further advantage that GBs present for investors is their resilience as shown in the recent Covid-19 health crisis. A comparison of two indices compiled by S&P 500, the S&P Eurozone Investment Grade Corporate Bond Index [6] and the Green Bond Select Index[7] highlights that the prices of GBs for a long time lower, have been gradually rising until they overtook those of traditional bonds from mid-June 2019 onwards. Moreover, when the pandemic crisis occurred, the price collapse of the basket containing traditional bonds was more pronounced compared to that observed in the GBs index.

It should also be pointed out that, although GBs issuances enable the financing of infrastructure investment projects with a concrete impact on environmental sustainability, there exist a negative phenomenon, the so-called greenwashing, which may partially destroy the sustainable value created at the societal level. By engaging in greenwashing companies issue this type of bond to signal their environmental commitment, without implementing the announced sustainable projects, represents a worrying factor for many investors. In this regard, a recent study has shown that there is no empirical evidence that greenwashing is widespread (Flammer, 2021). The risk that the issuance of GBs does not result in actual environmental improvements is very modest, since the costs associated with the placement of these bonds would make it economically inefficient to use this collection strategy for those companies that only intend to benefit from the green label without working towards greater sustainability of their business activities or the assets supporting it. The main rationale behind the growing issues of this type of bond would therefore be to be found in the signal of a concrete commitment to environmentally friendly and innovative projects that issuers want to provide to investors. However, the increasing issuances of GBs by private companies suggests that greenwashing is not to be underestimated. For example, Apple since 2016 has issued GBs worth $4.7 billion, including an amount of $2.8 billion issued in recent months; in 2021, Leasys, a subsidiary of FCA Bank, issued GBs for € 500 million, Unicredit Bank GBs for €1 billion and, finally, in the Asian market the Bank of China issued GBs for $ 232 million.

The aim of this article is to empirically investigate the complex dynamics of GB markets using simple but effective econometric models. Our main contribution to the extant literature consists

[6] The S&P Eurozone Investment Grade Corporate Bond Index measures the performance of debt issued by companies in euros, regardless of the domicile of the issuer and the market in which the issue is placed.

[7] The S&P Green Bond Select Index is a market-value-weighted index that measures the performance of globally issued Green Bonds whose issuance is conditioned on very stringent financial and extra-financial criteria.

of exploring the determinants of yields demanded for by investors and, more interestingly, the tradeoff between return and the risk of greenwashing inherently embedded in this type of securities. We find out that the yield promised by GBs to investors is not only determined by rating and volatility as suggested by standard theory, but is also influenced by the degree of the ESG dimension of the underlying infrastructure (whose construction is financed via the GB issuance) and the easiness of greenwashing practices. Our empirical analysis is based on a sample of 199 GBs issued by public sector entities and a sample of 199 GBs issued by private companies over the 2012-2019 period.

The article is organized as follows. Section 2 briefly reviews the literature on GBs. Section 3 contains a description of the trend in Green Bonds' issuances across the public and corporate issuing categories. Section 4 describes the data and the sample that has been used to carry out the econometric analysis, presents the methodological approach used, discusses the findings obtained, including those of robustness checks. Section 5 concludes.

2. Literature Review

GBs are a relatively recent phenomenon whose diffusion started not before 2013. Consequently, the scientific literature on GBs is still limited. However, in the last five years the scientific community has begun to study some peculiarities that can be associated with this type of bonds. Most of the empirical studies have tried to identify the existence of substantial differences with traditional bonds. This is the central argument. However, there remain several other open questions that need to be addressed if we are to better understand the role of this financial innovation in helping to make the world economy more sustainable. For example, what attracts investors and issuers to the green bond market? To what extent do green bond market participants see these bonds as an important tool for shifting capital from less sustainable to more sustainable investments? What do investors' and issuers' experiences tell us about the role of green bonds in promoting sustainability in practice? Do investors feel more emotionally invested when they buy GBs knowing that they can help improve environmental sustainability? Given their characteristics, can green bonds be issued at lower prices than traditional bonds?

Given the exponential growth of GB issuances in the capital markets over the past five years, the economics literature has primarily sought to explain the stock market reaction to corporate GB issuances and their potential spillover effects on issuers' stocks. Many of these articles are recent and share the use of the Event Study methodology that leads to the estimation of Cumulative Abnormal Returns (CARs).

In this regard, the results obtained by Flammer (2021) show that GBs issued by private firms are more prevalent in industries where the environment is important to the firm's operations (e.g., energy), furthermore, the stock market responds positively to the announcement of the issuance of GBs especially if they are certified by independent third parties and for first-time issuers. This produces positive CARs and improvements in long-term value and operating performance. In addition, following the issuance of green bonds, companies improve their environmental performance and experience increased ownership by green and long-term investors. The results indicate that issuing green bonds makes companies credibly seal their commitment to the environment, and the stock market responds positively to this signal.

Gianfrate and Peri (2019), analyzing 121 European green bonds issued between 2013 and 2017, find evidence that green bonds are financially better off than non-green bonds. The advantage is greater for corporate issuers and persists in the secondary market. Thus, green bonds can be an effective way to achieve a lower cost of capital for organizations that need to finance or refinance green projects.

Hachenberg and Schiereck (2018) compare the risk-return profiles of GBs with those of conventional (non-green) bonds by comparing the daily i-spreads of green bonds with those of conventional bonds and study their price differentials in a sample of 7032 green bonds and 14064 non-green bonds over the period from October 2015 to March 2016. Their evidence shows that AA-BBB rating classes of green bonds spreads are marginally narrower than non-green bonds of the same issuers. In addition, corporate green bonds spreads are smaller than their nongreen bond counterparts, while for government green bonds they are marginally wider. Issue size, maturity, and currency do not have a significant influence on price differences, while industry sector and ESG rating do.

Other studies have examined the performance of corporate GBs to investigate whether a so-called "green premium" exists. Based on a sample of 89 bond pairs, Bachelet et al. (2019) find that GBs have higher yields, are more liquid and less volatile than their closest counterparts in traditional bonds. More specifically, institutional GBs show a negative premium, while corporate GBs have a positive premium, unless the private issuer is committed to certifying the "greenness" of the bond. Overall, GBs can enjoy a negative premium and thus green investments can be financed at a discount. Hachenberg and Schiereck (2018) provide evidence that GBs on average do not trade significantly tighter than their counterparts. Zerbib's (2019) study reveals that the yield of a GB is lower than that of a conventional bond (- 2 basis points), thus implying a negative premium, which is more evident for financial and low-rated bonds.

Another aspect that can somewhat influence the yields of GBs is related to the total amount of issuance. As pointed out by Maltais and Nykvist (2020), another potential incentive for investors is associated with the size of the market and the size of institutional investors.

In the literature, only a few academic works have addressed public sector GBs. Among them, Braga (2020) performs a survey of the literature on GBs issued by the public sector highlighting that although the public sector plays a key role in fostering green transition and reducing the costs of green initiatives, studies on the performance of GBs issued by the public sector are still unclear. Regarding municipal bonds, Karpf and Mandel (2018) find that green issues appear to pay lower yields than comparable conventional bonds by realizing the so-called green premium.

In contrast, Wiśniewski and Zieliński (2019) argue that issuing sovereign GBs are the easiest way to attract investors and potentially increase the size of issues that can help reduce the cost of financing sustainable infrastructure. In addition, Heine et al. (2019) argue that public sector GBs can help accelerate the sustainable transition, especially if such issuance is coupled with active carbon pricing policies. Specifically, they argue that the issuance of GBs helps enable immediate investments in climate change mitigation and adaptation, and the bonds would be repaid by future generations in such a way that those who benefit from reducing future environmental damage share the burden of financing mitigation efforts undertaken today.

The main results on the nature of the global GB market arising from the most recent research described above are used to develop a set of four hypotheses (H1-H4). We therefore posit:

H1. *The higher the size of the GB issuance (reflecting that of the underlying infrastructure to be financed), the lower the yield to maturity required by investors that are compensated for by the sustainability impact increasing in the size of the infrastructural asset.*

H2. *Investors into GBs of local governments (that are closer to constituencies and their needs) require lower yields in exchange for the expected higher impact of the underlying infrastructure at local level.*

H3. *The higher (lower) the sustainability/ESG features of the infrastructure financed by the GB issuance, the lower (higher) the yield investors are willing to accept (forego) if called on to contribute to the realization of such infrastructural asset. This applies to both public sector and corporate GBs.* See for example Maltais and Nykvist (2020) and Zhiyong et al (2019).

H4. *A lower risk of greenwashing is associated with GB issuances made by services firms as compared to manufacturing firms, thus requiring a lower premium by investors.* See for example Flammer (2021).

The testing of such set of hypotheses seeks to support prior studies with new empirical evidence from the global GB market to construct a comprehensive framework of testable predictions on the expected performance consequences of such a new asset class.

3. Overall Trends in Green Bonds' Issuances

Green Bonds issued in international capital markets as of December 2020 accounted for 3.5% of total bond issuance (2016 was just under 1%).[8] This highlights the significant growth that this segment of debt securities has experienced over the last five years. As with traditional bonds, GBs can be issued by private companies (corporate segment) or by public sector institutions (e.g., states, local authorities). Although the public sector initially predominated in the placement of GBs, currently internationally the main issuers of this type of bond are private companies operating in a variety of industries (e.g., energy, telecommunications, etc.).

Considering the significant growth that the GBs market has had in the last four years, the European Central Bank (ECB) has declared that these bonds could become an instrument of monetary policy to promote policy measures by the countries of the Union for the mitigation of climate risks.

To better understand this market, a detailed analysis was conducted based on a sample of 3,635 Green Bonds, extracted from the Bloomberg database, with fixed and floating rate yields, placed internationally by both corporate and public sector issuers, in the period 2007-2020. The sample includes a total issued amount of GBs of €872.3 billion, of which €783.6 billion is still outstanding.

[INSERT FIGURE 1 ABOUT HERE]

Figure 1 shows the performance of GBs in international capital markets from 2007 to 2020. Since 2017, the number and volume of GBs issuances have increased significantly. In 2019, the volume of issuance increased by about 68% compared to 2018 (€219.4 billion GBs in 2019 versus 130.6 € billion GBs recorded in 2018). In 2020, the amount of GBs issued was €221.4

[8] NN Investment Partners estimates.

billion against a total number of issues of 886 (in 2017, the number of GBs issued was 456, an increase of 94.3%).

The sample of GBs currently tradable on capital markets includes both corporate issues and issues from public sector institutions. In particular, the latter category of bonds includes issuers of three types: (i) states; (ii) local governments; and (iii) supranational organizations (so-called SNATs), such as the European Investment Bank (EIB), or the European Bank for Reconstruction and Development (EBRD). Figure 2 shows that the majority of Green Bonds in circulation today have been issued by private companies (68%; 532.7 € billion). The share of GBs issued by public sector entities to finance sustainable infrastructure projects is still in the minority. More specifically, States (i.e., Central Government Treasuries) have issued 10 % of the outstanding GBs (€80.8 billion); local governments have issued 14% of the total GBs (€107.4 billion); SNATs the remaining 8% (€62.7 billion).

[INSERT FIGURE 2 ABOUT HERE]

Regarding the amounts placed, although the corporate segment has only started issuing GBs since 2013, the growth of their issuance over time has proceeded at a high pace so that - as shown in Figure 3 - the market is now driven by private company debt. In 2020 alone, the amount of GBs issued by the corporate segment was €158.2 billion, representing 20.2% of the market. Local authorities, in the same period, issued securities for a total of 33.4 billion euros, equal to 4.3% of the market. This was followed by sovereign issues made by governments, with a countervalue of €20.2 billion (2.6% of the market). Finally, supranational organizations issued GBs amounting to 9.5 billion euros in 2020 (1.2% of the market).

[INSERT FIGURE 3 ABOUT HERE]

4. Econometric analysis: Data, Findings and Robustness

4.1 Data

To analyze the dynamics of the international Green Bonds market and the factors that most influence their yields we use data from Bloomberg. In particular, we have selected a sample of 199 observations related to GBs issued by the public sector and a sample of 199 observations related to GBs issued by the corporate segment. The dataset used covers the 2012-2019 period for the issuances made by public sector entities and the 2013-2019 period for the issuances

made by private companies. Table 1 shows the descriptive statistics of our data on GBs issued by public sector entities and corporates.

[INSERT TABLE 1 ABOUT HERE]

Our data show that the average yield to maturity is higher in the corporate segment (1.8%) than in the public sector (0.8%) by one percentage point, however, public sector yields show less variability. Although volatility data are not perfectly comparable, as it is calculated over 260 days for the corporate sector and 90 days for the public sector, GBs issued by the public sector are much less volatile, thus confirming the theory that lower yields are associated with lower risk. Finally, the average size of issuances is similar for the two sectors, with a value of just over 500 million euros.

Figure 4 shows the geographic distribution of corporate sector GB issuances amounts. Our dataset includes over 92% of GBs' issuances made in Europe (70%), North America (14,3%), and Asia (8.1%).

[INSERT FIGURE 4 ABOUT HERE]

The geographic distribution of public sector GB issuance amounts is shown in Figure 5. In the dataset used, 84.2% of issuances are from supranational entities (SNAT), European countries, and Asian countries (42.9% SNAT, 32.9% Europe, 8.4% Asia).

[INSERT FIGURE 5 ABOUT HERE]

4.2 Empirical Modeling and Discussion of Findings

To better understand the dynamics of the international GB market as well as studying which factors most influence the returns that GBs promise to investors, an empirical analysis is conducted. More specifically, we employ a multiple regression technique estimated with the ordinary least squares (OLS) method leading to two distinct econometric models (Model PS, Model CR); one for public sector GBs and the other for corporate GBs. Model PS is based on a sample of 199 GBs issued by public sector entities in the 2012-2019 period. Model CR is based on a sample of 199 GBs issued by private firms (corporate GBs) in the 2013-2019 period.

In both econometric models PS and CR, the dependent variable is the *Yield to Maturity* (YTM) of the GBs, while the independent variables are different, except for two common regressors: Standard & Poor's rating and price volatility.

We begin by illustrating Model PS regarding GBs issued in international markets by three types of public sector entities: supranational organizations (SNATs), States (Sovereigns), local governments. The dependent variable is the yield to maturity (YTM) of the public sector GBs, calculated on the basis of the average of the bid and ask prices (mid-YTM). Model PS includes the following five independent variables: (1) Standard & Poor's rating; (2) price volatility over the last 90 days of market trading; (3) the GB issued amount; (4) the type of public sector issuer; (5) a dummy accounting for the application (or non-application) of ESG (Environmental, Social and Governance) criteria for the selection of the infrastructure project to be financed via the GB issuance. Definitions of dependent and independent variables are shown in Table 2.

[INSERT TABLE 2 ABOUT HERE]

Model PS obtains an R-squared of 73.6% and Adjusted R-squared of 72.9%, with its results being in line with standard economic theory. Our econometric analysis based on Model PS is presented in Table 3.

[INSERT TABLE 3 ABOUT HERE]

Our empirical evidence shows that as the rating assigned by Standard & Poor's increases (i.e., as the issuer's creditworthiness improves), the yield on public sector GBs decreases. A lower issuer creditworthiness risk translates into a lower investor demand for yield. Indeed, the coefficient for *S&P Rating* is negative and statistically significant at 1% level. The size of the coefficient (-0.95) reflects the impact that a change in the rating can have on average on the level of the public sector GB's yield to maturity: as the rating of a class increases, the yield of the public sector GB decreases on average by 95 basis points.

Moreover, our regression analysis reveals that as market volatility increases in the short term, the yield to maturity of public sector GBs increases. There exists a positive relationship between volatility and yield of these bonds. The coefficient for *Volatility (90 days)* shows a positive sign and a high statistical significance (at 1% level). This result is in line with expectations as higher volatility reflects a higher bond risk, which translates into higher returns

required by investors to be compensated for their inherent risk exposure. The size of the coefficient (0.57) implies that for a unit increase (equal to 1%) in volatility, the return on public sector GBs increases on average by 0.57%.

Model PS also shows that the amount of the public sector GBs issued, strictly related to the size of the underlying infrastructure that the public sector issuer intends to finance, is negatively correlated with the yield to maturity of the bonds. The coefficient of the variable *Issued Amount* is negative and strongly significant (at 1% level), unquestionably supporting H1. Investors are willing to forego a greater portion of their returns to facilitate the realization of impactful infrastructures. The greater the size of the infrastructure financed by the GB, the higher its expected impact on the sustainability of target territories. Such a downward pressure on the yield is exerted by the rise in market prices as a consequence of greater demand by investors for public sector GBs aimed at financing increasingly impactful infrastructures. The magnitude and the sign of the coefficient (- 0.44) imply that an increase of 1% in the issued amount of GBs reduces the yield on GBs on average by 0.44%.

Based on the positive sign and strong statistical significance (at 1% level) of the coefficient of the variable *Typology of Public Sector Issuer*, our analysis also demonstrates that if GBs are issued by local governments (rather than SNATs or Sovereigns), their proximity to constituencies favors the awareness of the most important regional needs leading to construction of more impactful infrastructures. As a result, investors are more prone to underwriting GBs of local governments (rather than of SNATs or States) by accepting lower returns (on average by 0,93%) in exchange for a more direct, effective impact of the financed infrastructural assets on their territories. SNATs' or Sovereign GBs are traded at lower prices as a result of a lower market demand, which translates into higher yields to maturity. Hence, our findings provide support for H2.

Finally, the coefficient for the ESG-based selection of the underlying infrastructure project (*ESG Project*) is negative and significant at 5% level, which moderately supports H3. More specifically, our econometric analysis reveals that, due to the negative relationship between the YTM of public sector GBs and the use of the ESG metrics for the selection of the underlying infrastructural assets, investors reward such a congruent choice by being willing to accept a lower return on their investments. The magnitude of the coefficient (- 1.12) implies that the ESG-based selection of the infrastructure financed through the issuance of a GB lowers the yield on average by 1.12%.

We next discuss the findings of Model CR aimed at detecting the key explanatory factors about the performance of corporate GBs issued by private companies in international markets over the last decade.

The dependent variable is the yield to maturity (YTM) of corporate GBs, calculated on the basis of the average of the bid and ask prices (mid-YTM). Model CR includes the following four independent variables: (1) Standard & Poor's rating; (2) price volatility over the last 260 days of market trading; (3) the ESG score of the financed infrastructure project; (4) a dummy accounting for sector of the corporate GB issuer (1 if the issuer is a services firm, 0 if the issuer operates in the manufacturing sector). Definitions of dependent and independent variables are shown in Table 4.

[INSERT TABLE 4 ABOUT HERE]

Model CR obtains an R-squared of 23.4% and Adjusted R-squared of 21.9%, with its results being in line with standard economic theory. Our econometric analysis based on Model CR is presented in Table 5.

[INSERT TABLE 5 ABOUT HERE]

Analogously to what applies to Model PS and in line with the economic theory, Model CR confirms that an improvement in the corporate issuer's creditworthiness (which translates into an upgrade in the rating assigned by Standard & Poor's) diminishes the return required by investors on corporate GBs they underwrite. Indeed, the negative coefficient for *S&P Rating* reflects a negative relationship between rating and yield to maturity. Higher investor demand for less risky (i.e., better rated) bonds produces higher prices in the market, which results in a downward pressure on yields. The related effect is relevant due to its high statistical significance (at 1% level). The size of the coefficient (-4.37) reflects the very high impact that a rating migration from one class to an upper class can have on average on the corporate GB return (- 437 basis points or – 4.37%) and vice versa.

The same empirical logic that is obtained in relation to (short-term) volatility in Model PS also applies to (long-term) volatility in Model CR. The coefficient of the variable *Volatility (260 days)* is strongly significant (at 1% level) and negative, which is consistent with the ordinary dynamics of bond markets: an higher risk exposure (reflected in higher price volatility) is rewarded with a greater return (YTM). The magnitude of the coefficient (0.42) implies that for

a 1% (marginal) increase in volatility, the yield to maturity of corporate GBs rises on average by 0.42%.

More interestingly, our econometric analysis suggests that there is an inverse relationship between the yield to maturity of GBs issued by private companies and the level of Environmental, Social and Governance connotation of the issuance, measured by the *ESG Score*, underlying the degree of sustainability of the infrastructure that needs to be financed via the bond issuance. The coefficient of the variable *ESG Score* is negative and very close to strong statistical significance (albeit significant at 5% level). Similarly to what occurs in the context of public sector GBs, investors into corporate GBs are willing to accept (forego) a lower (higher) return in exchange for supporting the construction and operation of increasingly sustainable infrastructures that may have an higher impact at local level with an overall, direct benefit for all citizens. The higher the sustainability dimension of the infrastructure project, the greater the portion of yield they are willing to give up in order to help support its construction. The magnitude of the coefficient (-1.19) implies that, as the ESG score of the project associated with the issuance of the corporate GB increases by one unit, there is an average 1.19% decrease in the yield to maturity of these securities. Such an empirical evidence also corroborates H3 for corporate GBs.

Importantly, Model CR demonstrates that greenwashing is a key inherent risk of the relatively new asset class of corporate GBs. Our empirical analysis effectively exhibits that the phenomenon of greenwashing may lurk in the manufacturing sector while being less perilous in the services sector. This interesting perspective is offered by the dummy variable of the *Sector* where the corporate GB issuers of our sample operate: the dummy variable (1 if the sector of the issuer is services - e.g. utilities, energy, telecommunications, banks & insurance - and 0 otherwise) is negatively related with the corporate GBs' yield to maturity (the coefficient has a negative sign). The magnitude of the coefficient (-3.13) implies that the yield decreases on average by 3.13% (311 basis points) in the case of GBs issued by companies operating in the services sector and vice versa in the case of GB issuances of manufacturing companies.

For investors allocating their resources into GBs issued by services' firms it would be easier and more immediate to monitor (post-issuance) a potential deceptive greenwashing activity carried out by the issuer, for example in the course of construction of an infrastructure featuring impactful sustainability characteristics that, after being announced at the pre-issuance stage, are not fulfilled post-issuance. This might be the case of a solar farm or the green design of a 5G telecommunications infrastructure. For instance, it is difficult for a utility company, which announces to issue a GB to finance the construction of a photovoltaic park, not to follow up on

this initiative and finance an alternative project that does not present characteristics of environmental sustainability. Hence, the risk of greenwashing is lower in the services sector and investors are more prone to accept lower returns as they need to be effectively compensated for a less costly and time-consuming monitoring activity. This form of investors' monitoring is less straightforward on issuers operating in the manufacturing sector (e.g., consumer goods, materials), thus leading to a higher probability of greenwashing practices and imposing higher risk premia for investors. However, the coefficient of the sector dummy is not statistically significant, which suggests that H4 can only be moderately supported.[9] Despite their modest statistical dimension, our findings have the merit of highlighting the practice of greenwashing and their different degree of diffusion across industries.

4.3 Robustness Checks

To check the robustness of our results we have collected a set of comparable ordinary (so called brown) bonds to be associated with the GBs issued by the same companies included in our sample used for Model CR for a total of 398 bonds (199 x 199 bonds). Four criteria have been fulfilled to select the brown bond matching the GB issued by the same firm: (1) similar size of the issuance; (2) proximity of the date of issuance; (3) similar maturity (within a range of 3 years apart); (4) same time period window (2010-2020). The distribution of GBs and comparable brown bond issuances made by the same sample of firms across the 2010-2020 period is displayed in Figure 6. It can be highlighted that the year characterized in our sample by the peak of GB issuances is 2019. The distribution of our sample firms across industrial sectors is shown in Figure 7. It can be noted that corporate GB issuers are concentrated in the financial and utilities/energy sector. Figure 8 shows how the apportionment of S&P's rating classes among our sample of corporate GBs; the majority of GB issuances are assigned A or BBB rating.

[INSERT FIGURES 6,7 AND 8 ABOUT HERE]

Consistently with Bachelet, Becchetti & Manfredonia (2019) and Zerbib (2019), we run an additional econometric model where the dependent variable is the spread between the *Yield to Maturity* (YTM) of the GB and that of the select brown bond issued by the same firm. Such a spread reflects the green premium (or "greenium") which is still considered as a puzzle by the recent academic research. Our model, named as Model GBS, is designed as a multivariate

[9] The small sample size may be responsible for the statistical insignificance of the sector dummy variable.

regression estimated with the ordinary least squares (OLS) method and is aimed at investigating whether the explanatory factors of corporate GB performance are also the drivers of a green premium required by investors. The independent variables of our Model GBS are the same as those of Model CR (*S&P Rating*, *260 days-Volatility*, *ESG Score*) with the exception of two: (i) the maturity (in years) of the GB; ii) a dummy variable with value 1 if the issuer operates in the financial sector and 0 otherwise. Table 6 exhibits the empirical findings of Model GBS.

[INSERT TABLE 6 ABOUT HERE]

Overall, the results of Model GBS corroborate our findings of Model CR. The signs of the coefficients of *S&P Rating* (-) and *Volatility (260 days)* (+) are in line with those of Model CR. Statistical significance (at 5% level) only applies to volatility. GBs' yields are negatively related with ratings: a rating upgrade lowers the risk premium required by investors and their return expectations, thus reducing the yield spread between GBs and their matched brown bonds. More volatile (and therefore riskier) GBs drive investors to demand for higher returns, thus amplifying the green premium (compared to conventional bonds).

Maturity is inversely related to the green premium implying that, consistently with standard bond dynamics, longer-term brown bonds impose higher yields while associated longer-term GBs require lower yields. This may be due to the fact that investors in GBs accept lower returns in exchange for financing underlying sustainable infrastructures with longer construction times and more enduring impact.

The negative sign and statistical significance (at 5% level) of the coefficient of the *ESG Score* confirms the inverse relationship between the ESG dimension of the underlying infrastructure and the yield demanded for by investors on GBs: investors tend to give up on return when offered the opportunity to contribute to the realization of high ESG, impactful infrastructural projects.

Finally, the coefficient of the *Financial Sector* dummy variable is positive (although not statistically significant). The green premium increases for GBs issued by firms operating in the financial sector, where potential greenwashing practices are less easily detectable by investors. Indeed, financial services are a special form of services characterized by a comparatively higher greenwashing risk as banks and/or insurance companies may need to cheat while engaging in sustainable activities to save on previously announced green investments and divert related resources toward more profitable operations.

5. Conclusions

Our empirical analysis conveys that GBs' return is not only determined by rating and volatility as suggested by standard theory, but is also influenced by the degree of the ESG dimension of the underlying infrastructure and the easiness of greenwashing practices. Interestingly, corporate opportunities for engaging in greenwashing may exist and their effects are tied to the type of sector of the issuer. Issuers in the manufacturing and financial services' sectors can more easily engage in greenwashing activities as related monitoring by investors is more complicated. More importantly, risk premia and related yields to maturity required by investors are strongly driven by the level of sustainability (measured by the ESG score) of the project being financed through the issuance of GBs.

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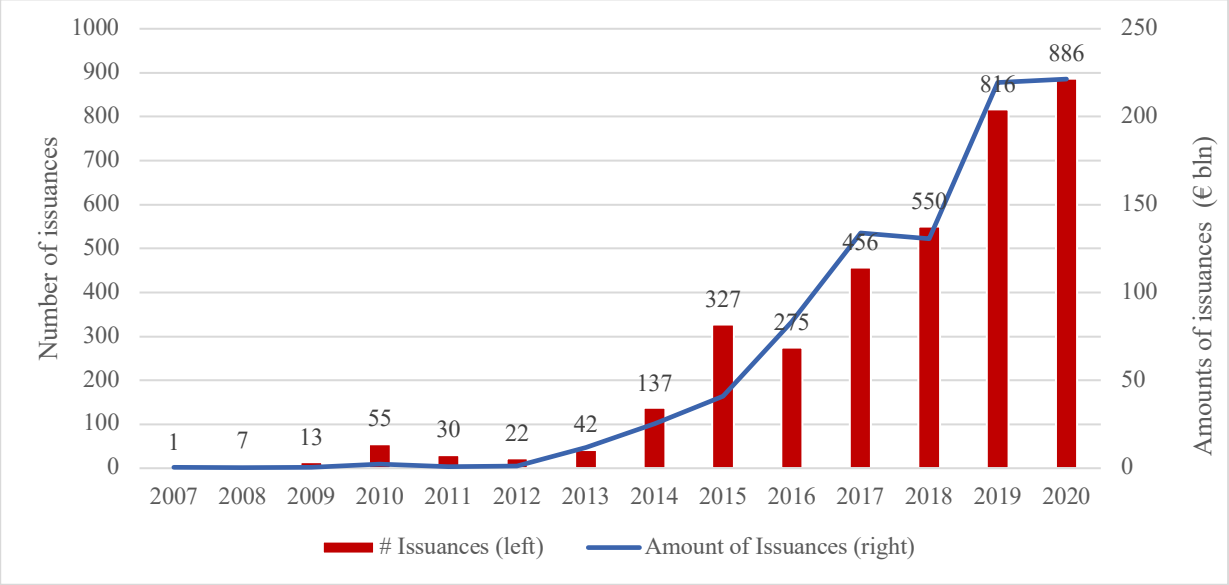
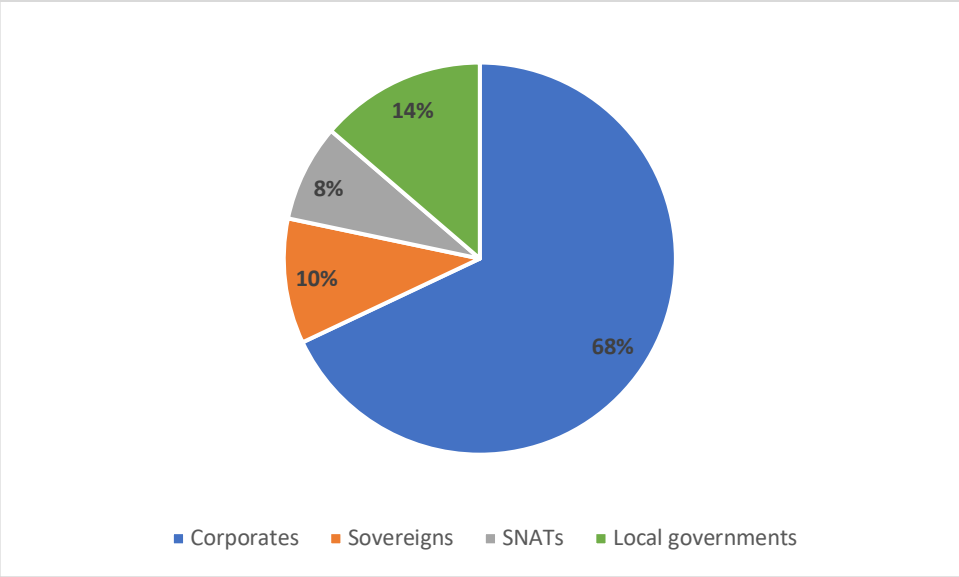
Figure 1. Number and Amounts of Green Bond Issuances (2007-2020)



Source: Bloomberg

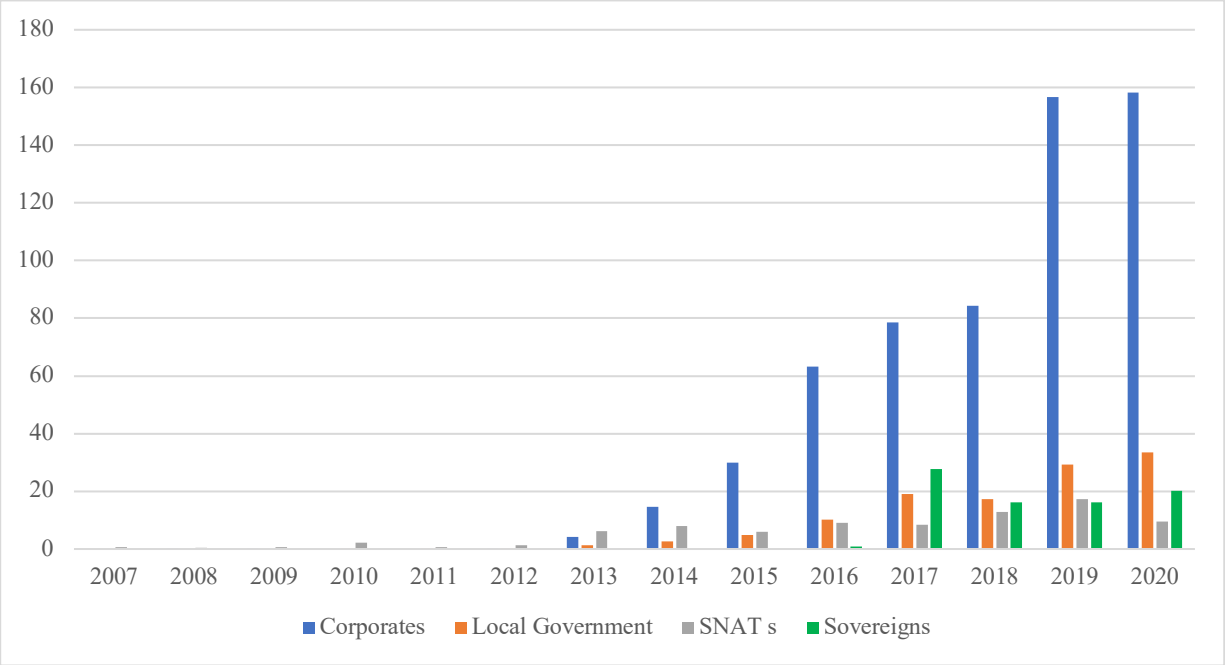
Figure 2. Distribution of Green Bonds Issuances Among Corporate and Public Sector Issuers



Source: Bloomberg

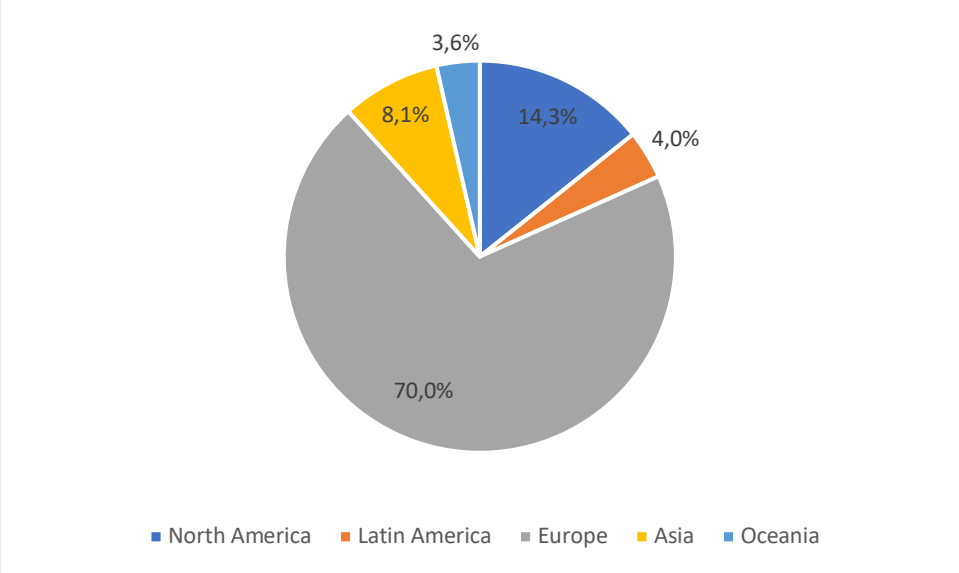
Figure 3. Amounts of Green Bonds Issuances by Issuer Category

(Billions of euros)



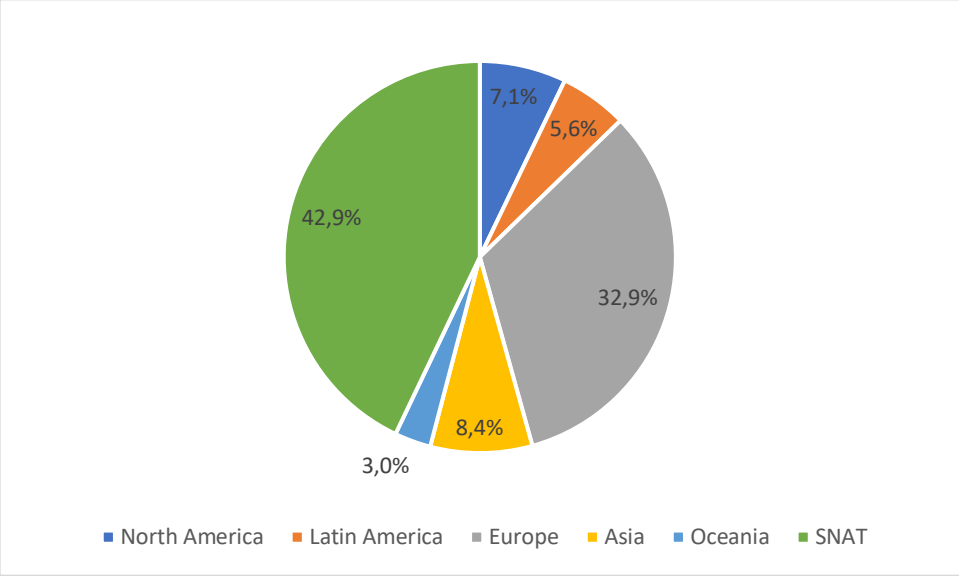
Source: Bloomberg

Figure 4. Corporate Sector: Distribution of Regional Green Bond Issuances



Source: Bloomberg

Figure 5. Public Sector: Distribution of Regional Green Bond Issuances



Source: Bloomberg

Table 1. Descriptive Statistics

		Yield to maturity	Volatility*	Amount issued#
Corporate	*mean*	1,8%	6,82	546.263.488
	std dev	13,5%	6,26	321.212.936
	min	-1,1%	0,29	15.817.671
	max	191,1%	34,87	1.852.766.798
Public	*mean*	0,8%	2,40	516.189.716
	std dev	3,4%	4,13	594.920.842
	min	-0,7%	0,04	875.928
	max	32,9%	35,30	6.100.399.058

* 260 days for Corporate and 90 days for Public

Euros

Source: Bloomberg

Table 2. Variables' Description: Econometric Model PS (*Green Bonds* Issued by Public Sector Entities)

Variable Name	Description
Yield to Maturity	Yield to maturity calculated on the basis of average prices between bid and ask quotations (so called *mid-YTM*)
S&P Rating	Official ratings assigned to Green Bonds by Standard & Poor's, converted into an increasing score ranging from 1, assigned to issuances with worst rating (in our sample, D) to 8, assigned to issuances with AAA rating
Volatility (90 days)	The standard deviation of the prices referring to the market trades of the last 90 business days
Amount Issued	Natural logarithm of the issued amount of Green Bonds
Public Entity Typology	Dummy equal to 1 if the GB issuer is a SNAT or a Sovereign, 0 if the GB issuer is a Local Government (such as municipal, province or regional entities)
ESG-Based Project	Dummy equal to 1 if the selected project to be financed with the GB issuance has been chosen applying the ESG (*Environmental, Social and Governance*) metric, 0 otherwise

Table 3. OLS Regression Results: Green Bonds Issued by Public Sector Entities

Dependent Variable: Yield to Maturity

Regressors	Coefficient	t-Student	P value
S&P Rating	-0.95** (0.159)	-6.02	0.000
Volatility (90 days)	0.57** (0.038)	14.89	0.000
Amount Issued	-0.44** (0.092)	-4.87	0.000
Public Entity Typology	0.93** (0.287)	3.24	0.001
ESG-Based Project	-1.12* (0.524)	-2.14	0.034
Constant	15.85** (2.203)	7.2	0.000
N° of observations: 199			
$R^2 = 0.736$; Adj $R^2 = 0.729$; Prob > F = 0.0000			

* level of statistical significance ≤ 5%, ** level of statistical significance ≤ 1%

Table 4. Variables' Description: Econometric Model CR (Green Bonds Issued by Firms)

Variable Name	Description
Yield to Maturity	Yield to maturity calculated on the basis of average prices between bid and ask quotations (so called *mid-YTM*)
S&P Rating	Official ratings assigned to Green Bonds by Standard & Poor's, converted into an increasing score ranging from 1, assigned to issuances with worst rating (in our sample, D) to 8, assigned to issuances with AAA rating
Volatility (260 days)	The standard deviation of the prices referring to the market trades of the last 260 business days
ESG Score	Summary measure of ESG-related information that each firm reports for the most recent available fiscal year. The number of disclosures is presented as a % of the total potentially disclosable ESG-related information. In our dataset, this percentage ranges from 9.65% to 75.21%.
Sector	*Dummy* equal to 1 if the issuer is a firm operating in the services sector (e.g., telecommunications, energy, utilities, finance), 0 if the issuer is a firm operating in the manufacturing sector (e.g., consumer goods, industrial goods, high-tech).

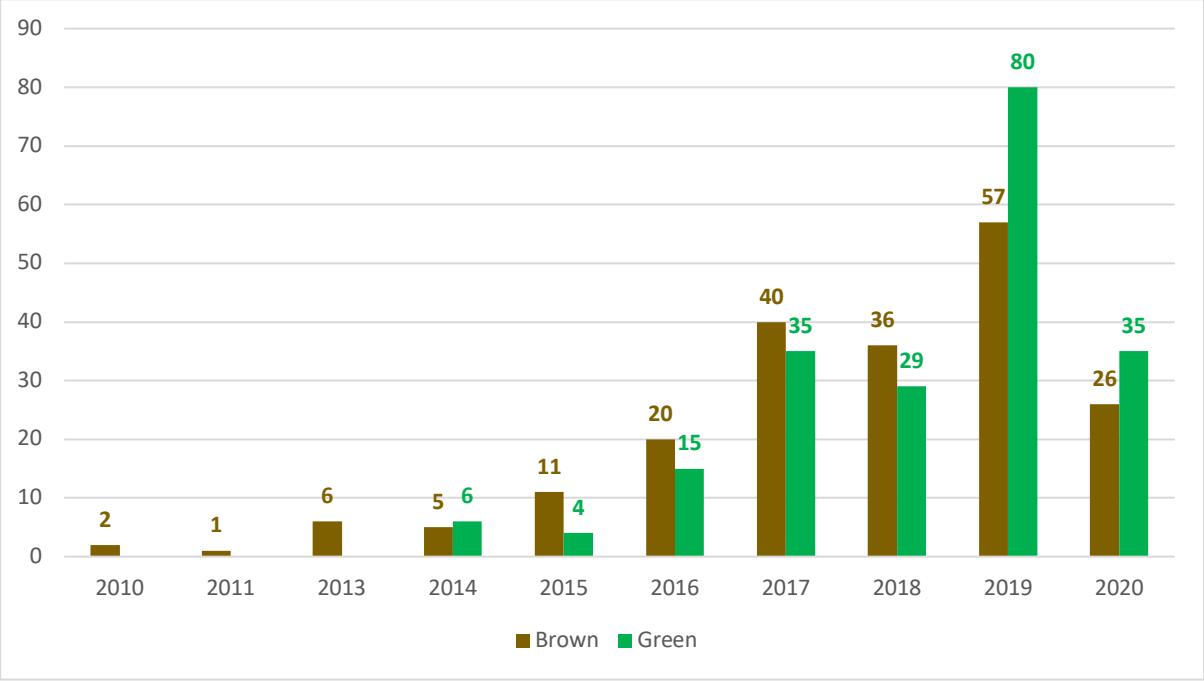
Table 5. OLS Regression Results: Green Bonds Issued by Firms (Corporate Green Bonds)

Dependent Variable: Yield to Maturity

Regressors	Coefficient	t-Student	P value
S&P Rating	-4.37 ** (0.969)	-4.52	0.000
Volatility (260 days)	0,42 ** (0.154)	2.78	0.006
ESG Score	-1,19 * (0.08)	-2.5	0.013
Sector	-3.13 (2.402)	-1.31	0.193
Costant	35.37 ** (8.010)	4.42	0.000
N° of observations: 199			
$R^2 = 0.234$; Adj $R^2 = 0.219$; Prob > F = 0.0000			

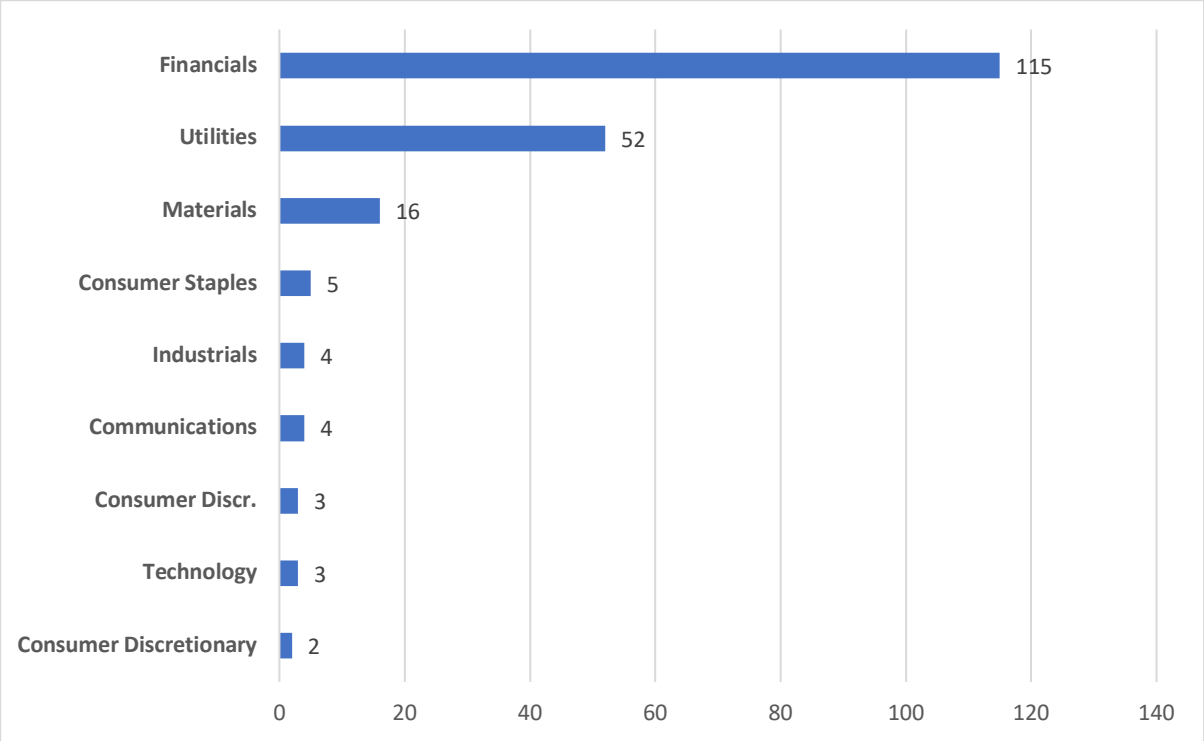
* level of statistical significance ≤ 5%, ** level of statistical significance ≤ 1%

Figure 6. Distribution of Green Bond and Comparable Brown/Ordinary Bond Issuances Across Years (2010-2020)



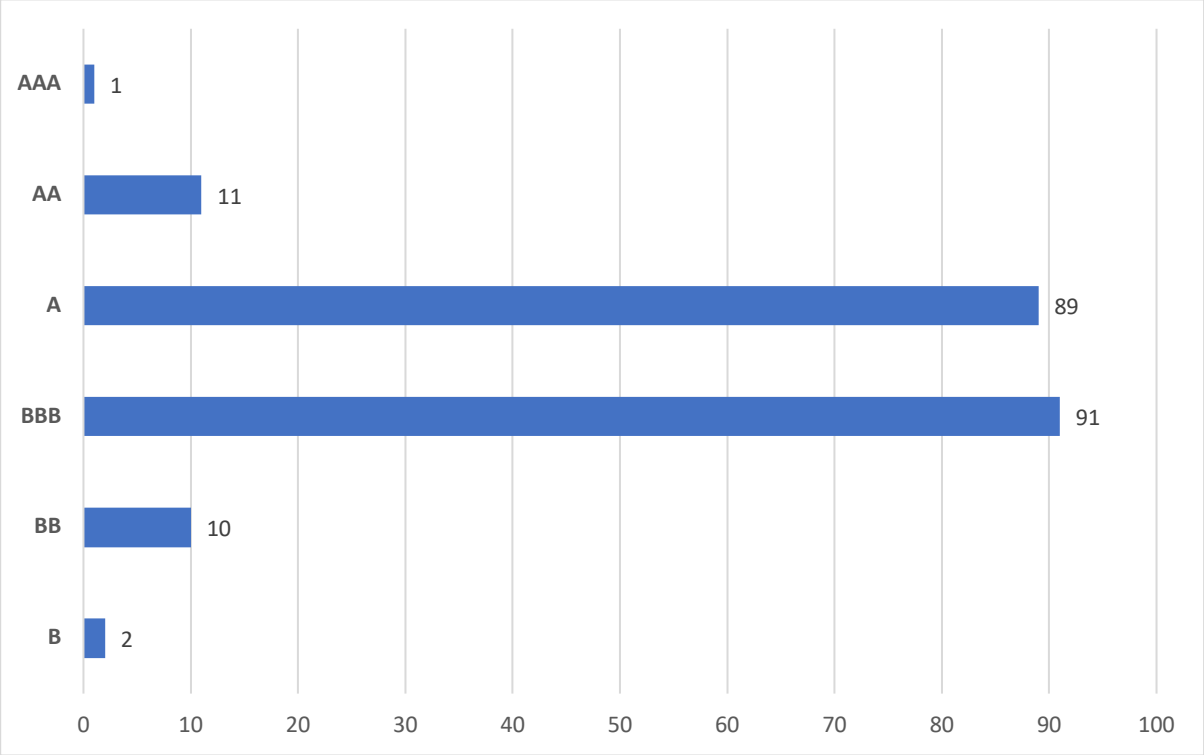
Source: Bloomberg

Figure 7. Distribution of Firms in the Sample Across Sectors (2010-2020)



Source: Bloomberg

Figure 8. Distribution of Firms in the Sample Across Rating Classes (2010-2020)



Source: Bloomberg

Table 6. OLS Regression Results: Green-Brown Bond Yield Spread (Corporates)

Dependent Variable: Green-Brown Bond Yield Spread

Regressors	**Coefficient**	**t-Student**	**P value**
S&P Rating-	-0.056 (0.108)	0.52	0.605
Volatility (260 days)	0.061* (0.029)	2.14	0.034
Maturity	-0.001* (0.001)	2.44	0.016
ESG Score	-0.001 (0.005)	-0.23	0.822
Financial Sector	0.092 (0.170)	0.55	0.587
Constant	-0.637 (0.647)	-0.98	0.326
N° of observations: 199			
$R^2 = 0.051$; Adj $R^2 = 0.027$; Prob > F = 0.065			

* level of statistical significance ≤ 5%, ** level of statistical significance ≤ 1%