# Estimating the *greenium*
# FPM - Assignment


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## 1 Introduction

During the last decade, things such as ESG (Environmental, Social and Governance) factors, CSR (Corporate Social Responsibility) and SRI (Sustainable and Responsible Investment) gained relevance both in corporate management and financial markets, as a response to the importance that society begun to give to climate change and social responsibility. Sustainable development is one key goal humanity must attain in the upcoming years, focusing especially on reducing carbon footprint, adopting technologies supporting a circular economy, and modifying current production standards.

A possible instrument to reach this goal is what is called green investment, represented mainly by *green bonds*. Green bonds, newly developed financial instruments of green financing, are bonds born with the goal of improving environmental impact and social welfare. Firms can issue green bonds to finance projects with positive environmental effects such as reducing CO2 emissions and pollution.

One of the main problems that green bonds have, is that there are no mandatory standards to be followed when issuing this type of financing. Even though some guidelines exist (e.g., the European recommendation for EU green bond standard[1]), these recommendations change among different countries and jurisdictions. Thus, to avoid green-washing concerns, most of these bonds are certified by third parties. However, such certifications are expensive, especially for first-time issuers, causing higher costs of financing debt for firms that want their green bonds to be certified.

Several studies have presented theoretical models where investors are willing to give up financial benefits to invest in environmentally friendly or socially responsible assets (e.g., Friedman and Heinle, 2016). Thus, researchers have tried to verify empirically if there exists a green bond premium in the market.

The "*greenium*" is defined as the difference in yield between a green bonds and regular (*brown*) bonds. A lot of authors investigated over this matter, finding different, thus not

[1] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/european-green-bond-standard_en

exhaustive, results. According to theory such difference should be negative: issuance costs are higher for green bonds thus firms will recover those extra costs lowering the coupon rate and socially responsible investors, that are expected to incorporate environmental benefits in their returns to investments, will accept a lower yield to maturity.

Empirical evidence is instead mixed, though several studies found no statistically significant evidence of greenium (Larcker and Watts (2019) and Flammer (2020)), Tang and Zhang (2020) found results in accordance to theory, reporting a reduction in the YTM of 6.94 bsp. This, however, becomes irrelevant after a fixed effect regression controlling for individual issuer effects. Also Bachelet et al. (2019) found evidence of negative greemium but only for institutional issuers, for private issuers, in fact, a significantly positive greenium was found. Moreover, private issuers without third-party verification appear to have relatively higher premia for green bonds with respect to verified ones, suggesting that lower transparency increases asymmetry of information between issuers and investors, generating doubts over the greenness of the bond and leading to the necessity of an higher yield to maturity at issuance.

Most studies adopted a bonds matching method or used fixed effects regressions. The authors that found no greenium in the market suggested that investors view green and brown bonds by the same issuers as almost exact substitutes when risk and payoff are held constant, so they are not willing to pay a premium for the assets.

In this analysis we tried to determine if there exists a greenium in the market using a broad data sample composed of both green and brown bonds from different non-financial issuers across several geographical areas and we employed both the fixed effects regressions method and the matching.

Our results are similar to those found in Larcker and Watts (2019) and Flammer (2020): green and brown bonds have on average the same yield to maturity, implying that the green bond premium does not exist.

We believe that a greenium cannot exist in the market, as supported by the analysis, for a few reasons. Firstly, ethic investors are not a big share of bonds' buyers and they are also usually retail investors. Hence, the biggest part of the market, especially investment funds, do not pay special attention to the environmentally friendly activities of firms, but more about bonds yields. Moreover, it is plausible to think that those firms that issue green bonds are willing to accept a higher cost of debt with respect to brown bonds, so leaving equal yield to green and brown bonds, in exchange for improving the image of the firm among stakeholders.

# 2 Data and methodology

## 2.1 Data

The source of the dataset is Refinitiv Eikon and reports all corporate bonds issued from 2019 by non-financial firms with fixed coupon and no optionality features. The sample is composed by 31,370 bonds and it contains information about the issuer, coupon rate, yield to maturity maturity date, issue Date, principal currency, country of issue, amount issued and sector. In order to be able to conduct our analysis, we cleaned the dataset by dropping all the duplicates. We also had 2 other variables that we dropped: Issuer Ticker and ISIN, the former because it contains the same information as Issuer, the latter as it presented too many missing values.

To conduct FE analysis we turned our data set into a panel by generating a variable taking different values according to different issuers (our "time" variable) and a dummy variable taking value 1 if the bond is green, zero otherwise. In the regression the coefficient of this dummy will precisely capture the greenium, because it will only depend on the difference between a green bond and a brown bond, without being influenced by other variables.

Then we generated the variable $year$, which catches only the year of $IssueDate$ and the variable $TTM$ (time to maturity, in years) as $(Maturity - IssueDate)/365$. We assumed that the yield to maturity refers to the YTM at time of issuance, not at the time when the data was extracted.

Finally, we focused on the Yield to maturity and dropped all the missing values and outliers that could cause distortions bydropping all the values of the YTM reporting a value smaller than zero (5 obs.) and also all the units beyond the $99^{th}$ percentile of the cumulative distribution (187 obs.). After such transformations, our sample was composed of 18379 observations, containing data on 4532 issuers, in 39 sectors, across 36 different countries and 27 currencies.

Them, to perform the matching analysis, we restricted the sample only to the firms which issued at least one green and one brown bond. The limited number of observations could seem reductive for the type of analysis, but it should be enough to extract useful conclusions.

Table 1 shows the summary statistics of the relevant numeric variables.

Table 1: Summary statistics

| | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|
| Green bond dummy | .0537483 | .2255265 | 0 | 1 | 18475 |
| Yield to maturity (%) | 4.774834 | 2.220836 | 0 | 18.433 | 18475 |
| Coupon rate (%) | 3.679923 | 2.08818 | 0 | 13.375 | 18475 |
| Time to maturity | 7.963719 | 8.164337 | .0986301 | 100.7233 | 18472 |
| log of amount issued | 18.77099 | 1.444842 | 9.10498 | 22.97655 | 18379 |

## 2.2 Methodology I - FE regression

Our first approach was based on a fixed effect regression. We treated the data as panel, which allowed us to control for unobserved variables that are constant at the issuer level.

We estimated 3 different model specifications:

$$\text{YTM}_{ij} = \beta_0 + \beta_1 d_{ij}^{\text{GB}} + \beta_2 r_{ij} + \beta_3 \text{TTM}_{ij} + \boldsymbol{\beta_4} S_{ij} + \boldsymbol{\beta_5} T_{ij} + \beta_6 A_{ij} + \varepsilon_{ij} \tag{1}$$

$$\text{YTM}_{ij} = \beta_0 + \beta_1 d_{ij}^{\text{GB}} + \beta_2 r_{ij} + \beta_3 \text{TTM}_{ij} + \boldsymbol{\beta_4} S_{ij} + \boldsymbol{\beta_5} T_{ij} + \varepsilon_{ij} \tag{2}$$

$$\text{YTM}_{ij} = \beta_0 + \beta_1 d_{ij}^{\text{GB}} + \beta_2 r_{ij} + \beta_3 \text{TTM}_{ij} + \varepsilon_{ij} \tag{3}$$

where $\text{YTM}_{ij}$ is the yield to maturity at issuance of bond $j$ of firm $i$, $d_{ij}^{\text{GB}}$ is a dummy indicating if the bond is green or not, $r_{ij}$ is the coupon rate of bond $j$ of firm $i$, $\text{TTM}_{ij}$ is the time to maturity in years of bond $j$ of firm $i$, $S_{ij}$ is a matrix of seniority dummies, $T_{ij}$ is a matrix of years dummies, and $A_{ij}$ is the amount issued of bond $j$ of firm $i$.

Moreover, we used a robust s.e. estimator to eliminate the risk of distortion from heteroskedasticity of the errors.

### 2.3 Methodology II - Matching

Our second approach to estimate the *greenium* follows a methodology similar to Flammer (2021). We did bonds matching, that is, copuling a green bond to a brown bond, at the firm level, by similarities in coupon rate, time to maturity and amount issued (taking logs of the latter). We rounded coupon rate to the nearest 0.25%, time to maturity (in years) to the nearest 0.25 years, and the log of amount issued to the unit. Then chose those bonds that, for each issuer, shared the same values. After the matching, we ended up with a sample of 288 bonds.

We then ran a two-sample t-test on the yield-to-maturity of green and brown bonds to see if there exists a significant difference between both types of bonds. The objective of this method is to compare bonds that only differ in the fact that they are green or not, but that are otherwise very similar.

## 3 Results

### 3.1 Analysis I - FE regression

Table 2 shows the estimates for $\beta_1$, $\beta_2$ and $\beta_3$ from the regressions specified previously.

Model (2) restriction is $\beta_6 = 0$ and its p-value is 0.234. This means that, after controlling for other factors, the amount issued is not significant.

Model (3) restriction (w.r.t. model (2)) is $(\boldsymbol{\beta}_4', \boldsymbol{\beta}_5')' = \mathbf{0}$. The related p-value was null, hence we had to reject the idea. Also, model (3) showed a drop in the $R^2$. Yet, we kept the model just for reference.

From the structure of our models, we can interpret $\beta_1$ as the difference in yield to maturity between a green and a non-green bond once other effects have been partialled out (i.e., the *greenium*). In each model, the green bond dummy significance test showed that we cannot reject the idea of it being 0. Therefore, the data did not bring evidence to support the existence of the *greenium*.

As the theory suggests, The data showed a positive relation between TTM and YTM and between the coupon rate and YTM.

Table 2: Regressions results fo Yield to maturity

| | (1) | (2) | (3) |
|---|---|---|---|
| Green bond dummy | -0.00805 | -0.00733 | 0.0472 |
| | (0.0358) | (0.0358) | (0.0343) |
| Coupon rate | 0.142*** | 0.139*** | 0.160*** |
| | (0.0170) | (0.0167) | (0.0155) |
| Time to maturity (years) | 0.0196*** | 0.0198*** | 0.0178*** |
| | (0.00217) | (0.00215) | (0.00214) |
| $N$ | 18376 | 18472 | 18472 |
| $R^2$ | 0.149 | 0.148 | 0.100 |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### 3.2 Analysis II - Matching

Table 3 shows the results of the t-test on the matched green and brown bonds. The estimated *greenium* is not statistically significant (p-value $\approx 0.75$).

Table 3: T-test of matched bonds

| | Non-green bonds | Green bonds | Diff. | p-value (diff.) |
|---|---|---|---|---|
| Yield to matutity | 3.266384 | 3.331929 | -.0655449 | .7515042 |
| $N$ | 288 | | | |

## 4 Conclusions

The analysis we conducted provided no evidence in favor of greenium existence, neither positive or negative as the coefficients we should have captured its presence resulted statistically insignificant, no matter the method applied.

Such results could be fitted by an entire spectrum of explanations, anyway, we decided to focus on the two extremes of it, as our analysis is quite limited and, given that, we cannot argue for a specific one. On the one side of the spectrum we depict a world in which, given the absence of mandatory standards over what a "green" bond is, what differentiates a green and a brown bond is just the name, with all bonds issued being de-facto brown. The other extreme interpretation is to consider green bonds not the product of greenwashing by firms but the result of their true commitment with all companies undergoing quite expensive certifications and constraining the money raised through green bonds to specific, environmentally friendly, initiatives.

In the first scenario, the absence of regulations results in no increases in issuance costs. This prevents companies from reducing coupon rates, as there are no increased costs to back up for, resulting in green and brown bonds having the same yield to maturity, ceteris paribus. In this setting, both institutional investors, buyers of green bonds, and companies, issuers of them, would experience gain in terms of image with no direct monetary losses.

In the second scenario, instead, companies would face increased issuance costs but decide to bare them, maintaining the coupon rate they would have set if the bond were to be brown so as to benefit in terms of reputation and image, potentially attracting more and more investors and thus compensating the direct monetary losses at issuance.

The possibility to discriminate between the two interpretations is limited by the nature of our study as we were not able to gain data on which green bonds were certified and which were not. Further limitations of our work concern the econometric analysis: model (1), (2) and (3) may not be the right specification for the DGP model and thus the inference we made could be biased. in addition, by running a FE regression we control for fixed effects at the firm level, however, there could be a bias coming from the omission of important variables changing between different bonds. Moreover, The sample we adopted for the matching analysis is quite limited (288), though comparable with the ones of other studies, such as Flammer (2020).

# 5 References

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