Greenium: Myth or Reality - Do Green Bonds have Lower Yields?

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Abstract This paper investigates the yields of green and brown bonds by employing regression analysis and controlling for the sector and several other conventional variables that may influence yield. The study is conducted on a sample of over 5,000 bonds, with more than 650 green bonds. All bonds are collected from the investment grade government, supranational, and/or corporate bond universe, issued in currency EUR. The study results showed that there is no significant difference between the yields on green and conventional bonds, for the government and corporate sector. For these sectors, green and conventional bonds are seen as perfect substitutes. However, green bonds of supranational institutions seem to have significantly lower yields than conventional bonds.

Keywords: • green bonds • yields • greenium • conventional bonds

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https://doi.org/10.4335/2023.3.21 ISBN 978-961-7124-14-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

Green bonds, as novel financial instruments, are gaining increasing attention in both professional and academic discourse. Green bonds are fixed income instruments, quite similar to conventional bonds. Same as with conventional bonds, an issuer of a green bonds is obligated to repay the principal at maturity, known as face value, and periodical coupons. The only difference between the two is that money collected from green bonds is to be used for projects, assets, and business activities that are considered to be "green", i.e. to have a positive effect on the environment (Ketterer et al, 2019). Other actors and financial institutions in the international financial market engage in these transactions as they wish to be responsible, but also to signal their green orientation. Due to these differences, there are anecdotal claims, especially among practitioners, that the yields of green bonds are lower than those of conventional bonds.

This study aims to evaluate if the positive effects resulting from the Corporate Social Responsibility and/or Environmental, Social and Governance orientation of companies have any additional benefit for investors in the international financial market. That is, the study will raise the question if investors, while evaluating different asset classes, implement sustainability in this process, besides the core variables of financial assets such as risk and return. The premium that is achieved by green bonds over conventional bonds with the same characteristics is recognized as "greenium" (i.e. green premium) (Alessi et al, 2019). On that note, Fama and French (2007) suggested that tastes and disagreements could affect asset prices, and that investors do not hold and value their assets only based on the expected payoffs. Moreover, these effects are not only temporary but, in contrast to conventional economics, they could persist in the long term.

In order to achieve the goal of investigating the potential difference in yields between green and conventional bonds, the study analysed a sample of over 5,000 bonds from the government, supranational, and/or corporate sector. About 15% of bonds in the sample are recognized as green bonds. The research used a quantitative method, that is, regression analysis in which the yield is regressed on a number of variables. The dummy variable is used for the qualitative characteristic of bond being green, in order to evaluate if there is any effect of this variable on the yields of different bonds. The following chapter will depict some of the main theoretical and empirical studies on the topic, followed by the methodological considerations and analysis of results. A discussion of the crucial results will be presented at the end of this study.

2 Literature review

The first green bond was issued by the European Investment Bank (EIB) in 2007, with a tenor of 5 years and it amounted to 600 million euros (Fatica et al, 2021). Afterward, the issuance of green bonds on the international financial market was on a constant rise. According to the Climate Bond Initiative (CBI, 2022) in 2021, the total amount of green bond issuance was almost 600 billion USD, which is almost double the figure from a year

before (in 2020 it was just above 300 billion USD). The highest amount is issued in currency EUR (248 billion), followed by USD (152 billion), and CNY (63 billion). The highest amount of bonds is issued by a corporate sector (non-financials and financials almost equally distributed), to be followed by the governments and government backed entities (CBI, 2022). According to the definition of the CBI, they calculated only bonds that are entirely green, that is, 100% of raised money is used for green purposes. Bearing in mind this immense growth, it is suggested that this topic is highly important in contemporary theoretical and empirical discourse.

Traditionally, the question of calculating bond yields was a technical issue primarily considered by financial statistics (Larsen, 1945). Price is calculated as the discounted value of all future cash flows. However, the discounted rate is not always known, and it should reflect the number of risk factors. Theoretical, but also empirical work suggests that a distinct set of risk factors influence different types of bonds, i.e. government bonds (Poghosyan, 2014), municipal bonds (Hastie, 1972), or corporate bonds (Liu et al, 2009).

Having that in mind, such studies seem to have a similar line of thought, where the bond yields are calculated on the basis of discounting process, while the discount factor includes different types of risks. The thought that there might be greenium, just because of the bond's inherited characteristic of being green, without any reasonable and apparent influence on risk (thus discount factor) seems to be an alternative view to this perspective. Thus, if the greenium exists, there might be some other factors that influence the price/yield on the financial market, outside the traditional view of the risk-return model. Such factors could be related to the Fama and French (2007) discussion on the disagreements and tastes in asset pricing. Specifically, this paradigm suggests that investors are engaged in socially responsible investing, a goal beyond profit, and assume certain tastes for asset classes similar to those in consumption goods (Fama and French, 2007). The second line of thought suggests that green bonds have a lower risk compared to conventional bonds (Fama, 1998). This decreased risk comes from regular monitoring of green bond allocation by third parties that should verify their green label (Löffler et al, 2021). Moreover, there is also an increased risk of conventional bonds due to certain climate change risks (e.g. carbon tax, risk of bad reputation from not doing business in a 'green' way, etc.), which ultimately changes the bond risk profile (Löffler et al, 2021). Thus, if the greenium exists there are two possible theoretical explanations. The first one is the tastes of investors differ, resulting in different prices of assets; and the second is that though these assets are similar in a number of contexts, they inheritably have different risk profiles, and consequently they carry different risks.

However, empirical studies examining the effect of green versus conventional bonds on yields, could not be delivered until a sufficient amount of green bonds is issued, enabling researchers to test this with appropriate models and sample size. As a result of the huge growth of green bond issuance, an increasing number of studies on the topic have been conducted in the last few years. Still, it does not seem that researchers made a definite

agreement on green bond yield i.e. if green bonds have lower, higher, or yield that is the same as conventional.

Baker et al (2018) conducted research on the U.S. corporate and municipal bond market, in order to evaluate the difference between green and conventional bonds. Their result suggested that, indeed, there is greenium. According to Baker et al (2018) the yield on green bonds is about 6 basis points lower than the yield on conventional bonds. Based on the panel data of about 200 bonds, Bachelet et al (2019) studied liquidity and premium on green bonds. This study showed lower yield (thus greenium) and higher liquidity of green bonds on the financial market, though this is only the case if the third party verifies the sustainability of a bond. If that is not the case, it seems that investors are penalising potential 'greenwashing' practices, actually resulting in reverse case where green bonds have lower price than conventional bonds. Kapraun et al (2021) investigated greenium on a large number of green bonds and found that the existence of greenium depends on some preconditions. Namely, they found evidence of greenium for bonds of government and supranational entities, and of corporate bonds with large issue size. Authors pointed out that creditability is an important factor for this premium, thus, these are entities that are considered more credible among the investors in their statements of green practices. Zerbib (2019) also found some evidence of the greenium. The author suggested that the premium on green bonds is significant, albeit small, and equals to 2 basis points. However, Zerbib (2019) recognized one of the main limitations of the study. Namely, in order to achieve a higher sample size, the author collected prices and yields also from some not frequently traded bonds. Thus, they might not accurately reflect their fair value, and consequently, it may lead to biased results for the greenium.

The yield difference between green and conventional bonds was also evaluated by Ehlers and Packer (2017). Authors found that at the primary market, green bonds were priced at greenium of about 18 basis points, relative to conventional bonds. However, they also examined the secondary market and found that there is no significant difference between the yields of green and conventional bonds. Likewise, Lau et al (2022) investigated the existence of greenium on, reportedly, one of the largest databases. They found very modest greenium, of only about one basis point. Having said that, the authors claimed that the greenium varies significantly with respect to different individual bonds, and the biggest factor for that is the risk of greenwashing. Hu et al, (2022) investigated the issue on the Chinese bond market. They found the evidence of a large greenium, essentially higher than that found on the international green bond market, both on the primary and the secondary market.

Larcker and Watts (2019) could attest to the claim that there is no consensus on this issue. Namely, these authors suggested that there is no significant difference between the price and yield of green and conventional bonds. If the risk and cash flows are controlled for, the green bond is a perfect substitute for the conventional bond, leaving no room for any form of greenium. That is, authors claim that investors are completely unwilling to trade any wealth in order to invest in sustainable projects (Larcker and Watts, 2019). On the

other hand, Karpf and Mandel (2017) presented opposing results to those that found greenium. Their study on the U.S. municipal bonds showed that the market is penalising green nature of the bond. This means that green bonds have a higher yield than comparable conventional bonds, calculating that the difference is about 8 basis points.

The overall review of the empirical literature suggests no consensus. Some studies found that the greenium is significant and relatively high (Hu et al, 2022; Ehlers and Packer, 2017; Baker et al, 2018), other authors found that this effect is relatively modest to low (Zerbib, 2019; Lau et al, 2022), while some authors claim that the greenium does not exist or it is negative, especially as a result of investors being repulsed by potential greenwashing practices (Larcker and Watts, 2019; Karpf and Mandel, 2017).

3 Methodology

In order to investigate the effect of the nature of sustainability of the bonds on the yield, the author of this study develops the standard equation for bond yields implemented by a number of authors in previous studies, such as Karpf and Mandel (2017), Baker et al (2018) or Fatica et al (2021). The study, however, includes a larger set of control variables, in an econometric model as follows:

$$Yield_i = \beta_0 + \beta_1 * Green_i + \beta_2 X_i + \cdots + \beta_n X_n + u \quad \textbf{(1)}$$

Where $Yield_i$ is the variable that represents the yield of each individual bond used in the sample, and *Green* dummy variable that takes the value of 1 in the case that the bond is green, and 0 otherwise. Besides these variables, a number of control variables that theoretically could influence the yield is used. Thus, the variables that are used are:

- *Yield*, a dependent variable that represents the yield of each individual bond used in the sample,
- *Green*, binary (dummy) variable that takes the value 1 if the bond is green and 0 otherwise. The sign and significance of this variable is what has been investigated in the study.
- *Duration*, representing modified duration of the bond. This is a measure of risk that represents the change in the value of the bond in the case that the interest rate changes, that is, it measures the sensitivity of the bond to interest rate changes. As such, we expect a positive sign for this variable, having in mind that the higher sensitivity (but also usually longer tenor bonds) requires higher yields in order to be attractive to investors.
- *Coupon*, represents the current period coupon. When the period coupon increases, the price of the bond decreases, meaning that the yield will increase. Thus, coupon is expected to have positive sign.
- *Rating*, this is the variable that quantifies the rating of the bond. Namely, if the bond has a rating of AAA, it has been assigned the highest value (in this study 11), if it has one notch lower rating, AA1, it is assigned a lower number (in this study that is

10), and so on. The lowest rating bond has a rating of BB2. Having in mind that, when the variable rating is increasing, we would expect that the yield is decreasing, thus, expecting a negative sign for this variable.

- *Option*, is the binary variable taking the value of 1 if the bond has a call option, and 0 if it doesn't (that is if the option is plain vanilla – bullet, having in mind that there weren't any bonds with the put option in the sample). One would expect a positive sign with this variable, having in mind that when this option exists, there is a higher risk for investors, which, thus, seek higher yield.
- *SubType*, referring to the subordination type of a bond. This is a quantitative representation of the variable, where it records higher value when the bond is secured and lower numbers when it is subordinated/unsecured (at different levels assigning them different values). Thus, having in mind that the higher number means lower risk for the investor, it will also mean lower yield, suggesting that one can expect a negative coefficient with this variable.
- *FaceValue*, which is a variable that represents the total outstanding value of the bond. It is usually reported that this could be a signal for liquidity of the bond, which results in lower risk with higher face value, suggesting that this variable has a negative sign of the coefficient.
- *AI*, which stands for accrued interest, recording the amount of coupon that is collected from the last coupon period until the date of data collection. The effect of accrued interest on yield is not straightforward, but it is suggested that the higher accrued interest (as cash flow received at present time) carries a lower risk, thus, it would be associated with the lower yield. This means that the accrued interest is expected to have a negative sign of the coefficient.

This study is conducted on a sample consisted of over 5,000 bonds from the investment grade government, supranational, and/or corporate bond universe, issued in EUR currency. About 15% of these bonds are recognized as green bonds, and the remainder just below 85% are conventional bonds. All bonds are collected from six indices of Bank of America, which are:

- GREN – ICE BofA Green Bond Index. This is the only index that is modified for the purpose of this study. Namely, only bonds that are issued in the currency EUR are collected, while those in other currencies (USD, CAD, etc.) are disregarded. This was done because all other bonds are bonds issued in EUR.
- E5AS – ICE BofA 1-10 Year All Euro Government Index, thus, government bond index.
- EB05 – ICE BofA 1-10 Year Euro Financial Index, an index of corporate bonds, where only financial companies are taken into account.
- EQ05 – ICE BofA 1-10 Year Euro Quasi-Government Index, which is an index of supranational institutions.
- EJ00 – ICE BofA Euro Industrials Index, and EK00 – ICE BofA Euro Utility Index, are both indices that are used for non-financial bond evaluation.

Based on that sample, this study will test five forms of the model (1). First will take into account all bonds in the sample, thus, 656 green bonds and 4,653 conventional bonds. Having tested the complete datasets, it seemed necessary also to test different types of bonds and this possible effect on yield. Thus, there were four additional models:

- For government bonds, consisted of 59 green and 254 conventional bonds,
- Supranational bonds, consisted of 125 green and 933 conventional bonds,
- Non-financial corporate bonds, consisted of 297 green and 2,341 conventional bonds, and
- Financial corporate bonds, consisted of 175 green and 1,125 conventional bonds.

Data was collected for the end of the day on 15 September 2022. Moreover, while indices were used to collect bonds and other information on them, each individual bond needed to be checked for non-green indices in order to check it, as bonds in generic indices could also be green bonds.

4 Results of analysis

Prior to elaborating on the regression results, some of the main descriptive statistics of the variables used in the model will be presented. This is outlined in the table 1-3, showing the mean and standard deviations of some of the main variables for the complete dataset and subsamples. It seems that there are no significant differences in average yields in each of these cases, except with non-financial corporate bonds, where the average yields on the green bonds are higher than the average yields on conventional bonds. Almost as a rule, the average duration of green bonds is higher than the average duration of conventional bonds, except in the case of financial corporate bonds. While average coupons are relatively close, the outstanding value of issuance is more or less similar, except in the case of government bonds, where larger issuance is recorded within green bonds (for other types, larger issuance is higher with conventional bonds). Reviewing the data on subordination type and maturity type, it seems that there are no significant differences between the dataset of green and conventional bonds. One significant difference for average rating seems to be for non-financial bonds. In summary of this segment, it seems that the only difference is a higher average rating of green non-financial corporate bonds (compared to conventional non-financial corporate bonds), but also the higher average yield. Additional regression analysis will shed more light on this issue.

Table 5: Descriptive statistics for complete dataset

		Complete dataset	
		Green	Conventional
Count		**656**	**4,653**
Yield	**Mean**	**3.353**	**3.250**
	St. Dev.	1.090	1.026
Modified duration	**Mean**	**5.776**	**4.711**
	St. Dev.	4.112	2.930
Coupon	**Mean**	**1.128**	**1.366**
	St. Dev.	1.011	1.171
Outstanding Value	**Mean**	**2,501**	**1,713**
	St. Dev.	6,467	4,407
Accrued interest	**Mean**	**0.501**	**0.672**
	St. Dev.	0.525	0.752
Rating	**Mean**	**5.454**	**5.617**
	St. Dev.	2.750	2.771
Subordination type	**Mean**	**4.738**	**4.739**
	St. Dev.	0.670	0.791
Option	**Mean**	**0.512**	**0.509**
	St. Dev.	0.500	0.500

Table 6: Descriptive statistics for government and supranational bonds

		Government bonds		**Supranational bonds**	
		Green	Conventional	Green	Conventional
Count		**59**	**254**	**125**	**933**
Yield	**Mean**	**2.249**	**2.230**	**2.484**	**2.489**
	St. Dev.	0.638	0.692	0.407	0.664
Modified duration	**Mean**	**5.839**	**4.731**	**8.123**	**4.516**
	St. Dev.	5.147	2.533	6.037	2.387
Coupon	**Mean**	**1.512**	**1.554**	**0.635**	**0.881**
	St. Dev.	1.721	1.795	0.640	1.134
Outstanding Value	**Mean**	**19,970**	**15,372**	**1,336**	**1,635**
	St. Dev.	11,028	11,952	1,793	1,785
Accrued interest	**Mean**	**0.613**	**0.679**	**0.292**	**0.454**
	St. Dev.	0.902	1.029	0.335	0.712
Rating	**Mean**	**6.712**	**6.890**	**9.224**	**9.032**
	St. Dev.	3.226	3.283	2.116	2.623
Subordination type	**Mean**	**5.000**	**5.000**	**5.000**	**5.009**
	St. Dev.	0.000	0.000	0.000	0.139
Option	**Mean**	**0.000**	**0.000**	**0.016**	**0.025**
	St. Dev.	0.000	0.000	0.125	0.155

Table 7: Descriptive statistics for corporate bonds

		Non-financial bonds		**Financial bonds**	
		Green	Conventional	Green	Conventional
Count		**297**	**2,341**	**175**	**1,125**
Yield	**Mean**	**3.771**	**3.485**	**3.635**	**3.623**
	St. Dev.	1.065	1.029	0.971	0.844
Modified duration	**Mean**	**5.911**	**5.173**	**3.848**	**3.905**
	St. Dev.	3.169	3.423	1.912	1.952
Coupon	**Mean**	**1.304**	**1.498**	**1.051**	**1.449**
	St. Dev.	0.812	1.029	1.066	1.196
Outstanding Value	**Mean**	**629**	**697**	**621**	**807**
	St. Dev.	233	297	242	402
Accrued interest	**Mean**	**0.596**	**0.752**	**0.452**	**0.684**
	St. Dev.	0.485	0.704	0.477	0.769
Rating	**Mean**	**6.016**	**4.298**	**4.931**	**5.244**
	St. Dev.	3.269	1.748	1.709	1.859
Subordination type	**Mean**	**4.879**	**4.940**	**4.223**	**4.037**
	St. Dev.	0.498	0.428	0.945	1.240
Option	**Mean**	**0.892**	**0.806**	**0.394**	**0.410**
	St. Dev.	0.310	0.396	0.489	0.492

Table 8: Regression results

	Complete dataset	Government bonds	Supranational bonds	Non-financial bonds	Financial bonds
Constant	**5.220*** **	**3.037*** **	**4.657*** **	**6.095*** **	**4.457*** **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Green	**0.017**	**-0.097***	**-0.153*** **	**0.064**	**-0.006**
	(0.573)	(0.065)	(0.001)	(0.211)	(0.899)
Duration	**0.080*** **	**0.081*** **	**0.046*** **	**0.099*** **	**0.173*** **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Coupon	**0.076*** **	**0.031**	**0.061** **	**0.130*** **	**0.117*** **
	(0.000)	(0.103)	(0.024)	(0.000)	(0.000)
Rating	**-0.188*** **	**-0.164*** **	**-0.140*** **	**-0.277*** **	**-0.208*** **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SubType	**-0.294*** **		**-0.217***	**-0.421*** **	**-0.121*** **
	(0.000)		(0.053)	(0.000)	(0.000)
Option	**0.171*** **		**0.843*** **	**0.231*** **	**0.128*** **
	(0.000)		(0.000)	(0.000)	(0.000)
Outstanding Value	**-0.028*** **	**-0.002**	**-0.021** **	**-0.293*** **	**-0.206*** **
	(0.000)	(0.263)	(0.013)	(0.000)	(0.000)
AI	**-0.057*** **	**-0.114*** **	**-0.139*** **	**-0.039**	**0.020**
	(0.006)	(0.001)	(0.001)	(0.242)	(0.499)
R squared	**0.508**	**0.735**	**0.471**	**0.384**	**0.573**
F test (prob.)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level.

The table above depicts the main results of the study, suggesting about the nature of the greenium. As already mentioned, five regression models were tested, the model with the complete dataset, and models with separately (i) government bonds, (ii) supranational bonds, (iii) non-financial corporate bonds, and (iv) financial corporate bonds. These models have the same independent variables, except in the case of government bonds, where all bonds were of the same subordination type and having no call option. One can observe quite different levels of the explanatory power of the model. As such, non-financial bond yields were explained the least, with just above 38% of the variability of yield that is explained. On the other hand, government bond yields were explained quite

comprehensively, where six independent variables are able to explain more than 73% of the variability of yield.

It seems that most of the variables used are statistically significant in most of the models. As such, duration is highly significant in all of the models, with the sign in line with a theoretical explanation. This is also the case with rating, subordination type, accrued interest, and outstanding value (as a signal for liquidity of the bond) that with an increase are reducing risk, thus lowering yield. Variable rating is highly statistically significant and among the most important variables that are affecting yield, supporting some results of previous empirical studies (e.g. Zerbib, 2019). Therefore, all of the control variables are in line with theoretical expectation, while each model, suggested by F stat is highly significant. This could be a good indication that the models used are robust and inferences that are obtained regarding variable of interest - green, sound.

However, reviewing the results for the variable green, it could be seen that in three models this variable is not significant at any conventional level of significance. Moreover, for the model of government bonds, it is significant only at a 10% level of statistical significance. Thus, it could be claimed that for government, non-financial corporate, and financial corporate bonds, yields do not differ significantly between green and conventional bonds. Only for the model of supranational bonds, the variable green is significant and negative. This would mean that green supranational bonds have lower yields than conventional supranational bonds. As an effect, supranational institutions may be in a position to raise money for sustainable projects cheaper than for other projects. Also, these results support the theoretical claims that investors might have certain tastes and attitudes towards certain ways of investing in assets, as suggested by Fama and French (2007). On the other hand, investors might be reluctant to invest in other forms of green bonds (e.g. government or corporate), as they could mistrust the issuer or be afraid of greenwashing.

5 Conclusion

The international financial market records the growing amount of green bond issuance. In contrast to conventional bonds, green bonds are used for projects that have “green” agenda. The green and conventional bonds are, for most parts, homogenous, except in their stated purpose, which for green bonds is related to helping to achieve a sustainable environment. This paper examined if there is a greenium i.e, if the price of green bonds is higher than the price of conventional bonds to compensate for this additional benefit, which consequently means they have a lower yield. This would mean that issuers would have lower costs of borrowing for green projects; hence, it would serve as an additional incentive for investing in environmentally friendly projects.

This paper regressed the yields of bonds on a number of variables suggested by the theory, but also included the binary variable denoting if the bond is green or conventional. The study was done on the secondary market collecting the data from the investment grade government, supranational, and/or corporate bond universe, issued in currency EUR.

Results suggest that the government and corporate sector bonds are perfect substitutes, with no significant difference in yields. Greenium is, however, found for supranational institutions, where green bonds have significantly lower yields than their conventional counterpart.

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