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Does Green Yield?

An analysis of the ‘greenium’ of green bonds

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ABSTRACT

In this thesis, the effect of a bond being tagged as green on its yield-to-maturity is studied. This was studied for US corporate bonds, traded between 2015-mid 2022. This is analysed by using a multivariate OLS (Ordinary Least Squares) regression, with yield-to-maturity as dependent variable and a dummy variable indicating whether or not the bond is tagged as green as independent variable of interest. Data on the yield and on control variables is extracted from the Wharton Research Data Service (WRDS) Corporate Bond Database. Data indicating whether or not the bond qualifies as 'green' is extracted from the Bloomberg Fixed Income Database. A very slight, but significant, discount (positive correlation between the bond being green and its yield), was observed. This implies that although green corporate bonds are priced at a slight discount, in general they are relatively similar priced to ordinary corporate bonds. No 'greenium' is thus found.

Keywords: Corporate bonds; Green bonds; Environmental; Social and governance (ESG); Sustainable Finance

JEL codes: G12; G14; G20; Q56

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CHAPTER 1 Introduction

The ESG (Environmental, Social and Governance) policy of companies is a hot topic. ESG policy encompasses a wide range of issues, including climate change, diversity and inclusion, human rights, corporate governance, and supply chain management. Enterprises want to show (and have to report) their awareness regarding corporate social responsibility (Arvidsson & Dumay, 2022). The financial market adapted to this, by creating green financial instruments, such as green bonds. The European Union Taxonomy Regulation (Taxonomy Regulation, 2020), defines when bonds can be labelled as green bonds. These standards are based on the Green Bond Principals, established by the International Capital Market Association (ICMA, 2021). These green bonds are bonds of which the yield (or an amount equal to the yield) is used for the financing/re-financing of sustainable (thus, ‘green’) projects, that are in line with the key-components of the Green Bond Principles (ICMA, 2021). The first green bond, then called a ‘climate awareness bond’, was issued by the European Investment Bank in 2007. More types of green loans and bonds hereafter quickly emerged. The financial industry plays an important role in the transition towards a circular economy (Schoute, 2022). This is illustrated by the increasing popularity of green bonds (Fatica et al., 2021). Green financing is also a topic that gains academic interest. Stroebel & Jeffrey (2021) showed that the effects of green finance on the transition towards a sustainable economy is regarded as a topic of importance by participants in the financial industry (i.e. academics, professionals etc.). Green financial instruments are attractive for companies to show their ESG awareness, these instruments are however regarded to come at a cost. According to Stubbington (Financial Times, 2021), ‘green’ bonds in general trade at a premium compared to their ‘conventional’ (i.e. non-green) peers, but this spread seems to be steadily decreasing. Measuring the yield-difference is however said to be difficult as comparable peer-bonds are not always available (Stubbington, 2021).

In the literature related to the yield of green bonds, there is no clear consensus on whether or not green bonds trade at a premium compared to their conventional peers. Zerbib (2019) found that there is a small premium for green bonds in comparison to conventional bonds. Karpf & Mandel (2017) on the contrary found that green US municipal bonds trade at a lower price (higher yield) than comparable conventional bonds. Baker et al. (2018) concluded quite the opposite. By regressing the after-tax yield of green US municipal bonds (a different method than used by Karpf & Mandel (2017)), they found that green bonds were sold at a premium. Bauer & Hann (2010) analyzed that public (listed) corporations with environmental concerns generally face a higher cost of debt. This was confirmed by Oikonomou et al. (2014) and Wenxia Ge & Liu (2015), who concluded that firms with a good corporate social performance are rewarded with lower corporate bond yields.

Although no clear consensus can be discerned, it seems that the general opinion is that green bonds tend to trade at a premium (the so-called ‘greenium’) compared to conventional bonds. The market for green financial instruments is however rapidly evolving and, as Stubbington (2021) and

Kanamura (2020) pointed out, the ‘greenium’ seems to be decreasing/disappearing. It is therefore relevant to study whether or not the term ‘greenium’ is (still) valid in relation to green bonds. Next to this, most studies regarding the yield of green bonds were conducted using municipal bonds (e.g. Baker et al., 2018) or did not focus on a specific type of bond solely (e.g. Zerbib, 2019). It is imaginable that there is a pricing difference between bonds issued by governmental entities, compared to corporate institutions. This study will therefore focus on more recently issued US corporate bonds, as less research on these types of bonds is conducted. The main research question is therefore the following:

Are ‘green’ labelled US corporate bonds, traded between 2015 - mid 2022, priced at a premium?

In order to answer this question, an ordinary least-squares regression will be used. Similar methodology was used by Baker et al. (2018), who measured the ‘greenium’ of US municipal bonds. The dependent variable will be the yield-to-maturity of the US corporate bonds in the sample. The independent variable of interest will be a dummy variable, indicating whether or not the bond is labelled ‘green’. Several control variables will be included in the model, in order to evade an omitted variable bias. Such control variables are the maturity of the bond, the credit rating of the bond, the total offering amount and the coupon rate of the bond. To assure the reliability of the results obtained with the OLS regression, a fixed effects panel regression (with fixed bond and fixed time effects) will also be run. This way it can be checked if the OLS regression results were biased due to omitted time-invariant variables.

The necessary data will primarily be obtained from Wharton Research Data Services (WRDS). WRDS offers a cleaned database for research on US corporate bonds. The dataset includes data on the monthly returns of over a million US corporate bond observations from mid 2002 till mid 2022. All variables of interest for this study (i.e. coupon amount, coupon rate, credit ratings, offering amount, time-to-maturity etc.) are included in this dataset. A slight shortcoming (with regard to this particular study) is that no variable that distinguishes between green bonds and conventional bonds is included in the dataset. This issue can be overcome by using additional data provided by Bloomberg. Bloomberg (2015) labels bonds as ‘green’ based on the Green Bond Principles, constructed by the International Capital Market Association (ICMA, 2021). These bonds thus qualify as green bonds under the EU Taxonomy Regulation (Taxonomy Regulation, 2020). In the WRDS dataset an identification variable indicating the issue number (ISIN) is included. A similar variable is also included in the Bloomberg Fixed Income dataset, which allows for linking the two datasets.

My hypothesis of finding a slight premium for green bonds was rejected based on the results of this study, as a very slight positive correlation between the corporate bond being green and the yield of the bond was observed, indicating a very slight discount for green bonds. However, the hypothesis of a decreasing/disappearing premium on US corporate bonds could be carefully confirmed, as the results indicate no premium. The effect of merely using corporate bonds, instead of a mix of bond types seems minimal.

The structure of this thesis is as follows. In the second chapter, the main literature related to this topic is reviewed. In the third chapter, the data on which this research is based is explained and analyzed. In the following chapter, the methodology that is used to arrive at the results of this thesis is presented. In chapter five, the results of this research are presented and discussed. In the chapter 6, conclusions based on the results of this research are drawn. At last, in chapter 7, limitations of the conducted analysis will be discussed.

CHAPTER 2 Theoretical Framework

Several authors have compared the yield of bonds labelled as ‘green’ with the yield of conventional bonds. A few authors studied a similar topic as this paper by applying a different research method. These publications will be discussed in this chapter and the general ideas that follow from these publications will be presented.

2.1 Related research

Zerbib (2019) studied the yield differential between green bonds and conventional bonds from 2013-2017. The study did not focus on a specific bond type, as a matching method was used to link green bonds to conventional bonds with similar characteristics. After pairing the bonds, a two-step regression procedure was applied, to analyse the yield differences. It was found that green bonds trade at a slight negative premium (thus, lower yield) compared to their conventional peers. Furthermore, the paper concluded that this negative premium was more striking for financial bonds and bonds with a lower rating.

Li et al. (2022) found that a premium on Chinese green bonds exists. They found that the yield spread is different between green bonds that are labelled and green bonds that are meeting the same criteria, but are not (yet) labelled as green. The yield spread for non-labelled green (Chinese) bonds is larger.

Baker et al. (2018), find that green municipal bonds are traded at a premium compared to conventional (municipal) bonds. They used similar methodology as the methodology used in this thesis (see chapter 4) to arrive at their results. Unlike Li et al. (2022), they found that the pricing effect for certified green bonds is larger than for uncertified bonds.

Ehlers & Packer (2017) also found that green bonds are issued at a higher price than conventional bonds. They concluded however that post-issuance performance of green bonds is not much different compared to conventional bonds. Green bonds are however more – opposite to what one might expect – exposed to environmental credit risks.

Tang & Zhang (2020) had similar findings. By regressing the yield spread on different variables, their findings suggest that green bonds have slightly lower yields at issuance. However, their findings are overall not very significant and they conclude that there is little evidence for a significant premium of green bonds compared to regular corporate bonds. Next to this, they found that issuance of green bonds positively affects a company’s stock price. The reaction of the stock market is stronger when issued by a corporation, compared to a financial institution. Overall, they conclude that shareholders profit from issuance of green bonds.

Bachelet et al. (2019) matched green bonds with ‘brown’ bonds with similar characteristics. Like Zerbib (2019) a matching method was used in order to link green bonds with suitable peers, whereafter a (OLS) regression was applied. They surprisingly found that green bonds overall have higher yields, show higher liquidity and are slightly less volatile. The authors suggest that green bonds might trade at a slight positive premium and green investments may thus be financed at a discount. They suggest that this might be caused, contrary to the findings of Ehlers & Packer (2017), by green investments being less exposed to stakeholder risks. However, when analyzing institutional/private issuers separately, the authors found a negative premium for institutional green bonds, but a positive premium (discount) for private green bonds. Which aligns with the findings of this thesis, namely the existence of a slight positive premium (discount) for green US corporate bonds.

Karpf & Mandel, (2017) also suggested that green bonds trade at lower prices/higher yield compared to 'brown' bonds. However, in a later research performed by these authors (Karpf & Mandel, 2018) they suggest that this discount has turned around in the recent years and became a premium (for green municipal bonds). Making green bonds an increasingly attractive investment for firms. It is interesting to compare this statement with the findings of Kanamura (2020), who suggest that the 'greenium' is disappearing/decreasing, implying that the superiority of green bond investments compared to conventional bonds is decaying. This shows that the 'greenium' is changing and evolving, more research is thus useful.

Hachenberg & Schiereck (2018) find a difference between the trading prices of corporate green bonds and governmental bonds, when comparing them with their non-green peers. Corporate green bonds trade tighter (lower yield) compared to their conventional peers. For government-related bonds this is the opposite. Furthermore, they find that *inter alia* issue size and maturity (controls that are also used in this thesis) do not influence the bond pricing significantly.

Larcker & Watts (2020) showed some criticism on the existing studies, mainly on Karpf & Mandel (2017) and Baker et al., (2018). They concluded that when applying a more realistic market setting and using a very tight matching method, the 'greenium' is essentially non-existent, when comparing green securities with almost identical non-green securities. This study focusses on the municipal (green) bond market.

Flammer (2021) noted that little research on corporate green bonds is available. By using the same methodology as Larcker & Watts, (2020) (a tight matching method), but applying this to corporate bonds merely, it was found that – consistent with Larcker & Watts's (2020) findings – there is no pricing difference between green and brown corporate bonds.

From the analyzed articles it follows that there is no clear consensus on whether or not green (corporate) bonds trade at a premium. There seem to be differences between types of bonds (i.e. corporate, municipal, treasury etc.). Green financial instruments are quite immature and their pricing seems to be evolving. Especially extensive, recent research on green corporate bonds is lacking. Also noticeable is that different methodology often leads to different results.

2.2 Hypotheses development

In order establish a solid understanding of yields and bond pricing, literature explaining and deepening the conceptual framework on the research topic of this thesis is also reviewed. In line with the analytical framework constructed by Fama & French (2007), I hypothesise to observe the existence of a slight premium for green-labelled bonds in comparison to conventional bonds. Based on their framework, investors with a preference for green financial assets are accepting lower (expected) returns on these assets. This suggests that green bonds should trade at a premium (thus lower yield) compared to conventional bonds. From a conceptual point of view, this is understandable as green bonds are likely to involve fewer future risks, which could justify a higher price. As most of the literature on this topic confirms the existence of a premium for green bonds, it is hypothesised to find similar results in this thesis. This implies that finding a negative relation between the bond being green and its yield-to-maturity is expected. Subsequently, the effect of merely using US corporate bonds (in contrast to other studies) in relation to the size of the 'greenium' will be interesting to observe. As corporate bonds are generally considered to be riskier compared to governmental bonds, they tend to trade at a lower price (higher yield). The volatility in yield is larger for the riskier corporate bonds and it can thus be expected that the yield of corporate bonds is more affected by 'being green'. This is also in line with the suggestion of Bachelet et al. (2019) that green bonds issued by private issuers trade at a discount, while green bonds issued by institutional issuers trade at a premium. Hachenberg & Schiereck (2018) do however suggest that when comparing green corporate bonds, with green governmental bonds, the corporate bonds trade tighter, suggesting a lower yield spread. Which indicates that the premium is larger for corporate bonds. This adds to the hypothesis of finding a premium for US green labelled corporate bonds. In the more recent literature on this topic (Larcker & Watts (2020) and Flammer (2021)) it is on the contrary concluded that no 'greenium' exist. This confirms the idea of Kanamura (2020) and Stubbington (2021) of a decreasing 'greenium'. Based on the existing literature on this thesis' topic, there are thus indications for a (larger) premium for green corporate bonds, however, also indications suggesting a small/non-existent premium or even a discount. Based on the majority of the literature, the hypothesis is therefore that a small negative correlation between the bond being green and the yield-to-maturity is likely to be observed.

CHAPTER 3 Data

3.1 Database description

The data that was used for this thesis research is extracted from two different databases. Data on the yield-to-maturity of different US corporate bonds traded between 1 January 2015 and 30 September 2022 was extracted from the Wharton Research Data Services (WRDS) Corporate Bond Database. The WRDS Corporate Bond Database is a cleaned database, of which the main data source is TRACE. TRACE is a facility to which bond over-the-counter fixed income security transactions are reported. All data on US corporate bonds is cleaned and made user-friendly by WRDS.

The WRDS Corporate Bond Database also includes several other (besides the yield-to-maturity) variables. Among these variables are identification variables and variables describing the characteristics of the bonds. The identification variables are string variables, such as identifier codes (i.e. Bloomberg Identifier, ISIN, TRACE Bond Symbol, CUSIP ID etc.), relevant dates (issue, maturity etc.), and more. The variables on the bonds characteristics are (primarily) numerical variables describing the bonds yield, coupon rate, time-to-maturity, offering price, offering amount, and more. Variables indicating the rating of the different bonds are also included. Both numerical ratings, as well as string variable ratings (AAA is highest rating) are included. The dataset includes ratings constructed by S&P, Moody and Fitch. The WRDS Corporate Bond Database consists of a total of 59 variables describing and characterizing the different bonds. The WRDS Corporate Bond Database contains data on the monthly returns of bonds traded since July 2002, until end September 2022, with over two million US corporate bond observations.

A slight shortcoming for the sake of this thesis research is that the WRDS database does not specify/contain a variable indicating whether or not the bond qualifies as green. Data on whether or not the bonds included in the WRDS database qualify as ‘green’ bonds is extracted from the Bloomberg Terminal fixed income database. Bloomberg (2015) labels bonds as ‘green’ based on the Green Bond Principals constructed by the International Capital Market Association (ICMA, 2021). According to Bloomberg (2015) the definition of a labelled green bond is as follows: “Labelled green bonds are fixed income instruments for which the proceeds will be applied towards projects or activities that promote climate change mitigation or adaptation or other environmental sustainability purposes.” For the labelling of green bonds, Bloomberg takes into account a) self-labelling as ‘green’ by the issuer, and/or b) additional statements from which the company’s commitment to deploy funds towards environmentally and sustainability-orientated projects follow. Acceptable funds are very broad (see Bloomberg New Energy Finance (2015), p. 2) and could be, for example, renewable energy projects as well as forestry management. The main criterium is that 100% of the bond proceeds have to be deployed for environmental sustainability-oriented activities.

3.2 Database linking

As the data for this research was extracted from two different databases (i.e. WRDS and Bloomberg), the two datasets had to be linked. Both datasets were imported into Stata18 and linked via a merging method. The bonds from the two datasets were merged based on their International Securities Identification Number (ISIN), a string variable which was included in both datasets. All the green bonds from the Bloomberg dataset were also included in the WRDS dataset, so all green bonds were matched.

3.3 Bond characteristics

Table 1. Characteristics of green and ordinary bonds

	Green					*Ordinary*				
Variable	**Mean**	**Median**	**Min**	**Max**	**Obs.**	**Mean**	**Median**	**Min**	**Max**	**Obs.**
Yield-to-Maturity (%)	0.026	0.026	0.005	0.055	273	0.009	0.029	-1	1	1,058,781
Time-to-Maturity (years)	9.590	7.647	0.042	30.897	273	8.094	4.608	0.003	101.414	1,058,781
Coupon Rate (%)	3.277	3.45	1.95	4.25	273	3.444	3.625	0	32	1,058,127
Offering Amount ($)	647,985	600,000	300,000	1,000,000	273	547,241	400,000	1	15,000,000	1,058,780
Numerical Rating S&P	6.703	8	5	9	273	8.248	8	1	22	747,756
Numerical Rating Moody	5.713	8	3	8	272	8.260	8	1	21	752,541
Numerical Rating Fitch	7.706	8	7	8	126	7.887	8	1	21	505,028

Note: The table shows descriptive statistics per variable. The number of observations changes, as not all information was available for every bond in the dataset. A lower numerical rating (regarding S&P, Moody and Fitch) implies a better rating on the alphabetical rating scale.

The total sample size of corporate bond observations (of bonds traded between 2015-2022) is 1,059,054, of which 1,058,781 observations are of ordinary corporate bonds and 273 observations are of bonds tagged as ‘green’ by Bloomberg (see Table 1). As WRDS reports monthly bond returns, the 273 green bond observations account for a total of six green corporate bonds. The number of traded green corporate bonds is thus fairly low. In the merged dataset, a dummy variable indicating whether or not the bond qualifies as a green bond is included. It shows "1" if the bond is tagged by Bloomberg as 'green' and "0" otherwise.

Table 2. T-test on differences in mean

Variable	***Mean*** *Green*	***Mean*** *Ordinary*	Difference
Yield-to-maturity (%)	0.026	0.009	0.017* (0.009)
Time-to-Maturity (years)	9.590	8.094	1.496*** (0.578)
Coupon Rate (%)	3.277	3.444	-0.168 (0.156)
Offering Amount ($)	647,985	547,241	100,745** (41,251)
Numerical Rating S&P	6.703	8.248	-1.545*** (0.174)
Numerical Rating Moody	5.713	8.260	-2.547*** (0.187)
Numerical Rating Fitch	7.706	7.887	-0.180 (0.223)

Note: A lower numerical rating (regarding S&P, Moody and Fitch) implies a better rating on the alphabetical rating scale. Standard errors are shown in parentheses. The significance of the t-test differences is shown by the stars: * p<0.10 ** p<0.05 *** p<0.01.

On average, the *Yield-to-Maturity*, which is measured in percentage, is higher (1.7% on average) for the green corporate bonds compared to the conventional corporate bonds, at a 10% significance level (see Table 2, row 1). The data on the yield-to-maturity is in hindsight normally distributed (also see Figure 1, Appendix A), but the sample of ordinary bonds does show some outliers, with extreme high/low yields.

The *Time-to-Maturity*, measured in years, of the bonds in the sample varies from a day, up to a maximum of 100 years. On average, green bonds tend to have a longer time-to-maturity (see table 2, row 2).

The *Coupon Rate*, measured in percentage, is found to be on average slightly lower for green bonds than for ordinary bonds. This finding is however not significant. The median coupon rate is also slightly lower for the green bonds, which might support the reliability of the difference in mean.

The *Offering Amount*, i.e. the size of the bond issue measured in USD (number of bonds, multiplied with the face value), is on average significantly higher by USD 100,745,- (5% significance level) for green corporate bonds, compared to conventional corporate bonds. The conventional bond sample might be influenced somewhat by outliers, minimum is USD 1, maximum USD 15 mio.

However, as the conventional bond sample is considerably larger (by over a million bond observations), the effect of these outliers can be considered to be relative.

In the dataset three variables indicating the rating of the bonds were included. Namely, variables indicating subsequently the Standard & Poor's (S&P) rating, the Moody's rating and the Fitch rating. The ratings for S&P and Fitch range from AAA (highest rating) to D (lowest rating), the Moody's rating ranges from AAA to C. The WRDS dataset includes variables indicating the numerical rating of the bond. This variable takes a lower value if the rating of the bond is better. This variable ranges from 1 (AAA- rating) to 22 (D-rating) (21 for Moody's). For all three types of rating, the green corporate bonds show on average a better rating. For the S&P rating the difference is 1.545 rating point, for the Moody's 2.547 (both results are significant on a 1% significance level). The difference is less noticeable (only 0.180 rating point) and insignificant for the Fitch rating. Furthermore, it is important to note that not for all variables in our dataset, the rating was reported. The sample size thus reduces when taking the rating into account. The S&P rating is included for 748,029 bond observations (1,059,052 is the total sample size of the dataset). For all 273 green bond observations the S&P rating is reported. The Moody's rating is reported for 752,813 bond observations, of which 272 are green. The size of the sample in which the Fitch rating is included is somewhat smaller, this rating is reported for 505,154 bond observations, of which 126 are green. As this is a substantial drop in the number of observations of green bonds, it is decided to not include the Fitch rating in the regression analyses of this thesis.

CHAPTER 4 Method

4.1 Choice of Method

The importance of a suitable methodology is not to be underestimated for this field of study. As described in the theoretical framework section (Chapter 2), previous studies using a different methodology tended to reach quite different results (also see Larcker & Watts (2020)). From the existing literature, it follows that there are two main methods that could be used. Namely, an OLS regression (not yet used for corporate bonds), in which the dependent variable is yield-to-maturity and the independent variable of interest green/non-green (dummy). This method was used by, among others, Baker et al. (2018) and Li et al. (2022). But not yet for corporate bonds specifically. The other method is a matching method, in which a green bond is matched with an ordinary bond with similar characteristics (except for the green/non-green) characteristic. This way differences in the bond's yield can only be caused by the effect of the bond being green or not. This methodology was used by, among others, Zerbib (2019), Larcker & Watts (2020) and Flammer (2021). Flammer (2021) is the first that used this methodology for green corporate bonds specifically.

The OLS regression method has not yet been performed for corporate bonds specifically, while the matching method has. Furthermore, the sample of corporate green bonds is very small. Only six green bonds are being traded, but these bonds are observed monthly, the number of observations is thus larger (273 corporate green bond observations). Therefore, in this research an OLS regression without matching method will be used to analyse the effects of a US corporate bond being green or not on its yield.

4.2 Primary Method

In order to examine the effects of a US corporate bond, traded between 2015-mid 2022, on its yield-to-maturity, the following multivariate regression model is constructed:

$$Yield_i = \alpha_0 + \beta_1 Green_i + \sum \beta_2 \boldsymbol{bond\_controls_i} + \varepsilon_i$$

$Yield_i$ refers to the yield-to-maturity of US corporate bond *i*; $Green_i$ is a dummy variable indicating whether or not the bond *i* is tagged as green by Bloomberg; $bond\_controls_i$ are several control variables indicating the characteristics of bond *i*. The control variables include: *Time-to-Maturity*, *Coupon Rate*, *Offering Amount* (issue size) and credit rating variables (S&P, and Moody's). Table 1 (see Chapter 3) defines the descriptive statistics for all variables in the model. Note that the Fitch credit rating control variable is excluded from the regression analyses, as including this variable would cause a too substantial drop in the number of green bond observations.

The OLS regression method is a suitable method for this research as with this method the relationship between one or more independent variables and a dependent variable can be measured. In this research, that is the relationship between the greenness of a bond and its yield. By minimizing the sum of the squared difference between the observed and the predicted values for each observation, a straight regression line can be constructed. The larger the sample the more likely it is to find significant results. As the sample of this research is large and fairly normally distributed (see Figure 1, Appendix A), this method suits the data. Other assumptions that need to hold in order for this method to be suitable are: linearity (a linear relationship between the independent and dependent variable), independence of the observations, no existence of multicollinearity (highly correlated independent variables) and homoskedasticity/no heteroskedasticity (constant variance of the residuals). It is believed that this thesis' dataset satisfies these assumptions. However, to eliminate the possibility of heteroskedasticity in the model, heteroskedasticity robust standard errors will be applied to the regression models. At last, it is important to note that Stata18 automatically eliminates variables for which multicollinearity shows from the regression model, this did not occur in this research's regression tests. It is therefore believed that the OLS regression model suits the collected data and reliable results can be obtained using this method.

For this research, multiple regression tests have been run. Firstly, a regression including only the dependent variable (i.e. *Yield-to-Maturity*) and the independent variable of interest (i.e. *Green*) has been run. After this, the regression was run several times again, each time adding a new control variable. This way the robustness of the regression results could be checked, as a significant change in the coefficient of the variable *Green* when a new control is added could imply that the results are not robust. In total seven OLS regression tests have been run.

4.3 Secondary Method

The choice of method is important, as previous research on this topic has shown that a different methodology can lead to different outcomes (Larcker & Watts, 2020). In order assure the validity of the results obtained by the multivariate pooled OLS regression model used in this thesis, a panel regression with fixed firm/bond and time effects will also be applied to the data.

The difference between the two methods (OLS and panel regression with fixed effects) lies in the fact that the panel regression accounts for time-invariant differences between the bonds. The data of this thesis suits this method, as the WRDS dataset reports monthly returns for the bonds included in the dataset, there are thus multiple observations per bond. The bond returns (i.e. yield) are thus observed across time. The dataset therefore qualifies as panel data.

By controlling for the fixed characteristics of the bonds, the coefficient of *Green* will not be influenced by these fixed effects. The estimated coefficient of *Green* and the control variables will therefore not be biased by omitted time-invariant characteristics. By applying this method, omitted variable bias that is caused by heterogeneity in the data can thus be avoided, as the panel data controls for unobservable or unavailable/non measurable effects that are correlated with the independent variable *Green*. The obtained coefficient of *Green* then represents a common effect across the bonds, while time and individual bond heterogeneity is controlled for.

There are two types of fixed effects that can be controlled for: Firm/bond fixed effects and Time fixed effects. Bond fixed effects consist of variables that are constant over time, but vary across the bonds. In this research the *Bond Type* (Debenture, Medium Term Note, Medium Term Note Zero) and the credit rating (S&P and Moody's) will be used as Bond fixed effects. Time Fixed effects are variables that change over time but are constant across the bonds. In this research the variable *Month* will be used as Time fixed effect. *Month* refers to the monthly point in time at which the bond returns were reported. The WRDS dataset includes monthly returns for each bond. This monthly reporting moment is the same for all bonds in the dataset. Similar fixed (firm and time) effects were used in the paper of Baker et al. (2018).

For the fixed effects panel regression, the bonds were clustered in groups based on their ISIN identifier code. This resulted in 16,181 groups when credit rating fixed effects were controlled for and 81,887 groups when only fixed time effects (*Month*) were taken into account. The total number of unique bonds in the full dataset is thus 81,887 bonds (of which six bonds are green). The time variable was the monthly reporting date.

In order to assess the effects of a bond being green on its yield while controlling for time and bond invariant effects, the following regression formula was used:

$$Yield_{i,t} = \alpha_i + \beta_1 Green_{i,t} + \sum \beta_2 \boldsymbol{bond_{controls_{i,t}}} + u_i + \varepsilon_{i,t}$$

$Yield_{i,t}$ refers to the yield-to-maturity of US corporate bond *i* at time *t*; $Green_{i,t}$ is a dummy variable indicating whether or not the bond *i* at time *t* is tagged as green by Bloomberg; $bond\_controls_{i,t}$ are several control variables indicating the characteristics of bond *i* at time *t*. α_i refers to the unknown intercept for each bond *i*. u_i, is the error term within bond *i*, $\varepsilon_{i,t}$, refers to the overall error term. The control variables include: *Time-to-Maturity*, *Coupon Rate*, *Offering Amount* (issue size).

In this research, multiple fixed effects panel regressions have been run. Firstly, a regression test that did not include any control variables, but did control for both bond and time fixed effects. Subsequently, the same regression only controlling for time fixed effects, because the sample for this regression is larger since credit rating fixed effects are excluded. Hereafter, the same two regressions were ran including the control variables. See Table 5 for the results of these regression tests.

Similar to the standard OLS regression model (see paragraph 4.2), heteroskedasticity robust standard errors will be applied to the fixed effects panel regression tests, to avoid the possibility of heteroskedasticity in the models.

By applying this secondary method, the robustness of the primary method – the pooled multivariate OLS regression – can be tested. Obtaining (relatively) similar results from the fixed effect panel regressions, forms an indication of the the OLS regression model being robust. As this indicates that the OLS model is not biased due to time-invariant omitted variables.

CHAPTER 5 Results & Discussion

5.1 OLS regression results

Table 3. Regression results

	Yield (1)	Yield (2)	Yield (3)	Yield (4)
Green	0.017***	0.013***	0.019***	0.017***
	(0.001)	(0.001)	(0.001)	(0.001)
Time-to-Maturity		0.002***	0.001***	0.001***
		(0.000)	(0.000)	(0.000)
Coupon Rate			0.017***	0.016***
			(0.000)	(0.000)
Offering Amount				0.000***
				(0.000)
Constant	0.009***	-0.011***	-0.057***	-0.061***
	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted-R^2	0.000	0.024	0.099	0.102
Obs.	1,059,054	1,059,054	1,058,400	1,058,400

Note: Yield-to-Maturity is the dependent variable. Green is the independent variable of interest. The other variables are control variables. Green is a dummy variable. Each column shows a different regression, with more/less variables included. In each regression, yield-to-maturity is the dependent variable. The model uses heteroskedasticity robust standard errors. The numbers in parentheses show the standard errors. The significance of the t-test differences is shown by the stars: * p<0.10 ** p<0.05 *** p<0.01.

Table 4. Regression results including credit ratings

	Yield (1)	Yield (5)	Yield (6)	Yield (7)
Green	0.017***	-0.002*	-0.000	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Time-to-Maturity				0.001***
				(0.000)
Coupon Rate				0.003***
				(0.000)
Offering Amount				0.000***
				(0.000)
Numerical Rating S&P		0.007***	0.005***	0.005***
		(0.000)	(0.000)	(0.000)

Numerical Rating Moody			0.002***	0.001***
			(0.000)	(0.000)
Constant	0.009***	-0.017***	-0.016***	-0.031***
	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted-R^2	0.000	0.200	0.204	0.240
Obs.	1,059,054	748,029	715,635	715,635

Note: Yield-to-Maturity is the dependent variable. Green is the independent variable of interest. The other variables are control variables. Green is a dummy variable. A lower numerical rating (regarding S&P and Moody's) implies a better rating on the alphabetical rating scale. Note that the Fitch credit rating is excluded from the regression analyses, as too many green bonds had to be excluded from the sample when adding this variable. Each column shows a different regression, with more/less variables included. In each regression, yield-to-maturity is the dependent variable. The model uses heteroskedasticity robust standard errors. The numbers in parentheses show the standard errors. The significance of the t-test differences is shown by the stars * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

The results from the OLS regressions that have been run for this thesis can be found in Table 3 and Table 4. Table 3 includes the results for the regressions in which the control variables *Time-to-Maturity*, *Coupon Rate* and *Offering Amount* are subsequently added to the model. For each of these regression tests, it shows that a bond being green has on average a slight positive effect on the bond's yield. Implying the price of a green US corporate bond is on average lower than that of a conventional US corporate bond. Adding the control variables *Time-to-Maturity*, *Coupon Rate* and *Offering Amount* subsequently to the model does neither change the sign, nor the magnitude (substantially) of the effect of the bond being green on the yield, which implies that the model is robust. From the first four regression tests, shown in table 1, it can be concluded that on average the effect of the bond being green positively affects the yield with 1.3-1.7 percent. The control variables do, based on the results presented in Table 1, on average not seem to have a large effect on the bonds' yield. The most notable effect is that of the *Coupon Rate*, which influences the bonds yield on average positively. A one percent increase in the *Coupon Rate* will, on average, increase the *Yield-to-Maturity* with 1.6-1.7 percent. All regression results in table 1 are highly significant (on a 1% significance level). This applies to both the dependent variable of interest (i.e. *Green*), as well as the control variables. The adjusted R-squared value is however fairly low, especially for the regression in which only the variable *Green* is included (for this regression the adjusted R-squared is equal to 0.000). This implies that the model is not able to explain much of the variation in the bonds' yield-to-maturity.

Interestingly, when adding the credit rating control variables (i.e. *Numerical Rating S&P*, *Numerical Rating Moody*), the size of the positive effect of the bond being green on its yield reduces. This indicates that there is likely to be a correlation between both the credit rating and the bond being green and the credit rating and the *Yield-to-Maturity*. The significance of the results also reduces. In regression analysis 5 and 7 (with only *Green* and credit rating variables included, see Table 4), the results for variable *Green* are very small and not very significant. In the full regression model with all (control) variables included (regression model 7, Table 4), the results are however still highly significant (1% significance level). In this model the positive effect of the bond being green on the *Yield-to-Maturity* is, on average, only 0.3 percent. Indicating that there is a very small, but significant higher yield for green bonds on average. Which would imply that green US corporate bonds trade at a slight discount compared to conventional US corporate bonds (the green bonds are thus slightly lower priced). The effect of the credit ratings on the bonds' yield is very small (but significant). On average, a higher numerical credit rating (which implies a lower alphabetical rating) increases the bonds' yield slightly. Which is not surprising, as lower rated bonds are logically lower priced. Also, worth noting is that in the full regression model with the credit-rating variables added (regression model 7, Table 4), the coefficient of *Coupon Rate* reduced substantially, to only 0.003. This implies that a one percent increase in the *Coupon Rate* increases the *Yield-to-Maturity* with only 0.3 percent.

The adjusted R-squared value of the full regression model (regression model 7, table 4) with all control variables included increased to 0.240, which is still relatively low. This implies that there are most likely still unconsidered variables that have a substantial influence on the bonds' yield-to-maturity.

5.2 Fixed effects panel regression results

Table 5. Fixed effects panel regression results

	Yield (8)	**Yield (9)**	**Yield (10)**	**Yield (11)**
Green	-0.003	0.023***	0.020***	0.000
	(0.002)	(0.002)	(0.007)	(0.001)
Time-to-Maturity			0.001***	0.001***
			(0.000)	(0.000)
Coupon Rate			0.016***	0.002***
			(0.000)	(0.000)
Offering Amount			0.000***	0.000***
			(0.000)	(0.000)
Constant	-0.031***	0.009***	-0.059***	0.023***
	(0.000)	(0.000)	(0.001)	(0.000)
F-statistic	1.51 (df = 1; 16,180)	137.53*** (df = 1; 81,886)	2138.76*** (df= 4; 81753)	858.26*** (df = 4, 16,180)
Adjusted-R²	0.481	0.021	0.118	0.515
Obs.	715,635	1,059,054	1,058,400	715,635
Number of bonds	16,181	81,887	81,887	16,181

Fixed Effects				
Rating (S&P en Moody's)	Yes	No	No	Yes
Bond Type	Yes	No	No	Yes
Month	Yes	Yes	Yes	Yes

Note: Yield-to-Maturity is the dependent variable. Green is the independent variable of interest. The other variables are control variables. Green is a dummy variable. With regard to the fixed effects; 'Yes' shows when the fixed effect is included in the model, 'No' when it is not. Rating and Bond Type can be regarded as fixed firm effects. Month refers to the month in which the bond returns are reported and is thus a fixed time effect. Note that the Fitch credit rating is excluded from the regression analysis, as too many green bonds had to be excluded from the sample when adding this variable. The numbers in parentheses show the standard errors, except for the F-statistics row, where it shows the degrees of freedom. The model uses heteroskedasticity robust standard errors. The significance of the t-test differences is shown by the stars * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

To test the validity and robustness of the primary method of this research (i.e. the multivariate pooled OLS regression) a fixed effects panel regression was performed, including fixed bond and fixed time effects. Table 5 shows the results obtained with this method. Only when controlling for merely fixed time effects, significant results were obtained (regression 9 & 10). These results indicate, similar to the standard OLS regression results (Table 3 & 4), a positive correlation on average between the bond being green and its yield. The F-statistics of the regression models in which significant results were obtained (regressions 9 &10) are high, implying that all the coefficients in the model are jointly different than zero. The control variables do not indicate noteworthy different results than obtained from the normal OLS regressions. Although significant results were obtained, the extent to which the models (regression 9 & 10) are able to explain the variance in *Yield* is questionable, as the adjusted R-squared value of these models is very low (0.021 and 0.118 respectively). The adjusted R-squared value of regression model 8 and 11 is higher (0.481 and 0.515 respectively), however these models do not obtain a significant result for the coefficient of *Green*. This is likely caused by the fact that these models include credit rating as a fixed effect and the sample of bonds for which the credit rating is included is substantially smaller.

In conclusion, the reliability of the results obtained with this secondary methodology is somewhat low. However – as this is the reason that this secondary methodology was applied – the results support the results obtained with the multivariate pooled regression model, namely the existence of a positive correlation between the bond being green and its yield. The standard OLS model (see paragraph 5.2) can thus be considered reliable and not biased by time-consistent omitted variables.

5.3 Robustness

When only considering the OLS regression model, it can be stated that the robustness of the full regression model (regression 7, Table 4) is somewhat questionable. Although at first adding more variables to the model did not seem to change the coefficient of the independent variable of interest

Green (see Table 3), the inclusion of the credit-rating control variables did change the size of the coefficient of *Green*. This implies that this variable might not be fully independent of other variables that are not included in the model. This is confirmed by the low adjusted R-squared value of the full model, which is 0.240 (see regression 7, table 4). This low value shows that the model is not able to explain all variation in the yield-to-maturity. The model could thus suffer from some omitted variable bias.

A reason for the change in size of the coefficient of *Green* when the credit-rating variables are added to the model, could possibly lay in the fact that when these variables are included, the regression model is based on a substantially smaller number of observations. This is due to the fact that not for all US corporate bonds (traded between 2015 - mid 2022) credit-ratings were included in the dataset. The sample on which the regression was run was thus smaller. The effect of this should not be underestimated, as it is a substantial drop in sample size. Namely, in the regression without the credit-rating variables included, the sample size is 1,058,400 bond observations, with the credit ratings included the size of the sample dropped to 715,635 bond observations. It is important to note that even though the overall sample reduced, the sample of green corporate bonds did not reduce (it remained at 272 bond observations). For this reason, the Fitch credit rating variable was not included in the regression models, as this would cause the drop in the total sample size to be even larger and also cause a substantial drop in the sample size of green bonds (to 126 green bond observations). Nevertheless, if the model is fully robust, a change in sample size should not impact the coefficient of the variable of interest much. It can thus be concluded that the regression model might not be fully robust.

When taking into account the results of the fixed effects panel regression, as presented in Table 5, the robustness of the OLS model is more supported. As by using this different methodology, more or less similar results are obtained, namely a positive correlation between the bond being green and its yield. The positive correlation found in the fixed effects panel regression is however larger than in the OLS regression model with all control variables included. It can be concluded that the OLS model is likely not much biased by time-invariant omitted variables. This adds to the robustness of the primary (i.e. the standard OLS model) model. It is therefore believed that valid results that don't suffer much from omitted variable bias have been obtained with the standard OLS model. However, as the adjusted R-squared value is also low for the fixed effects panel regressions (namely, 0.245), there are more factors that have not been included in the model but affect the variance in *Yield*. Not too strong conclusions can thus be drawn based on this model's output.

5.4 Discussion

It is interesting to compare the results of this thesis, with the existing views established in the literature on this topic. The prevailing view in the literature, established by (among others) Baker et al. (2018), Zerbib (2019) and Ehlers & Packer (2017), is that green bonds trade at a slight premium compared to conventional bonds. Larcker & Watts (2020) however concluded that no such premium exists. Flammer

(2021) also did not observe green bonds trading at a premium, when focussing on corporate bonds specifically. The more recent literature on the yield difference between green and non-green bonds thus suggest non-existence of a premium, which is in line with the suggestions of Kanamura (2020) and Stubbington (2021) that the green bond premium is diminishing.

Similar to the paper of Karpf & Mandel (2017) on the 'greenium' of bonds, the findings of this thesis also suggest that a green bonds trade at a slight discount. When adding the credit rating variables to the OLS model (as shown in Table 4) the size of coefficient *Green* reduces (still positive), suggesting that the size of this discount is relatively small. This discount could almost be considered neglectable, as the results suggest (significantly) that the bond being green only increases the *Yield-to-Maturity* with 0.3 percent on average. The results of this paper therefore confirm the view that the premium for green bonds has diminished and even disappeared.

Finding a discount/no premium in the US corporate bond market leaves room for discussion. Intuitively, based on the framework constructed by Fama & French (2007) which suggests investors with a preference for green financial assets accept lower (expected) returns on these assets, one would expect to observe a negative correlation between the bond being green and its yield. However, as Flammer (2021) and Larcker & Watts (2020) point out, this conceptual hypothesis is inconsistent with industry practice. In a survey conducted by the State Treasurers Office of California on green bonds, the survey participants all stated that their firm would not forego yield for green bonds (Chiang, 2017, p. 14). In practice, green bonds have to compete with conventional bonds on price, which could explain the pricing discount/non-existent premium.

The effect of merely using corporate bonds instead of all bond types should also be discussed. Flammer (2021) was the only author that assessed corporate bonds specifically. She used the same methodology as Larcker & Watts (2020) who researched the yield difference of green and conventional municipal bonds in specific. The two papers show similar results for the two types of bonds: no premium. This thesis more or less confirms their findings, since the results of this study also indicate that no premium exists (even a slight discount). From this it could be carefully concluded that there is no essential difference in yield between bond types (corporate or governmental). In general, corporate bonds are priced lower as typically more risk is involved. Even though the study of Hachenberg & Schiereck (2018) implied the opposite, namely that green corporate bonds should be priced higher than green conventional bonds. The results of this study compared with the results of other studies, indicate that the effect of the bond being green on its pricing does not differ substantially for corporate bonds. More research on this could however be valuable, as in this research only focussed on corporate bonds and not on other bond types. No certain conclusions can thus be drawn.

At last, the implication for the financial market as a whole should be discussed. Considering the pricing of green corporate bonds does not seem to substantially differ from the pricing of conventional corporate bonds, moreover even a slight discount seems to exist, one could question if it is advisable for firms to issue green bonds. Green bonds namely restrict firms in their investment policies, as the proceeds of green bonds can only be invested in sustainable projects. There are however, next to the difference in pricing argument (which is thus a weak argument), other rationales for issuing green bonds. First of all, signalling. By issuing green bonds companies can signal their environmental commitment to investors credibly (see Flammer, 2021, p. 500). It is imaginable that the signalling of environmental commitment will gain importance in the coming years, as environmental concerns are increasing. Also, it can be argued that issuing green bonds can be used as a form of greenwashing. Having a green image has several advantages to firms, such as having better access to finance. Cheng et al. (2014) showed that better corporate social responsibility performance leads to less capital constrains. Even though the results from this study show that there does not seem to be a pricing advantage for firms when issuing green bonds, instead of conventional bonds, there are other advantages that should not go unnoticed.

5.5 Hypotheses discussion

The hypothesis formulated in the Theoretical Framework (paragraph 2.2) of a small negative correlation between a US corporate bond being green and its yield, cannot be confirmed. Since the effect of the corporate bond being green on its yield is found to be relatively small, but slightly positive, it has to be concluded that no 'greenium' on US corporate bonds exists. The (sub)hypothesis of a decreasing/disappearing 'greenium', based on the findings of Kanamura (2020) and Stubbington (2021) and the more recent literature of Flammer (2021) and Larcker & Watts (2020) (who observed no 'greenium'), can be partly confirmed, since the results of this study indeed indicate no existence of a premium, more so a slight discount. At last, the expectation that by using a sample of merely corporate bonds, a larger premium would be found (based on the findings of Hachenberg & Schiereck (2018)), also has to be rejected. The results obtained in this thesis are more aligned with the general view of corporate bonds trading at a lower price, as more risk is involved. This is in line with the findings of Bachelet et al. (2019) that green bonds issued by private issuers trade at a discount, although green bonds issued by institutional issuers trade at a premium.

CHAPTER 6 Conclusion

The aim of this thesis was to discern if ‘green’ labelled corporate bonds are priced at a premium. This was researched for US corporate bonds, traded between 2015 - mid 2022. Issuing green corporate bonds is a way for companies to demonstrate their environmental commitment towards investors. It could also lead to better access to other debt financing. The prevailing view in the literature that green bonds trade at a premium seems to be subject to developments. The ‘greenium’ is likely to be decreasing/disappearing. Especially more recent papers suggest the premium to be already non-existent. Little research on corporate bonds specifically has been conducted.

The main method used to research this topic is a multivariate OLS regression with *Yield-to-Maturity* as dependent variable and a dummy variable *Green* indicating whether or not the bond is tagged as green by Bloomberg as independent variable. Next to this, several control variables were added to this model. In order to assure the validity of the results obtained with this method, a secondary method was also applied to the data. Namely, a panel regression, with fixed entity/bond effects and fixed time effects. The results (resulting from both methods) showed the existence of a slight pricing discount for green corporate bonds compared to non-green bonds. It was found that a US corporate bond being green has a slight positive effect on the yield-to-maturity of the bond. This suggests that a small discount for green bonds exists. The existence of a discount is different to what the majority of (older) papers suggests, but in line with the view of a diminishing ‘greenium’. This thesis adds to the existing literature by confirming that the disappearing ‘greenium’ also applies to corporate bonds and might even be more pronounced for these types of bonds. The pricing advantage for firms of issuing green bonds instead of conventional bonds, hence having lower cost of capital, is non-existent.

Despite the fact that the pricing advantage for firms of issuing green bonds, in contrast to what is often suggested, does not seem to exist, other positive effects of issuing green bonds should not be underestimated. Mapping these effects in further research is important, since green bonds are likely to gain importance in the coming years, as climate change has to be mitigated rapidly. Also, continued research on the yield/pricing of green bonds should take place. The market for green bonds is still young and likely to develop and mature in the coming period of time. Furthermore, the views of investors towards green financing and firms CSR performance are rapidly evolving, which could impact the pricing of green financing instruments. These developments should be monitored in future research. At last, even though this study gave some insight in pricing difference between green bonds issued by corporate issuers versus non-corporate issuers (such as governmental issuers), this difference could be more extensively and more specifically analysed in future research.

CHAPTER 7 Limitations

In order to establish a well-founded understanding of the implications of the results found in this thesis research, it is important to touch upon the limitations of the applied research method. Larcker & Watts (2020) provide a critical analysis on the (fixed effects) linear regression methodology used in the paper of Baker et al. (2018) and Karpf & Mandel (2017). According to Larcker & Watts (2020), the regression method that Baker et al. (2018) used is inadequate since the fixed effects that are used as control variables are likely to be ineffective controls, as for example, green issuers may outperform non-green issuers in general (within the sample period). This could lead to bias estimates nevertheless. Larcker & Watts (2020) argue (credibly) that their matching method eliminates this bias and show that a regression method does indeed lead to different results. They however also note, that with regard to municipal bonds the matching method is preferred, but that in the corporate bond market this method might be less applicable. This is due to the fact that in the municipal bond market often very similar green and non-green bonds are issued, which allows for tight matching. This is less so in the corporate bond market, in which the sample of green bonds is way smaller. In this thesis I therefore chose to make use a multivariate (pooled) regression model, but also applying a fixed effects panel regression to check if applying a (slightly) different methodology to the data would not cause the results to be different. Fairly similar results were obtained.

Another critical note of Larcker & Watts (2020) on the papers of Baker et al. (2018) and Karpf & Mandel (2017), is that exempting tax-effects could lead to results that are biased towards a green bond discount. Green bonds are often exempted from taxation, but not all of them are. The effect of a bond being tax-exempt is valuable to consider. For future research on this topic, it is interesting to include the effect of the bond being tax exempt or not in the regression model.

At last, a limitation of this research is that, even though the results are in general highly significant, the adjusted R-squared values of the regression models (of both the normal OLS and fixed effects panel regression) are low. The applied regression models were thus not able to explain most of the variation in the *Yield-to-Maturity*. For future research it could thus be advisable to use a more extended model, with more control variables (and possibly different fixed bond and time effects), in order to capture a larger part of the factors that influence the *Yield-to-Maturity*.

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APPENDIX A Figures

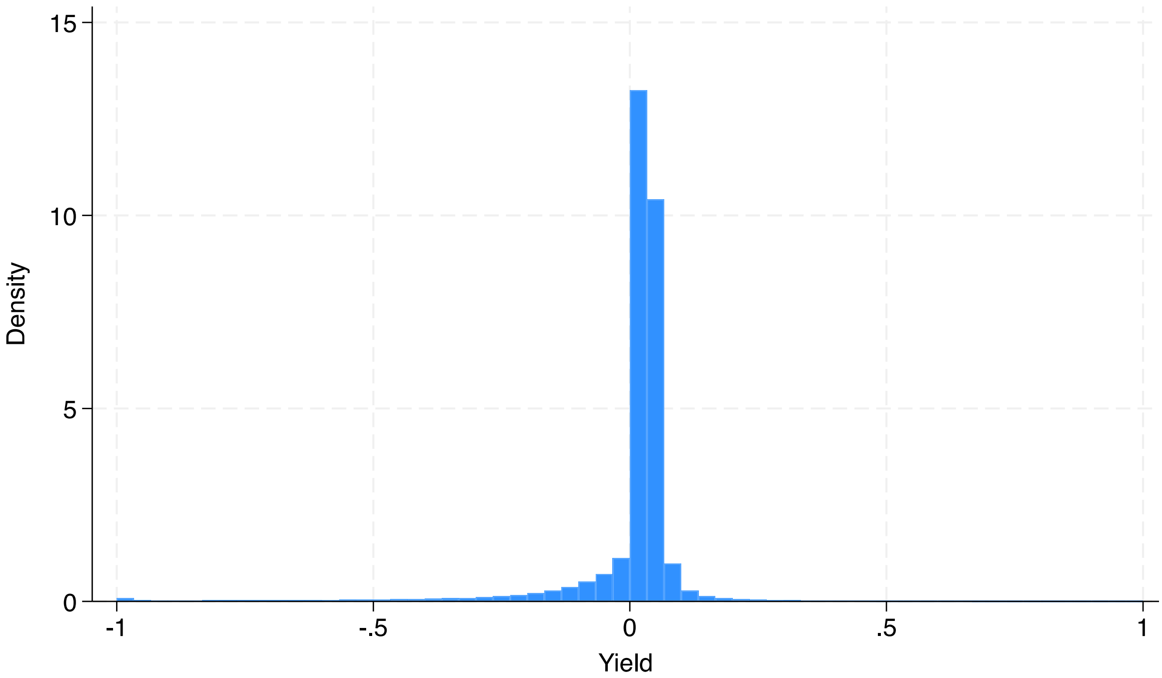

Figure 1 Distribution of Yield Data