Shades of Green: An Examination Into Second Party ESG Ratings In The Municipal Green Bond Market

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Abstract

Since the end of the pandemic the market capitalization of green bonds and investor interest in sustainable investments has grown massively. The tidal wave of ESG funds has accompanied many claims of greenwashing and extreme variation in investment quality. While many investors focus on doing their own due diligence, second party ratings are an important source of information for capturing overall risk and characteristics of a security. This paper aims to take a deeper look at how HIP Investor's (a popular ESG rating firm) ratings correlate to real-world yield and bond characteristics. Yield refers to the annualized return that investors receive from a bond, and lower yields at issuance reduce borrowing costs for the issuer. It is generally established in popular and academic literature that green bond designation does not directly lead to a benefit for issuers in terms of their cost of capital expressed through interest rates. This paper examines the yield at issuance effects for degrees of "actual greenness" and other inputs that may lead to a security to fit well in an ESG focused or impact fund. Within a sample of green bonds, the estimated yield to worst spread premium for a best-in-class (environmentally) ESG issuer is -23.9 basis points compared to a worst-in-class issuer holding all else equal. When considering non-environmental factors such as human health, the effect is larger at -71.4 basis points. For social wealth considerations, the directionality is reversed at 17.9 basis points. More research is needed to better understand and apply these results. This decrease in interest rates can result in millions of dollars of savings for larger issuances.

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Introduction:

While the municipal bond market comprises roughly 4 trillion dollars in outstanding debt obligations (SIFMA), it is underdiscussed compared to the enormous 10 trillion-dollar corporate bond market. Municipal issuers ranging from school boards to water and power agencies to universities all borrow money through this market to fund their projects. The revenues from holding these bonds are almost always tax exempt which leads to lower yields and tighter spreads to the US Treasury benchmark rate. Though often less profitable to asset managers and less studied by financial researchers than corporate bonds, municipal bonds warrant increasing attention, as their issuance results in billions of dollars of tax obligations for the general population. A single basis point increase in pricing could cost a school district thousands of dollars a year, money that comes directly out of their budget and propensity to achieve their goals. Understanding the factors that satiate investor demand and result in lower costs of borrowing are therefore of the upmost importance for borrowers and the general tax base that must eventually make payments.

Many factors affect the way a bond is priced and the interest rate that the issuer must pay. The most important factor is risk – how likely is it that a lender (the bondholder) receives their expected cashflows in full. However, in recent years, sustainable investment has become increasingly attractive to investors through designations referred to broadly as Environmental and Social Governance (ESG). Green bonds are the primary instrument that aims to demonstrate a commitment to the environment, and social bonds are the somewhat more nascent classification that indicates special considerations towards social factors such as equity. Sustainability bonds are more relevant in the corporate bond market than in the municipal market but indicate that an issuance has considerations and relevant disclosures related to both green and social bonds (International Capital Market Association, 2021). There are numerous different emerging labels for bonds such as transition bonds that finance the decarbonization of otherwise "brown" issuers like oil and gas companies that are not eligible to issue green bonds (Herman et al., 2020). The diversity of novel naming conventions for these bonds makes it difficult for many investors to tell from the label alone which bonds are actually funding sustainable projects or sustainable issuers. Conventional wisdom within the industry is that ESG bond designations, such as green-bond designation, do not provide any benefit to issuers in the form of lower yield at issuance (Sower, 2022). Increased demand for ESG related securities is often the result of better information through disclosures (Yang et al, 2021). However, these disclosures are often not mandatory, and can vary widely from issuer to issuer. Furthermore, this stamp is binary and doesn't convey the degrees to which an issuer can adhere to ESG and green principles. These variations lead me to believe that there may be significant differences between the green quality of different green labeled bonds. Even if receiving the label of green does not lower yields in a matched pair specification (Larcker and Watts, 2020), there may be yield effects to be found on the actual greenness of the issuer.

Although many asset managers and investors continue to pour money into ESG labeled funds, the actual impact of their investment is almost always unclear. Without clear methodology and understanding of the impact, investors and companies expose themselves to reputational and regulatory risk (Deloitte, 2022). In order to justify the placement of funds in certain products and projects, many asset managers use ESG rating firms like Sustainalytics or HIP to quantify their investments impact. These metrics can aim to explain the actual environmental impact of the use of proceeds or the greenness of the issuer. They also attempt to explain the "social" score of an issuers DEI or equity commitments, though these can sometimes be more controversial and difficult to explain.

The aim of this paper is to examine the shades of green within the green bond market. This takes the form of increased demand for issuances to fund measures such as sewer/water plants, clean energy, or equitable development that are in line with activist investors goals. Do municipal bonds (munis) issued for the purposes of funding projects that align with ESG principles result in lower interest rate spreads for borrowers? Do proprietary ESG ratings correlate with price at issuance in a way that might result in increased or decreased investor interest?

I answer this question primarily through newly issued bonds' yield to worst at issuance spread to a benchmark index. The use of a spread to a benchmark index is important because general macroeconomic factors unassociated with issuers can massively impact the observed yield at issuance that determines how expensive their new debt obligation is. In a period of high interest rates, the rates that a AAA rated issuer can pay are as high as that of a non-investment grade issuer might have paid in near-zero interest rate times (Bloomberg L.P. (n.d.). BVAL AAA Muni Callable Curve). Furthermore, analysis of yield spreads as a tool of understanding how other factors are affecting the effective cost of borrowing for those who issue in the municipal market is common practice amongst academic research to this day (Bordo, M. D., & Duca, J. V., 2023).

Along with a regression analysis, individual case studies may be helpful in understanding the effect of implementing ESG principles in municipal issuances. There are two places I look for qualitative information: requests for proposals (RFP) from local governments that are considering issuing tax-exempt municipal bonds and in the official statements (OS) of past issuances. These will both contain preliminary and ex-post information from public finance officials regarding their desires or skepticism surrounding seeking green-bond designation.

Overall, in this paper I aim to provide a comprehensive understanding of how ESG principles within the green bond market affect the prices paid by investors in the municipal market. The discovery of a tangible and statistically significant benefit in pricing could change the way in which governments finance their projects and the types of projects they fund. The lack thereof raises interesting questions about potential mispricing from an efficient hypothesis perspective that warrants further research.

Literature Review:

Municipal bonds can be issued by states, cities, counties, and other governmental authorities (Investor.gov). These bonds can also be issued by local governments on the behalf of non-profits such as universities, hospitals and others. Furthermore, certain public private partnerships can be funded with municipal debt which effectively allows for-profit businesses to access the municipal market. Regardless of the obligor, these bonds contain many oddities that make them both more difficult and more interesting to study. The majority of munis – but not all - are issued on a tax-exempt basis meaning that interest earned is not subject to federal taxes (IRS 2019). As a result, the ideal investor is one who would have the highest tax obligation from the gains from the bond. This makes it likely that the average investor for municipal bonds is older and wealthier than the general population. In fact, roughly 60% of all municipal bond holders are over the age of 65 (Municipal Bonds for America).

Whether these bonds are subject to state or local taxes varies from place to place. This tax advantage results in lower yields to maturity than equivalent taxable bonds, and therefore saves money for the issuers. However, the lost income in federal taxes may be a higher price than the benefits that municipal issuers receive. The efficient market hypothesis would expect an even lower than observed yield to account for the foregone tax revenue, idiosyncratic risk and investor demand factors can account for these deviations (Riegel, 2021). Notable examples of where this yield premium comes from include difficulty in purchasing these bonds, lack of general knowledge, or a low percentage of population that can access the full benefits of tax-avoidance at the highest marginal tax rate. None of these explanations sit within the traditional risk weighted return pricing theory, so perhaps the same kind of idiosyncratic factors or investor demand functions for ESG debt could be applied to understand how yields are priced for issuers.

The simplest and most reductionist form of ESG investing is green, social or sustainability bond certification. Whether or not this certification results in a lower yield at issuance (often dubbed the "greenium" or the premium bondholders pay to invest sustainably) has been hotly contested in the decade since the first green bond was issued. The methodology for examining differential pricing effects in the bond market is well established and can easily be applied for the aims of this paper. However, one area of sustainable investing that needs further research is in preventing greenwashing, which is the term used to describe the misleading of investors, stakeholders, or firms about the details of a portfolio fund or company practice in relation to climate change (Dow Jones & Company, 2020). This phenomenon can hurt not just those who are misled, but the funds themselves. Hedge funds that are guilty of greenwashing underperform both genuinely green funds and conventional funds when adjusted for risk (Liang et al, 2021).

Green Bond Premium:

By using a matched pair specification, borrower characteristics can be held constant whilst varying another characteristic that one aims to study. This methodology was used by Crabbe and Turner (1995) to show a lack of liquidity premium in corporate bond markets in 1992 and is potentially a suitable specification for examining a green premium. Prominent research into the existance of a greenium in the municipal markets has already used matched pairs to investigate the existance of a greenium (Larcker and Watts, 2020). This specification is able to hold all of the issuer-specific risk constant and examine how an equivalent green and non-green bond are priced at the same moment in time.

$$t = \frac{1}{N}\sum_{i=1}^{N}(Y_i^G - Y_i^{NG})$$

Y_i^G represents the yield of a green bond match i and Y_i^{NG} represents the yield of a non-green bond match i. By subtracting the yield at issuance of a green bond from the yield at issuance of a non-green bond issued at the same time with identical risk characteristics the difference in yield due to the green designation can be summed and averaged easily.

This analysis is possible because municipal bonds are often split into multiple tranches for different use of proceeds or liens of credit. This feature translates easily into an ESG aware market with green segments and regular segments issued on the same day with the same line of credit available for payments. The only difference between these two tranches is that the green certified segment can only be used to finance projects with certain aims deemed to be green. The classical asset pricing model would imply that because both tranches have the same risk of default the returns paid to bond-holders should be the same. In fact, from Larcker and Watts, 2020 work, the vast majority of the issuances have identical yield structures (no savings for green issuances on any bonds), and on average bond yields were .45 basis points higher for green bonds compared to matched non-green bonds. While this evidence is discouraging, I still believe that there is strong reason to reinvestigate the factors that affect this price within an ESG framework.

Firstly, the study conducted by Larcker and Watts, (2020) was completed prior to the Covid-19 pandemic with only approximately 5 years of data on a new and rapidly growing market. Much has happened since this time. During the Covid-19 pandemic investors preferences for risky assets fell dramatically (Himanshu, 2021), and interest rates went near zero followed by the fastest rise in decades (Board of Governors of the Federal Reserve System, 2022). These macro-economic factors in combination with the fact that ESG investing is becoming increasingly commonplace in the news media and in activist investors' playbooks indicate that the question should be revisited to check for changes. Furthermore, there may be parts of the observed yield that can be explained by the greenness of the overall issuer rather than the specific use of proceeds. If an issuer is willing to issue green labeled bonds, it could send signals of creditworthiness or general fit for ESG portfolios that doesn't necessarily vary from bond tranche to bond tranche. Although matched pair specification is often considered the gold standard, it may not be a viable way to truly answer this question of how greenness affects the yields of new debt. When the issuer characteristics themselves are impacting how green an issuance may be, holding issuer related traits constant may not be ideal.

Yield Isolation Techniques:

Regression techniques for isolating yields from specific factors of the market are well established and easily replicable. I detail a recent study that uses techniques useful to analysis in my paper. Butler and Yi (2021) found that there is a significant, and large relationship between the age of the tax-base liable for the municipal bond debt and the costs of issuance. This leads me to wonder if climate related concerns could be analyzed with a similar methodology. Both age of a tax-base and the climate concerns relating to a project funded by bonds can be considered intertwined in risk of repayment, making this paper an excellent background reference to understanding and disentangling various correlative and causative factors. This effect is found by calculating the yield spread of municipal bonds to a synthetic treasury bond. This spread is then regressed against the variable of interest, aging, and other controls. The full regression is below:

$$Bond\ Spread_{it} = \beta_0 + \beta_1 Aging_{st} + \beta_2' X_{st}^1 + \beta_3' X_{it}^2 + \eta_s + \eta_t + \eta_m + \epsilon_{it}$$

where *i* is an index for the bond, *s* is the state, *t* is the year, and *m* is the month. The vector of variables X_{st}^1 is the vector of state characteristics that act as control for disentangle for other effects that could compromise the regression on age such as migration rate, tax rates, and the state's fiscal health. $X_{it}^2 + \eta_s + \eta_t + \eta_m$ represent bond characteristic to account for macroeconomic trends. Notably credit ratings are not included in the regression because rating reflects default risk, a key part of bond spreads and their question of interest. Their OLS regression ultimately showed a 6.5 basis point increase in bond yields for every standard deviation increase in population age.

Secondary Market Greenium:

German government issuance for identical green bonds priced at lower yield to maturities when compared to conventional bonds over their lifetime (Pastor et al, 2022). They estimate that on average over the bonds lifetimes the greenium (spread between a green and conventional bond) was -4.6bps and that held to maturity the green bond would yield less than a conventional bond.

This is a different analysis than that of Larcker and Watts who solely looked at yield at issuance in their matched pair specification. Yield at issuance is a primary concern to issuers who have to pay more when their interest rates rise, but investors are likely to be most concerned with held to maturity returns and changes in secondary market valuations for bonds held in mark-to-market portfolios. The German green assets outperformed brown assets in recent years due to increased demand on the secondary market driving down yields further as investor preferences changed. It appears likely that if investors continue to reallocate their portfolios towards green assets in anticipation increased demand and higher prices on their green municipal bonds, then increased demand on the primary market should reveal a negative greenium to reflect future capital appreciation expectations.

Data and Descriptive Statistics:

Selection and Sources:

There are two main sources of data used in this paper. The first dataset used in the regression is from the Bloomberg Terminal which is used daily by professions to inform their trading and investment decisions. The time frame of data collected is from January 2013 until November 2022, as green-bond nomenclature for municipal bonds first originated in 2013, and limiting the search to this period eliminates risk of accidentally green-labeled bonds from outside the sample. Within this broader sample, the selection of excluded bond categories follows the same protocol as Larcker and Watts (2020) in their Where's the Greenium paper. Only fixed-rate bonds are used because of the difficulty of obtaining prior rates and unique characteristics from floating rate bonds. Green bonds are first identified in the Bloomberg Terminal as 'Green Purpose' and 'Self-Identified Green.' All federally taxable securities are excluded to keep the tax treatment equal across the sample. When an issuer issues on a taxable basis the yield at issuance is always higher due to investors needing to be compensated for the tax-burden. This difference makes them unsuitable for comparison in the sample. The resulting bonds are fairly boiler plate, but standardization should make any greenium readily apparent.

Nearly of the resulting bonds share the same issuer and/or offering date, but with differing maturity amounts, coupons, maturity dates, and more variable qualities. This is because it is rare for issuers to come to market with a singular bond rather than multiple maturity lengths for their debt. This characteristic of bonds should make it relatively easy to see how varying certain characteristics change yield holding other aspects constant. There are data for the following categories: issuer name, coupon, dated date (the day at which this bond came to the primary market), maturity date, maturity size, yield at issuance, spread at issuance, and CUSIP – a unique identifier. Coupon refers to the payments made prior to the maturity date, often semi-annual or annual. Maturity date is the day the bond pays out the maturity size. I call this maturity size to differentiate from the payments made during the lifetime of the bond through coupons, though all of these payments are discounted to the present and expressed through the yield at issuance. The spread at issuance refers to the difference in yield from the bond to a benchmark. This benchmark is often a treasury bond, useful for its risk-free characteristics, or a AAA average such as the Refinitiv MMD scale or in this paper's case, the Bloomberg BVAL index.

The second source of data used is from Human Impact + Profit Investor (HIP), a securities rating and data collection company. They review and assign ratings to over 235,000 municipal bonds including those from all 50 states, DC, and Puerto Rico. A variety of sectors are rated including state and local governments, universities, public healthcare institutions, utilities, and many more. Although diverse, they do not rate all bonds that are outstanding, so it's important to understand what their selection process is. HIP is a private, for-profit company that receives the majority of their funding from institutional investors who want to better understand two things. There are three situations that lead to a bond receiving a rating by HIP. Firstly, their clients pay to rate assets that they already own to better understand how their portfolio stands in terms of their key impact metrics. Secondly, their clients pay to understand how notable new issuances might fit into their portfolio in order to make investment decisions. Lastly, municipal bonds in index funds (ETFs) are rated to boost the remaining coverage to roughly 90% of the most popular indices. This means that some of the ratings were created for outstanding bonds, and some are rated as they come to market.

HIP rates their chosen bonds across five primary categories: Health, Wealth, Earth, Equality, Trust, and an aggregate Total metric. These characteristics can be thought of as more quantifiable elements that determine ESG. Health, Wealth and Equality map to "social," earth maps to "environmental," and trust maps to governance. The specific inputs to each of the five pillars are proprietary information, and each subsector has differing inputs. For local governments, Earth is determined, in part, by renewable energy consumption. Part of the Wealth pillar for a housing authority is a housing affordability metric. Some pillars may have more than one input or contain zero input metrics and therefore receive no rating for that category. Although many sectors exclude a certain pillar entirely, all bonds in the HIP data set have at least four of the five pillars and all have a score for Total. These categories are given a score between zero and one that goes out to seven decimal places.

Another source of reference materials for this paper are found in the Electronic Municipal Market Access (EMMA) which is an online database provided by the self-regulatory agency Municipal Securities Rulemaking Board (MSRB). All issuers are required to upload their final official statements (OS) to EMMA after a bond sale. The official statement includes final yields, prices, maturity sizes, use of proceeds and other important pieces of information about the issuance. I primarily use this source to verify the accuracy of outliers and otherwise interesting data from Bloomberg and HIP. For example, I examine the fine print of the OS to see if the use of proceeds is accurate for a bond labeled unexpectedly in a certain subsector by HIP.

High-Level Summary Statistics:

Approximately 10,500 green bonds were identified through the Bloomberg Terminal, and roughly 9,500 have not matured yet and are still outstanding. This implies that only ~1000 green-bonds have passed their maturity date, highlighting the infancy of the green-designated market for municipal bonds. However, this quantity of 9,500 is over 3x larger than the ~2,900 number cited by Larcker and Watts (2020). Within the sample of green bonds, the average coupon rate is 4.14%, and the most common (mode) coupon rate is 5%. The average maturity size is approximately $11.5 million. This may seem somewhat low, but it's important to realize that when an issuer comes to market with a green or conventional bond issuance, they are often issuing multiple bonds across the yield curve. The highest single maturity size green bond in my sample is a $950 million term bond for the State of Florida. The increase in total dollar issuance of green bonds is particularly notable when compared to the Larcker and Watts finding of an average issuance size of $5.36 million at the time of their data collection in July of 2018. As a result of the municipal green-bond market maturing, differences from Larcker and Watts result may arise.

The HIP dataset includes roughly 240,000 bonds and uses the same unique identifier as the Bloomberg data, the CUSIP. This makes it trivially easy to match the HIP ratings to the bonds and their characteristics pulled from the Bloomberg terminal. After matching the bonds from both datasets, 4,222 bonds remain in the overall sample, implying that roughly 5,000 bonds in the green bond sample from Bloomberg have not been rated by HIP. Only 99 of the bonds contained ratings for all five pillars, so in order to properly assess all of the green bonds in the sample multiple regressions have to be run. Each of the bonds in Table 1 has been rated by HIP but are not necessarily green bonds. This information is displayed to highlight differences from the original population dataset to green bond only sample. This allows me to get a better understanding of how representative the sample is within the universe of rated bonds. Since the HIP ratings are not universally known, it is important to understand what the reasonable scope of ratings is for each category before looking at the set I am analyzing in Table 2.

Table 1: All HIP Rated Bonds Summary Data

Variable	Obs	Mean	Std. dev.	Min	Max
HIPTotal	239,254	.6056345	.0819421	.0667574	.9853167
HIPHealth	239,247	.613874	.1245238	.002951	1
HIPWealth	221,331	.5664658	.1535482	0	1
HIPEquality	177,031	.5998601	.1485741	.0009131	1
HIPEarth	171,010	.5583055	.1858917	0	1
HIPTrust	118,643	.7520517	.19122713	0	1

Table 2: HIP Summary Data - Green Bonds

Variable	Obs	Mean	Std. dev.	Min	Max
HIPTotal	4,422	.7645678	.0967583	.3564623	.9853167
HIPHealth	4,422	.8134481	.1109441	.4497962	1
HIPWealth	3,597	.4407139	.1917238	0	.8296674
HIPEquality	1,177	.8075591	.1489508	.3799437	1
HIPEarth	3,924	.7577974	.1276669	.3324226	1
HIPTrust	3,819	.8174231	.1710707	.1449224	1

From Tables 1 and 2, we can observe high level characteristics of the sample and the differences in the green-labeled only sample. In Table 1 HIPTotal and HIPHealth have the most observations of any of the pillars with every single bond receiving a HIPTotal rating and only eight observations are missing for HIPHealth. For the green bond sample in Table 2, there are no observations missing with 4,422 observations for both of these pillars. The HIPTrust pillar contains the fewest ratings in Table 1 but contains relatively many in the green bond sample in Table 2. The pillar with the fewest observations is HIPEquality which will significantly limit the sample available in a regression that includes it.

When compared to the sample, the highest rated and the lowest rated bond in every category from the general dataset is also in the green bond set except for in the HIPWealth pillar which contains the 0 rated wealth pillar and does not include the 1 rated wealth pillar. Furthermore, the average ratings within the green bond sample are significantly higher in every regard except for the HIPWealth pillar which is nearly a standard deviation lower from the average of the dataset. In regard to variance, the green bond set is slightly more dispersed for HIPTotal but mixed for the other categories.

Overall, it appears that the green-bond sample is generally of a higher rating quality than the general sample. The question remains on the direction of causality. Does issuing a green-bond lead to disclosures that result in higher ratings, or do more trustworthy and environmentally friendly issuers flock towards labeling their bonds green? Both stories seem plausible. An issuer that does a green-bond assessment may become more aware of their shortcomings and correct for them in the near or long term. Additionally, issuers that have already been improving their commitment to ESG principles are surely more likely to consider green bond designation in the first place. Regardless, the green-bond indicator may be an imperfect signal to investors on their ESG quality, but tends to move in the correct direction. Importantly, these ESG issuers generally have a lower rating for HIPWealth. If this metric is a valid for examining an issuers social well-doing, then it is interesting to see it lower for green issuers and warrants further investigation.

Sectoral Overview:

The subsector breakdown between the entire HIP rated bond population and matched pair sample of green bonds identified by the Bloomberg terminal differs starkly. While the bonds rated by HIP has no majority subsector rated, the most common subsector is K-12 School Districts.

Table 3: Subsector Frequency

Subsector	HIP Population Frequency	Matched Sample Frequency
K-12 School Districts	21.25% (50,840)	3.30% (146)
Cities	14.44 (34,550)	4.48 (220)
Water	12.84 (30,712)	51.83 (2,292)
Universities	9.58 (22,926)	8.86 (392)
States	9.16 (21,912)	2.89 (128)
Road Authorities	8.78 (21,006)	15.31 (677)
Hospitals	6.25 (14,956)	1.90 (84)
Counties	5.56 (13,309)	2.46 (109)
Housing Agencies	4.96 (11,856)	2.22 (98)
Electric Utilities	4.39 (10,505)	6.24 (276)
Community Colleges	2.64 (6,307)	0.00 (0)
Corporates	0.12 (294)	0.00 (0)
Sovereign Countries	0.03 (77)	0.00 (0)
Agencies	0.00 (4)	0.00 (0)

This result makes sense because investors in real portfolios are going to want a diversified set of bonds to ensure that their risks don't all lie within one industry/sector. Furthermore, it is logical that investors that care enough to pay money to get their investments rated or view the existing rating of their bonds would be invested in clearly socially good entities like a school. For more information on how bonds are selected for rating refer to the *selection/sources* section. Only 3.30% of the sample green bonds contain K-12 School District bonds, and it is not readily apparent why so many schools forgo getting their bonds certified as green. It may be the case that many of these bonds have social designations, but that is an investigation for future papers. Note that issuers get certified with the binary green label, whereas generally investors generally prompt a HIP rating.

Within the sample of green bond matches, the majority are categorized by HIP as water (51.83%) and the second most common subsector is road authorities. Water likely is such a large portion of the green bond sample because of how readily apparent it is that municipal water authorities are cleaning water. The subsector itself may be close to definitionally green so certification may seem natural or easier than others that may need to change from their traditional operations more starkly (International Capital Market Association, 2021). This explanation is also sufficient to explain why the second largest subsector in the sample are road authorities. A quick glance through the official statements (accessed through EMMA) of several bond issuances shows that many of these issuances are for public transit initiatives (rails, buses, etc) that provide less carbon intensive alternatives to using personal vehicles.

Having established the most relevant subsectors to the sample and population data, I identify which HIP variables are missing from each major subsector. Full data and correlations are shown in tables in the appendix.

This data primarily serves to aid in informing me of which variables to exclude from the regression and how the exclusion impacts the sample in which I am drawing conclusions upon. I detail here some important exclusions and important subsector correlations that are relevant to the results. Within water, road authorities and Universities, HIPHealth and HIPWealth both have low correlation coefficients and often move in different directions depending on the sector. The only exception is in the cities, counties and states category which has a high correlation value between health and all available pillars. Notably, water, road authorities and electric utilities are all missing HIPEquality. Universities lack HIPEarth. Cities, Counties, and States exclude HIPTrust. Furthermore, some water issuances include wealth, and some do not. All of this was considered when selecting variables and interpreting results.

I hesitate to make any claims that certain sectors that tend to have high ratings in one category tend to do worse in another because the previous tables only looked at the sample of matched green bonds. There was not sufficient time to complete this analysis to a sufficiently in-depth degree, so it has been omitted. Future research into proprietary ESG rating analysis should examine how differing subsectors are rated to better understand intra-market trends.

Empirical Specification:

To assess the impact of variable greenness within a sample of green labeled bonds I first run the follow baseline OLS mixed-effects regression:

$$Spread_i = \beta_0 + \beta_1' \chi_i^1 + \beta_2' \chi_i^2 + \epsilon_{it}$$

where $\beta_1' \chi_i^1$ represents a vector of chosen indicator variables pointing towards the degree of ESG adherence for each bond. In the subscript the *i* represents the specific bond, identified by its CUSIP (a unique identifier). The comma in the superscript of the coefficient indicates that the coefficient is different for each of the variables in the vector χ. The specific variables that are contained within χ_i^1 are detailed in the 'Relevant Variable Selection' section below. $\beta_2' \chi_i^2$ represents control variables, detailed later in this section, to be included in the regression that are unrelated to ESG considerations. *Spread* represents the bond's yield spread at issuance collected from the Bloomberg Terminal specification explained earlier in the paper. This regression form is heavily inspired by Butler and Yi's Aging and Public Financing Costs paper. I chose to follow this specification because it makes it easy to represent and separate the different components that are expected to impact bond spread.

Green Bond Specific Variable Selection:

From the HIP pillar variables discussed before, not all could be included. Inclusion of all available variables would restrict the dataset beyond a usable size due to the missing values for particular HIP variables. Because of this restriction, I choose as many of the explanatory HIP variables as possible without including redundant information or losing the scope of the dataset. Much of the decision came down to correlation coefficients, and those can be viewed in the appendix. Correlation coefficients are important to consider in this decision-making process because they can identify a rough idea of how much information is lost by the exclusion of certain variables without an entire regression. For example, in the colinear case, when variables move together 1:1 no information is gained from including both. Conceptually, we should expect vaguely positive correlation between all of these variables – prosperous towns, regions, and other issuers should flourish in many ways at once – but there is not a distinct empirical underlying reason why this must be. I examine specific interactions below to gain insight into the numerical ESG characteristics to make my decision on what to include.

One of the most difficult decisions that I have had to make is whether or not to include HIPTotal or not. The decision was ultimately made on the basis of an either/or choice with HIPHealth, which has a correlation coefficient of .7096 with HIPTotal in the green bond matched sample. All correlation coefficients are viewable in Table 7 in the appendix. A simple OLS regression between the two variables is shown below.

$$HIPTotal_i = \beta_1 HIPHealth_i + \varepsilon$$

This regression has an r-squared value of .5035, the coefficient on HIPHealth is .618, and the p value is 0.000. Taken together this indicates that HIPHealth is responsible for over 50% of the variance in HIPTotal to all levels of statistical significance. HIPTotal and HIPHealth both have values for all observations and will not limit the sample size, so size is not a factor in the decision. To decide between the two, I primarily looked at correlation with the other choice variables. In this regard, within the sample HIPHealth is lower for all other pillars except for HIPWealth. Conceptually, in the unrestricted population, all pillars are contributing to the HIPTotal metric, but are not contributing to the health metric. Overall, it appears to be a better choice to include HIPHealth than to include HIPTotal.

The next most common pillar variable in the population dataset after HIPHealth is HIPWealth. From the correlation analysis, wealth has relatively low correlation to the other variables and is likely to contain a large amount of information not contained elsewhere. Specifically, it is not a strong correlate to the health pillar in either the population or the sample. The overall sample size remains at 3,597 with this inclusion, which is still large. Additionally, the lost observations from the inclusion of wealth in the regression primarily come from water, which is already the largest subsector in the sample and contains over a thousand observations remaining with values for wealth. Overall, much more information is gained from the inclusion of wealth than is lost from the dropped observations.

HIPEquality is excluded because few observations contain a value for this variable. Neither water nor road authorities have values for the equality metric, and a total of 3,245 observations are lost when the regression includes HIPEquality. Even though it must be excluded on the sole basis of how much data is dropped from the inclusion, it is still important to attempt to get an idea of what information may be contained within it. HIPEquality is relatively uncorrelated with all metrics except for HIPEarth which it is strongly correlated with.

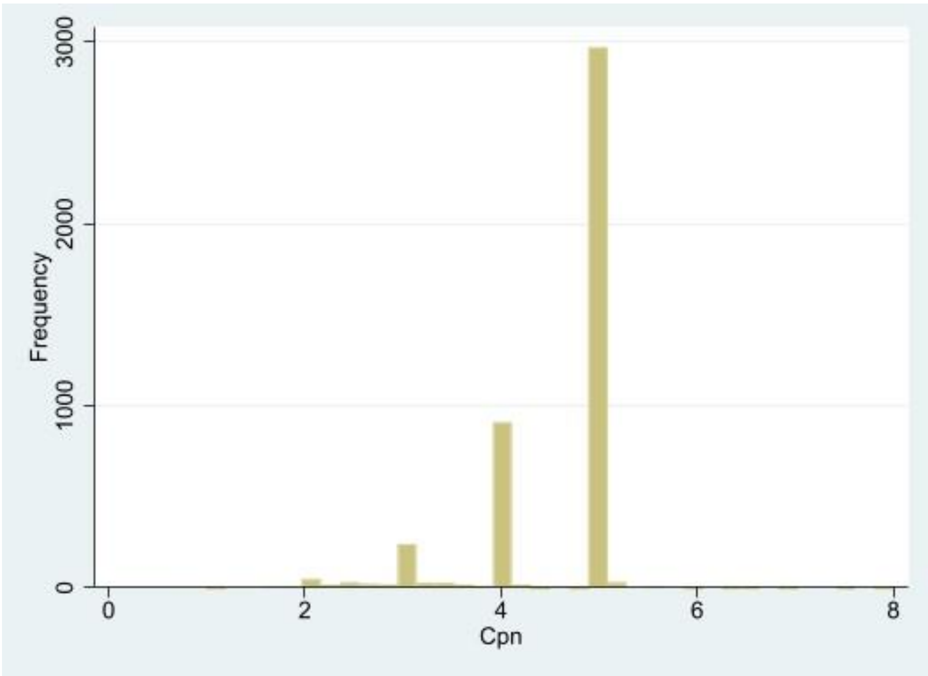
This leaves only decisions about HIPEarth and HIPTrust. The inclusion of HIPEarth drops all universities, 20 K-12 school districts, and all but one hospital for a total of 498 dropped observations. The inclusion of HIPTrust drops all cities, all counties, all K-12 school districts, and all states for a total of 604 dropped observations. Both of these inclusions would lose a similar number of observations, but the variety and diversity of observations decreases markedly more from the inclusion of HIPTrust. On the basis of correlation with other pillars, which of these two metrics provides more new information is also ambiguous. Though HIPEarth correlates heavily with the excluded variable, HIPEquality, it also correlates with all of the other variables already included in the regression like HIPHealth and HIPWealth. While there is no clearly better variable for inclusion, I chose to include HIPEarth in the primary regression, with a secondary regression including HIPTrust to see how the results change.

Lastly, I chose to exclude subsectors from the regression. Many subsectors contain only a few observations, and I do not want to distract the paper from its primary focus of ESG indicators effects on yield by including sectoral variables of interest into the regression. I imagine that it is likely that different sectors price differentially and some investors focus on different sectors, but without the time and accurate controls, unnecessary noise would be introduced to the mode. Furthermore, some of the subsectors inherent greenness or lack thereof should be captured by the HIP variables.

Control Variable Selection:

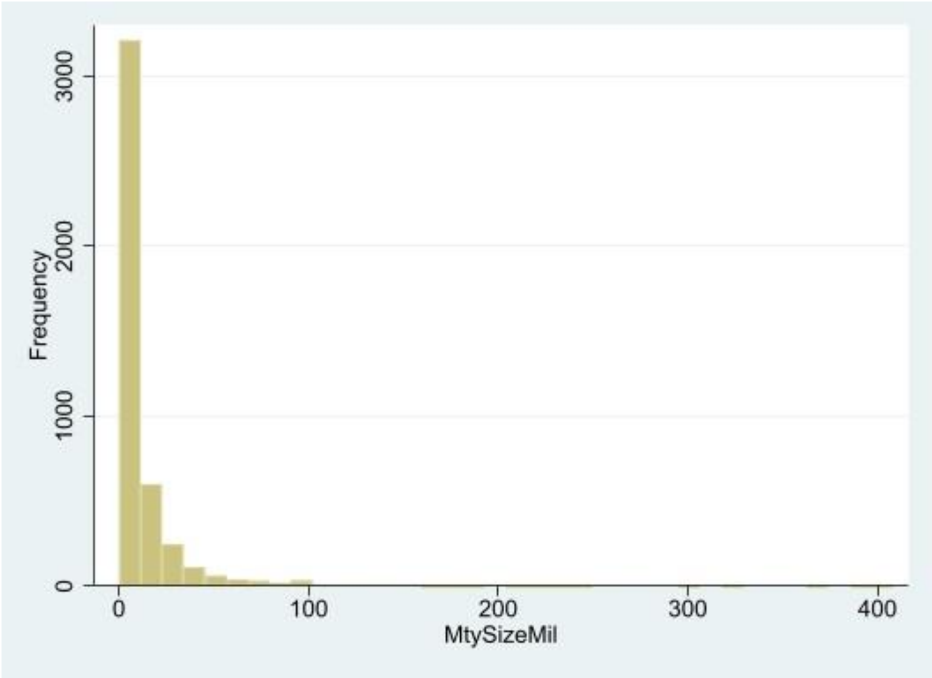
Control variable selection was easier than the variables of interest because they are conceptual in nature and frequently used in multiple regressions from the literature review section.

Graph 1: Coupon (%) Frequency Histogram

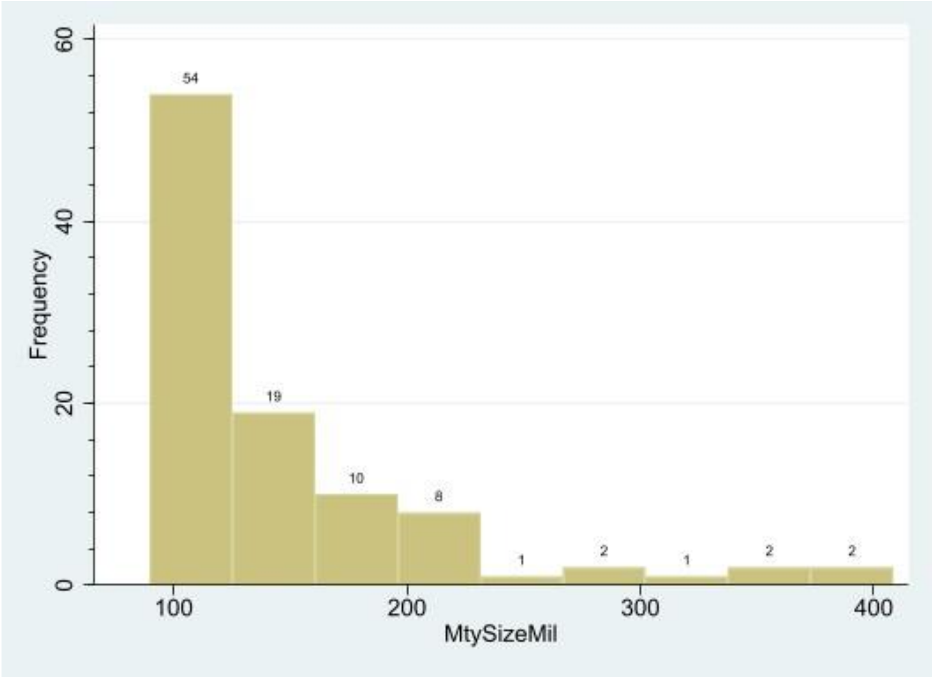


From the graph, we observe that the coupons in the sample are heavily centered around 5%. Notably there are no 0% coupon bonds, that pay their entire principal at maturity with no intermediate payments.

Graph 2a: Maturity Size (millions) Frequency Histogram



Graph 2b: Maturity Size (millions) Frequency Histogram
2 standard deviations above the mean

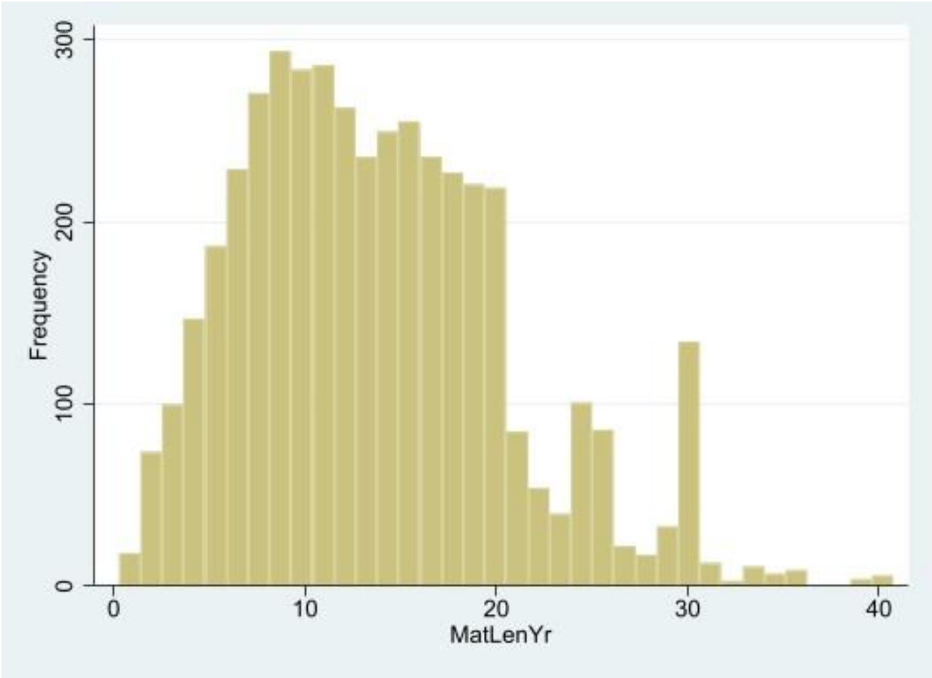


Maturity size is included to control for liquidity premiums. The greater the amount of outstanding debt by an issuer or for the individual bond, the more liquid it should be.

According to the liquidity preference framework there should be some pricing differential for the more liquid (larger) bonds expressed in the yield (Keynes, 1936). Additionally, we see from Graph 2a that the data is heavily centered around 10 million, and outliers go out as far as 400 million. Graph 2b narrows in on the right tail only showing bonds with a face value above 89 million which is the 2nd standard deviation above the mean of 13 million. As we can see, there is only a handful of issuances after 200 million. The scarceness of massive bond issuances is expected, as the majority of issuances are smaller by definition (forty 10-million-dollar issuances costs the same as one 400-million-dollar issuance). Additionally, for most major debt issuances, multiple bonds at differing maturity dates rather than a single bond with a very large face value.

All of these values are all in nominal terms. This is done because time value of money and inflation expectations are inherently built into debt obligations because they are payable in the nominal terms defined in the future. The average maturity size in the green bond matched sample is 13.03, which is higher than all green bond sample of 11.5 million earlier in the data section.

Graph 3: Maturity Length (years) Frequency Histogram



Maturity Length is included as a control variable to account for term premium and the generally upward sloping yield curve. A longer-term bond must make payments for longer and has more opportunities for default and interest rate risk, so the borrower is generally compensated. Because none of this is an explanatory part of the HIP variables it needs to be included to avoid omitted variable bias. From the graph, we see that these bonds are generally not due until a few years after their issuance, with a definitive spike at the 30-year mark. There also is a noticeable drop-off at 20 years. The average maturity length is 13.76 years.

Similar to the Butler and Yi (2021) paper, I do not include credit ratings in the regression because credit rating would likely explain part of what I aim to explain with the ESG ratings from HIP. Credit ratings indicate to investors the odds of a default by considering fiscal soundness, creditworthiness, and trustworthiness. All three of these are factors that could be demonstrated by an issuer with good ESG ratings, so inclusion in the model would likely be inappropriate. A quick glance at the relationship between credit ratings and HIP ratings show dispersion and no definitive association, so I am not choosing to exclude because of collinearity, but to more effectively isolate the yield effects explained by the included HIP variables. This is not to say that credit ratings and ESG ratings are at odds, or that one is necessarily a better metric than another for explaining yield spreads, but that the interpretation of ESG ratings should be clearer and more isolated without credit ratings in the regression.

Results and Interpretation:

The results of the OLS regression shown in the empirical specification are detailed in table 4.

Table 4: Yield Spread Regressors

Variable	**Coefficient**
Coupon	1.42
Maturity Size (millions)	.265***
Maturity Length (years)	4.76***
HIPHealth	-77.8***
HIPWealth	19.2***
HIPEarth	-24.8***
Constant	53.8***

* p < .10, ** p < .05, *** p < .01
Observations: 3,107
Adj r^2: .4682

All variables are statistically significant to the .01 level except for the coupon variable. This is different than the prediction made when selecting my control variables, as I initially thought that coupon payments would affect the way a bond prices. One possible explanation for this phenomenon is that coupons are heavily centered around 5% with very few other observations.

The other controls in the sample are all significant and point in the expected direction. As mentioned earlier in the paper, when maturity size increases the liquidity of the bond increases. The resulting liquidity premium raises the price paid by investors on the bond and therefore lowers the yield they receive. Within the green bond sample we can expect a quarter of a basis point decrease in yield for every million dollars of issuance. This may not sound like much, but when considering that some bond issuances can have hundreds of million in outstanding debt or more, this pricing differential could be very large. This is consistent with existing literature which found that liquidity premiums account for nine to thirteen percent of yield captured across maturities of AAA bonds (Wang et al, 2008). This liquidity effect was able to explain more yield the lower the credit quality of the bond was, and had high enough average basis point changes to be reasonable compared to my findings. However, for these ultra large bonds, there is reason to believe that a logarithmic scale may be more appropriate to model with and is shown in Table 5. The log of maturity size in millions variable is somewhat less significant with a t value of 4.28 compared to the 9.83 value for the maturity size in millions variable. However, little else changes from this variation, and the key conclusions and directionality remain constant. It is ambiguous which specification is more appropriate, but overall, the changes in the Adj r^2 are marginal and the variables still point in the same direction with similar levels of significance. There is value in understanding and seeing that both specifications are able to make sense of the data, so I show both in this paper.

Table 5: Yield Spread Regression – Log Variation

Variable	Coefficient
Coupon	1.08
Log of Maturity Size (millions)	2.64***
Maturity Length (years)	4.91***
HIPHealth	-85.3***
HIPWealth	20.2***
HIPEarth	-21.4***
Constant	55.5***

* p < .10, ** p < .05, *** p < .01
Observations: 3,107
Adj r^2: .4548

I return to the initial regression in Table 4 because of its slightly better underlying significance characteristics. The maturity length variable is entirely reasonable, significant, and points in the correct direction. The yield curve, with respect to maturity length, is generally upward sloping, so we would expect bonds that have longer lengths in the regression to have a greater yield. This is a baseline obvious observation that shows that the model is behaving normally and is not particularly interesting beyond that. It's important to reiterate that a lower yield implies a lower cost of borrowing for issuers and therefore a lower return for investors. Bonds that have longer until they mature face more risk from default to interest rate risk and more, so investors require a higher return on investment in the form of lower prices and higher yields. In the following analysis of the HIP pillar variables an indicator of a lower yield indicates higher prices paid for the bond at issuance due to investor demand increases or risk expectations.

All of the variables of interest selected, HIPHealth, HIPWealth, and HIPEarth are statistically significant and large. Better scores on HIPHealth and HIPEarth appear to tighten bond spreads whilst HIPWealth appears to be associated with an increase in bond spreads. I believe that HIPHealth and HIPEarth move in the expected direction, but do not yet understand why HIPWealth may raise the cost of capital for issuers within the green bond sample. Issuers that invest in the health of their constituency are more likely to have a working and healthy body of people to pay taxes and meet their locality's debt obligation. This is consistent with existing literature Butler and Yi (2020) who showed health of a constituency in the form of age lowers the cost of capital. In regard to HIPEarth, I believe that this indicator is moving in the logical and expected direction as well. One possible explanation for this result is that an issuer that is investing in prevention of climate change and mitigation of its impacts - as reflected through this HIPEarth variable - is one that is more likely to have sustainable cash flows in the future to pay off their debt obligation. It seems entirely reasonable to me that an issuer preparing for potential future problems like climate change would be one that investors view as less risky.

HIPWealth being associated with increased spreads can likely be attributed to a few different factors. Firstly, perhaps investing in the financial well-being of the constituency may not result in overall better financial health for the issuer. Investors may view an issuer who is concerned strongly with the financial well-being of their population as being less responsible with their own money. I'm not sure I fully buy this story, and would certainly need more investigation to understand, but it's at least plausible. Secondly, HIPWealth could be an imperfect indicator within a green-bond sample. Sense this variable is an attempt to analyze social equity in wealth – one part of the *S* in *ESG* - social bonds may be a more appropriate sample to examine.

Lastly, constant is large, positive, and significant. This is expected because the average bond spread for all of the bonds in the sample is 54.98 basis points. So, if we hold all variables constant, we will get a value very close to our average spread. If we place the average value for each variable into the regression equation, the resulting expected spread at issuance is roughly 60 bps.

Conclusion:

Investor inflows into ESG labeled funds have often been shrouded in mystery and the factors that result in an investment decision have been opaque at best and often illustrative of green washing (Dow Jones & Company, 2020). Asset managers have a fiduciary responsibility to make sound investment decisions for their beneficiaries and yield and default risk are the primary factors of determining what is sound. In order to examine how ESG investing can be an input in sound investment decision, I have used proprietary ESG metrics through HIP Investor to analyze the outcome variable of the investors' choice, the yield.

By only examining green-bonds, I have examined whether or not investors price in ESG differences beyond just the green label. Having found that these ESG impact metrics are statistically significant, I can state that sustainable investment, and its relevant input indicators, can be used as a proxy to estimate sound financial investment. This is not to say that these ESG ratings have predictive power to determine excess returns from the market (alpha), that is outside of the scope of this paper, but to say that they can be an indicator of how a bond is priced. Green bonds tend to be greener than a broader market, but within the sample, greenness varies significantly, and this variation results in real world effects on the cost of capital for issuers. Not all green bonds are created equal, and the yield pricing differentials show us that the market knows this too.

Future Research Areas:

Overall, there is still a large amount of work that needs to be done in examining ESG ratings and their predictive power. Examining other ratings from firms such as Sustainalytics or MSCI with the same level of discretion and analysis will require a larger budget but may be applicable to a wider investor base. Unfortunately, due to data limited in the Bloomberg Terminal, I only had access to a limited pool of yields accessible. By increasing the scope of bonds with yield spread data available, the same research can be replicated beyond a green-bond sample. This could take the form of internet scraping for yield at issuances and comparing them to synthetic treasury bonds to gain spread data. Sustainable investors do not limit themselves to investing in green labeled bonds, so looking past the shades of green into the entire market would make for a more representative sample and scale of applicability of any conclusions.

Additionally, analyzing the social bond market or other impact-focused bond issuance may result in differing pricing effects for similarly HIP rated bonds. ESG bond designation can only tell investors so much, and increasing the information available to make better more informed choices can only serve to increase the efficiency of the markets. If the financial markets are to be a driver of change in the fight against climate change, then increasing our collective understanding of how to invest sustainably whilst still considering investor returns should be a focus for financial economists globally.

Appendix:

Table 6: Variable Correlations – All HIP Rated Bonds

	HIPHealth	HIPWealth	HIPEarth	HIP Equality	HIPTrust	HIPTotal
HIPHealth	1.00 (239,247)					
HIPWealth	.1640 (221,324)	1.00 (221,331)				
HIPEarth	.1182 (171,010)	.1940 (153,151)	1.00 (171,010)			
HIPEquality	.0272 (177,024)	.0795 (176,361)	.3163 (108,788)	1.00 (177,031)		
HIPTrust	.1737 (118,636)	-0.1187 (101,390)	-0.0600 (78,424)	.0770 (56,420)	1.00 (118,643)	
HIPTotal	.7681 (239,247)	.4350 (221,331)	.4645 (171,010)	.3776 (177,031)	.4010 (118,643)	1.00 (239,254)

Table 7: Variable Correlations – Green Bonds

	HIPHealth	HIPWealth	HIPEarth	HIP Equality	HIPTrust	HIPTotal
HIPHealth	1.00 (4,422)					
HIPWealth	.1168 (3,597)	1.00 (3,597)				
HIPEarth	.3525 (3,924)	.3655 (3,099)	1.00 (3,924)			
HIPEquality	.1140 (1,177)	-0.2122 (2,994)	.5125 (679)	1.00 (1,177)		
HIPTrust	.1966 (3,819)	-0.0447 (1,177)	.1676 (3,344)	-0.0223 (574)	1.00 (3,819)	
HIPTotal	.7096 (4,422)	.0851 (3,597)	.5878 (3,924)	.4248 (1,177)	.6052 (3,819)	1.00 (3,819)

Table 8: GB Correlation Between Included Variables - Water

	HIPHealth	HIPWealth	HIPEarth	HIPTrust
HIPHealth	1.00 (2,292)			
HIPWealth	.0488 (1,467)	1.00 (1,467)		
HIPEarth	.3528 (2,292)	-0.1837 (1,467)	1.00 (2,292)	
HIPTrust	.2656 (2,292)	.1938 (1,467)	.2034 (2,292)	1.00 (2,292)

Table 9: GB Correlation Between Included Variables – Road Authorities

	HIPHealth	HIPWealth	HIPEarth	HIPTrust
HIPHealth	1.00 (677)			
HIPWealth	-0.2409 (677)	1.00 (677)		
HIPEarth	-0.1228 (677)	-0.1970 (677)	1.00 (677)	
HIPTrust	-0.0225 (677)	-0.8148 (677)	0.4022 (677)	1.00 (677)

Table 10: GB Correlation Between Included Variables – Cities, Counties & States

	HIPHealth	HIPWealth	HIPEquality	HIPEarth
HIPHealth	1.00 (457)			
HIPWealth	.4237 (457)	1.00 (457)		
HIPEquality	.3146 (457)	.1463 (457)	1.00 (457)	
HIPEarth	.3283 (457)	-0.0151 (457)	.3561 (457)	1.00 (457)

Table 11: GB Correlation Between Included Variables – Universities

	HIPHealth	HIPWealth	HIPEquality	HIPTrust
HIPHealth	1.00 (392)			
HIPWealth	-0.1209 (392)	1.00 (392)		
HIPEquality	.4167 (392)	-0.1024 (392)	1.00 (392)	
HIPTrust	-0.1204 (392)	.1405 (392)	-0.1109 (392)	1.00 (392)

References:

Bloomberg L.P. (n.d.). BVAL AAA Muni Callable Curve. Retrieved March 22, 2023 from Duke University Bloomberg terminal.

Board of Governors of the Federal Reserve System (US), Federal Funds Effective Rate [FEDFUNDS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/FEDFUNDS, December 12, 2022.

Bordo, M. D., & Duca, J. V. (2023). How the new fed municipal bond facility capped municipal-treasury yield spreads in the Covid-19 recession. Journal of the Japanese and international economies, 67, 101245. https://doi.org/10.1016/j.jjie.2022.101245

Butler, A. W., & Yi, H. (2022). Aging and public financing costs: Evidence from U.S. Municipal Bond Markets. Journal of Public Economics, 211. https://doi.org/10.2139/ssrn.3301648

Chen, J. (2022, October 10). Yield to worst (YTW): What it is and the formula to calculate it. Investopedia. Retrieved March 21, 2023, from https://www.investopedia.com/terms/y/yieldtoworst.asp#:~:text=Key%20Takeaways-

,Yield%20to%20worst%20is%20a%20measure%20of%20the%20lowest%20possible,for%20a%20shortened%20investment%20period.

Crabbe, L. E., & Turner, C. M. (1995). Does the liquidity of a debt issue increase with its size? evidence from the corporate bond and medium-term note markets. The Journal of Finance, 50(5), 1719-1734. doi:10.1111/j.1540-6261.1995.tb05194.x

Deloitte. (May 2022) *Greenwashing risks in asset management*. Retrieved March 30, 2023 from https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/financial-services/greenwashing-risks-in-asset-management.pdf

Dow Jones & Company. (2020, November 9). What is greenwashing? here is what investors need to know. The Wall Street Journal. Retrieved April 10, 2023, from https://www.wsj.com/articles/what-is-greenwashing-here-is-what-investors-need-to-know-11604881371

Herman, R. P., Sarmento, E. de M., Deschryver, P., & de Mariz, F. (2020). Chapter 13: The Role of Transition Finance Instruments in Bridging the Climate Finance Gap. In Global Handbook of Impact Investing: Solving global problems via Smarter Capital Markets towards a more sustainable society (pp. 461–497). essay, John Wiley &; Sons, Inc.

Himanshu, et al. (2021) Impact of COVID-19 on Portfolio Allocation Decisions of Individual Investors. Journal of Public Affairs, vol. 21, no. 4, https://doi.org/10.1002/pa.2649.

HIP Investor. (2023) Portal for HIP Ratings, Pillars, Metrics. https://hipinvestor.com/

International Capital Market Association. (2021, June). Sustainability Bond Guidelines. ICMA. Retrieved March 26, 2023, from https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/guidance-handbook-and-q-and-a/

International Capital Market Association. (2021, June). Green Bond Principles. ICMA.

Retrieved March 28, 2023, from https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

IRS, 2019. Complying with Arbitrage Requirements: A Guide for Issuers of Tax-Exempt Bonds.

Keynes, John Maynard, 1883-1946. (1936). The general theory of employment, interest and money. London: Macmillan,

Larcker, D. F., & Watts, E. M. (2020). Where's the greenium? Journal of Accounting and Economics, 69(2-3), 101312. https://doi.org/10.1016/j.jacceco.2020.101312

Liang, Hao; Sun, Lin; and Teo, Melvyn.(2021). Greenwashing: Evidence from hedge funds. 1-68. Research Collection Lee Kong Chian School of Business.

Municipal bonds. Municipal Bonds | Investor.gov. (n.d.). Retrieved March 25, 2023, from https://www.investor.gov/introduction-investing/investing-basics/investment-products/bonds-or-fixed-income-products-0

Pastor, L., Stambaugh, R., & Taylor, L. (2022). Dissecting green returns. SSRN. https://doi.org/10.3386/w28940

Riegel, K. A. (2021). Solving the muni puzzle: Who benefits from tax exemption of government debt? Public Finance Review, 49(1), 71–105. https://doi.org/10.1177/1091142120960372

SIFMA, (2022). US Municipal Bonds Statistics.

SIFMA, (2022). US Corporate Bonds Statistics.

Sower, S. (2022, November 17). Market participants feeling way toward ESG's future. The Bond Buyer.

Yang, Y, et al. (2021). Does ESG Disclosure Affect Corporate-Bond Credit Spreads? Evidence from China. Sustainability, vol. 13, no. 15, 2021, p. 8500., https://doi.org/10.3390/su13158500.

Wang, J., Wu, C., & Zhang, F. X. (2008). Liquidity, default, taxes, and yields on municipal bonds. Journal of Banking & Finance, 32(6), 1133–1149. https://doi.org/10.1016/j.jbankfin.2007.09.019

What are muni bonds? Municipal Bonds for America. (n.d.). Retrieved March 26, 2023, from https://munibondsforamerica.org/resources/what-are-muni-bonds/