

Green Bond Performance Primer

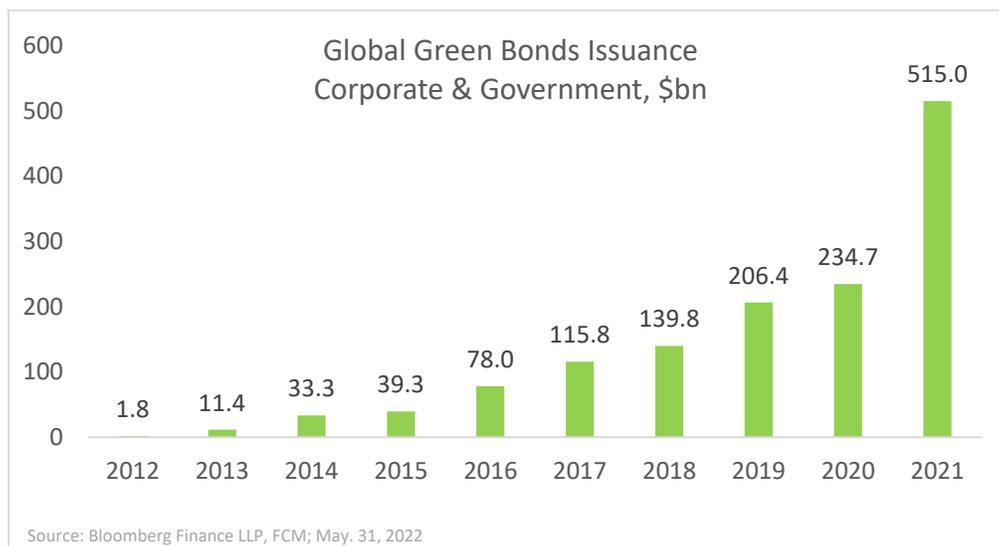
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Summary

The focus of this paper is to compare the performance of green bonds to the broad market using global bond indices, as well as to compare the performance of tax-exempt municipal green bonds to taxable U.S. dollar green bonds. We also attempt to quantify the benefits to going green by comparing new issue pricing and subsequent performance of issuer-labeled municipal green bonds to conventional bonds from the same issuer. Preceding the performance analysis are highlights of market growth, the development of market standards, and index eligibility.



Market Standard

Growth of the green bond market has imposed the need for broadly accepted guidelines for both issuers and investors. According to Bloomberg data, green bond issuance increased from \$39.3 billion in 2015 to \$515.0 billion in 2021 and was up an astounding 119% over 2020 figures.

An important step in the development of the market was a set of Green Bond Principles (GBP) agreed to by a consortium of banks that furnished standards against which investors may assess green credentials of labelled issuance.

There is a strong investor preference for green bonds to be assessed independently from issuers. Benchmark indices from the Bloomberg MSCI Green Bond Index family and from S&P Dow Jones Indices are another important step toward transparency and market standardization, providing investors with the means to evaluate performance and assess risk. MSCI ESG Research determines index eligibility for the Bloomberg indices and reflects central tenets of GBP, while S&P Green Bond Indices rely on Climate Bonds Initiative (CBI) criteria to determine index eligibility.

Nevertheless, “green-washing” by some issuers pushes the boundaries of what may be acceptably considered a green use of proceeds and continues to strain market credibility. Additionally, some fund managers have become targets of regulators for labeling certain products as being “green” investments, when many of the underlying investments woefully don’t meet such standards. Despite a market that has “grown-up”, issuer and investment manager self-labeling practices that push the limits of reasonableness continue to be a concern for investors.

Index Eligibility

For inclusion in the Bloomberg MSCI Global Green Bond Index both self-labeled green bonds and unlabeled bonds are evaluated using stated criteria. Bonds that fund projects which comply with an eligible MSCI Green Bond category and where the issuer provides sufficient transparency on the use of proceeds can be considered for the index even if it is not explicitly marketed as green. Once defined as green, further eligibility rules are applied that require all bonds to comply with Bloomberg Global Aggregate Index criteria. While the Bloomberg MSCI Green Bond Index allows for multiple subindices defined by sector, credit quality, region, currency, maturity, use of proceeds, as well as issuer-capped indices, no municipal sub-index is available at this time despite taxable municipals being index eligible. That said, in their 2021 Municipal Benchmark Governance Review announcement, the Bloomberg index team noted among the primary topics to be considered were the development of ESG Municipal bond indices as well as the evaluation of new index candidates such as additional Municipal Taxable sub-indices (based on maturity, ratings and classifications).

For inclusion in the S&P Green Bond Index only CBI-labeled green bonds are considered, subject to additional S&P Dow Jones Indices eligibility criteria. There are several sub-indices available, including the S&P U.S. Municipal Green Bond Index designed to measure the performance of U.S. green-labeled tax-exempt municipal bonds and the S&P Green Bond U.S. Dollar Select Index designed to measure the performance of taxable bonds denominated in U.S. dollars.

Municipal Green Bond Issuance

Total issuer-labeled municipal green bond issuance (taxable and tax-exempt) comprised only 5% of total municipal bond issuance in 2021, although in dollar terms the amount more than doubled in the last two years. The proportion of total issuance has also increased steadily as has the number of issuers, with nearly 200 accessing the “green bond market” in 2021 compared with 119 two years ago. Table 1 compares municipal green bond issuance to taxable municipal issuance – another niche segment of the market – and to total issuance.

Table 1: U.S. Municipal Bond Issuance (\$ billions)

Year	Total	Taxable	% of total	Green	% of total	# Issues	# Issuers
2014	\$305	\$22	7%	\$3	1%	298	16
2015	\$377	\$27	7%	\$4	1%	531	29
2016	\$428	\$28	7%	\$7	2%	906	41
2017	\$410	\$32	8%	\$11	3%	1,102	46
2018	\$318	\$25	8%	\$4	1%	905	54
2019	\$411	\$69	17%	\$10	3%	1,831	119
2020	\$470	\$142	30%	\$16	3%	2,228	148
2021	\$464	\$115	25%	\$22	5%	3,012	193

Source: Bloomberg Finance LLP, FCM; May 31, 2022

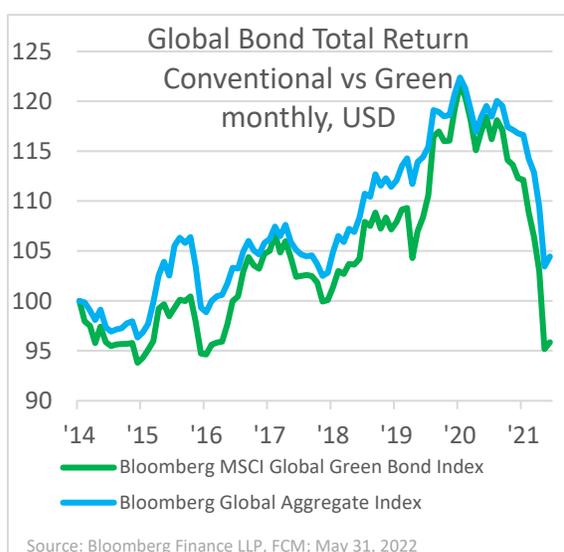
Performance

The performance of green bonds appears to track the performance of similar conventional bonds, with performance attribution differences primarily explained by characteristics such as duration, quality, and currency. In the case of the Bloomberg MSCI Global Green Bond Index, performance has lagged that of the Global Aggregate Index in six of the past eight years (2022 performance is through May). In years the green bond index outperformed (2017, 2020) or lagged the least (2019) interest rates fell (using the 10-year U.S. Treasury as a proxy), implying higher duration and greater positive convexity than the Global Aggregate Index. The correlation of annual total returns between the two indices was 0.99, while the correlation versus the change in the 10-year U.S. Treasury yield was -0.88 and -0.91, respectively. Table 2 displays index characteristics and the charts following the table show total return for the two global indices.

Table 2: Global Bond Index Characteristics

As of 05/31/2022	Bloomberg MSCI Global Green Bond Index	Bloomberg Global Aggregate Index
Yield to Worst (%)	2.47	2.52
Option-Adjusted Duration (years)	7.7	7.1
Market Value (billions)	\$819	\$62,538
Option-Adjusted Spread (bps)	101	49
Time to Maturity (years)	8.8	8.9
Constituents	984	28,193

Source: Bloomberg Finance LLP, FCM; May 31, 2022



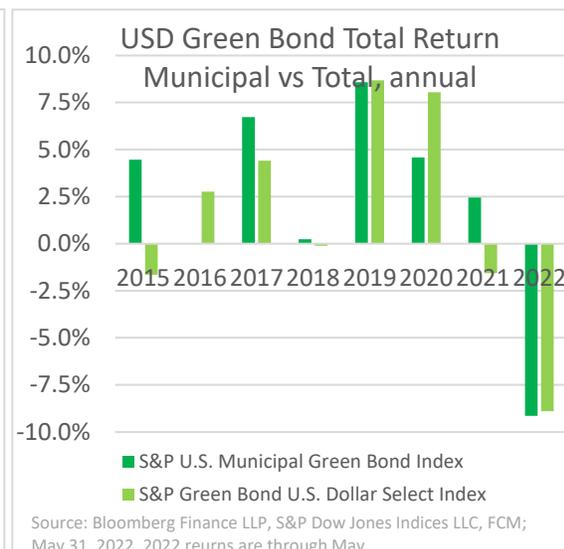
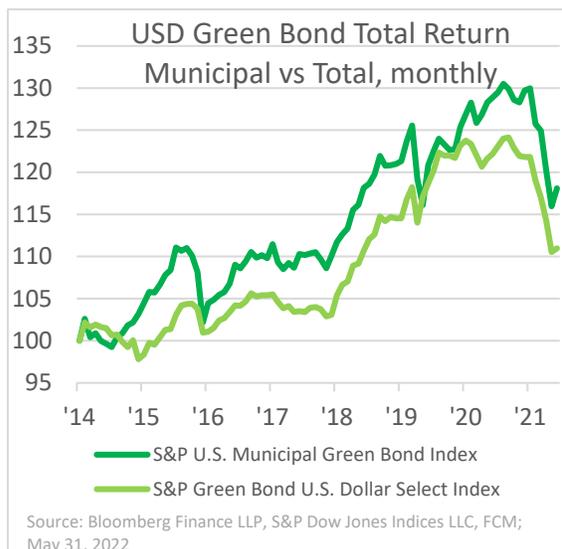
Past performance is no guarantee of future results
See "Important Additional Information" for definitions of key terms

In the U.S. dollar green bond market, annual index performance is more closely related to changes in U.S. rates, with the correlation versus the 10-year U.S. Treasury yield at -0.95 for the S&P Green Bond U.S. Dollar Select Index. However, the correlation of annual returns is less significant, though still robust, at -0.82 for the S&P U.S. Municipal Green Bond Index. Likewise, the two U.S. indices don't share the closer correlation exhibited between the global indices, with the correlation of annual total returns at 0.83 over the past eight years (2022 performance is through May). Since 2014, the municipal green bond index cumulative total return outpaced the parent index by 711 basis points, however, most of the outperformance occurred in the early years of that period. Table 3 displays index characteristics and the charts following the table show total return for the two U.S. dollar green bond indices.

Table 3: USD Green Bond Index Characteristics

As of 05/31/2022	S&P Green Bond U.S. Dollar Select Index	S&P U.S. Municipal Green Bond Index
Yield to Worst (%)	4.29	3.07
Modified Duration (years)	5.5	9.5
Market Value (billions)	\$219	\$62
Option-Adjusted Spread (bps)	n/a	n/a
Time to Maturity (years)	7.5	14.2
Constituents	376	3,635

Source: Bloomberg Finance LLP, S&P Dow Jones Indices LLC, FCM; May 31, 2022



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Benefits to Going Green?

We ask the question from two perspectives: from the issuer's in terms of borrowing costs and from the investor's in terms of relative performance. To answer the question, we compared issuer-labeled municipal green bonds to conventional bonds from the same issuer, controlling for security type, tax status, maturity, call date, coupon, and side of market. Specifically, our approach measured the issue spread of each bond pair (green versus conventional) as well as captured the "green bond alpha," or the performance of a green bond relative to its conventional counterpart in secondary market trade activity. In this year's analysis we established the null hypothesis, based on last year's less rigorously applied conclusions (due to computational limitations), that there is no statistically significant difference between municipal green bonds and their conventional counterparts – neither from the issuer's standpoint nor from the investor's. What our updated work found surprised us. Drawing on a 3-year period ending in 2022, we identified 570 bond pairs that traded on a given day (t_0) and then traded again on another day in the future (t_1) – from this data set we were able to calculate the "green bond alpha." Of those 570 pairs, 248 were issued on the same day (some as far back as 2014), allowing us to fairly calculate the difference in issue spreads (green versus conventional). First, Table 4 summarizes the municipal bonds analyzed.

Table 4: Average performance of municipal green bond vs conventional bond from same issuer (controlling for security type, tax status, maturity, call date, coupon, and side of market)

570 CUSIP Pairs*	Green Bond Average	Conventional Bond Average
Maturity Size, mn	\$25.5	\$24.3
Maturity Year	2030	2030
1st Call Date	2027	2027
Coupon	4.8%	4.8%
Spread at Issue, bp	25	24
Green Bond Alpha, bp	3	n/a

Source: Bloomberg Finance LLP, MSRB, FCM; May 31, 2022

*Spread at issue is for only the 248 bond pairs that were issued same day.

Spread at issue is measured as the issue yield minus the benchmark curve on the issue date. For tax-exempt bonds the benchmark is the Bloomberg AAA Baseline Curve and for taxable bonds it is the US Treasury Curve. Green bond alpha reflects difference in yield between a green bond and its conventional counterpart at $t=1$ minus the difference at $t=0$ if both bonds traded on those dates within a 3-year period ending March 2022. A positive value implies that the green bond yield change was greater and therefore underperformed.

We found that new issue pricing for the sample of 248 municipal bond pairs (issued by the same entity on the same day, and controlling for security type, tax status, maturity, call date, and coupon) slightly favored the conventional bond. The chart below shows the distribution of the issue spread differences. While the data set is normally distributed with a center on zero (no issue spread difference), it has an apparent fatter right tail (green bond price penalty versus conventional bond). A paired 2-sample t-test for means generated a t-statistic for a two-tailed distribution of 3.679 with a p-value of 0.000287, which is statistically significant at the 95% confidence interval. The result indicates strong evidence against the null hypothesis, as there is less than a 5% probability the null is correct (and the results are random). Therefore, we reject the null hypothesis that there is no statistically significant difference between green and conventional bond new issue pricing. Table 4a summarizes the comparison of new issue pricing for green versus conventional municipal bonds.

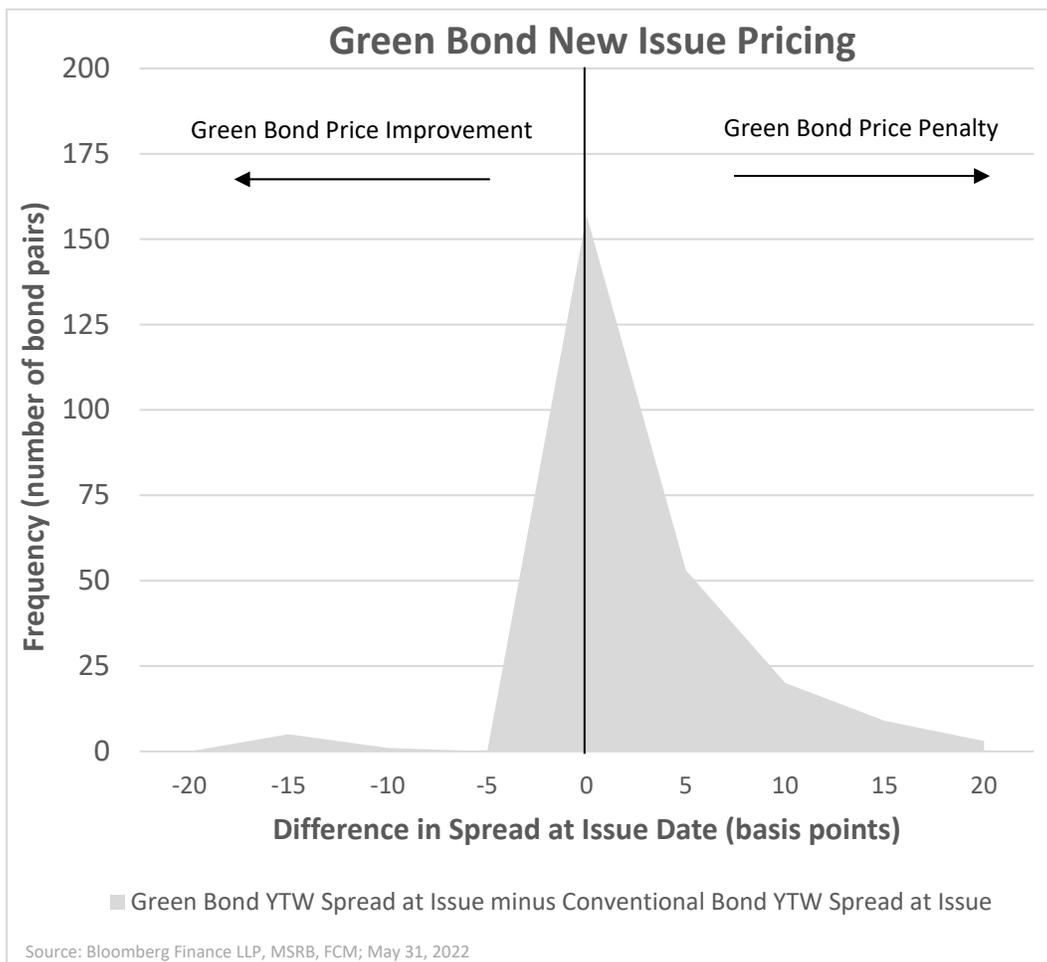


Table 4a

Summary of Green Bond vs. Conventional Bond Pricing at Issuance	Green Bond Spread at Issue vs Conventional Average
% of green bonds seeing price improvement	14%
% of green bonds seeing price penalty	34%
% of green bonds seeing no price difference	52%
Average pricing difference at issue (bp)	1
Average green bond price improvement (bp)	-4
Average green bond price penalty (bp)	5

Source: Bloomberg Finance LLP, FCM; May 31, 2022

Compares only municipal bonds issued on the same day, or 248 out of 570 total pairs.

Overall, 52% of new issues saw no price difference compared with conventional new issues, 14% saw a price improvement, and 34% saw a price penalty. Of those issues seeing a price improvement the average was -4 basis points, and of those seeing a price penalty the average was 5 basis points.

From the investor's standpoint, like the new issue market, we found that there was a tendency for conventional bonds to outperform. Trade history for the sample of 570 municipal bond pairs (controlling for security type, tax status, maturity, call date, coupon, and side of market) slightly favored the conventional bond. The chart below shows the distribution of the "green bond alpha" for different sides of the market. While the data set using mid-market pricing is normally distributed with a center on zero (no performance difference between trades at t_0 and trades at t_1), it has an apparent fatter right tale (green bond trades at a higher yield at t_1 versus t_0). The same side of market distributions point to a center between 0 and 5 basis points. A single-sample t-test generated a t-statistic for a two-tailed distribution of 2.223 with a p-value of 0.026617, which is statistically significant at the 95% confidence interval. The result indicates strong evidence against the null hypothesis, as there is less than a 5% probability the null is correct (and the results are random). Therefore, we reject the null hypothesis that there is no statistically significant difference between green and conventional bond performance. Table 4b summarizes the comparison of trade history for green versus conventional municipal bonds.

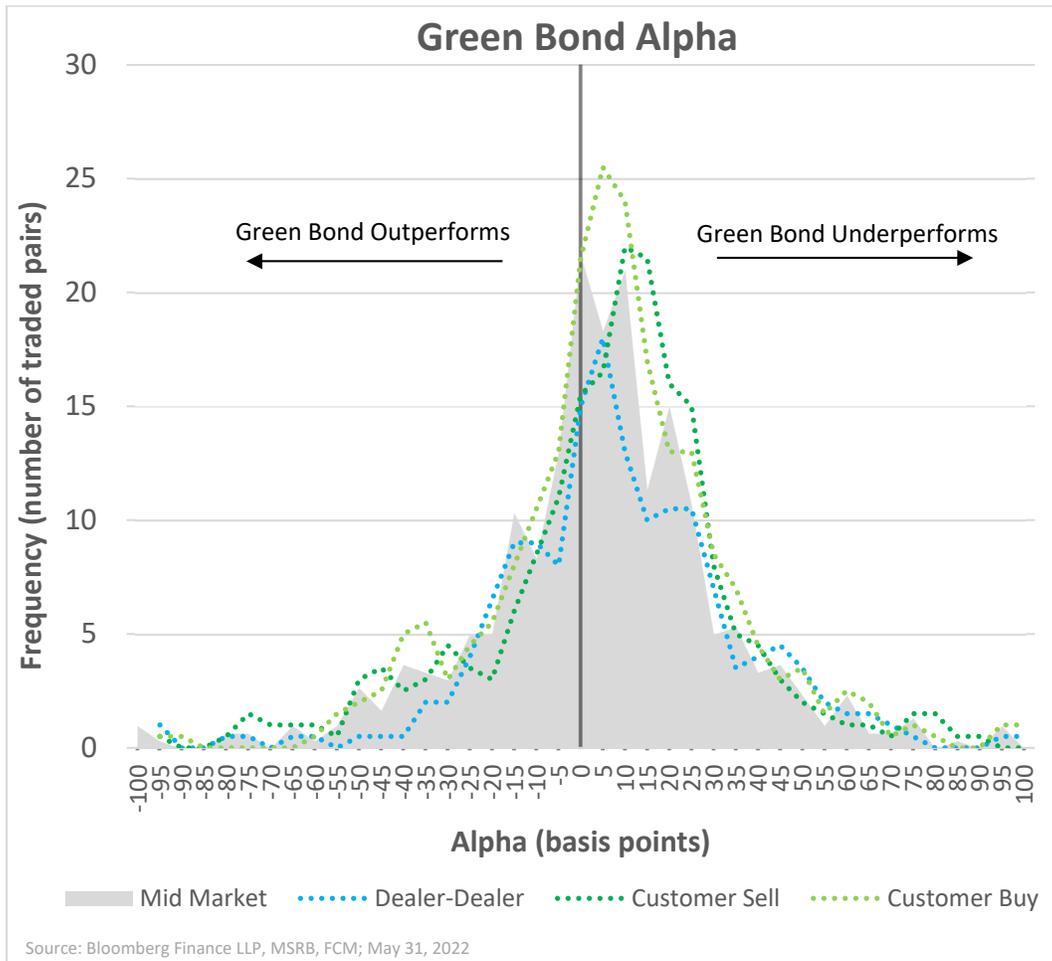


Table 4b

Summary of Green Bond vs. Conventional Bond Performance	Green Bond Alpha
% of green bonds that outperformed	43%
% of green bonds that underperformed	56%
% of green bonds seeing no performance difference	2%
Average alpha (bp)	3
Average green bond outperformance (bp)	-23
Average green bond underperformance (bp)	23

Source: Bloomberg Finance LLP, MSRB, FCM; May 31, 2022

Overall, only 2% of traded pairs saw no performance difference, whereas 43% of green bonds outperformed and 56% underperformed. Of those traded pairs where the green bond outperformed the average was by -23 basis points, and of those where the green bond underperformed the average was by 23 basis points (rounded figures).

Important Additional Information

Key Terms:

Correlation - Measures that show the validity of a comparison to a benchmark index based on the historical relationship between portfolio returns and index returns.

Option Adjusted Duration - Bond prices typically move in the opposite direction to changes in interest rates. If interest rates rise, bond prices usually fall (and vice versa).

Duration is a measure that helps approximate the degree of price sensitivity of a bond to changes in interest rates. Although stated in years, duration is often explained as an estimate of the percentage price change of a bond in response to a one percent change in interest rates. Bonds with higher duration have greater sensitivity to changes in interest rates and will generally experience a more significant drop in value as interest rates rise. For bonds with embedded options (for example callable or puttable bonds), the duration measure must be adjusted to account for the fact that the bond's embedded options may change the expected cash flows of the bond. For example, if a bond is called, interest payments cease and principal is returned earlier than the bond's maturity. The option-adjusted measure of duration is referred to as Option Adjusted Duration (OAD).

Option Adjusted Spread - A bond's yield is typically comprised of two components: 1) the yield on a similar benchmark security (typically Treasury securities) and 2) a premium above the yield on a similar benchmark security which seeks to compensate an investor for the credit risk associated with a particular bond. This premium is referred to as yield spread or simply "spread." For bonds with embedded options (for example callable or puttable bonds), the spread measure must be adjusted to account for the fact that the bond's embedded options may change the expected cash flows of the bond. For example, if a bond is called, interest payments cease and principal is returned earlier than the bond's maturity. The option-adjusted measure is referred to as Option Adjusted Spread (OAS).

Yield to Worst - the lowest potential yield that can be received on a bond without the issuer actually defaulting; calculated by making worst-case scenario assumptions on the issue by calculating the returns that would be received if any in-whole mandatory redemptive provisions are exercised by the issuer; partial redemptive provisions (such as sinking funds) are not included in yield to worst calculations; the yield to worst metric is used to evaluate the worst-case scenario for yield to help investors manage risks and ensure that specific income requirements will still be met even in the worst scenarios.

Index Definitions

Bloomberg MSCI Global Green Bond Index and Bloomberg Global Aggregate Index

The Bloomberg MSCI Green Bond Index offers investors an objective and robust measure of the global market for fixed income securities issued to fund projects with direct environmental benefits. An independent research driven methodology is used to evaluate index-eligible green bonds to ensure they adhere to established Green Bond Principles and to classify bonds by their environmental use of proceeds. The index was created in November 2014, with index history backfilled to January 1, 2014. Sectors included are Treasury, corporate, government-related, taxable municipal, and securitized bonds. The index is a multi-currency benchmark that includes local currency debt markets tracked by the Bloomberg Global Aggregate Index. Eligibility for index inclusion are the same for both indices unless otherwise noted below. Principal and coupon must be denominated in one of the following eligible currencies: CAD, CLP, MXN, USD, CHF, CZK, DKK, EUR, GBP, HUF, ILS, NOK, PLN, RUB, SEK, ZAR, AUD, HKD, JPY, KRW, MYR, NZD, SGD, THB. Eligible currencies will not necessarily have debt included in the index if no securities satisfy the inclusion rules. New currency inclusion is reviewed annually through the index governance process. Securities must be rated investment grade (Baa3/BBB-/BBB- or higher) using the middle rating of Moody's, S&P and Fitch; when a rating from only two agencies is available, the lower is used; when only one agency rates a bond, that rating is used. In cases where explicit bond level ratings may not be available, other sources may be used to classify securities by credit quality. Fixed minimum issue size are set for all local currency markets, including 300mn USD (excluding MBS, ABS, and CMBS), CAD, EUR, CHF, AUD; 200mn GBP; 35bn JPY; 1bn USD MBS pass-throughs; 25mn USD ABS and CMBS tranches; 2bn DKK, NOK, PLN, ZAR, ILS, HKD, MYR; 2.5bn SEK; 10bn MXN, CZK, THB; 20bn RUB; 500mn NZD, SGD; 200bn HUF; 100bn CLP; 500bn KRW. Eligible coupons include fixed, callable fixed-to-floating are eligible during their fixed-rate term only, bonds with a step-up coupon that changes according to a predetermined schedule. Unlike other Bloomberg Aggregate Bond Indices, the Global Green Bond Index does not have a 1-year minimum time to maturity and will hold bonds until final maturity. Fixed-rate perpetual bonds are not included. Only fully taxable issues are eligible. Security types include fixed-rate bullet, puttable, sinkable/amortizing and callable bonds, taxable municipal securities (Build America Bonds with the tax credit to the issuer are eligible, those with tax credits issued to investors are considered tax exempt), original issue zero coupon bonds, bonds issued through underwritten MTN programs, enhanced equipment trust certificates (EETC), certificates of deposit, fixed-rate and fixed-to-float (including fixed-to-variable) capital securities, loan participation notes, US Agency CMBS, Malaysian government Sukuk. The following securities are excluded: contingent capital securities, including traditional CoCos and contingent write-down securities with explicit capital ratio or solvency/balance sheet-based triggers, bonds with equity type features (e.g., warrants, convertibles, preferreds, DRD/QDI-eligible issues), inflation-linked bonds, floating-rate issues, fixed-rate perpetuals, tax-exempt municipal securities, private placements, sinkable Russian OFZ bonds issued prior to 2009, USD25/USD50 par bonds, structured notes, pass-through certificates, Non-ERISA eligible CMBS, US agency MBS hybrid ARMs, Formosa bonds, Illiquid securities where reliable pricing is unavailable. All index-eligible bonds are priced on a daily basis. Pricing sources are by region. US Aggregate Index: Most index-eligible bonds are priced on a daily basis by Bloomberg's evaluated pricing service, BVAL. Certain segments of Eurodollar issues and LATAM USD-denominated bonds are priced by third-party sources. Pan-European Aggregate Index: pricing is provided by a combination of BVAL and third-party sources. Prices for CHF-denominated bonds are sourced from the Swiss stock exchange. Asian-Pacific Aggregate Index: pricing is provided by a combination of BVAL and third-party sources on a daily basis. 144A/Eurodollar Indices: pricing is provided by a combination of BVAL and third-party sources. Canadian Index: pricing is provided by Reuters. Bonds in the index are priced on the bid side. The initial price for new corporate issues entering the index is the offer side; after the first month, the bid price is used. Japanese, Euro, and Sterling treasury bonds use mid prices. T+1 calendar day settlement basis for all bonds except MBS, which are priced for Public Securities Association (PSA) settlement in the following month and discounted back to same-day settlement. At month-end, settlement is assumed to be the first calendar day of the following month, even if the last business day is not the last day of the month, to allow for one full month of accrued interest to be calculated.

Important Additional Information

S&P U.S. Municipal Green Bond Index

The index is a sub-index of the S&P Green Bond Index. The S&P Green Bond Indices are comprised of a universe of global bonds labelled “green” by Climate Bonds Initiative (CBI) and subject to eligibility criteria. A green-labelled bond is a bond whose proceeds are used to finance environmentally friendly projects. To be eligible for the S&P U.S. Municipal Green Bond Index the bond issuer must be a U.S. state (including the Commonwealth of Puerto Rico and U.S. territories) or local government or agency such that interest on the bond is exempt from U.S. federal income taxes but may be subject to alternative minimum tax (AMT). The bond must be denominated in U.S. dollars. As of the rebalancing date, the bond must have a minimum term to maturity greater than one calendar month. For any bond with an announced full call, the call date must be greater than one calendar month. The amount outstanding, or par amount, is used to determine the weight of the bond in the index. The bond must have a minimum par amount of US \$ 2 million to be eligible for inclusion. The following bond types are specifically excluded: commercial paper, derivative securities (inverse floaters, forwards, & swaps), notes, taxable municipals, variable rate debt (except for known step-up/down coupon schedule bonds), defaulted bonds. The minimum credit rating for inclusion is BBB-/Baa3/BBB-. The lowest of all available ratings (S&P, Moody’s and Fitch) is used as the index rating. New issues must be rated by at least one rating agency (S&P, Moody’s or Fitch) to be considered at the next rebalancing. Bonds that are no longer rated or have defaulted are removed at the next rebalancing.

S&P Green Bond U.S. Dollar Select Index

The index is a sub-index of the S&P Green Bond Index. The S&P Green Bond Indices are comprised of a universe of global bonds labelled “green” by Climate Bonds Initiative (CBI) and subject to eligibility criteria. A green-labelled bond is a bond whose proceeds are used to finance environmentally friendly projects. To be eligible for the S&P Green Bond U.S. Dollar Select Index the bond must be denominated in U.S. dollars. Each bond must have at least 12 months to final maturity at the time of issuance to be included, and have at least one month remaining until maturity at each rebalancing date. No bond matures in the index. The minimum par outstanding must be US\$ 200 million or greater. The following bond types, in addition to those excluded from the parent, are specifically excluded from the sub-index: tax-exempt municipal bonds, private placement with no registration, convertible securities, perpetual securities. The minimum credit rating for inclusion is BBB-/Baa3/BBB-. The lowest of all available ratings (S&P, Moody’s and Fitch) is used as the index rating. New issues must be rated by at least one rating agency (S&P, Moody’s or Fitch) to be considered at the next rebalancing. Non-rated bonds issued by U.S. government sponsored enterprises, such as FNMA, Freddie Mac, etc., are eligible for inclusion. Bonds that are no longer rated or have defaulted are removed at the next rebalancing.

S&P Green Bond Index

The index is a market value-weighted index designed to measure the performance of the green bond market. The S&P Green Bond Indices undergo a rebalancing process once a month. Unless otherwise noted all eligibility criteria apply to all indices. Eligibility factors specific to the sub-indices are listed above under the specific sub-index heading. Green bonds issued from any country and in any currency are eligible for index inclusion. Bonds must be flagged as “green” by CBI to be eligible for index inclusion. For a bond to be flagged green the issuer must clearly indicate the bond’s “green” label and the rationale behind it, such as the intended use of proceeds. CBI uses company disclosures to make the “green” determination. Each bond must have a maturity greater than one month from the rebalancing date. No bond matures in the index. The following coupon types are eligible for index inclusion: fixed, floaters, zero coupon, fixed-to-float, step-up. For USD and CAD denominated bonds which have multiple registrations, the 144a version will be eligible and the Reg-S will be excluded. For all other currency denominated bonds which have multiple registrations, the Reg-S will be included while the 144a will be excluded. Bonds issued up to the rebalancing reference date (regardless of the settlement date). Standard index settlement convention is same-day (e.g. T+0), unless otherwise specified. For month-ends that fall on a weekend, the interest accrued during the month will be reflected within the calendar month, regardless of settlement convention. For rates that are not available at month-end (e.g. a rate with an unknown reset), the accrual will be based on the current rate and adjusted the first business day of the next month. The following bond types are specifically excluded from the indices: bills, inflation-linked, STRIPS. Bid Price – Thomson Reuters and Securities Evaluations | ICE Data Services are the designated pricing sources. Bonds not priced by Thomson Reuters or Securities Evaluations | ICE Data Services are not eligible for index inclusion.

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Diversification does not ensure a profit or guarantee against a loss. Interest income earned from tax-exempt municipal securities generally is exempt from federal income tax, and may also be exempt from state and local income taxes if you are a resident in the state of issuance. A portion of the income you receive may be subject to federal and state income taxes, including the federal alternative minimum tax. In addition, you may be subject to tax on amounts recognized in connection with the sale of municipal bonds, including capital gains and "market discount" taxed at ordinary income rates. "Market discount" arises when a bond is purchased on the secondary market for a price that is less than its stated redemption price by more than a statutory amount. Before making any investment, you should review the official statement for the relevant offering for additional tax and other considerations.

The municipal market can be adversely affected by tax, legislative, or political changes and the financial condition of the issuers of municipal securities. Investing in municipal bonds for the purpose of generating tax-exempt income may not be appropriate for investors in all tax brackets or for all account types. Tax laws are subject to change and the preferential tax treatment of municipal bond interest income may be revoked or phased out for investors at certain income levels. You should consult your tax adviser regarding your specific situation.

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