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**Article**

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Article

# Survey of Green Bond Pricing and Investment Performance

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**Abstract:** Green bonds are similar to conventional bonds but are specifically earmarked to raise money to finance climate or environmental projects. There have been anecdotes of green bonds being priced tighter than similar conventional bonds by the same issuers. Our survey of academic literature indicates that most papers show the yield of a green bond is lower than that of the equivalent conventional bond at issuance (also known as green premium or greenium). However, green bond pricing studies by Climate Bonds Initiative produce mixed results. The conflicting results are likely explained by differences in sample selections, time periods, methodologies, and the properties of the respective issuing entity and the bond. In addition, we examine investment returns from select green bond funds and green bond indexes. The assets under management of those funds are still small and they underperform their benchmark indexes.

**Keywords:** green bond; green bond index; green premium; greenium; Paris Climate Agreement; primary market; green bond mutual fund; green bond ETF

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## 1. Introduction

Green bonds are similar to plain vanilla conventional bonds, but with a dedicated green use of proceeds. The green bond market aims therefore to unlock private capital to finance climate or environmental solutions. The funded projects typically involve renewable energy, energy efficiency, clean water, sustainable natural resources and land use, climate change adaptation, and pollution prevention and control. They are issued in the form of senior unsecured obligations, project finance, and revenue bonds, as well as securitizations with collateralized projects or assets. Furthermore, green bonds, like other bonds, vary in credit ratings and in maturities. Regardless of structure, labeled green bonds are issued pursuant to the Green Bond Principles (GBP) or Climate Bonds Standard (CBS). The GBP framework ([International Capital Market Association 2018](#)) includes criteria for the use of proceeds, the issuer's process for project evaluation, the management of proceeds, and reporting both at the time of issuance and on a periodic basis thereafter. Certification under CBS ([Climate Bonds Initiative 2019a](#)) confirms that the bond is fully aligned with the GBP, using best practice in required areas, and financing assets consistent with the goals of the Paris Climate Agreement. The certification scheme has pre-issuance and post-issuance requirements. Verification by an approved verifier is mandatory in the certification process. Issuers then use the certification in marketing materials to launch the green bond. After issuance, ongoing certification includes requirements for annual reporting with public disclosure. The certification, independent verification, and ongoing reporting add costs to green bond issuance in the short run. However, those standards will increase investor confidence and thus the market size that will benefit the issuers ([Cochu et al. 2016](#)). Beyond the green certification, rating agencies, such as Moody's Investors Service and S&P Global Ratings, assess each covered green bond issue and monitor the use of funds or environmental impact thereafter ([Moody's Investors Service 2017](#); [S&P Global Ratings 2017](#)). As the market continues to develop, more consistent green bond standards are likely to replace the evaluations by rating agencies.

The market started with less than \$1 billion in 2007. Additional issuance was slow through 2012. In 2013, more green bonds were issued than the previous six years combined. Another big jump came in 2017 when the new issues totaled \$162.1 billion. The market continued the upward trend, and new issues reached a new record of \$257.7 billion in 2019. Although the new issuance has grown substantially in recent years, the green bond market is still small and has potentials to become a significant segment in the global fixed-income market.

One important contributing factor to the development and growth of the green bond market is the increasing requirements to finance climate and environmental solutions. The Paris Climate Agreement provides an additional motivation for investors to direct some of their investments towards climate solutions. Green bonds are tailored to unlock private capital to meet the funding requirement to promote climate or other environmental sustainability purposes. The need to finance climate or environmental solutions in combination with growing investor demand will continue to lift green bond issuance.

Most of the research publications on the financial aspects of greenness (part of the Environmental, Social and Governance (ESG) criteria) have focused on financial measures and the equities market. Accumulated research found that companies that pay attention to ESG concerns have higher equity returns. This research instead focuses on the green bond market of the environmental (E) factor. This paper surveys publications on green bond pricing at issuance and discusses returns of green bond index-based investments. In the primary market, there are conflicting results with regard to the existence of green bond premiums. The mixed results are likely due to differences in sample selections, time periods, methodologies, ratings, currencies, and the properties of the respective issuing entity and the bond. In addition, we examine investment returns from select green bond funds and green bond indexes. The assets under management of those funds are still small and they underperform their benchmark indexes.

The paper is organized as follows. Section 2 provides a literature review. Section 3 discusses the development of the green bond market. Section 4 includes a detailed survey of green bond pricing in the primary market. Many papers show green bonds are priced at a lower yield than the similar conventional bonds by the same issuer (also known as green premium or greenium). Several do not find such a greenium. The studies from the Climate Bonds Initiative (CBI) indicate all are possible, meaning green bonds are priced below, on, or above their own yield curve. Section 5 discusses green bond indexes and green bond funds. Finally, Section 6 concludes the paper with suggestions to foster the growth of the green bond market.

## 2. Select Literature on ESG and Green Bond Market

There are large volumes of publications that cover the relation between ESG factors and various measures of corporate financial performance. Among them, some focus on each of the individual factors. This paper discusses green bonds within the “E” factor.

### 2.1. Select Literature on ESG

Dixon-Fowler et al. (2013) found that the environmental factor had a strong positive influence on financial performance, small firms benefited as much or more than large firms, and US firms benefited more than their international counterparts. Climent and Soriano (2011) showed that environmental mutual funds underperformed conventional funds with similar characteristics during a 1987–2009 sample period. However, for a sub-sample period of 2001–2009, the empirical results did not show significant difference in their performances. In corporate governance area, Love (2010) reviewed prior publications and found that most studies in the literature provided evidence of a positive relation between corporate governance and valuation, operating performance or stock returns.

Friede et al. (2015) conducted an exhaustive overview of academic research on the linkage between ESG criteria and corporate financial performance. Based on 2200 individual studies, the authors documented that a large majority of studies reported positive ESG impact on corporate financial

performance and that such a positive relation was stable over time. In developed markets, more than 38.0 percent of studies showed a positive impact on corporate financial performance while only 7.7 percent found a negative relation. In studies of emerging markets, 65.4 percent showed a positive relation while 5.8 percent found a negative relation. Among the three ESG factors, studies on the environmental factor resulted in 58.7 percent positive findings, for the social factor 55.1 percent, for the governance factor 62.3 percent, and for all three criteria combined 35.3 percent.

Morgan Stanley (2015) analyzed data from US-based mutual funds and separately managed accounts and showed that investing in sustainability often exceeded the performance of comparable traditional investments, on both an absolute and a risk-adjusted basis. Sustainable equity mutual funds produced equal or higher median returns and equal or lower volatility than traditional funds for 64 percent of the sample periods. Koller et al. (2019) identified five ways a strong ESG proposition contributes to corporate valuation: facilitating top-line growth, reducing costs, minimizing regulatory and legal interventions, increasing employee productivity, and optimizing investment and capital expenditures.

Madhavan et al. (2020) used data on 1312 US equity mutual funds and analyzed the link between ESG scores and returns, style factor loadings, and alphas. They showed strong positive relations between alphas and ESG scores. Matos (2020) surveyed the literature on ESG investing. In institutional investing, one objective is to reduce exposure to investments with greater ESG risks. The survey also identified that historically institutional investors tended to focus mostly on corporate governance (G) among ESG factors. On the environmental and social dimension, there is a big focus on climate change. Drei et al. (2019) also explored the impact of ESG investing on asset pricing in the stock market. They showed that ESG can be considered a risk factor in the Eurozone, but an alpha strategy in North America. The social factor has gained traction in recent years and is no longer the laggard pillar. In addition, factor investing and ESG investing have become more connected in recent years.

## 2.2. Select Literature on Green Bonds

In the green bond area, Ehlers and Packer (2017) addressed issues related to green bond certification and the environmentally related financial risks of green bonds. Deschryver and Mariz (2020) proposed measures to overcome the challenges in the continued growth of the green bond market. Cochu et al. (2016) also identified bottlenecks and proposed policy measures to facilitate green bond issuance. Many other academic publications have focused on the comparison of yields between green bonds and similar conventional bonds. The yield premium or discount for a green bond is the yield difference between a green bond and an equivalent conventional or brown bond issued by the same issuer. A greenium exists when there is a yield discount for a green bond. Put differently, the green bond price is at a premium.

Many academic papers showed various degrees of greenium. Preclaw and Bakshi (2015) showed green bonds traded at a statistically significant 17 basis points tighter in an options-adjusted spread. Gianfrate and Peri (2019) found that green bonds were issued with a statistically significant average greenium of about 18 basis points. The greenium for corporate issuers was larger, at 21 basis points. Zerbib (2019) showed only a small greenium of two basis points.

Bachelet et al. (2019) found green bonds from institutional issuers had negative yield premia whereas those from private issuers had positive premia with respect to their brown correspondents, unless the private issuer committed to certify the bond green. Similarly, Hyun et al. (2019) indicated that green bonds certified by an external reviewer enjoyed a greenium of about six basis points. Furthermore, green bonds that obtained a CBI certification had a yield discount of around 15 basis points. Baker et al. (2018) showed the after-tax yields at issuance for green bonds were roughly six basis points below yields paid by equivalent conventional bonds. The yield discount increased with external certification and registration with the CBI.

Nanayakkara and Colombage (2019) showed that green bonds traded with a tighter spread of 62.7 basis points. Hachenberg and Schiereck (2018) also found that labeled green bonds traded tighter

than non-green bonds by the same issuers. [Fatica et al. \(2019\)](#) showed, from their panel data regressions, that there was a greenium for green bonds issued by supranational institutions and corporates. [Bour \(2019\)](#) identified the yield discount of green bonds, on average, at 23.2 basis points. The green premium varied with ratings, currencies, and issuer sectors. Finally, [Kapraun and Scheins \(2019\)](#) showed a significant greenium of 20 to 30 basis points for green bonds in the primary market.

However, others found no evidence of the yield discount for green bonds. For example, [Larcker and Watts \(2020\)](#) found a very small green bond yield discount. Thus, they concluded that the greenium was essentially zero. [Partridge and Medda \(2020\)](#) showed there was no conclusive evidence of greenium in the primary market. Furthermore, results from [Östlund \(2015\)](#) indicated no evidence of a green premium and that green bonds were traded at a discount compared to their conventional counterparts. [Karpf and Mandel \(2017\)](#) also showed a green bond discount in secondary market yields in a large sample of municipals.

Such mixed results are likely due to differences in sample selections, time periods, methodologies, ratings, issuer sectors, currencies, and the properties of the respective issuing entity and the bond. Those mixed results were documented in CBI studies as well. The CBI studies differed from others in that CBI compared the green bond yields with the issuers’ own yield curve. Other publications mainly utilized regressions and matching methods (comparing yields of a green bond and a conventional bond with similar maturity by the same issuer).

### 3. Green Bond Market Development

The European Investment Bank issued the first green bond in 2007. The total annual issuance in 2007 was \$0.8 billion, stayed at less than \$4 billion in subsequent years, and jumped to \$11.0 billion in 2013. Thereafter, the market has grown rapidly. By 2019, green bond issuance hit a record \$257.7 billion. The total was 51 percent over the 2018 volume of \$170.6 billion. [Table 1](#) lists annual issuance volume.

**Table 1.** Annual issuance of green bonds.

Year	Volume (\$ Billion)
2007	0.8
2008	0.4
2009	0.9
2010	3.9
2011	1.2
2012	3.1
2013	11.0
2014	36.6
2015	41.8
2016	81.0
2017	155.5
2018	170.6
2019	257.7

Source: Climate Bonds Initiative (CBI) ([www.climatebonds.net](http://www.climatebonds.net)).

Several factors contributed to the growth of the market. The first is strong government policy support, especially in countries in Asia and Europe. The target to slow the increase in the global average temperature specified in the Paris Climate Agreement requires large sums of funds to facilitate the transition towards a low-carbon economy. Furthermore, private institutions have increased fundraising from the green bond market. For borrowers, issuing green bonds is consistent with corporate social responsibility and, at least in some cases, saves financing costs.

Commonly recognized standards (such as GBP) add clarity and increase demand for green bonds from investors. Similarly, CBS provides standard criteria for labeling debt instruments consistent with the GBP and the goals of the Paris Climate Agreement to limit warming to under 2 degrees. In addition, rating agencies track and provide assessment of green bonds’ adherence to the stated

promises. As an example, Moody’s Green Bond Assessment provides an evaluation of an issuer’s approach to managing, administering, allocating proceeds to, and reporting on environmental projects financed with green bond proceeds. The assessments are expressed in the scale GB1 (excellent), GB2 (very good), GB3 (good), GB4 (fair), and GB5 (poor). With such information, investors know their moneys are used to support the environment. S&P’s Green Evaluations evaluates the relative environmental impact of the issue. It considers the funding’s transparency, its governance, and the relative net environmental impact. With such evaluations by those agencies, investors have comfort that their investments are used as promised. Note that such green bond evaluations by rating agencies will likely be discontinued once more uniform and consistent standards for issuing green bonds are adopted.

Many investors include an environmental mandate in their asset allocation. The green bond indexes provide a benchmark to track the performance of their green bond investments. The available green bond indexes include Solactive Green Bond Index, S&P Green Bond Index, BoA Merrill Lynch Green Bond Index, and Bloomberg Barclays MSCI Green Bond Index. In addition, there are several Chinese green bond indexes that measure the on-shore Chinese Renminbi denominated green bonds. [Liaw \(2018\)](#) showed that monthly returns between S&P and BoA Merrill Lynch are highly and positively correlated. Adding both at the same time in a portfolio results in limited diversification benefits for investors.

Several vehicles are available for investing in green bonds, including green bond new issues, green bond mutual funds, and green bond exchange-traded funds (ETFs). Subscription to new issues is a common approach to investing in this segment of the fixed-income market. There are also mutual funds and ETFs tailored for investors to gain exposure in green bonds. [Table 2](#) lists the green bond mutual funds and green bond ETFs. The sizes of those green bond mutual funds and ETFs are still small. The largest is Amundi Planet Emerging Green One that started with \$1.42 billion. This will improve as the new issuance continues to increase.

**Table 2.** Green bond mutual funds and ETFs.

<b>Green Bond Mutual Funds and ETFs</b>	<b>Inception</b>
Allianz IG Green Bond Fund	November 2018
Amundi Planet Emerging Green One	March 2018
Calvert Green Bond Fund	October 2013
Mirova Global Green Bond Fund	February 2017
TIAA-CREF Green Bond Fund	November 2018
Franklin Liberty Euro Green Bond ETF	April 2019
iShares Global Green Bond ETF	November 2018
Lyxor Green Bond ETF	February 2017
Lyxor Green Bond ESG Screened ETF	October 2019
VanEck Vectors Green Bond ETF	March 2017

Source: [Climate Bonds Initiative \(2019b, 2019c, 2020a, 2020b\)](#)

#### **4. Green Bond Pricing in the Primary Market**

The green bond issuance process is similar to that of a regular bond, with an added emphasis on governance, traceability and transparency designed to increase investors’ confidence in the green credentials of the bond. The green certification requires issuers to use the funds as promised and to report on such on a regular basis. Since the first corporate green bond was issued in 2013, there have been anecdotes of green bonds pricing being tighter than similar conventional bonds.

Many green bonds are similar to their brown equivalents. Thus, we would not expect them to be more expensive than conventional vanilla bonds. A green premium is therefore somewhat of an anomaly, primarily due to unmet demand for green debt. The demand is driven largely by investors with a green mandate but also by regular investors interested in green bonds as a way to gain exposure

to the green theme. This section surveys reports on green bond pricing in the primary market to explore if there exists a green bond yield discount (also known as “greenium”).

#### 4.1. No Evidence of Green Premium

Several academic papers showed no greenium. For example, [Larcker and Watts \(2020\)](#) examined matched pairs of green and non-green municipal bonds and showed that when risks and returns were held constant, municipal investors viewed green and non-green bonds by the same issuer as almost exact substitutes. Comparing the two samples, the yield difference between green and non-green municipal bonds was 0.45 basis points, a very small green bond yield discount. Thus, they concluded that the greenium was essentially zero. [Partridge and Medda \(2020\)](#) found that an index comprised of green municipal bonds outperformed the closest S&P index from 2014 to 2018. There was a statistically significant greenium of five basis points in the secondary market. However, there was no conclusive evidence of a greenium in the primary market. [Karpf and Mandel \(2017\)](#) used secondary market yields in a large sample of municipals and found a green bond price discount.

[Östlund \(2015\)](#) analyzed the spread differentials between green and conventional bonds of the same issuer to find out whether investors exhibit a green preference. The results showed no evidence of a greenium and indicated instead that green bonds were traded at a discount compared to their conventional counterparts.

#### 4.2. Evidence of Green Premium

However, many academic papers showed evidence of a greenium in the primary market. [Preclaw and Bakshi \(2015\)](#) performed a regression analysis and the results indicated that green bonds traded at a statistically significant 17 basis points tighter in options-adjusted spread, after taking into consideration Moody’s weighted rating factors, spread duration, and time since issuance. These factors capture credit risk, investment length, and the liquidity premium in off-the-run securities, respectively. [Gianfrate and Peri \(2019\)](#) adopted a propensity score matching approach to study 121 senior bullet EUR green bonds between 2013 and 2017. They found that green bonds were issued with a statistically significant average negative premium (greenium) of about 18 basis points. The greenium for corporate issuers was larger, at 21 basis points. [Bachelet et al. \(2019\)](#) examined the characteristics of a sample of green bonds matched with their closest brown bonds. They found green bonds from institutional issuers had negative premia. Green bonds from private issuers had positive premia compared to their brown correspondents, unless the private issuer committed to certify the bond green. They argued that the green verification was to reduce asymmetric information and provide guarantees to investors against greenwashing. [Nanayakkara and Colombage \(2019\)](#) analyzed the pricing difference between green bonds and conventional bonds. They used option-adjusted credit spread to investigate if investors were willing to pay a premium price for green bonds over conventional bonds. The results of their panel data regression showed that green bonds were traded with a tighter spread of 62.7 basis points.

[Hyun et al. \(2019\)](#) used liquidity-adjusted yield premium of green bonds over their synthetic conventional bonds to investigate how greenness is priced in the bond market. Their empirical results indicated that, on average, there was no significant yield premium or discount on green bonds. However, green bonds certified by an external reviewer enjoyed a greenium of about six basis points. Furthermore, green bonds that obtained a CBI certificate showed a discount of around 15 basis points. [Fatica et al. \(2019\)](#) showed, from their panel data regressions, there was a greenium for green bonds issued by supranational institutions and corporates. However, there was no effect for green bonds issued by financial institutions. [Bour \(2019\)](#) explored the existence of a greenium and the bond-specific variation therein. The yield spread between the green and similar conventional bonds was estimated. The study controlled for residual liquidity effects by using the bond’s bid-ask spread as a proxy and identified the yield discount of green bonds, on average, at 23.2 basis points. The green premium varied with ratings, currencies, and issuer sectors.

Zerbib (2019) used green bonds as an instrument to identify the effect of pro-environmental preferences on bond prices. The approach was a matching method followed by a two-step regression procedure to estimate the yield differential between a green bond and a similar conventional bond. The results indicated a greenium of two basis points. Baker et al. (2018) studied US municipal green bonds and found that municipal green bonds were priced at a premium to otherwise similar ordinary bonds. The after-tax yields at issuance for municipal green bonds were roughly six basis points below yields paid by equivalent conventional bonds. The yield discount increased with external certification and registration with the CBI.

Additionally, Kapraun and Scheins (2019) considered a large sample of over 1500 green bonds issued worldwide and estimated the differences in yields of green and comparable conventional bonds. The primary market results revealed a significant greenium of 20 to 30 basis points for green bonds. This yield discount varied across currencies, issuer types, and over time. In particular, bonds issued by more credible entities or bonds denominated in major currencies were priced at lower yields. On the other hand, green bonds traded at higher yields in the secondary market, except for those issued by governments and supranational institutions.

#### 4.3. Mixed Results

CBI started to survey the green bond pricing in the primary market in 2016 (Climate Bonds Initiative 2017a, 2017b, 2017c, 2018a, 2018b, 2019a, 2019b, 2019c, 2020a). The surveys focus on USD and EUR denominated labeled green bonds with an issue size of more than \$200 million (the size requirement was increased to \$300 million after Q2 2017 and to \$500 million in 2018). Sample selection criteria also include investment grade and a term maturity of at least three years. CBI performs pricing analyses only for green bonds where there are sufficient data to construct the issuer's yield curve. A greenium exists if the new green bond is plotted below the issuer's yield curve. When a green bond is plotted on the issuer's own yield curve, there is no yield discount or premium. When a new green bond is plotted above the issuer's yield curve, there is a new issue premium. Such a new issue premium is a standard feature, as the issuer pays for a new bond to attract new investment.

We reviewed all reports from CBI on green bond pricing in the primary markets from 2016 to 2019. The main findings in those studies included pricing relative to the initial price talk, oversubscription, greenium, and performance in immediate secondary markets. As Table 3 shows, the new issues were often priced tighter than the initial price talk relative to vanilla bonds issued during the same period. The observations also showed that the average oversubscription levels for green bonds were in line or higher than the vanilla bond market. Furthermore, a majority of green bonds exhibited tighter spreads 7 and 28 days after the pricing date. The studies also indicated that green bonds attracted a broader range of investors, investors with a green mandate, and regular investors interested in gaining exposure to the green theme.

As noted earlier, CBI studies examine green bond pricing at issuance only for those with sufficient data to build the issuer's own yield curve. A total of 132 green bonds met this requirement. Table 3 lists the results of pricing at issuance under Greenium, On Curve, and Yield Premium. Among the sample of 132 green bonds, 61 were priced above the issuer's own yield curve. Sellers paid a higher yield for those new green bonds in comparison to where seasoned bonds from the same issuer traded in the secondary market. There were 43 new green bonds priced on the issuer's yield curve, consistent with those traded in the secondary market from the same issuer. Only 28 green bonds exhibited a greenium.



**Table 3.** Summary of main findings.

Time	Pricing Tighter than Initial Price Talk	Oversubscription	New Issue Pricing	Tighter Spread after 7 Days	Tighter Spread after 28 Days
January–March 2017	EUR: 11.2 bps USD: 15.3 bps *	EUR: 2.7 USD: 3.16	Greenium: 6 On Curve: 4 Yield Premium: 4	70%	63%
April–June 2017	EUR: 6.3 bps USD: 15.4 bps *	EUR: 2.3 ** USD: 2.8	Greenium: 2 On Curve: 2 Yield Premium: 6	71%	53%
July–September 2017	EUR: 11 bps * USD: 12.1 bps *	EUR: 2.7 USD: 2.5 **	Greenium: 2 On Curve: 4 Yield Premium: 6	79%	74%
October–December 2017	EUR: 11 bps USD: 13 bps	EUR: 2.9 USD: 2.7 **	Greenium: 3 On Curve: 0 Yield Premium: 3	47%	52%
January–June 2018	EUR: 8 bps * USD: 18 bps *	EUR: 2.3 ** USD: 3.4 **	Greenium: 0 On Curve: 5 Yield Premium: 13	90%	66%
July–December 2018	EUR: 10 bps USD: 11 bps	EUR: 2.6 ** USD: 1.9	Greenium: 2 On Curve: 5 Yield Premium: 14	56%	67%
January–June 2019	EUR: 17 bps * USD: 19 bps *	EUR: 3.9 ** USD: 4.1	Greenium: 6 On Curve: 15 Yield Premium: 12	59%	57%
July–December 2019	EUR: 13.3 bps * USD: 13.7 bps *	EUR: 2.8 ** USD: 2.7 **	Greenium: 7 On Curve: 8 Yield Premium: 3	57%	58%

Notes: Pricing column: bps is basis points and \* denotes above market average. Oversubscription column: \*\* denotes higher than vanilla bonds. New issue pricing is evaluated only for bonds with sufficient data to construct the issuer's yield curve. The "Greenium" denotes the discount in yield for the new issue, "Yield Premium" represents the additional yield issuer pays to investors to attract new investment, and "On Curve" denotes absence of yield discount or premium. The spread percentage in the last two columns represents the percentage of green bonds tightened more than their corresponding index.

Those mixed results were reported in a survey by the [Climate Bonds Initiative \(2020b\)](#) as well. This was a survey of treasurers from companies that issue green bonds. Close to half (48 percent) of the treasurers indicated the cost of funding green bonds is similar to that of vanilla equivalents, 42 percent of treasurers considered the cost to be lower, and several replied that costs were higher.

## 5. Green Bonds in the Secondary Market

With the introduction of green bond indexes and green bond funds (including exchange-traded funds (ETFs)), green bond investing becomes part of index asset allocation and thus deepens and broadens the investor base. Each green bond index has its own methodology for selecting the component bonds. The index allows investors to invest in a portfolio of green bonds to diversify company-specific risks, while maintaining a green exposure. There are several green bond indices: Solactive Green Bond Index, S&P Green Bond Index, BofAML Green Bond Index, and Bloomberg Barclays MSCI Green Bond Index. Separately, China also introduced the China Green Bond Index to track investment performance for onshore Renminbi denominated green bonds. For investors, there are green bond funds offered by various investment management companies. Many are index-based funds.

### 5.1. Green Bond Indexes

The first index to track the performance of green bonds was the Solactive Green Bond Index ([Solactive AG 2015](#)). It is a rules-based, market value weighted index calculated to track the performance of its component bonds. This index includes green bonds that have an amount outstanding of at least

\$100 million and a minimum remaining maturity of six months. The index excludes convertible bonds and inflation-linked bonds. Each bond is weighted by its market value with a maximum of 5 percent per bond.

The S&P Green Bond Index includes labeled green bonds by issuers who have clearly disclosed information about the use of proceeds, or the issuers have obtained an independent second opinion (S&P Dow Jones 2016). Each component bond has maturity greater than one month from the rebalancing date. No bond matures in the index. The index excludes Bills, STRIP and inflation-linked instruments. Note that STRIP denotes separate trading of registered interest and principal of securities.

The BofAML Green Bond Index includes debt of corporate and quasi-government issuers but excludes securitized and collateralized securities (Bank of America 2014). Each component bond has an investment grade rating, at least eighteen months to final maturity at the time of issuance, and at least one month remaining to final maturity as of the rebalancing date. The index selection also requires a fixed coupon schedule.

The Bloomberg Barclays MSCI Green Bond Index includes corporate, government-related, and securitized green bonds with an investment grade and fixed coupon rate (Barclays MSCI 2015). The index holds bonds until maturity and is rebalanced every month. In addition, Bloomberg Barclays MSCI offers the US Green Bond Index and Euro Green Bond Index separately.

Each of these indexes comprises different portfolios of green bonds. Table 4 shows the returns of these indexes and the Bloomberg Barclays Aggregate Bond Index from January 2014 to October 2019. Those returns do not show any pattern.

**Table 4.** Performance of bond indexes.

Time Period	S&P Green Bond Index	Bloomberg Barclays MSCI Green Bond	Solactive Green Bond Index	Bloomberg Barclays US Aggregate Index
01/02/2015–12/30/2015	−6.71%	0.50%	3.79%	0.14%
01/02/2016–12/30/2016	1.80%	1.96%	3.74%	2.53%
01/03/2017–12/30/2017	11.19%	2.20%	−2.51%	3.58%
01/03/2018–12/28/2018	−2.80%	−0.72%	1.79%	−0.02%
01/03/2019–10/30/2019	5.11%	6.94%	8.74%	8.04%

Source: Bloomberg.

## 5.2. Green Bond Mutual Funds and ETFs

Green bond funds are a convenient way for investors to access this new asset class to expand their investment choice. As Table 2 shows, Calvert Green Bond Fund was the first. The asset under management (AUM) was \$475.5 million as of April 30, 2020. The annual returns were as follows: 4.94% in 2014, −0.26% in 2015, 3.66% in 2016, 3.01% in 2017, 0.29% in 2018, and 8.01% in 2019. The performance generally lagged behind its benchmark index, the BofAML Green Bond Index.

Other funds or ETFs listed in Table 2 all started in 2017 or after. The AUMs of those funds are still small. For example, VanEck Vectors Green Bond ETF had an AUM of \$32.23 million as of 30 April 2020. Its year-to-date (YTD), one-year, and three-year returns underperformed its tracking index (S&P Green Bond Index). The other ETF, iShares Global Green Bond ETF, commenced in 2018 and had an AUM of \$74.89 million (19 May 2020). This ETF performance also trailed behind its benchmark index, the Bloomberg Barclays MSCI Green Bond Index. The largest of them all, Amundi Planet Emerging Green One, started with an AUM of \$1.42 billion at its inception in 2018.

## 6. Conclusions

Green bonds can make a contribution to support the Paris Climate Agreement for a cleaner environment. The green bond market has grown substantially since 2013, but it remains small in the fixed-income market. In this paper, the green bond premium (greenium) is calculated as the difference between the yield of a green bond and that of an equivalent conventional bond by the same

issuer. Many research reports that showed evidence of green bond premiums also found an increased greenium if the bond had an independent green reviewer or certification. This implies that such certification can increase transparency and boost investor confidence. It represents a good opportunity for borrowers to expand their funding capacity for green projects as investors take a haircut in yield to support the environment.

However, several reports showed no evidence of green bond yield discount at issuance and green bonds trade at a higher yield in the secondary market. CBI studies indicated some green bonds are priced below while some are priced on or above their own yield curve. Thus, there is no guarantee that green bonds enjoy a lower cost. The conflicting results are likely explained by differences in sample selections, time periods, methodologies, ratings, currencies, and the properties of the respective issuing entity and the bond.

The urgent need to finance climate and environmental solutions makes green bonds attractive. In order to further develop the green bond market, [Deschryver and Mariz \(2020\)](#) proposed measures to unlock the potential of green bonds to finance the sustainability goals. Those measures include standardization of the green bond market, high standards of disclosure and reporting, development of synergies with other sectors and instruments, and facilitation of investment in emerging economies. [Ehlers and Packer \(2017\)](#) argued that more consistent standards for issuing green bonds across jurisdictions will help further develop the market. [Cochu et al. \(2016\)](#) added raising awareness of green bond benefits and mandatory disclosure of green indicators to foster growth of the market. In addition, it is necessary to have a widely accessible secondary market for investors to trade or invest. Currently, the green bond mutual funds and green bond ETFs are very small. Expanding the menu of green bond mutual funds and ETFs is fundamental to a wider investor base. Liquidity will then be enhanced. A more active secondary market supports the primary market. Large sums of new issues further benefit the secondary market. Such positive snowball effects are likely to lead to a large and efficient green bond market.

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