SUSTAINABILITY ON THE RISE:
AN ANALYSIS OF THE GREEN BOND MARKET PERFORMANCE

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EXECUTIVE SUMMARY

Green bonds have an important role to play in supporting a global transition to a low carbon economy. With the focus on sustainability, including initiatives – many of which were addressed in the recent federal budget program - such as renewable energy, electric vehicles, electrification of industrialized processes and the broader net-zero movement, green bonds have emerged as an instrument that can be used to facilitate the direction of capital flows to dedicated projects that address climate challenges and opportunities which traditional securities may not adequately address.

The value of the green bond market grew five-fold from 2007 to 2021. Investors are increasingly recognizing the value of green bonds in meeting environmental and social goals, resulting in greater demand for these investments. The significant potential of green bonds in addition to their arguable underutilization, indicates there is a clear need to better understand this security type, its risk and return characteristics, along with its trading history. It is also evident that there is a need for greater standardization and transparency in green bond documentation and reporting. Furthermore, increased harmonization of criteria across different certification bodies and more broadly across bond markets would be effective in terms of reducing confusion and increasing comparability across the green bond universe, which in turn could serve to increase credibility and improve general investor sentiment for the security type.

This paper provides an overview of the various green fixed income securities, including descriptions of their intended purpose and identifiable characteristics. It goes on to provide an overview of the risk and return characteristics of green bonds in the Canadian and US markets, along with comparative performance relative to conventional bonds. The paper discusses investor benefits of investing in green bonds from both a qualitative and quantitative perspective and provides valuable insight into current investor sentiment towards green bond investments.

The key finding from this research demonstrates that while Canadian green bonds are not yet commanding a premium price (ie. they are priced at a discount), the Canadian yield spread curve shows a diminishing trend, indicating that investors are slowly recognizing the investment value of the green bond and are increasingly willing to pay less of a discount for the bond's green label.

The paper discusses observed trends and differences by industry and across jurisdictions (Canada/US). Findings show that the US green bond market tends to price bonds at a premium, whereas the Canadian green bond market has tended to price at a discount. Having said that, as noted above, it is important to recognize that over time, this observed discount is narrowing, demonstrating that investors are increasingly willing to pay a higher price for green bonds in Canada.

Finally, the paper discusses the available green bond indices, and their utility in providing a benchmark for comparison in terms of quantitative performance such as yields and returns as well

as qualitative performance, including levels of disclosure and reporting. This information is particularly valuable when observing trading metrics over time in the secondary market.

The purpose of the paper is to inform buy side investors including asset managers, pension funds and investors on the topic of green bond fixed income securities – including their characteristics, recent performance and trending and benchmarks - to inform their decision-making in the context of investment portfolio allocation.

Understanding the characteristics of the green bond security type along with its potential risks and benefits can help investors make more informed investment decisions and comfortably transition towards incorporating green bonds into their respective investment portfolios. This paper briefly addresses the issues and considerations from an issuer perspective, and future research could be complementary and beneficial to study these issues and considerations in greater detail.

INTRODUCTION

Green bonds are fixed-income financial instruments that are used to fund eco-friendly projects and tackle climate risk. The first green bond was issued in 2007 by the European Investment Bank (EIB) (Flammer, 2019). These bonds are usually issued by private and public entities. Projects that are eligible for green bond classification include renewable energy, green buildings, clean transportation, waste management, and many others. To qualify for green bond status, the issuer must demonstrate that the proceeds will be used for sustainable purposes. Often this process entails obtaining an ESG rating from a third-party agency to help validate the environmental or social benefits of the project or activity being financed. In addition, there are several certification processes that can be used to support green bond status, with the most commonly used ones including:

1. **Climate Bonds Standard**: This certification process was developed by the Climate Bonds Initiative, an international organization that promotes investment in projects that mitigate climate change. https://www.climatebonds.net/climate-bonds-standard-v3
2. **International Capital Market Association (ICMA) Green Bond Principles**: The principles cover the process of issuing and managing green bonds, including the use of proceeds and reporting on environmental impact. https://www.icmagroup.org/sustainable-finance/
3. **Certification by third-party organizations**: In addition to the above standards, there are several third-party organizations such as Sustainalytics, Vigeo Eiris, and DNV GL that provide certification services for green bonds. These organizations typically evaluate the environmental and social impact of the projects or activities being financed, and issue a certification based on their assessment.

Motivation for the Research

The main objective of this research is to conduct a thorough analysis of the performance of the green bond market, with a focus on comparing it to conventional bonds. Additionally, the research aims to assess the performance of green bond indices in relation to traditional bond indices[i]. By examining these different aspects of the green bond market, this research seeks to deepen the reader's understanding of its performance and potential as a sustainable investment option.

This research aims to provide valuable insights into green bonds in both Canada and the US, which can assist investors in making informed investment decisions. It is critical to examine the risk characteristics of green bonds to fully comprehend their significance in today's investment landscape in terms of the valuable role they currently play (along with their potentially more significant role) in financing the transition to a low-carbon economy. Given the growing focus on sustainability, including initiatives such as renewable energy, electric vehicles, electrification of industrialized processes and the broader net-zero movement, green bonds have emerged as a potential solution to address climate-related challenges that traditional securities may not adequately address. Green bonds provide numerous benefits to investors. Including:

- **Tax incentives**: In some countries such as the United States, China and India, investors may be eligible for tax incentives, such as tax credits or deductions, for investing in green bonds. These incentives can help increase the return on investment for investors.
- **ESG requirement fulfillment**: as many institutional investors, such as pension funds and insurance companies, are required to meet certain environmental, social, and governance (ESG) standards.

i Green bond indices are financial benchmarks that track the performance of a specific set of green bonds. There are several green bond indices that are available in the market, and some examples include: Bloomberg Barclays MSCI Green Bond Index; S&P Green Bond Index; Solactive Green Bond Index. Green bond indices provide investors with a method of tracking the performance of the green bond market and to identify investment opportunities that align with their values and financial goals.

- **Green premiums**: Green bonds may offer a premium over conventional bonds due to their environmental and social benefits. This premium can provide investors with a higher return on investment and help incentivize issuers to continue issuing green bonds.

While green bonds offer several benefits, they also pose additional risks compared to conventional bonds, such as greenwashing and regulatory policies. Understanding these risks and benefits can help investors make more informed investment decisions and comfortably transition towards incorporating green bonds into their respective investment portfolios.

Insightful Research Findings for the Canadian Market

The research findings discussed herein present a contrasting perspective on the performance of green bonds, compared to a well-known study by Ehlers and Packer (2016). The findings indicate a positive yield spread difference between Canadian green bonds and conventional bonds at the time of issuance, over the period studied. This suggests that the green bonds observed were offered at a discounted price to conventional bonds, implying investors were not yet willing to pay a premium for them.

This result is different from previous literature, which suggested that green bonds were being offered at a premium price. Furthermore, the Canadian yield spread curve is showing a diminishing trend, indicating that investors are slowly recognizing the investment value of the green bond security and are increasingly willing to pay a smaller discount (i.e. higher price) for the bond's green label. By demonstrating that Canadian green bonds are not yet commanding a premium price and are demonstrating a trend towards narrowing discounts, the research discussed herein provides valuable insights into the current state of the green bond market and investor sentiment towards these types of investments.

In contrast, the US green bond market demonstrates results consistent with prior studies, with an average negative yield spread.

Green bond indices, on the other hand, showed promising growth between 2017 and 2020 (over 60% cumulative return) but suffered a severe decline from 2021 to 2022 (dropping by 40%) as the global bond market went underwater. Fortunately, the indices are showing signs of a rebound, and as such higher growth and lower volatility can be expected in the future as more investors recognize the market value of green fixed-income investments.

Green Bond Identification, Performance and Comparison against Benchmark Indices

This paper will start by analyzing the current conditions of the green bond market, which includes differentiations against other green fixed-income instruments, green bond issuance by year, industry, and country, and recent green bond certifications.

Then, green bond performance is analyzed, focusing on Canadian and US green bond premiums by first describing the data studied and methodology utilized along with its limitations, followed by a presentation of the comparative results.

Finally, the performance of the green bond indices will be examined in terms of their annual and cumulative performances. Through the study of individual green bonds, the green bond indices, and the green bond market, the reader will gain an understanding of the most current performance, trends, and characteristics of green bonds.

PART I: GREEN BOND MARKET OVERVIEW

Green Bonds vs. Other "Sustainable" Bonds

Green bonds differ from other sustainability-related bond labels by their intended use of proceeds. There are other popular green fixed-income securities, such as sustainability bonds, climate bonds, social bonds, and sustainability-linked bonds. As aforementioned, green bonds are used to raise dedicated funds for dedicated projects that are specifically environmentally beneficial. On the other hand, sustainability-linked bonds, or

Table 1: Characteristics of Different Global Green Fixed Income Bonds

Bond Type	Definition	Origin	Market Size	Related Certification	Project Examples
Green bonds	Fixed-income securities used to finance environmentally friendly projects	European Investment Bank in 2007 to address climate change	$1.45 trillion	Climate Bonds Standard, CICERO Shades of Green, Moody's Green Bond Assessment	Green buildings, energy efficiency, retrofits, sustainable water management systems
Sustainability bonds	fixed income securities are used to finance a range of sustainable projects	The World Bank in 2017 to promote sustainabilithy	$150 billion	Sustainability bond guidelines, social bond certification by ICMA	Affordable Housing, sustainable transportation, renewable energy.
Climate bonds	Fixed-income securities are used to finance projects aimed at reducing greenhouse gas Emissions or mitigating the effects of climate change	The World Bank in 2008 to address climate change	$1.06 Trillion	Climate Bonds Standard, CICERO Shades of Green, Moody's Green Bond Assessment	Energy-efficient buildings, sustainable forestry, and agriculture, climate adaptation
Social Impact bonds	Fixed-income securities used to finance social projects	Social Finance UK in 2010 to reduce reoffending ex-offenders	$800 million	Social Impact Bond Certification by ICMA	Re-entry programs for ex-offenders, homelessness prevention, and addiction treatment
Sustainability-Linked bonds	Fixed-income securities that link the interest rate to the achievement of sustainability goals	Enel in 2019 to link interest rates to issuers' sustainability	$150 billion	Sustainability-Linked Bond Principles by ICMA	Water conservation, bidiversity protection, diversity, and inclusion

Source: Climate Bond Initiative, GIIN, Environmental Finance, ICMA

Note: Currency in USD

SLBs, being part of a newer and smaller market, are used to raise funds for any use, including general corporate purposes, with their applicable interest rate tied to the company's sustainability targets (Wilkes & Furness, 2022). To better understand the differences, the respective definitions, histories, market sizes as of 2022, and examples of relevant green projects are presented below.

Building on the descriptions above, a sustainability bond is a type of bond that is issued to finance projects or activities that have a positive impact on the environment, society, or both. Like green bonds, sustainability bonds are designed to support sustainable development initiatives, however, they may have a broader scope than simply environmental projects, such as social development projects including affordable housing, education, healthcare, or community development; sustainable infrastructure including public transportation, waste management, or water treatment facilities; and projects that promote gender equality and women's empowerment. The use of proceeds from a sustainability bond should be clearly defined in the bond's indenture or framework. Typically, the use of funds is restricted to projects or activities that have a clear social or environmental benefit, such as those previously mentioned. It is not common for the use of funds to be extended to general operational or administrative expenses, as these are not considered to be directly tied to sustainable development.

Social Impact Bonds (SIBs) are a flexible financing tool that can be applied to a wide range of social issues and interventions, including those focused on promoting Diversity, Equity and Inclusion ("DEI"). For example, a SIB could be used to fund a program targeted at improving employment outcomes for disadvantaged or marginalized groups, such as job training or apprenticeship programs.

Although all of these bonds fall under the term "green fixed income" securities (used interchangeably with the term "Sustainable Bonds", and not to be confused with "Sustainability Bonds" or "Sustainability-Linked Bonds", which are each different security types, as illustrated in Table 1 above), these bonds differ by their market size and scope of relevant projects. The market size of the bond categories described in Table 1 are presented as of 2022. The top two green fixed income securities, based on aggregate market value of bond issuances are green bonds ($1.45T), and climate bonds ($1.06T) (Climate Bonds Initiative, 2022 & Lester, 2022). The first green bond was issued by the EIB in 2007, which started the trend of green fixed-income issuance and led to many other forms of bonds in the market. Each class of green fixed income bond has different incremental criteria, some of which are listed in the column "Related Certifications" in the table above.

Outlook for Green Bonds

The increasing momentum in green bond issuance and market demand has facilitated an increase in the standardization and clarity of definition for green bonds. Furthermore, a growing ecosystem of verifiers and assurance providers currently exists to examine the measurement processes involved and environmental integrity associated with green bonds. The OECD's report "Mobilising the Debt Capital Markets for a Low Carbon Transition" (OECD, 2015) provides insights and recommendations for accelerating the transition to a low-carbon economy through the mobilization of debt capital markets. However, it is imperative to recognize that the growth rate of green bonds depends on several critical elements, including policy and regulatory factors, market conditions, and financing trends. Key barriers with respect to the development of a deep and robust green bond market include the lack of a robust, clear green bond definition, limited availability of reliable data, low levels of understanding and standardization, regulatory barriers, and limited investor demand (OECD, 2015). Advances have been made since the 2015 OECD report however, these issues remain fundamental challenges to growth in the green bond market. Policymakers and issuers need to focus on these challenges to grow a sustainable green bond market with environmental integrity.

Encouragingly, numerous green bond indices already exist. A green bond index is a type of financial benchmark that monitors the performance of a collection of green bonds. Such indices can assist in addressing challenges faced by the green bond market by serving as a standard for issuers and investors to evaluate the performance of green bonds relative to traditional bonds. Furthermore, such indices can aid in increasing transparency and credibility in the market, which can bolster investor confidence and, in turn, stimulate greater demand for green bonds. There are already several emerging green bond indices and exchange listings available, including the Bank of America Merrill Lynch Green Bond Index, Barclays MSCI Green Bond Index, S&P Green Bond Index, and Solactive Green Bond Index.

Major investors such as Barclays, HSBC, and Deutsche Bank have committed to investing a significant amount of assets into green bonds, demonstrating their support for the development of the green bond market. To achieve the International Energy Agency's (IEA) target of limiting global warming to 2 degrees Celsius (2DS) by mid-century, green bond issuance must materialize at a significant scale and in a market where investors are capable of absorbing the supply. This in turn means that the green bond market must grow rapidly and with a high level of demand from investors to support the financing of sustainable projects and activities (OECD, 2015).

Table 2: Green vs. Ordinary Bond Issuance by Year

Issue Year	Number of Green bonds	Number of Ordinary bonds	Issuance of Green bond ($B)	Issuance of Ordinary bonds ($B)
2022	1,694	162,985	499.04	53,124.63
2021	1,905	158,685	650.58	63,564.60
2020	1,044	177,015	287.38	67,073.28
2019	848	185,779	265.51	49,624.34
2018	576	192,362	164.99	47,295.71
2017	481	173,322	161.63	48,822.47
2016	281	147,384	99.47	46,182.88
2015	336	132,942	51.19	39,555.66
2014	139	123,513	36.86	36,801.79
2013	46	114,852	16.02	34,974.81
2012	22	100,588	2.15	38,471.58
2011	30	86,402	1.19	35,885.62
2010	54	83,402	3.95	36,683.57
2009	13	86,601	0.92	37,192.69
2008	7	115,458	0.43	29,549.77
2007	2	118,395	0.84	24,839.84
Total	7,478		2,242.15	689,643.25

Note: All dollar amounts expressed in USD as of issue date.

Source: Bloomberg

Issuance of Green Bonds: 2007 to 2022

In the following section, the bond data studied replicates and extends the work presented in Flammer's paper which covers the period up until 2018 (2020). Obtained from Bloomberg's fixed-income database, the sample of selected bonds includes all bonds issued between January 1, 2007, and December 31, 2022, with restriction to the Bloomberg asset classes "corporate" and "government." This search yields a total of 2,159,685 bonds issued during the sample period, with 7,478 labelled as green bonds according to Bloomberg's green instrument indicator.

As illustrated by the value and volumes of bonds presented in Table 2, green bonds have been gaining momentum in the financial market over the last 15 years. The literature by Flammer covers the growth and quantitative issuance of green bonds across time, countries, industries, and credit ratings. These factors provide insights into the performance of green bonds under various conditions. 2007 saw only a single green bond issuance, worth $0.84B. Over the next decade, the number of green bond issuances increased significantly, reaching 576 in 2018 with a total issuance value of approximately $165 billion by that year. In 2022, the market had expanded further, with 1,694 green bonds issued with a total aggregate value of $499.04B.

Figure 1 depicts a comparison between the green bond market and the conventional bond market by presenting the ratio between the two bond types in dollars over time. It is worth noting that, although still a relatively small proportion, the ratio of green to ordinary bonds has shown a remarkable increase between 2007 and 2021, with a slight decline in 2022. Furthermore, in terms of both the number and dollar amount of issuances, green bonds have surpassed the 1% mark of the conventional bond market. Additionally, the upward sloping trend of both panels in Figure 1 provides compelling evidence to support the notion that the green bond market has been expanding at a faster pace than the traditional bond market.

Figure 1: Ratio of Global Green to Ordinary Bonds

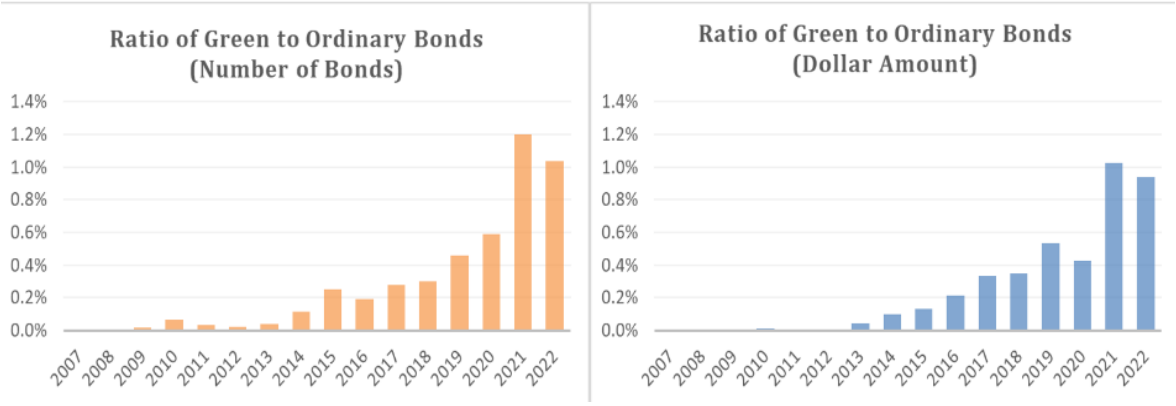
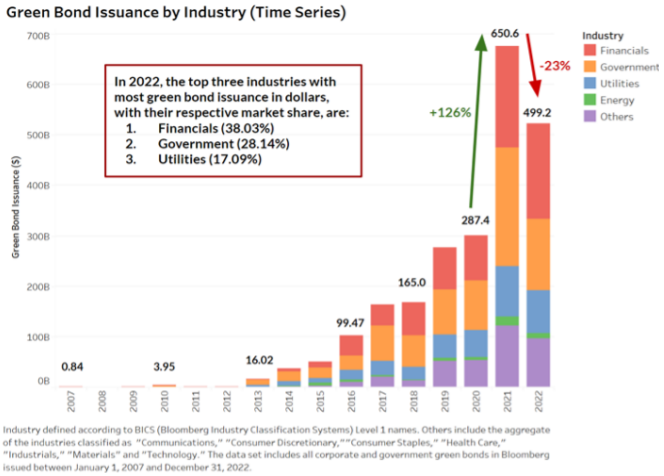


Figure 2 below presents green bond issuance by industry: financials; government; utilities; energy and others.

Figure 2:



Three key findings are addressed from figure 2:

Firstly, the government ($182.6B) and financial industry ($150.9B) are the top two sectors with the most issuance by dollar value of green bonds. In recent years, "government" and "financials" have shown the greatest upward trend when it comes to the issuance of green bonds. "Utilities" also comes out to be the third issue in the green bond issuance with 17.09%, which is to be expected as the nature of the industry revolves around basic amenities such as electricity.

Secondly, the value of the green bond market has grown substantially from 2007 to 2021, representing a more than five-fold growth. This trend indicates that investors are increasingly recognizing the value of green bonds in meeting environmental and social goals, resulting in greater demand for these investments.

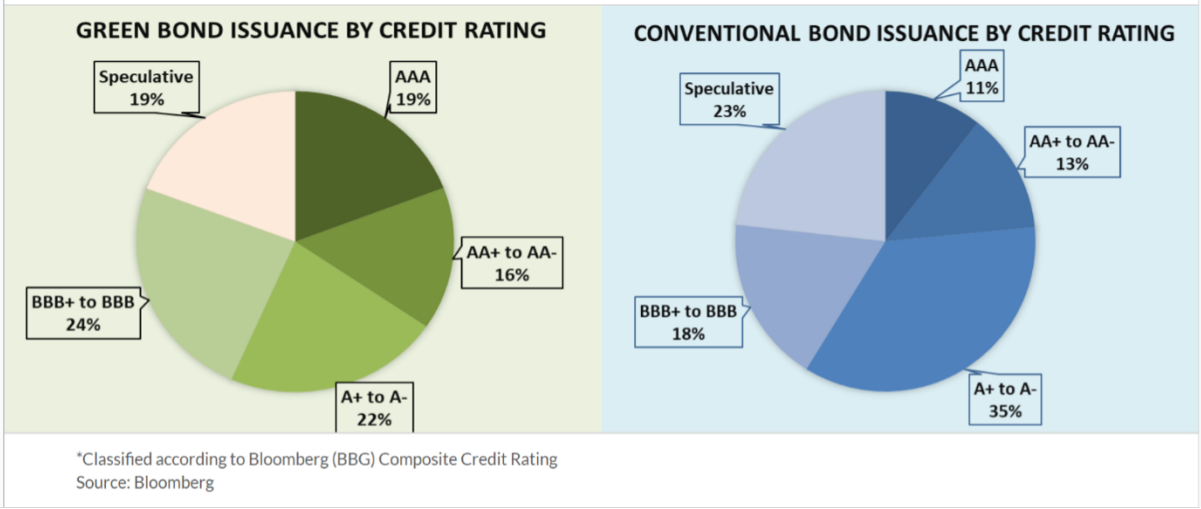
Thirdly, there is a major spike (126%) in green bond issuance from 2020 to 2021. There are various reasons for this observation. Firstly, there were many benefits and incentives that were introduced on a global scale in 2021, like tax incentives and subsidy bonds (CBI, 2023). To add on, interest rates were at historic lows due to the stimulus/ relaxed government monetary policy airing from COVID-19 pandemic (0.25%), causing investors to seek alternative investment opportunities. With the ongoing climate risk, green bonds became an attractive choice to earn a return while contributing back to the environment and fulfilling an organization's ESG responsibility, such as following through on commitments made by organizations to align with stakeholder expectations and climate targets. Furthermore, the European Union's Taxonomy Regulation, which came into effect in July 2020 and defines the criteria for sustainable activities and finance, explains why these conditions led to an increase in the issuance of green bonds (EU, 2023).

It is worth noting that the observed decline in green bond issuances from 2021 to 2022 can be attributed to two major factors: the increase in interest rates over the period and the normalization of the COVID-19 pandemic. Canadian interest rates rose from 0.06% in January 2021 to 4.325% by December 2022, making green bonds less attractive to investors. When interest rates are low, investors may be more willing to accept lower yields on green bonds in exchange for the social and environmental benefits they provide. However, as interest rates rise, investors may be more inclined to seek out higher returns elsewhere.

It's also possible that the decrease in green bond issuances is simply a short-term fluctuation and not necessarily indicative of a long-term trend. The green bond market has shown strong growth over the past decade, and the underlying demand for sustainable investments is expected to continue to drive growth in the coming years.

From Figure 3, it is evident that there is a relatively equal distribution of credit ratings across the credit rating spectrum amongst the green bonds, whereas the conventional bonds have a dominant sector of A+ to A-, at 35%. It is worth noting that green bonds' status relies heavily on external review for their certification and rating. Green bonds are a relatively new financial instrument ,

Figure 3: Comparison of Bond Issuance by Credit Rating



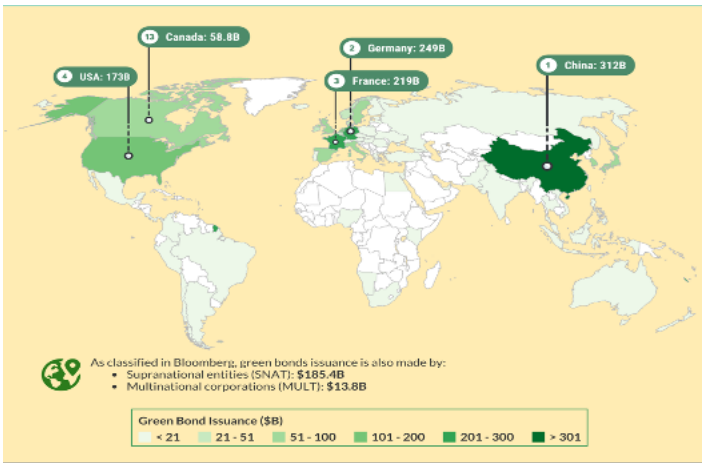
*Classified according to Bloomberg (BBG) Composite Credit Rating
Source: Bloomberg

and as such, credit rating agencies may still be refining their methodologies for evaluating them. Additionally, the environmental and social goals of green bonds may pose unique challenges for credit rating agencies, as they may need to consider factors beyond traditional financial metrics when assessing creditworthiness. This could potentially lead to inconsistencies as well as a more cautious approach to assigning credit ratings, resulting in a more evenly distributed range of ratings.

Simply having a "green" status does not justify its yield and premium. The "shade of green" plays a significant role in the performance of green bonds, which is not reflected in conventional bonds. The "greenness" of green bonds is dependent on the potential long-term impact and proceeds of the projects (Beutel, 2022). Typically, the credit ratings of the green bonds carry the same credit rating as the issuer's other debt obligations (Segal, 2023). It should be noted that for the purpose of this study, the specific elements that make up the credit ratings of green bonds were not identified or studied. Therefore, while the distribution of credit ratings among green bonds is discussed, the "greenness" or sustainability quality of the underlying projects and activities financed by these bonds were not assessed.

From a global distribution perspective, the main issuers of green bonds are China ($312 B), Germany ($249B) and France ($219B) in terms of total issuance between 2007 and 2022. It is worth noting that the European countries started a large-scale issuance program in 2013 which has grown continuously ever since. The rapid increase in green bond issuance in 2013 was mainly catalyzed by the release of the Green Bond Principles by the International Capital Market Association in 2013, which provided a framework for the issuance of green bonds, giving investors greater confidence in this new market. In 2017, there was a major spike in the issuance of green bonds in Europe, reflecting the European Union's (EU) implementation of several policies, regulations and frameworks to support the issuance of green bonds and sustainable finance. Some examples of associated activities include (i) in March 2017, the European Commission launched a consultation on a proposed Green Bond Standard; and (ii) the European Investment Bank (EIB) introduced its Green Bond Framework in 2017, which provided a framework for the issuance of green bonds by the bank.

Figure 4: Green Bond Issuance by Country: Total USD Issuance amount from 2007 to 2022



In 2016, Asia was also a major issuer of green bonds (Flammer, 2019). The increase in green bond issuance in Asia was primarily driven by government initiatives and policies promoting sustainable finance and environmental protection, as well as the growing demand for green investments from institutional investors and the public. Many Asian countries, including China and India, announced ambitious targets to reduce their carbon emissions and transition to a low-carbon economy at the United Nations Climate Summit held on September 23, 2014.

Interestingly, the US is ranked 4th in terms of the overall size of issuance of green bonds, with $173B. Comparatively, Canada is only ranked 13th with $58.8B in aggregate issuance, making it a relevant, yet small player in the market. From 2007 to 2022, the trend of increased global issuance shows that more countries are recognizing both the social and economic value of green bonds and are willing to allocate resources to finance these green projects and securities. Thus, relevant for this paper, the potential for the Canadian and US green bond markets is observed to grow notably from their respective current positions as domestic investors increasingly recognize the value of green investments.

Table 3: Characteristics of the Certifications

	CBI Climate Bond Certification	Green Bond Indices	CICERO Second Opinions	Moody's Green Bond Assessments	Standard & Poor's Green Evaluation
Capital's Usage is related to Green Investment	X	X	X	X	X
Specific Eligibility Criteria by Industry Sector	X	X			X
Detailed Assessments of Greenness			X	X	X
Specific Quantitative Weight Factors				X	X
Ongoing Monitoring After Issuance				X	

Source: Green Bond Finance and Certification Journal. BIS Quarterly Review September 2017

Green Bonds' Certifications

As indicated in the study by Ehlers and Packer (2016), currently, there are five main green bond identifications and certifications. They are CBI Climate Bonds Certification, Green Bond Indices, CICERO Second Opinions, Moody's Green Bond Assessments, and Standard & Poor's Green Evaluations. Each of these certifications has different criteria and characteristics. Firstly, the bonds' funds must be associated with green investment to obtain the CBI Climate Bonds Certification, which has specific eligibility criteria with respect to the assets' carbon value in different sectors (for example, incorporating different drivers such as transport, water, and land use). For example, for renewable energy projects, the certification requires that the project must use specific types of technology and meet certain environmental and social standards.

The Green Bond Indices have similar criteria as the CBI Climate Bonds Certification. The only slight difference is that the green bond indices can serve an ongoing monitoring function, while the CBI Climate Bond Certification cannot. The Green Bond indices have different methodologies depending on the index being used. Notably, the frequency of monitoring for Green Bond Indices can vary depending on the specific index provider and the methodology used. Next, the CICERO Second Opinions can be obtained by ensuring the funds are tied to green investment and using CICERO's three degrees of positive assessments to determine the shades of green. The varying quantitative weights represent the allocation of factors that determine the greenness. For example, Moody's Green Bond Assessments allocate a 40% weight factor to the use of proceeds, whereas Standard & Poor's Green Bond Evaluations allocate a 60% weight factor to this identical criteria (Ehlers & Packer, 2016).

Despite their rigor, the certifications still present some limitations, such the inconsistencies noted above, in addition to weaknesses associated with assessing the environmental financial risks of green bonds. The multiple certification bodies and standards for green bonds can create confusion and make it difficult for investors and issuers to compare different green bonds against each other. Harmonizing standards and criteria across different certification bodies can serve to reduce confusion and increase comparability across the green bond universe.

Further to the above, the certifying bodies and the industry can improve communication by providing clear and concise information regarding the benefits and limitations of different certification methodologies. This level of disclosure can help investors and issuers make informed decisions regarding the most suitable certification to pursue.

PART II: GREEN BOND PERFORMANCE ANALYSIS

Green Bond Premium

Data and Methodology

To analyze the performance of green bonds, the methodology of Ehlers and Packer (2016), and Zerbib (2017) is followed. The first initiative involves the calculation of the yield spread between green bonds and conventional bonds, which is defined as the "green bond premium" (Zerbib, 2017). Taking the initial set of bond data from Bloomberg, as used in Flammer's paper extension, we proceed with the analysis by filtering it in several steps in order to focus the analysis on the Canadian and US green bond markets. First, to avoid duplication with the previous literature, the dataset is limited to bonds issued between 2018 and 2022. Then, the dataset is limited to investment grade bonds, as defined by bond ratings given between AAA and BBB by the Bloomberg ("BBG") Composite. The dataset is further restricted to only bonds issued in local currency (CAD and USD, respectively) and fixed rate coupon, for the ease of calculation of YTM and of comparison between bonds. After filtering through this set of criteria, there are 119 green bonds and 1,930 conventional bonds remaining for the Canadian market. For the US

market, because of its sheer size, additional pre-screening is performed on conventional bonds to only include the ones that possess the same BBG ticker as existing green bonds. A total of160 green bonds and 1,447 conventional bonds are obtained for the US market.

To calculate the yield spread of green bonds, the green bond is matched with one conventional bond of the same characteristics in terms of the issuer, maturity, credit rating, and coupon type. An effect that needs to be considered is liquidity, which can be assessed by the bond's issuance amount and issue date. As liquidity may affect the yield level, the effect is limited by restricting the range for these two bond characteristics. The same restriction is used for the issuance amount as Zerbib (2017): the conventional bonds should have an issued amount less than four times but greater than one quarter of the issued amount of the green bonds. The reason behind this ratio assumption is to ensure a meaningful comparison between green bonds and conventional bonds. If the conventional bond has an issued amount that is too small compared to the green bond, it may not be a fair comparison since the scale and impact of the projects funded by the two bonds could be vastly different. On the other hand, if the conventional bond has an issued amount that is too large compared to the green bond, it may not be a relevant comparison since the projects funded by the two bonds may not be similar in terms of their environmental impact.

As for the issue date, Zerbib suggested to "restrict the range of conventional bonds to those with an issue date that is six years earlier or six years later than the green bond's issue date" (2017). However, since the issuance date is already limited to between 2018 and 2022, no further action is needed.

Finally, 20 Canadian and 15 US yield spreads were obtained using the following process:

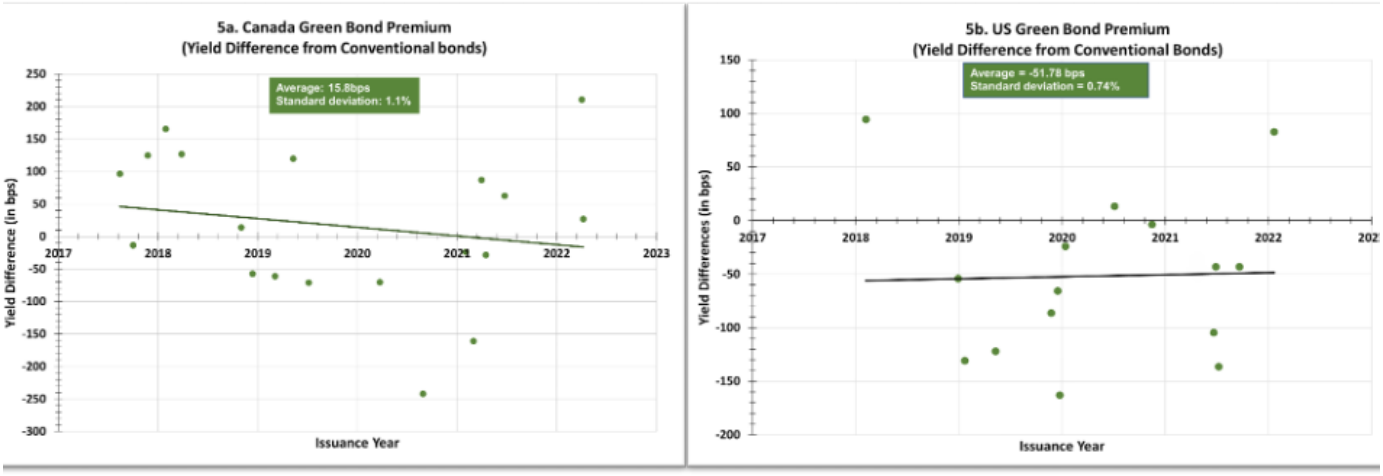
1. Calculate the yield to maturity (YTM) of matched bonds, green and conventional using excel built-in YIELD function from the data collected on face value, issuance price, issuance date, coupon rate, coupon frequency and maturity date of the bonds.
2. For green bonds that possess the same characteristics, take the average of the YTMs to present it as a single YTM datapoint; do the same thing for the conventional bonds. This is to ensure that for the same issuer, maturity, and credit rating, only one datapoint exists for each of the green bond and conventional bond YTM data.
3. Subtract the resulted YTM of conventional bonds from that of the green bond to obtain the yield spread: Yield Spread= YTM_{Green}- $YTM_{Conventional}$

Limitations of the Method

Like Zerbib's (2017) methodology, the selected method does present some limitations, notably the potentially inaccurate use of the matching method in breaking down the green bond yield and the omission of some illiquidity measures. Firstly, there is no consensus as to how exactly a bond's yield should be broken down. Thus, the matching method may not yield the most robust result concerning the green bond yield spread. Then, although the cost of liquidity has been incorporated by limiting the dataset using indirect proxies based on the bond's characteristics: its age, the amount issued, and the coupon, there are two other classes of illiquidity measures that have not been included in the method:

- Illiquidity proxies based on trading activities, such as the bid-ask spread, volume, number of trades, and number of dealers.
- Estimators of market impact, transaction costs, or turnover.

Figure 5: Canadian Green Bond Premium (5a) Vs. US Green Bond Premium (5b)



This exclusion may further limit the robustness of the result. Nevertheless, the method discussed herein presents a simple and straightforward analysis of the green bond premium and provides quantitative inputs that ease the investor's understanding of the green bond performance, making the results relevant despites the limitations.

Figure 5a shows Canadian green bonds have a higher YTM than their comparable conventional bonds, implying they are traded at lower prices. On average, a 15.8 bps yield premium is observed for green bonds against non-green bonds for the Canadian market and a -51.78 bps yield premium for the U.S. market. To explain the observation, the positive yield for Canada's green bonds could be due to various reasons: unsettled issues of 'greenwashing," overcomplexity of simple financial products, unclear pricing differentials between green and vanilla bonds (McKenzie, 2021).

'Greenwashing' occurs when there is a deceptive promotion of the perception that an organization's products or services are environmentally friendly. For example, there are products that are described as 'green", but do not follow the accepted use of proceeds or reporting requirements as set out in the bond indenture. Several simple examples could include cleaning products that claim to be environmentally friendly but contain harmful chemicals or clothing made from synthetic materials that claim to be sustainable. Such activities taint the credibility of green bonds. There is a lack of direct investor protection provisions, which leads to a significant risk of greenwashing. Adding to that, the higher perceived risk of green projects makes it reasonable that investors demand higher compensation.

Another limitation of green bonds is their reputation from investors as being a complex product, due to the variety of criteria, reporting guidelines, and overlapping roles of market players. The ever-changing principles and guidelines fatigue and confuse the buy-side, especially with the unclear pricing benefits of green premium (ie. more expensive from the investor's perspective). It is hard to measure the impact of 'green proceeds' that correspond back to profitability and performance, which can make this financial instrument unattractive from a risk and return perspective. This perceived or real unattractiveness leads to a lack of liquidity in the green bond market, which can propel it into a vicious cycle of demand and supply.

On the other hand, the downward sloping line means that the Canadian market is starting to recognize the value of green bonds. There are major developments taking place with respect to the documentation of greenness and the distinction between certifications and ratings (McKenzie, 2021). For example, in 2019, the Toronto Stock Exchange (TSX) launched a new initiative called

the TSX Green Future Index, which tracks the performance of companies listed on the exchange that derive significant revenue from green products, services, or technologies. Furthermore, in 2020, the CBI launched a new certification scheme for green bonds in Canada, which is designed to align with the country's green bond guidelines and market practices. While there has been significant progress, in the same year, the CBI also published a report called "Canada's Green Bond Market: Opportunities and Challenges," which provides an overview of the country's green bond market and highlights the need for greater standardization and transparency in green bond documentation and reporting.

Major key investors, like pension funds and sovereign wealth funds, that support the development of the green bond market will strengthen the bonds as a dynamic capital markets product that supports genuine economic and societal needs (McKenzie, 2021). These investors use green bonds as a signal of ending poverty and as a diversification tool (Giugale, 2018), and they work effectively as a hedging instrument against carbon futures and energy commodities (Jin, Han, Wu & Zeng, 2020). These advances contribute significantly to the expansion of the green bond market.

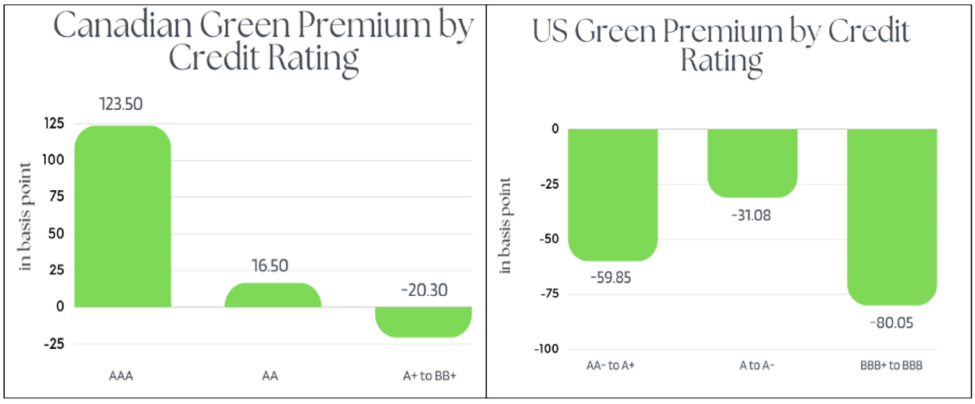
It is important to note the contrasting results between the Canadian and U.S. green bond markets shown in Figure 5. It shows that the U.S. green bond market has an average negative yield (-51.78 bps). This implies that the U.S. green bond market is more developed and recognized by the corresponding investors than Canada, which is to be expected due to the large difference in market size, the developed regulatory framework, and government support. The U.S. market shows a slightly positive trendline, indicating a minor decrease in valuation due to its already developed market interest (indicating slight softening in demand) and the decline in demand during the pandemic. However, through t-test results, the trendline slope proves to be insignificant, indicating that the trend might not persist. According to Vanguard's Tim Buckley, it is proving difficult to make big commitments to the climate fervor without disrupting the fiduciary duties (Keeley, 2023). It is also worth pointing out that the U.S. market shows a tighter spread than Canada's market, with a lower standard deviation, further showing the higher interest and liquidity in the US green bond market.

Yield Spread by Credit Rating

Figure 6a shows AAA- and AA-rated Canadian green bonds are priced lower than conventional bonds from the same issuers. This implies that higher-rated green bonds are priced at a discount in comparison to the respective conventional bonds. Figure 6a also shows that for riskier borrowers (A+ and BB+ issuers), the yield difference becomes negative, indicating a higher demand for the riskier green bonds relative to the riskier non-green ones. The result does not reflect the difference in credit risk between issuers within the same rating category, as the effect of this element is excluded in the bond matching process. The negative yield difference may also contribute to the smaller size of the green bond market for riskier issuers as supply and demand imbalances (with lower supply) can result in lower yields. It is possible that the underdeveloped nature of green bond ratings could contribute to this phenomenon, as there may be less information available for investors to properly assess the risk associated with green bonds. This could lead to a situation where investors are willing to pay more for green bonds from riskier issuers due to a lack of information on the actual credit risk of these bonds. Additionally, it is possible that the positive environmental impact of green bonds could be outweighing the perceived credit risk of the issuer for some investors, leading to a higher demand and lower yields for green bonds from riskier issuers.

In contrast, a Bank of International Settlement (BIS) study shows green bonds are traded at lower yields or a higher price (2017). It is important to point out that there is no data for Canadian AA-rated green bonds from 2018 to 2022, hence why there is no yield spread for AA-rated bonds.

Figure 6: Canadian (6a) vs. US (6b) Green Bond Premium by Credit Rating



Figures 6a and 6b show contrasting results. The U.S. green bonds show a negative green bond premium across all credit ratings, in contrast to the Canadian green bonds, which show a positive difference in the higher-rated bonds, noting that U.S. doesn't have the higher rating category of AAA like Canada does. In the US, the rating agencies tend to be more conservative in assigning the highest credit ratings due to past events such as the 2008 financial crisis. Additionally, US issuers may choose not to issue bonds in the highest rating category, as the costs associated with maintaining that rating may not be worth the benefits. This implies that the U.S. green bonds are priced at a premium, which is anticipated with all the benefits that come with the green status. It also means there is an existing demand across the credit ratings, and the U.S. green bond market is relatively deeper compared to Canada's green bond market.

PART III: GREEN BOND INDICES PERFORMANCE

Green bond indices provide equally useful information on the performance of green bonds, especially in the secondary market. By comparing the performance of different green bond issues, the actual volatility of green bonds can be better illustrated and communicated to investors and help them better measure the performance of green bond returns. In the following analysis, four major green bond indices are focused on; the MSCI Global Green Bond Index (BBG Ticker: GBGL), the S&P Green Bond Index (BBG Ticker: SPUSGRN), the Bank of America Merrill Lynch (BAML) Green Bond Index (BBG Ticker: GREN), and the Solactive Green Bond index (BBG Ticker: SOLGREEN). All returns are calculated using the index daily prices obtained from Bloomberg and denoted in USD. For the MSCI Global Green Bond Index, two available versions of the index are analyzed, USD hedged return and unhedged return, separately to distinguish the impact of currency fluctuations on the index's performance.

Two main findings are addressed in Table 4:

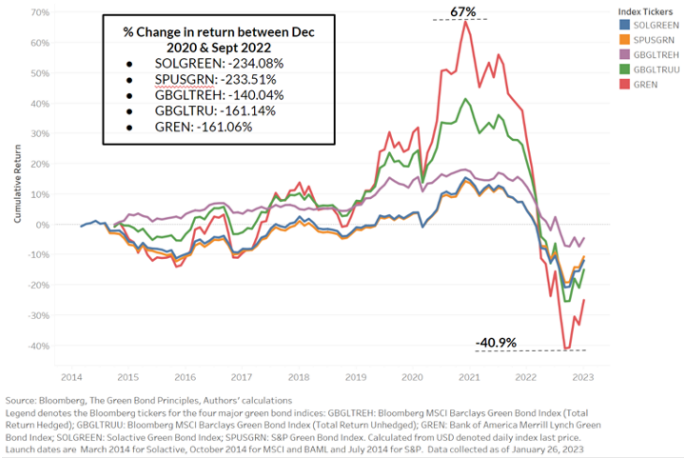
Firstly, these unhedged indices have a positive correlation with each other. By looking at the table longitudinally, the gross return performance of the four unhedged indices does not differ particularly significantly in each time series. While looking at the table horizontally, each of the indices has a similar volatility trend for the gross return, which reaches a peak at 3 months and a trough at 1 year.

Secondly, hedging the indices can effectively minimize the volatility and risk of index performance. Comparing the hedged and unhedged green bond indices of the MSCI Global Green Bond Index, the unhedged green bond index shows a higher volatility in USD total return than the hedged green bond index. However, although hedging reduces the risk of excessive index underperformance, it also reduces the likelihood of index outperformance.

Table 4: Index Performance - Gross Return (as of January 26, 2023)

	1M	3M	6M	YTD	1Y	5Y	MAX	Launch Date
MSCI Global Green Bond Index								Oct 2014
Hedged	1.997%	3.212%	-5.362%	2.949%	-15.686%	-1.964%	-0.557%	
Unhedged	3.938%	10.379%	-1.075%	4.477%	-17.835%	-3.226%	-1.380%	
S&P Green Bond Index	3.732%	10.317%	-0.221%	4.130%	-15.479%	-2.520%	-1.309%	Jul 2014
BAML Green Bond Index	4.241%	10.772%	-0.651%	4.241%	-17.567%	-0.961%	-1.497%	Mar 2014
Solactive Green Bond Index	3.947%	10.753%	-0.322%	4.103%	-16.615%	-3.086%	-1.410%	Oct 2014
Note:	5Y & MAX are annualized returns; MAC denote the cumulative return since launch date; all prices collected are expressed in USD							

Figure 7: Index Cumulative Return



Source: Bloomberg, The Green Bond Principles, Authors' calculations
Legend denotes the Bloomberg tickers for the four major green bond indices: GBGLTREH: Bloomberg MSCI Barclays Green Bond Index (Total Return Hedged); GBGLTRUU: Bloomberg MSCI Barclays Green Bond Index (Total Return Unhedged); GREN: Bank of America Merrill Lynch Green Bond Index; SOLGREEN: Solactive Green Bond Index; SPUSGRN: S&P Green Bond Index. Calculated from USD denoted daily index last price. Launch dates are March 2014 for Solactive, October 2014 for MSCI and BAML and July 2014 for S&P. Data collected as of January 26, 2023

According to Figure 7, the performance of indices from 2014 to 2023 can be divided into three phases. From 2014 to 2018, the cumulative return of all indices has maintained a moderate growth trend, which is in line with the growth of the green bond market at that time. During 2014–2018, the green bond market was still an emerging market for most investors who remained on the sidelines, and few of them were willing to invest.

However, since 2018, as the green bond market has gradually outperformed the ordinary bond market, a rising number of investors have enhanced their confidence in the green bond market, which is therefore reflected in the cumulative performance of green bond indices. From 2018 to 2022, the cumulative return of all green bond indices suddenly shows a significant growth trend.

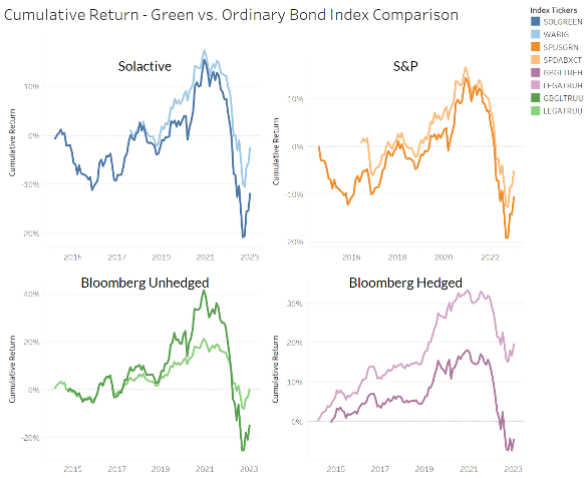
The green bond market was hit hard by severe geopolitical tensions and rising inflation in 2022, which severely hampered the global bond markets. Green bond issuance declined across the board in 2022, resulting in a return performance of the green bond index in 2022 that had a precipitous decline. However, the index began to rebound at the beginning of 2023.

Green vs. Global Aggregate Bond Indices

For a comprehensive overview of the performance of green bond indices, they are compared to major global aggregate bond indices, which measure the performance of the overall global bond markets. As for the methodology, each green bond index is associated with a global bond index with the same index provider and similar composition in terms of bond ratings, maturity, currency, issuer type, and regions. As a result, the Bloomberg Barclays MSCI Green Bond index is compared with the Barclays Global Aggregate Index (BBG ticker: LEGA), the S&P Green Bond index is compared with the S&P Global

Developed Aggregate Ex-Collateralized Bond Index (BBG ticker: SPDABXCT), and the Solactive Green Bond index is compared with the Solactive World All Bonds Index (BBG ticker: WABIG). Unfortunately, a perfect match for the Bank of America Merrill Lynch Green Bond Index was not available. Thus, the latter is included in the global green bond index cumulative return chart but not in the comparison infographic. All data is collected from Bloomberg. The dataset includes all the last daily prices in USD for each index from its launch date up until January 26, 2023.

Figure 8: Cumulative Return - Green vs Ordinary Bond Index Comparison



Note: Lighter lines represent the overall global bond indices and darker lines are the green bond indices

Looking at Figure 8, the unhedged green bond indices (Solactive, S&P, and Bloomberg) have a high correlation with their global bond indices counterparts, as they followed an uptrend between 2017 and 2021 and suffered a drastic decline in performance from mid-2021 to 2022. This general decrease in bond issuance can be due to the reluctance of lenders to lock into high-interest fixed-income products under the global instability caused by geopolitical tensions and supply chain disruptions, as stated by Climate Bond Initiatives (George, 2023). There are many other major economic events, like the ongoing Ukraine war, and post-pandemic recovery, that affect the financial market and cause 'permacrisis". In fact, with starting yields being quite low at the beginning of 2022, almost the entire bond market, especially long-term bonds, suffered declines as interest rates hiked rapidly over the year (Jones, 2022). However, with the exception of the MSCI unhedged index pair, all global bond indices have had a higher overall return and, without exception, experienced less downfall than their green comparables. That can indicate that the performance of green bond indices is more sensitive to the aforementioned bad times and macro events.

Future outlook

Fortunately, market players offer an optimistic outlook for both the broader bond market and the green bond market in 2023, a transition "from pain to gain," as stated in the Vanguard Perspective report (2023). In fact, all bond indices mentioned above have rebounded from 2022, having between 2 and 4% positive returns since the beginning of the year until January 26. To add on, major key players, like the US, Europe, China, and Canada, are contributing to the net-zero targets, which cover 91% of global GDP. These factors allow Climate Bonds to predict that 2023 will be a stellar year for green bonds.

CONCLUSION

Overall, this paper offers a unique view of the green bond market's performance. The focus of the study began with the analysis of green bond premiums for both the Canadian and US markets. Contrasting the previous studies, the data sample reviewed in this study revealed that from 2018 to 2022, the Canadian green bonds have a positive yield spread compared to conventional bonds with similar characteristics. The positive yield spread implies that Canadian green bonds are priced at a discount relative to conventional bonds, thus indicating a lack of interest and incentives for investors to select green bonds as an investment preference in Canada. Fortunately, there is a diminishing trend in the spread difference, meaning Canadian investors are slowly starting to recognize the value of green bonds and increasing their market demand. A negative Canadian green bond premium can be

expected in the future as the yield trends to the negative side in 2023. On the other hand, the findings on the US green bonds are consistent with prior literature. In the same sample period, an average negative green bond yield spread was found across all ratings, indicating that they are valued at a premium by investors. However, a slight positive trend line indicates that US green bonds lost recognition slightly in 2022, which is likely to be resolved as demand for green financing and investing picks up in the post-pandemic world.

Then, the performance of green bond indices was analyzed across time and compared to global aggregate bond indices. It is interesting to realize that many of the green bond indices have higher volatility than aggregate bond indices meaning that such investments are sensitive to market conditions and investors' perspectives. In fact, the green bond indices suffered greater adversity in 2021 when the global bond market was on the decline because of global supply chain disruptions and political tensions, among other macro-variations. Fortunately, many offer an optimistic outlook for green bonds as the market has rebounded since the last quarter of 2022. The recognition of climate risks and opportunities combined with countries' dedication to reaching their net-zero target can make green bonds a more attractive investment choice in the future. Acknowledging the recent rebound, offsetting headwinds for Canada could include externalities such as the current U.S. political landscape. Emerging challenges towards ESG investment has grown in recent years. In the United States a coalition was formed led by 19 Republican Governors to halt ESG investment practices. On the Federal level, President Biden issued his first veto against a bill to stop ESG investment strategies. Growing opposition towards ESG investment strategies is clear in some parts of the U.S. However, it's impact on Canada, the U.K, Euro zone and other advanced economies remains unclear at this stage.

Within this paper we have identified numerous benchmarks and indicators that can be used by buy-side investors (as well as issuers) to monitor potential changes in sustainable bond investor sentiment and appetite due to the above noted point.

To delve deeper into the topic, a potential future extension of work could be to apply the methodology used herein to study the green bond premium of other markets, such as the European Union or China. Performing such studies would allow readers to understand how investors' preferences and incentives for investing in green bonds are potentially different across countries, as well as gauge the relative attractiveness of green bonds across various markets. In addition, as the topic is only touched on very briefly, it would be insightful to explore the topic of how green bonds are differentiated from other sustainable fixed income instruments, such as SLBs. An in-depth quantitative analysis of a variety of these instruments will allow investors to have a better grasp of the investing opportunities they are presented with and better guide their sustainable investment decisions.

Finally, we note that this piece of research is largely focused on laying out a foundational understanding of green bonds and their performance, providing greatest utility to the buy side of the market. As such, follow on research would be beneficial to focus on the issuer perspective, to study the issue of whether there is an observable and measurable benefit to green bond issuance in terms of basis point reduction in the coupon rate at issuance. This assessment would in turn be compared against the incremental costs associated with issuing a sustainable bond versus a conventional bond in terms of fees, regulatory and reporting costs, to determine whether the incremental costs more than offset the savings associated with a sustainable bond issuance.

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