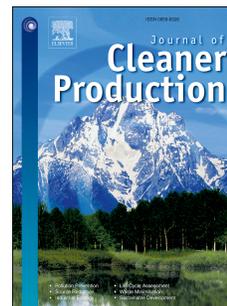


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## Abstract

The green bond market is emerging as an impactful financing mechanism in climate change mitigation efforts. Studies investigating this market have revealed the notion of a 'green premium' or 'greenium' within green bond pricing, including insights into influential characteristics and drivers that govern it. However, methodological heterogeneity among these studies has resulted in general ambiguity regarding a consensus over the existence of the green premium. This research addresses this gap through a systematic literature review with the aim of establishing a consensus on the existence, or nonexistence, of a green premium in the green bond market. The review examines studies published between 2007 and 2019. A ranking of the green bond characteristics most likely to exhibit a green premium is organised, including a framework of driving factors. The findings confirm a consensus on the existence of a green premium within 56% of primary and 70% of secondary market studies, particularly for those green bonds that are government issued, investment grade, and that follow defined green bond governance and reporting procedures. The green premium varies widely for the primary market; however, an average greenium of  $-1$  to  $-9$  basis points on the secondary market is observed. Overall, our findings highlight the crucial role of strengthening environmental preferences amongst bond market participants; including implications for bond pricing theory, by suggesting that future bond pricing should consider noneconomic motives of investors, such as environmental preferences; and, for future growth implications as a catalyst towards the financing of climate change mitigation efforts globally.

Keywords: Green Bonds; Green Economy; Environmental Risk; Socially Responsible Investment.

### **Highlights:**

- Systematic literature review investigates a consensus on a green premium in the green bond market.
- Drivers of the green bond premium are investigated.
- Bond characteristics most likely to exhibit a green premium are organised and ranked.
- A consensus is established on the green premium within green bond prices.

## 1 Introduction

The global green bond (GB) market has emerged as a promising avenue for financing a transition to a lower-carbon, resilient economy (Banga, 2019). In the four years leading up to 2019, global GB issuances recorded a fivefold increase, reaching over US\$ 257 billion annually (CBI, 2019), and they are expected to reach US\$ 1 trillion per year by 2030 (Fatin, 2019). The explosive growth of the market has demonstrated a clear unified momentum towards pro-environmental preferences for both bond issuers and investors alike. So bullish is this sentiment, that evidence has emerged of a 'green premium', or 'greenium' (the terms are used interchangeably), which is defined as the difference between the yields on a conventional bond (CB) and a GB with similar characteristics (Agliardi & Agliardi, 2019). A 'greenium' implies that the yield an investor is willing to accept for a 'green' asset is lower than that of conventional counterparts. In the primary market, where new bond issuances are offered to the market, these price differentials would be represented in a higher price for a GB than for a CB on the issue price. On the secondary market, after bonds have been issued, they are traded freely on the open market and are subject to price movements. In other words, the presence of a negative greenium in either primary or secondary markets would imply that a GB is trading at a lower yield (or higher price) versus a CB of similar characteristics; this means that a pro-environmental investor would be willing to accept a lower yield by the issuer in exchange for the opportunity to invest in a green alternative. For investors, this notion suggests nonfinancial benefits evident through a deeper exploration of the drivers of the green premium, which are addressed in this study. For issuers, the implementation of projects which target environmental action is rewarded through a lower cost of finance. The capitalisation of pro-environmental investor preferences offers an important catalyst towards delivering the estimated US\$ 46 trillion investment required to avoid 'dangerous' impacts of climate change, considered to involve a 2-4.5 °C rise in global average temperature by 2050 (OECD, 2017; Sherwood et al., 2020). Since 2007, the GB market has delivered a cumulative US\$ 512 billion towards green assets (CBI, 2018), and is expected to continue to make substantial contributions to this end (Fatin, 2019).

As the GB market has developed, the quantity of literature examining GB pricing and characteristics has grown. Literature investigating the green premium is diverse, employing unique methodological, control variable(s) or data sampling differences, which have resulted in general ambiguity regarding a consensus over the existence of a greenium in the GB market. Individually, these studies offer crucial insights into pricing differentials of green versus conventional bonds as well as the drivers governing these price differences. Taken together, a consensus can be assessed, which has previously been absent in the literature. Further insights can also be assessed, including the GB characteristics that are commonly associated with a green premium and broader driving factors governing the demand for GBs. This study therefore seeks to address this research gap through a systematic literature review, with the aim of identifying, synthesising, and examining

studies that claim the existence (or nonexistence) of the green premium in the primary and secondary markets. The review provides insights into the following three fundamental questions:

- 1) What are the driving factors for the demand of green bonds, from social, economic, and environmental perspectives?
- 2) What is the consensus on the existence of a greenium within the primary and secondary green bond markets?
- 3) Which green bond characteristics most commonly exhibit a green premium?

To address these three research questions, this study first engages with existing literature to propose a framework of the driving factors and detractors governing the demand for GBs and the propensity for a green premium. These factors are organised into social, economic, and environmental drivers which are either stimulating or detract from pro-environmental preferences for GB issuers and investors globally.

Second, a review of 15 peer-reviewed academic and industry studies, which focus on an analysis of the green premium, is undertaken to derive a novel, broad-based consensus on whether a greenium exists in these studies, and by what margin. The scope includes papers that investigate both private and public GB issuances, and those published between 2007 and 2019. Many of these studies engage global datasets, which draw on both developed (Baker et al., 2018; Gianfrate & Peri, 2019; Karpf & Mandel, 2018) and emerging markets (Bachelet et al., 2019; Nanayakkara & Colombage, 2019; Tang & Zhang, 2018). The inclusion of emerging market data is particularly relevant for the implications of this study with regards to engagement with a global, generalised narrative on the state of the GB and also regarding future implications. Recently, GB issuance has shown the most growth in emerging markets and non-traditional currencies such as the Chinese Yuan Renminbi (CNY) (Chiesa & Barua, 2019), although a significant portion of studies are based on the European and US bond markets.

Lastly, the circumstances in which the green premium most frequently arises are investigated. Observations from the systematic literature review are grouped into data sample characteristics, which are organised by subgroups that include the study timeframe, bond type, credit rating, and governance. Furthermore, influential bond characteristics are organised and ranked using a correlation analysis to reveal green premium determinants.

The review highlights the crucial role of strengthening environmental preferences amongst bond market participants and the institutions that support them. For both issuers and investors, environmental social governance (ESG) objectives are increasingly motivating business decisions, particularly as the benefits of social and environmental capital—gained from ethical investment practices—increasingly align with economic objectives. The findings of this paper confirm that there is value in the ‘green’ bond label; the

majority of studies in this review confirm the existence of a green premium in primary and secondary GBs compared with their CB counterparts—particularly for bonds trading on the secondary market. Furthermore, this study finds that bond governance characteristics, such as adherence to recognised GB certification standards, and the engagement of a third-party reviewer to validate and report on the use of GB proceeds, are essential factors driving the green premium.

These findings have significant implications for governments, industry, and the future growth of the GB market in general. The presence of a green premium in the primary and secondary markets demonstrates strong investor demand in pro-environmental projects, resulting in plausible financing benefits. For academia, this research has implications for bond pricing theory by suggesting that future bond pricing should consider noneconomic motives of investors, such as environmental preferences. GBs offer an investable medium which connects investors' willingness to act on climate change, despite being at a marginal cost, with a practitioner's ability to deliver cleaner production.

The remainder of this paper is organised as follows. Section 2 provides an overview of the maturing GB market, regulatory developments, and narratives on the evidence for the green premium. Existing literature is organised into a framework of the key drivers of the green premium. Section 3 presents the methodology of the study, outlining the steps of its systematic literature review. Section 4 establishes the results of the review and engages with a discussion on the implications of the findings. Finally, Section 5 concludes the paper with a discussion of research implications and future work.

## 2 Background

### 2.1 *The maturing green bond market*

The introduction of the first GB in 2007 was the start of a formalised process to connect capital markets to 'green' investments with measurable, and often verified,<sup>1</sup> environmental outcomes. GBs are a relatively new type of bond, defined by the International Capital Markets Association (ICMA) as "any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new or/and existing eligible green projects" (ICMA, 2018a). This means environmentally or climate-friendly projects, such as renewable energy, green buildings, clean transportation, sustainable waste management, sustainable land use, biodiversity, and clean water. 'Sustainability' bonds and 'social' bonds have also

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<sup>1</sup> Third party verification is emerging as a standard on many new Green Bond issuances. Proceeds are tracked and reported upon. There are developing standards through the Climate Bonds Initiative and the International Capital Management Association, among others (ICMA, 2018a).

emerged, which co-exist with GBs following a similar ‘socially responsible’ mandate; however, they have different focuses such as food security, affordable housing, and access to essential services for specific population groups. This paper focuses on GBs, and crucially how they perform within the primary and secondary bond markets versus comparable conventional bonds, in addition to the factors governing their growth. The literature review focuses on sources from academia and industry.

## 2.2 *Regulatory maturation*

The momentum of continued issuance and market demand has led to a growing consensus on what constitutes a GB (ICMA, 2015); however, the lack of systematic rules and standardisation of green definitions is a shared and enduring source of concern cited by participants in the market. Issuers face reputational risk from ‘greenwashing’ if proceeds are not used for their intended purposes or if issuers are unable to prove that proceeds directed to projects are having a positive environmental impact (KPMG, 2015). Early GB issuances were largely self-reported, and therefore lacked clear typologies on their ‘greenness’ (Kidney, 2019). In response, there has been a market-led effort to develop a standardised approach to assessing the environmental integrity and impact of GBs. Voluntary market-led initiatives including the ‘Green Bond Principles’ (GBP) promote transparency in the disclosure of bond proceeds. Initiatives such as the ‘Climate Bonds Standard’, administered through the Climate Bonds Initiative (CBI), outline certification procedures for GBs. Regional guidelines have also emerged, such as China’s ‘Green Bond Assessment and Verification Guidelines’ of the People’s Bank of China and China Securities Regulatory Commission; the European Union (EU)’s ‘Green Bond Standards’ of the EU High-Level Expert Group on Sustainable Finance; and the Green Bond Standards of the Association of Southeast Asian Nations (ASEAN). Engagement of second- and third-party verifiers who assess and report on GB asset allocations is increasingly common among certification guidelines. The number of bonds issued alongside external review has increased from 53% in 2014 to 83% in 2018. Regulatory maturation has been a critical factor in improving data consistency among GB studies (Bour, 2019).

## 2.3 *Evidence of the green bond premium*

The maturation of the market has enabled market observers to investigate GB characteristics, particularly with the emergence of GB indices that improve the quality and availability of GB data; the first was available in 2013 by the CBI, followed by Bloomberg in 2014, and then the later additions of ‘Cbonds’, ‘Dealogic’, and ‘Environmental Finance’ in 2015 (ICMA, 2018b). These databases have provided a basis for much of the academic literature and are the primary source of data for GB-related studies. The application of consistent data sources and samples has led to robust and comparable studies which have focused on specific elements of GB characteristics.

Early investigation into the existence of a GB greenium was predominantly led by industry. Barclays bank examined yield differentials of a broad global sample derived from the Bloomberg Global Green Bond Index. The study examines the secondary market between March 2014 and August 2015. An ordinary least squares (OLS) regression of the credit spread that decomposes common risk factors points to a negative premium of 17 bps (Preclaw & Bakshi, 2015). HSBC (2016) and Bloomberg (2017) follow with their own investigations, employing different methodologies and samples. HSBC finds no green bond premium (HSBC, 2016), whilst Bloomberg finds a negative premium in EUR-denominated government bonds only (Shurey, 2017).

Building on earlier studies (Baker et al., 2018; Gatti & Florio, 2018), Zerbib (2019) quantifies ‘pro-environmental’ preferences evident in bond prices using a matching method, and subsequently applies a two-step regression procedure to compare yield spreads between green and conventional bonds in the secondary market. A negative premium of 2 basis points (bps) is found across a sample spanning from July 2013 to December 2017 (Zerbib, 2019). The negative premium is more pronounced for financial and low-rated bonds. Elhers and Packer (2017), however, do not note any price premiums in their secondary market analysis, but they do find a price premium for GBs in the primary market (Ehlers & Packer, 2017). Similarly, in a study employing different control variables on a wider set of data (2007–2017), Tang (2018) finds no price premium when using a yield spread analysis between the same issuing firm in the same year, although in a broad sample finds that GBs are issued at a yield spread 6.94 bps lower than corporate bonds issued by similar firms (Tang & Zhang, 2018). Evidence from the US municipal GB market suggests that the green premium is a more recent phenomenon. Examining the yield curve of a large dataset of US municipal bonds, Karpf and Mandel (2018) find that overall, the yield curve of GBs are systematically below CB yields (Karpf & Mandel, 2018).

As part of the maturation of the GB regulatory environment, GB disclosure costs, or ‘green transaction costs’, have been an initial concern in the development of the GB market (Febi et al., 2018). The Climate Bonds certification process, for instance, adds costs of approximately 0.1 bps. The engagement of a third-party to verify asset allocations and reporting requirements is also required at additional cost. In total, voluntary reporting costs are reported to be approximately 0.5–3 bps (Kidney, 2019).

A review of emerging literature examining GB pricing reveals a broad base of useful observations to obtain a greater understanding of the GB premium, its drivers, and the GB characteristics that determine it. The initial evidence suggests a confirmation of the existence of a green premium on GB prices; however, a consensus is required. The present study addresses this gap through a systematic literature review, which organises individual studies that have investigated the GB premium to deliver a generalised consensus on the green premium, as well as the plausible driving factors and GB characteristics most commonly associated with the green premium in bond pricing.

## 2.4 Drivers of the green premium

Recent literature has focused on determining drivers of the growth of the GB market ; however, investigations into the drivers of the green premium, using a systematic approach, are largely absent in the literature. This study proposes a framework of these drivers based on literature that has investigated GBs, which is organised into core *social*, *economic*, and *environmental* factors. These factors have been found to influence GB versus CB pricing characteristics in the primary and secondary bond markets.

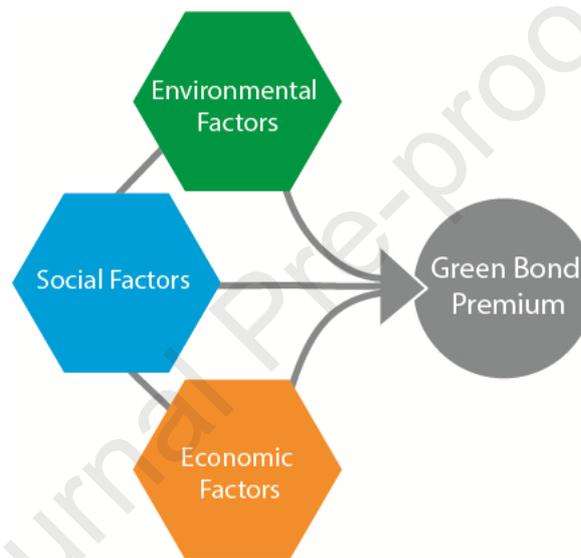


Figure 1. Drivers of the ‘green premium’ for bond investors and issuers.

### 2.4.1 Social drivers

In broad terms, the growth of the GB market coincides with an increasing trend towards corporate social responsibility (CSR) practices among public and private organisations (Febi et al., 2018), and an increasing demand for socially responsible investment (SRI) products amongst investors (Maltais & Nykvist, 2020). These trends compliment the growth of the social and sustainability bond markets, which co-exist with the GB market, to promote positive change in society and the environment. ESG criteria, which are related to both CSR and SRI objectives, have been gaining traction as a measure of firms’ approach to collective issues deemed important to society. Such issues include a focus on a firm’s approach to environmental stewardship of nature; social issues including human rights and diversity; and issues of governance, which include management structure and employee relations among others. A 2018 report surveying over 500 respondents finds that almost 90% of institutional investors worldwide changed their voting or engagement policies in the

previous 12 months to pay more attention to ESG considerations (Endelman, 2018). As of 2018, US\$11.6 trillion of all professionally managed assets, comprising US\$1 of every US\$4 invested in the United States, were under ESG investment strategies. Climate change mitigation in particular was amongst the top criteria for institutional money managers, who specialise in managing the securities portfolios of institutional investors (US-SIF, 2018).

Ethical or SRI practices aim to support socially 'good' enterprises, which increasingly encompass initiatives that support climate change mitigation efforts. SRI is not a new concept, having origins in Jewish, Christian, and Islamic traditions, although more recently being driven by government regulation. Early examples date back to medieval Christian beliefs, which imposed ethical restrictions on loans based on the Old testament. In the 17<sup>th</sup> Century, Quakers settling in North America refused to profit from the weapons and slaves trades. The 19<sup>th</sup> century saw publicly led initiatives by social investors, taking a stance against profiteering from war, alcohol, tobacco, gambling, and social injustice among others. Social drivers towards environmental sustainability gain traction from 1986, coinciding with the Chernobyl nuclear power plant disaster as well as the Exxon Valdez oil spill, one of the worst environmental disasters in US history. In recent times, government-supported initiatives in the form of an SRI regulatory environment have helped to facilitate the growth of the market, particularly for institutional investors (such as in pension, sovereign wealth, and insurance funds). These initiatives have included broadened product disclosure requirements and tax concessions for market participants pursuing SRI objectives (for a comprehensive list see (Renneboog et al., 2008)). Investment products that violate the core credence of SRI principles, so-called 'sin' stocks, have less institutional ownership because they are subject to societal norms (Hong & Kacperczyk, 2009). Hedge funds and private capital are less represented, although they are increasingly subject to these expectations.

Related to these trends is the emergence of 'ethical consumerism', evident in the propensity for some individuals to rationalise purchase decisions, even at a greater cost, increasingly aligned with environmental concerns according to personal values (Gupta, 2015). The societal norm of questioning the environmental sustainability of the status quo and a common consensus on the threat of global climate change are arguably driving an increasingly imbued sense of personal moral obligation amongst market participants. As individual representatives of the primary institutions that comprise modern society, namely government, corporate institutions, and investors, it is expected that the push and pull factors facilitating the supply and demand of climate-aligned investments will grow. Bollen (2007) argues that investors may have a multi-attribute utility function, which is not only based on the standard risk-reward optimisation but also incorporates a set of personal and societal values (Bollen, 2007).

GBs offer a medium for convergence between organisational capital-raising for CSR-related objectives and SRI interests, particularly towards environmental considerations. Arguably, the motivations of GB

participants are not entirely altruistic. It could be argued that GBs offer market participants a degree of community recognition and reputational prestige. Association with GBs, for both the issuer and investors, offers a degree of social capital. Although social capital as a concept is difficult to quantify, positive economic effects have been found for corporate firms highly engaged in CSR- and/or ESG-related activities, which are discussed in more detail in the next subsection. The findings of this paper confirm that investors value the green label as well as its associations with the social capital gained from ethical investment practices.

#### 2.4.2 *Economic drivers*

*Economic drivers* of the GB premium have been well established in the literature, and have been largely attributed to the undersupply of green-labelled investment products, particularly as growing interest has resulted in a scarcity premium for green issues. The demand-side growth of GBs is evidenced by the frequent oversubscription of new GB issuances globally, particularly where tax incentives are in place (Burton, 2018; Siswantoro & Iop, 2018). In the US municipal bond market, for example, GBs selling in the primary market are oversubscribed by more than three times on average (Burton, 2018). In India, some concessions in the form of tax exemptions have been introduced to stimulate the domestic demand for GBs. The tax-free bond issued by the Indian Renewable Energy Development Agency Limited in 2016 was oversubscribed by more than five times (Agliardi & Agliardi, 2019).

In addition, GBs have been found to offer diversification benefits, and therefore lower risk for bond investors (Daszynska-Zygadlo et al., 2018; Pham, 2016; Reboredo & Ugolini, 2019). In a 2012 study, Iderst et al. find that GBs exhibit a low correlation with other fixed income securities and therefore provide diversification benefits to investors (Iderst et al., 2012). Preclaw and Bakshi (2015) suggest that GBs are less risky or volatile than CBs, particularly when aligning the tighter spreads with risk-adjusted returns. Since long-term investors are well represented within the GB market (Hong & Kacperczyk, 2009), their presence may imply lower liquidity among GB issuances, and thus price stability (Preclaw & Bakshi, 2015). In effect, mitigating for negative influences of ‘short-termist’ investment behaviour which has led to problematic asset price bubbles within financial markets (Callen & Fang, 2013; Croce et al., 2011).

For issuers, firms that are highly engaged in CSR have been found to achieve favourable stock returns (Derwall et al., 2005; Kempf & Osthoff, 2007; Konar & Cohen, 2001). Similarly, these activities have been found to enable firms to benefit from a lower cost of equity capital (Dhaliwal et al., 2011; El Ghouli et al., 2011). In one example, Tang (2018) finds that corporate announcements of an upcoming GB issuance have positive effects on that corporation’s stock prices, resulting in a cumulative abnormal return within 10 days of the announcement (Tang & Zhang, 2018).

#### 2.4.3 *Environmental drivers*

Lastly, *environmental drivers* are proposed, which are more broadly associated with both economic and social drivers. In theory, GBs offer a means to demonstrate a proven and measurable impact (through third-party verification) towards environmental concerns in a way that resonates with ESG reporting principles. They offer a means for mitigating broad environmental risk concerns (Clapp, 2018), although these are difficult to quantify because they are accrued collectively. As part of corporate ESG reporting criteria, GBs offer synergies with carbon-reporting requirements, which can be more directly associated with efforts to mitigate environmental impacts and climate change. Investors are better able to enact targeted climate change mitigation efforts because GBs are invested in a wide range of environmentally beneficial assets, ranging from solar power generation to ‘green’ affordable housing (MacAskill et al., 2019). Studies note that voluntary nonfinancial disclosure of proceeds is an important factor in governing market prices for GBs; the pricing benefits often exceed the cost (Baker et al., 2018; Hyun et al., 2019). For example, Hyun (2019) finds that GBs that engage an independent third-party reviewer report a 7 bps green premium. This green premium is more pronounced (i.e., 9 bps) for GB issuances with both an independent third-party reviewer as well as certification through the CBI. Evidence from the support of nonfinancial disclosure suggests that investors and issuers alike place a high value on ESG impact reporting.

Collectively, these social, economic, and environmental drivers have supported the development of the GB market and the green premium.

### 3 Methodology

A systematic literature review is the primary methodology for this study. A systematic review “aims to comprehensively locate and synthesise research that bears on a particular question, using organised, transparent, and replicable procedures at each step in the process” (Littell, 2008; Stechemesser & Guenther, 2012).

The review draws upon previous studies which focus specifically on analysing and identifying pricing discrepancies of ‘green’ versus comparable ‘conventional’ bonds of similar characteristics. The method follows a three-step process (Fink, 2010). In the first step, key research questions, databases, and appropriate search terms are refined. Steps two and three involve screening criteria for both practical criteria (study timeframes and sources) and for methodological screening criteria (methods and paper focus). These steps dictate which resources are included and excluded from the sample.

### 3.1 *Study process*

#### 3.1.1 *Step 1: Research questions, databases, and appropriate research terms*

A systematic approach to search terms is established to ensure appropriate content matching relevant to our research question. Journal articles and industry reports published within the 2007–2019 period (as of October 1, 2019) are the primary focus. The search criteria favour a broad keyword: ‘Green Bond’. In this way, all relevant literature can be screened while seeking to mitigate the effects of confirmation bias. It is found that papers apply different terminologies to pricing asymmetries, since not all papers explicitly use the ‘greenium’ or ‘green premium’ label. The scholarly databases used in this study are Scopus, Web of Science, and Google search. Where applicable, industry reports frequently cited in the literature are included in the review. The search results are limited to articles in the English language.

#### 3.1.2 *Step 2: Practical screening criteria*

Peer-reviewed journal papers with a robust methodology take priority in the review; however, a range of sources including book chapters, conference proceedings, news articles, and reputable industry analysis reports are used (typically published by major banking institutions). In total, 96 journal articles and 16 targeted industry reports are considered under the initial scoping criteria. The screening methodology is visualised in Figure 2.

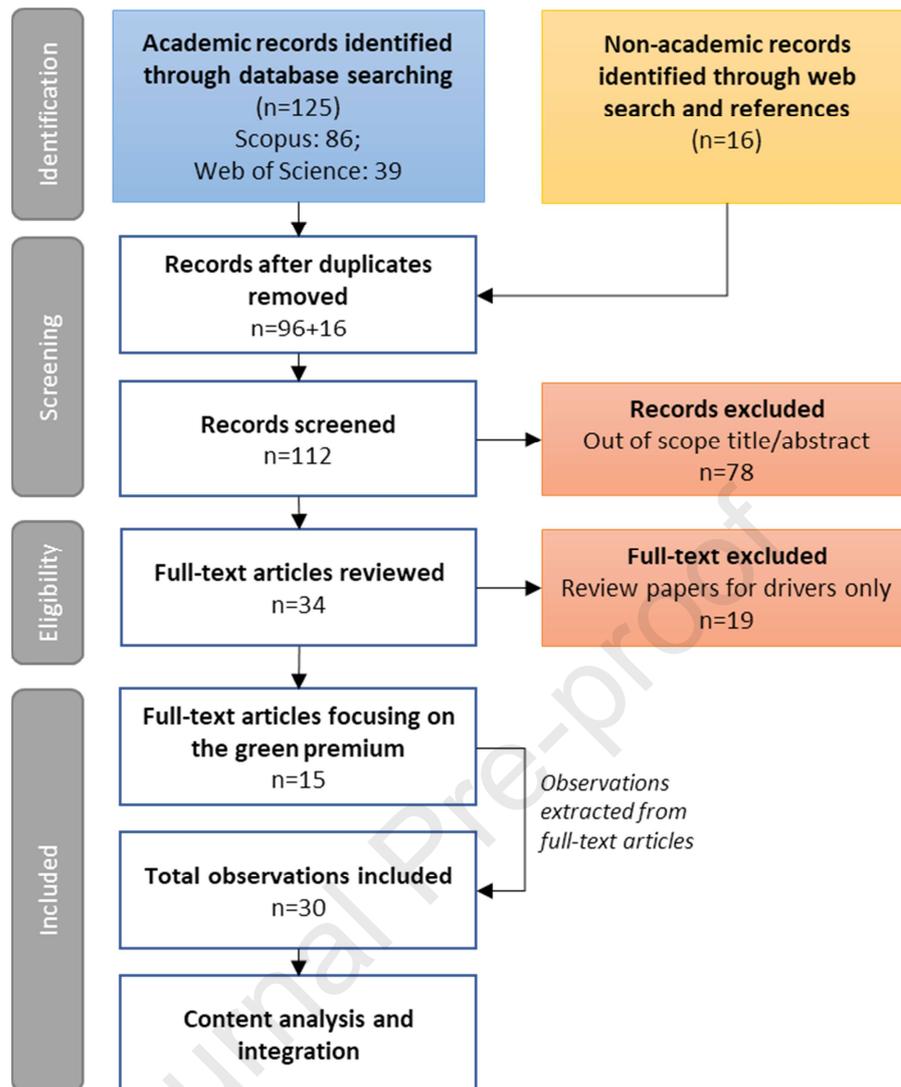


Figure 2. Systematic review methodology

Broad drivers of the green premium are informed by 34 full-text articles, which are assessed for eligibility in the final review. These articles provide useful insights into broader narratives related to the green premium; however, 19 are excluded from the final analysis. Only studies that examine GBs in the primary and/or secondary market and provided quantitative results are eligible for inclusion. In total, 15 full-text articles are included in the final analysis. Several articles examine the greenium characteristics of GBs matched with CBs under differing scenarios, controlling for effects such as size, rating, alignment with GB principles, and third-party verification, among others, within the primary and secondary markets; these articles offer several relevant ‘observations’ that are carried forward. Several papers provide multiple observations of GB pricing characteristics under varying control variables or data samples (primary and secondary market data). Where this analysis is supported by a robust analysis, these relevant findings are carried forward as separate

observations in our sample. Through this process, a total of 30 observations are included to derive the consensus.

### 3.1.3 Step 3: Methodological screening criteria

The review broadly focuses on peer-reviewed articles that specifically examine the pricing differentials of green bonds compared with conventional bonds and that are also able to answer the fundamental research question of this paper, namely whether a green premium is evident. Governing factors found to be impacting GB growth are also noted.

Studies examining the green premium in the primary market use a basket of comparable issuances to graph a yield curve. Through this, pricing differentials can be determined for GBs versus CBs in the same basket. Within secondary markets, a common methodology employs an ordinary least squares (OLS) or generalised least squares (GLS) regression using fixed effects (FE) applied to time series data. Alternative approaches to time-varying correlations include the dynamic conditional correlations (DCC) method. DCC techniques are widely applied for the analysis of daily data. Bond yield, maturity, issued amount, rating, group, and currency are common independent variables used in OLS and GLS regressions. Data limitations are noted when comparing studies that apply heterogeneous methodologies, data samples, and control variables; however, the aim of the methodical screening criteria is to be subjective toward the conclusions of each study.

No single methodology nor control variable is favoured in this review—control variables are important determinants in each study. These are noted as a data limitation of the present study and are outlined in the next section. Of the empirical works on GBs analysed in this paper, many are focused on estimates of the GB premium and its relationship with bond characteristics such as rating, issued amount, governmental versus nongovernmental issuer, liquidity, or volatility. This review aims to more simply examine whether a premium exists and under what conditions. Article conclusions on spreads and under what conditions are noted (i.e., GB with third-party verification vs. CB benchmark, GB labelled vs. CB benchmark). Where a basis point yield differential is found, the median result amongst the article sample is carried forward. Studies that show no statistical significance are also carried forward.

## 3.2 Sample overview

Whilst the literature examining the GB market is still in its infancy, broad and robust subsets of key characteristics exist for comparison. Specifically, different data samples can be clustered and compared based on categories such as *timelines*, *sector samples* (corporate, municipal, or both), *issuer* (same or mixed),

*location* (emerging or developed markets), and specific GB governance characteristics such as adherence to the *GBP*, *CBI Certification*, and whether samples include a *third-party assessment*.

Broadly, the timeframe is well studied. Samples in this study range from the inception of the GB market in 2007 to 2019. An average time sample timeframe of 6 years' worth of bond market data points is used, and 2015 is the most studied year for the GB market. Studies beyond 2013 yield the greatest number of observations in the literature, which is attributed to greater data availability on GBs through compiled indices from this year. As noted, the first becomes available in 2013 from the CBI, followed by Bloomberg in 2014, and then the later additions Cbonds, Dealogic, and Environmental Finance in 2015. An overview of the papers examined in this systematic literature review is presented in Table 1.

Table 1 - Literature investigating the green bond premium.

Author	Green premium?	Description
(Agliardi & Agliardi, 2019)	Yes	Yield curve comparison to assess green bond performance over time from 1 corporate EU utility provider. 338 observations are assessed from the issuance date in 2017. 1 secondary market observation is carried forward.
(Bachelet et al., 2019)	Mixed	A global sample of 89 private and institutional bond couples were assessed controlling for bond characteristics. Ordinary Least Squares (OLS) and Fixed Effects (FE) regression methodologies were used. The time frame of the study was between 2013-2018. 3 secondary market observations are carried forward.
(Baker et al., 2018)	Yes	A US sample of 2,083 green municipal bonds issued between 2010-2016 and 19 corporate green bonds issued between 2014-2016 are examined using an OLS regression. 3 secondary market observations are carried forward.
(Preclaw & Bakshi, 2015)	Yes	A global dataset of green bonds issued between 2014-2015 are assessed using a OLS regression. 1 secondary market observation is carried forward.
(Bour, 2019)	Yes	The yield spreads of a synthetically matched global sample of 536 bonds were analysed. The sample examined performance over the 2014-2018 period. 1 secondary market observation is carried forward.
(Harrison, 2019)	Mixed	Yield curve comparison of 61 EU and US green bonds issued in the first half of 2019. 3 primary market observations are carried forward.
(Ehlers & Packer, 2017)	Yes	Analysis of the credit spread on issuance of a cross-section of 21 EU and US green bonds between 2014-2017. 1 primary market observation is carried forward.
(Gatti & Florio, 2018)	Mixed	Investigated issue spreads on a broad sample of 246 bond couples between the 2007-2015 period. 3 primary market observations are carried forward.
(Gianfrate & Peri, 2019)	Yes	European (EU) focused study score matching a broad sample of 121 green bonds issued between 2013-2017. 2 primary market and 1 secondary market observations are carried forward.
(Hachenberg & Schiereck, 2018)	Mixed	Analysis of the i-spreads (using a yield curve) between a global sample of 617 matched corporate bonds between 2015-2016. 4 secondary market observations are carried forward.
(Hyun et al., 2019)	Yes	A global dataset of 60 green bonds, paired with synthetic conventional counterparts. Yield-spreads and regression (fixed effects and cross-sectional) methodologies were used. The sample included 1,365 bond-month observations between the 2010-2017 period. 3 secondary market observations are carried forward.

(Karpf & Mandel, 2018)	No	A large sample of 1,880 US municipal bonds were assessed between the 2010-2016, using the Oaxaca-Blinder decomposition method. The study noted observations in latter years trended towards a green premium. 1 secondary market observation is carried forward.
(Nanayakkara & Colombage, 2019)	Yes	A mixed, global dataset 82 green bond issues representing 52 companies in 25 countries formed the basis of the study. Bonds were matched and compared using a panel data regression over the 2016-2017 period. 1 secondary market observation is carried forward.
(Tang & Zhang, 2018)	Mixed	A global dataset of 665 corporate issuances are examined between the 2007-2017 period. 2 secondary market observations are carried forward.
(Zerbib, 2019)	Yes	A global study of 110 green bonds following a matching procedure and a two-step (fixed effects and cross-sectional) regression. The analysis examined corporate issuances from the same issuer over the 2013-2017 period. 1 secondary market observation is carried forward.

### 3.2.1 Data limitations

The nonhomogenous particularities of studies included in this review are acknowledged. Results will differ with the application of varying data samples, time, bond rating, control measures for liquidity and maturity, methodologies, and statistical analysis techniques. Notably, each study employs its own robustness checks; however, the use of individual methodologies and control variables on similar datasets are found to yield conflicting results. In the US municipals market, for example, pricing is highly sensitive to tax features (Atwood, 2003). Despite similar data sets, Karpf finds a positive greenium on US municipal bonds (Karpf & Mandel, 2018), whereas Zerbib and Baker, drawing from moderately different methodologies and control variables, find a negative greenium (Baker et al., 2018; Zerbib, 2019).

Some ambiguity exists over what constitutes a GB, because the GB label remains unstandardised. CBI and Bloomberg, for instance, cite ‘many shades of green’ for GB allocations (Kidney, 2019); therefore, some studies engage with a broader definition when matching comparable bonds. This ambiguity can lead to misleading bps estimates on the green premium since studies employ different datasets, particularly for datasets taken prior to 2013 and the establishment of more robust GB taxonomies and databases.

Our study draws from all relevant studies within our observation period. These studies are diverse in nature, drawing from a variety of data samples; for example, (Nanayakkara & Colombage, 2019) employ a large dataset with worldwide coverage (25 countries) of GBs, whereas (Agliardi & Agliardi, 2019) focus on an in-depth review of a single corporate bond. It is acknowledged that the studies that draw conclusions from a smaller sample size hold equal weight to those studies with a larger sample size. Further, the review includes a relatively small sample size which has been based on the existing literature available in the English language.

The purpose of this study is to categorise and critique existing research, thereby enabling a general consensus on GB drivers and premiums to be established from the current broad body of research. This study

does not deem it feasible, with the current body of research and empirical data, to make definitive claims on pricing impacts.

#### 4 Results and discussion

Data analysis categorised and coded the main findings of each review article; specifically, it sought to determine whether a green premium exists in both the primary and secondary markets, and the basis point difference. Several studies have included analyses and conclusions on both the primary and secondary markets (Ehlers & Packer, 2017; Gianfrate & Peri, 2019), and these are included as separate observations. Furthermore, studies that have provided multiple conclusions (i.e., on GB nuances, such as CBI certified green bonds vs. noncertified bonds) are included as separate observations where a clear conclusion is provided (Bachelet et al., 2019; Baker et al., 2018; Ehlers & Packer, 2017; Gatti & Florio, 2018; Gianfrate & Peri, 2019; Hachenberg & Schiereck, 2018; Harrison, 2019; Hyun et al., 2019; Karpf & Mandel, 2018; Tang & Zhang, 2018; Zerbib, 2019). Figure 3 summarises the results of the literature review regarding the consensus on the presence of a greenium in the GB market.

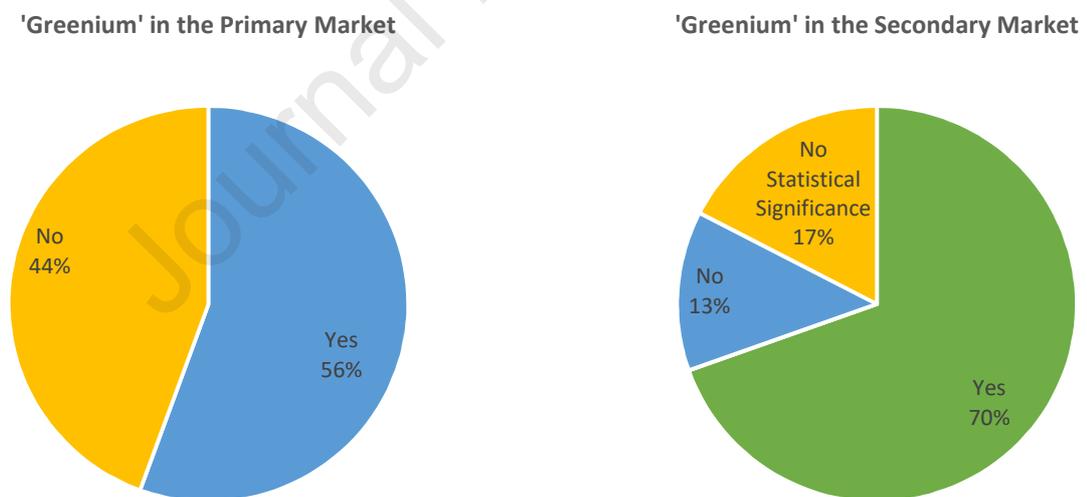


Figure 3 – Literature consensus on the existence of a green premium in the primary and secondary market.

The findings reveal mixed results for the existence of a green premium in the primary market, and also a more pronounced consensus amongst studies examining the secondary market. This study notes the risk of confirmation bias within these studies; however, it remains an interesting observation that a broad consensus exists on the existence of a greenium in 70% of studies examining the secondary GB market. Within the

primary market, there does not appear to be sufficient evidence (i.e., 56%) that a greenium exists. The implications of these findings are expanded upon in the discussion.

#### 4.1 Average green premium

Basis point spreads are documented for each study for both the primary and secondary markets. The average spreads between GBs and CBs largely confirm the existence of the greenium in most studies covering the secondary market. Moreover, the control variables and methodologies used have a significant impact on bps results amongst studies. The findings vary widely in the primary market, where greenium spreads range from  $-85$  to  $+213$  bps. Our study highlights the urgent need for further investigation into GB prices in the primary market. The variances in results within the primary market data suggest that further investigations are required that employ a larger data sample than is currently available in the literature. As a result, this study does not present an average bps green premium for the primary market.

Within the secondary market, however, bps spreads are more consistently focused between  $-1$  and  $-9$  bps, meaning that investors in the secondary market are willing to invest in GBs that are comparable to CBs, accepting a  $-1$  to  $-9$  bps lower yield in exchange for pro-environmental credentials. Figure 4 organises the average green premium, from the studies examined, into basis point ranges.

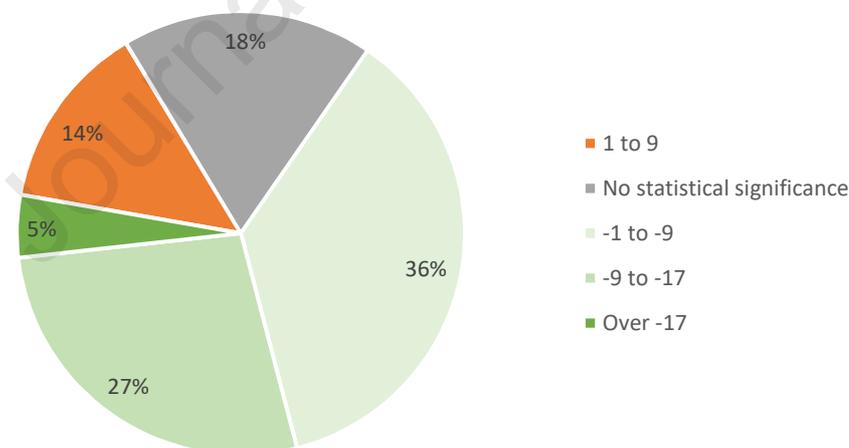


Figure 4 - Average sample green premium (bps) in the secondary market.

#### 4.2 Determinants of the green premium

Our results confirm the existence of the green premium in a broad sample of studies; however, it is helpful to note under what circumstances the green premium most frequently arises. To understand the determining factors guiding the green premium, we employ SPSS to perform a correlation analysis using the Pearson

correlation coefficient. Key determinants of the existence of the green premium are compared with data sample characteristics. Specific bond sample characteristics among the studies are noted, including the following: issuer (government/municipal or corporate), bond credit rating (investment grade, noninvestment grade, or mixed), timeframe, GBP (yes, no, or mixed), CBI certified (yes, no, or mixed), and evidence of third-party assessment (yes, no, or mixed).

Table 2 presents the results of the correlation analysis. Correlation coefficients between 0.5 and 0.7 indicate variables that can be considered to be moderately correlated, whereas correlation coefficients with a magnitude between 0.3 and 0.5 indicate variables with a low correlation.

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Table 2 - Green bond premium correlation analysis.

		Green premium	Bond type	Bond credit rating	Green bond principles	Climate bond certified	Third party assessment	Issuer	
Spearman's rho	Green premium	Correlation Coefficient	1.000	-.188	.302	.465	0.926	.365	.169
		Sig. (2-tailed)	.	.441	.275	.080	.000	.221	.517
		N	19	19	15	15	10	13	17
	Bond type	Correlation Coefficient	-.188	1.000	.018	-.281	.366	.042	-.238
		Sig. (2-tailed)	.441	.	.946	.259	.268	.882	.312
		N	19	23	17	18	11	15	20
	Bond credit rating	Correlation Coefficient	.302	.018	1.000	.767**	.632	.913**	.194
		Sig. (2-tailed)	.275	.946	.	.001	.178	.000	.507
		N	15	17	17	14	6	10	14
	Green bond principles	Correlation Coefficient	.465	-.281	.767**	1.000	.645*	.830**	.357
		Sig. (2-tailed)	.080	.259	.001	.	.044	.000	.191
		N	15	18	14	18	10	14	15
	Climate bond certified	Correlation Coefficient	0.926	.366	.632	.645*	1.000	.896**	.245
		Sig. (2-tailed)	.000	.268	.178	.044	.	.000	.524
		N	10	11	6	10	11	11	9
	Third party assessment	Correlation Coefficient	.365	.042	.913**	.830**	.896**	1.000	.290
		Sig. (2-tailed)	.221	.882	.000	.000	.000	.	.336
		N	13	15	10	14	11	15	13
	Issuer	Correlation Coefficient	.169	-.238	.194	.357	.245	.290	1.000
		Sig. (2-tailed)	.517	.312	.507	.191	.524	.336	.
		N	17	20	14	15	9	13	20

\*. Correlation is significant at the 0.05 level (2-tailed). \*\*. Correlation is significant at the 0.01 level (2-tailed).

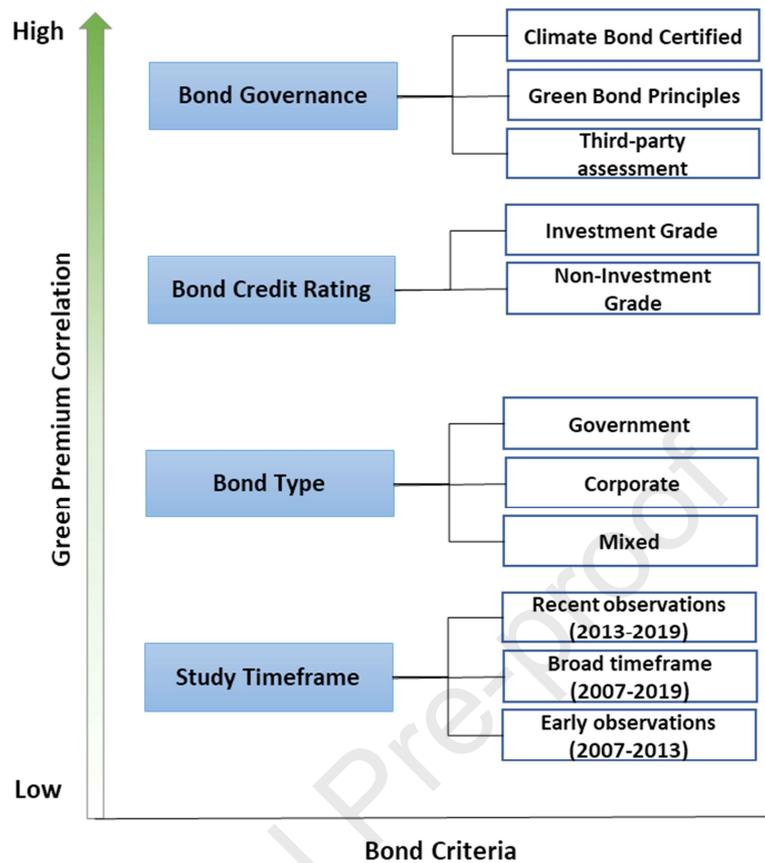


Figure 4. Green premium determinants by GB characteristics

Figure 4 summarises the main findings of the correlation analysis. Bond governance characteristics are determined to have the greatest impact on whether a green premium is evident in the bond market. GBs with a CBI certification label, that are investment grade, and that are issued by government/municipal organisations are highly correlated with a green premium. Notably, part of the reporting requirements for securing the CBI certification label include the engagement of a third-party assessor and typically follow the GB principles. The implications of these findings suggest that the systematic rules and standardisation that accompany strong GB governance reduce informational asymmetries, which helps to overcome investors' doubts on the 'greenness' of a particular GB—both at issuance and reporting of ongoing performance. These findings confirm that investors are willing to pay a premium for investments that offer clear ESG-related reporting on fund proceeds, by up to 15 bps on secondary markets (Hyun et al., 2019; Baker et al., 2018). With regard to bond credit rating characteristics, investment grade bonds tend to provide the most predictable existence of a greenium within a range of  $-2$  to  $-6$  bps (Bachelet et al., 2019; Hachenberg & Schiereck, 2018; Hyun et al., 2019; Zerbib, 2019). By contrast, bond type and study timeframes offer less reliable predictors of a greenium in bond prices.

### 4.3 Discussion

This review has engaged with literature that has investigated the green bond market. The first research objective explored the driving factors for the demand of green bonds from broad social, economic, and environmental perspectives. Social and environmental factors have been found to include intensifying CSR and ESG trends (Endelman, 2018; Febi et al., 2018) and an increasing demand for SRI products (Maltais & Nykvist, 2020). The findings have confirmed that investors value GBs with strong bond governance procedures, such as engagement of third-party assessment and adherence to green bond standards, such as CBI certification. It is clear that investors value social and environmental factors of GBs. Economic driving factors include risk diversification and, lower volatility as compared to CBs (Preclaw & Bakshi, 2015). The findings of the study suggest that bond risk and volatility considerations were secondary to governance procedures previously noted. These factors are interrelated, and together shape a broader narrative towards understanding investor motivations that drive the green premium.

The second research objective has been to establish a consensus on the existence of the green premium within the primary and secondary GB markets. Overall, the review has underscored a consensus on a green premium within the GB market. GBs have been trading at a premium (that is, at a lower yield) compared with CBs in the majority of studies included in this review. This is particularly pronounced within the secondary market (as observed in (Baker et al., 2018; Bour, 2019; Nanayakkara & Colombage, 2019), among other studies) but less pronounced for primary markets (ie. (Ehlers & Packer, 2017; Gatti & Florio, 2018; Harrison, 2019)). It can be noted that GB issuances on the primary market are often oversubscribed (Burton, 2018), indicating a strong demand for SRI products, although this has not yet translated into a green premium in GB primary market pricing in a meaningful way. These findings suggest that some bond investors have noneconomic motives. Proactive SRI investors who target—but are unable to—secure primary market issuances may be directed to the secondary market. Our results confirm earlier predictions by (Renneboog et al., 2008) in that investors derive nonfinancial utility from investing in SRI practices. With time, more pronounced evidence of a greenium in primary markets is expected to emerge as issuers seek to capitalise on the pro-environmental preferences of bond investors. For GB issuers, our results are contrary to the prior findings of (Baumol & Blackman, 1992), who predict that a bond premium related to CSR concerns will not be feasible in a competitive economy. However, the authors should point out that the scientific, corporate, and political acknowledgement and concern for CSR, climate change, and other environmental matters have become more prominent in advanced economies in the last three decades since Baumol and Blackman conducted their study. Indeed, whilst some CSR-related initiatives incur a greater initial cost, the aggregated

benefits have been found to return long-term benefits through a wider web of interconnected social, economic, and environmental factors, as presented in this paper.

The final objective of the study has been to investigate which GB characteristics are most frequently associated with the green premium. The review underscores that investors value GB's with strong governance procedures (Baker et al., 2018; Hyun et al., 2019). These findings support the notion that the investors in the GB market are driven by supporting climate aligned objectives with verified and measurable outcomes, which are an important part of GB governance procedures (Bachelet et al., 2019), and, are in line with SRI investment practices.

## 5 Conclusion

Increasing awareness of the negative impacts of climate change is driving an ever-growing focus on environmental sustainability among global investors and the general public. The growth of the GB market and the green premium phenomena has created the need to review and organise the individual contributions made in the literature to date. In response, this study has conducted a systematic literature review with the aim of synthesising studies that assert the existence (or nonexistence) of the green premium or greenium (used interchangeably), on GB prices in the primary and secondary markets, and that correlate the green premium with bond characteristics. Moreover, this study investigated the broader environmental, social, and economic drivers and detractors governing the green premium. Although the drivers share synergies; environmental and social drivers—in theory—are expected to have the greatest effects on the demand and future growth implications for the GB market.

Broadly speaking, a mixed—although marginally positive consensus—exists among the examined studies that focus on a green premium in the primary GB market. That is, a portion of investors are willing to pay a higher price for GBs, and therefore accept a lower yield for a GB versus a comparable CB. These findings have practical implications for issuers and the growth of the GB market in general. Issuers may benefit from engaging with the GB market to finance low-carbon initiatives at a lower cost, particularly for government organisations that engage with GB governance criteria, such as the third-party verification of bond proceeds. As more issuers become aware of plausible capital-raising benefits of the green premium, there are implications for the growth of the GB market overall. For academia, this research has implications for bond pricing theory by suggesting that future bond pricing should consider noneconomic motives of investors, such as environmental preferences. The green premium may serve as a positive side effect for driving organisational innovation that adapts operations towards environmental purposes. These implications are significant across sectors, such as innovative financial products (i.e., green mortgages and green insurances) or practical applications (i.e., green infrastructure and green building), where incentives for green credentials

may have previously been lacking. Within the secondary market, the literature provides a more pronounced consensus on a green premium. The practical implication of these findings is that investors derive nonfinancial utility from SRI practices; furthermore, they offer some compelling theoretical insights into the future of the GB market and primary issuance pricing. A consistent green premium in the secondary market could lend pressure to future primary market issuance prices, because secondary market prices are an indicator of what the market will bear. Bond governance characteristics were found to be the strongest determinant of a green premium. GBs associated with the CBI certification label, that are of investment grade, and are issued by government/municipal organisations, were found to be determinants of a green premium. Because GBs are a relatively new financial construct, investors may be seeking to reduce their risk profile by focusing on lower risk assets.

Limitations of the study included a limited sample size, and non-homogeneity of study particulars; such as time, sample size, bond profile and control variables. The review focused on the English language only. In future research, these limitations may be addressed. With the continued growth of the market and availability of robust data sets, future research may offer an opportunity to apply multiple regression analyses to predict the plausible GB premium given particular bond characteristics. The correlation assessment in this study identified a limited range of possible green premium determinants. Future studies would benefit from a comprehensive breakdown of green premium determinants, such as geographical region, currency, market sector, and comparisons of GB standards not covered in this review. As more data becomes available on GB pricing characteristics, a future systematic literature review is recommended which engages with a larger sample size, including a broader scope of languages. As public support grows for action on mitigating the worst effects of climate change, it is anticipated that the GB market will continue to establish itself as a critical, impactful step towards meeting the Sustainable Development Goals established by the United Nations and continue the economic transformation towards cleaner production.

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**Declaration of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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