





The Price of Sustainability: Green Bond Premium in Brazil

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Abstract

This study investigates the existence of a Green Bond Premium in the Brazilian debt capital market, focusing on the issuance cost from the issuer's perspective. Based on a sample of 263 securities issued between 2017 and 2022, a multivariate regression was applied to estimate the relationship between Green Bond classification and bond spreads. Results indicate that sustainable bonds were associated with higher spreads, with the Green Bond variable showing a positive and statistically significant coefficient at the 1% level. These findings reject the presence of a Green Bond Premium for issuers and suggest that the motivation to issue such securities is driven more by strategic and reputational factors than by cost reduction. The model showed good explanatory power and allowed the rejection of hypotheses that Green Bonds lead to lower interest rates or reflect lower perceived risk. Future research should include panel data and liquidity variables to enhance explanatory capacity.

Keywords: Green Bonds; Green Bond Premium; Capital Markets; Sustainable Finance; Cost of Debt.

1 Introduction

In 1992, Brazil hosted the United Nations Conference on Environment and Development, popularly known as Rio 92. This event marked a major international milestone in the fight against climate change, being the first meeting to bring together all member countries of the United Nations (UN) to discuss global initiatives for promoting sustainability. It also led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC),

which organizes periodic meetings among member countries, known as Conferences of the Parties (COP).

In November 2021, the UNFCCC held the Twenty-Sixth Conference of the Parties (COP26) in Glasgow, Scotland. The event brought together approximately 200 member countries to reaffirm their commitments under the Paris Agreement, whose main objective is to keep the cumulative rise in global average temperatures below 1.5°C—a threshold beyond which the Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report, indicates a high likelihood of severe impacts on sea levels, precipitation volumes, soil fertility, and other environmental phenomena (IPCC, 2021).

Achieving these targets requires adequate financing for the development of more efficient production processes, low-carbon technologies, and improvements in energy efficiency. In this context, the role of Sustainable Finance becomes increasingly relevant, through the provision of financial products aimed at projects and objectives aligned with ESG criteria. These instruments take various forms and are made available in Brazil through both the banking system and the capital markets.

In capital markets, ESG products generally refer to fixed-income securities whose proceeds must be allocated to projects with positive environmental, social, or governance impacts. For the sake of simplification, all such securities falling under any of these categories will be referred to as *Green Bonds* throughout this work.

According to the Brazilian Federation of Banks (FEBRABAN, 2016), Green Bond issuers benefit from two main advantages over conventional bond issuance: (i) an expanded investor base, as they attract funds with mandates targeting sustainable investments; and (ii) reputational gains, through increased visibility of ESG projects and a strengthened institutional image for the issuer.

Despite the growing investor demand for sustainability-linked assets, Green Bonds also present heightened risks and limitations for issuing firms, which face restrictions on the use of proceeds—limited exclusively to specific projects—as well as the potential for increased debt costs should they fail to meet the targets set forth in the bond agreements. To encourage the issuance of more Green Bonds (and, consequently, more target-setting), it is important that these instruments offer more attractive interest rates than traditional debt securities—a

phenomenon observed by several authors in international capital markets and referred to as the *Green Bond Premium* (Baker et al., 2018; Slimane et al., 2020; Zerbib, 2017). The challenge with this system is that, by accepting the Green Bond Premium, the investor forfeits a portion of potential returns, making the investment less attractive.

These characteristics suggest that Green Bonds may be less advantageous for issuers compared to conventional bonds, while also being less appealing to investors. Nevertheless, since 2016, there has been continuous growth in the issuance of ESG-linked securities in the Brazilian capital market, as illustrated in Table 1. This expansion may be explained by the granting of the Green Bond Premium, though to date, the non-financial benefits appear more evident than direct financial incentives, rendering the primary driver behind the increased issuance of such bonds uncertain.

Given the rapid growth of Green Bond issuance in the Brazilian market and the fact that these bonds often carry interest rates very close to those of traditional private fixed-income securities, this study seeks to address the following questions:

- (i) Does a Green Bond Premium exist in the Brazilian capital market?
- (ii) How do firms justify the decision to issue Green Bonds in Brazil?

The main objective of this study is to identify pricing differences between traditional fixed-income securities and Green Bonds issued in the Brazilian capital market, relating the presence or absence of the Green Bond Premium to firms' decisions to issue such instruments.

The specific objectives include:

- (i) Examining the potential determinants of firms' capital structure, as well as the theories proposed for the choice between equity financing, debt issuance, or selling ownership stakes;
- (ii) Examining the possible structures of a Green Bond;
- (iii) Analyzing the pricing of traditional securities and Green Bonds in Brazil;
- (iv) Determining the main factors behind a company's decision to issue a Green Bond and an investor's decision to allocate capital to this type of asset in Brazil;

- (v) Identifying the theory that best explains the decision-making process of Brazilian companies in choosing to issue Green Bonds.

Table 1: External Assessments for ESG Asset Validation in Brazil

Year	Number of Green Bonds	Issued Volume (R\$ million)	Average Maturity (years)
2016	2	1,200	6.50
2017	6	444	11.80
2018	4	794	12.00
2019	14	4,849	14.06
2020	33	11,785	8.99
2021	96	27,499	8.22
2022*	53	27,546	8.76
Total	208	74,118	9.25

Note. * Data until the end of October 2022.

Source: Author's elaboration based on NINT (2022).

According to the Capital Markets Bulletin of the Brazilian Financial and Capital Markets Association (ANBIMA, 2022), approximately 82% of capital raised in the Brazilian capital market between January and September 2022 took place through the issuance of fixed-income securities. As the primary financing instrument in the Brazilian market, these securities represent a strategic funding source for enabling sustainable projects.

Based on data from NINT (2022), of the 1,492 fixed-income issuances carried out in the domestic market during the same period, only 46 received an external evaluation. This figure highlights the growth potential of sustainable finance in the country. However, understanding this expansion process requires a deeper analysis of the factors influencing firms' decisions to issue Green Bonds.

As with any debt operation, the interest rate (or coupon) defines the financial cost for the issuing company over the maturity of the bond, serving as a central element in managerial decision-making. Given the non-financial benefits—such as access to new investors and reputational gains—the role of pricing in this decision becomes less evident, particularly in a context where the existence of a Green Bond Premium has not yet been clearly established.

2 Theoretical Framework

2.1 Capital Structure

A firm's decision to raise funds through debt or equity—via new shareholder contributions—to finance value-generating projects can be interpreted from several theoretical perspectives and has been the subject of important academic contributions over the past decades. The starting point of this debate is the classical work by Modigliani and Miller (1958), which was later expanded and complemented by various theoretical approaches.

2.1.1 Agency Costs

One of the main factors influencing the choice between debt and equity is agency costs, which arise from conflicts of interest among shareholders, creditors, and managers. These conflicts shape preferences for different capital structures, as each party seeks to mitigate perceived risks (Harris & Raviv, 1991).

The first type of conflict occurs between shareholders (principals) and managers (agents). It is assumed that managers do not always allocate available resources in the most efficient way to maximize firm value; instead, they may divert part of them for personal benefit, such as perks, luxury assets, or increasing their own compensation. This behavior occurs because managers do not directly capture the financial gains from the appreciation of projects, which accrue to the shareholders (Harris & Raviv, 1991).

Debt issuance acts as a control mechanism over resource allocation by limiting the amount of free cash available within the firm. Since the amount raised through debt must be repaid to creditors over time, value creation becomes essential, thereby encouraging more efficient management (Jensen & Meckling, 1986).

Another relevant agency cost is the Cost of Financial Distress, related to the conflict between shareholders and creditors. When debt is used for financing, creditors bear a portion of the insolvency risk, while any excess returns are appropriated exclusively by shareholders. This can lead to excessively risky investments, a situation known as asset substitution—yet another cost associated with debt issuance (Jensen & Meckling, 1986).

2.1.2 Tax Benefit of Debt

Another key factor in the choice between debt and equity is the tax advantage associated with debt financing. Interest payments on debt are deductible from the corporate income tax base, unlike dividends. Although both represent cash outflows, debt payments are deducted from taxable income (EBIT), thereby reducing the tax burden, while equity distributions are made from net income (Wang, 2013).

Therefore, debt issuance tends to represent a lower cost for the firm when compared to equity issuance.

2.1.3 Static Trade-off Theory

The Static Trade-off Theory proposes that there exists an optimal capital structure point at which the firm's value is maximized. Beyond this point, the marginal cost of debt exceeds its benefits, making additional debt financing less advantageous.

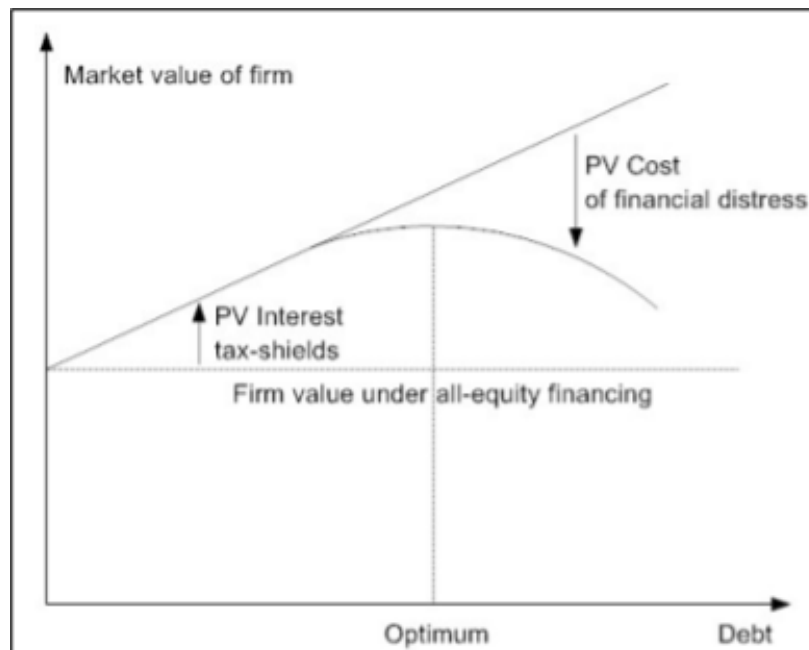


Figure 1: Representation of the Static Trade-off Theory

Source: WANG (2013, p. 10)

As a result, the firm seeks to balance the tax benefit of debt against the agency costs

associated with its use. Once this balance is achieved, firms are expected to favor equity financing, such that leverage tends to remain close to this optimal point (Myers, 1984).

2.1.4 Information Asymmetry

Information asymmetry arises when one party involved in a transaction—such as investors or creditors—possesses less information than corporate insiders, including managers. This informational imbalance can lead to adverse selection problems, as formalized by Akerlof (1970), resulting in inefficient market outcomes and a suboptimal allocation of resources.

In the context of corporate finance, information asymmetry plays a central role in shaping firms' financing decisions. According to Myers and Majluf (1984), when firms issue new equity, external investors may interpret this decision as a negative signal about firm value. This signaling problem emerges because managers are better informed about the firm's true prospects, leading investors to suspect that shares are overvalued. Consequently, equity issuance may trigger a decline in stock prices and a loss of value for existing shareholders.

Similar informational frictions are also present in credit markets. Watson and Wilson (2002) argue that lenders face difficulties in accurately assessing borrowers' risk, which may result in credit rationing and restricted access to external financing. Overall, these informational constraints not only affect firms' access to capital but also underpin the financing hierarchy proposed by the Pecking Order Theory, discussed in the following section.

2.1.5 Pecking Order Theory

Building on information asymmetry, the Pecking Order Theory posits that firms follow a financing hierarchy when funding their projects: they prioritize internal funds, then debt, and issue new equity only as a last resort. This hierarchy reflects the costs associated with asymmetric information and adverse selection in capital markets.

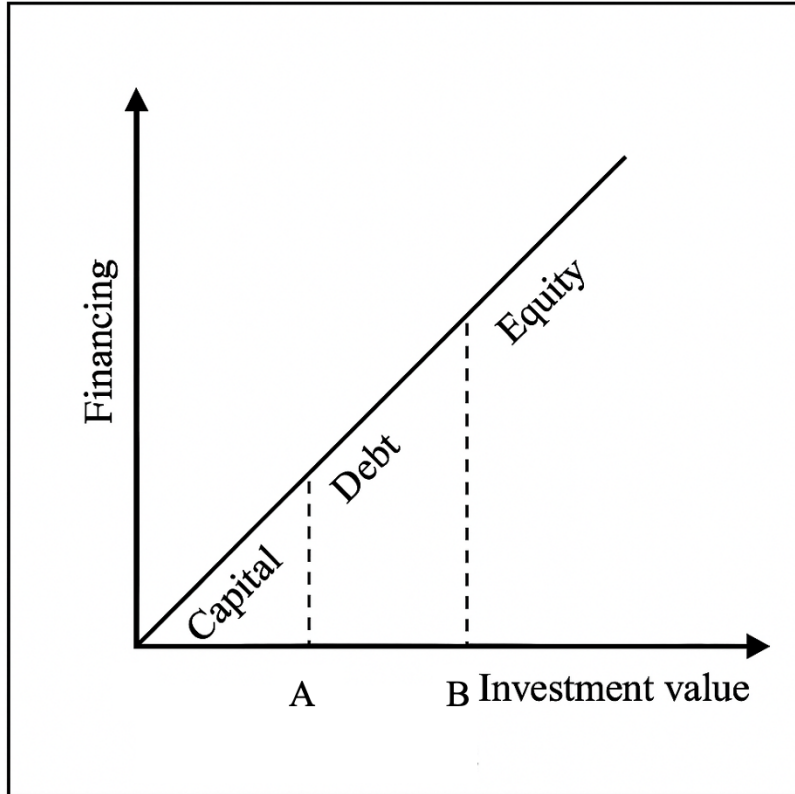


Figure 2: Representation of the Pecking Order Theory

Source: WANG (2013, p. 15)

As illustrated in Figure 2 (Wang, 2013), once the investment value exceeds the firm's available internal capital (point A), financing shifts to external sources. In this case, debt is always preferred over equity issuance due to the market value reduction caused by information asymmetry between new and existing shareholders. Equity financing will only be used if the investment value exceeds the firm's debt capacity (point B).

According to Wang (2013), the decision to issue new equity depends on whether the costs arising from information asymmetry are lower than the net present value (NPV) of the proposed investment. If this condition is not met, the firm is expected to forgo the investment.

2.2 Green Bonds

Securities aimed at financing ESG-related projects and goals may present different scopes, depending on the thematic areas of the projects to which the proceeds will be allocated. According to the International Capital Market Association (ICMA), these instruments can be classified into four main categories, as illustrated in Table 2.

Table 2: Classification of ESG Bonds

Classification	Description
Green Bonds	Fixed-income securities whose proceeds are exclusively allocated to the financing of new and/or existing projects with positive environmental impact.
Social Bonds	Fixed-income securities whose proceeds are exclusively allocated to the financing of new and/or existing projects with positive social impact.
Sustainability Bonds	Fixed-income securities whose proceeds are allocated to the financing of new and/or existing projects that generate, jointly, positive environmental and social impacts.
Sustainability Linked Bonds (SLB)	Fixed-income securities whose structural features (primarily interest rates) are linked to the achievement of pre-established sustainability targets.

Source: ICMA (2021).

2.2.1 Green Bond Principles (GBP)

Given the lack of standardization in the criteria and issuance procedures for Green Bonds—here understood as securities falling under any of the categories described in Table 2—the International Capital Market Association (ICMA) developed a set of guidelines known as the Green Bond Principles (GBP). This document sets out the eligibility and due diligence procedures that issuers should follow when structuring their bonds. The GBP are based on four main pillars (ICMA, 2021):

- (i) **Use of proceeds:** The issuer must specify how the proceeds will be used, describing the eligible projects and the expected environmental benefits. The main eligible project

categories are listed in Table 3. A single project may fall under more than one category, and the list is not intended to be exhaustive.

- (ii) **Process for project evaluation and selection:** The issuer must disclose the eligibility criteria adopted, as well as any certifications and environmental or social risk mitigation mechanisms used to select (or exclude) the financed projects.
- (iii) **Management of proceeds:** The proceeds must be held in a segregated account and drawn down as project-related expenditures occur. This practice promotes transparency and ensures that the funds are used for the intended purposes. Independent audits of this process are also recommended.
- (iv) **Reporting:** The issuer must provide regular reports with updates on project progress, funds allocated, and estimated impacts. Reporting should occur annually until the full completion of the projects.

Table 3: Eligible Use of Proceeds for Green Bond Issuances

Category	Examples
Renewable Energy	<ul style="list-style-type: none"> • Generation, transmission, storage, or use of solar, wind, bioenergy, hydropower, tidal, and geothermal energy.
Energy Efficiency (equipment and products)	<ul style="list-style-type: none"> • Sustainable buildings (retrofit and new constructions) • Efficient storage systems • Efficient heating systems • Smart grids

Source: ICMA (2021); FEBRABAN (2016).

Table 3 (continued)

Category	Examples
Pollution Prevention and Control	<ul style="list-style-type: none"> • Wastewater treatment • Emissions control (GHG and other pollutants) • Soil decontamination • Recycling and generation of high value-added products
Sustainable Management of Natural Resources	<ul style="list-style-type: none"> • Energy generation from waste and environmental monitoring • Low-carbon agriculture • Sustainable forestry and forest management • Conservation, restoration, and recovery of native vegetation • Rehabilitation of degraded areas
Biodiversity Conservation	<ul style="list-style-type: none"> • Sustainable fishing and aquaculture • Protection of terrestrial, coastal, marine, riverine, and lacustrine habitats • Sustainable use of biodiversity
Clean Transportation	<ul style="list-style-type: none"> • Implementation of ecological corridors • Production and use of electric and hybrid vehicles • Non-motorized vehicles • Rail and metro systems • Multimodal transportation • Infrastructure for clean vehicles

Source: ICMA (2021); FEBRABAN (2016).

Table 3 (continued)

Category	Examples
Sustainable Water Resource Management	<ul style="list-style-type: none"> • Water treatment and depollution • Infrastructure for water capture and storage • Water distribution infrastructure • Watershed protection • Sustainable urban drainage systems • Flood control systems
Climate Change Adaptation	<ul style="list-style-type: none"> • Climate or early-warning monitoring systems • Resilience infrastructure (dams and/or other structures) • Development or use of varieties resistant to extreme climate conditions
Eco-efficient Products, Technologies, and Processes	<ul style="list-style-type: none"> • Eco-labels or sustainability certifications • Development of biodegradable or renewable products and technologies • Eco-efficient products and processes

Source: ICMA (2021); FEBRABAN (2016).

2.2.2 Green Bonds in Brazil

In Brazil, there is no official regulation specifically defining the classification of fixed-income securities as Green Bonds. As a result, the classification may be based on various guidelines published by different institutions. This multiplicity of criteria increases the risk of greenwashing, defined by Ottman (2012) as:

When an organization exaggerates or misleads consumers about the environmental attributes of its offerings. Accusations of greenwashing may originate from

various sources, including environmentalists, the press, consumers, competitors, and the scientific community, and may be serious, long-lasting, and highly damaging to a company's reputation. (Ottman apud Alves, 2012, p.18).

To reduce the risk of greenwashing and provide greater clarity to investors interested in sustainable bonds, FEBRABAN and the Brazilian Business Council for Sustainable Development (CEBDS) developed the *Guide for the Issuance of Green Bonds in Brazil*. This document outlines the steps issuers must follow for their securities to be recognized as Green Bonds, based on the guidelines of major international financial institutions. Most of the recommendations are aligned with the GBP, supplemented by guidance for specific economic sectors. Among the core requirements of the guide is the External Review.

In this process, an independent entity conducts environmental due diligence on both the project and the issuer, in order to ensure compliance with internationally recognized eligibility standards, such as the GBP and the Climate Bond Standards, as defined by the Climate Bonds Initiative (CBI).

According to FEBRABAN, the External Review can be carried out in four formats:

- (i) **Second Opinion:** A technical assessment issued by an auditor or specialized consultancy, based on the evaluator's expertise and without requiring the use of standardized criteria.
- (ii) **Verification:** An assessment based on a specific methodology—either proprietary or third-party—resulting in a verification report. These methodologies generally follow the principles of the GBP and the CBI.
- (iii) **Certification:** The bond issuance is audited based on criteria defined by a certifying body, for which the evaluator must be formally qualified. Until 2016, the only recognized certifying body was the CBI.
- (iv) **Rating:** The assignment of a score to the eligibility of the projects and to the management of proceeds, similar to credit risk assessments. This is generally conducted by rating agencies or research institutions.

Table 4: Principles Adopted by Major ESG Rating Agencies for External Green Bond Evaluation

Evaluator	Guidelines
S&P Global Ratings	<ul style="list-style-type: none"> • Green Bond Principles (ICMA)
NINT	<ul style="list-style-type: none"> • Green Bond Principles (ICMA) • Performance Standards of the International Finance Corporation (IFC)
Resultante ESG	<ul style="list-style-type: none"> • Climate Bond Standards (CBI) • Green Bond Principles (ICMA)
Bureau Veritas	<ul style="list-style-type: none"> • Green Bond Principles (ICMA)
ISS ESG	<ul style="list-style-type: none"> • Climate Bond Standards (CBI) • Green Bond Principles (ICMA)
Sustainalytics	<ul style="list-style-type: none"> • Green Bond Principles (ICMA) • The Sustainability-Linked Loan Principles (LSTA)

Source: Author’s elaboration based on external review reports.

2.2.3 Fixed-Income Instruments in the Brazilian Capital Market

According to ANBIMA (2021), the main fixed-income instruments in the Brazilian capital market are: debentures, promissory notes, financial bills (letras financeiras), Credit Rights Investment Funds (FIDCs), and securitized operations (Real Estate Receivables Certificates – CRIs and Agribusiness Receivables Certificates – CRAs). Among these, infrastructure debentures—designed for projects of public interest—offer income tax exemption for investors, which increases demand and, consequently, may reduce the cost of debt for the issuer. The same tax benefit applies to securitized operations, which also enjoy tax exemption.

Despite Brazil’s commitments under international agreements—such as the Kyoto Protocol and the Paris Agreement (COP21)—sustainable projects are still not included among

the incentivized sectors under Law No. 12.431/2011, which regulates tax benefits in the capital market. As a result, Green Bonds do not have access to the same cost-reduction mechanisms via tax exemption as infrastructure debentures.

Due to their simplicity, flexibility, and wide sectoral applicability, debentures have become the dominant format for Green Bond issuance in Brazil. Since 2016, the amount raised through green debentures (both traditional and infrastructure-related) totals approximately R\$44.5 billion (NINT, 2022).

2.3 Findings from National and International Empirical Studies

Several empirical studies have compared the yields of Green Bonds with those of conventional debt instruments, especially in the United States. Notable contributions include those by Oikonomou et al. (2014), Karpf and Mandel (2017), Zerbib (2016; 2018), and Nanayakkara & Colombage (2019), whose findings are not always consistent. Other authors, such as Menz (2010), Bauer and Hann (2014), Magnanelli and Izzo (2017), and Ghouma et al. (2018), explored the relationship between corporate social responsibility and the cost of debt in the contexts of the United States, Europe, and Canada.

While Oikonomou et al. (2014), Nanayakkara & Colombage (2019), and Bauer & Hann (2014) found a relationship between better ESG indicators and lower funding costs, the other studies reported no significant differences. It is worth noting that few of these studies used exclusively private bond data traded in capital markets—with Nanayakkara & Colombage (2019) and Zerbib (2016) being exceptions—highlighting a gap in the international literature.

With regard to capital structure, Lebel, Lajili Jarjir, and Sassi (2020) observed that the issuance of Green Bonds is associated with a decline in firms' stock prices. Xiangsheng and Shuxiu (2019), on the other hand, showed that the main determinants of issuance are the availability of suitable financial instruments and the existence of eligible projects. Their findings align with the Pecking Order Theory, which suggests that debt is only used after internal funds are exhausted, thereby avoiding share dilution.

To date, no peer-reviewed studies have been found investigating the existence of a Green Bond Premium in Brazil or its relationship with the capital structure of issuing firms. In this sense, the present study seeks to apply well-established international methodologies to

the Brazilian market context, offering a clearer analysis of the financial benefits associated with Green Bond issuance in the country.

3 Methodology

3.1 Research Classification

According to Gil (2019), although each social research project may have a specific objective, it is possible to classify them by purpose, using broad groupings known as levels of research. Based on this categorization, the present study is classified as descriptive research, as it aims to establish relationships among different variables—in this case, the classification of debt instruments as Green Bonds, the existence of a Green Bond Premium, and the logic behind the capital structure used by firms when deciding to issue such instruments.

The research can also be classified according to the nature of the data analyzed and the type of design adopted (Gil, 2019). Regarding the nature of the data, this is a quantitative study, as it uses a deductive approach and statistical techniques to explain the behavior of the variables (Richardson, 1999). In terms of research design, it is an *ex post facto* study, in which the data refer to events that have already occurred, making the independent variables non-manipulable (Gil, 2019).

3.2 Sample and Period

The sample considered in this study includes both conventional debt instruments and Green Bonds issued by companies in the Brazilian capital market between 2017 and 2022. This time frame was defined to increase the number of Green Bond observations, given that the database used covers issuances starting in 2017. As of the date this study was written, the most recent registered issuance occurred in September 2022, which was adopted as the upper limit of the time window.

To improve comparability between the two types of issuance, only conventional bonds issued by companies that also carried out at least one Green Bond issuance were included. The financial instruments considered were: institutional debentures, infrastructure deben-

tures, CRIs (Real Estate Receivables Certificates), and CRAs (Agribusiness Receivables Certificates).

The securities analyzed have interest rates indexed to either the CDI (+) or the IPCA (+). When an issuance had multiple tranches, each tranche was treated as a distinct security.

3.3 Data Collection and Analysis

The construction of the database began with the listing of Green Bonds issued in the Brazilian market, as recorded in the ESG Debt Database from NINT (2022). From this dataset, the bonds associated with the financial instruments listed in Table 5 were selected.

Using the list of Green Bond issuers, a query was conducted on the ANBIMA Data platform (ANBIMA, 2022) to collect information on issuance volume, maturity dates, coupon rates, and credit ratings, as well as to identify the conventional debt securities issued by the same firms and their respective characteristics.

To standardize the two types of coupons (CDI+ and IPCA+), the returns of NTN-Bs and LFTs on the respective issuance dates were used, based on data from the Brazilian Treasury’s Yield History (2022).

Table 5: Financial Instruments by Issuance Year (Number of Offerings)

Instrument	2017	2018	2019	2020	2021	2022	Total
CRA	1	–	1	4	14	2	22
CRI	–	–	–	–	4	3	7
Debentures	3	9	23	15	54	26	130
Infrastructure Debentures	6	5	19	23	35	16	104
Total Offerings	10	14	43	42	107	47	263

Source: Author’s elaboration.

IPCA and GDP variation rates were obtained from SIDRA, the data system of the Brazilian Institute of Geography and Statistics (IBGE, 2022).

Table 6: Green Bonds and Conventional Bonds in the Sample

Offering Type	No. of Issues	Volume (R\$ mn)	Tax-Exempt	CRA	CRI	Debentures	Infra Debentures
Conventional	125	56,496	50	7	1	75	42
<i>Green Bonds</i>	138	51,346	83	15	6	55	62
Total	263	107,843	133	22	7	130	104

Source. Author’s elaboration.

The final sample consisted of 263 debt instruments, as detailed in Table 5 and Table 6.

3.4 Variable Definition

To compare interest rates between conventional debt instruments and Green Bonds, it is necessary to account for external risk and liquidity factors (such as country risk, inflation, market liquidity, among others), which vary over time. Therefore, even if a bond presents identical characteristics and is issued by the same company, the interest rates may differ depending on the issuance date, reflecting prevailing market conditions (Steven & Kleinstein, 1991).

In order to eliminate these external variations and isolate the effective interest rate premium paid by firms, we construct the dependent variable *GSpread*, defined as the annual interest rate of the bond minus a risk-free rate (RFR), following the methodology proposed by Weil (1989). Due to the different indexation mechanisms across the analyzed bonds, different RFRs are adopted for coupons indexed to IPCA and CDI.

For IPCA-indexed bonds, the RFR corresponds to the yield on the NTN-B with the closest maturity date to that of the bond (Franklin Jr. et al., 2012), as described in the following equation:

$$GSpread_{IPCA_{i,t}} = Coupon_i - NTN\ B\ Rate_{i,t} \quad (1)$$

where $\text{GS}_{\text{IPCA}_{i,t}}$ is the interest rate spread of bond i over the NTN-B on day t of issuance, Coupon_i is the bond’s nominal interest rate, and $\text{NTNB Rate}_{i,t}$ is the yield of the NTN-B with maturity closest to bond i on date t .

In the case of “CDI +” bonds, the RFR used is the return of the LFT with the closest maturity to that of the bond (Paula & Faria Jr., 2012), as shown below:

$$\text{GS}_{\text{CDI}_{i,t}} = \text{Coupon}_i - \text{LFT Rate}_{i,t} \quad (2)$$

where $\text{GS}_{\text{CDI}_{i,t}}$ is the interest rate spread of bond i over the LFT on day t of issuance, Coupon_i is the bond’s nominal interest rate, and $\text{LFT Rate}_{i,t}$ is the return on the LFT with the closest maturity to bond i on date t .

As the variable of interest, we define the dummy variable GB_i , which takes the value 1 if bond i is a Green Bond and 0 if it is a conventional bond.

3.5 Statistical Tests

The econometric model adopted in this study is derived from the works of Nanayakkara and Colombage (2019) and Zerbib (2016), consisting of a multivariate regression estimated using Ordinary Least Squares (OLS) applied to cross-sectional data. Although the original authors used panel data—that is, repeated observations over time—the low liquidity of the Brazilian secondary market for debt securities made it impossible to collect consistent time series for the analyzed instruments (Gujarati, 2006).

Therefore, the model was adapted for cross-sectional data using the information available at the time of the primary issuance. According to Wooldridge (2010), such a dataset allows for the analysis of the relationship between variation in the explanatory variables and the behavior of the dependent variable, under the assumption of time-fixed effects.

Table 7: Description and References of the Variables

Variable	Definition	Unit	Reference(s)
GS_{spread}_i	Interest rate spread of bond i relative to the yield of the corresponding government bond on the issuance date.	% p.a.	Nanayakkara & Colombage (2019); Zerbib (2016)
α	Intercept term in the function.	–	n/a
GB_i	Dummy equal to 1 if bond i is a Green Bond, and 0 otherwise.	–	Nanayakkara & Colombage (2019); Zerbib (2016)
Tax_i	Dummy equal to 1 if bond i is tax-exempt, and 0 if not.	–	–
Amt_i	Issued volume of bond i .	R\$ million	Zerbib (2016); Karpf & Mandel (2017)
$Term_i$	Maturity of bond i .	Years	Zerbib (2016); Karpf & Mandel (2017)
$Rating_i$	Credit rating of bond i (scale from 1 to 16, ascending by risk level).	–	Zerbib (2016); Karpf & Mandel (2017)
TR_i	Yield of the government bond corresponding to bond i at the issuance date.	% p.a.	Nanayakkara & Colombage (2019); Karpf & Mandel (2017)
$IPCA_i$	12-month IPCA variation measured in the month of issuance of bond i .	%	Nanayakkara & Colombage (2019)
$GDPG_i$	12-month GDP variation measured in the quarter of issuance of bond i .	%	Nanayakkara & Colombage (2019); Karpf & Mandel (2017)

Source. Author's elaboration

Table 7 (continued)

Variable	Definition	Unit	Reference(s)
μ_i	Error term.	–	n/a

Source. Author's elaboration

Considering the theoretical foundations of the aforementioned models and the specificities of the Brazilian corporate debt market, the econometric specification proposed is:

$$\text{GSpread}_i = \alpha + \beta_1 \text{GB}_i + \beta_2 \text{Tax}_i + \beta_3 \text{Amt}_i + \beta_4 \text{Term}_i + \beta_5 \text{Rating}_i + \beta_6 \text{TR}_i + \beta_7 \text{IPCA}_i + \beta_8 \text{GDPG}_i + \mu_i \quad (3)$$

The variables are described in Table 7

3.6 Construction of Macroeconomic Variables

To construct the variable GDPG_i , the following formula was used:

$$\text{GDPG}_i = \frac{\text{GDP}_i - \text{GDP}_0}{\text{GDP}_0} \times 100 \quad (4)$$

where GDP_i is the Brazilian GDP reported by IBGE for the quarter in which bond i was issued, and GDP_0 is the Brazilian GDP reported 12 months prior to that quarter.

To construct the variable IPCA_i , the following formula was applied:

$$\text{IPCA}_i = \frac{\text{IPCA}_1 - \text{IPCA}_0}{\text{IPCA}_0} \times 100 \quad (5)$$

where IPCA_1 is the inflation index reported by IBGE for the month in which bond i was issued, and IPCA_0 is the inflation index reported 12 months before that month.

3.7 Hypotheses and Expected Results

The hypotheses formulated for this study are as follows:

- **H1: Green Bonds are traded with a negative Green Bond Premium.**

This hypothesis will be confirmed if the coefficient of the variable GB is negative,

indicating that bonds classified as Green Bonds are associated with a lower cost of financing. This effect has been documented by Nanayakkara and Colombage (2019), Zerbib (2016), and Ehlers and Packer (2017).

- **H2: Tax-exempt bonds exhibit lower interest rates.**

Securities such as infrastructure debentures, CRIs, and CRAs offer tax benefits to investors and therefore tend to have lower funding costs. This hypothesis will be confirmed if the coefficient of the variable Tax is negative.

- **H3: Brazilian firms follow the logic of the Static Trade-off Theory when issuing Green Bonds.**

According to this theory, financing decisions aim to maximize the net benefit by considering both the costs and advantages associated with debt (Wang, 2013). This hypothesis will be validated if the coefficient of the variable GB is less than or equal to zero.

- **H4: Investors demand Green Bonds due to information asymmetries.**

According to Nanayakkara and Colombage (2019), Green Bonds are perceived as less risky assets, justifying lower spreads. This hypothesis will be confirmed if the variable GB has a negative coefficient, indicating that investors are willing to forgo part of their return in exchange for lower perceived risk.

4 Results Analysis

4.1 Descriptive Analysis of the Data

Table 8 presents the descriptive statistics of the sample used in this study:

Table 8: Descriptive Statistics of the Sample

Variable	Mean	Std. Dev.	Median	Min	C.V.	Max
GSpread	1.8451	1.6604	1.4568	-0.2700	0.8999	10.856

Source. Author's elaboration

Table 8 (continued)

Variable	Mean	Std. Dev.	Median	Min	C.V.	Max
Amt	410.05	366.38	319.00	5.0000	0.8935	2200.0
Term	8.2861	4.8670	7.0000	1.0000	0.5874	25.000
Rating	4.9316	5.8697	1.0000	1.0000	1.1902	16.000
TR	2.3732	2.2264	3.0700	0.0200	0.9381	6.2100
IPCA	6.9449	3.3012	6.1000	1.8800	0.4753	12.130
GDPG	1.1404	2.8608	1.9240	-3.8787	2.5085	4.7120

Source. Author's elaboration

It is worth noting that the maturities (*Term*) of the analyzed bonds ranged from 1 to 25 years, with a coefficient of variation of 58.7% relative to the mean. The offering volumes (*Amt*) ranged from R\$5 million to R\$2.2 billion, showing a coefficient of variation of 89.3%. This wide spectrum of offering characteristics results from a sample that includes all bonds found in the Green Bond database used in this study, which meet the predefined criteria set forth in Sections 3.2 and 3.3, as well as all conventional bonds issued by the same companies as found in the ANBIMA Data platform.

This selection was carried out to generalize the scope of analysis of the Brazilian Green Bond market and to provide greater robustness to the study.

It is also relevant to highlight, as shown in Table 6, that the proportion of Green Bonds to conventional bonds in the sample is 52% to 48%, respectively. Likewise, the proportion of tax-exempt to non-exempt bonds is approximately 50% for each category. These proportions indicate a degree of homogeneity in the sample, which enhances the reliability of the econometric tests conducted.

Table 9: Correlation Matrix

	GSpread	Amt	Term	Rating	TR	IPCA	GDPG
GSpread	1.0000						
Amt	-0.2919	1.0000					

Source. Author's elaboration.

Table 9 (continued)

	GSpread	Amt	Term	Rating	TR	IPCA	GDPG
Term	-0.3022	0.0023	1.0000				
Rating	0.6727	-0.3683	-0.2271	1.0000			
TR	-0.4022	-0.0454	0.6267	-0.2362	1.0000		
IPCA	-0.0914	0.0156	-0.0393	0.0291	0.0493	1.0000	
GDPG	-0.1553	-0.0073	-0.0332	0.0334	0.0335	0.6579	1.0000

Source. Author's elaboration.

From the correlation matrix, we observe that the independent variables do not exhibit high correlations among themselves, suggesting the absence of multicollinearity in the model. The highest correlation was found between the inflation rate (*IPCA*) and GDP growth rate (*GDPG*), which showed a correlation of 65.8%.

To formally test for multicollinearity in the model, Variance Inflation Factors (VIFs) were calculated for all variables. According to Gujarati (2006), the VIF captures the rate at which variances and covariances increase in the presence of multicollinearity. It is calculated using the following equation:

$$\text{VIF}_J = \frac{1}{1 - R_J^2} \quad (6)$$

where:

- VIF_J is the Variance Inflation Factor for variable X_J relative to the other independent variables.
- R_J^2 is the coefficient of determination from a linear regression in which X_J is the dependent variable and the remaining independent variables from the main model are used as regressors.

Thus, the VIF indicates how much of the variance of an independent variable is explained by the others. The higher the R^2 from the auxiliary regressions, the stronger the explanatory relationship and the greater the VIF.

Table 10: Variance Inflation Factors (VIF)

Variable	VIF
GB	1.277
Tax	4.096
Amt	1.189
Term	1.771
Rating	1.387
TR	4.210
IPCA	1.890
GDPG	1.904

Source. Author's elaboration.

Considering that the maximum value of the VIF is 100 (when $R_j^2 = 1$), the exclusion threshold for the tested variables was set at 10, that is, when $R_j^2 \leq 0.90$ (Gujarati, 2006). Based on this criterion, all variables were retained in the model.

4.2 Results of the Econometric Model

Table 11 presents the results of the multivariate regression with the dependent variable *GSpread*. The variable of interest, *GB*, displayed a positive and statistically significant coefficient at the 1% level, indicating that bonds classified as Green Bonds were associated with a higher spread compared to conventional bonds. This result contradicts the hypothesis of a Green Bond Premium from the issuer's perspective, as it suggests a higher cost for sustainable bonds.

At the firm-level characteristics, the offering volume (*Amt*) did not show a statistically significant effect on spreads. However, the variable *Rating* had a negative and statistically significant coefficient, in line with the risk-return trade-off logic, thus reinforcing the model's adherence to expected pricing behavior in the market.

At the macroeconomic level, the variable *TR* exhibited a negative and statistically significant coefficient, suggesting that increases in public bond yields were not followed by

proportional increases in private bond yields. The variable *GDPG* also showed a negative coefficient, indicating that periods of economic growth are associated with lower credit spreads, which is consistent with reduced systemic risk. The variable *IPCA*, in contrast, was not statistically significant.

The variable *Tax*, which indicates tax exemption, was not statistically significant at the 5% level, leading to the rejection of Hypothesis H2. This suggests that the income tax exemption in the analyzed issuances did not result in significantly lower spreads, possibly because it is already priced in or offset by other risks, such as liquidity or sectoral concentration.

The adjusted R^2 of 54.59% indicates that the model explains a substantial portion of the observed spread variation across the sampled bonds, which is satisfactory considering the heterogeneity of issuances and indexers. The F-statistic and its associated p-value confirm the overall statistical significance of the model.

Based on the results, it is inferred that the cost of debt was not the primary factor driving the decision to issue Green Bonds in the analyzed sample, which is inconsistent with the logic of the Static Trade-off Theory (H3). Moreover, the absence of a negative premium for Green Bonds indicates that investors did not internalize informational or reputational benefits as factors justifying the acceptance of lower returns, thus also leading to the rejection of Hypothesis H4.

The variable *Tax* was not statistically significant at the 5% level, again supporting the rejection of Hypothesis H2. Therefore, it is not possible to assert that tax-exempt bonds offered lower interest rates than conventional bonds in the analyzed sample.

Table 11: Multivariate Regression Model. Dependent Variable: *GSpread*

Variable	Coefficient
Constant (α)	1.7606 (0.26) ^{***}
<i>Firm-level variables</i>	
<i>GB</i>	0.3322 (0.15) ^{**}

Source. Author's elaboration.

Table 11 (continued)

Variable	Coefficient
<i>Tax</i>	0.2186 (0.26)
<i>Amt</i>	-0.0004 (0.00) ^{***}
<i>Term</i>	-0.0151 (0.02)
<i>Rating</i>	0.1583 (0.018) ^{***}
<i>Country-level variables</i>	
<i>TR</i>	-0.2411 (0.06) ^{***}
<i>IPCA</i>	-0.0006 (0.02)
<i>GDPG</i>	-0.0936 (0.04) ^{**}
Mean GSpread	1.8451
Residual Sum of Squares	317.95
R^2	0.5598
Adjusted R^2	0.5459
F(7, 255)	18.426
Std. Dev. of GSpread	1.6604
Regression Std. Error	1.1188
p-value (F)	0.0000
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$	

Source. Author's elaboration.

Based on the coefficient estimated for the variable *GB*, it is also possible to infer the

behavior of both issuing firms and investors within the sampled bonds. From the firm’s perspective, the positive coefficient indicates that the cost of debt is not the primary driver behind the decision to issue a Green Bond. For the firms in the sample, sustainable bonds exhibited higher interest rates compared to conventional ones. This result suggests that the issuance of Green Bonds does not follow the logic of the Static Trade-off Theory, leading to the rejection of Hypothesis H3.

From the investor’s standpoint, the model does not provide sufficient evidence to conclude that investment decisions in Green Bonds are based on information asymmetry. This is due to the fact that, for the analyzed securities, investors did not forgo returns in exchange for reduced risk as signaled by external evaluations. Hence, Hypothesis H4 must also be rejected.

5 Conclusion

This study aimed to investigate the existence and direction of the Green Bond Premium in the Brazilian debt capital market, as well as to understand the factors influencing both the issuance and allocation of resources in these instruments.

Using an Ordinary Least Squares (OLS) regression model applied to a sample of 263 bonds issued between 2017 and 2022, the Green Bond indicator variable (*GB*) was found to have a positive and statistically significant coefficient at the 1% level with respect to the dependent variable *GSpread*.

This result indicates that bonds labeled as sustainable were associated with higher spreads compared to conventional ones, contradicting the hypothesis of a Green Bond Premium from the issuer’s perspective.

The central contribution of this study is to provide the first empirical evidence—based on the Brazilian market—that Green Bonds do not yet offer a favorable financial differential in terms of issuance cost.

The results suggest that the motivation behind the issuance of these bonds may be more closely related to qualitative factors, such as strategic positioning, reputation, or access to ESG-dedicated funds, rather than to immediate financial advantages.

As the market evolves and mechanisms for evaluation and transparency become more consolidated, it is possible that investors will begin to more efficiently price the lower risk associated with sustainable bonds.

Although this trend has been observed in international studies, it has not yet clearly materialized in the Brazilian context.

Among the limitations of this research, the most noteworthy are the inability to analyze secondary market trading and the relatively small sample size—reflecting the still-nascent stage of sustainable finance in the country.

For future research, we recommend the incorporation of liquidity variables, the use of panel data, and the inclusion of post-2022 observations as the Green Bond market continues to develop.

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