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Bachelor’s Thesis in Financial Economics

The Effect of Green Bond Labels in Emerging Markets

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Abstract

This study examines the influence of the green bond label on bond yields in emerging markets. Employing a matching method along with a comprehensive regression analysis, this research estimates the yield differential between green bonds and equivalent conventional bonds from April 2023 to April 2024. The results reveal a small, yet significant, negative premium where the yield of green bonds is lower than that of conventional bonds, averaging a -4.8 basis points differential for the entire sample. The premium is notably larger for higher-rated bonds and those issued in Chinese Yuan, suggesting distinct market behaviors. The findings highlight that the influence of investors' sustainable investment preferences on bond prices, while modest, does not currently act as a disincentive for investors to engage with and expand the green bond market in these regions.

Keywords: Green bonds, emerging markets, bond yields, greenium, investor preferences

JEL Classification: G12, G15

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1. Introduction

Since their introductory issuance by the European Investment Bank (EIB) in 2007, green bonds have risen with remarkable velocity and become forerunners of a new financial epoch that promises an alignment of investment flows with environmentally sustainable projects (Cortellini & Panetta, 2021). In 2019, the EIB Board of Directors agreed to increase their climate and environmental commitment as part of the European Union's (EU) objective of becoming the first region to endorse carbon neutrality by 2050. More commitments toward reducing emissions within the investment industry include the Montréal Carbon Pledge initiated by the United Nations in 2014, that made institutions disclose the carbon footprint of their investments, and by 2015 the total assets under management represented approximately USD 10 trillion (UNFCCC, 2014). However, as economic powerhouses align forces in a transition towards green economies, emerging markets are expected to be adversely affected and least able to cope with shocks in their social and economic systems (European Investment Bank, 2020). This necessitates incentives for investors to channel capital into these markets, ensuring that the transition towards sustainability does not come at the expense of growth and stability.

Green bonds (GSSS bonds) are fixed-income instruments aimed to raise funds toward green, social, sustainability and sustainability-linked projects. Green bonds issued by private or public institutions commit the use of funds obtained to a climate cause and represent a broader type than the other three. Social bonds are earmarked toward projects related to health, gender, employment and affordable housing, among others. Sustainability bonds cover a combination of social and green activities such as low-carbon transport, renewable energy and other related items. Finally, sustainability-linked bonds not only raise funds for environmentally significant projects but also integrate performance-based incentives to ensure the realization of set sustainability objectives. Such incentives include coupon linked or other step-downs associated with the goals or achievements with them often being pre-defined or time-bound (Climate Bonds Initiative, 2022). This form of debt raising has allowed countries and companies to continue their economic growth while doing so in a sustainable way.

However, this commitment to sustainability often carries implicit costs and benefits that manifest in the financial terms of the bonds themselves. The green premium, also known as "greenium" which is investigated and discussed throughout this paper, is the yield difference between a green bond and an equivalent conventional bond. A negative premium stem purely from the green label and allows the issuer a cheaper form of debt and could show that investors are willing to give up basis points (bps) of yield due to the funds being earmarked toward a sustainable project (IFC-Amundi, 2023).

This notion of sacrificing yield for sustainability is particularly relevant in emerging markets, which are characterized by their dynamic growth and evolving financial landscapes. However, there is no generally agreed consensus on what is defined as an emerging market. Kearney (2012) defines them as countries with characteristics similar to a developed market but that are not fully matured. In general, these countries have experienced a rapid GDP growth, per capita income, and an increasing equity market liquidity with a secure financial system. This rapid growth is helped by the issuance of bonds to raise debt and sustain the growth over a longer time period. Further, a lot of importance has been put on these countries to grow sustainably, in which green bonds play a significant role and have become a prominent and rapidly growing debt instrument for the selected countries.

Issuance of green, social, sustainability, and sustainability-linked bonds saw its pinnacle in 2021 with issuances totaling above the USD trillion mark, from which emerging markets represented 16 percent of issuance. Since then, emerging markets annual market volume has held strongly, only decreasing by one percent in 2023. Moreover, sovereigns of these markets are now issuing more bonds that finance a combination of green and social projects, rather than green projects exclusively (World Bank, 2024). This reflects a strong commitment to fund projects sustainably, signaling a notable shift in priorities even as these markets navigate the growth phases.

As issuance of green bonds continues to rise, and financial investors take up the challenge of becoming key actors in the energy and environmental transition, it is unavoidable to address the problem of greenwashing. Although analyzing where the bond proceeds are ultimately being placed could be complex and time consuming, it remains crucial to evaluate the impact of the bond yield on achieving environmental objectives. To reduce the amount of greenwashing and legitimizing funds, several certifications have been introduced. One prominent source for this comes from Climate Bonds Initiative (CBI) that has launched certifications and alignments in order to reduce the amount of greenwashing and also ensure investors that the funds are used in an appropriate manner. The certified bonds are thus independently approved to ensure that the use of proceeds complies with the objective of capping global warming at two degrees Celsius (Climate Bonds Initiative, 2022).

Looking ahead, the difference in yield between a green bond and a comparable conventional bond, namely the greenium, is expected to widen in emerging markets relative to advanced markets, supporting the fixed-income asset class in these developing economies (IFC-Amundi, 2023). However, green bonds are priced using the same variables as conventional bonds, and as the market for sustainable financed projects is expected to experience a continued expansion, it is reasonable to question the validity of the greenium outlook. Analyzing the yield of green bonds and its driving forces in comparison with conventional bond yields in emerging markets remains underexplored and provides a great understanding of these forward-looking market dynamics.

1.1. Purpose

The purpose of the thesis is to analyze how green bond yields compare to conventional bonds in emerging markets. More specifically, the study aims to test the significance of the most important characteristics affecting bond yield and evaluate the impact of bonds labeled as green. The study will delve deeper into green bonds in a restricted sample of countries defined as emerging markets, and analyze the ask yield of these bonds, controlling for maturity, issue amount, liquidity, credit rating, sector and currency. Although the subject of environmental investing and their products have been broadly documented, this thesis will contribute to a part of the literature that is evidently scarce, as green bonds represent a rather new and a fast-growing asset class, especially in emerging markets (Cortellini & Panetta, 2021). This in turn would provide more color into a market that has not been covered to this extent in terms of green bonds.

The findings of this study are intended to serve as a crucial resource for investors, policymakers, and academics interested in the intersections of finance, sustainability, and market behavior. By interpreting the financial implications of green bonds, the research will highlight approaches that could enhance the effectiveness of green financing, and thus support broader environmental objectives. Moreover, the insights accumulated could guide policy establishments and investment strategies that prioritize sustainability and consequently influencing market behavior in a way that supports long-term environmental objectives.

1.2. Research Questions

Given the complex interplay of factors influencing green bond yields, this study narrows in focus to dissect how specific attributes impact financial outcomes. This approach allows for a more granular understanding of the explicit and intrinsic effects of green labels in a comparison with equivalently designed conventional bonds. Thus, the fulfillment of this thesis's objective hinges on the exploration of two central research questions.

1. How does the green label affect bond yields in emerging markets?
2. To what extent do the yield-impacting variables significantly affect the yield of green bonds in emerging markets?

These questions are designed to uncover the direct and indirect effects of environmental labeling on bond pricing in the secondary market and to assess the role of various financial and macroeconomic factors in shaping these effects. By delving into these areas, the research aims to provide empirical evidence that could influence future financial practices and policies towards a more sustainable economic framework.

1.3. Structure of the Thesis

The thesis is structured to delve into the dynamics of green bond yields in emerging markets and the associated greenium. Section 1 begins with an introduction that sets the context and outlines the study's importance. Section 2 outlines relevant financial and macroeconomic theories. Section 3 surveys existing research to establish a foundation for the study. Section 4, the methodology, describes the analysis techniques and data handling. Section 5 provides comprehensive details about the dataset. Section 6 presents the empirical results and the findings from the statistical analyses, followed by a discussion in Section 7 that interprets these results in light of the established theories. The thesis ultimately ends with a conclusion in Section 8, and subsequently references and appendices that enhance the understanding and provide material for further inquiry.

2. Theoretical Framework

2.1. Investor Preferences and Asset Pricing Models

Sharpe (1964) introduces the Capital Asset Pricing Model (CAPM) as an attempt to predict the behavior of capital markets. It is also used to evaluate investor preferences and explain risk and return tradeoffs, with the capital market line as a base. A higher risk, with a diversified portfolio, leading to a higher expected rate of return. Further, the equilibrium in the capital markets is derived based on multiple assumptions, two of them being: investors are able to borrow and lend funds on equal terms, and homogeneity among investor expectations.

Asset pricing models such as the capital asset pricing model, with various interpretations, say that all investors know the true joint distribution of asset payoffs. The knowledge in turn produces expectations for rational equilibrium prices. Further, a common assumption is that investors are only concerned with the payoff of their investments. Cohen (2009), Daniel and Titman (1997), find that the last assumption often shows incorrect. Factors such as loyalty or a desire to belong and general preferences to hold certain assets such as growth stocks or value stocks render the assumption false, leading to certain assets being held too long or not held at all.

Due to its restrictive nature, the CAPM fails to explain average stock returns. Evidence provided by, among others, Fama and French (1992) and Vishny et al. (1994) display that there exists a value premium which makes low priced stocks relative to fundamentals such as earnings or book value have stronger returns compared to the return predicted by the CAPM. Following earlier work, investors' tastes can shift equilibrium prices as shown by Fama and French (2007). Connections can be made to Hong and Kacperczyk (2009) where they investigate the price of sin and effects of social norms in markets. Hong and Kacperczyk find that publicly traded companies involved with producing tobacco, alcohol and gaming are less held by norm-constrained institutions and thus can be exploited by arbitrageurs. This is further evidence of the CAPM not holding.

An alternative asset pricing model that is more flexible in its assumptions is the Arbitrage Pricing Theory (APT). Developed by Stephen Ross in 1976, the APT has been reinterpreted several times due to its elastic nature. It is based on the fact that markets sometimes are inefficient and thus produces opportunities where this can be exploited over a very short period before securities move back to fair value. It is a multi-factor model but the paper in itself does not mention the number or the identities driving the expected return and current price. Most rely on macroeconomic factors to explain expected returns in assets, such as corporate bond spreads, GDP growth and inflation rates. The security's sensitivity to these factors is then deciding its expected return, a large difference contrary to the CAPM where a single beta is used. Fama and French (1993) adopts this line of thinking when developing the three-factor model, most relevant for this paper are the two bond-market factors, related to maturity and default risks. The study uses time series regression to examine the effect of the term premium and the default premium, which captures most of the variation in the government and corporate bond portfolios Fama and French creates. The stock-market factors are however linked to the bond returns through their shared variation. One of these being the discount rate, where long-term bonds and stocks act very similarly.

Evidence provided by the two portfolios shows that corporate bonds with longer maturities exhibits a higher return than the government portfolio. Further, average returns on corporate bonds with lower credit ratings are higher. The authors follow this by stating that bonds are good candidates for rejecting asset-pricing equations.

3. Literature Review

As green bonds, in relative terms, represent a newer debt instrument, the literature investigating differences in yield between those and conventional bonds is scarce. Although much research has been made on how social responsibility impacts financial performance and stock prices, as firms refinance more often through debt than equity, pressure from the debt market could have a larger impact on a company's sustainability projects (Oikonomou et al., 2014). Financing these projects through the issuance of green bonds has become more prevalent in later years and so has the research surrounding them. When it comes to the yield difference most of the evidence points to the conclusion of an existing difference in yield between green and conventional bonds. The most common view is that the yield of an otherwise equivalent green bond is lower than their comparable conventional bond (Zerbib, 2019; Baker et al., 2018; Ehlers and Packer, 2017).

Although parts of the method in finding these results are slightly different, all find a negative premium except for Karpf and Mandel (2018) and Hachenberg and Schiereck (2018). Hachenberg and Schiereck (2018) examine i-spreads between 63 matched pairs of bonds. The authors find that A-rated green bonds trade tighter than their conventional synthetic bond and discover the same result for the rest of the sample, although without significance. Finally, the authors conclude that the increased cost of issuing green bonds through external certification or second-party opinions are offset by their price differential to non-green bonds.

Karpf and Mandel (2018) investigate the U.S. municipal bond market, where these bonds are generally smaller in nominal amounts than corporate bonds. The authors construct two different yield curves where one consists of green and one of conventional bonds. Following this, the Oaxaca-Blinder decomposition method is used which split up the bonds into one "explained" and one "unexplained" part, with the "explained" part showing the fundamental part explaining the yield difference between green and conventional. The "unexplained", on the other hand, shows the yield difference not attributable to fundamental differences between the bonds, and thus are explained by the green label exclusively. The results show that if the green bonds would have been evaluated as conventional bonds, they would have yielded an average 7.8 basis points less. However, a time difference is subsequently employed, showing that the premium eventually turns negative in 2015 to 2016. The authors mainly attribute this change to credit quality increase and a reputational increase for green bonds.

Baker et al. (2018) also investigates the municipal bond market in the U.S. during the same time period as Karpf and Mandel (2018), between 2010 and 2016. Baker et al. (2018) finds that in the primary market green bonds are issued at around 5 to 9 basis points lower, which is a more negative premium than that for corporate bonds, showing support that the smaller issue size of the municipal bonds could contribute to the premium. The authors also find that when a green and conventional bond is issued at the same time the premium does not exist in the primary market but rather emerges over time in the secondary market. Furthermore, the discoveries show that the third party which verified the green bond has an impact on the yield. Zerbib (2019) find an average premium of -2.3 basis points in a sample of 110 bonds. Main contributors to the difference stemmed from sector and rating of the bonds, where financial and lower rated bonds show a more negative premium. In line with this result, Ehlers and Packer (2017) find an average credit spread differential of 18 basis points when looking at 21 different green and conventional bonds between 2014 and 2017. The premia is mainly explained by a high demand relative to supply regarding the green bonds. Further support for this can be found in Bauer and Smeets (2015) where the increased demand during this period could rise from an increased number of individuals with strong social identification toward sustainable funds and investments. In that same vein, Riedl and Smeets (2013) covers that more investors accept a lower yield for the same amount of risk as an otherwise identical conventional investment, which goes against traditional models in finance.

The method for finding the results differ some between the papers. Zerbib (2019), Ehlers and Packer (2017), and Hachenberg and Schiereck (2018) use a matching method, also called a direct method. Where all factors of the bonds are the same except for the green label. The conventional bond is also synthesized from two conventional bonds with close maturities to the green bond they are being matched with. Similar approaches are used by other authors (Baker et al., 2018) to find comparable bonds. Due to liquidity having an impact on the yield of a bond, Longstaff (2004), Zerbib (2019) and Baker et al. (2018) use liquidity controls to eliminate that effect.

Furthermore, when discussing the existence of the greenium, Zerbib (2019) cites Fama and French (2007), noting that when a cohort of investors develops a preference for a certain type of asset, equilibrium prices shift and the capital asset pricing model (CAPM) fails to explain asset return. There are further psychological explanations referenced from Hartzmark and

Sussman (2018) that can clarify the yield difference such as altruism or social pressure to invest in these instruments. In contrast to the additional capital inflow based on these psychological factors, the impact they have on price is limited. Following Becker and Ivashina's (2015) paper where insurance companies holdings were analyzed, a smaller yield difference between equivalent bonds have not led to a shift between the assets and thus small differences in yield between green and conventional should not lead to large reallocations.

4. Methodology

This chapter outlines the methodological framework employed to investigate the green bond yield determinants and the yield differentials between green and conventional bonds in emerging markets. Given the complexity of the financial markets and the multifaceted nature of bond yields, a robust and well-structured approach is essential for accurate analysis. Consequently, the methodology is designed to dissect the specific effects of the green label on bond yields and to analyze the influence of yield determining variables on the yield of green bonds alone, while controlling for several influential factors.

Deploying a matching method enables a comparative analysis between green and conventional bonds. By aligning pairs of bonds based on key characteristics, this method aims to isolate the premium attributable to the green label. Furthermore, the study concentrates on creating matched pairs that are equivalent in all respects except for the green label, thereby enabling the attribution of observed yield differentials to the green certification. The subsequent sections detail the matching process (Section 4.1), the liquidity proxy (Section 4.2), and the regression models used to analyze the determinants of green bond yields, the differential between green and conventional bond yields, and the effect of the green label (Sections 4.3). Additionally, restrictions and robustness checks of the chosen methods are described to ensure the reliability and validity of the findings.

4.1. Synthetic Bonds and Matching Method

Initially developed by Mallin et al. (1995) and later adapted by several papers (Gregory et al. 2003; Kreander et al., 2005), this study uses a matching method to compare and analyze the effect of the green label. This direct method has been used in the past when evaluating performance of ethical funds compared to non-ethical funds. In more recent papers, the method is further applied when evaluating bonds (Zerbib, 2019; Hachenberg and Schiereck, 2018; Ehlers and Packer, 2017). This study utilizes the matching method by pairing each green bond with a synthetic comparable conventional bond of similar characteristics. These include maturity, currency, credit rating, sector and issue amount, with a sample drawn over the same time period. This approach minimizes confounding variables, potentially influencing the yield. The sample of bonds under analysis encompasses issuances between January 1, 2018 and

March 30, 2024 with no maturity restrictions, excluding perpetuities. Thus, the study provides a robust temporal canvas for analysis.

When matching the sample of green bonds with comparable conventional bonds, yield influencing variables need to match to obtain a solid estimate. Hence, one synthetic bond is built from two separate conventional bonds, *CB1* and *CB2*. The conventional bond pair has the same country of origin, issuing currency, issuing sector and credit rating as the green bond they are matching. In addition to these criteria, the issue amount of these conventional bonds is carefully chosen to fall inside the restriction of no less than one-third and no more than three times the green bond's issue amount. Similarly, the months to maturity difference between the green and its conventional counterpart's maturity date is restricted to minimum zero months and maximum 80 months. However, given the intricacies of finding conventional bonds with simultaneously matching maturity, a weighting method is implemented to account for this difference.

The synthetic bonds are built by weighting the maturity of the two comparable bonds relative to the green bond. Reflecting methodologies validated by seminal research (Zerbib, 2019; Hachenberg and Schiereck, 2018), this study employs a distance-weighting technique that quantitatively adjusts for the discrepancies in months to maturity. This technique ensures that the synthetic bond is a closer proxy to the green bond in terms of time to maturity, providing a more accurate comparison for yield analysis. Maturity is distance-weighted as:

$$\alpha_{CB1} = \frac{d_2}{d_1+d_2} \; ; \; \alpha_{CB2} = \frac{d_1}{d_1+d_2}$$

where α_{CB1} and α_{CB2} represents the maturity weight of CB1 and CB2 respectively, $d_1 =$ |Green Bond maturity - CB1 maturity| and $d_2 =$ |Green Bond maturity - CB2 maturity|. These weights are assigned to the conventional bond pairs' ask yields, ultimately constructing the synthetic conventional bond's ask yield by:

$$y_{i,t}^{CB} = \alpha_{CB1} y_{i,t}^{CB1} + \alpha_{CB2} y_{i,t}^{CB2}$$

where $y_{i,t}^{CB}$ is the weighted yield of the synthetic bond used in Eq. (2) and Eq. (3).

4.2. Liquidity Proxy

As a proxy for liquidity, the percentage bid-ask spread is used for the green bonds and the corresponding conventional bond pairs, like Zerbib (2019). Other liquidity proxies used include issue amount, by Hachenberg and Schiereck (2018), and number of transactions in the past 30 days, as Karpf and Mandel (2018) uses. However, as these bonds operate in a less liquid market than in developed regions, this could lead to inconsistencies and skewed results. Moreover, trading volume is another method of measuring liquidity. Research papers have used it as a proxy for liquidity in the past using the database TRACE (Trade Reporting and Compliance Engine). However, TRACE is only available for US Dollar denominated bonds and as this study investigates several different currencies, TRACE cannot be used consistently throughout the analysis. The bid-ask spread has been widely used as a measure for liquidity and is deemed more suitable for this thesis.

For the synthetic bond, the two separate bid-ask spreads of the conventional bond pairs are weighted by their respective total weights α_{CB1} and α_{CB2}, in line with the method used to weight the respective ask yields:

$$BA_{i,t}^{CB} = \alpha_{CB1} BA_{i,t}^{CB1} + \alpha_{CB2} BA_{i,t}^{CB2}$$

where $BA_{i,t}^{CB}$ denotes the bid-ask spread of the synthetic bond, as used in Eq. (1). This weighted bid-ask spread is then utilized within Eq. (2) to gauge the fixed-effects by quantifying the spread difference between the green bond and its synthetic counterpart. The equation is as follows:

$$\Delta BA_{i,t} = BA_{i,t}^{GB} - BA_{i,t}^{CB}$$

4.3. Regression Models

This section of the study introduces three regression models to explain the intricacies influencing bond yields and the greenium. Initially, a cross-sectional regression is employed to identify the determinants of bond yields at a single point in time, offering a static analysis of the yield-impacting variables. This snapshot provides insight into the specific factors that affect green bond yields, including credit rating, sector classification, and currency, as well as their contribution to the yield differentials observed between the green and synthetic conventional bonds. The cross-sectional regression thus serves a dual purpose by assessing the static impact of various factors on green bond yields and underpinning the yield differential model by comparing these yields at a particular point across the sample. Subsequently, given the insufficient time-series variation in the dataset, two Ordinary Least Squares (OLS) regressions are employed when analyzing the yield differentials and the effect of the green bond label.

Description of independent variables

Variable	*Type*	*Unit*	*Description*
Maturity	Quantitative	Months	Months to maturity from date of observation point.
Issue Amount	Quantitative	mUSD	The issue amount of the green bond.
Bid-ask Spread	Quantitative	%	Bid-ask spread as described in section 4.2.
Credit Rating	Qualitative		Dummy variable consisting of three different ratings based on Fitch's disclosed ratings: High (AAA+ to AA-), Medium (A+ to BBB+) and Low (BBB- to B-).
Sector	Qualitative		Dummy variable consisting of Government, Financials and Technology.
Currency	Qualitative		Dummy variable for the issuing currency: US Dollar, Euro, Chinese Yuan and Taiwanese Dollar.

4.3.1. Green Bond Yields

The first regression investigates the determinants that drive the yields of green bonds. This analytical approach enables the identification and measurement of the static influence of yield determining factors' dynamics on the pricing of green bonds at a specific moment in time. The regression model can thus illuminate the direct relationships between these factors and the yields.

$$y_i^{GB} = \beta_0 + \beta_1 Maturity_i + \beta_2 \log{(Issue\ Amount)_i} + \beta_3 BAspread_i + \beta_4 RatingDummies_i + \beta_5 SectorDummies_i + \beta_6 CurrencyDummies_i + \varepsilon_i \quad (1)$$

4.3.2. Bond Yield Differential

Building on the insights gained from the cross-sectional analysis of green bond yields, the empirical investigation extends beyond a static analysis by evaluating the yield differentials between green bonds and their synthetic conventional counterparts. This model leverages an OLS regression that encompasses data spanning a broader range, which aims to mitigate potential volatility inherent in static analyses that could result from shorter time frames. Consequently, this regression focuses on the yield premium or discount, namely the greenium, which may arise due to the environmental attributes of green bonds. The yield differential is calculated as:

$$\Delta y_{i,t} = y_{i,t}^{GB} - y_{i,t}^{CB}$$

where $y_{i,t}^{GB}$ and $y_{i,t}^{CB}$ represents the green and the equivalent synthetic conventional bond i's closing weekly ask yield at time t. Furthermore, controlling for liquidity is carried out through the liquidity proxy $\Delta BA_{i,t}$.

$$\Delta y_i = \beta_0 + \beta_1 Maturity_i + \beta_2 \log{(Issue\ Amount)_i} + \beta_3 \Delta BAspread_i + \beta_4 RatingControl_i + \beta_5 SectorControl_i + \beta_6 CurrencyControl_i + \varepsilon_i \quad (2)$$

4.3.3. Green Bond Label Effect

In advancing to the core analysis of this thesis, an OLS regression model is employed, similar to the approach used by Zerbib (2019), who incorporates a green dummy variable in his analysis. This model utilizes data collected over the extended period to thoroughly analyze the yield-determining variables on the ask yield of both green and conventional bonds. Central to this model is the green dummy variable, which is designed to capture the specific impact of the green label on bond yields.

$$y_i = \beta_0 + \beta_1 GreenDummy_i + \beta_2 Maturity_i + \beta_3 \log\,(Issue\ Amount)_i + \beta_4 \Delta BAspread_i + \beta_5 RatingControl_i + \beta_6 SectorControl_i + \beta_7 CurrencyControl_i + \varepsilon_i \qquad (3)$$

4.4. Restrictions and Robustness Checks

In the sample, bonds issued by entities of which its government is an immediate parent are categorized as "government” in the sector classification. Moreover, the study emphasizes the importance of liquidity as a determinant of bond yields. Hence, it restricts the sample used to bonds with a minimum of USD 300 million in issued amount. This threshold mitigates the potential distortion of yields by a liquidity premium, which can disproportionately affect the pricing of bonds with lower issue amounts (Hachenberg and Schiereck, 2018).

To uphold the integrity of the findings, the research incorporates robustness checks. This includes sensitivity analyses, which test the stability of the results across different model specifications and control for a variety of confounding factors. This is conducted by excluding specific controls for credit rating, sector and currency from the respective models.

Moreover, the study employs robust standard errors to ensure the reliability of the regression outcomes. This is motivated by the potential presence of heteroscedasticity where error variances could vary with issue size, market volatility and other unobserved factors. Employing robust standard errors enhances the accuracy and reliability of statistical inference by addressing inconsistencies in the standard errors that may arise from heteroscedasticity. Consequently, this method aims to ensure that the findings are robust to violations of classical OLS assumptions, and thereby enhance the credibility of the outcomes.

5. Data

When deciding which countries that are included and classified as an emerging market, classifications from Morgan Stanley Capital International (MSCI) are used. MSCI assesses countries and places them in four different indexed markets: Developed, Emerging, Frontier and Standalone Markets (MSCI, 2023). The assessment is based on five market accessibility criteria, namely openness to foreign ownership, ease of capital inflows and outflows, efficiency of the operational framework, availability of investment instruments and stability of the institutional framework. For the assessment of the five accessibility criteria, an additional 18 distinct measures, mainly based on investor experience, are used. This in turn yields 24 countries with three different ratings per category and country.

The study initially uses a sample of 1408 green bonds across 21 countries, issued between January 1, 2018 and March 25, 2024 (Table A1). This includes all countries listed as emerging markets by MSCI, except Saudi Arabia, Qatar and Kuwait due to absence of data. The sample is later narrowed down to 77 green bonds based on the issue amount and maturity restrictions, together with their compatibility for matching with comparable conventional bonds, all of which are used in regression equation (1) through (3), with varying number of observation points.

Regression equations (2) and (3), namely the bond yield differential and the effect of the green bond label, utilize data sets of 2632 and 5264 observations, respectively. The data comprises weekly closing ask yields collected over the course of a year, from April 28, 2023 to April 26, 2024. Here, it is important to note that some bonds included in the sample were issued post-April 2023. As a result, these bonds do not have a complete year of weekly data available. Consequently, the weeks prior to the issuance of these bonds have been excluded from the sample to maintain consistency and accuracy in the data set used for the regression analyses.

5.1. Data Collection

From the 24 countries listed by MSCI, further filtering is made to obtain data of better quality by only using green bonds from countries above the predetermined issue size. This is conducted by sorting total issuances for each emerging market during the period of observation, to reduce volatility and unrepresentative results. The data of all individual bonds is collected from Refinitiv Eikon. Moreover, several filtering options are used to find green and conventional bonds that are comparable, including issue amount, credit rating, maturity and issuing currency.

The green bonds obtained are verified by the third-party organization Climate Bonds Initiative (CBI). CBI provides verification on the bonds used in this paper through objective approaches. These include evaluation of the issuer's approach, management of proceeds, organization and disclosure on use of proceeds and credit ratings. Moreover, all bonds collected are either CBI-certified or CBI-aligned. The CBI-certified bonds are independently approved to ensure that the use of proceeds complies with the objective of capping global warming at two degrees Celsius. The CBI-aligned bonds have not thus far received certifications from CBI. However, they align with CBI's definition of a green bond and are thus included in the sample (Climate Bonds Initiative, 2022).

6. Empirical Results

6.1. Descriptive Statistics

The descriptive statistics below offer a comprehensive snapshot of the green bond market across various sectors and credit ratings. This data captures pivotal aspects of the bonds within the sample, including the average yield, average maturity, and the number of green bonds issued by entities with diverse credit ratings. Through the lens of these statistics, patterns and disparities in yields and maturities that may correlate with creditworthiness and geographic location can be detected. The summary tables below provide a foundation for deeper analysis and discussion on the sample of green bonds used in this study.

Table 1. Description of the sample of 77 green bonds used in section 6.2. The individual bond yields are calculated as daily average closing ask yields during April 2024. Average maturity shows months to maturity from April 2024. Full distribution of average bond yields and maturity by country can be seen in Table A2.

		Government	Financials	Technology	Other Sectors	Total
High Rating	Avg. Yield (%)	4.642	5.154	2.190		4.342
	Avg. Maturity (months)	37	30	58		39
	Nb. of Green Bonds	25	4	5		34
Mid Rating	Avg. Yield (%)	3.531	5.195		5.433	3.892
	Avg. Maturity (months)	37	83		34	43
	Nb. of Green Bonds	23	4		2	29
Low Rating	Avg. Yield (%)	4.940	4.496			4.908
	Avg. Maturity (months)	111	43			106
	Nb. of Green Bonds	13	1			14
Total	Avg. Yield (%)	4.287	5.099	2.190	5.433	4.276
	Avg. Maturity (months)	53	55	58	34	53
	Nb. of Green Bonds	61	9	5	2	77

The table above illustrates that while average yields across sectors and credit ratings generally align, the technology sector stands out with significantly lower yields. Notably, within the government sector, high-rated green bonds offer higher yields compared to their medium-rated counterparts, despite having the same average maturity in months. This indicates that factors beyond credit ratings influence green bond yields in various sectors.

Table 2. Descriptive statistics of the sample of bonds used in subsections 6.3 and 6.4. It illustrates the distribution of the ask yield and bid-ask spread across all 77 bond pairs.

	Min.	1st Quart.	Median	Mean	3rd Quart.	Max.
Number of weeks per bond	5	15	42	35	53	53
Ask yield of green bond (%)	1.369	4.072	5.060	4.624	5.512	8.372
Ask yield of synthetic bond (%)	1.370	4.090	5.116	4.672	5.583	8.256
Bid-ask spread of green bond (%)	0.002	0.095	0.209	0.244	0.344	1.099
Bid-ask spread of synthetic bond (%)	0.002	0.095	0.194	0.256	0.368	1.406

The descriptive statistics of the 77 bond pairs demonstrate a substantial variation in the number of weekly yield observations, which span from a minimum of 5 to a maximum of 53. The ask yields of both green and synthetic bonds display consistency across most statistical metrics, suggesting that the green label has only a limited impact on bond pricing. However, the bid-ask spreads show more significant variability, with synthetic bonds generally featuring higher average spreads, whereas green bonds present a greater median spread. This variability in bid-ask spreads necessitates further analysis in subsequent models to clarify its implications on bond pricing dynamics.

6.2. Green Bond Yields

This section presents a detailed quantitative analysis aimed at uncovering the determinants that significantly influence green bond yields. Using a cross-sectional regression model, this examination focuses on evaluating how months to maturity, bid-ask spread, and issue amount impact bond yields, together with credit rating, currency and sector. These variables have been selected based on their theoretical and empirical relevance, as highlighted in the literature, and their practical implications in the bond market dynamics. The model is designed to isolate the effects of these key financial metrics, enabling a clear understanding of their individual contributions to the yield variations observed in green bonds. This analytical approach assists in assessing the fundamental pricing mechanisms of green bonds while providing a foundation for comparing these green financial instruments with conventional bonds in similar market conditions.

Table 3. Results of Green Bond Yield regression. This table displays regression results for the yield on green bonds as influenced by bond attributes across four models: (a), (b), (c), and (d). Yield is a percentage average of the daily closing ask yields during April 2024, with credit ratings categorized as High, Medium, Low. Maturity reflects months to bond maturity, while the issue amount is logged in millions of USD. Sectors include Government, Financials and Technology. Currencies are evaluated against USD, including CNH, EUR, and TWD. Models are adjusted for robustness, with 77 observations each, providing adjusted R-squared values for variance explanation. Standard errors are displayed in parenthesis.

	Dependent variable: Green Bond Yield			
	Cross-sectional Regression with Robust Standard Errors			
	(a)	(b)	(c)	(d)
Maturity	-0.001*	-0.002*	-0.001*	-0.000
	(0.001)	(0.001)	(0.001)	(0.002)
log(Issue Amount) (mUSD)	-0.350***	-0.242**	-0.359***	-0.042
	(0.103)	(0.101)	(0.106)	(0.318)
Bid-Ask spread	0.619*	1.167***	0.627*	1.545
	(0.344)	(0.266)	(0.329)	(1.362)
High Rating	-0.496***		-0.502***	0.271
	(0.147)		(0.142)	(0.558)
Medium Rating	-0.057		-0.009	-1.102*
	(0.162)		(0.149)	(0.627)
Financial Sector	-0.141	-0.219***		-2.173***
	(0.239)	(0.200)		(0.415)
Government Sector	-0.181	-0.399***		-1.995***
	(0.211)	(0.137)		(0.410)
Technology Sector	-0.180	-0.729***		-5.100***
	(0.235)	(0.137)		(0.864)
Currency USD	0.070***	0.825***	0.701***	
	(0.137)	(0.109)	(0.137)	
Currency CNH	-2.724***	-2.338***	-2.761***	
	(0.192)	(0.107)	(0.178)	
Currency EUR	-0.952***	-0.783***	-0.958***	
	(0.218)	(0.216)	(0.196)	
Currency TWD	-3.165***	-2.961***	-3.171***	
	(0.168)	(0.130)	(0.156)	
Constant	7.235***	6.237***	7.113***	6.679***
	(0.751)	(0.647)	(0.737)	(2.492)
Observations	77	77	77	77
Adjusted R-squared	0.961	0.949	0.960	0.417

*Note: *p < 0.1 ; **p < 0.05 ; ***p < 0.01*

The regression outcomes presented in Table 3 provide pivotal insights into the factors influencing green bond yields in emerging markets. The outcomes reveal a consistent negative relationship between the months to maturity and green bond yields across all models, although with varying degrees of statistical significance. Except in model (d), the longer maturities generally correlate with lower yields. Similarly, the logarithm of the issue amount also negatively correlates with bond yields, exhibiting stronger statistical significance. The inconsistency in the variables' significance across the models could be attributable to the differences in the adjusted R-squared values across the models. Models (a) through (c) exhibit very high adjusted R-squared values, ranging from 0.95 to 0.96, indicating a robust explanatory power in these models, whereas model (d), which excludes currency controls, has a significantly lower R-squared of 0.42. This highlights the crucial role of issuing currencies in the pricing of green bonds, with each included currency showing significant effects on bond yields, especially notable in bonds issued in CNH or TWD.

On the other hand, the bid-ask spread presents a nuanced influence on yield variations. In all models, a wider spread correlates with higher yields, reflecting the liquidity premium that investors demand for less liquid bonds. Similar to months to maturity and logarithmic issue amount, bid-ask spread shows no significance in model (d). Also, model (a) and (c) exhibit substantial similarities in both coefficient size and statistical significance, highlighting the importance of currencies and credit ratings as control variables.

Furthermore, the sector in which the bond is issued, and its credit rating shows varying influence. Although serving as important control variables in the analysis, different sectors and credit ratings show divergent sizable and statistically significant impact on green bond yields. Bonds rated as high credit shows to be generally associated with lower yields, with remarkably high significance in model (a) and (c), compared to medium-rated bonds. However, the sector variables exhibit no statistical significance in these models, suggesting that the sector of issuance may not play a decisive role in determining the yields of green bonds in these models.

6.3. Bond Yield Differential

This section explores the yield differentials between green bonds and their conventional counterpart. First, the study employs a t-test to analyze the statistical significance of the yield difference, allowing an objective assessment of whether green bonds systematically offer different yields compared to conventional bonds. Subsequently, using the same series of regression models as in subsection 6.2, this analysis quantifies the greenium and how it is influenced by the yield determining variables. Each regression model, labeled (a) through (d), progressively excludes specific control variables, allowing a nuanced understanding of how these factors independently and collectively influence the yield discrepancy.

Table 4. Results of the t-tests.

Description	Paired t-test
Mean Difference	-0.048
Std. Error of Difference	0.005
t-Statistic	-9.232
Df	2631
p-Value	0.000
95% CI	[-0.058, -0.038]

The results from the t-test indicate a statistically significant mean difference in yields, favoring green bonds with an average yield that is 4.8bps lower than the conventional bonds. Moreover, the t-statistic of approximately -9.2 strongly rejects the null hypothesis, suggesting that green bonds frequently exhibit lower yields across the sample. The extremely low p-value further confirms the statistical significance of this difference, with 95% confidence interval ranging from -5.8 to -3.8bps. Consequently, the results confirm the presence of a negative yield differential, and more specifically a greenium associated with green investments in these markets.

Table 5. Results of Bond Yield Differential regression. This table displays regression results for the yield differential as influenced by bond attributes across four models: (a), (b), (c), and (d). The yield differential is captured as weekly closing ask yields between April 28, 2023 and April 26, 2024, with controls for credit rating, sector and currency. Bid-ask spread is captured simultaneously as the weekly ask yield, maturity reflects months to bond maturity, while the issue amount is logged in millions of USD. Models are adjusted for robustness, with 2632 observations across all 77 bond pairs, providing adjusted R-squared values for variance explanation. Standard errors are displayed in parenthesis.

	Dependent variable: Bond Yield Differential			
	OLS Regression with Robust Standard Errors			
	(a)	(b)	(c)	(d)
Maturity	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
log(Issue Amount) (mUSD)	-0.048***	-0.040***	-0.065***	-0.063***
	(0.011)	(0.010)	(0.009)	(0.010)
ΔBid-Ask spread	-0.053	0.125**	-0.047	-0.094
	(0.063)	(0.063)	(0.065)	(0.066)
Rating control	Yes		Yes	Yes
Sector control	Yes	Yes		Yes
Currency control	Yes	Yes	Yes	
Constant	0.678***	0.491***	0.495***	0.671***
	(0.100)	(0.088)	(0.065)	(0.100)
Observations	2632	2632	2632	2632
Adjusted R-squared	0.205	0.083	0.158	0.068

*Note: *p < 0.1 ; **p < 0.05 ; ***p < 0.01*

The regression results from the models displayed in the analysis of bond yield differentials elucidate significant patterns and insights. Predominantly, the analysis shows that months to maturity has a consistently negligible impact on the yield differential across all models, suggesting that the time until maturity does not significantly differentiate the yields between green and conventional bonds in emerging markets.

Similarly, the bid-ask spread shows no significant impact on the yield differential, except for one specific model configuration. When credit rating controls are excluded (b), the bid-ask spread is found to contribute an average increase of 12.5bps to the yield differential, hinting at a potential liquidity premium for green bonds in this model setup. However, the low adjusted

R-squared of 0.08 in this model indicates limited explanatory power, suggesting that other unaccounted factors might play a significant role in explaining the yield differences.

Furthermore, the logarithm of the issue amount consistently shows a significant negative effect on yield differentials, with coefficients ranging from -4.0bps (b) to -6.5bps (c) for every percentage increase in mUSD issue amount. This pattern underscores the influence of bond size on yield differentials, indicating that larger issue sizes are associated with narrower yield gaps between green and conventional bonds, holding other factors constant.

The adjusted R-squared values for the models presented provide insight into the overall explanatory power of the variables in predicting the yield differentials between green and conventional bonds. While these values fluctuate across different model specifications, they consistently remain low, underscoring a modest explanatory capacity overall. Notably, the model incorporating the full spectrum of control variables (a) yields the highest adjusted R-squared of 0.21, suggesting that it captures a more comprehensive range of influences on yield differentials. Despite this relative improvement, the generally low values across all models highlight the complexity of bond yield dynamics and suggest that additional factors, potentially unaccounted for in the current framework, significantly influence these differentials.

While the adjusted R-squared values provide a quantitative measure of the models' capacity to explain yield differentials, a detailed examination of the distribution of these differentials across the entire sample offers further empirical insights. This broader statistical perspective helps illuminate the actual extent of yield differences between green and conventional bonds, evaluating both typical and extreme cases within the dataset. Table 6 summarizes this distribution, which ultimately helps answer the magnitude of the greenium that is being studied.

Table 6. Distribution of yield differentials and bid-ask spreads across the full sample of bonds, with 2632 observations consisting of weekly closing ask yields and bid-ask spreads between April 28, 2023 and April 26, 2024.

	Min.	1st Quart.	Median	Mean	3rd Quart.	Max
Yield differential (%)	-2.261	-0.107	-0.039	-0.048	0.012	2.314
Bid-ask spread differential (%)	-0.740	-0.007	-0.000	-0.012	0.007	0.007

As evident from the table, the yield differential between green and corresponding conventional bonds exhibits, on average, a reduction of 4.8bps. This negative average yield differential, or greenium, suggests that investors are willing to accept lower yields for bonds labeled as environmentally friendly. However, the distribution of yield differentials further reveals that while the mean greenium is -4.8bps, the range is notably broad. This indicates a substantial volatility in how individual bonds are valued relative to their conventional counterpart, which is also evident in the distinct yield discrepancies between countries as displayed in Table A2.

Similarly, the bid-ask spread differential shows a modest mean of -0.012%, with a range from -0.740% to 0.007%. This underscores the liquidity conditions of green bonds relative to conventional peers in emerging markets, with generally narrower spreads for green bonds. However, as shown in Table 5, bid-ask spread differential exhibits a weak statistical significance. This indicates that while there is a general trend towards slightly better liquidity for green bonds, the trend may not be robust enough to be considered a decisive factor in the pricing or trading dynamics of these bonds.

6.4. Green Bond Label Effect

Table 7 displays the distinctive impact of the green label on bond yields in emerging markets, the central inquiry of this thesis. It represents a fundamental component that seeks to unveil the financial consequences of environmental labeling within these bond markets. Employing detailed regression models that account for the same economic and financial variables as in subsections 6.2 and 6.3, together with a dummy variable for the green bond label, this segment investigates the effect of labeling a bond green on its yield compared to corresponding conventional bonds. The regression results are crucial for determining whether the market attributes a significant premium to bonds based on their environmental characteristics.

Table 7. Results of Bond Yield regression with Green Bond Label Effect. This table displays regression results for the yield as influenced by bond attributes across four models: (a), (b), (c), and (d), with a green dummy variable as the main variable of interest. The yield is captured as weekly closing ask yields between April 28, 2023 and April 26, 2024, with controls for credit rating, sector and currency. Bid-ask spread is captured simultaneously as the weekly ask yield, maturity reflects months to bond maturity, while the issue amount is logged in millions of USD. Models are adjusted for robustness, with 5264 observations accounting for all green bond observations together with the corresponding conventional synthetic bonds, providing adjusted R-squared values for variance explanation. For complete regression output, see Table A4. Standard errors are displayed in parenthesis.

	Dependent variable: Bonds' Yield			
	OLS Regression with Robust Standard Errors			
	(a)	(b)	(c)	(d)
Green dummy	-0.047***	-0.038***	-0.047***	-0.048
	(0.013)	(0.014)	(0.013)	(0.030)
Maturity	-0.002***	-0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
log(Issue Amount) (mUSD)	-0.492***	-0.264***	-0.491***	-0.096***
	(0.021)	(0.020)	(0.017)	(0.036)
Bid-Ask	0.622***	1.383***	0.619***	0.526***
	(0.098)	(0.084)	(0.100)	(0.098)
Rating control	Yes		Yes	Yes
Sector control	Yes	Yes		Yes
Currency control	Yes	Yes	Yes	
Constant	8.647***	6.716***	8.427***	6.955***
	(0.153)	(0.133)	(0.124)	(0.244)
Observations	5264	5264	5264	5264
Adjusted R-squared	0.894	0.873	0.893	0.421
*Note: *p < 0.1 ; **p < 0.05 ; ***p < 0.01*				

The findings from the regression results indicate that the green label on bonds consistently induce a negative effect on the yield, holding all other variables constant, as evidenced by the negative coefficients associated with the green dummy variable across model (a) through (d). This effect is highly significant in all models except in model (d), which also has the lowest adjusted R-squared of 0.42. Model (a) through (c) shows notably high adjusted R-squared values, ranging from 0.87 in model (b) to 0.89 in model (a) and (c), suggesting that the inclusion of all control variables improves the results. Also, the size of the green label effect varies slightly across different model specifications, reflecting the sensitivity of the green bond premium to the inclusion and exclusion of various control variables.

Moreover, the regression results demonstrate a consistently negative relationship between the logarithm of issue amount and bond yields across all models, similar to the yield differential regression as displayed in Table 5. However, the effect varies explicitly with a range from -9.6bps in model (d) to -49.2bps in model (a) for every percentage increase in mUSD issue amount, holding other variables constant.

Conversely to the yield differential regression, bid-ask spread and months to maturity shows a continuously significant relationship across all models. The coefficients for months to maturity are consistently negative, and highly persistent in magnitude in all models except (d). Moreover, the coefficient for bid-ask spread, although displaying more variation in magnitude, exhibits a positive effect in all models. This indicates that higher bid-ask spreads, and thus less liquid bonds, correlate with higher average yields.

7. Discussion

7.1. Results

The negative and statistically significant bond yield differential in emerging markets aligns with previous studies conducted in mature markets, except for Karpf and Mandel (2018). This is evidence that investors, even in less developed markets, are willing to give up yield otherwise found in conventional bonds with identical risk and structure to fund sustainable projects. The similar result could partly be explained by financial markets becoming more and more intertwined by globalization and technology developments, patterns thus becoming similar across different markets. Especially since investments into emerging markets have been common by various financial institutions for a long time.

Earlier empirical findings that investigate green premiums have been restricted to mainly USD and EUR-denominated bonds, as they are the largest issuing currencies. For Zerbib (2019) and Hachenberg and Schiereck (2018), currency is not a driving factor in the yield differential, though Zerbib (2019) suspects that the currency may have an impact in less developed markets. As the currency is shown to be a significant factor in determining the yield difference in this study, it largely serves as a proxy for the country that is issuing the bond. There are clear patterns that green bonds issued in CNH and TWD exhibit lower yields as shown in Table 3, supported by the notably high adjusted R-squared. Looking at the bond yield differential regression (Table A3), the positive coefficient for the CNH variable says that bonds issued in CNH, and in turn issued in China, carry a more negative greenium. Conversely for TWD, the negative coefficient shows that the premium is smaller, holding other variables constant.

There could be several non-pecuniary motives as to why green bonds are preferred. Hartzmark and Sussman (2018) theorizes about the non-pecuniary motives and concludes that altruism could be a driving factor, investors derive value in the bonds from the fact that others benefit from the funds raised. Another motive could be social pressures, either by trying to impress others or avoid social backlash if green assets were not owned. Similar psychological pressures are also showcased by Bauer and Smeets (2015) which could lead to more inflows into green bonds instead of conventional counterparts, which in turn drives yields down. These reasons would also render the CAPM or similar asset pricing models false, as Cohen (2009), Daniel and Titman (1997) theorize about. Loyalty to these assets due to a desire to belong, a general preference or convenience could also be a factor as to why the greenium exists. A second term that reflects the environmental attributes is needed to properly account for the extra demand that is derived from this, in line with Baker et al. (2018). However, the three-factor model developed by Fama and French (1993) based on Ross' (1976) APT model is still highly relevant as maturity and credit rating is partly explanatory for the green bond yields. Consequently, the yield difference, albeit small, could be utilized by arbitrageurs as suggested by Hong and Kacperczyk (2009) where the fundamentals cannot explain why there should be a difference in yield.

Karpf and Mandel (2018) and Baker et al. 's (2018) discussions on the supply and demand of green bonds leading to a premium could still be relevant, even after several years of massive increases in issuances. China, the largest issuer, issued USD 84 billions of CBI certified and aligned green bonds in 2023 (CBI, 2023). In the same year they issued USD 10 trillion in conventional bonds (The People's Republic of China, 2024), showing the massive discrepancy in amounts issued. As green bonds have become a popular investment for diversification and sustainability purposes, the demand has been increasing which in turn drives the prices up and yields down, inducing a negative greenium relative to conventional counterparts. Following this, the bid-ask spreads further support the higher demand for green bonds as they are traded with tighter spreads than their synthetic peers, which Hachenberg and Schiereck (2018) also shows. Further evidence is shown in Table 3 where wider spreads correlate with higher yields, supported by Longstaff (2004). When the demand by investors is met, the yield spread between green and conventional counterparts should in theory shrink. Baker et al. (2018) concludes that a subset of investors sacrifices a small amount of yield to hold green bonds in the US municipal bond market, a similar conclusion can be drawn from this thesis' emerging market sample where bonds issued in the government sector incur the largest increase in the greenium (Table A3).

There are concerns that emerging markets would struggle to find cheaper financing due to lower credit ratings and smaller projects. The findings of this study show that medium ratings exhibit a significant negative impact on the bond yield differential (Table A3), supported by Karpf and Mandel (2018) who discusses this theory regarding credit ratings and their impact on the premium. The authors claim that in the US municipal markets, as credit rating rose throughout their period of writing, the premium moved toward zero. Although the premium exists, a solution to find a larger premium for lower credit ratings could be to pool several green bonds into tranches of bonds through multilateral development banks, such as the World Bank, to increase their security and provide financial and fiduciary guarantees. However, a problem that could arise if too many bonds are pooled is balance sheet swelling. Also, implementing such measures might compromise the transparency in documenting the use of proceeds, as a principal-agent problem could arise, where misalignments between issuer intentions and investor expectations become more prevalent.

The findings from this study, showing an average greenium of -4.8bps, should not discourage investors to buy these products, in line with Zerbib's (2019) paper. This conclusion is also supported by Becker and Ivashina (2015) studying insurance companies holdings in corporate bonds. The authors show that a 100bps differential led to a reallocation between 3.6% and 7.4% of holdings. Thus, a 4.8bps differential should not be substantial enough for reallocation purely due to the yield difference.

The premium itself should encourage companies and countries to issue more green bonds, and the results are in line with Oikonomou's et al. (2014) theories that pressures such as the greenium, could have a large impact on a company's sustainability projects. The cheaper source of funding promotes the sustainable growth that is necessary to reach the various climate goals.

7.2. Limitations

Although being comprehensive in its approach to analyze green bond yields and the effect of the green bond label in emerging markets, this thesis acknowledges certain limitations that may influence the results and interpretations of the findings. One of the principal limitations of this study concerns the size of the dataset. Zerbib (2019) observes daily bond yields from July 2013 to December 2017, ultimately resulting in 33,127 observations in the yield differential analysis with a mean of 341 daily observations per bond. Karpf and Mandel (2018) also have a more comprehensive dataset including 1,880 US municipal bonds. Conversely, this study is limited to 77 green bonds and a maximum of 5264 observations, potentially affecting the reliability of the predictions and recommendations.

Additionally, given the complexity of green bond markets and emerging markets, there is potential for heterogeneity which may result in the findings not being universally applicable across all geographic locations or market conditions. Green bond markets are subject to regulatory differences, as well as disparity in environmental standards that are being followed. Kearney's (2012) description of emerging markets as countries with attributes of developed market but not fully matured suggests a variability in financial systems and market dynamics. These factors can influence the perception and performance of green bonds, potentially exposing the results to unfavorable effects if green bonds significantly vary between countries with robust regulatory frameworks promoting sustainable investments and countries with less developed institutional support and higher economic volatility.

8. Conclusion

This thesis provides empirical evidence on the effect of green bond labels on bond yields within emerging markets, analyzing bonds issued between January 2018 and March 2024. Employing cross-sectional and OLS regressions, together with a matching method to create synthetic conventional bonds, the study analyzes 77 bond pairs to identify the drivers behind the bond yield differentials and the influence of the green label. The cross-sectional regression shows several significant variables impacting the yield of green bonds in emerging markets. The liquidity proxy and issue amount both exhibits negative values, indicating that wider spreads and lower issue amounts correlates with higher yields, displaying the effect liquidity has on yields.

This paper evidences a low, but significant, green premium in the final OLS regression, showing that investors are willing to give up basis points of yield to invest in a bond with environmental attributes. Notably large differentials are shown in the Chinese market, while bonds issued in TWD exhibits smaller differentials. The greenium itself is theorized to stem from various sources. These could be diversification opportunities leading to a high demand relative to the lower supply compared to conventional bonds, psychological factors such as altruism, or social pressures. The premium, however, is low enough that investors should not be discouraged to own and further support these assets.

The negative greenium can be used by corporations and countries to obtain cheaper funding while growing their economy in a sustainable way. However, lower credit ratings exhibit a smaller premium than higher ones, which could be especially troublesome for emerging market economies as credit scores are generally lower than for mature markets. To address these issues, strategies could be implemented, such as bonds in tranches backed by multilateral development banks to increase the premium through higher credit ratings. Although, this might compromise the transparency in documenting the use of proceeds. To further elaborate this, one could investigate non-certified bonds to find conclusions regarding investor ethics and potential greenwashing being reflected by higher yields. Also, exploring how different shades of green investments are impacted by their respective labels could provide another perspective on the potential issues of greenwashing in emerging markets.

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Appendix

Table A1. Distribution of the initial sample containing 1408 green bonds across 21 countries.

Country	Number of issues	Total issuances per country (USD)
China	513	140 669 642 184
South Korea	220	51 178 509 809
Chile	20	11 374 773 605
Indonesia	15	10 949 980 729
India	47	10 847 683 940
UAE	24	8 575 922 969
Brazil	105	8 535 197 678
Taiwan	80	7 542 136 404
Hungary	25	7 507 949 682
Poland	15	6 759 945 606
Philippines	21	4 617 088 460
Turkey	11	3 517 770 672
Mexico	14	3 103 985 171
Thailand	44	2 783 108 663
Czech	5	2 539 170 000
Greece	5	2 031 340 000
Egypt	2	1 500 000 000
Malaysia	224	1 282 851 105
South Africa	14	1 008 089 831
Columbia	3	100 999 925
Peru	1	27 146 619

Table A2. Description of the sample of 77 green bonds with average yield of the individual bond calculated over the daily closing ask yields during April 2024.

		Chile	China	Czech Republic	Greece	Hungary	India	Indonesia	Philippines	Poland	South Korea	Taiwan	UAE
Government													
High Rating	Avg. Yield (%)		2.53						3.98	3.84	5.22		
	Avg. maturity (months)		83						43	15	29		
	Nb. of Green Bonds		3						4	1	17		
Mid Rating	Avg. Yield (%)	3.93	2.05							3.01	5.16		5.74
	Avg. maturity (months)	190	15							44	52		35
	Nb. of Green Bonds	1	11							2	5		4
Low Rating	Avg. Yield (%)		4.36			3.95	5.50	5.19					
	Avg. maturity (months)		17			49	79	180					
	Nb. of Green Bonds		2			2	3	6					
Financials													
High Rating	Avg. Yield (%)			3.53							5.69		
	Avg. maturity (months)			51							23		
	Nb. of Green Bonds			1							3		
Mid Rating	Avg. Yield (%)	5.93		4.46									
	Avg. maturity (months)	115		51									
	Nb. of Green Bonds	2		2									
Low Rating	Avg. Yield (%)				4.49								
	Avg. maturity (months)				43								
	Nb. of Green Bonds				1								
Technology													
High Rating	Avg. Yield (%)										4.93	1.50	
	Avg. maturity (months)										94	49	
	Nb. of Green Bonds										1	4	
Mid Rating	Avg. Yield (%)												
	Avg. maturity (months)												
	Nb. of Green Bonds												
Low Rating	Avg. Yield (%)												
	Avg. maturity (months)												
	Nb. of Green Bonds												
Other sectors													
	Avg. Yield (%)										5.43		
	Avg. maturity (months)										34		
	Nb. of Green Bonds										2		

Table A3. Results of Bond Yield Differential regression. This table displays regression results for the yield differential as influenced by bond attributes across four models: (a), (b), (c), and (d). The yield differential is captured as weekly closing ask yields between April 28, 2023 and April 26, 2024. Bid-ask spread is captured simultaneously as the weekly ask yield, maturity reflects months to bond maturity, with issue amount logged in millions of USD. Sectors include Government, Financials and Technology. Currencies include USD, CNH, EUR, and TWD. Models are adjusted for robustness, with 2632 observations each across all 77 bond pairs, providing adjusted R-squared values for variance explanation. Standard errors are displayed in parenthesis.

	Dependent variable: Bond Yield Differential			
	OLS Regression with Robust Standard Errors			
	(a)	(b)	(c)	(d)
Maturity	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
log(Issue Amount) (mUSD)	-0.0477***	-0.0402***	-0.0648***	-0.0625***
	(0.0108)	(0.0101)	(0.0088)	(0.0101)
Bid-Ask	-0.0532	0.1251**	-0.0465	-0.0938
	(0.0634)	(0.0634)	(0.0649)	(0.0656)
High Rating	-0.0829***		-0.1079***	-0.1139***
	(0.0154)		(0.0166)	(0.0149)
Medium Rating	-0.3207***		-0.3086***	-0.1728***
	(0.0243)		(0.0243)	(0.0205)
Financial Sector	-0.2358***	-0.2591***		-0.1716*
	(0.0673)	(0.0702)		(0.0685)
Government Sector	-0.3159***	-0.2735***		-0.2174**
	(0.0693)	(0.0699)		(0.0687)
Technology Sector	-0.2115***	-0.1738**		-0.1372*
	(0.0714)	(0.0711)		(0.0692)
Currency USD	-0.0572***	-0.0932***	-0.0477***	
	(0.0096)	(0.0116)	(0.0103)	
Currency CNH	0.3280***	0.0843***	0.2865***	
	(0.0278)	(0.0173)	(0.0259)	
Currency EUR	0.0706***	0.0163	0.0969***	
	(0.0163)	(0.0143)	(0.0174)	
Currency TWD	-0.0725***	-0.1246***	0.0227	
	(0.0260)	(0.0283)	(0.0210)	
Constant	0.6784***	0.4908***	0.4953***	0.6712***
	(0.0995)	(0.0883)	(0.0653)	(0.0996)
Observations	2631	2631	2631	2631
Adjusted R-squared	0.2050	0.0829	0.1577	0.0676

*Note: *p < 0.1 ; **p < 0.05 ; ***p < 0.01*

Table A4. Results of Bond Yield regression with Green Bond Label Effect. This table displays regression results for the yield as influenced by bond attributes across four models: (a), (b), (c), and (d), with a green dummy variable as the main variable of interest. The yield is captured as weekly closing ask yields between April 28, 2023 and April 26, 2024, with controls for credit rating, sector and currency. Bid-ask spread is captured simultaneously as the weekly ask yield, maturity reflects months to bond maturity, while the issue amount is logged in millions of USD. Models are adjusted for robustness, with 5264 observations accounting for all green bond observations together with the corresponding conventional synthetic bonds, providing adjusted R-squared values for variance explanation. Standard errors are displayed in parenthesis.

	Dependent variable: Bonds' Yield			
	OLS Regression with Robust Standard Errors			
	(a)	(b)	(c)	(d)
Green Dummy	-0.0468***	-0.0383*	-0.0469***	-0.0479
	(0.1289)	(0.0141)	(0.0129)	(0.0299)
Maturity	-0.0021***	-0.0024***	-0.0021***	-0.0001***
	(0.0021)	(0.0002)	(0.0002)	(0.0002)
log(Issue Amount) (mUSD)	-0.4925***	-0.2644***	-0.4908***	-0.0955*
	(0.0212)	(0.0197)	(0.0173)	(0.0355)
Bid-Ask	0.6223***	1.3833***	0.6194***	0.5255***
	(0.0982)	(0.0839)	(0.0995)	(0.0982)
High Rating	-0.6952***		-0.7039***	-0.3385***
	(0.0268)		(0.0237)	(0.0477)
Medium Rating	-0.2877***		-0.2786***	-1.4551***
	(0.0289)		(0.0285)	(0.0539)
Financial Sector	-0.1837***	-0.2580***		-0.6920***
	(0.0386)	(0.0421)		(0.0609)
Government Sector	-0.2178***	-0.4767***		-1.0711***
	(0.0331)	(0.0318)		(0.0441)
Technology Sector	-0.0714	-0.7563***		-3.8265***
	(0.0507)	(0.0438)		(0.1013)
Currency USD	0.5181***	0.6717***	0.5295***	
	(0.0316)	(0.0286)	(0.0315)	
Currency CNH	-2.7319***	-2.3006***	-2.7494***	
	(0.0429)	(0.0298)	(0.0406)	
Currency EUR	-0.8086***	-0.7616***	-0.7994***	
	(0.0396)	(0.0389)	(0.0363)	
Currency TWD	-3.6519***	-3.3732***	-3.5042***	
	(0.05393)	(0.0511)	(0.0418)	
Constant	8.6466***	6.7161***	8.4265***	6.9549***
	(0.1531)	(0.1326)	(0.1243)	(0.2437)
Observations	5264	5264	5264	5264
Adjusted R-squared	0.8939	0.8733	0.8929	0.4209

*Note: *p < 0.1 ; **p < 0.05 ; ***p < 0.01*