Pricing of green bonds: Exploring green premium in the primary bond market

Tony Karhinen

Department of Finance and Economics

Hanken School of Economics

Helsinki

2025

HANKEN SCHOOL OF ECONOMICS

Department of: Finance and Economics	**Type of work**: Master's Thesis
Author: Tony Karhinen	**Date**: 27.6.2025
Title of thesis: Pricing of green bonds: Exploring green premium in the primary bond market	

Abstract:

The transition to a climate-neutral economy requires significant investment in sustainable projects, and green bonds are key instruments for facilitating this shift. Although green bonds are mainly distinguished from conventional bonds by the earmarking of proceeds for environmentally beneficial projects, there remains mixed consensus regarding a potential pricing difference in bond markets, particularly in the primary market.

This thesis contributes to the existing literature by analyzing the existence of a green premium or "greenium" in the euro-denominated corporate bond market. It further examines whether regulation, standard alignment and external verification influence the pricing outcomes. In addition, the thesis analyses whether pricing differs between green bonds issued by banks versus non-bank corporates.

A fixed effects regression analysis is conducted on a dataset of 20866 euro-denominated bonds issued between 1.1.2018 and 25.3.2025. The results from the regressions do not show consistent or robust evidence of greenium, meaning no systematic pricing difference between green and conventional bonds in the primary bond market, particularly when accounting for issuer-, bond-, and time-specific heterogeneity. The analysis shows no robust evidence that regulation, standard alignment, or third-party verification significantly affect pricing. Nor was any consistent greenium difference found between green bonds issued by banks and those issued by non-bank corporates.

This study contributes to green bond pricing literature by providing an updated primary market-specific analysis of the euro-denominated corporate bond segment. It captures a larger and more recent dataset while also offering unique insights into the impact of regulation, transparency efforts, and the differences between bank and non-bank issuers. Further research could explore demand-side factors such as investor preferences and fund flows, as well as more deeply assess the impact of evolving regulations such as EU Taxonomy and the European Green Bond Standard on pricing dynamics.

Keywords: Green Bond, Fixed Effects Regression, Primary market Greenium, Euro-denominated, Corporate Sector

SVENSKA HANDELSHÖGSKOLAN

<table>
<tr><td>Institution:
Institutionen för finansiell ekonomi och nationalekonomi</td><td>Arbetets art:
Magisteravhandling</td></tr>
<tr><td>Författare:

Tony Karhinen</td><td>Datum:
27.6.2025</td></tr>
<tr><td colspan="2">Avhandlingens rubrik:

Prissättning av gröna obligationer: En studie om förekomsten av grön premie på primärmarknaden</td></tr>
<tr><td colspan="2">Sammandrag:

Övergången till en klimatneutral ekonomi kräver enorma investeringar i hållbara projekt. Gröna obligationer har blivit ett centralt finansieringsinstrument för att stödja denna omställning. Även om gröna obligationer skiljer sig från konventionella obligationer genom att emissionslikviden öronmärks specifikt för miljörelaterade ändamål, råder det delade uppfattningar om det förekommer en prisskillnad mellan gröna och konventionella obligationer, särskilt på primärmarknaden.

Denna avhandling syftar att bidra till den befintliga forskningen genom att undersöka förekomsten av grön premie, eller ”greenium”, på den eurodenominerade marknaden för företagsobligationer. Avhandlingen analyserar även om reglering, standardanpassning och extern verifiering påverkar prissättningen, samt om prisskillnader mellan gröna obligationer emitterade av banker respektive icke-bankföretag.

Analysen baserar sig på en fast effekt-regressionsmodell och omfattar 20 866 eurodenominerade företagsobligationer emitterade mellan 1.1.2018 och 25.3.2025. Resultaten av analysen visar inga entydiga eller statistiskt robusta belägg för förekomst av greenium, det vill säga ingen systematisk prisskillnad upptäcks mellan gröna och konventionella obligationer, särskilt när det kontrolleras för obligations-, emittent-, och tidsspecifika skillnader. Analysen finner även inga robusta belägg för att reglering, standardanpassning eller extern verifikation har någon signifikant påverkan på prissättningen. Dessutom identifieras ingen skillnad i greenium mellan bank och icke-bankföretags gröna obligationer.

Studien bidrar till den existerande litteraturen om gröna obligationers prissättning genom en uppdaterad och primärmarknadsspecifik analys av eurodenominerade företagsobligationer. Framtida forskning skulle kunna undersöka efterfrågedrivna faktorer, såsom investerares preferenser och kapitalflöden, samt analysera hur utvecklingen av regelverk såsom EU:s taxonomi och den europeiska standarden för gröna obligationer påverkar prissättningen på primärmarknaden.</td></tr>
<tr><td colspan="2">Nyckelord: Gröna obligationer, greenium, fast effekt-regression, primärmarknad, eurodenominerade företagsobligationer</td></tr>
</table>

CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

The transition towards a climate-neutral economy is one of the biggest challenges facing society today, requiring substantial investments to support the transition. Green bonds are effective financial instruments to fund green projects that facilitate the transition. According to the World Bank (2015) a green bond is defined as "a debt security that is issued to raise capital specifically to support climate-related or environmental projects." The key difference between green and conventional bonds lies in the use of proceeds, as green bonds are earmarked specifically for finance or re-finance environmentally beneficial projects.

Rapid growth has characterized the green bond market in recent years, despite its relatively young status compared to the broader bond market. Green bond issuance began with the European Investment Bank in 2007, but it was not until around 2014 that annual issuance volumes experienced a marked increase (Climate Bonds Initiative, 2019). In 2019, the global issuance volume totaled USD 265 billion, increasing to USD 570 billion in 2021, and reaching USD 575 billion in 2023 (S&P Global, 2024). Europe remained the dominant region, accounting for 54% of global issuance in 2023 (S&P Global, 2024). This growth has been strongly supported by global policy initiatives such as the Paris Agreement, which united nearly 200 countries in legally binding climate commitments (Bachelet, Becchetti, & Manfredonia, 2019), and the UN Sustainable Development Goals (SDGs), which promote sustainable economic growth (United Nations, 2015). Achieving these goals will require financial resources estimated at USD 5–7 trillion annually by 2030 (UNCTAD, 2014), underscoring the critical role of green bonds in financing climate and sustainability initiatives (Alamgir & Cheng, 2023).

During the expansion of the green bond market, researchers and market participants began investigating the presence of potential green premium or "greenium", defined as a yield discount on green bonds compared to equivalent conventional bonds. Such a discount suggests that green bond issuers may benefit from lower borrowing costs, and simultaneously investors would be ready to forgo yield for financing environmentally beneficial projects. However, the existing literature presents mixed evidence regarding the presence of a greenium. Studies such as Zerbib (2019) and Caramichael and Rapp (2024) present evidence of a negative greenium. Partridge and Medda (2019) report similar outcomes in the secondary bond market but do not find strong evidence of a greenium in the primary market. Similarly, Larcker and Watts (2019) find no notable differences in the pricing of green versus non-green bonds.

This thesis aims to contribute to the ongoing debate regarding the existence of a greenium by analyzing potential pricing differences between green and conventional bonds in the euro-denominated corporate primary bond market, using a panel fixed effects regression model. In addition, the analysis examines whether factors such as regulation, standard alignment, and external verification influence the pricing of green bonds. Furthermore, it explores whether the pricing of green bonds issued by banks differs from those issued by other corporate entities.

1.1 Purpose of the study

This thesis aims to examine the existence of a green premium ("greenium") in the corporate primary market for euro-denominated bonds. It explores the impact of regulation, standard alignment, and verification on the presence of a greenium. Additionally, the study investigates whether the existence of a greenium differs depending on whether the issuer is a bank or a non-bank corporation.

1.2 Research questions

The purpose of this study is to answer the following research questions:

Is there a greenium in the corporate euro-denominated primary bond market?

Does regulation have an impact on greenium in the corporate euro-denominated primary bond market?

Does standard alignment and external verification influence the existence of greenium in the corporate euro-denominated primary bond market?

Is there a difference in greenium between green bonds issued by banks and non-bank corporates in the euro-denominated primary bond market?

1.3 Contribution

This thesis contributes to the debate on the existence of greenium in bond markets. While some studies find evidence of negative greenium, others argue that no such premium exists. This study contributes specifically to the discussion on the pricing in the primary market. Unlike many other studies that focus on greenium across different geographical regions or currencies, this study focuses exclusively on the euro-denominated market. Furthermore, the limited availability of green bond data has been a key constraint in previous literature. However, as the green bond market has expanded in recent years, this analysis benefits from a larger and more comprehensive dataset.

1.4 Scope

The empirical analysis focuses on corporate bonds issued in euro between the period 1.1.2018 – 25.3.2025. The geographical scope is not limited to European issuers only.

1.5 Use of Artificial Intelligence

In this thesis artificial intelligence (ChatGPT, n.d.) has been used for identifying grammar errors, organizing the reference list and debugging and providing insights on R-studio codes used in the empirical analysis. No AI-generated text has been directly used in this study.

1.6 Structure

The second chapter will discuss the fundamentals of bonds, including bond markets, valuation, and pricing. It will then delve into green bonds and the green bond market in detail. Finally, the chapter will examine the concept of information asymmetry in credit markets and its relevance to green bonds.

The third chapter presents and discusses previous research findings from existing literature about green bond pricing. The fourth chapter explains the data collection process and the relevant variables for the empirical part of the study.

Chapter five focuses on the methodology of the thesis itself, presenting statistical hypotheses, statistical models, and their interpretation. The chapter ends with model diagnostics to identify potential issues in the models and actions taken to ensure robustness.

The results of the empirical analysis are presented in chapter six, accompanied by tables and a discussion of the findings. Lastly, chapter seven summarizes the empirical findings, concludes the results, and gives the author's suggestions on future research within the topic.

2 THEORETICAL FRAMEWORK

2.1 Bonds

Bonds are financial securities that are issued by governments, municipalities or corporations to raise capital for various projects. Bonds function as debt securities where the issuer agrees to repay the principal amount, or face value, at a predetermined maturity, and make periodic interest payments known as coupons to bondholders, until the maturity date of the bond. The interest payments compensate investors for the time value of money and credit risk associated with their investment.

The specific terms of a bond, including principal amount, coupon rate, maturity date and payment schedule are outlined in a bond certificate, which are crucial to issuers and investors. Bonds can have many structural differences, particularly in terms of coupon type. Fixed-rate bonds pay a constant interest rate until maturity, while floating-rate bonds have variable interest rates that adjust periodically based on an underlying reference rate. Zero-coupon bonds, on the other hand, do not pay periodic interest but are typically issued at a discount and redeemed at full face value upon maturity. Bonds may also contain embedded call or put options, allowing flexibility to investors and issuers. Convertible bonds are a type of bond that include an option to exchange the holdings for a fixed number of the issuing entity's shares at a predetermined price. (Fabozzi, 2005)

2.2 Bond issuance

Bonds are typically issued in the primary market through an underwriting process, in which an investment bank or a syndicate of banks collaborates with the issuer to distribute the bonds to investors. The role of investment banks in an issuance process may include one or more of the following: advisory services on terms and the timing of issuance to the public, buying the securities from the issuer and selling the securities to the public. If an investment bank functions as an underwriter of an issuance, it may mean buying the securities from the issuer at a set price, accepting the risk of reselling the securities to investors. This process is also known as "firm commitment". On the other hand, the investment bank can merely sell the securities on behalf of the issuer, which is called a "best-efforts agreement", where the investment bank sells, but does not buy the issue. In this situation the investment bank does not take the risk of needing to sell at a lower price if the securities do not attract investors. Due to the risk of financial loss, there is typically more than one investment bank shares the risk as underwriters. (Fabozzi, 2005)

The fee earned from an underwriting is the difference between the price the investment bank bought securities from the issuer and the price at which they resell to investors, which is called “gross spread”. (Fabozzi, 2005)

In addition to the traditional syndicate underwriting model, other models are widely used. A “bought deal” is a type of underwriting process where the lead underwriter or syndicate of underwriters offers a firm bid to purchase a specific amount of bonds from the issuer at a predetermined interest rate and maturity. The issuer has a short time to accept or reject the bid. Once the issuer accepts the bid, the underwriter/underwriters distribute the securities to investors, which may already have been pre-sold to institutional clients. (Fabozzi, 2005)

An auction process is a competitive process where issuers announce terms that underwriters or investors may submit bids to. The syndicate’s lowest yield or cost for the issuer secures the bond issuance. This type of underwriting process is commonly used in bond issuances by governments or municipalities. (Fabozzi, 2005)

Medium term notes programs (MTNs) are debt instruments issued on a continuous basis instead of as single transactions under a pre-established issuance program. MTN issuers are generally corporations, financial institutions and governments (Fabozzi, 2005). MTNs are common in both the United States and in Europe, but their market structures and regulatory requirements differ. For instance, Euro Medium-Term Notes (EMTN) programs are issues outside U.S and Canada, where the country of issue typically deals in euro currencies. The market is generally dominated by private placements but also includes publicly listed issues. MTN programs provides issuers flexibility to tailor maturities, interest structures, issuance amounts, and may also be cost effective since issuers can tap issues when market conditions are favorable (Fabozzi, 2005).

Lastly, bond issues may be underwritten on reverse inquiry, where the investors proactively request for issuance of specific terms. These types of bond underwriting are usually issued in smaller tranches, where typically investment banks facilitate the issues on investors’ specific needs. (Fabozzi, 2005)

2.3 Debt capital markets

Debt capital markets or DCM refer to the financial market where various entities raise funds through fixed income instruments such as bonds, loans, or securitized products. Unlike the equity markets, which involve ownership stakes, DCM enables various entities to access funding while committing to interest payments. Capital is lent to fund projects with different risks and yield characteristics. Investors will demand more yield for funding riskier investments and vice versa. From the issuer's standpoint, an increase in project risk corresponds to a higher cost of capital.

The origins of the debt capital market can be traced back to the 1300s when Venetian citizens were able to invest in government-issued bonds (Baker, Filbeck, & Spieler, 2019). Since then, global debt capital markets have expanded significantly. According to the Global Debt Report by OECD (2024), total OECD government bond debt rose from USD 30 trillion in 2008 to USD 54 trillion by the end of 2023. Similarly, global corporate bond debt grew from USD 21 trillion to USD 34 trillion over the corresponding period. The report underscores that the outstanding debt of non-investment grade bonds (below BBB- rated) totalled USD 3,4 trillion, a figure that has almost doubled since 2008 (OECD, 2024). The combined volume of global sovereign and corporate bonds nearly reached USD 100 trillion by the end of 2023, which, in perspective, a figure roughly comparable in scale to global GDP (OECD, 2024).

2.4 Bond pricing

This part will introduce the fundamental principles of bond pricing and valuation, including the role of coupon payments and yields, and their relationship with bond prices. It will then examine factors that influence bond valuation.

2.4.1 Bond price, yield and coupon

The value of a bond, like that of any financial instrument, is determined by the present value of its expected cash flows, which include periodic coupon payments and the principal repaid at maturity (Fabozzi, 2005).

The present value of a bond can be expressed as:

$$PV = \sum_{t=1}^{T} \frac{C}{(1+r)^t} + \frac{V}{(1+r)^T}$$

Bonds pay periodic coupon payments that can be weekly, monthly, quarterly, semi-annually or annually. Generally, Europe fixed rate bonds tend to pay annual coupons and floating rate bonds are typically linked to a reference rate like Euribor, which pays quarterly or semi-annually coupons. Put simply, coupon payments represent the costs of borrowed funds for issuers, and compensation for borrowed funds for investors. The coupon amount can be determined by multiplying the coupon rate with the face value of the bond. (Fabozzi, 2005)

It is crucial to distinguish that the coupon rate is not the same as Yield to Maturity (YTM). While the coupon rate reflects the fixed annual interest payments relative to the bond's face value, YTM represents the total expected return for an investor who holds the bond until maturity. For instance, if a bond is traded below face value, the YTM will be higher than the coupon rate. Conversely, when a bond trades above face value, the YTM falls below the coupon rate. However, if a bond is trading at face value, the coupon rate is equal to YTM. This relationship reflects the fundamental inverse correlation between bond yields and prices: the higher the yield, the lower the bond price, and vice versa. (Berk and DeMarzo, 2017)

In the context of greenium in the bond market, it would mean that investors would be ready to forgo yield, compared to an equally valued bond. From an issuers' perspective this would mean that the issuer can access cheaper financing through a green bond issue versus issuing a non-green bond, all else being equal.

2.4.2 Interest rates

Changes in interest rates affect investor demand for yield and directly influence bond prices. When interest rates fall, bond prices rise. Conversely, rising interest rates cause bond prices to fall. A bond's sensitivity to interest rate movements depends largely on its maturity and coupon rate. Bonds with shorter maturities are less sensitive because their cash flows are received over a shorter time horizon, while longer-term bonds are more sensitive due to their distant cash flows. Similarly, bonds with higher coupon rates are less affected by interest rate changes, as they deliver more cash flow upfront compared to otherwise identical low-coupon bonds. This sensitivity is commonly measured by duration, which estimates the percentage change in a bond's price in response to a 1% change in interest rates. A higher duration indicates more price sensitivity (Berk & DeMarzo, 2017).

Berk and Demarzo (2017) define the base interest rate as the minimum interest rate an investor will demand or that an issuer must pay for a security that is not a U.S treasury security. Securities issued by the U.S department of Treasury are considered risk free, as they are perceived to carry no credit risk. Therefore, the U.S. treasury yields serve as a benchmark for comparable securities within U.S. financial markets. Similarly, in the euro area the yields of German sovereign bond are widely regarded as the benchmark rates for euro-denominated securities. German government securities, or Bunds, are regularly issued with maturities from 12 months up to 30 years, thus forming a comprehensive yield curve for the euro area that serves as a critical reference for pricing bonds in the eurozone.

2.4.3 Credit quality

A central concept in credit markets is credit risk. Credit risk refers to the possibility that an issuer will be unable to fulfil its financial commitments. In the context of bonds, it specifically refers to the risk that the issuer will be unable to make principal or coupon payments. In addition, credit risk also includes risk of a bond's value decreasing because the market perceives an increased risk of default of an issuer or that the issuers credit rating outlook or rating itself is lowered by a rating agency. (Fabozzi, 2005)

Credit ratings are formal opinions given by credit rating agencies whose primary objective is to assign credit rating to debt obligations and to monitor the issuers overall credit quality (Fabozzi, 2005). The U.S Securities and Exchange Commission (SEC) designates certain agencies as Nationally Recognized Statistical Rating Organizations (NRSROs) who can make credit ratings (Stolper, 2009). The rating agencies are Moody's, Standard & Poor's and Fitch Ratings. The agencies assign credit ratings to issuers on a scale AAA to D, where AAA is the highest quality with lowest risk, and D indicates default. These ratings are typically grouped into categories, where investment grade bonds are rated AAA to BBB-, which represents the lower credit risk. Bonds rated in the range from BB+ to B- are speculative grade bonds, and lastly CCC+ to D are classified as highly speculative, substantial risk, or are in default. (Fabozzi, 2005)

Credit market issuers often depend on third-party ratings to convey creditworthiness, thereby affecting bond prices. Therefore, a change in credit rating may directly impact on the issuer's cost of debt. However, credit rating agencies have faced criticism for their lack of accuracy and the fact that issuers pay for the ratings and therefore may create a conflict of interest (Stolper, 2009).

The credit spread of a bond represents the yield differential between the bond and a risk-free instrument with the same maturity (Fabozzi, 2005). For euro-denominated bonds this could be the difference in the euro bond and the comparable German sovereign bond yield. A bond's credit spread primary reflects the credit risk of a bond. However, the yield difference is not solely driven by the credit risk, for instance, corporate bonds are less liquid and may contain embedded options and therefore influence the spread (Fabozzi, 2005).

2.4.4 Macroeconomic conditions

Bond yields are influenced by different macroeconomic factors. If the expectations are that inflation will be higher in future, investors will demand greater yields for the erosion of purchasing power, which results in lower issue prices. Similarly, during periods of strong economic growth, investors tend to prefer riskier asset classes such as equities, thus reducing the demand for bonds and lowering issue prices. Also, Central banks like the European Central Bank (ECB) and the Federal Reserve influence market interest rates directly through their monetary policy decisions. The Governing Council of ECB claims to aim for 2 % inflation over the medium term in the euro area (European Central Bank, 2019). Therefore, the monetary policy measures taken to achieve the 2 % inflation target, will directly affect short-term interest rates, while long-term market interest rates are influenced indirectly due to market expectations about future monetary policy.

2.4.5 Bond issue specific pricing factors

There are various other factors impacting the final pricing of a bond. Bond-specific characteristics that affect the pricing include maturity of a bond, coupon type, and payment frequency, payment rank or seniority, potential securitization in the form of collateral, including call or other embedded options.

Another important factor in bond pricing is liquidity risk. Highly liquid assets are safer and priced accordingly as they can be more easily converted into cash in a shock scenario (Liu, 2006). In bond markets, corporate bonds tend to be less liquid than government bonds, leading to the inclusion of liquidity premium in the corporate bond pricing. Furthermore, the expected liquidity of corporate bonds on the secondary market also influences their pricing in the primary market (Goldstein, Hotchkiss and Pedersen, 2019).

2.5 Green bonds

The World Bank (2015) defines a green bond as "a debt security that is issued to raise capital specifically to support climate-related or environmental projects". The key difference between a green bond and a conventional is that green bonds use of proceeds is specifically channelled to projects that benefit the environment.

The first green bond was issued by multilateral institutions, European Investment Bank and The World bank in 2007 (Climate Bonds Initiative, 2019). However, in early years the green bond issuance volumes were low, up until 2014 where after which the volumes have grown rapidly. The first corporate and municipal issuers issued their first green bonds in 2013, whereafter other corporations and municipalities followed this trend. (Climate Bonds Initiative, 2019).

The International Capital Market Association (ICMA) outlines four main categories of labelled green bonds under the Green Bond Principles (GBP) framework (ICMA, 2021). Each category aligns with the GBP guidelines, promoting transparency and accountability in green financing. The four types are defined as follows:

1. **Standard green use of proceeds bond**: Proceeds of this type of bonds are earmarked for projects that are backed by the issuer's entire balance sheet. Issuers are therefore fully responsible for repayment and carry the same credit rating as conventional bonds issued by the same issuer. The funds raised are designated to projects that are environmentally beneficial.

2. **Green revenue bond**: So-called, non-recourse-to-the-issuer bond, where cash flows from taxes or fees etc. serve are the collateral for the debt. Proceeds may be allocated to either related or unrelated green projects.

3. **Green project bond**: The bond is tied to one or multiple specific green projects. Investors in green project bonds are exposed to project-specific risks and may have limited or no recourse to the issuer.

4. **Green securitized bond:** Collateralized by one or more specific green projects, these types of bonds are typically covered bonds that are asset-backed by a pool of green assets. Investors have recourse to the issuer and, if the issuer is unable to pay, to the covered pool.

2.5.1 Green bond issuance

Green bond issuers can be corporates, governments or supranational institutions. Many elements of green bond issuance are like a conventional one. For instance, entities are obliged to provide financial information to their investors, regulators and rating agencies. However, green bond issuances do come with additional processes. The World Bank (2015) describes that for most green bond issuers the process is

1) Defining the green project(s).

2) Establish project selection process.

3) Earmark and allocate proceeds.

4) Monitor and report.

The steps pre-issuance to determine which type of green projects are supported, if the project will be promoting low-carbon development or perhaps climate-resilient growth. The selection is usually reviewed by external experts to make sure that the technical standards align with what is viewed as acceptable. As soon as project(s) are identified, issuers undergo formal review and an approval process that includes screening and identifying environmental impacts and securing board-level approval from the issuer. Following approval, issuers allocate and earmark proceeds. Lastly, issuers play a key role in overseeing the implementation of green projects and disclosing how proceeds are allocated, along with the projected environmental outcomes. (World Bank, 2015)

Many issuers make their own green bond frameworks under ICMA green bond principles or the EU green bond standard on voluntary basis. Even though different frameworks drive towards a more transparent market of green bonds there is a problem with the lack standardization with the frameworks. Bonds under different frameworks are more difficult to compare between each other, since the standards are different. For example, the EU green bond standard is stricter than ICMA, which creates inconsistency how green bonds are perceived globally. Some frameworks again do not require issuers to report on the actual environmental impact of funded projects, and in other frameworks this is included. When green bonds are not under a clear and consistent standard, there will be increased risk of intentional or unintentional greenwashing. Greenwashing refers to the practice where issuers provide misleading or lying about their true environmental impacts (Xu et al., 2025). In the broad picture, due to the lack of standardization, allows issuers to mark bonds as "green" even if the projects financed has significant carbon footprint.

2.6 Green bond market

Compared to the overall bond market, the green bond market is still in its early stages. Since the first green bond issuance in 2007, the market experienced slow growth for almost a decade before expanding significantly. The volume of globally issued green bonds in 2019 totaled USD 265 billion and in 2021 the annual volume was up to USD 570 billion, in 2023 the total volume was USD 575 billion (S&P Global, 2024). Europe is widely regarded as the largest green bond market and according to S&P Global (2024) in 2023 Europe accounted for 54% of global green bonds. Figure 1 illustrates the annual issuance volume in the euro-denominated green bond market from 2015 to 2024, showing that the total volume increased from 17 billion in 2015 to 277 billion euros in 2024. Figure 2 illustrates the share of euro-denominated green bonds in percentage of the total volume issued. The share of green bonds of the total bond issuance volume increased from 0,41 % in 2015 to 5,58 % in 2024

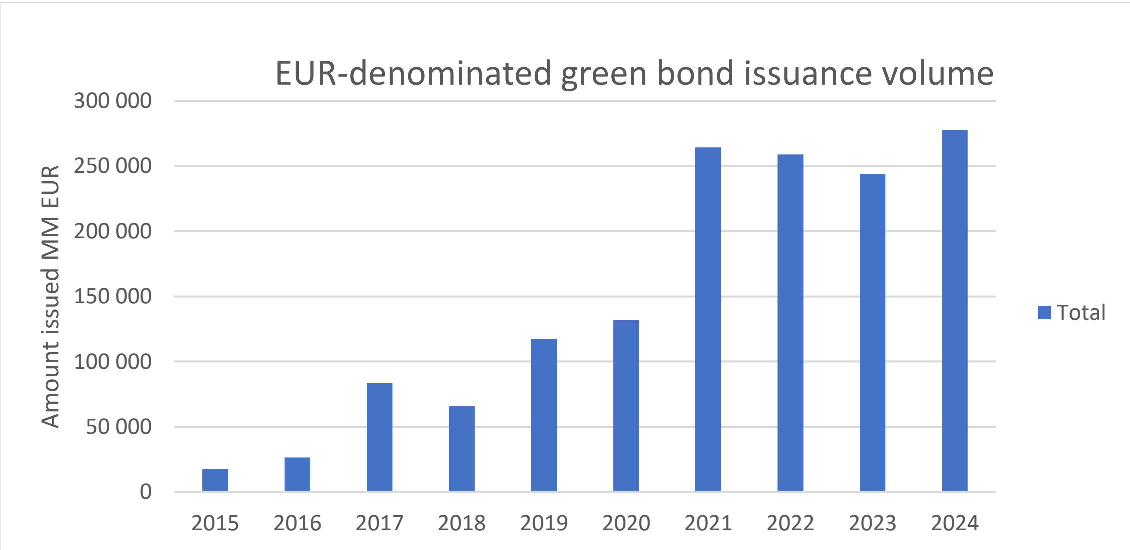

Figure 1 **Annual issuance volume of euro-denominated green bonds**

Note. *Data retrieved from Bloomberg Terminal (Bloomberg L.P., 2025), using the Fixed Income Search (SRCH) function*

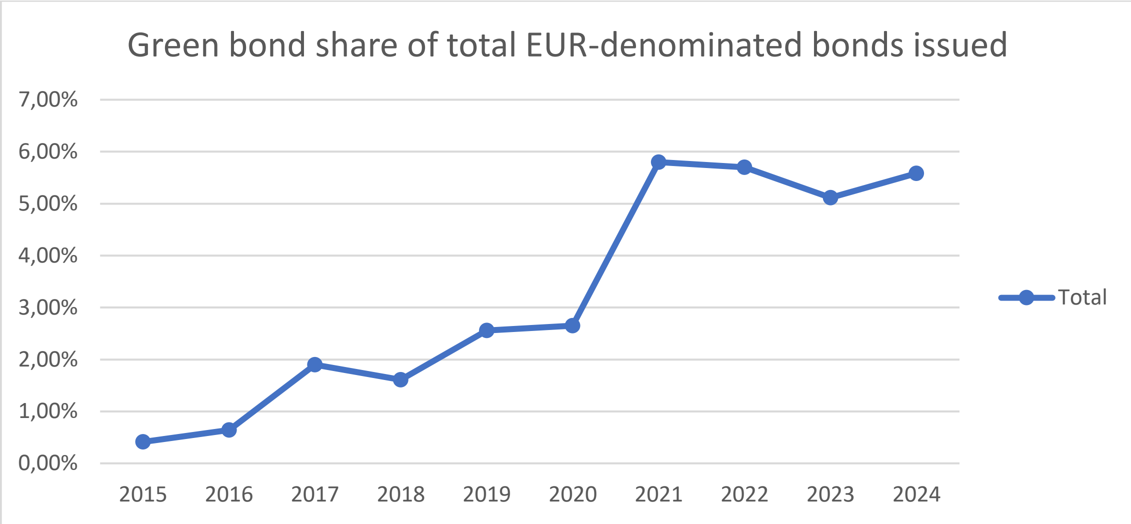

Figure 2 **Share of green bonds compared to total amount issued bonds in EUR**

Note. *Data retrieved from Bloomberg Terminal (Bloomberg L.P., 2025), using the Fixed Income Search (SRCH) function*

The Paris Agreement, adopted in 2015, marked the first legally binding global climate accord, in which nearly 200 countries committed to collectively reducing global warming (Bachelet, Becchetti, & Manfredonia, 2019). Alongside the Paris Agreement, the United Nations Sustainable Development Goals (UN SDGs) (United Nations, 2015) have also played a significant role in driving the growth of the green bond market. Both frameworks aim to balance economic development with environmental sustainability by regulating carbon emissions and promoting investments in renewable energy (Alamgir & Cheng, 2023).

These global initiatives demand substantial capital flows toward environmentally beneficial projects. To achieve the UN SDGs by 2030, it is estimated that annual investments of USD 5–7 trillion will be required (UNCTAD, 2014).

2.7 Green projects

As mentioned earlier in this chapter green bond funds are allocated to projects that are environmentally beneficial. In this part we will examine in more detail the specific criteria and characteristics that define environmentally beneficial projects. ICMA describes in green bond principles (GBP) that issuers should ensure that proceeds generated from bond issuance should be properly tracked. Tracking can be by crediting proceeds to a designated sub-account or sub-portfolio, or through other suitable methods. When all or part of the proceeds are intended for refinancing, ICMA advises that issuers estimate the share used for financing compared to refinancing. Issuers are also expected to specify which investments or project portfolios are being refinanced and to state the look-back period applied to the eligible green projects. (ICMA, 2021)

The Green Bond Principles (GBP) acknowledge a range of green project categories that support environmental goals, including climate change mitigation and adaptation, conservation of natural resources and biodiversity, as well as pollution prevention and control (ICMA, 2021).

In table 1 are listed project categories that dominate current and expected activities in the green bond market. These projects include investments, assets and other related expenditures, including research and development R&D, that may align with one or more category and/or environmental objectives. (ICMA, 2021)

Table 1 Green project categories defined by GBP

Category	Definition
Renewable energy	Production, transmission, appliances and products related to renewable energy.
Energy efficiency	New and refurbished buildings, energy storage, district hearing, smart grids, appliances and products
Pollution prevention and control	Reduction of air emissions, greenhouse gas control, soil remediation, waste prevention, waste reduction, waste recycling an energy/emission -efficient waste to energy
Environmentally sustainable management of living natural resources and land use	Environmentally sustainable agriculture, animal husbandry, fishery, aquaculture, forestry and climate smart farm inputs.
Terrestrial and aquatic biodiversity	Protection of coastal, marine and watershed environments

Clean transportation	Electric, hybrid, public, rail, non-motorized, multi-modal transportation, infrastructure for clean energy vehicles and reduction of harmful emissions
Sustainable water and waste management	Sustainable infrastructure for clean and/or drinking water, wastewater treatment, sustainable urban drainage systems, river training and other types of flooding mitigation
Climate change adaptation	Efforts to make more resilient infrastructure to climate change, information systems: climate observation and early warning systems
Circular economy adapted products, production technologies and processes	Design and introduction of reusable, recyclable, refurbished materials/components and products, certified eco-friendly products
Green buildings	That meets region, national or internationally recognized standards for environmental performance

(ICMA, 2021)

Issuers who issue green bonds according to GBP are expected to communicate the environmental efforts of their green project(s) to investors but also express environmental and social risks linked to the project choice and how they are managed. Additionally, issuers are encouraged to align above with overall sustainability goals and policies. This would include following standards, taxonomies and eligibility criteria while disclosing any relevant certifications. (ICMA, 2021)

2.8 Information assymetry

The main cause of credit market imperfections is asymmetric information. Asymmetric information occurs when one party possesses more information than the other. In credit markets this typically occurs when the borrower has knowledge advantages relevant to a project returns or can take actions that are not observed by the lender (Freixas and Rochet, 2008). Mainly, there are two main consequences of asymmetric information: Moral hazard and adverse selection.

Moral hazard occurs when the borrower and the lender have conflicting interests, where the lender is not fully able to observe or verify the borrower's actions. Borrowers may take excessive risk, choose projects with high private benefits but poor financial returns or even divert funds after receiving the loan. (Freixas and Rochet, 2008)

Adverse selection occurs when borrowers have payoff-relevant private information of project success that the lender does not know about at the time of contracting. Types of private information can be regarding project's underlying technologies, borrowers' management abilities or the true value of collateral. Borrowers may attempt to exploit their informational advantage and may sell the project to lenders at overvalued terms. Even if borrowers do not intend to exploit the lender, the lender might fear this would happen. (Freixas and Rochet, 2008)

2.8.1 Verification

As mentioned previously in 2.4.3, participants in bond markets rely heavily on credit ratings, which are third-party verifications provided by credit rating agencies. A credit rating serves as a tool that signals the quality of the project, which in this case is addressed to the issuer or the bond security. Credit ratings, therefore, reduce information asymmetry in bond markets. However, research suggests that credit ratings do not fully resolve issues of asymmetric information. For instance, Lu, Chen and Liao (2010) analysed the relationship between corporate yield spreads and information asymmetry, finding that investors charge a substantial risk premium for information asymmetry, independent of other controlled factors.

Zhang, Li and Liu (2021) argue that green bonds issued by corporates reduce information asymmetry, thereby lowering their cost of capital. When corporates adopt green financing policies, they are also disclosing more relevant information to meet regulatory requirements (MacAskill et al., 2020).

2.8.2 Green bond certifications and standards

The growing issuance of green bonds and the increased demand have helped with creating a consensus on the characteristics that define a green bond (ICMA, 2015). Despite this progress, the absence of uniform rules and clearly defined standards for what constitutes "green" remains a concern among market participants. If issuers cannot verify that the proceeds are funding projects with real environmental benefits or if the funds are not allocated as originally intended, they risk being accused of greenwashing and may suffer reputational damage (KPMG, 2015).

In response to the lack of standards in the early days of green bond issuances, voluntary market led initiatives such as the Green Bond Principles (GBP) by ICMA have promoted transparency in disclosure of green bond proceeds (ICMA, 2021). In parallel, the Climate Bond Initiative (CBI) created the Climate Bonds Standard which is a certification scheme providing sector-specific criteria aligning green bonds with climate goals (Climate Bonds Initiative, 2023). Among other frameworks, CBI certification has become the most widely used label in the bonds market. Additionally, other regional standards have been implemented, such as the European Union (EU) Green Bond Standards that was introduced by an EU high-level expert group on sustainable finance or China's Green Bond Assessment and Verification Guidelines issued by the People's Bank of China and the Securities Regulatory Commission. (MacAskill et al., 2020)

Certifications and standards for the use of proceeds in financing green projects are in great importance in the green bond market. Studies highlight that green bond certifications reduce asymmetric information and provide guarantees to investors against greenwashing, which in turn may contribute to the existence of a negative greenium. (Bachelet, Becchetti and Manfredonia, 2019; MacAskill et al., 2020)

Green bond issuers may also want to enhance their transparency on their green bond framework through a Second Party Opinion (SPO), which is an opinion on framework's alignment with recognized green bond principles. These opinions are typically provided by external ESG service providers. (Climate Bonds Initiative, 2014)

On the other hand, even though third-party verification and certification of green bonds may improve transparency and lead to negative premium pricing, it is important to recognize that third-party verifications and green bond certifications come with additional costs. For instance, Bloomberg argues that if green bond premiums do not cover the additional costs, then issuers are not incentivised to go green. (Shurey, 2017)

2.9 Sustainable Finance Disclosure Regulation

The Sustainable Finance Disclosure Regulation (SFDR) is a part of EU legislation (Regulation (EU) 2019/2088) that came into effect on 10 March 2021, aiming to strengthen transparency in sustainable investing. Since its application, market participants and advisors have been required to disclose Environmental, Social and

Governance (ESG) risks and sustainability factors in their investment decision processes (European Commission, n.d.; Regulation (EU) 2019/2088). The main objective is to attract private capital towards environmentally friendly projects to help Europe shift to a net-zero economy. As investors are required to increase reporting on sustainability risks and impacts, the regulation indirectly puts pressure on issuers to improve their quality and transparency on sustainability information of ESG disclosures. Although the SFDR does not itself regulate green bonds directly, it has an indirect impact on the market.

2.10 Signaling theory

One of the rationales behind issuing green bonds is the so-called signaling theory. As previously discussed, asymmetric information is often present in credit markets between companies and investors. Issuing a green bond can be interpreted, according to signaling theory, as a firm's way of signaling its environmental commitment by funding green projects. Therefore, investors may perceive green bond issuers as more committed to sustainability.

Flammer (2021) discusses how the signaling rationale behind green bond issuance gives rise to several empirically testable implications. Firstly, the issuance of green bonds is expected to cause a positive stock market reaction, particularly when the bonds are certified or issued by first-time issuers, as these factors enhance the credibility of the environmental commitment being signaled. Secondly, firms can improve their environmental performance by reducing CO_2 emissions, even though the green bond proceeds may be too small to drive large-scale improvements alone, the act of issuance signals a strategic shift towards sustainability. Thirdly, by issuing green bonds, companies may attract a broader investor base with specific environmental preferences.

3 PREVIOUS LITERATURE

This chapter discusses previous literature relevant to this study, with focus on findings related to greenium.

3.1 Negative greenium

3.1.1 The effect of pro-environmental preferences on bond prices: Evidence from green bonds?

In this study Zerbib (2019) explores the green bond yield premium for the period 2013-2017. The primary objective of the study if investors' pro-environmental preferences are reflected in bond prices.

The analysis sample size totals 110 green bonds from the secondary market between July 2013 and December 2017, which at the time accounted for 17 % of total green bond volume. The researcher estimates the yield of a synthetic conventional bond for each green bond through a matching method. The synthetic bonds are created to be comparable to the small amount of green bond data available. This counterfactual bond shares the key characteristics as issuer, currency, maturity, rating and structure. Followingly, a fixed effect panel regression is performed to control for liquidity differences to isolate the green premium. (Zerbib, 2019)

The results show a statistically significant -2 basis point greenium for the sample, meaning that green bonds are priced 2 basis points lower than conventional counterparts. The author highlights that sector and credit rating as significant drivers of the findings and even though statistically significant greenium was found, its economic significance is small, and it should not should disincentive investing in green bonds. (Zerbib, 2019)

3.1.2 The green corporate bond issuance premium

The most recent paper included in this thesis is titled *the green corporate bond issuance premium* by Caramichael and Rapp (2024). Their analysis focuses on a global panel of green and conventional bonds in the primary market to assess whether corporate green bond issuers experience a cost advantage.

In the analysis they collected 129 043 conventional corporate bonds and 1169 green corporate bonds of 12 736 corporations globally. The bond-level data is collected from

Bloomberg Back Office and supplement data is from Refinitiv Workspace. Caramichael and Rapp (2024) restrict their bond sample to only fixed- or zero-coupon bonds with a notional issuance amount a minimum of USD 500 000. Only private sector and state-owned enterprises are included in the sample, but supranational or municipal entities are cancelled out. Additionally, only green bonds issued in euro and US dollar are included since they are the most established and liquid green bond markets. However, they do not have currency restrictions for conventional bonds, instead if issuers from the green bond sample have issued at least additional bond in another currency where it has least a total volume of USD 10 billion issued. The yield spread of the final bond sample is taken as difference between issue yield and the linearly interpolated government bond yield curve of corresponding currency.

A fixed-effects regression is employed for the estimation of greenium. Caramichael and Rapp (2024) argue that the fixed effect regression approach allows more observations over the matching method where one green bond issuer needs to have at least two comparable conventional bonds for appropriate matching. Also, the fixed effect allows them to include issuers with less frequent bond issues, such as small- and medium-sized businesses in the sample, which would be underrepresented if using the matching method approach.

The findings in the paper show that green bonds have a 8 basis point lower credit spread on the primary market, representing 5 % borrowing cost reduction for corporate issuers in their sample. Caramichael and Rapp (2024) highlights the fact that the paper does not establish a causal relationship between regulation and negative greenium. Instead, they explain that greenium appears to be driven by excess demand on green bonds origin from oversubscription and bond index inclusion (Caramichael and Rapp, 2024).

3.1.3 Financing the response to climate change

Baker et al. (2018) *Financing the response to climate change: The pricing and ownership of US green bonds* studied the green premium in the US municipal bond market with a green bond sample of 2083 municipal bonds between 2010 and 2016.

The data for the study is collected from Mergent for municipal bonds, excluding floating rate bonds that the authors explain to be rarely green. The final sample totals 643 299 conventional and 2083 green bonds. The bond yields are determined at issue after-tax, since some green bonds in the sample was issued under specific programs that were taxable. To find whether greenium exists in the sample, after-tax yields are regressed on green bond indicators and maturity, credit rating and time as fixed effect control variables. (Baker et al. 2018)

The results show that US municipal green bonds are issued at a premium with lower yields than conventional. The reasoning to negative greenium is argued to be due to investor preference for sustainable investments, particularly for bonds with small par value or low risk. They also highlight the importance of standardization for green bond certification, since external verification strengthens pricing. (Baker et al. 2018)

3.2 Mixed results

3.2.1 Do shareholders benefit from green bonds?

Tang and Zhang (2020) in their paper analyses stock price reactions on green bond issuance. Further they explore 1) financing cost 2) investor attention and 3) firm fundamentals as potential sources of cause to the reaction.

The dataset for this study includes green bonds issued by corporates in 28 countries between 2007 to 2017 in the primary market. The sample includes a total of 132 unique public issuers and totals a sample of 1510 green bonds. Methods applied in the study are matching method, a regression model and diff in diff analysis. (Tang and Zhang, 2020)

The results indicate that green bond issuance positively impacts stock prices. The results show little evidence that green bonds are issued with lower yields than conventional ones. They find a -6,94 bps pricing difference between green and conventional for the full sample, but after issuer's characteristics are applied, the pricing difference disappears. Instead, they find increased institutional ownership and improved stock liquidity after green bond issuance. Overall, the findings suggest that shareholders benefit from green bond issuances, but it is not driven by greenium or reduction in cost of capital, but rather attract more attention and investors, which can support corporates can enlarge their investor base by issuing green bonds. (Tang and Zhang, 2020)

3.2.2 The evolution of pricing performance of green municipal bonds

Partridge and Medda (2019) compares the performance of green municipal bonds compared to conventional ones. The analysis is performed on US municipal bonds on both secondary and primary markets.

The green bond dataset is formed of both green-labelled bonds and non-labelled bonds. The non-labelled bonds use of proceeds is analysed to be climate aligned. The sample size of labelled bonds equal 680 bonds and when climate aligned non-labelled bonds are added the sample size increases to 1200 bonds. Two different techniques are performed to test if greenium exists in the US municipal market between 2014 to 2018. Firstly, yield analysis on paired green and conventional bonds and secondly an index benchmarking analysis, where the green bond sample is indexed and benchmarked to S&P investment grade municipal index. (Partridge & Medda, 2019)

Partridge and Medda (2019) finds strong evidence of greenium on the secondary market between 2014 and 2017, but primary market evidence is less clear. They do not find greenium in the primary market between 2014 and 2017, however the authors claimed to discover small signs greenium in 2018, which could be explained by the increased volume in the latest year of the study. They argue that the primary market could experience greenium when the issue volume increases.

3.3 No greenium

3.3.1 Where is the Greenium?

In the paper "*Where is the Greenium*", Larcker and Watts (2019) explores the existence of greenium in the US municipal primary bond market between 2013 and 2018.

The data for the analysis is collected from Bloomberg of self-labelled green bonds resulting to a sample of 2896 green bonds from 90 unique issuers. The sample of green bonds is then matched with a pool of 652 391 conventional bonds. In the matching procedure each green bond is matched with a non-green bond that are identical in terms such as issuer, rating and call dates. Additionally, each pair should be issued by same issuer under the exact same day. All pairs with a call option or unidentical coupon rate is excluded. Credit spread differences due to maturity differences are restricted so that maturity dates of the securities matching in other terms do not exceed one year. Finally, they end up with a total of 640 matched pairs from 30 unique issuers. The greenium is then estimated by performing Kernel Density estimation and nearest neighbour matching. (Larcker & Watts 2019)

The results show economically identical pricing of green bonds and conventional counterparts meaning that investors are not willing to forgo yield for the green label and rather value them equal. The results are consistently robust even when controlling for liquidity and institutional ownership. Therefore, the outcome of the analysis says that greenium is equal to zero. (Larcker & Watts 2019)

3.3.2 Are green bonds priced lower than their conventional peers?

The paper by Wu (2022) addresses a few research questions. Firstly, if green bond issuers stocks perform better when green bond issuance is announced and secondly if a green bond premium exists on the Chinese green bond markets and thirdly, if a green bond premium exists in the global green bond market.

For answering the questions whether the Chinese and the global green bond market prices any premium several regressions are performed. The methodology follows the same steps as Zerbib (2019), creating bond pairs of a green bond and a synthetic conventional peer, then through a fixed effect regression check how the green-conventional yield is affected by green premium and liquidity spread. Finally, regressing green premium with green bond specific control variables. The Chinese data sample consists of 146 green bonds from March 2010 to June 2019 and respectively the global sample consists of 385 green bonds from February 2016 to June 2018. (Wu, 2022)

The findings from both the Chinese and global bond market show no significant green premium. More specifically, the mean of green premium for both markets were above zero, indicating no negative premium. In the later regressions, there is found to be a significant positive impact of green certification on green bond premium. Finally, the findings show no results of negative green premium, but instead positive impact from green bond certifications. (Wu, 2022)

3.4 Summary of previous research

The existing literature regarding the existence of greenium in the green bond markets show mixed findings. Zerbib (2019) reports a negative greenium of -2 basis point in the secondary bond market, driven by investor preferences. Caramichael and Rapp (2024) finds an -8-basis point greenium in the global primary bond market, linked to strong investor demand rather than regulation. Baker et al. (2018) show that U.S municipal green bonds are issued at lower yields than conventional peers, particularly when certified, due to investors sustainability preferences.

Tang and Zhang (2020) find small signs of pricing advantages for green bonds but disappears once firm characteristics are accounted for. Partridge and Medda (2019) in turn find evidence of greenium in the secondary market, but limited evidence in the primary market, with small signs of greenium when issuance volumes increase.

Conversely, studies such as Larcker and Watts (2019) and Wu (2022) observe no yield differences between green and conventional bonds in primary bond markets. Wu (2022) highlights that green certification increases financing costs for green bonds, making them priced higher than conventional ones.

Overall, the presence of a greenium appears to be a context dependent puzzle. Differences in methodologies, market segments, time periods, and bond types all contribute to varying results. Therefore, drawing definite conclusions about the existence of greenium remains complex and requires further analysis, particularly as the green bond market continues to grow.

4 DATA

In this chapter we will discuss the data collected for the empirical analysis of this thesis. by discussing the process of data collection and in detail the variables needed for the statistical analysis. Followed by descriptive statistics on the data sample.

4.1 Data collection

The bond data for this analysis is collected from Refinitiv Workspace. The first step is to look at the whole universe of bonds denominated in euro and filtering bonds issued by corporates between the period 1.1.2018-25.3.2025. Thereafter, a column for the universe of bonds which indicates whether a bond is labelled green in the database. The number of bonds in the database universe was 112 143 bonds, of which 2037 were labelled green.

In line with previous research, such as Caramichael and Rapp (2024), the sample is further restricted to include only fixed-rate and zero-coupon bonds to ensure comparability. For instance, floating-rate bonds are excluded, as they are not directly comparable due to their differing pricing dynamics. A minimum nominal issue amount of 5 000 000 euros is required to exclude small deals that are potentially more illiquid and subject to different pricing dynamics than larger, more standardized bond issues. The maximum tenor is set to 15 years, due to data availability constraints and to ensure a more homogeneous maturity structure across bonds. We only consider private companies in the sample, but we do allow state owned companies.

Following these restrictions, the characteristics of the green bonds in the sample were examined more closely. It was found that none of the green bonds are (1) zero-coupon bonds or (2) sinkable, puttable, or convertible. To ensure comparability, conventional bonds with any of these features were also excluded from the sample, as such features can affect bond pricing. Additionally, bonds with missing data required for yield calculations were removed. The final sample after all restriction totals 20 866 bonds of which 1306 are green bonds.

In addition to the bond specific data from Refinitiv, other data sources have been used to collect necessary data for the analysis. German yields are collected from the German central bank's statistics web site (Bundesbank.de, 2025), Euro corporate high yield Index spread from the website of Federal Reserve Bank of ST. Louis (Stlouisfed.org, 2025) and Euro corporate investment grade spreads from Bloomberg. These variables are described more in detail in the section 4.1.2.

4.1.1 *Bond yield spread*

The yield spread is an effective measure to compare bonds issued in different interest environments and is the main variable of interest in this analysis. For each bond in the sample the yield is calculated with the Excel function YIELD based on issue price, tenor, coupon rate, coupon frequency. Due to the lack of bond-specific data, we assume an Actual/Actual day count convention and a redemption price of 100 for all bonds. The reasoning behind calculating yields manually is that databases do not provide yield at issue data for all bonds. By computing the yields independently, a broader set of euro-denominated bonds can be included, enabling a more comprehensive analysis of the primary bond market. This approach is also adopted by Caramichael and Rapp (2024). To validate the accuracy of the self-calculated yields, a robustness checks on a subsample is presented in Chapter 6.6, using yield-at-issue data points retrieved directly from Refinitiv Workspace.

To calculate the yield spread, a suitable benchmark must be used. Following Caramichael and Rapp (2024), who use government bond yields as a benchmark, this analysis applies a similar method. Given that the sample includes only euro-denominated bonds, the German yield curve is used as the benchmark. German government securities are widely regarded as a "risk-free" reference in the euro area due to Germany's strong credit rating, liquidity. A daily yield curve is constructed for German federal securities (Bunds), using maturities ranging from 6 months to 15 years. A linearly interpolated maturity-matching procedure is then performed to match each individual bond's tenor with the corresponding point on the German yield curve at the issuance date. After these steps, the yield spread at issuance is calculated using the following formula:

$$Yieldspread = Bond\ yield\ at\ issue - German\ sovereign\ yield\ at\ issue \qquad 1)$$

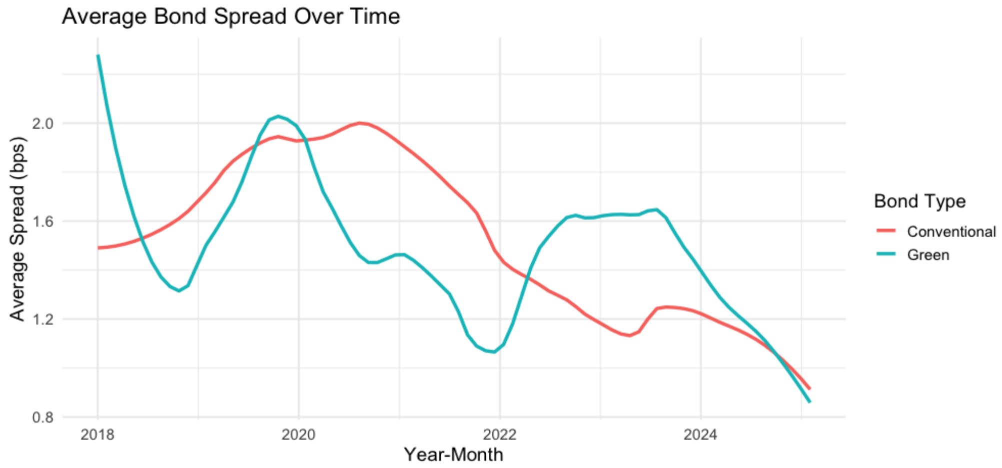

Figure 3 **Sample average green and conventional bond spread over time (2018-2025)**

4.1.2 Other variables

For the empirical analysis in the following chapter, various variables are collected with explanatory power over bond yield spreads. All control variables are selected based on those used by Caramichael and Rapp (2024). These variables are divided into bond-specific variables and variables describing the broader credit market conditions, as presented in Table 2.

Table 2 Bond and credit market variables

Variable	Description
Nominal amount issued	Total amount issued in EUR
Years to maturity	Difference between issue date and maturity date in years
Credit rating	Composite rating derived from Moody's and Fitch credit ratings
Issuers parent company	Name of issuing entity's parent company
Seniority	Payment rank in the scenario of default
Callable	Indication if bond has a call option

Level, slope and curvature of benchmark	Describes the level, slope and curvature of German federal securities
Volatility	30-day volatility measure on the 10-year German 10-year bond yield
High yield bond spread index	Index of Euro corporate high yield option adjusted spreads
Investment grade bond spread index	Index of Euro corporate investment grade option adjusted spreads

The bond specific variables, amount issued, years to maturity, credit rating, seniority are often used when controlling bond specific characteristics that affect the yield of a bond at issuance. These controls are expected to explain a significant proportion of the credit spread observed on newly issued bonds.

The credit rating variable is constructed as a composite rating where the underlying ratings are the bond ratings by Moody's and Fitch. The scale of the composite rating is AAA-C where AAA is the highest credit quality and C is the lowest. If a bond has received a rating from only one of the two rating agencies, that rating received equals the composite rating. However, if a bond has received a rating from both agencies, the composite rating is an average of both ratings and rounded down.

In addition to bond specific controls, it is essential to control for the effect of the ultimate parent of the issuer. This is important because bond pricing is often driven by factors of the issuing entity itself, but also creditworthiness and reputation of the parent company may influence pricing, especially when the issuer is a subsidiary.

To capture the interest rate environment at each issue date a principal component analysis is conducted on the German sovereign yield curve based on term structure of maturities from 1 year to 10 years. The factors derived from this technique provides the slope, level and curvature of the German yield curve for each bond issue date in the sample. The first principal component is the level which corresponds to the overall level of interest rates across maturities. A high level indicates an overall high level of interest rates and vice versa. The second principal component is the slope which reflects the steepness of the curve or more precisely the difference between short- and long-term yields. The third principal component is the curvature, which captures the convexity of the yield curve. It reflects the deviation of mid-term yields from the linear path between long- and short-term yields. In addition to the principal components, the realized 30-day volatility of the 10-year German government bond is included to account for short-term historical volatility and overall market uncertainty.

To capture aggregate credit risk, the analysis includes the ICE BofA Euro High Yield Index, representing high-yield corporate bond spreads, and the Bloomberg Euro Aggregate Option-Adjusted Spread, which reflects investment-grade bond spreads.

4.2 Descriptive statistics

Table 3 presents descriptive statistics for the full bond sample, first for the green bonds and then for conventional bonds. The sample includes 1306 unique green bonds, and 19 560 unique conventional bonds. Analysing the table, it can be observed that, on average, green bonds have larger issue sizes, longer tenors and higher credit ratings. Green bonds tend to be issued in periods with slightly lower interest rate and volatility environments, but also when the overall corporate credit spreads are lower.

Table 3 Descriptive statistics of the bond sample

Bond Type	Variable	Observations	Mean	SD	25th	Median	75th
Green	Yield spread	1306	1,44	1,29	0,77	1,08	1,7
Green	Amount Issued (MEUR)	1306	387,73	340,96	50,00	500,00	600,00
Green	Coupon %	1306	2,24	1,92	0,5	1,86	3,75
Green	Tenor (years)	1306	7,1	2,82	5	7	9
Green	Rating	1306	3,68	4,34	0	0	8
Green	Level	1306	0,03	3,34	-2,95	-2,01	3,8
Green	Slope	1306	0,07	0,39	-0,07	0,18	0,35
Green	Curvature	1306	-0,03	0,14	-0,09	-0,04	0,05
Green	30-day realized vol.	1306	0,04	0,02	0,03	0,04	0,05
Green	IG Index Spread	1292	1,23	0,36	0,93	1,13	1,46
Green	HY Spread	1276	3,97	0,9	3,25	3,65	4,5
Conventional	Yield spread	19560	1,5	1,69	0,67	1,01	1,7
Conventional	Amount Issued (MEUR)	19560	212,66	319,10	20,00	50,00	300,00
Conventional	Coupon %	19560	2,45	2,02	0,75	2,4	3,5

Conventional	Tenor (years)	19560	6,5	3,43	4	6	9
Conventional	Rating	19560	2	3,49	0	0	3
Conventional	Level	19560	0,37	3,37	-2,85	-1,59	4,06
Conventional	Slope	19560	0,02	0,4	-0,31	0,14	0,34
Conventional	Curvature	19560	-0,01	0,15	-0,08	-0,02	0,1
Conventional	30-day realized vol.	19560	0,05	0,02	0,03	0,04	0,06
Conventional	IG Index Spread	19480	1,28	0,37	0,99	1,18	1,51
Conventional	HY Index Spread	18937	4,07	0,96	3,36	3,79	4,62

5 METHOD

This thesis aims to determine whether a greenium exists in the primary corporate bond market. Previous literature has employed various methodologies to analyze this phenomenon, yet there is no clear consensus on the most effective approach. The two most used methods are matching techniques and regression analysis.

This study adopts a fixed effects panel regression approach. The method selection is in line with Caramichael and Rapp (2024). The method allows to include a more comprehensive data sample compared to the matching method, which often significantly reduces the amount of green bonds since it requires at least two conventional bonds in addition to a green bond. Moreover, the matching approach results in sample bias due to the overrepresentation of firms with stronger capital access and regular bond issuance, while small-and medium-sized companies are underrepresented (Caramichael and Rapp, 2024). Another problem causing biases in the matching method, is the fact that only green bond issuers are represented in the control group sample of conventional bonds. It is shown that green bond issuers in fact are different from issuers solely issuing conventional bonds (Flammer, 2021). These biases can be addressed using the regression model.

5.1 Base regression model

The fixed effect regression model aims to estimate the existence of greenium by regressing yield spread against an indicator variable for green bonds, while holding other factors constant.

The baseline panel regression with fixed effect is defined as:

$$YieldSpread_{i,f} = \alpha \, Green_i + \beta \, ControlVariables\,_{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f} \qquad (2)$$

The model is inspired by the approach of Caramichael and Rapp (2024), but with a few key differences. First, controlling currency and regional variation is unnecessary, as the sample includes only euro-denominated bonds. Second, the control variables are selected specifically to explain variation in euro-denominated yield spreads, rather than variation across multiple currencies.

The dependent variable in the model is the yield spread of each bond i, by ultimate parent f issued in time t of year month m . The main independent variable of interest is the green bond indicator, a dummy variable giving value of 1 if the bond is labelled green, and 0 otherwise. The coefficient on the green bond variable captures the average difference in yield spreads between green and conventional bonds

The vector $\beta\ ControlVariables\ _{i,t}^{T}$ includes both bond and macro-level numeric variables observed for bond i at issue date t .The numeric bond specific variables are log years to maturity and log nominal issue amount. The macro level variables are level, slope and curvature of the German sovereign yield curve, the 30-day realized volatility of the 10 year-German bond yield, the option adjusted spread of euro investment grade corporate bonds and the difference between the high yield index spreads and investment grade index spreads.

Additionally, the vector $\mu_{i,m,f}^{T}$ includes non-numeric fixed effects on bond, firm and time-level to capture potential nonlinearities and to absorb unobserved heterogeneity in the model. More specifically, we control for ultimate parent company, bond credit rating, seniority, call option and year to month. The standard errors are clustered on ultimate parent f and year/month m to for the model to consider firm specific unobservable characteristics, but also the year/month is clustered to consider bonds issued in the same month in the same year that may be subject to same market conditions or macro shocks.

Based on the methodology by Caramichael and Rapp (2024) potential bond-specific time variation in credit risk, maturity risk, and call option sensitivity is controlled for by including the following interaction terms: (High-yield index spread x Rating), (Level x Callable), (Slope x Callable), (Curvature x Callable), (Volatility x Callable), and (Slope x Maturity).

5.2 Regression model post SFDR

The second regression model aims to identify whether the implementation of the The Sustainable Finance Disclosure Regulation (SFDR) contributed to potential greenium in the bond market following its enforcement on 10 March 2021. To analyse this, the model incorporates an interaction term between the green bond indicator and a post-SFDR variable, which takes the value of 1 for bonds issued after 10 March 2021, when the SFDR regulation came into effect, and 0 otherwise. This interaction allows for an examination of whether there are any pricing differences between green and conventional bonds following the introduction of SFDR. The model is defined as:

$$YieldSpread_{i,f} = \alpha\ Green\ x\ PostSFDR_{i} + \beta\ ControlVariables\ _{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f} \qquad (3)$$

5.3 Regression model CBI aligned bonds

The third regression model aims to identify whether a greenium exists for green bonds that are aligned with the Climate Bond Initiative (CBI). More specifically, green bonds that follow the CBI taxonomy and guidelines. The goal is to see if CBI alignment affects yields since it addresses one of the biggest challenges in the whole sustainable finance space: Greenwashing. While the green bond market grew rapidly without any market wide standard it is crucial to know that all bonds are not created equal even though they are labelled green. A constant question on the market is whether labeled green bonds truly meet environmental goals. This is where third-party standards such as CBI show their high relevance. Therefore, this analysis aims to find whether green bonds aligned with CBI impacts yields due to their commitment to the standard and potential increased credibility.

If in fact the CBI alignment commands lower yield compared to the whole green bond group, it suggests that investors value the effort of added credibility. On the other hand, a higher yield would indicate that standard commitment would be a sign of investors demanding more yield for green bonds that are CBI aligned compared to any other green labeled bond.

In the model we use the baseline model but add an interactive CBI dummy with the green bond indicator. The interactive dummy takes value 1 for all green bonds that are CBI aligned and 0 otherwise. The model is defined as:

$$YieldSpread_{i,f} = \alpha \quad Green_i \, x \, CBI\_aligned_i + \beta \; ControlVariables\,^T_{i,t} + \mu^T_{i,m,f} + \epsilon_{i,f} \; (4)$$

5.4 Regression model second party opinion (SPO)

The fourth model investigates whether greenium exists if a green bond has obtained a second party opinion (SPO) from a specialized ESG agency. It assesses environmental integrity and alignment of the bonds use of proceeds with the framework applied. This model aims to capture whether there is a greenium when a bond has obtained additional second party opinion. The rationale behind this model is that SPO might enhance credibility and transparency of green bonds help address information asymmetry and potential greenwashing concerns. Investors may view green bonds with SPOs more trustworthy since they are reviewed by a second party. In this scenario, investors would accept lower yields for transparency efforts.

A negative coefficient for the SPO would indicate lower cost of capital for the issuer, and investors would be ready to forgo yield for green bonds with additional SPOs.

The model is the same as the baseline model, but we change the green bond indicator to an interactive dummy variable: The variable takes value of 1 if the bond is green and has obtained a second party opinion and takes value 0 otherwise. The model is defined as:

$$YieldSpread_{i,f} = \alpha\ Green\ x\ SPO_i + \beta\ ControlVariables\ _{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f} \qquad (5)$$

5.5 Regression model for bank issued bonds

In the last model we want to analyse whether greenium exists for bank issuers. There are a few reasons to explore the existence of greenium for bank issuers. Firstly, banks are not only issuers, but also intermediaries and allocators of green capital. Banks often channel the green bond capital to underlying green loan portfolios where they indirectly finance various green assets or projects rather than one or a few specific projects, like other corporate issues.

Previous research like Caramichael and Rapp (2024) finds significant negative greenium specifically for green bonds issued by banks and discusses that banks may be compensated for certifying, monitoring and extending green loans to their clients, but also that banks may potentially benefit from greater regulatory preparedness for transparency and climate-related financial disclosures as potential drivers of their findings. Conversely, Fatica et al., (2020) find no evidence of pricing advantage for financial institutions, which the authors suggest may be due to the difficulty investors face in linking bank-issued green bonds to specific, transparent green projects given banks role in indirect financing.

Additionally, given that a large share of euro-denominated green bonds in the corporate primary market is issued by banks, it is crucial to assess whether these issuers are rewarded with a greenium. This motivates a closer examination of greenium in the banking sector.

If green bonds issued by banks in fact would be priced at lower yield than other issuers it would indicate that investors perceive bank-issued green bonds as more credible or less risky. If bank-issued green bonds are priced higher than other issuers, investors could perceive more risky or less credible, possibly because they are less directly linked to tangible environmental projects.

For this model, we build upon the baseline fixed effects model by introducing both an interaction term between the green bond indicator and a bank issuer dummy, as well as the standalone bank dummy itself. This approach allows us to separately estimate the average difference in yield spreads between green bonds issued by banks and green bonds issued by non-bank corporates, and the overall difference in yield spreads between bank and non-bank issuers, regardless of whether the bond is green. The model is defined as:

$$YieldSpread_{i,f} = \alpha_1\ Green_i\ x_i + \alpha_2\ Bank\_issuer_{\ i} + \alpha_3\ Green_i\ x\ Bank\_issuer_i\ x_{\ i} + \beta\ ControlVariables_{\ i,t}^{\ T} + \mu_{i,m,f}^{T} + \epsilon_{i,f} \quad (6)$$

5.6 Statistical hypothesis

The statistical hypotheses are the following:

Model 1: Baseline greenium

$$YieldSpread_{i,f} = \alpha\ Green_i + \beta\ ControlVariables_{\ i,t}^{\ T} + \mu_{i,m,f}^{T} + \epsilon_{i,f}$$

$$H_0\colon \alpha = 0$$
$$H_1\colon \alpha \neq 0$$

This can be interpreted as:

The null hypothesis assumes that there is no difference in euro-denominated corporate issue yield spread between green and conventional bonds. The null hypothesis assumes that investors are not willing to forgo yield for the green label, and issuers assumed that the risk is equal to the conventional bonds. The yields of both bond types should be comparable.

A negative yield premium in the euro-denominated corporate bond market would indicate that a greenium exists, meaning that investors are accepting lower returns for supporting environmentally beneficial projects while issuers can lower their cost of capital. Some previous research has indicated the existence of a negative yield premium in different bond markets. The existence of a negative premium could be due to many factors, including reduced information asymmetry, higher investor demand and greater market liquidity.

A positive yield premium suggests that green bonds come with higher yields than conventional bonds. There is not much evidence of a positive premium in previous literature. However, this scenario could be linked to moral hazard or adverse selection in form of greenwashing, where issuers could exploit investor demand by misrepresenting the environmental benefits of their project or that investors would be afraid that issuers may be misleading with the projects' true environmental impact.

Model 2: Post-SDFR

$$YieldSpread_{i,f} = \alpha\ Green\ x\ PostSFDR_i + \beta\ ControlVariables\ _{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f}$$

$$H_0:\ \alpha \quad = 0$$
$$H_1:\ \alpha \quad \neq 0$$

Model 3: CBI aligned

$$YieldSpread_{i,f} = \alpha \quad Green_i\ x\ CBI\_aligned_i + \beta\ ControlVariables\ _{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f}$$

$$H_0:\ \alpha \quad = 0$$
$$H_1:\ \alpha \quad \neq 0$$

Model 4: Bank issuer

$$YieldSpread_{i,f} = \alpha_1\ Green_i\ x_i + \alpha_2\ Bank\_issuer\ _i + \alpha_3\ Green_i\ x\ Bank\_issuer_i\ x\ _i + \beta\ ControlVariables\ _{i,t}^{T} + \mu_{i,m,f}^{T} + \epsilon_{i,f}$$

$$H_0:\ \alpha_3 = 0$$
$$H_1:\ \alpha_3 \neq 0$$

5.7 Model diagnostics

Fixed effects models are commonly used in panel data analysis that allows for unobserved heterogeneity across entities. Fixed effect models rely on a few key assumptions, namely strict exogeneity, no perfect multicollinearity, homoscedastic and no serial correlation. (Wooldridge, 2010)

Strict exogeneity, more formally:

$$E(u_{it} \mid x_{i1}, x_{i2}, \dots, x_{iT}, c_i) = 0, t = 1,2,\dots,T.$$

Where the error term is uncorrelated with all values of the explanatory variable for unit i over time. This ensures that the fixed effect estimator is unbiased and consistent, even in the presence of time invariant omitted variables, if those are constant for each unit and potentially correlated with the regressors. (Wooldridge, 2010)

The second assumption is no perfect multicollinearity, which means that the error term has constant variance and is uncorrelated over time within each unit. The assumption ensures that the matrix of time-demeaned explanatory variables has full column rank. (Wooldridge, 2010)

The third fixed effect model assumption is homoscedasticity and no serial correlation of idiosyncratic errors. (Wooldridge, 2010) The assumption implies two things of the idiosyncratic error term:

1. The variance of the error term is constant over time

2. The error term is not correlated across time.

To ensure valid inference from the fixed effect model we can firstly address that the strict exogeneity assumption holds, since all bond specific variables are known before the yield spread is set, therefore it is very unlikely for see reverse causality in the model. For instance, maturity, issue amount, seniority and whether a bond is labeled green are predetermined before the yield spread is set.

To ensure violation towards the second assumption, a Variance Inflation Factor (VIF) test. The VIF analysis reveals the control variables IG Index spread (VIF 13,28), Slope (VIF 10,98) and Slope x Maturity (VIF 11,06) shows signs of multicollinearity. While these values exceed the commonly referenced threshold of 10, they are removed from the model to avoid inflated standard errors which reduce the risk of multicollinearity affecting the reliability of the coefficient estimates.

For the third assumption we perform the Breusch-Pagan test for heteroskedasticity and Wooldridge test for autocorrelation. The results of the test indicate that we do not deal with first-order autocorrelation in the residuals, while there is evidence of heteroskedasticity. To address this, all main regressions are estimated using cluster-robust standard errors, clustered by issuer and year-month, which provide robust results that deal with both heteroskedasticity and serial correlation.

In addition to these measures, outliers in bond yield spreads are examined. Extreme values are identified at both the lower and upper ends of the distribution, potentially reflecting data errors. To reduce their influence, the yield spread variable is winsorized at the 1% level in both tails.

6 RESULTS

In this chapter the regression results for all the different models will be presented. In all models the yield spread is the dependent variable. Standard errors are presented in parentheses under each estimation coefficient.

In the regression tables, asterisks are used to indicate statistical significance of each coefficient estimate based on its p-value:

+ is for p-value < 0,1, the coefficient is statistically significant at a 10% level.

* Is for p-value < 0,05, where the coefficient statistically significant at a 5% level.

** Is for p-value < 0,01, where the coefficient statistically significant at a 1% level.

*** Is for p-value < 0,001, where the coefficient statistically significant at a 0,1% level

6.1 The baseline regression model results

In table 4 the results are presented from the baseline model analysing the potential greenium existence in the dataset. The green bond coefficients are systematically negative in all specifications. What can be observed is that the green bond coefficient becomes slightly more negative reaching -0,105 in specification 6 where all numeric controls and interactions are added, and a statistical significance is present on a 5 % level only in model specification 6. When adding fixed effects controls the magnitude of the green coefficient drops and the coefficients are not statistically significant. The model fit improves drastically when the ultimate parent control is added, indicating that a large part of the variation in bond yields is explained by differences across issuers. In the final specification 10, which includes all fixed effects controls and robust standard errors clustered on issuer and month level, the green bond coefficient is -0,013 and statistically insignificant.

Table 4 Baseline model regression

	1. Green Only	2. + Size & Maturity	3. + Credit Spreads	4. + Yield Curve	5. + Volatility	6. + Interactions	7. + Issuer FE	8. + Bond Structure FE	9. + Time FE	10. + Clustered SEs
Green	-0.043	-0.029	-0.066	-0.068	-0.068	-0.105*	-0.038	-0.023	-0.013	-0.013
	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)	(0.044)	(0.035)	(0.036)	(0.036)	(0.040)
Log(Issue Amount)		-0.027***	-0.107***	-0.116***	-0.116***	-0.150***	-0.084***	-0.060***	-0.058***	-0.058***
		(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.018)	(0.016)	(0.017)	(0.017)
Log(Maturity)		0.085***	-0.003	-0.170***	-0.169***	-0.267***	0.287***	0.246***	0.259***	0.259***
		(0.019)	(0.020)	(0.020)	(0.020)	(0.021)	(0.057)	(0.059)	(0.061)	(0.070)
HY - IG Spread			0.069***	0.092***	0.068**	0.061**	0.236***	0.202***	0.036	0.036
			(0.018)	(0.019)	(0.023)	(0.023)	(0.025)	(0.025)	(0.049)	(0.070)
HY Spread × Rating			0.031***	0.032***	0.032***	0.028***	0.011***	0.034***	0.033***	0.033***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.005)	(0.004)	(0.006)
Yield Curve Level				-0.093***	-0.100***	-0.102***	-0.042***	-0.042***	-0.238***	-0.238***
				(0.003)	(0.005)	(0.005)	(0.009)	(0.008)	(0.046)	(0.060)
Yield Curve Slope				0.234***	0.254***	0.264***	0.177***	0.174***	0.399**	0.399*
				(0.027)	(0.029)	(0.034)	(0.042)	(0.044)	(0.122)	(0.168)
Yield Curve Curvature				0.528***	0.588***	0.358***	0.537***	0.598***	0.339	0.339
				(0.083)	(0.088)	(0.098)	(0.126)	(0.111)	(0.213)	(0.229)
30-day Volatility					1.773+	-1.105	3.374***	3.588***	3.658**	3.658*
					(0.910)	(0.911)	(0.796)	(0.769)	(1.239)	(1.527)
Level × Callable						0.014*	0.022*	0.032**	0.026*	0.026*
						(0.007)	(0.011)	(0.011)	(0.011)	(0.012)
Slope × Callable						-0.030	-0.088	-0.084	-0.063	-0.063
						(0.059)	(0.066)	(0.065)	(0.065)	(0.063)
Curvature × Callable						0.956***	-0.112	-0.163	-0.159	-0.159
						(0.171)	(0.170)	(0.166)	(0.159)	(0.160)
Volatility × Callable						11.956***	0.162	-1.113	-0.137	-0.137
						(0.556)	(0.870)	(1.729)	(1.281)	(1.162)
Num.Obs.	20866	20866	20120	20120	20120	20120	20120	20120	20120	20120
R2	0.000	0.002	0.033	0.074	0.074	0.097	0.774	0.792	0.797	0.797
R2 Adj.	0.000	0.001	0.033	0.074	0.074	0.097	0.748	0.768	0.773	0.773
FE: Ultimate_Parent							X	X	X	X
FE: rating								X	X	X
FE: Seniority								X	X	X
FE: Callable								X	X	X
FE: ym									X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6.2 Regression results post SFDR

The regression results in Table 5 explore whether the implementation of the Sustainable Finance Disclosure Regulation (SFDR) in March 2021 had an impact on green bond pricing. To test this, an interaction term between the green bond indicator and a post-SFDR dummy variable is included. This allows identification of whether green bonds issued after SFDR came into effect exhibit different yield spreads compared to those issued before the regulation came into force.

In the first two model specifications, both the green bond coefficient and the interaction term Green × post-SFDR are statistically significant, indicating a larger greenium in the pre-SFDR period, which appears to diminish post-SFDR. Specifically, the positive and significant interaction term suggests that green bonds issued after the SFDR came into force were associated with higher yield spreads relative to earlier green bonds, implying a weaker greenium post-regulation. However, this effect does not persist in the fully controlled specifications. Once issuer fixed effects and bond-specific controls are introduced in model (3), both the green bond coefficient and the interaction term lose statistical significance. The same holds in model (4), which applies standard error clustering by issuer and month of issuance. This suggests that the initial observed effect is not robust once differences across issuers, bond characteristics, and market timing are accounted for.

Table 5 Model 2 regression summary

	1. Green + PostSFDR	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green	-0.220**	-0.256**	-0.028	-0.028
	(0.080)	(0.078)	(0.054)	(0.054)
Post-SFDR Period	-0.541***	-0.169***	0.031	0.031
	(0.022)	(0.034)	(0.060)	(0.038)
Green × post-SFDR	0.332***	0.249**	0.021	0.021
	(0.096)	(0.094)	(0.078)	(0.080)
Log (Issue Amount)		-0.153***	-0.058***	-0.058***
		(0.008)	(0.017)	(0.017)
Log (Maturity)		-0.267***	0.259***	0.259***
		(0.021)	(0.061)	(0.070)
HY - IG Spread		0.026	0.037	0.037
		(0.024)	(0.049)	(0.070)
HY Spread × Rating		0.028***	0.033***	0.033***
		(0.001)	(0.004)	(0.006)
Yield Curve Level		-0.088***	-0.238***	-0.238***
		(0.006)	(0.046)	(0.060)
Yield Curve Slope		0.268***	0.400**	0.400*
		(0.034)	(0.122)	(0.168)
Yield Curve Curvature		0.223*	0.338	0.338
		(0.101)	(0.213)	(0.229)
30-day Volatility		-0.479	3.667**	3.667*
		(0.921)	(1.241)	(1.528)
Level × Callable		0.012+	0.026*	0.026*
		(0.007)	(0.012)	(0.012)
Slope × Callable		-0.037	-0.063	-0.063
		(0.059)	(0.065)	(0.063)
Curvature × Callable		0.952***	-0.159	-0.159
		(0.171)	(0.159)	(0.160)
Volatility × Callable		11.946***	-0.137	-0.137
		(0.555)	(1.281)	(1.163)
Num.Obs.	20866	20120	20120	20120
R2	0.027	0.099	0.797	0.797
R2 Adj.	0.027	0.098	0.773	0.773
R2 Within			0.054	0.054
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6.3 Regression results with CBI alignment

Table 6 examines whether alignment with the Climate Bonds Initiative (CBI) taxonomy is associated with differences in green bond pricing. The regression model distinguishes between bonds that are aligned with CBI and those that are not, with conventional bonds serving as the reference group.

The first two specifications (1) and (2) show statistically significant negative coefficient for green bonds aligning with CBI. Notably the first model (1) appears to have a statistically significant positive coefficient for green bonds that are not aligned with CBI. However, once issuer fixed effects and bond structure controls are introduced in model (3), and standard errors are clustered in model (4), both coefficients become statistically insignificant. This suggests that the initial differences in yield spreads may be explained by issuer characteristics, bond structure, or timing, rather than alignment alone. Nonetheless, it is noteworthy that the sign of the coefficients remains consistent across all specifications negative for CBI-aligned bonds and positive for non-aligned green bonds even though their magnitudes decrease. This pattern suggests a possible investor preference for bonds that align with established frameworks like the CBI taxonomy, although the effect is not robust after controlling for key confounding factors.

Table 6 Model 3 regression summary

	1. Green + CBI	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green (Not CBI-Aligned)	0.197*	0.148	0.036	0.036
	(0.093)	(0.092)	(0.062)	(0.060)
CBI-Aligned	-0.308**	-0.321**	-0.061	-0.061
	(0.104)	(0.102)	(0.064)	(0.059)
Log (Issue Amount)		-0.149***	-0.058***	-0.058***
		(0.008)	(0.017)	(0.017)
Log (Maturity)		-0.267***	0.259***	0.259***
		(0.021)	(0.061)	(0.070)
HY - IG Spread		0.060**	0.036	0.036
		(0.023)	(0.049)	(0.070)
HY Spread × Rating		0.028***	0.034***	0.034***
		(0.001)	(0.004)	(0.006)
Yield Curve Level		-0.103***	-0.237***	-0.237***
		(0.005)	(0.045)	(0.060)
Yield Curve Slope		0.264***	0.401**	0.401*
		(0.034)	(0.122)	(0.168)
Yield Curve Curvature		0.358***	0.342	0.342
		(0.098)	(0.212)	(0.228)
30-day Volatility		-1.076	3.658**	3.658*
		(0.911)	(1.241)	(1.529)
Level × Callable		0.014*	0.026*	0.026*
		(0.007)	(0.011)	(0.012)
Slope × Callable		-0.026	-0.063	-0.063
		(0.059)	(0.065)	(0.063)
Curvature × Callable		0.951***	-0.159	-0.159
		(0.171)	(0.159)	(0.160)
Volatility × Callable		11.921***	-0.145	-0.145
		(0.556)	(1.281)	(1.161)
Num.Obs.	20866	20120	20120	20120
R2	0.000	0.098	0.797	0.797
R2 Adj.	0.000	0.097	0.773	0.773
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6.4 Regression results with SPO

Table 7 represents the regression results aiming to investigate whether the presence of Second Party Opinion (SPO) is associated with differences in yields spreads for green bonds. model (1), SPOs are associated with higher yield spreads, but the negative and significant interaction term Green × SPO suggests that green bonds with an SPO have lower yields than those without, indicating a potential greenium when external validation is present. However, once controls are added in model (2), and especially issuer fixed effects and bond structure controls that are included in model (3) and (4) the interaction effects become statistically insignificant. Similarly to the earlier regressions, these results indicate that early signs SPO impact on green bond spreads is largely explained by issuer and structural differences rather than SPO itself.

Table 7 Model 4 regression summary

	1. Green + SPO	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green	0.011	-0.106	-0.054	-0.054
	(0.074)	(0.071)	(0.040)	(0.041)
SPO	0.260**	0.147	0.025	0.025
	(0.093)	(0.093)	(0.056)	(0.056)
Green × SPO	-0.338**	-0.139	0.043	0.043
	(0.130)	(0.127)	(0.069)	(0.071)
Log (Issue Amount)		-0.151***	-0.058***	-0.058***
		(0.008)	(0.017)	(0.017)
Log (Maturity)		-0.268***	0.259***	0.259***
		(0.021)	(0.061)	(0.070)
HY - IG Spread		0.063**	0.036	0.036
		(0.023)	(0.049)	(0.070)
HY Spread × Rating		0.028***	0.034***	0.034***
		(0.001)	(0.004)	(0.006)
Yield Curve Level		-0.102***	-0.238***	-0.238***
		(0.005)	(0.045)	(0.060)
Yield Curve Slope		0.263***	0.400**	0.400*
		(0.034)	(0.122)	(0.168)
Yield Curve Curvature		0.363***	0.337	0.337
		(0.098)	(0.213)	(0.229)
30-day Volatility		-1.131	3.667**	3.667*
		(0.912)	(1.239)	(1.525)
Level × Callable		0.014+	0.026*	0.026*
		(0.007)	(0.012)	(0.012)
Slope × Callable		-0.030	-0.064	-0.064
		(0.059)	(0.065)	(0.063)
Curvature × Callable		0.960***	-0.156	-0.156
		(0.171)	(0.159)	(0.160)
Volatility × Callable		11.932***	-0.115	-0.115
		(0.556)	(1.280)	(1.161)
Num.Obs.	20866	20120	20120	20120
R2	0.000	0.098	0.797	0.797
R2 Adj.	0.000	0.097	0.773	0.773
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6.5 Regression results on green bonds issued by banks

In table 8 the focus lays on whether green bonds are priced differently when they are issued by banks. The model interacts the green bond indicator with a banking sector dummy to separate the effects for green vs. non-green and bank vs. non-bank bonds.

In the first model specification (1) green bonds issued by non-bank issuers show a statistically significant greenium of -59 basis points, while non-green bank bonds show to be priced -143 basis points lower than other issuers non-green bonds. However, the green bonds issued by banks seem to have a statistically significant positive coefficient of +58, meaning bank issued green bonds are priced higher than non-bank issuer green bonds. This pattern persists in model (2), which controls for bond characteristics, but once issuer and bond structure fixed effects are introduced in models (3) and (4), the greenium for non-bank green bonds and the interaction term both lose statistical significance, though the banking sector dummy remains significant.

Table 8 Model 5 regression summary

	1. Green × Banking	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green Bond (Non-Bank)	-0.589***	-0.437***	-0.084	-0.084
	(0.055)	(0.054)	(0.058)	(0.060)
Banking Sector (Non-Green)	-1.426***	-1.481***	-0.693***	-0.693***
	(0.021)	(0.023)	(0.121)	(0.126)
Green × Banking	0.580***	0.529***	0.107	0.107
	(0.081)	(0.080)	(0.076)	(0.082)
Log(Issue Amount)		-0.241***	-0.055**	-0.055**
		(0.007)	(0.017)	(0.017)
Log(Maturity)		-0.198***	0.272***	0.272***
		(0.019)	(0.057)	(0.065)
HY - IG Spread		0.107***	0.035	0.035
		(0.021)	(0.049)	(0.071)
HY Spread × Rating		0.021***	0.034***	0.034***
		(0.001)	(0.004)	(0.006)
Yield Curve Level		-0.079***	-0.239***	-0.239***
		(0.005)	(0.044)	(0.061)
Yield Curve Slope		0.276***	0.410***	0.410*
		(0.031)	(0.120)	(0.169)
Yield Curve Curvature		0.506***	0.369+	0.369
		(0.089)	(0.215)	(0.241)
30-day Volatility		1.000	3.369*	3.369*
		(0.829)	(1.343)	(1.564)
Level × Callable		0.022***	0.024*	0.024*
		(0.007)	(0.011)	(0.011)
Slope × Callable		-0.139**	-0.057	-0.057
		(0.053)	(0.064)	(0.062)
Curvature × Callable		0.204	-0.145	-0.145
		(0.156)	(0.156)	(0.156)
Volatility × Callable		2.518***	-0.054	-0.054
		(0.528)	(1.326)	(1.259)
Num.Obs.	20866	20120	20120	20120
R2	0.185	0.254	0.801	0.801
R2 Adj.	0.185	0.254	0.777	0.777
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6.6 Summary

The regression analysis reveals statistically significant coefficients in several model specifications. However, a consistent pattern emerges across all models: as additional control variables are introduced, particularly ultimate parent fixed effects, bond structural characteristics, and time fixed effects, the negative coefficient on the green bond indicator consistently loses statistical significance. Table 4 demonstrates well the loss of statistical significance in specification 7, once the ultimate parent fixed effects are included. We observe similar types of loss in statistical significance in the models including post-SFDR period, CBI-alignment, SPOs and banking sector issuers. A significant improvement in model fit in the models, seen in the increased value of R-squared after including issuer fixed effects underscores the importance of including issuer-specific factors in explaining yield spread variation.

These results indicate that the initial statistically significant coefficients are likely driven by differences in the issuer characteristics, bond features and timing, rather than systematic pricing premium for green bonds. The results support that the null hypothesis cannot be rejected for any of the statistical hypothesis.

6.7 Subsample robustness check

As stated in section 4.1.1, yield spreads for the full sample are self-calculated due to the limited availability of bond yield data. However, from the complete dataset comprising 20 866 individual bonds, yield at issuance data was available for a subsample of 6471 bonds from Refinitiv Workspace database. To assess whether the self-calculated yields affects the regression outcomes, I re-estimate the same regression models using this subsample of 6471 bonds for which yield data was directly retrieved from Refinitiv Workspace. This comparison allows for an evaluation of the robustness of the outcomes and to identify whether there are discrepancies between the self-calculated yields and those directly reported in the database. Table 9 presents the distribution of bonds in the subsample.

Table 9 Number of bonds per category in the subsample

Description	Number of bonds
Total Bonds	6471
Green Bonds	803
Total Post-SFDR Bonds	3342
Green Bonds Post-SFDR	570
CBI-Aligned Green Bonds	614
Green Bonds with SPO	803
Total Bank-issued Bonds	1923
Green Bonds by Banks	188

6.8 Subsample vs. full sample

The regression results for the subsample analysis, presented in Appendix 2, reveal that the green bond coefficients in the subsample baseline models (specifications 1–6) are generally more statistically significant and indicate a stronger negative greenium compared to the full sample results in Table 4. However, in both the subsample and full sample, the statistical significance of the greenium disappears once issuer-, bond-, and time-specific fixed effects are included.

In the post-SFDR models, green bond coefficients in the post-regulation period are positive across both samples, but statistically significant only in the full sample's specifications (1) and (2). As additional controls are introduced, these coefficients become statistically insignificant, indicating that the observed differences are absorbed by firm-level and temporal factors.

In the regressions including the CBI-alignment indicator, the coefficients for CBI-aligned bonds are consistently negative across all specifications. The key difference between the full sample and the subsample lies in statistical significance: while the CBI effect becomes insignificant in the fully controlled full-sample model, it remains statistically significant at the 5% level in the subsample. The subsample results indicate that CBI-aligned green bonds are priced approximately 14.7 basis points lower.

Comparing the SPO models, there do not appear to be notable differences between the subsample and full sample. Across both samples, the green bond indicator becomes statistically insignificant once fixed effects (issuer, bond structure, and time) are included, confirming the trend seen in other robustness checks.

The regressions results incorporating banking sector interactions. In both the full and subsample the coefficients for green bonds issued by non-banks in specifications (1) and (2) are statistically significantly negative. However, this effect disappears in the specifications (3) and (4) with the fully controlled models once issuer- and bond-level fixed effects are included. In contrast, bonds issued by banks (non-green) consistently show large negative coefficients in both samples, suggesting lower spreads for banks generally. However, the interaction term Green × Banking is significantly positive in early models, indicating that the greenium is smaller or even absent for green bonds issued by banks. In fact, in the subsample, the interaction coefficient is +41.7 bps in model specification 2 and remains marginally significant (10% level) even in the fully clustered model, with a coefficient of +10 basis points.

In summary, the results from the subsample largely align with those of the full sample. After controlling for key explanatory variables, no statistically significant difference in pricing is observed between green bonds and their conventional counterparts. While the subsample does show a statistically significant negative premium for green bonds aligned with the CBI standard, and a statistically significant positive greenium for bank-issued green bonds, these findings are not statistically significant across the full sample and therefore do not provide conclusive evidence of systematic pricing differences.

7 DISCUSSION

This thesis set out to analyse the existence of greenium in the euro-denominated corporate primary bond market, and whether regulation, standard alignment, external verification and issuer type influence the yield spreads.

To address the first research question: *Is there a greenium in the corporate euro-denominated primary bond market?* The panel fixed effects regressions in Table 4, examining differences in yield spreads within the full green bond sample, showed no consistent evidence of a greenium particularly after controlling for firm characteristics, bond-specific features, and time fixed effects. The results are robust even in the subsample regression results (Appendix 2, Baseline regression), where the early models suggest a statistically significant greenium, which disappears when full model specification is applied. The statistical null hypothesis cannot be rejected, since there is not enough evidence that green bonds are issued with lower spread than conventional non-green bonds. These results are in line with existing literature (Tang & Zhang, 2020; Larcker & Watts, 2019; Wu, 2022) finding no significant greenium in primary bond markets. The results in the baseline model showed similar findings to Tang and Zhang (2020) who also observed small signs of negative greenium, which disappeared when accounting for issuer and time specific heterogeneity.

To answer the second research question: *Does regulation have an impact on greenium in the corporate euro-denominated primary bond market?* The analysis tested whether the introduction of the Sustainable Finance Disclosure Regulation (SFDR) affected pricing differences between green and non-green bonds. This was done by including a dummy variable for bonds issued after the regulation came into effect in March 2021. The regression results from both the full sample and the subsample show no consistent evidence of statistically significant pricing differences following the implementation of SFDR. Consequently, the null hypothesis could not be rejected. These findings differ from those of Caramichael and Rapp (2024), who found evidence of a negative greenium after the SFDR's adoption date on April 18, 2019. However, even in their study, the observed premium disappeared once issuer-specific dynamics were accounted for. They also noted the lack of sufficient evidence to establish a causal link between the regulation and the greenium. It is important to highlight two key distinctions between the studies. First, Caramichael and Rapp (2024) measured the regulatory impact from the adoption date in 2019, whereas this study uses March 2021, when the SFDR formally took effect. Second, the present study covers a longer time horizon, extending through 2025, while

Caramichael and Rapp focused only on the immediate years following the regulation's adoption, years that coincided with a sharp increase in green bond issuance. These differences in methodological timing and sample scope may explain the divergence in findings.

To answer the third research question: *Does standard alignment and external verification influence the existence of greenium in the corporate euro-denominated primary bond market?*

Firstly, the effect of standard alignment was assessed using a dummy variable indicating whether a green bond was aligned with the Climate Bonds Initiative (CBI) standards. In the full sample analysis, the coefficient for CBI-aligned green bonds was consistently negative, suggesting a potential pricing advantage. However, the effect lost statistical significance once firm-, bond-, and time-specific controls were applied. In contrast, the subsample analysis, limited to bonds with available yield data, showed a statistically significant negative coefficient, indicating that CBI-aligned green bonds were associated with yield spreads approximately 14.7 basis points lower, significant at the 5% level, even after controlling for issuer and bond characteristics.

These findings from the subsample suggest that CBI alignment may enhance investor confidence and reduce the cost of debt for issuers, implying that some investors may be willing to accept lower yields in exchange for credible environmental signaling. However, as the subsample covers only about one-quarter of the full dataset and includes only bonds with complete yield information, the results cannot be generalized with certainty. Given the absence of consistent significance in the full sample, the null hypothesis cannot be rejected, and no robust evidence is found that standard alignment systematically affects the existence or magnitude of greenium in the broader market.

Secondly, the effect of external verification was examined through a dummy variable for bonds that received a Second Party Opinion (SPO). The regression results from the full sample analysis showed no statistically significant effect of SPOs on yield spreads under the full model specification. These findings remained consistent in the subsample analysis. Thus, there is no evidence that external verification through SPOs influences pricing in the primary market, and the null hypothesis could not be rejected.

Finally, this study aimed to answer the fourth research question: *Is there a difference in greenium between green bonds issued by banks and non-bank corporates in the euro-*

denominated primary bond market? To analyse this, an interaction term between green bond status and bank issuer was included in the regression model.

The results from the regressions show positive coefficient for bank issued green bonds, suggesting that bank issued green bonds are on average priced higher than non-bank green bonds. There is however no statistical significance for the full model specification in the full sample model, while in the subsample model the coefficients remain statistically significant on a 10 % level with indicating a + 10 bps positive greenium for bank-issued bonds. However, due to the limited scope of the subsample and the lack of significance in the full sample, the evidence is not strong enough to conclusively reject the null hypothesis of no difference in greenium by issuer type.

In both the full and subsample regressions, the Green × Banking interaction term was positive, indicating that green bonds issued by banks are, on average, associated with higher yield spreads compared to green bonds issued by non-bank corporates. However, statistical significance varies by model specification. In the full sample, the Green × Banking interaction is statistically significant in early models, indicating a greenium of +53 to +58 basis points, but loses significance in the fully specified model, where the coefficient remains +10.7 basis points. Similarly, in the subsample, the interaction term is significant in initial models (+37.5 to +41.7 basis points) and remains +10.0 basis points, marginally significant at the 10% level in the final model.

Overall, these results suggest that green bonds issued by banks are priced less favorably compared to those issued by non-bank corporates, but the strength and robustness of this relationship depends on model specification. While the subsample results provide some weak evidence of a pricing difference by issuer type, the lack of consistent significance in the full sample implies that the null hypothesis cannot be conclusively rejected. The findings contrast with Caramichael and Rapp (2024), who found significant negative greenium for bank issued bonds, arguing that this could be potentially linked to banks regulatory preparedness and certification credibility. However, the results in this analysis are more aligned with Fatica et al. (2020), who found no pricing benefit for financial institutions, likely due to the opacity of indirect green financing.

Given the prominent role banks play as both issuers and intermediaries in the green bond market, these findings underscore the complexity of investor perception. Investors may be more cautious toward bank-issued green bonds due to the difficulty in tracing proceeds to specific, tangible green projects, which can undermine the perceived credibility of their environmental impact. In conclusion, while banks are central to the allocation of green capital, this analysis does not find robust evidence that they are systematically rewarded with a greenium, and the statistical null hypothesis cannot be rejected.

In conclusion, this analysis does not find robust or consistent evidence of greenium in the euro-denominated corporate primary bond market, particularly when controlling for firm- and bond-specific heterogeneity.

The findings suggest that investors are not willing to forgo yield for environmental preferences and simultaneously issuers are not systematically able to reduce their cost of debt. Although, the signaling theory and asymmetric information remain relevant. When issuing green bonds, transparency efforts such as CBI alignment and external verification may still function as strategic signal of environmental commitment, even if this does not directly reflect in lower yield spreads. It is still possible that such signals are priced in the secondary bond markets more evidently, supported by findings from (Zerbib, 2019; Partridge and Medda, 2019) or in equity markets, as seen in (Tang and Zhang, 2020).

Additionally, other potential benefits of green bond issuance have been highlighted in previous literature. Flammer (2021) finds that issuing green bonds can lead to improvements in firms' environmental performance. Moreover, green bond issuance may help broaden the investor base by attracting capital from investors with environmental preferences (Tang and Zhang, 2020; Baker et al., 2018). These strategic and reputational benefits may over time, enhance firm value, even if such effects are not immediately reflected in primary bond market pricing.

8 CONCLUSION

This thesis explored the existence of greenium in the euro-denominated corporate primary bond market, focusing on whether yield spreads differ systematically between green and conventional bonds. In addition, it examined the role of regulation and transparency efforts such as standard alignment and external review, as well as issuer type, specifically comparing bank and non-bank issuers, influencing the presence of greenium.

To answer these questions, fixed effects panel regressions were conducted on a dataset on euro-denominated bonds, using both a full sample and a more limited subsample with available yield data directly accessible from Refinitiv Workspace. The results across all model specifications showed no consistent or robust evidence of greenium, particularly when issuer-, bond-, and time-specific heterogeneity was accounted for. The results from this analysis are in line with findings from previous studies such as Tang and Zhang (2020), Larcker and Watts (2019), and Wu (2022), all of which found limited or no pricing advantage for green bonds in the primary market. While the results are not in line with findings of greenium such as Zerbib (2019), Caramichael and Rapp (2024), or Baker et al. (2018), these differences may be attributed to variations in market segments, methodological approaches, time horizons, or regional focus.

More broadly, these findings contribute to the ongoing debate on whether green bonds deliver tangible financial advantages to issuers. Although the results do not point to an immediate pricing benefit, they do not rule out other long-term or reputational gains. There are a few limitations that should be acknowledged. First, due to the lack of access to yield data, yields for the sample had to be self-calculated, increasing the risk of estimation errors. However, the subsample results were largely consistent with those of the full sample, which supports the robustness of the calculated yields. Second, the dataset is limited to euro-denominated corporate bonds, which constrains the generalizability of the findings across other currencies, regions, and issuer types, such as municipalities and sovereigns. Third, the scope of data is restricted to publicly available bond data and does not consider issuer specific ESG performance, investor preferences or supply/demand factors in the bond market, which are all variables that may play a role in the result outcome.

Despite the limitations, the thesis contributes to the existing literature with an emphasis on the euro-denominated primary bond market, which has received comparatively less attention in the research space. Also, unlike many other studies relying heavily on data from the early years of the green bond market, this thesis covers an extended and more recent time period that includes the implementation of the Sustainable Finance Disclosure Regulation (SFDR), allowing for an updated assessment of regulatory impacts. By incorporating issuer heterogeneity and evaluating transparency mechanisms such as CBI alignment and Second Party Opinions, the analysis offers a more nuanced view of the factors that may influence pricing in today's more mature and regulated green bond environment.

For future research, it would be particularly interesting to explore demand-side factors, such as investor mandates, ESG preferences and fund flows and how they shape the green bond pricing. Moreover, as the regulatory frameworks EU taxonomy and European Green Bond Standard continue to take shape, future studies could assess whether these initiatives help reduce information asymmetries and enhance the credibility of green bond labels and ultimately influence the pricing in the primary bond market.

REFERENCES

Alamgir, M., & Cheng, M.-C. (2023). Do green bonds play a role in achieving sustainability? *Sustainability, 15*(13), 10177. https://doi.org/10.3390/su151310177

Bachelet, M. J., Becchetti, L., & Manfredonia, S. (2019). The green bonds premium puzzle: The role of issuer characteristics and third-party verification. *Sustainability, 11*(4), 1098. https://doi.org/10.3390/su11041098

Baker, M., Bergstresser, D., Serafeim, G., & Wurgler, J. (2022). The pricing and ownership of US green bonds. *Annual Review of Financial Economics, 14*(1). https://doi.org/10.1146/annurev-financial-111620-014802

Baker, M. P., Bergstresser, D. B., Serafeim, G., & Wurgler, J. A. (2018). Financing the response to climate change: The pricing and ownership of U.S. green bonds. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3275327

Berk, J. B., & DeMarzo, P. M. (2017). *Corporate* finance (4th global ed.). Pearson.

Bloomberg L.P. (2025). *Annual issuance volume for euro denominated bonds*. Bloomberg Terminal.

Deutsche Bundesbank. (2025). *Time series database*. https://www.bundesbank.de/

Caramichael, J., & Rapp, A. C. (2024). The green corporate bond issuance premium. *Journal of Banking & Finance, 162*, 107126. https://doi.org/10.1016/j.jbankfin.2024.107126

ChatGPT. (n.d.). *AI assistant*. OpenAI. Retrieved March 10, 2025, from https://chat.openai.com

Climate Bonds Initiative. (2014). *External review*. https://www.climatebonds.net/market/second-opinion

Climate Bonds Initiative. (2019). *Explaining green bonds*. https://www.climatebonds.net/market/explaining-green-bonds

Climate Bonds Initiative. (2023). *The Standard*. https://www.climatebonds.net/standard/the-standard

European Central Bank. (2019). *Introduction*. https://www.ecb.europa.eu/mopo/intro/html/index.en.html

European Commission. (2023). *Sustainability-related disclosure in the financial services sector*. https://finance.ec.europa.eu/sustainable-finance/disclosures/sustainability-related-disclosure-financial-services-sector_en

European Parliament, & Council of the European Union. (2019). *Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector. Official Journal of the European Union, L 317*, 1–16. https://eur-lex.europa.eu/eli/reg/2019/2088/oj/eng

Fabozzi, F. J. (2005). *The handbook of fixed income securities*. McGraw Hill Professional.

Fatica, S., Panzica, R., & Rancan, M. (2020). The Pricing of Green Bonds: Are Financial Institutions Special? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3623146

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics, 142*(2), 499–516. https://doi.org/10.1016/j.jfineco.2021.01.010

Freixas, X., & Rochet, J.-C. (2008). *Microeconomics of banking*. MIT Press.

Goldstein, M. A., Hotchkiss, E. S., & Pedersen, D. J. (2019). Secondary market liquidity and primary market pricing of corporate bonds. *Journal of Risk and Financial Management, 12*(2), 86. https://doi.org/10.3390/jrfm12020086

H Kent Baker, Filbeck, G., & Spieler, A. C. (2019). *Debt markets and investments*. Oxford University Press.

ICMA. (2021). *Green Bond Principles: Voluntary process guidelines for issuing green bonds*. International Capital Market Association. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/

KPMG. (2015). *Gearing up for green bonds*. https://assets.kpmg.com/content/dam/kpmg/pdf/2015/03/gearing-up-for-green-bonds-v1.pdf

Larcker, D. F., & Watts, E. (2019). Where's the greenium? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3333847

Liu, W. (2006). A liquidity-augmented capital asset pricing model. *Journal of Financial Economics, 82*(3), 631–671. https://doi.org/10.1016/j.jfineco.2005.10.001

Lu, C.-W., Chen, T.-K., & Liao, H.-H. (2010). Information uncertainty, information asymmetry and corporate bond yield spreads. *Journal of Banking & Finance, 34*(9), 2265–2279. https://doi.org/10.1016/j.jbankfin.2010.02.013

MacAskill, S., Roca, E., Liu, B., Stewart, R. A., & Sahin, O. (2020). Is there a green premium in the green bond market? Systematic literature review revealing premium determinants. *Journal of Cleaner Production, 280*(2), 124491. https://doi.org/10.1016/j.jclepro.2020.124491

OECD. (2024). *Global debt report 2024: Bond markets in a high-debt environment*. OECD Publishing.

Partridge, C., & Medda, F. R. (2019). The evolution of pricing performance of green municipal bonds. *Journal of Sustainable Finance & Investment, 10*(1), 1–21. https://doi.org/10.1080/20430795.2019.1661187

Shurey, D. (2017). Investors are willing to pay a 'green' premium. *Bloomberg New Energy Finance Note, 1*(8).

Spglobal.com. (2024). *Sustainability insights research: Sustainable bond issuance to approach $1 trillion in 2024*. https://www.spglobal.com/ratings/en/research/pdf-articles/240213-sustainability-insights-research-sustainable-bond-issuance-to-approach-1-trillion-in-2024-101593071

Stolper, A. (2009). Regulation of credit rating agencies. *Journal of Banking & Finance, 33*(7), 1266–1273. https://doi.org/10.1016/j.jbankfin.2009.01.004

Stlouisfed.org. (2025). *ICE BofA Euro High Yield Index Option-Adjusted Spread*. Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/BAMLHE00EHYIOAS

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance, 61*, 101427. https://doi.org/10.1016/j.jcorpfin.2018.12.001

UNCTAD. (2014). *World investment report 2014: Investing in the SDGs – An action plan*. United Nations Conference on Trade and Development. https://unctad.org/system/files/official-document/wir2014_en.pdf

UNEP et al. (2016). *Green finance – A growing imperative*. http://unepinquiry.org/wp-content/uploads/2016/05/Green_Finance_A_Growing_Imperative.pdf

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. https://sdgs.un.org/2030agenda

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

World Bank. (2015). *What are green bonds?* https://www.worldbank.org/en/news/feature/2015/01/22/what-are-green-bonds

Wu, O. Y. (2022). Are green bonds priced lower than their conventional peers? *Emerging Markets Review*, 100909. https://doi.org/10.1016/j.ememar.2022.100909

Xu, M., Tse, Y. K., Geng, R., Liu, Z., & Potter, A. (2025). Greenwashing and market value of firms: An empirical study. *International Journal of Production Economics, 284*, 109606. https://doi.org/10.1016/j.ijpe.2025.109606

Zhang, R., Li, Y., & Liu, Y. (2021). Green bond issuance and corporate cost of capital. *Pacific-Basin Finance Journal, 69*(101626), 101626. https://doi.org/10.1016/j.pacfin.2021.101626

APPENDIX 1 MODEL DIAGNOSTIC TEST RESULTS

Test	Statistic	P-value	Null Hypothesis (H_0)
Durbin-Watson Test	DW = 1.6664	< 2.2e-16	No autocorrelation
Breusch-Pagan Test	BP = 1119.5, df = 13	< 2.2e-16	Homoskedasticity
Wooldridge Test (FE panel)	F = 55.98, df = (1, 18084)	< 7.66e-16	No serial correlation
Shapiro-Wilk Test (residuals)	W = 0.77735	< 2.2e-16	Residuals are normally distributed
VIF Test	All VIF < 4	—	No severe multicollinearity

APPENDIX 2 SUBSAMPLE REGRESSION RESULTS

	1. Green Only	2. + Size & Maturity	3. + Credit Spreads	4. + Yield Curve	5. + Volatility	6. + Interactions	7. + Issuer FE	8. + Bond Structure FE	9. + Time FE	10. + Clustered SEs
Green	-0.102+	-0.121*	-0.170***	-0.139**	-0.139**	-0.140**	-0.005	0.007	0.005	0.005
	(0.052)	(0.052)	(0.050)	(0.051)	(0.051)	(0.049)	(0.041)	(0.034)	(0.033)	(0.031)
Log (Issue Amount)		0.069***	-0.032*	-0.036**	-0.036**	-0.096***	0.046***	0.044**	0.043**	0.043**
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.015)	(0.015)
Log (Maturity)		-0.116**	-0.317***	-0.357***	-0.356***	-0.442***	0.334***	0.338***	0.342***	0.342***
		(0.038)	(0.038)	(0.038)	(0.038)	(0.037)	(0.034)	(0.034)	(0.033)	(0.034)
HY - IG Spread			0.056*	0.079**	0.063+	0.086*	0.460***	0.382***	0.136	0.136*
			(0.027)	(0.030)	(0.035)	(0.034)	(0.031)	(0.039)	(0.089)	(0.066)
HY Spread × Rating			0.036***	0.038***	0.038***	0.033***	0.003+	0.023***	0.020***	0.020***
			(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.005)	(0.004)	(0.005)
Yield Curve Level				-0.029***	-0.034***	0.046***	0.043***	0.048***	0.020	0.020
				(0.005)	(0.008)	(0.010)	(0.006)	(0.007)	(0.060)	(0.069)
Yield Curve Slope				0.058	0.071	-0.075	-0.032	0.006	0.661***	0.661**
				(0.043)	(0.045)	(0.063)	(0.033)	(0.033)	(0.183)	(0.203)
Yield Curve Curvature				0.412**	0.460**	-0.389*	0.190+	0.143	0.769+	0.769
				(0.137)	(0.148)	(0.196)	(0.112)	(0.124)	(0.402)	(0.463)
30-day Volatility					1.289	-6.918***	2.017*	2.806**	2.964+	2.964
					(1.490)	(1.495)	(0.996)	(0.973)	(1.723)	(2.642)
Level × Callable						-0.134***	-0.033***	-0.031**	-0.029**	-0.029**
						(0.010)	(0.008)	(0.010)	(0.009)	(0.011)
Slope × Callable						0.147+	-0.086	-0.091	-0.100+	-0.100
						(0.083)	(0.058)	(0.061)	(0.059)	(0.065)
Curvature × Callable						1.729***	0.132	0.159	0.184	0.184
						(0.243)	(0.170)	(0.196)	(0.180)	(0.194)
Volatility × Callable						14.144***	2.420*	1.156	0.920	0.920
						(0.770)	(0.946)	(1.485)	(1.445)	(1.836)
Num. Obs.	6471	6471	6295	6295	6295	6295	6295	6295	6295	6295
R2	0.001	0.006	0.104	0.110	0.110	0.171	0.876	0.891	0.898	0.898
R2 Adj.	0.000	0.006	0.104	0.109	0.109	0.169	0.848	0.865	0.872	0.872
R2 Within							0.282	0.301	0.084	0.084
R2 Within Adj.							0.280	0.300	0.082	0.082
RMSE							0.49	0.46	0.44	0.44
FE: Ultimate_Parent							X	X	X	X
FE: rating								X	X	X
FE: Seniority								X	X	X
FE: Callable								X	X	X
FE: ym									X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

	1. Green + PostSFDR	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green	-0.171+	-0.209*	-0.054	-0.054
	(0.094)	(0.086)	(0.046)	(0.043)
Post-SFDR Period	-0.046	-0.139**	0.182+	0.182*
	(0.037)	(0.051)	(0.108)	(0.074)
Green × post-SFDR	0.113	0.119	0.089	0.089
	(0.113)	(0.104)	(0.057)	(0.055)
Log (Issue Amount)		-0.098***	0.043**	0.043**
		(0.013)	(0.014)	(0.015)
Log (Maturity)		-0.447***	0.340***	0.340***
		(0.037)	(0.033)	(0.034)
HY - IG Spread		0.052	0.138	0.138*
		(0.036)	(0.089)	(0.066)
HY Spread × Rating		0.033***	0.020***	0.020***
		(0.001)	(0.004)	(0.005)
Yield Curve Level		0.059***	0.020	0.020
		(0.011)	(0.060)	(0.069)
Yield Curve Slope		-0.071	0.663***	0.663**
		(0.064)	(0.183)	(0.203)
Yield Curve Curvature		-0.553**	0.746+	0.746
		(0.205)	(0.402)	(0.464)
30-day Volatility		-6.584***	3.082+	3.082
		(1.499)	(1.729)	(2.651)
Level × Callable		-0.136***	-0.029**	-0.029**
		(0.010)	(0.009)	(0.011)
Slope × Callable		0.142+	-0.102+	-0.102
		(0.083)	(0.059)	(0.065)
Curvature × Callable		1.772***	0.180	0.180
		(0.243)	(0.181)	(0.195)
Volatility × Callable		14.231***	0.864	0.864
		(0.771)	(1.447)	(1.843)
Num.Obs.	6471	6295	6295	6295
R2	0.001	0.172	0.898	0.898
R2 Adj.	0.000	0.170	0.872	0.872
R2 Within			0.086	0.086
R2 Within Adj.			0.083	0.083
AIC	22504.6	20773.5	10125.0	10125.0
BIC	22531.7	20881.5	18741.6	18741.6
RMSE			0.44	0.44
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

	1. Green + CBI	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green (Not CBI-Aligned)	0.128	0.141	0.122*	0.122*
	(0.102)	(0.097)	(0.054)	(0.050)
CBI-Aligned	-0.301**	-0.363***	-0.147**	-0.147**
	(0.114)	(0.108)	(0.055)	(0.053)
Log (Issue Amount)		-0.095***	0.044**	0.044**
		(0.013)	(0.014)	(0.015)
Log (Maturity)		-0.442***	0.341***	0.341***
		(0.037)	(0.033)	(0.034)
HY - IG Spread		0.085*	0.133	0.133*
		(0.034)	(0.088)	(0.065)
HY Spread × Rating		0.033***	0.020***	0.020***
		(0.001)	(0.004)	(0.005)
Yield Curve Level		0.046***	0.025	0.025
		(0.010)	(0.060)	(0.069)
Yield Curve Slope		-0.075	0.676***	0.676**
		(0.063)	(0.183)	(0.202)
Yield Curve Curvature		-0.383+	0.797*	0.797+
		(0.196)	(0.400)	(0.459)
30-day Volatility		-6.889***	2.999+	2.999
		(1.493)	(1.726)	(2.616)
Level × Callable		-0.134***	-0.029**	-0.029*
		(0.010)	(0.009)	(0.011)
Slope × Callable		0.151+	-0.100+	-0.100
		(0.083)	(0.059)	(0.065)
Curvature × Callable		1.709***	0.177	0.177
		(0.243)	(0.180)	(0.194)
Volatility × Callable		14.114***	0.865	0.865
		(0.769)	(1.448)	(1.831)
Num.Obs.	6471	6295	6295	6295
R2	0.002	0.172	0.898	0.898
R2 Adj.	0.001	0.170	0.872	0.872
R2 Within			0.086	0.086
RMSE			0.44	0.44
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

	1. Green + SPO	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green	-0.088	-0.073	0.000	0.000
	(0.094)	(0.088)	(0.043)	(0.043)
SPO	0.130	0.060	0.017	0.017
	(0.094)	(0.090)	(0.061)	(0.068)
Green × SPO	-0.142	-0.150	-0.008	-0.008
	(0.144)	(0.135)	(0.072)	(0.078)
Log(Issue Amount)		-0.096***	0.043**	0.043**
		(0.013)	(0.014)	(0.015)
Log(Maturity)		-0.442***	0.341***	0.341***
		(0.037)	(0.033)	(0.033)
HY - IG Spread		0.089**	0.136	0.136*
		(0.034)	(0.089)	(0.066)
HY Spread × Rating		0.033***	0.020***	0.020***
		(0.001)	(0.004)	(0.005)
Yield Curve Level		0.047***	0.020	0.020
		(0.010)	(0.060)	(0.069)
Yield Curve Slope		-0.075	0.662***	0.662**
		(0.064)	(0.183)	(0.203)
Yield Curve Curvature		-0.389*	0.769+	0.769+
		(0.196)	(0.402)	(0.462)
30-day Volatility		-6.955***	2.961+	2.961
		(1.495)	(1.722)	(2.642)
Level × Callable		-0.134***	-0.029**	-0.029**
		(0.010)	(0.009)	(0.011)
Slope × Callable		0.148+	-0.101+	-0.101
		(0.083)	(0.059)	(0.065)
Curvature × Callable		1.736***	0.186	0.186
		(0.243)	(0.180)	(0.194)
Volatility × Callable		14.135***	0.925	0.925
		(0.770)	(1.444)	(1.834)
Num.Obs.	6471	6295	6295	6295
R2	0.001	0.171	0.898	0.898
R2 Adj.	0.000	0.169	0.872	0.872
R2 Within			0.084	0.084
R2 Within Adj.			0.082	0.082
AIC	22504.7	20780.1	10132.5	10132.5
BIC	22531.8	20888.1	18749.1	18749.1
RMSE	1,38	1,26	0.44	0.44
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

	1. Green × Banking	2. + Controls	3. + Fixed Effects	4. + Clustered SEs
Green Bond (Non-Bank)	-0.253***	-0.246***	-0.032	-0.032
	(0.057)	(0.055)	(0.043)	(0.037)
Banking Sector (Non-Green)	-0.889***	-0.664***	-0.202	-0.202
	(0.038)	(0.047)	(0.126)	(0.125)
Green × Banking	0.375**	0.417***	0.100+	0.100+
	(0.116)	(0.113)	(0.058)	(0.058)
Log(Issue Amount)		-0.157***	0.040**	0.040*
		(0.013)	(0.015)	(0.015)
Log(Maturity)		-0.421***	0.346***	0.346***
		(0.037)	(0.032)	(0.032)
HY - IG Spread		0.086**	0.135	0.135*
		(0.033)	(0.091)	(0.067)
HY Spread × Rating		0.033***	0.020***	0.020***
		(0.001)	(0.004)	(0.005)
Yield Curve Level		0.031**	0.020	0.020
		(0.010)	(0.061)	(0.068)
Yield Curve Slope		-0.027	0.678***	0.678**
		(0.063)	(0.182)	(0.203)
Yield Curve Curvature		-0.225	0.800*	0.800+
		(0.193)	(0.403)	(0.454)
30-day Volatility		-3.544*	3.143+	3.143
		(1.491)	(1.770)	(2.632)
Level × Callable		-0.103***	-0.028**	-0.028*
		(0.010)	(0.009)	(0.011)
Slope × Callable		0.054	-0.101+	-0.101
		(0.082)	(0.059)	(0.064)
Curvature × Callable		1.299***	0.165	0.165
		(0.241)	(0.178)	(0.190)
Volatility × Callable		7.734***	0.826	0.826
		(0.896)	(1.442)	(1.797)
Num.Obs.	6471	6295	6295	6295
R2	0.081	0.196	0.898	0.898
R2 Adj.	0.081	0.194	0.872	0.872
R2 Within			0.088	0.088
R2 Within Adj.			0.085	0.085
AIC	21961.9	20584.4	10107.7	10107.7
BIC	21989.0	20692.4	18724.3	18724.3
RMSE			0.44	0.44
Std.Errors	IID	IID	by: Ultimate_Parent	by: Ultimate_Parent & ym
FE: Seniority			X	X
FE: Callable			X	X
FE: Ultimate_Parent			X	X
FE: rating			X	X
FE: ym			X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001