OPEN ACCESS
Journal of Financial Management, Markets and Institutions
Vol. 13, No. 2 (2025) 2550007 (29 pages)

DOI: 10.1142/S2282717X25500070

World Scientific
www.worldscientific.com

BANK GREEN TRANSITION OR GREENWASHING? HOW TRULY GREEN ARE THE PROJECTS FINANCED BY GREEN BONDS ISSUED BY EUROPEAN BANKS?

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Received 21 May 2025
Revised 20 October 2025
Accepted 18 November 2025
Published 22 December 2025

Banks play a pivotal role in supporting the real economy throughout the transition toward a more environmentally sustainable model. Among the initiatives available to them, the issuance of green bonds represents a concrete means of demonstrating a commitment to sustainable finance. However, for such initiatives to be credible, banks must ensure that green bond issuance translates into measurable and timely improvements in their environmental performance. This research stems from the skepticism around banks issuing green bonds, as a result of which they may not benefit from a greenium (a premium on the yield of green bonds in favor of the issuer), perhaps because they are not perceived by investors as reliable in implementing green projects. Consequently, investors may perceive the "environmental benefit" and allocation of bond proceeds as less direct and transparent, and the impact of green bank bonds as reduced. The findings document that the ESG score (comprehensive and per pillar), the GHG Scope 1, Scope 2 and Scope 3 emissions, as well as the alignment with the climate-related SDGs (SDG-7 and SDG-13), exert a negative, statistically significant impact on the yield. In contrast, the green bond label and the number of SDGs have a positive, statistically significant effect on bond yields. This indicates that the green bond label or the alignment with the SDGs that are not relevant to green projects do not convince investors to accept lower returns, whereas more specific or relevant indicators do.

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Keywords: Green bond; Greenium; Sustainable Development Goals (SDGs); Environmental, Social, Governance (ESG); Greenhouse Gas (GHG) scope 1, scope 2, scope 3; UN responsible bank.

1. Introduction

Green bonds (GBs) are bonds whose proceeds are used to finance or refinance, in part or in full, new and/or existing green projects. They appeal to certain candidate issuers and investors. In particular, issuers that undertake projects aiming at environmental sustainability may choose to issue green bonds. In such a way, they can attract long-term funding for the projects that qualify. At the same time, investors with a more responsible — sustainable profile, who tend to scrutinize the use of the capital they offer, may select to invest in green bonds (Wacker *et al.* 2020, Poufinas 2022).

In general, bonds and related projects are labelled as "green" if they comply with the ICMA Green Bond Principles (ICMA 2018, Rose 2019) or the European Green Bond Standard (EU Regulation 2023/2631). Prior to the entry into force of the latter regulation (also called EuGB Regulation), the regulatory framework was largely non-binding and market-driven, with no formal European framework. The EuGB Regulation is a voluntary standard that is part of the broader sustainable finance framework that includes the Taxonomy Regulation. One of the main objectives of the EuGB Regulation is to reduce greenwashing and ensure that bonds marketed as green actually meet rigorous and comparable standards. Most of the provisions of this regulation came into force on 21 December 2024, but some issuers are still adopting the ICMA' Principles, instead of the "European green bond" label, because the requirements for alignment with the Taxonomy Regulation seem difficult and costly to meet.

In the absence of a binding European regulation, green bonds have gained popularity over the last decade as they are perceived as instruments that support sustainable and climate-friendly objectives and, as such, are used for a positive purpose (Ehlers & Packer 2017). Furthermore, the European Union's Green Deal and similar initiatives in other countries (e.g. Canada, the United Kingdom, etc.) have encouraged the allocation of pandemic recovery funds to companies that have adopted climate and environmentally friendly practices or even activities, with the aim of achieving a green transition (Wacker *et al.* 2020, Poufinas 2022). This popularity is reflected in the growth of green bond issuance; the cumulative volume has reached USD 2.8 trillion, whereas the new issues soared to USD 587.6 billion in 2023 (approximately +15% since 2022) (Climate Bonds Initiative 2024b). Green bonds issued worldwide by financial institutions account for 27.3% (28% in Europe) in 2023 of the total bond issuances, ranking the financial institutions second after corporate green bond issuers (Statista 2024a,b). This reflects the large contribution of banks to the green bond market.

Undoubtedly, banks — being among the most important and growing issuers of green bonds, akin to other corporations, may utilize green bonds predominantly to send a signal to investors regarding their commitment to the environment (Sangiorgi & Schopohl 2023, Daubanes *et al.* 2022, Flammer 2021). However, it is not so undeniable that the issuance of green bonds leads to notable and immediate enhancements in the environmental initiatives supported by banks. To dispel the notion of greenwashing, it would be imperative to demonstrate that after the issuance of green bonds, a decrease in the issuer's emissions score and/or a reduction in CO_2 emissions occurs, along with a decrease in lending to polluting sectors.

Consequently, a critical consideration concerns whether the issuance of green bonds by banking institutions constitutes a credible signal of a substantive commitment to the green transition or, alternatively, whether it is perceived in certain cases as a strategic exercise in greenwashing (Forbes 2021, Kellogg Insight 2021). In the case of a credible signal, the green label may be associated with a yield discount, accepted by investors who exhibit a strong preference for environmental objectives and are therefore willing to trade financial return for perceived environmental impact.

Considering that investors are consistently mindful of the risk of greenwashing, issuers usually opt for an external review of their green bonds to make them less worried. The review process can be in the form of a second-party opinion, verification, certification, and green bond scoring/rating, from the simplest to the most comprehensive (ICMA 2018, Regulation (EU) 2023/2631, Poufinas 2022). The process makes the issuance of green bonds more costly than conventional bonds due to expenses associated with external reviews documenting the bond's serious and genuine green purposes. In this way, investors are reassured about the alignment of the bond's proceeds with environmental objectives. In practice, independent external reviewers send a signal to investors that reduces asymmetric information and encourages them to disregard the possibility of greenwashing.

A relatively small number of firms offer services to independently assess, verify, or certify a bond's green bona fides. They include well-known rating firms, such as Moody's Investors Service, and specialized firms, such as Paris-Vigeo Eiris, Sustainalytics (based in Amsterdam), ISS-ESG, and Cicero, a division of a renowned Norwegian climate research institute, are key players in the field (Bloomberg 2019). Considering the sample of green bonds analyzed in this research, the list of external reviewers is provided in Table A.1 of Appendix A.

Banks tend to rely on external reviews more frequently than other corporate issuers. In fact, over 90% of green bonds issued by banks (in numerical terms) have been reviewed by third parties, while other corporate issuers only reach 66% (Flammer 2021).

Based on the above, the contribution of this paper lies in the recognition that, in the banking sector, the green label alone is not perceived as a reliable/sufficient indicator to justify a greenium. Therefore, the research aims to identify indicators that could lead to a greenium, as indicated in the literature for other economic sectors. More specifically, and this is the novelty, the document provides evidence that investors consider other characteristics of bonds and issuers as determining factors in assessing the concrete implementation of green projects proposed by the bank. These factors, if properly considered by the issuers, can lead to a greenium, i.e. a reduction in financing costs for the issuer. Finally, the research confirms that the presence of an external reviewer reduces information asymmetry between the investor and the issuer and helps to reduce the bond yield paid by the issuer. The paper also introduces a new element: the effect of external review becomes stronger as we move from second-party opinion providers to ESG agents, third-party certifiers and green bond auditors.

2. Literature Review

Corporate green bonds are financial instruments that respond to two joint but different objectives: the requirements of capital markets (for example: return, liquidity and investor confidence) and sustainability goals (for example: credibility, accountability and measurable impact). Their effectiveness depends on the degree to which they are perceived as both financially viable and environmentally genuine.

The literature has examined these two closely related objectives, often presenting a comparison between green bonds and traditional bonds from the same issuer.

One of the first aspects analyzed concerns the existence of a greenium, i.e. a lower return for investors who choose to allocate funds to green bonds not only for their financial returns, but also because they appreciate the environmental objectives pursued by these instruments (Cheong and Choi 2020, Chesini 2024). For example, Sangiorgi and Schopohl (2021) find that institutional investors are increasingly active in the green bond market, driven by considerations such as environmental impact and alignment with sustainability goals. Their survey of European asset managers revealed that a significant majority are actively investing in green bonds, with motivations ranging from ethical considerations to regulatory compliance, instead of simply return.

Among the numerous studies that have examined the premiums in the green bond market, several of these do not find any significant difference for green bonds, confirming that investors are not willing to pay a premium to acquire a green bond (Shishlov *et al.*, 2016). In this regard, Flammer (2021) demonstrates that the cost of capital argument, according to which companies would issue green bonds to benefit from a cheaper source of financing, is inconsistent (Apergis *et al.* 2023).

Several other studies emphasize the role of non-financial drivers to justify the existence of different yields between green and conventional bonds issued by the same issuer. Zerbib (2019) finds that green bond yields are on average 1–2 basis points lower than conventional bonds, reflecting investors' willingness to pay for green projects. Similarly, Löffler *et al.* (2021) demonstrate that green bond yields are a statistically significant 15–20 basis points lower than those of comparable conventional bonds. Hachenberg & Schiereck (2018) note that green bonds enjoy a demand-side advantage in secondary markets, which points to the strong interest of large asset managers and pension funds. In general, institutional investors play a dominant role in these analyses, while retail investors are less studied in the literature.

Consequently, considering that financial returns do not seem of utmost relevance in explaining the reasons behind investor demand for green bonds, the search for the motivations and assessments that drive investors toward these instruments has become an interesting topic in the literature. In general, investors face asymmetric information and are worried about greenwashing. Signaling theory plays a key role in explaining why companies issue green bonds and how investors interpret the "green credentials" of the issuing company (Luo and Lyu 2025). However, as Dryden and Pulieri (2025) note, inconsistent definitions and weak verification frameworks in green bond markets erode the instruments' credibility, increasing information asymmetries and complicating investors' efforts to reliably assess the environmental impact of bond proceeds.

The issuance of green bonds should reduce information asymmetry about a firm's environmental commitment and serve as a credible signal of a firm's environmental responsibility and long-term green strategy (Arhinful *et al.* 2025). This signal raises concerns about potential greenwashing, where the label "green" may not correspond to substantive environmental outcomes. Reboredo (2018) shows that while green bonds are weakly correlated with traditional financial markets, they do not necessarily provide significant environmental benefits beyond mere signaling.

To address greenwashing concerns, external reviews and, in particular, second-party opinions (SPOs) have become central. The issue of transparency in the use-of-proceeds reporting remains a major challenge. Shishlov *et al.* (2016) emphasize that the credibility of the green bond market hinges on transparent reporting and the role of independent reviewers. Recent studies investigate whether external verification improves pricing and investor confidence. Flammer (2021) found that bonds with an external review enjoy stronger investor demand and, in some cases, tighter spreads. However, SPOs are also subject to potential conflicts of interest, as they are paid by issuers.

According to Dorfleitner *et al.* (2022), investors reward corporate green bonds that are accompanied by positive external reviews with a premium in the sense of lower yields that issuers have to correspond to investors and higher bond prices. Mitchell *et al.* (2025) argue that the development of robust certification systems is critical for ensuring credibility and maintaining investor trust in green finance, but that there is still no globally consistent standard for SPO methodologies, leading to divergent verification practices among providers. In order to circumscribe who can be a third-party reviewer, a list of Approved Verifiers under the Climate Bonds Standard is posted by the Climate Bonds Initiative (2024a).

The relationship between external reviews and greenwashing remains a central concern in the green bond market. Zhu *et al.* (2023) show that third-party certification alone is insufficient to prevent greenwashing, as illustrated by the Chinese green bond market. They argue that certification mechanisms must be complemented by effective information disclosure and appropriate government incentives — such as tax deductions, financial subsidies, and priority approvals for verified issuers — to enhance credibility and distinguish genuinely green issuers from opportunistic ones. Similarly, Sheng *et al.* (2021) find that third-party verification significantly reduces information asymmetry and is associated with lower issuance costs for green bonds. Their results further suggest that verification, when supported by consistent governmental measures, can mitigate — though not fully eliminate — greenwashing behavior. In line with these findings, but with more optimistic findings, Bachelet *et al.* (2019) observe that third-party verification contributes to narrowing information asymmetries between issuers and investors, thereby facilitating financing conditions and reinforcing the market's confidence in the environmental credibility of green bonds.

In addition, Flammer (2020) shows that green bond issuance leads to significant improvements in both environmental performance and market reactions only when green bonds are certified by independent third parties. Finally, Allman and Lock (2024) find that while external reviews do not substantially affect the green bond premium on average, issuers domiciled in common law countries benefit more from external reviews, and funding costs tend to be lower when reviews come from more reputable external reviewers.

The literature reviewed so far has focused primarily on corporate green bonds, neglecting the distinctive characteristics of bank issuers, despite their strong involvement in the green bond market and the expectation that banks should actively contribute to the decarbonization of the economy. Surely, issuing a green bond represents a signal that the bank is committed to sustainability and this should reduce information asymmetry about a bank's environmental commitment (Gabr and Elbannan 2024). However, as mentioned, banks have the ability to issue green bonds to finance both their own internal projects and green lending initiatives requested by their clients. Furthermore, banks could invest in green projects, also issuing conventional bonds. Consequently, investors may perceive the proceeds allocation as even less transparent than other corporate green bonds and the "green" impact of bank bonds as reduced. There is a suspicion that banks issuing green bonds may not benefit from a greenium (a premium on the yield of green bonds in favor of the issuer), because they are not perceived as reliable in implementing green projects (Fatica *et al.* 2021).

This raises the first research question: How environmentally friendly are the green projects financed by green bonds issued by banks?

It is possible to observe that investors in bank green bonds often cannot directly observe whether an issuer's projects are truly sustainable. Thus, the greenium emerges as a market outcome showing how much asymmetric information has been reduced through credible commitments. If a greenium exists, it means that investors accept lower returns because they gain non-financial utility, in this case expressed by the investment of the proceeds to environmental projects (investor preference theory). On the contrary, if a greenium does not exist, or issuers must even pay investors a higher return, this suggests that information asymmetry remains unresolved or investors distrust the green label that characterized the bond issuance. In order to avert the risk that investors perceive a case of greenwashing, issuers should provide a more credible signal than the mere issuance of green debt. The signaling theory clearly explains why issuers have to resort to external reviewers to send a credible signal (also because it is expensive) (Zirek and Unsal 2023).

This raises the second research question: Do bank green bonds accompanied by some form of external review resolve information asymmetry issues and allow bank issuers to pay lower returns to investors?

To explain the behavior of the investors in green bond markets, the literature mentioned above has adopted different theories of investor preference for sustainability, the asymmetric information theory and the signaling theory, but these theories do not address other relevant aspects. Namely, what could concretely help issuers decrease the cost of debt (i.e. generate a greenium), if the green bond label isn't enough to convince investors and external reviewers don't fully solve the greenwashing problem.

This raises the third and most relevant research question: what factors can contribute to reducing the yield on green bonds for bank issuers and generating a greenium, as has been found in the literature for other issuers?

The issuance of green bonds by banks is of paramount importance, as it channels capital toward many different environmental sustainability and climate change mitigation projects. Appropriate incentives should be provided to encourage such issuance. When the proceeds of green bonds are genuinely targeted at environmentally beneficial projects and are perceived as credible by investors, they may command a greenium that reflects investors' reduced perception of information asymmetry and greater confidence in the issuer's environmental commitments. Certainly, in the absence of direct government support or subsidies, banks' motivation to issue green bonds must come solely from market-based incentives, such as the greenium. This price advantage is a key lever for promoting sustainable finance in the banking sector.

The present study fills a gap in the literature by indicating that investors value other information beyond the simple "green" label, which, if properly considered by bank issuers, can help reduce their borrowing costs.

3. Data and Variables

This research seeks to undertake a comprehensive analysis of the determinants of bank green bond yields, with particular attention to the relationship between green bond issuance and the environmental performance of the issuing banks. As an initial step, the study examines the yield differential between green bonds and their conventional counterparts. The presence of a yield premium or discount, commonly referred to as the "greenium", is interpreted in light of the prevailing theoretical frameworks and empirical findings in the existing literature.

To this end, two datasets of European bank bonds (green and conventional) from Bloomberg's fixed-income database are compiled (Bloomberg 2020). Other studies that use Bloomberg as a source of data on green bonds include Flammer (2021) and Tang and Zhang (2020).

The datasets cover the bank issuances from 2013 to 2023. There are no green bank bonds before 2013 in the Bloomberg database. The dataset includes 4,821 conventional bonds and 720 green bonds issued by European banks.

The dependent variable in the model is the yield to maturity at the time of issuance (YLD_YTM_MID). Other bond-specific variables are extracted from the Bloomberg database and used in the econometric models as independent variables.

To evaluate the environmental and climate performance of the bond, data on the environmental and climate risk are needed, considering either the individual bond and/or the bank issuer. By manually extracting the ticker of each bank issuer of green bonds, it is possible to retrieve data on the ESG evaluations provided by different providers for each bank. The analysis considers the environmental and climate scores and ratings attributed by Bloomberg, Sustainalytics, and MSCI. Some data are time-series data and permit us to appreciate the evolution of sustainable bank performances. Unfortunately, some banks have issued green bonds, but do not present an ESG score on Bloomberg.

When utilizing ESG ratings, a notable issue arises due to their availability mostly for publicly traded banks, resulting in a strong correlation between the presence of an ESG rating and the size of the bank. To address this challenge, we supplement this metric with another indicator signaling a bank's sustainability focus, namely the fact that a bank is a signatory to the UN Principles for Responsible Banking. We added this information manually to our dataset. The banks that sign the UN agreement about responsible banking activity are nearly 350 at the time of writing; only 62 are bond issuers in the dataset. The UN Principles for Responsible Banking represent a manifestation of greenness and have already been used in Apergis *et al.* (2023).

Finally, macroeconomic variables, concerning the countries where the banks are domiciled, are included in the dataset.

The description of independent bond-specific variables, bank-specific variables and macro-economic variables used in the models is presented in Table 1.

The dataset contains the credit rating of each bond assigned by one or more of the following rating agencies (Moody's, S&P, Fitch). To convert the string data into numerical data, the conversion shown in Table 2 is used.

Furthermore, in the dataset, the variable GB_Assurance_Providers_List represents the list of assurance providers, also referred to, in more regulatory terminology, as "external auditors". The list includes four types of providers: Second-Party Opinion, Third-Party Certifier, ESG agent and Green Bond Auditor. In order to map this variable correctly, we follow the ICMA classification (ICMA 2018, Poufinas 2022) to establish the order of importance/simplicity in the external review process. As shown in Table 3, external reviewers are classified from the simplest/most basic to the most advanced/demanding. Typically, a Second-Party Opinion (SPO) provider assesses the green bond issuer's framework, ensuring that it is in line with established guidelines, such as the Green Bond Principles (GBP) set by the International Capital Market Association (ICMA). In particular, the SPO provider assesses whether the intended use of the bond proceeds is consistent with recognized environmental sustainability standards. It issues a report or opinion on whether the bond's projects or activities are truly green, based on Environmental, Social and Governance (ESG) criteria. This assessment takes place prior to the bond issue.

Table 1. Independent variables.

Independent variable	Description
Bond-specific variable	
Payment rank	Identifies the ranking of a security or an instrument as specified in the initial offering documentation or as derived from original language or local market conventions.
CPN	Current interest rate of the security.
Amount outstanding	Current amount of the issue outstanding. In this case it corresponds to the amount issued.
Credit rating Moody's	Issue level rating assigned by Moody's.
Credit rating Fitch	Issue level rating assigned by Fitch.
Credit rating SP	Issue level rating assigned by Standard & Poor.
Credit ratings average	The average of the ratings for each bond.
GB Assurance Providers list	Assurance provider is the second-party that offers reviews and consultation, audits or third-party certifications (see also Table 3 for the numerical ranking).
Sustainable Development Goal n. 7	Clean and affordable energy
Sustainable Development Goal n.13	Takes urgent action to combat climate change and its impact.
Number of Sustainable Development Goals (SDGs) declared to be pursued by the bond issuance	Manually calculated considering the number of SDGs declared by the bank.
Indicator UN responsible Banks	Indicates if the bank belongs to the group of UN responsible banks.
Covered Bond indicator	Indicates if the bond is a covered bond.
Green bond indicator	Indicates if the bond is green.
Indicator UN responsible Banks	Indicates if the bank belongs to the group of UN responsible banks.
COV19	Dummy variable indicating if the bond was issued during the COVID-19 time-period.
Bank-specific variable	
ESG total score	Provides the Bloomberg score evaluating the company's aggregate Environmental, Social and Governance (ESG) performance. The score is based on Bloomberg's view of ESG financial materiality. The score is a generalized weighted mean of the Pillars Scores where the weights are determined by the pillar priority ranking. Values range from 0 to 10 (10 is the best).
GHG scope 1	Amount of scope 1 greenhouse gas (GHG) emissions of the company in thousands of metric tonnes of carbon dioxide equivalent (CO2e). GHG emissions are defined as those gasses which contribute to the trapping of heat in the Earth's atmosphere, including carbon dioxide (CO2), methane, nitrous oxide and others. Examples of scope 1 emissions include emission from combustion in owned or controlled boilers, furnaces, vehicles and emissions from production in owned or controlled process equipment.
GHG scope 2	Reflects the estimated value of indirect emissions of the company in thousands of metric tonnes of carbon dioxide equivalent (CO2) associated with the generation of purchased energy such as electricity. Scope 2 emissions are those emitted that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity.

Table 1. (*Continued*)

Independent variable	Description
GHG scope 3	Emissions all non-scope 2 indirect emissions, such as extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.
Environmental score	Provides the Bloomberg score evaluating the company's aggregate Environmental performance. The score is based on Bloomberg's view of Environmental materiality. Values range from 0 to 10. 10 is the best.
Social score	Provides the Bloomberg score evaluating the company's aggregate Social performance. The score is based on Bloomberg's view of Social materiality. Values range from 0 to 10. 10 is the best.
Governance score	Provides the Bloomberg score evaluating the company's aggregate Governance performance. The score is based on Bloomberg's view of governance materiality. Values range from 0 to 10. 10 is the best.
Macro-economic variable	
GDP	Gross Domestic Product
Debt/GDP	The ratio of a country's debt to its gross domestic product.
Inflation	The rate that measures the change of the cost of living in a country.
Euribor index	It refers to the rate at which banks lend money to each other.
VIX index	Volatility index. It measures the expected volatility of the stock market.

Source: Created by the authors.

Table 2. Bond ratings — transformation to numerical scale.

Assigned rate	Moody's	S&P	Fitch
7	Aaa	AAA	AAA
6	Aa1 to Aa3	AA+ to AA−	AA+ to AA−
5	A1 to A3	A+ to A−	A+ to A−
4	Baa1 to Baa3	BBB+ to BBB−	BBB+ to BBB−
3	Ba1 to Ba3	BB+ to BB−	BB+ to BB−
2	B+ to B−	B1 to B3	B1 to B3
1	CCC+ and below	Caa1 and below	Caa1 and below

Source: Created by the authors.

An SPO is typically qualitative and focuses on the compliance of the bond's framework and projects with market standards. In contrast, a third-party certifier provides a more formal certification based on its own recognized standard, such as the Climate Bonds Standard of the Climate Bonds Initiative (CBI). It typically verifies, in a more structured and quantitative manner, that the bond meets specific environmental criteria, providing certification before and sometimes after issuance. The ESG agent typically works with issuers and investors to provide ongoing ESG insights, monitoring and reporting. It offers reports, scores or advice on the issuer's

Table 3. Ranking of external reviewers.

Type of provider	ICMA	Importance	Number of providers
Second (2nd) party consultant	Second (2nd) party opinion	1	11
ESG agent	Verification	2	6
Third (3rd) party certifier	Certification	3	2
Green bond auditor	Green bond scoring	4	8

Source: Created by the authors.

overall ESG performance. In the current sample of bank green bonds, ESG agents are mainly other large European banks (see Table A.1, Appendix A). Finally, the green bond auditor rigorously assesses whether a green issue is in line with a reputable international framework such as the Green Bond Principles. Sometimes, the assurance it provides ensures that the use of proceeds is correctly allocated and complies with what is promised in the bond framework (Allman and Lock 2024).

Finally, a dummy variable concerning the time period of the pandemic is included as a control variable to account for factors that may influence the dependent variable; including it helps to isolate the effect of key independent variables.

Table 4 represents the summary statistics of the variables included in the econometric model.

4. Methodology

Using different independent variables and focusing on green bonds issued by banks, we adopt a methodology similar to that presented by Fatica *et al.* (2021) and Kapraun *et al.* (2021). More specifically, we have

$$\text{yields}_{it} = a_0 + a_1 \text{ Green }_{it} + a_2 X_{it} + a_3 Z_{c,t} + \delta_i + \varphi_t + \zeta_c + \varepsilon_{it}, \tag{1}$$

where yields_{it} denotes the yield at issuance of bond i at time t, Green_{it} is the Green variable of interest of bond i at time t, X_{it} is a vector which includes a set of a bond i characteristics at time t, Z_{ct} is a vector which includes a set of macro-economic variables concerning country i at time t, δ_i represents bond fixed effects, φ_t shows time fixed effects, ζ_c shows country fixed effects, ε_c is the residual from Eq. (1). Preliminary tests on the panel data framework are reported in Appendix B.

From the above estimates, we obtain the regression residuals and we attempt to show which of the recommended variables can explain them. To this equation, we add another equation similar to Apergis *et al.* (2022), enhanced by one of the approaches discussed in Jakob *et al.* (1996), García-Berthou (2001), Freckleton (2002), Windmeijer (2005) and Jurado *et al.* (2015):

$$\varepsilon_{it} = c_0 + c_1 \text{ ESG}_{it} \quad \text{or} \quad \text{GHG}_{it} + c_2(\text{ESG}_{it} \text{ or } \text{GHG}_{it}) \times \text{Green}_{it} + \delta_i + \varphi_t + \eta_{it}, \tag{2}$$

where ε_{it} is the residual from Eq. (1), ESG_{it} is a vector of ESG scores and ratings, GHG_{it} is a vector of measures concerning greenhouse gas emissions, (ESG_{it} or

Table 4. Summary statistics.

Variables	Mean	SD	Min	Max
Yields	3.356	4.214	0.424	34.713
Payment rank[&]	0.979	1.119	0.000	4.000
CPN	1.776	2.391	0.010	17.520
Amount outstanding	764,314,982.5	55,38,267,717	0.000	95,020,000,000
Currency[&&]	1.061	2.346	0.000	17.000
UN responsible banks[&&&]	0.329	0.470	0.000	1.000
Covered bond[&&&&]	0.616	0.274	0.000	1.000
Green bond indicator[&&&&&]	0.388	0.346	0.000	1.000
ESG total score	3.731	1.325	0.959	5.699
ESG environmental score	3.099	1.927	0.000	5.890
GHG Scope 1	397.215	2,255.712	0.0046	13,163
GHG Scope 2	132.970	574.506	0.058	3,320.920
GHG Scope 3	4,739.246	22,461.723	0.107	114,128
GB_Assurance_Providers_—–List[&&&&&&]	2.946	1.354	1.000	4.000
Sustainable_ Development_ Goals-7 Affordable and Clean Energy*	0.909	0.288	0.000	1.000
Sustainable_Development_ Goals-13 Climate Action**	0.785	0.411	0.000	1.000
No_of_SDGs***	4.444	2.428	0.000	13.000
Social score	3.000	2.000	0.000	8.000
Governance score	6.000	2.000	1.000	8.000
Credit ratings Moody's	6.004	2.315	1.000	10.000
Credit ratings Fitch	2.351	2.664	1.000	7.000
Credit ratings SP	6.426	2.392	1.000	10.000
Credit ratings average	4.927	2.457	1.000	9.000
Euribor index	0.614	1.408	−0.505	4.160
VIX index	20.081	6.860	10.678	85.621
GDP	6.39981E+11	9.52752E+11	10,551,030,597	4.45608E+12
Debt/GDP	80.71	42.23	12.72	237.43
Inflation	2.543	3.516	−2.097	19.705
No. of observations	35,425			

Notes: SD = standard deviation. [&]A dummy variable where: 0=Sr Non-Preferred, 1=Sr Preferred, 2=Secured, 3=Sr Unsecured, 4=Subordinated. [&&]A dummy variable where: 0=IDR, 1=MXN, 2=INR, 3=CNY, 4=BRL, 5=ISK, 6=HUF, 7=CZK, 8=TRY, 9=TWD, 10=SEK, 11=NOK, 12=AUD, 13=JPY, 14=CHF, 15=GBP, 16=USD, 17=Euro. [&&&]A dummy variable where: 1=YES, 0=NO. [&&&&]A dummy variable where: 1=YES, 0=NO. [&&&&&]A dummy variable where: 1=YES, 0=NO. [&&&&&&]A dummy variable where: 1-Second party consultant, 2=ESG agent, 3=3rd party certifier, 4=Green bond auditor, *0 if this is not shown among the targets and 1 if it does, **0 if this is not shown among the targets and 1 if it does, ***the total number of SDGs in relevance for the specific bond, and 0 if there is no value 0. Credit ratings Moody's is a dummy variable running from 1 for Aaa bonds to 10 for Baa3 bonds. Credit ratings Fitch is a dummy variable running from 1 for AAA bonds to 4 for BBB bonds and 5 for the remaining bonds. Credit rating SP is a dummy variable running from AAA bonds to 10 for BB^- bonds. Finally, Credit ratings average is the average of the three credit ratings above.

$GHG_{it}) \times Green_{it}$ is the interaction term between the green bond indicator/dummy variable and the ESG, E, S, G, GHG Scope 1, GHG Scope 2, GHG Scope 3 performance metrics of the issuing banks and η_{it} is the residual from Eq. (2).

The second equation uses the residual of the first equation as a dependent variable (being one of the variants of two-stage regressions) in an attempt to capture the effect of environmentally related variables (ESG scores, GHG emissions), along with SDG ratings and the existence of a Green Bond Assurance Provider. The employment of two-stage regression is justified by the fact that the panel 2SLS methodology explicitly considers potential endogeneity issues (including reverse causality) that alleviate the concerns set by the referee. Equation (1) is similar to the one introduced in Apergis *et al.* (2022) and Apergis *et al.* (2023). It does not encounter the effect of ESG or GHG emissions. Consequently, Eq. (2) is used to unveil the influence of ESG or GHG emissions on the residual of Eq. (1), i.e. the unexplained part. However, when examining the impact of a company's (ESG) profile on its bond yields, endogeneity could pose an empirical concern. Firms with lower yields may have greater financial flexibility and thus invest more in ESG initiatives, or unobserved firm characteristics (such as management quality or long-term strategic goals) may simultaneously influence both ESG performance and borrowing costs. In such cases, ordinary least squares (OLS) estimation could yield biased and inconsistent results due to the correlation between the explanatory variable (ESG) and the error term. The Two-Stage Least Squares (2SLS) estimator offers a solution by isolating the exogenous component of ESG variation through the use of valid instruments, i.e. variables that are correlated with ESG but orthogonal to the error term in the bond yield equation. This approach has been widely adopted in empirical finance to address reverse causality and omitted variable bias in studies of firm characteristics and financial outcomes (Angrist & Krueger 2001).

5. Empirical Results

The baseline estimation results are presented in Table 5, with columns indicating certain specifications. Column (1) displays the bivariate estimates, while Column (2) shows the estimates when the remaining variables, except the macroeconomic variables, are included. Finally, Column (3) includes all the variables available. The modelling equation also includes a dummy variable that explicitly considers the recent pandemic crisis event (Vortelinos *et al.* 2024). This dummy variable, COV19, takes units from 2020 to 2021 and zeros otherwise (Vortelinos *et al.* 2024).

The results of all three columns clearly document the positive and statistically significant impact of the Green Bond Indicator factor on bond yields. In terms of the remaining determinants of yields, the estimates are in accordance with theoretical expectations; more specifically, payment rank, CPN, currency, debt/GDP, and inflation exert a positive effect on yields. In contrast, the amount outstanding, the indicator of covered bond, UN responsible bank, ESG total score, ESG environmental score, GHG scope 1, 2 and 3, GDP, the Euribor index, and the VIX index have a negative impact on yields. Finally, the COVID-19 pandemic exerted a positive impact on bond yields (Dragomir *et al.* 2022).

Table 5. Panel estimations (dependent variable = yields).

Variables	(1)	(2)	(3)
Constant	0.464**	0.452**	0.385*
	[0.03]	[0.03]	[0.06]
Green bond indicator	0.196***	0.174***	0.118***
	[0.00]	[0.00]	[0.00]
ΔPayment rank		0.348**	0.319**
		[0.03]	[0.03]
△CPN		0.272**	0.226**
		[0.03]	[0.04]
ΔAmount outstanding		−0.136***	−0.097***
		[0.00]	[0.01]
Currency		−0.058**	−0.055**
		[0.03]	[0.03]
Covered bond		0.055***	0.041***
		[0.00]	[0.01]
UN responsible bank		−0.029*	−0.018
		[0.09]	[0.12]
Credit ratings average		0.128***	0.109***
		[0.00]	[0.00]
△GDP			−0.151***
			[0.00]
ΔDept/GDP			0.060***
			[0.01]
Inflation			0.053***
			[0.01]
ΔEuribor index			0.066***
			[0.00]
ΔVIX index			0.058**
CoV19			[0.02]
	0.155***	0.143***	0.116***
	[0.00]	[0.00]	
Diagnostics			
R^2-adjusted	0.37	0.51	0.60
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.18]	[0.44]	[0.52]
Hansen test	[0.24]	[0.48]	[0.51]
Difference Hansen test	[0.46]	[0.62]	[0.79]
Bond/Bank fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
LM test	[0.00]	[0.00]	[0.00]
No. of observations	35,425	35,425	35,425

Notes: Column (1) displays the bivariate estimates, Column (2) shows the estimates when the remaining variables, except the macroeconomic variables, are included, and Column (3) includes all the variables available. Figures in brackets denote *p*-values. LM stands for the Lagrange Multiplier test for random effects (Breusch and Pagan 1980). AR(1) is the first-order test for residual autocorrelation. AR(2) is the test for autocorrelation of order 2. Hansen is the test for the overidentification check for the validity of instruments. The difference-in-Hansen test checks the exogeneity of the instruments. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

5.1. *Result interpretation*

As it is possible to notice in Table 5, by moving along the model specifications with the addition of bond-specific and then macroeconomic variables, the magnitude of the coefficients diminishes in absolute value, whereas the significance remains the same (with the exception of one variable, as explained below). The first is the outcome of the spread of the explanatory capacity in more variables; the second is proof that the variables added do not harm the importance of the previously considered variables — on the contrary, they complement it.

The model outputs in Table 5 indicate that the Green Bond indicator posts a positive statistically significant impact on the yield at the 1% level across all three specifications. As a matter of fact, when the indicator changes from 0 to 1 (i.e. from conventional to Green), the yield increases by approximately 0.2 (as per the coefficient of the equation, as displayed in Table 5). This increase drops to approximately 0.17 and 0.12 in the models that incorporate the bond-specific and macroeconomic variables. This is in line with part of the extant literature, among which Apergis *et al.* (2023). A potential interpretation is that the green label on its own is not sufficient to convince investors to accept a lower yield (a positive greenium). By contrast, when such a bond is issued by a bank, they seem to become skeptical/reserved and require a higher return; as a matter of fact, this may be a signal of perceived/suspicion of greenwashing. As banks are heavily regulated, the suspicion/risk of greenwashing on its own, along with the increased costs of sustaining and proving the green label (together with the alignment with the ESG/GHG principles where appropriate) could lead to higher overall funding costs (due to potentially more difficult funding) for the issuing banks, depicted by the higher yield (Kim & Lyon 2015, Epstein-Reeves 2012). On the other hand, the characterization of a bank as a UN responsible bank exerts a negative statistically significant effect on the yield at the 10% level in the second specification (and marginally at the third specification). This is also compatible with part of the relevant literature, such as Apergis *et al.* (2023). This is probably due to the fact that the investors are willing to accept a lower yield when the overall stance of the bank is in favor of global initiatives, such as the Principles for Responsible Investing, compared to partial/fragmented undertakings, such as the issuance of green bonds. They most likely perceive this as a stronger commitment and more sustainable, longer-term policy rather than a green bond issuance to support projects (whose greenness may be disputed).

Going to the bond-specific variables, we observe that the Payment rank influences the yield in a positive, statistically significant manner at the 1% level in both model specifications (2 and 3) that it applies. The way this variable is designed, this finding indicates that as the bond seniority deteriorates, the yield increases. This pretty much reflects the increased yield required by investors from a bond issue when the security provided decreases, as the risk they have to bear by investing in the bond is higher. Similarly, the Covered bond variable affects the yield in a positive and statistically significant manner at 1% in both model specifications (2 and 3) that it was considered. This is in accordance with the previous finding that the green bond label does not suffice to convince investors to accept a lower yield. As covered bonds (especially when green) are covered by certain proceeds (in the case of green bonds, the proceeds of the projects that qualify as green), it seems that it is not perceived as enough to justify a positive greenium. In contrast, the Payment rank is most likely considered as a globally accepted assessment and influences the yield in the previously described way; i.e. the higher the seniority, the lower the yield. The effect of the Credit ratings average is in line with these findings; more specifically, it exerts a negative and statistically significant impact (at 1%) across all model specifications and all panels. This implies that the worse the score assigned to an issuer, the higher the yield is. This is an immediate outcome of the information that the credit rating discloses; the worse it is, the more the risk borne by investing in a bond issue (and issuer) becomes, which justifies a higher yield.

Furthermore, the Coupon (CPN) shows a positive statistically significant effect at the 1% level on the bond yield, which practically confirms the positive relation of yield with the bond coupon rate, as they both mirror higher bond risk. Both the coupon rate and yield are the investors' compensation for accepting it. In addition, the Amount outstanding posts a negative, statistically significant impact on yields. Larger amounts are most likely drawn by larger banks, with higher credit ratings, which attract investor interest, who are eventually eager to receive a lower yield. Finally, the Currency is negatively significantly correlated at the 5% level with the yield, which points out that as we gradually move to stronger currencies, such as the Swiss Franc, the British Pound, the US Dollar, and the Euro, the bond yield decreases. Apparently, investors (as the universe under investigation is EU banks) perceive any bond issuance in Euro primarily (and the other three secondarily) as safer; in that case, the required yields decrease.

Turning now to the macroeconomic variables introduced in the third specification, we can observe that the GDP posts a negative statistically significant impact at the 1% level. This expresses a potential increased security emanated by bonds issued by banks domiciled in "richer" (in terms of GDP countries), which justifies a lower yield. At the same time, the Debt/GDP variable exerts a positive, statistically significant effect at the 1% level on the yield. This signifies that bonds issued by banks residing in more "indebted" countries (as proxied by Debt/GDP) are viewed as less secure, which leads to a higher yield. Inflation exercises a positive statistically significant influence at the 1% level. This is the outcome of the fact that higher inflation leads to higher interest rates, which in turn result in higher bond yields.

Moving to the market-related variables, we notice that both the Euribor index and the VIX index are positively correlated with the yield (at the 1% and 5% significance level, respectively). The former is probably due to the fact that when the equity market (as proxied by the Euribor index) rises, investors tend to leave the safety of bonds to take advantage of the ascending stock prices. This implies that they sell bonds, which leads to a price drop, hence a yield increase. The latter may have a similar explanation; i.e. that as volatility increases, investors expect a higher return from the equity market and if this is realized, then they are willing to move from the bond market to the stock market. Thus, as before, selling bonds reduces their price and increases their yield. However, one could argue that the opposite may hold true; i.e. that soaring equity market volatility drives investors to the safety of bonds, which leads to a bond price increase and yield decrease. Nevertheless, for an extended period during the years of our study, the Quantitative Easing (QE) programs led by the Central Banks distorted this expectation; both bond and stock markets moved in parallel and low market volatility co-existed with low yields, justifying the observed positive correlation.

Table 6 (all panels) attests the effect of a series of responsibility-/sustainability-/impact-investment driven variables. These are the ESG, E, S, and G scores (panels A, B, C, and D, respectively), as well as the GHG Scope 1, Scope 2, and Scope 3 scores (panel E). We observe that as we cross the model specifications with the inclusion of bond-specific and then macroeconomic variables, the size of the coefficients lessens in absolute value, whereas the significance does not change.

The findings provide evidence that all these variables exhibit negative statistically significant negative impact at the 1% level on the residual (thus the yield). This is in line with Apergis *et al.* (2022). More specifically, as the ESG score increases by 1 unit, the yield drops approximately by 0.36, 0.34, and 0.32 in the three model

Table 6. Panel estimations (dependent variable = Residuals from Table 5).

Variables	(1)	(2)	(3)
Panel A: ESG Total Score			
Constant	0.164*	0.143*	0.115*
	[0.06]	[0.07]	[0.09]
ΔESG score	−0.361***	−0.342***	−0.324***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
△ESG score	0.247***	0.229***	0.206***
	[0.00]	[0.00]	[0.00]
GB_Assurance_Providers_List	0.095***	0.106***	0.144***
	[0.01]	[0.01]	[0.00]
Sustainable_Development_Goals - 7	−0.065**	−0.081**	−0.096**
	[0.03]	[0.02]	[0.02]
Sustainable_Development_Goals - 13	−0.065**	−0.075**	−0.104***
	[0.03]	[0.02]	[0.01]
No_of_SDGs	0.137***	0.154***	0.168***
	[0.00]	[0.00]	[0.00]
Diagnostics			
R^2-adjusted	0.54	0.55	0.58
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.39]	[0.42]	[0.44]
Hansen test	[0.38]	[0.45]	[0.47]
Difference Hansen test	[0.55]	[0.60]	[0.64]
Bond/Bank fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES

Table 6. (*Continued*)

Variables	(1)	(2)	(3)
LM test	[0.00]	[0.00]	[0.00]
No. of observations	35,425	35,425	35,425
Panel B: ESG Environmental Score			
Constant	0.232*	0.221*	0.204*
	[0.08]	[0.08]	[0.08]
ΔESG enviromental score	−0.353**	−0.339**	−0.312***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
ΔESG environmental score	0.186***	0.165***	0.148***
	[0.00]	[0.00]	[0.00]
GB_Assurance_Providers_List	−0.081**	−0.103***	−0.124***
	[0.03]	[0.01]	[0.00]
Sustainable_Development_Goals - 7	−0.074**	−0.096**	−0.113***
	[0.03]	[0.02]	[0.01]
Sustainable_Development_Goals - 13	−0.066**	−0.079**	−0.120***
	[0.04]	[0.03]	[0.00]
No_of_SDGs	0.122***	0.131***	0.135***
	[0.00]	[0.00]	[0.00]
Diagnostics			
R^2-adjusted	0.64	0.65	0.67
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.52]	[0.47]	[0.50]
Hansen test	[0.49]	[0.58]	[0.57]
Difference Hansen test	[0.64]	[0.66]	[0.71]
Bond/Bank fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
LM test	[0.00]	[0.00]	[0.00]
No. of observations	35,425	35,425	35,425
Panel C: ESG Social Score			
Constant	0.235*	0.204*	0.177*
	[0.06]	[0.08]	[0.09]
ΔESG social score	−0.296***	−0.244***	−0.263***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
ΔESG social score	0.219***	0.202***	0.189***
	[0.00]	[0.00]	[0.00]
GB_Assurance_Providers_List	−0.082**	−0.114***	−0.138***
	[0.02]	[0.00]	[0.00]
Sustainable_Development_Goals - 7	−0.083**	−0.101***	−0.126***
	[0.02]	[0.00]	[0.00]
Sustainable_Development_Goals - 13	−0.074**	−0.092*	−0.125***
	[0.02]	[0.02]	[0.00]
No_of_SDGs	0.128***	0.136***	0.151***
	[0.00]	[0.00]	[0.00]
Diagnostics			
R^2-adjusted	0.64	0.66	0.69
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.47]	[0.45]	[0.49]
Hansen test	[0.41]	[0.48]	[0.52]
Difference Hansen test	[0.53]	[0.57]	[0.59]
Bond/Bank fixed effects	YES	YES	YES

Table 6. (*Continued*)

Variables	(1)	(2)	(3)
Country fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
LM test	[0.00]	[0.00]	[0.00]
No. of observations	30,625	30,625	30,625
Panel D: ESG Governance Score			
Constant	0.217*	0.183*	0.153
	[0.09]	[0.10]	[0.15]
ΔESG govemance score	−0.281***	−0.249***	−0.232***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
△ESG governance score	0.302***	0.296***	0.288***
	[0.00]	[0.00]	[0.00]
GB_Assurance_Providers_List	−0.083**	−0.107***	−0.130***
	[0.02]	[0.01]	[0.00]
Sustainable_Development_Goals - 7	−0.077**	−0.090**	−0.112***
	[0.03]	[0.02]	[0.00]
Sustainable_Development_Goals - 13	−0.074**	−0.085**	-0.110***
	[0.03]	[0.02]	[0.00]
No_of_SDGs	0.126***	0.131***	0.149***
	[0.00]	[0.00]	[0.00]
Diagnostics			
R^2-adjusted	0.56	0.59	0.63
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.48]	[0.46]	[0.50]
Hansen test	[0.41]	[0.47]	[0.52]
Difference Hansen test	[0.54]	[0.56]	[0.55]
Bond/Bank fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
LM test	[0.00]	[0.00]	[0.00]
No. of observations	30,625	30,625	30,625
Panel E: GHG Scope 1, Scope 2, Scope 3			
Constant	0.201*	0.178	0.167
	[0.08]	[0.11]	[0.13]
ΔGHG scope 1	−0.256***	−0.240***	−0.231***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
ΔGHG scope 1	0.266***	0.257***	0.250***
	[0.00]	[0.00]	[0.00]
ΔGHG scope 2	−0.235***	−0.213***	−0.198***
	[0.00]	[0.00]	[0.01]
Green bond indicator x			
ΔGHG scope 2	0.247***	0.233***	0.219***
	[0.00]	[0.00]	[0.00]
ΔGHG scope 3	−0.195***	−0.178***	−0.165***
	[0.00]	[0.00]	[0.00]
Green bond indicator x			
ΔGHG scope 3	0.228***	0.213***	0.192***
	[0.00]	[0.00]	[0.00]
GB_Assurance_Providers_List	−0.081**	−0.090**	−0.133***
	[0.03]	[0.02]	[0.00]
Sustainable_Development_Goals - 7	−0.074**	−0.082**	−0.092**

Table 6. (*Continued*)

Variables	(1)	(2)	(3)
	[0.03]	[0.03]	[0.02]
Sustainable_Development_Goals - 13	−0.069**	−0.074**	−0.102***
	[0.04]	[0.03]	[0.01]
No_of_SDGs	0.114***	0.132***	0.135***
	[0.00]	[0.00]	[0.00]
Diagnostics			
R^2-adjusted	0.56	0.55	0.57
AR(1)	[0.00]	[0.00]	[0.00]
AR(2)	[0.48]	[0.45]	[0.50]
Hansen test	[0.44]	[0.56]	[0.52]
Difference Hansen test	[0.59]	[0.56]	[0.60]
Bond/Bank fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
LM test	[0.00]	[0.00]	[0.00]
No. of observations	30,625	30,625	30,625

Notes: Columns (1)–(3) describe the residuals from the corresponding columns in Table 4. Figures in brackets denote p-values. LM stands for the Lagrange Multiplier test for random effects (Breusch and Pagan 1980). AR(1) is the first-order test for residual autocorrelation. AR(2) is the test for autocorrelation of order 2. Hansen is the test for the overidentification check for the validity of instruments. The difference-in-Hansen test checks the exogeneity of the instruments. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

specifications, respectively (as per the coefficients depicted in Table 6). This is approximately 10–11% of the mean value of the yield (as shown in Table 4), which reveals the materiality of the effect of the ESG score in the determination of the bond yield. The individual scores post similar effects. The increase of E by 1 unit leads to a yield drop of 0.35, 0.34, and 0.31, respectively (accounting also for circa 9–11%). The increase of S by 1 unit results in a yield drop of 0.30, 0.24, and 0.26 (accounting for roughly 7–9%). The increase of G by 1 unit produces a yield drop of 0.28, 0.25, and 0.23 (accounting for approximately 7–8%). The GHG Scope 1, Scope 2, and Scope 3 scores exhibit similar effects, where a 1-unit increase gives a 0.26/0.24/0.23, 0.24/0.21/0.20, and 0.20/0.18/0.17 yield drop, respectively (corresponding to a percentage of 5–8%). This influence witnesses that as the score/rating of the issuing bank on these variables/disciplines increases, the bond yield decreases. As investors realize that a bank commits to the standards that these scores reflect and is returning value to the environment, the society and the investors (as mapped by these variables), then they are willing to earn a lower yield. This may be due to the fact that they perceive such an attitude as exposing the banks to less/lower environmental, societal and investment risks, which in its turn supports a lower yield.

A similar observation can be made for the SDG-7 and SDG-13 variables, i.e. they post a negative, statistically significant influence (at the 1% or 5% level) to the residual (and thus the bond yield) across all model specifications (1, 2, and 3) and across all panels (A, B, C, D, and E). They both reflect the support of projects that are relevant to the greenness of the bonds (Yan *et al.* 2024, Kamran *et al.* 2024). As a matter of fact, a 1-unit increase of the SDG-7/SDG-13 variables results in a yield drop from 0.07 to 0.13, representing approximately 2–4% of the yield. The materiality is lower than that of ESG and GHG emissions, but is still considerable. Consequently, in line with the aforementioned findings, this particular outcome confirms the fact that investors are willing to accept a lower yield from a green bond only when they are convinced that it truly finances a green project. Projects that are aligned with these specific SDGs are considered relevant and justify a yield reduction (opposite to the green label on its own, as realized above).

Interestingly enough (and thanks to the sharp observation of the anonymous reviewer) the effect of the interaction terms between the green bond indicator/dummy variable and the ESG, E, S, G, GHG Scope 1, GHG Scope 2, GHG Scope 3 performance metrics of the issuing banks turns out to be positive statistically significant (at the 1% level). This provides some evidence that the way banks use the funding generated from the issuance of green bonds (whether they employ it to finance genuinely green projects and borrowers or otherwise) matters. As a matter of fact, the positive sign of the coefficient (and thus the positive influence on the yield) indicates that the skepticism of the green bond label seems to prevail. Consequently, even if the issue/issuer is aligned with the ESG or GHG emission principles, investors seem to be cautious and still expect a higher yield when a bond is marked as green.

In contrast, the No. of SDGs has a positive statistically significant effect (at 1%) on the residuals (hence the bond yields), across all model specifications and panels. This showcases that simply financing projects that support several, possibly irrelevant SDGs, with the same bond issue, does not convince investors to receive a lower yield. Vice versa, they seem to be skeptical/suspicious, especially when more and/or non-environmental/non-climate related goals are added and expect a higher yield (as with the green label only). In contrast to the formerly discussed variables, we see that the coefficients of SDG-related variables increase in absolute value as we move across the three model specifications, with varying significance levels.

GB Assurance Provider has a negative statistically significant impact (at the 1% or 5% level) across all specifications and panels (except for panel A). In this case, a 1-unit increase, i.e. the shift to a more demanding assessment level, leads to a 0.08 to 0.14 yield drop, standing for circa 2–4% of the yield. Again, this is indicative of noticeable explanatory power, yet lower than that of the ESG (comprehensive and constituent) score. This shows that investors are willing to accept a lower yield when such an accredited party issues an opinion, apparently feeling more secure that an external, independent provider has assessed the undertaking (Simeth 2022, Ghitti *et al.* 2023). Furthermore, as the level of the assessment becomes stronger from opinion to audit (Second party consultant, ESG agent, third party certifier and Green bond auditor), the yield seems to become lower, reflecting an increased sense of protection. This confirms in part the results of Dorfleitner *et al.* (2022). The relevant diagnostics are reported at the bottom of Table 5. They support the validity of the instruments used, while difference-in-Hansen tests imply the exogeneity of the instruments employed.

Next, from the above estimates, we obtain the regression residuals and we attempt to show which of the recommended variables can explain them. This is one of the two-stage regression analysis approaches employed by the extant literature and helps policymaking decisions as it can reflect the causal effect of policies (especially when such policies are not already in place). The new results are reported in Table 6.

6. Conclusion

This study explores the presence of asymmetric information between bank issuers and green bond investors. Asymmetry can make investors skeptical about the signal that issuers send regarding their environmental commitment.

By employing a series of panel estimations, we were able to find evidence that the green bond label on its own is not sufficient to reduce the yield of green bonds issued by banks; on the contrary, it causes an increase. Conversely, when ESG scores and greenhouse gas emissions are considered together, there is a statistically significant negative impact on yield. The same applies when green projects claim to pursue SDGs 7 and 13. The greenwashing perceived by investors is produced by the existence of asymmetric information. Apparently, investors are willing to accept a lower yield (positive greenium in favor of the issuer) when banks commit to pursuing more robust environmental and social objectives as part of their strategy and do not simply aim to characterize a bond as green to signal their environmental commitment. This may be because investors perceive that such a broader commitment by the issuing banks leads to less environmental, societal and investment risk exposure, which in its turn justifies a lower yield.

The existence of an external independent assurance provider also exerts a negative effect (except for one case), indicating that investors feel more secure when an accredited external, independent party issues an opinion (having previously assessed the undertaking). Furthermore, as the level of the assessment becomes stronger from opinion to audit (second party consultant, ESG agent, third party certifier and green bond auditor), the yield seems to become lower, potentially reflecting an increased perceived security.

The aforementioned findings attest that banks that pursue the raising of capital to support green projects should not focus merely on labeling the bond (and the underlying projects) green, but should rather support global initiatives and principles relevant to environmental (including climate), societal, governance and sustainability goals. This can be done by aligning their overall strategies and operating models with such targets, acting as signatories of the relevant initiatives and proving with their spirit that they indeed support such actions. Involving certified third parties to validate this commitment and attentiveness can further heighten the acceptance of the greenness of the bond considered by the investors. All these considerations can result in lower green bond yields compared to the equivalent plain vanilla bond yields.

All interested parties can benefit from this route. Namely, investors can feel more confident about the greenness of a bond issue that is labelled green. Regulators can enforce/request/recommend the adoption of such broader initiatives, as it seems to lead to increased acceptance by the investing audience. The issuing bankers will have a more successful story to tell and they can aim for lower green bond yields. Finally, the environmental (as well as the societal and governance) interests will be better represented as there will be alignment of the issue with the underlying targets/objectives of the respective initiatives.

Finally, it is worth noting that the dataset used in the research provides us with data from 2013 to the end of 2023. However, as it has been mentioned above, at the end of 2023, a non-binding European regulation on green bonds (EuGB regulation) was issued, which is now in force. Our findings fit well with the goals of European regulators to encourage greater transparency and communication from issuers in order to eliminate greenwashing and create an efficient green bond market. The issuance of green bonds by banks has direct implications for EU sustainable finance policy. Alignment with the EU Taxonomy Regulation and registered external verification are crucial to ensure that proceeds are genuinely directed toward environmentally sustainable activities, thereby reducing the risk of greenwashing and enhancing market integrity. At the institutional level, the European Banking Authority and the European Central Bank have emphasized the need for banks to integrate climate-related disclosures and taxonomy-aligned metrics into their prudential and risk reporting frameworks. Together, these policy developments call for a coherent reporting ecosystem in which green bond issuance, bank-level disclosures, and investor information duties are harmonized to foster both credibility and capital allocation efficiency in sustainable finance.

Future research venues include the study of non-European banks, as well as the consideration of other sectors, especially those whose greenness is questioned. Furthermore, the analysis carried out could be repeated in the coming years because greenium evolves over time in line with changes in banks' behavior. The EuGB Regulation, if adopted on a large scale by banks issuing green bonds, could significantly reduce the information asymmetries identified in the research and lead to a greenium that would encourage banks to support the real economy through the transition to an environmentally sustainable development model.

Appendix A. External Review Providers

Table A.1 displays the list of external review providers along with their role/capacity in the green bond assessment process.

Table A.1. Providers of external review.

Providers	Role
ABN Amro Bank NV	ESG Agent
BayernLB	Green Bond Auditor
Carbon Trust	2nd Party Consultant (*)
CICERO Senter for Klimaforskni	2nd Party Consultant
Climate Bonds Initiative	3rd Party Certifier
Credit Agricole CIB	ESG Agent
Deloitte Touche Tohmatsu	Green Bond Auditor
Deutsche Bank	ESG Agent
DNV GL Group AS	Green bond auditor
ING Bank NV	ESG Agent
ING Groep	ESG Agent
ISS Corporate Solutions	2nd Party Consultant
ISS ESG	2nd Party Consultant
ISS-oekom	2nd Party Consultant
KPMG International	3rd Party Certifier
Landesbank Baden-Wuerttemberg	Green Bond Auditor
LBBW Securities LLC	Green Bond Auditor
Moody's Investors Service Inc	2nd Party Consultant
Oekom Research AG	2nd Party Consultant
PwC	Green Bond Auditor
rfu Business Consulting	2nd Party Consultant
S&P Global Inc	Green Bond Auditor
Standard & Poor's	Green Bond Auditor
Sustainalytics BV	2nd Party Consultant
UniCredit Bank AG	ESG Agent
Vigeo Eiris USA LLC	2nd Party Consultant
Vigeo SASV	2nd Party Consultant

Note: *The Carbon Trust has offered carbon neutral verification since 2012 till September 2023.

Appendix B. Cross Dependence and Unit Root Tests

The first part of the empirical analysis explores the presence of cross-dependence in our panel data framework. The cross-sectional dependence (CD) statistic by Pesaran (2004) is based on a simple average of all pair-wise correlation coefficients of the OLS residuals obtained from standard augmented Dickey–Fuller regressions for each variable in the panel. Under the null hypothesis of cross-sectional independence, the CD test statistic follows asymptotically a two-tailed standard normal distribution. The results, reported in Table B.1, uniformly reject the null hypothesis of cross-section independence.

Next, a second-generation panel unit root test is employed to determine the degree of integration of the respective variables. The Pesaran (2007) panel unit root test considers that the null hypothesis is a unit root. The results, reported in Table B.2, illustrate the presence of a unit root in the levels across all panel variables, while in terms of their first differences, the testing procedure indicates the presence of stationarity across all of them. In the case of the time series variables, Table B.2 also

Table B.1. Cross dependence test.

Variables	*p*-values
Yields	0.00
CPN	0.00
Amount outstanding	0.00
ESG Total score	0.00
ESG Environmental score	0.00
ESG Social score	0.00
ESG Governance score	0.00
GHG Scope 1	0.00
GHG Scope 2	0.00
GHG Scope 3	0.00
No_of_SDGs	0.00
Residuals	0.00
GDP	0.00
Debt/GDP	0.00
Inflation	0.00

Notes: The test is based on the sum of correlation coefficient squares among cross-sectional residuals. This test, which is asymptotically standard normal distribution, examines the null hypothesis of cross-sectional independence.

Table B.2. Unit root tests.

	CIPS	
Variables	Levels	1st differences
Panel variables		
Yields	−6.224***	
Payment rank	−1.316	−6.341***
CPN	−1.116	−5.893***
Amount outstanding	−1.258	−6.251***
ESG Total score	−1.209	−6.052***
ESG Environmental score	−1.348	−6.113***
ESG Social score	−1.188	−6.012***
ESG Governance score	−1.246	−6.237***
GHG Scope 1	−1.219	−6.115***
GHG Scope 2	−1.203	−6.074***
GHG Scope 3	−1.118	−5.895***
No_of_SDGs	−1.164	−6.328***
Residuals	−6.558***	
GDP	−1.161	−6.682***
Debt/GDP	−1.064	−6.773***
Inflation	−6.449***	
Time series variables		
Euribor index	−1.138	−6.247***
VIX index	−1.291	−6.439***

Note: $^{***}p \leq 0.01$.

reports the results of the General Least Squared Dickey–Fuller test recommended by Elliott *et al.* (1996). They support the presence of a unit root across both variables.

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