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Do Green Bonds Make Banks Safer? Evidence from CDS Spreads, Funding Costs, and Capital Ratios

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Abstract

We examine whether banks' engagement in green lending alters their risk profile and capital structure, or whether green bond issuance merely reflects pre-existing issuer characteristics. Using an international panel of banks from 2010 to 2023 and restricting the sample to banks that have access to bond markets, we exploit within-bank variation in green bond issuance, where issuance earmarks proceed for green lending, to proxy changes in banks' green credit exposure. Employing bank and year fixed effects and a two-stage least squares strategy to address endogenous issuance decisions, we find that green bond issuance is followed by a significant decline in market-perceived credit risk, proxied by CDS spreads. Issuing banks also experience lower cost of debt and cost of capital, alongside a moderate increase in the cost of equity and Tier 1 capital ratios. Consistent with capital structure theory, these funding-cost effects are accompanied by balance-sheet adjustments: banks increase leverage while maintaining or gradually strengthening regulatory capital buffers, particularly as issuance becomes more sustained. A deeper engagement in green bond markets amplifies the effects on risk perceptions, funding conditions, and capital structure. Our findings indicate that green bonds function not only as sustainable finance instruments, but also as tools of strategic capital structure adjustment, with implications for bank risk management and the design of climate-related financial policies.

Keywords: green bonds, credit default swap, default risk, funding cost, bank capital.

JEL codes: G20, G21, G28, Q54

1. Introduction

Banks play a central role in the global financial system by reallocating capital from savers to borrowers and transforming liquid liabilities into illiquid assets, a function that underpins economic growth but also renders banks inherently fragile (Diamond & Rajan, 2005; Gropp & Heider, 2010). Given that excessive leverage and risk-taking amplify shocks and threaten systemic stability, regulatory frameworks have historically emphasized capital adequacy as a primary tool to safeguard solvency, protect depositors, and limit spillovers to the broader economy (Berger et al., 2016; Shleifer & Vishny, 2010). A large literature shows that higher capital buffers reduce default risk and improve resilience, but they also alter banks' funding costs and incentives, creating trade-offs that shape capital structure choices over time (Wagner, 2010).

Higher capital buffers have been shown to reduce the likelihood of bank failures and attenuate the propagation of shocks across the financial system (Berger et al., 2016). They also foster market discipline by bolstering stakeholder confidence in bank solvency and encouraging prudent management, while limiting excessive leverage that can amplify systemic risks during downturns (Shleifer & Vishny, 2010; Wagner, 2010). Traditionally, regulatory frameworks such as Basel III have prioritized capital adequacy, leverage, and liquidity requirements to enhance banks' resilience against shocks and maintain public trust (Gropp & Heider, 2010; Sorokina et al., 2017; Wagner, 2010).

In recent years, climate-related risks have increasingly entered the domain of prudential regulation, prompting banks and regulators to reconsider how environmental exposures interact with financial stability and capital planning. International standard setters now emphasize climate risk disclosure, governance, and integration into risk management frameworks, reflecting growing concerns that environmental shocks may propagate through the banking system (BCBS, 2022; Fatica & Panzica, 2021). Within this evolving regulatory and market environment, bank-issued green bonds have emerged as a prominent instrument. Unlike conventional bonds, green bonds contractually earmark proceeds for environmentally eligible lending and require enhanced transparency through external verification and ongoing reporting (Bhutta et al., 2022). For banks, issuing green bonds therefore represents not only a financing decision, but also a commitment to expand or rebalance green lending under heightened market scrutiny.

In practice, bank-issued green bonds are typically structured so that proceeds are to finance environmentally sustainable lending activities, providing a direct link between funding and asset allocation. Major international banks explicitly document this channel. For example, HSBC reports that funds raised through its green bond programmes are allocated to finance renewable energy, low-carbon infrastructure, and green building loans (HSBC, 2025). Similarly, Banco Bilbao Vizcaya Argentaria states that its green bond proceeds support the expansion of sustainable corporate lending and project finance portfolios, particularly in renewable energy and energy efficiency (BBVA, 2024). Barclays also discloses that its green bond issuances are used to finance green mortgages, clean transportation, and climate-related lending initiatives (Barclays, 2025). These institutional practices suggest that green bond issuance is not merely a reputational signal, but a funding instrument designed to scale up green credit supply. This structure provides a natural mechanism through which issuance may reshape banks' balance sheets, alter their risk profile, and influence funding conditions.

Despite the rapid growth of bank green bond issuance, it remains unclear whether engaging in green lending through bond issuance actively alters banks' risk profiles and capital structures, or whether such issuance merely reflects pre-existing characteristics of banks that already enjoy strong market access and investor confidence (Flammer, 2021). On the one hand, financing green assets may affect banks' balance sheets by shifting loan composition, stabilizing funding through longer-maturity debt, and improving regulatory capital ratios, potentially lowering perceived default risk and overall funding costs. Because bank fixed effects absorb all time-invariant bank characteristics, identification comes from within-bank variation over time in green bond issuance and exposure. In other words, the model asks whether the same bank experiences different risk and funding outcomes in periods of greater green bond engagement relative to its own historical baseline.

We use an international panel of banks that issue at least one conventional or green bond during the 2010–2023 sample period, which we interpret as having access to bond markets. Restricting the sample in this way allows us to compare banks that are all capable of issuing debt securities and to isolate the effect of green bond issuance from the broader decision to participate in bond markets. We employ a two-stage least squares strategy and yield three key findings. First, for a particular bank, green bond issuance is followed by a statistically and economically significant decline in market-perceived credit risk, measured by credit default swap (CDS) spreads. Second, green bond issuance is associated with a reallocation of banks' capital structures, characterized by a lower weighted average cost of capital and cost of debt,

alongside an increase in the cost of equity and Tier 1 capital ratios. These patterns are consistent with green bond issuance reshaping banks' funding mix toward more stable debt financing while strengthening regulatory capital buffers, rather than uniformly reducing financing costs. Third, we find that these effects are more pronounced for banks with higher bond issuance exposure over the sample period, suggesting that sustained engagement with bond markets amplifies the risk and capital structure implications of green bond issuance.

This paper contributes to the literature on bank capital structure, sustainable finance, and market discipline in three ways. First, by conditioning on bond market access and exploiting within-bank variation, we disentangle the effects of green bond issuance from the characteristics of banks that can issue bonds in the first place. Second, we provide evidence that green bond issuance has tangible implications for banks' capital structures and market-based risk perceptions, beyond a pure signalling role. Third, our findings speak to ongoing policy debates on the role of sustainable finance instruments in promoting financial stability, highlighting that green bonds may function not only as tools for environmental financing but also as instruments of strategic capital management.

The rest of the paper is structured as follows. Section 2 reviews the related literature and develops the testable hypotheses. Section 3 describes the data, variable construction, and sample selection. Section 4 outlines the empirical strategy. Section 5 presents the main results on credit risk, funding costs, and capital structure adjustments, together with additional robustness analyses. Section 6 concludes with implications for bank risk management and climate-related financial policy.

2. Literature Review & Hypothesis Development

2.1. Bank Green Bond Issuance

Bank-issued green bonds are debt instruments whose proceeds are contractually earmarked for financing or refinancing environmentally eligible assets, most commonly green loans (Bhutta et al., 2022). Issuers are typically required to specify eligible project categories ex ante, obtain external verification or certification, and provide ongoing reporting on the allocation and use of proceeds. Unlike conventional bonds, green bonds therefore impose additional disclosure, monitoring, and reputational constraints on issuing banks, which can affect both asset allocation and funding decisions (Bedendo et al., 2023). For banks, green bond issuance represents a commitment to expand or rebalance green lending activities while simultaneously accessing longer-maturity bond financing under heightened market scrutiny.

As a result, green bond issuance offers a natural proxy for time-varying changes in banks' green credit exposure, conditional on bond market access, and provides a setting to examine whether engagement in green lending feeds back into banks' risk profiles and capital structures rather than merely reflecting pre-existing issuer characteristics.

2.2. Bank Green Bond Issuance and Market-Perceived Credit Risk

Market-based measures provide a forward-looking assessment of bank risk that complements traditional accounting indicators. Common market-based risk proxies include CDS spreads, bond yield spreads, equity return volatility, and market-implied default probabilities. Among these measures, CDS spreads are particularly informative because they represent the price of insuring against bank default and therefore directly reflect investors' expectations of credit risk and financial stability (Ballester et al., 2025). Unlike accounting-based indicators, which are backward-looking and updated only periodically, CDS spreads adjust continuously as new information arrives and incorporate market expectations about banks' funding conditions, asset quality, regulatory pressures, and exposure to macroeconomic shocks. For this reason, CDS spreads are widely used in the banking and corporate finance literature as a market-based measure of perceived credit risk.

Several theoretical perspectives suggest that green financing activities may influence market perceptions of bank risk. From a signalling perspective, green bond issuance may convey information about banks' environmental risk management capabilities and commitment to sustainable lending, thereby signalling higher-quality firms and improved governance to investors (Flammer, 2021; Spence, 1973). Stakeholder theory further suggests that firms that align their activities with broader stakeholder expectations face lower reputational and regulatory risks, particularly as environmental accountability and climate-related disclosure requirements increase in financial markets (Freeman, 1984). From a risk management and portfolio perspective, increasing exposure to environmentally sustainable projects may improve the diversification and resilience of banks' loan portfolios, reducing vulnerability to climate-related transition and physical risks (Bolton & Kacperczyk, 2021). The resource-based view additionally emphasizes that developing expertise in sustainable finance can generate competitive advantages and stronger lending relationships, potentially leading to more stable borrower portfolios and improved risk outcomes (Barney, 1991).

Consistent with these mechanisms, a growing literature documents that green-labelled securities and environmentally credible issuers tend to trade at lower credit spreads, consistent

with reduced transition risk, stronger investor demand, and enhanced market discipline (Ballester et al., 2025; Gianfrate & Peri, 2019; Zerbib, 2019). At the firm level, broader environmental and ESG performance has also been associated with narrower CDS premia and improved downside protection, reflecting lower tail risk and greater resilience to adverse shocks (Albuquerque et al., 2019).

For banks, the relationship between green bond issuance and market-perceived credit risk is theoretically ambiguous ex ante. On the one hand, issuing green bonds may reduce CDS spreads if it facilitates funding diversification, lowers rollover risk, strengthens regulatory capital through retained earnings, or credibly signals proactive management of climate transition risks (Ehlers et al., 2020; Flammer, 2021). On the other hand, green bond issuance is often undertaken by larger, more sophisticated banks that already enjoy favourable market access, raising concerns that observed differences in CDS spreads may reflect issuer characteristics rather than a causal "green" effect.

Crucially, if green bond issuance conveys economically meaningful information to markets, its impact on perceived bank risk should strengthen as banks deepen their engagement in green bond markets. Repeated issuance increases the credibility of climate-related commitments, improves transparency regarding the use of proceeds, and establishes a track record of green lending activities. In contrast, sporadic or one-off issuance may have limited informational value and therefore fail to meaningfully alter investors' perceptions of bank risk. Accordingly, the risk-reduction effect of green bond issuance should become more pronounced as banks issue green bonds more frequently and in larger amounts over time.

Taken together, these considerations lead to two related but distinct testable predictions.

H1a (Average Credit Risk Effect)

Bank green bond issuance lowers market-perceived credit risk, measured by CDS spreads.

H1b (Issuance Intensity Effect)

The negative association between green bond issuance and CDS spreads strengthens with the intensity of green bond issuance, measured by the number and amount of green bond issuances.

If green bond issuance conveys credible information about banks' climate risk management and funding stability, its implications for market perceptions should strengthen as

banks accumulate experience in green bond markets. Repeated participation and larger cumulative issuance may enhance investor learning, improve disclosure credibility, and signal sustained commitment to green financing. Consequently, the effect of green bond issuance on bank risk and funding conditions may depend on the extent of a bank's prior engagement in green bond markets.

Following Brambor et al. (2006), we test whether the effect of green bond issuance varies with banks' exposure to green bond markets. This leads to a set of exposure-based hypotheses that complement the baseline effects developed earlier.

H1c (Exposure Effect)

The negative association between green bond issuance and CDS spreads becomes stronger as banks accumulate greater exposure to green bond markets.

2.3. Bank Green Bond Issuance and Banks' Capital Structure

Green bonds differ from conventional debt instruments because they combine earmarked use-of-proceeds, enhanced disclosure, third-party verification, and ongoing reporting obligations. These institutional features can influence issuers' funding conditions, investor base, and balance-sheet dynamics beyond the mechanical effect of additional debt issuance (Baker et al., 2018; Bhutta et al., 2022; Zerbib, 2019). From a corporate finance perspective, such features may affect firms' capital structure choices by altering financing costs and investor demand (Modigliani & Miller, 1963; Myers & Majluf, 1984). For banks, whose business models rely heavily on leverage and market confidence, green bond issuance may therefore have direct implications for regulatory capital and funding stability.

Several theoretical channels link green bond issuance to bank capital adequacy. First, capital structure theory suggests that firms adjust their financing mix in response to changes in funding costs and investor demand (Frank & Goyal, 2009; Myers & Majluf, 1984). If green bonds reduce the marginal cost of debt or expand the investor base, banks may experience improved refinancing conditions and lower funding costs, which can increase retained earnings and gradually strengthen regulatory capital ratios. Second, from a stakeholder and signalling perspective, issuing certified green bonds may signal stronger environmental risk management and governance practices to investors and regulators (Flammer, 2021; Parmar et al., 2010; Spence, 1973). Such signals may reduce perceived transition risk and enhance market confidence, improving banks' ability to access funding on stable terms. Third, financial intermediation and liquidity risk theories emphasize that diversified funding sources and stable

investor bases can reduce rollover risk and funding volatility for banks (Allen et al., 2011). Because green bonds often attract long-term ESG-oriented investors, sustained issuance may strengthen banks' funding stability and indirectly support higher regulatory capital buffers.

These mechanisms are particularly relevant in banking, where capital adequacy plays a central role in market discipline and regulatory oversight. Well-capitalized banks face lower funding risk, greater regulatory flexibility, and improved market confidence, while weak capital positions can amplify perceived credit risk and funding costs (Berger et al., 2016; Wagner, 2010). If green bond issuance improves funding stability or credibly signals stronger risk management in the context of climate transition, market participants may expect issuing banks to maintain stronger regulatory capital positions over time.

Importantly, the effect of green bond issuance on capital adequacy must be interpreted conditional on access to bond markets, since only banks that can issue debt securities can choose between conventional and green bond financing. Conditioning on bond market access therefore isolates the capital structure implications of green bond issuance from broader differences in financial market participation.

Taken together, these arguments lead to the following hypothesis.

H2a (Capital Structure Effect)

Conditional on bond market access, banks that issue green bonds maintain stronger regulatory capital positions, reflected in higher Tier 1 capital ratios and overall capital adequacy.

H2b (Issuance Intensity Effect)

The positive association between green bond issuance and capital structure strengthens with the intensity of green bond issuance, measured by the number and amount of green bond issuances.

2.4. Bank Green Bond Issuance and the Cost of Fundings

A large empirical literature documents that environmentally credible firms tend to benefit from modest reductions in debt financing costs. Using matched samples of green and conventional bonds, Zerbib (2019) and Baker et al. (2018) report a small but statistically significant "greenium," reflected in lower yields at issuance and stronger secondary market performance. These effects are generally attributed to investor preferences for environmentally labelled assets and to improved liquidity and demand conditions in green bond markets.

Related studies further show that environmental performance and ESG credibility are associated with lower loan spreads and bond yields, consistent with reduced perceived risk and broader investor demand (Chava, 2014; El Ghoul et al., 2011; Goss & Roberts, 2011).

Recent evidence suggests that the greenium may be particularly pronounced for financial institutions. Using a comprehensive sample of green bonds issued between 2013 and 2022, Aswani and Rajgopal (2025) document that green bonds issued by financial firm's trade at a secondary-market premium of approximately 8 basis points relative to matched conventional bonds. They attribute this premium to investor preferences and to the role of financial institutions as intermediaries channelling funds toward green lending, rather than to improvements in borrowers' short-term performance or emissions outcomes. Importantly, their findings indicate that the greenium earned in bond markets does not necessarily translate into greener lending outcomes at the loan level, underscoring that green bond pricing primarily reflects funding-side and market-perception effects.

For banks, the above-mentioned findings imply that green bond issuance can lower debt financing costs through investor demand and market discipline channels, even in the absence of immediate improvements in underlying loan performance. Consistent with this view, Ehlers et al. (2020) argue that green-labelled debt can mitigate perceived transition risk and expand the investor base for financial institutions, compressing funding spreads. Given banks' heavy reliance on debt financing, such effects are likely to translate into a lower cost of debt and, potentially, a reduction in the weighted average cost of capital, conditional on corresponding adjustments in equity financing. Accordingly, we posit:

H3a (Funding Cost Effect)

Bank green bond issuance lowers funding costs, reflected in a reduction in banks' cost of debt and weighted average cost of capital.

H3b (Issuance Intensity Effect)

The negative association between green bond issuance and banks' funding costs strengthens with the intensity of green bond issuance, measured by the number and amount of green bonds issued.

H3c (Exposure Effect)

The negative association between green bond issuance and banks' cost of debt and weighted average cost of capital becomes stronger for banks with greater exposure to green bond markets.

2.5. Bank Cost of Equity and Capital Structure Trade-offs

Debt investors may reward green bond issuance with lower required returns, but the implications for equity holders are less clear. Asset pricing studies suggest that firms with strong environmental credentials may benefit from investor preference effects or reduced downside risk, potentially lowering the cost of equity (Albuquerque et al., 2019; Pástor et al., 2021). However, for banks, green bond issuance may also induce capital structure adjustments that increase equity risk.

First, if green bond issuance lowers debt costs and stabilizes funding, banks may respond by increasing leverage, which mechanically raises the equity risk premium. Second, equity investors may be more sensitive than debt investors to the upfront costs, long payback periods, and execution risks associated with sustainability investments (Baker et al., 2018; Flammer, 2021). Empirical evidence on stock market reactions to green bond announcements is mixed, with some studies documenting muted or heterogeneous equity responses depending on certification quality and post-issuance balance sheet adjustments (Tang & Zhang, 2020).

Taken together, these considerations suggest that green bond issuance may increase the cost of equity even as it lowers debt financing costs and reduces overall funding risk. We therefore hypothesize:

H4a (Equity Risk Compensation Effect)

Bank green bond issuance increases bank's cost of equity.

H4b (Exposure Effect)

The positive association between green bond issuance and banks' cost of equity becomes stronger for banks with greater exposure to green bond markets.

2.6. Bank Leverage, Funding Mix, and Issuance Exposure

Banks operate with inherently high leverage and face binding regulatory constraints, and hence, instruments that broaden the pool of debt investors and stabilize funding conditions can influence optimal capital structure choices. Prior research shows that credible green bond issuance expands investor demand and improves debt market access (Baker et al., 2018; Zerbib,

2019), increasing banks' capacity to finance assets with debt. When equity issuance does not adjust proportionately, this substitution toward debt can raise debt-to-equity ratios.

Importantly, the effects of green bond issuance may depend on the exposure and persistence of issuance. Banks that issue green bonds repeatedly may benefit more from learning effects, sustained market scrutiny, and deeper integration of green lending into their balance sheets. Consistent with this view, Flammer (2021) finds that firms with repeated green bond issuance exhibit more pronounced shifts toward labelled debt financing. In a regulated banking context, such dynamics may translate into higher leverage without a commensurate increase in perceived risk.

This leads to the following hypothesis:

H5a (Leverage Effect)

Bank green bond issuance increases banks' debt-to-equity ratio.

H5b (Issuance Intensity Effect)

The negative association between green bond issuance and banks' debt-to-equity ratio strengthens with the intensity of green bond issuance, measured by the number and amount of green bonds issued.

3. Data and Variables

3.1. Data and Sample Construction

The dataset includes a panel of banks over the period 2010–2023. The sample covers financial institutions from 94 countries, including advanced, emerging, and developing economies (EMDEs), as classified by the World Bank. Such a broad coverage allows us to exploit substantial cross-country variation in regulatory environments, financial market development, and climate policy exposure, while focusing on within-bank dynamics over time.

We use an international panel of banks that issue at least one conventional or green bond during the 2010–2023 sample period, which we interpret as having access to bond markets. This design ensures that identification comes from within-bank variation in green bond issuance, rather than from differences between banks that issue bonds and those that do not. By conditioning on bond market access, we isolate the effect of issuing green bonds from the broader decision to participate in debt markets.

3.2. Green Bond Issuance Data

We construct a comprehensive dataset on green bond issuance using Workspace, covering the period 2012–2023. The raw data includes 8,282 green bonds issued across 59 countries and all sectors. Over the same period, the broader universe of conventional and labelled bonds in Workspace totals 118,738 instruments with an aggregate issuance volume of approximately USD 12.78 trillion, spanning issuers from 94 countries.

To link green bond issuance activity to our bank-level panel, we implement a multi-step matching procedure. Specifically, we apply fuzzy name matching techniques to map issuer identities in the Workspace bond database to banks in our master sample. This process allows us to identify the amount and number of green bonds issued by each bank over time. Following manual verification and consistency checks, we successfully match 1,890 green bond issues with a total issuance value of approximately USD 535.45 billion to banks in our final dataset. These matched bonds form the basis for constructing bank-level green bond variables used in the empirical analysis.

Using the matched sample, we construct several measures of green bond activity. First, we define GBdummy as a binary indicator equal to one if a bank has at least one green bond outstanding in year t, and zero otherwise. Second, we construct two cumulative measures of green bond intensity at the bank-year level: the cumulative outstanding green bond amount and the cumulative number of green bonds outstanding up to year t. These variables are then transformed into natural logarithmic values and denoted as lnGBamount and lnGBnumber, respectively. Third, to capture issuance exposure over time, we construct two additional cumulative measures: issue-based exposure, defined as the cumulative number of years in which a bank has issued green bonds up to year t, and amount-based exposure, defined as the cumulative outstanding green bond amount up to year t (similar to GBamount). Both exposure measures are likewise transformed into natural logarithmic form. Together, these variables allow us to capture whether a bank participates in green bond markets, the scale of its outstanding green bond activity, and the persistence of its engagement over time.

3.3. Dependent Variables

This study examines how green bond issuance relates to banks' market-perceived risk, capital strength, leverage, and funding costs. To capture these characteristics, we construct multiple dependent variables as follows.

Credit default swap spreads

CDS spreads provide the most direct and forward-looking measure of market-perceived bank risk, as they incorporate investor expectations about solvency, funding stability, and exposure to systemic shocks. CDS data are obtained from the National University of Singapore Credit Research Initiative (CRI NUS) database, which provides daily single-name CDS spreads for over 80,000 exchange-listed firms across 133 economies. CDS spreads represent the annual cost, in basis points, of insuring against default on a given reference entity and are widely used as forward-looking measures of market-perceived credit risk.

For each bank, we compute annual averages of daily CDS spreads to align with the bank–year panel structure of our dataset. We then take the natural logarithm of these annual averages to reduce skewness and limit the influence of extreme values. Using multiple maturities (1-year to 5-year) allows us to examine how green bond issuance relates to perceived default risk across short-, medium-, and longer-term horizons. In practice, the 5-year CDS contract is typically the most liquid segment of the market and is often viewed as the benchmark measure of firm-level default risk (Ballester et al., 2024; Chava et al., 2026), while shorter maturities capture more immediate market reactions.

CDS spreads capture investors' real-time assessment of a bank's creditworthiness, reflecting expectations about default probability, capital adequacy, funding stability, and exposure to macro-financial shocks. As such, they provide a market-based complement to accounting measures of risk.

Capital adequacy

To examine balance-sheet resilience, we use two regulatory capital measures obtained from Workspace, namely, (i) Tier 1 capital ratio: Tier 1 capital divided by risk-weighted assets, and (ii) Total capital adequacy ratio: Total regulatory capital (Tier 1 + Tier 2) divided by risk-weighted assets. These ratios reflect banks' loss-absorbing capacity and are central to prudential regulation under Basel frameworks. Higher capital ratios indicate stronger solvency buffers and greater ability to withstand financial stress.

We use both measures for two reasons. First, Tier 1 captures core equity-based capital, while total capital adequacy includes additional loss-absorbing instruments classified as Tier 2. Second, using both measures provides a robustness check, as green bond issuance may affect broader balance-sheet composition and funding conditions rather than core equity directly.

Importantly, standard green bonds are generally issued as senior debt and are not typically counted as regulatory capital under Basel III unless specifically structured to meet Tier 2 eligibility criteria. As such, any association between green bond issuance and capital

ratios is more likely to reflect indirect balance-sheet effects rather than a mechanical inclusion in regulatory capital (Ehlers & Packer, 2017).

Funding costs

To assess financing conditions, we consider three complementary measures, namely, Cost of debt, Cost of equity, and Weighted Average Cost of Capital (WACC). Corresponding data are obtained from Bloomberg. These measures reflect the market-implied required returns on debt and equity financing. The cost of debt captures borrowing conditions, while the cost of equity reflects shareholders' required compensation for risk. WACC combines both components and provides a comprehensive measure of overall funding costs.

Leverage

We measure leverage using the debt-to-equity ratio, sourced from Workspace. This variable captures the extent to which banks rely on debt financing relative to equity. Because banks operate with structurally high leverage, even modest changes in funding structure can materially affect risk exposure and market perceptions.

3.4. Control Variables

Bank-level financial and market data are primarily sourced from Workspace (Fornari et al., 2026) and Bloomberg, which provide comprehensive coverage of balance sheet variables, funding structure, market-based risk measures, and bond issuance activity. Country-level macroeconomic and institutional controls are obtained from the World Development Indicators and related international databases. Details of all variable description are in Appendix A.1. and summary statistics for all variables are reported in Table 1.

4. Methodology

4.1. Research Design

Our baseline empirical specification relies on bank fixed-effects models, which exploit within-bank variation in green bond issuance over time while controlling for time-invariant differences in bank characteristics. This approach allows us to compare periods in which the same bank issues green bonds to periods in which it does not, thereby mitigating concerns that cross-sectional differences between banks drive the results.

A remaining concern is that green bond issuance may still be endogenously related to unobserved improvements in bank fundamentals or funding conditions. For example, banks anticipating improved creditworthiness or favourable market conditions may be more likely to

issue green bonds. To evaluate this possibility, we complement the fixed-effects specification with an instrumental-variables (IV) approach and formally test for endogeneity.

Specifically, we employ a two-stage least squares (2SLS) strategy using two country-level instruments: the ND-GAIN climate vulnerability index and the share of renewable energy consumption. Countries with higher climate vulnerability and stronger energy transition momentum tend to exhibit greater regulatory attention, policy support, and investor demand for green finance, increasing the likelihood that banks operating in these environments issue green bonds. These factors shape the supply and demand conditions for green bond issuance at the country level, independently of banks' idiosyncratic balance sheet dynamics. The exclusion restriction relies on the assumption that country-level climate vulnerability and renewable energy adoption affect banks' risk and capital structure primarily through their influence on green financing incentives, rather than through direct effects on bank-specific outcomes. Our identification does not require that these instruments be unrelated to macroeconomic conditions per se; rather, it requires that any direct effects on banks' market-perceived risk or capital structure operate at a broad, country-level horizon and be absorbed by year-fixed effects and country-level controls. Conditional on these controls, variation in the ND-GAIN index and renewable energy consumption captures differential pressure and opportunity to engage in green finance, not contemporaneous shocks to individual banks' credit risk or funding costs.

Importantly, these instruments vary at the country–year level, whereas identification in the main specification relies on within-bank variation over time. Conditional on bank fixed effects, year fixed effects, and macroeconomic controls, the instruments capture changes in the institutional environment that affect green bond issuance but are unlikely to directly influence bank-specific risk outcomes such as CDS spreads or funding costs in the short run.

We formally assess the presence of endogeneity using Durbin–Wu–Hausman tests. When the null hypothesis of exogeneity is rejected, we report 2SLS estimates to correct for potential endogeneity. When exogeneity cannot be rejected, we rely on the fixed-effects estimates, which remain more efficient under standard assumptions. This approach allows the data to determine the appropriate estimation method while maintaining a consistent empirical framework.

As with any IV strategy, identification relies on assumptions that cannot be directly tested. However, the consistency of results across fixed-effects and IV specifications provides

reassurance that the observed relationships between green bond issuance, bank risk, and funding conditions are not driven by reverse causality or omitted variable bias.

4.2. Baseline Econometric Specification

We estimate the following baseline model at the bank–year level:

$$\boldsymbol{Y_{ict} = \alpha_0 + \alpha_1 GB_{ict} + \alpha_2 X_{ict} + \alpha_3 Z_{ct} + BFE + YFE + \varepsilon_{ict}} \qquad \textbf{(1)}$$

where $i$indexes banks**,** $c$indexes countries, and $t$indexes years**.** Accordingly, the dependent variable Y_{ict} captures several dimensions of banks' risk, funding conditions, and capital structure. Specifically, we examine the logarithm of CDS spreads across maturities from one to five years as a market-based measure of perceived default risk, regulatory capital ratios (Tier 1 capital ratio and total capital adequacy ratio), leverage measured by the debt-to-equity ratio, and funding costs, including the cost of debt, cost of equity, and the weighted average cost of capital. The key explanatory variable GB_{it}measures banks' engagement in green bond markets using several alternative proxies: (i) an indicator equal to one when a bank has outstanding green bonds ($GBdummy$), (ii) the logarithm of the cumulative outstanding amount of green bond issuances ($lnGBamount$), and (iii) the logarithm of the cumulative number of green bond issuances ($lnGBnumber$). The vector X_{ict} includes bank-level control variables commonly used in the banking literature, such as bank size, profitability, asset quality, liquidity, leverage, market valuation, and stock return volatility. Finally, Z_{ct} represents country-level controls capturing macroeconomic and institutional conditions, including GDP growth, institutional quality, banking sector concentration, and the slope of the yield curve. $\varepsilon_{ict}$is the error term.

All specifications include bank fixed effects and year fixed effects. Standard errors are clustered at the bank level to account for serial correlation in outcomes within institutions.

The coefficient on green bond exposure is interpreted as the within-bank change in CDS spreads associated with changes in green bond activity.

4.3. Interaction Econometric Specification

To examine whether the impact of green bond issuance depends on the depth and persistence of banks' engagement in green bond markets, we extend the baseline specification by interacting green bond issuance with measures of issuance exposure:

$$\boldsymbol{Y_{it} = \beta_0 + \beta_1 GBdummy_{ict} + \beta_2 Exposure_{ict} + \beta_3 (GBdummy_{ict} \times Exposure_{ict}) + \beta_4 X_{ict} + \beta_5 Z_{ct} + BFE + YFE + \mu_{ict}} \qquad \textbf{(2)}$$

where $Exposure_{ict}$ captures the accumulated engagement of a bank in green bond markets. We consider two complementary exposure measures that reflect different dimensions of market participation. Issue-based exposure is defined as the logarithm of the cumulative number of years in which a bank has issued green bonds up to year t. This measure captures persistence in market participation: banks that repeatedly return to the green bond market are more likely to develop issuance expertise, strengthen disclosure practices, and build credibility with investors.

Amount-based exposure, in contrast, reflects the scale of a bank's engagement in green bond financing. It is defined as the logarithm of the cumulative outstanding amount of green bonds issued up to year t, corresponding to the variable $lnGBamount$ used in the empirical analysis. While the issue-based measure captures persistence in participation, the amount-based measure captures the economic scale of a bank's green bond activity over time.

These exposure measures are interacted with the green bond issuance dummy to test whether the effect of green bond issuance depends on the extent of a bank's engagement in green bond markets. In this specification, the coefficient on $GBdummy$ represents the effect of green bond issuance when exposure is low, while the interaction coefficient captures how this effect changes as issuance exposure increases. Following the interaction framework of Brambor et al. (2006), the marginal effect of green bond issuance therefore varies across different levels of exposure, allowing us to assess whether deeper participation in green bond markets strengthens or weakens the observed relationships between green bond issuance and banks' risk, funding costs, and capital structure.

5. Results

All result tables below are included in the List of Tables section.

5.1. Descriptive Statistics

Figures 1 and 2 illustrate the evolution of bank green bond issuance across regions over time. Figure 1 reports the number of green bonds issued annually by region, while Figure 2 shows the corresponding issuance value. The figures reveal a clear expansion in green bond activity over the sample period, particularly after 2017, consistent with the broader growth of sustainable finance markets.

[Insert Figures 1 – 2 here]

In the early years of the sample, issuance activity is relatively modest and concentrated in a few regions. Over time, however, issuance accelerates markedly, with particularly strong growth observed in Europe and East Asia. The surge around 2020–2021 coincides with heightened policy focus on climate transition, the introduction of green recovery programs following the COVID-19 pandemic, and increased investor demand for sustainable assets. While issuance levels remain lower in regions such as Sub-Saharan Africa and Latin America, participation has gradually broadened, indicating a progressive geographical diversification of the market.

Figure 2 complements this pattern by documenting the evolution of issuance value. Total proceeds rise sharply over time, peaking in the early 2020s. Europe accounts for a substantial share of total issuance volume, followed by East Asia and North America, reflecting the presence of large and frequent bank issuers in these regions. The steady increase in issuance size suggests not only a growing number of transactions but also an expansion in deal scale and repeated issuance by established market participants.

Together, these descriptive patterns highlight two key features of the bank green bond market. First, issuance is highly concentrated among a subset of large and internationally active banks, consistent with the idea that market access and disclosure capacity are prerequisites for participation. Second, issuance exposure increases over time, both in terms of frequency and total volume, which motivates our use of cumulative measures of green bond exposure at the bank level.

[Insert Table 1 here]

Table 1 reports descriptive statistics for the main variables used in the analysis. The sample covers the period 2012–2023 and consists of an international panel of financial institutions across 94 countries. To ensure comparability and avoid structural differences between issuers and non-issuers, the empirical analysis is conducted on banks that have access to bond markets at least once during the sample period. All continuous bank-level variables are winsorized at conventional tails to mitigate the influence of extreme observations while preserving cross-sectional variation.

Panel A in Table 1 presents statistics for the outcome variables capturing banks' capital structure, funding costs, and market-based credit risk. On average, banks in the sample exhibit a weighted average cost of capital of 6.34%, with a mean cost of debt of 2.58% and cost of equity of 10.03%, consistent with the funding structure of large internationally active financial institutions. The average Tier 1 capital ratio is 14.67%, and the average total capital adequacy

ratio is 17.19%, indicating that most banks operate with capital buffers well above minimum regulatory thresholds.

Leverage, measured as the debt-to-equity ratio, averages 4.75, reflecting the inherently leveraged nature of banking institutions. Market-based credit risk, proxied by CDS spreads, displays substantial variation across maturities. The mean log CDS spread increases monotonically from 2.15 for 1-year contracts to 2.79 for 5-year contracts, consistent with an upward-sloping term structure of perceived default risk. The wide range of CDS values suggests meaningful cross-sectional and temporal variation in investors' assessments of bank creditworthiness.

Panel B in Table 1 reports descriptive statistics for the key explanatory variables capturing green bond activity. The green bond issuance dummy has a mean of 0.075, indicating that issuance remains relatively infrequent (7.5%) at the bank-year level among institutions with bond market access. Measures of cumulative green bond intensity exhibit substantial dispersion across banks. The logarithm of cumulative green bond amount outstanding has a mean of 1.49 and a standard deviation of 5.26, with values ranging from 0 to 24.42, indicating a highly skewed distribution of issuance activity. This pattern reflects the fact that a small group of large banks accounts for a substantial share of green bond issuance, while many banks issue green bonds only occasionally. Similarly, the logarithm of the cumulative number of green bonds issued has a mean of 0.062 and a standard deviation of 0.346, again indicating relatively low average issuance activity but meaningful cross-bank variation. Relative to conventional bond issuance in banking markets, which typically occurs more frequently and at larger scale, these figures suggest that green bond financing remains a small but growing component of banks' funding structures, while still exhibiting considerable heterogeneity in participation across institutions.

As far as bank-specific characteristics are concerned in Panel C of Table 1, the average bank in the sample is large, with a mean log total asset size of 22.14. Profitability, measured by ROAA, shows substantial dispersion, reflecting differences in business models, economic environments, and cyclical conditions across countries. Asset quality indicators such as non-performing loan ratios vary considerably across banks, consistent with heterogeneity in credit risk exposure and supervisory environments.

Funding structure variables also display wide variation. The deposits-to-assets ratio averages 44.10%, while leverage (debt-to-total assets) averages 20.07%, indicating differences in reliance on wholesale versus deposit funding. Governance and ESG-related indicators, including board characteristics and environmental pillar scores, exhibit substantial cross-

sectional variation, suggesting that banks differ significantly in their institutional structures and sustainability engagement.

Finally, Panel D in Table 1 reports country-level macroeconomic controls. Average GDP growth is 2.93%, with wide dispersion reflecting the inclusion of both advanced economies and emerging markets. Institutional quality, measured by the World Governance Indicator (WGI), averages 63.76 but varies markedly across countries. The yield curve slope and banking sector concentration also show meaningful variation, capturing differences in monetary conditions and financial market structure across jurisdictions.

Overall, the descriptive statistics reveal three key features of the sample. First, banks are generally well-capitalized and operate with high leverage, consistent with modern regulatory frameworks. Second, green bond issuance is relatively concentrated among a subset of institutions, creating substantial heterogeneity in green financing exposure. Third, there is considerable variation in market-based credit risk, funding costs, and balance sheet characteristics across banks and over time, providing a suitable empirical setting to examine how changes in green bond issuance relate to bank risk and capital structure dynamics.

5.2. Bank Green Bond Issuance and Market-Perceived Credit Risk

This section examines whether green bond issuance by banks affects market-perceived credit risk, as reflected in CDS spreads. CDS contracts provide a forward-looking, market-based measure of default risk that incorporates investors' assessments of capital strength, funding stability, and exposure to transition risk. Given the central role of CDS spreads in bank funding markets, understanding how green bond issuance shapes CDS pricing is critical for evaluating the financial implications of sustainable finance at the bank level.

We estimate within-bank panel models that exploit variation in green bond exposure over time while controlling for bank fixed effects, year fixed effects, and time-varying bank and country characteristics. Standard errors are clustered at the bank level. Identification therefore comes from changes in a given bank's outcomes relative to its own historical baseline, conditional on bond market access and common macroeconomic shocks.

5.2.1. Baseline Fixed-effects Results & Addressing Endogeneity: 2SLS Estimates

To test Hypothesis H1a (Average Credit Risk Effect), we begin by estimating fixed-effects models relating CDS spreads to green bond issuance across maturities from one to five years.

[Insert Table 2 here]

Panel A of Table 2 reports the baseline fixed-effects estimates. Across all maturities, the coefficients on GBdummy are negative, indicating that banks' CDS spreads decline after entering the green bond market. The magnitude is modest but economically consistent across the term structure, ranging from −0.0356 for one-year CDS to −0.0274 for five-year CDS. Although these estimates are not statistically significant, the pattern suggests a systematic reduction in market-perceived credit risk following issuance.

Importantly, the maturity gradient is monotonic: the estimated effect declines gradually as maturity increases. This pattern is consistent with the interpretation that markets initially reassess banks' near-term funding conditions and transparency following green bond issuance, with effects that persist but attenuate over longer horizons.

A key concern is that green bond issuance may be endogenous to unobserved improvements in bank fundamentals and forward-looking managerial decisions. Banks do not issue green bonds randomly. Instead, issuance is typically timed alongside broader balance-sheet adjustments, refinancing plans, investor-relations strategies, or anticipated improvements in credit quality. For example, a bank expecting stronger profitability, lower default risk, or improved market access may simultaneously strengthen its capital position and enter the green bond market. In such cases, part of the observed reduction in CDS spreads may reflect underlying improvements in fundamentals rather than the causal effect of green bond issuance itself. While bank fixed effects control for time-invariant heterogeneity, they cannot eliminate this type of time-varying, forward-looking selection into issuance.

To address this concern, we implement a two-stage least squares strategy that exploits exogenous variation in the incentives to issue green bonds across countries and over time. Specifically, we instrument green bond issuance using two country-level factors: climate vulnerability (ND-GAIN) and the share of renewable energy consumption. The justification of these two variables was previously explained in Section 4.

Panel B of Table 2 reports the IV estimates. The coefficients remain negative across all maturities but become substantially larger in magnitude and highly statistically significant. The estimated effect is −1.358 ($p < 0.01$) for one-year CDS, −1.327 ($p < 0.01$) for two-year CDS, −1.205 ($p < 0.01$) for three-year CDS, −1.061 ($p < 0.01$) for four-year CDS, and −0.913 ($p < 0.01$) for five-year CDS.

These results indicate that fixed-effects estimates likely understate the true effect of green bond issuance on market-perceived credit risk. A plausible mechanism is selection: banks

tend to issue green bonds when they anticipate improved funding conditions or stronger performance, which compresses spreads even before issuance is observed. Once this endogeneity is addressed, the underlying credit-risk effect becomes more pronounced.

Instrument diagnostics support the validity of the IV strategy. The Kleibergen–Paap F-statistics (≈ 83 across specifications) indicate strong instruments, and Anderson–Rubin and Stock–Wright tests confirm the statistical significance of the IV estimates. The Durbin–Wu–Hausman tests consistently reject exogeneity across maturities ($p < 0.01$), reinforcing the importance of accounting for endogenous issuance decisions. These findings provide strong evidence that green bond issuance is associated with a meaningful reduction in market-perceived credit risk across the CDS term structure, with particularly large effects once selection into issuance is accounted for.

While the baseline estimates capture the average effect of issuance, theory suggests that market responses may depend on the depth of engagement in green financing. Repeated issuance can strengthen credibility, improve transparency, and signal a sustained strategic commitment rather than a one-off labelling exercise. To capture this heterogeneity, we later interact green bond issuance with cumulative issuance exposure and interpret the results using marginal effects following Brambor et al. (2006).

5.2.2. Alternative Measures of Green Bond Intensity

To ensure that the baseline findings are not driven by the binary issuance indicator alone, we next consider continuous measures of green bond activity based on the outstanding amount and number of green bonds to test Hypothesis H1b (Issuance Intensity Effect).

[Insert Table 3 here]

Table 3 reports results using the log of cumulative green bond amount outstanding (lnGBamount) and the log of the cumulative number of green bond issues (lnGBnumber), focusing on five-year CDS spreads.

The fixed-effects estimates again show negative but statistically weak associations. In contrast, the 2SLS results indicate stronger and statistically significant effects. The coefficient on lnGBamount is −0.025 ($p < 0.05$), while lnGBnumber shows a larger negative effect of −0.303 ($p < 0.05$) under IV estimation.

These results suggest that not only the presence of green bond issuance, but also the depth of participation in green bond markets contributes to lower CDS spreads. Banks with

larger outstanding green bond portfolios or more frequent issuance histories are perceived as less risky by credit markets.

Endogeneity tests provide additional support for the IV approach. The Kleibergen–Paap statistics indicate adequate instrument strength, while Anderson–Rubin and Stock–Wright tests confirm the statistical significance of the IV coefficients. Durbin–Wu–Hausman tests indicate the presence of endogenous selection into issuance intensity ($p < 0.05–0.10$), consistent with the idea that stronger banks may scale up issuance as conditions improve.

Overall, the continuous-exposure results reinforce the baseline interpretation: green bond issuance is associated with lower CDS spreads, and the effect becomes stronger when accounting for endogenous issuance decisions and the cumulative scale of green financing activity.

5.2.3. Heterogeneity by Issuance Exposure & Marginal Effects

While the baseline estimates capture the average effect of issuance, theory suggests that market responses should depend on the persistence and credibility of banks' engagement in green financing. To test this mechanism or Hypothesis H1c (Exposure Effect), we interact the issuance indicator with measures of cumulative exposure.

[Insert Table 4 here]

Table 4 examines whether the impact of green bond issuance varies with accumulated issuance exposure. Panel A uses issue-based exposure, while Panel B uses amount-based exposure as alternative proxies for the depth of banks' participation in green bond markets.

Testing these channels is important because markets may distinguish between occasional issuers and banks that sustain green bond activity over time. If credit-risk benefits strengthen with higher issue-based exposure or larger cumulative issuance amounts, this would suggest that repeated and scaled participation enhances credibility, investor trust, and perceived funding stability rather than green issuance being treated as a one-off signal. Across all maturities, the interaction terms are negative and statistically significant. For example, in the issue-based exposure model, the GB × exposure coefficient is −0.279 ($p < 0.10$) for one-year CDS and remains significant at −0.172 ($p < 0.10$) for five-year CDS. Similarly, in the amount-based exposure model, the interaction coefficients range from −0.0896 to −0.0617 and are statistically significant across maturities. These results indicate that the credit-risk benefits of green bond issuance strengthen as banks accumulate issuance experience. Importantly, in models with interaction terms, the coefficient on GBdummy alone does not represent the

marginal effect of issuance. Following Brambor et al. (2006) interpretation must be based on the combined marginal effect of issuance and exposure.

To provide an economically meaningful interpretation of the interaction results, we compute and plot the marginal effect of green bond issuance on CDS spreads across the distribution of cumulative issuance exposure. Because the specification includes an interaction term between green bond issuance and exposure, the coefficient on the issuance dummy alone does not represent the total effect. Instead, the marginal effect of issuance is given by:

$$\frac{\partial CDS_{it}}{\partial GBdummy_{it}} = \beta_1 + \beta_2 \times Exposure_{it}$$

where β_1 is the coefficient on the green bond issuance dummy and β_2 is the coefficient on the interaction term between issuance and exposure. This formulation implies that the effect of green bond issuance varies continuously with the bank's accumulated participation in the green bond market.

[Insert Figure 3 here]

Figure 3 plots the marginal effect of green bond issuance as a function of cumulative issuance experience, measured as the logarithm of the number of years in which a bank has issued green bonds up to year t. The figure shows clear heterogeneity across banks. For institutions with little or no prior issuance experience, the marginal effect is small and statistically indistinguishable from zero, indicating that a one-off green bond issuance does not immediately alter market perceptions of credit risk. As issuance experience accumulates, however, the marginal effect declines steadily and eventually becomes negative.

The dotted vertical line marks the estimated threshold level of exposure at which the marginal effect crosses zero. In log terms, this occurs at approximately 1.71. Translating this into levels:

$$Issuance\ years = e^{1.71} \approx 5.5\ years$$

This implies that the credit-risk benefits of green bond issuance become statistically meaningful only after a bank has accumulated roughly five to six years of issuance experience. Economically, this pattern is consistent with a credibility mechanism: repeated issuance builds a track record, enhances investor learning, and signals a sustained commitment to green financing rather than a one-off labelling strategy.

[Insert Figure 4 here]

Figure 4 presents the corresponding marginal effects using amount-based exposure, measured as the logarithm of the cumulative total value of green bonds issued by a bank up to year t. The same mechanism emerges along a scale dimension. For banks with small cumulative issuance volumes, the marginal effect remains weak and statistically uncertain. As cumulative issuance increases, the marginal effect becomes increasingly negative, indicating that larger and more sustained engagement in green bond markets is associated with lower market-perceived credit risk. The threshold shown in the figure of USD 418 million represents the level of cumulative issuance at which the marginal effect turns negative, after which additional issuance is associated with a statistically significant decline in 5-year CDS spreads.

Taken together, the two figures convey a consistent message. Markets do not appear to reward green bond issuance mechanically. Instead, the reduction in CDS spreads materializes only once banks establish either sustained issuance experience (time dimension) or sufficiently large cumulative issuance volumes (scale dimension). In economic terms, the magnitude of the implied CDS compression for high-exposure banks is comparable to changes typically associated with improvements in capital strength or funding stability, underscoring the importance of persistent and credible participation in green bond markets.

5.2.4. CDS Maturity Structure & Interpretation

Comparing results across maturities provides additional insight into the transmission mechanism through which green bond issuance affects market-perceived credit risk. The effects are strongest and most statistically robust at short and medium maturities (1–3 years), where both fixed-effects and IV estimates indicate significant reductions in CDS spreads following green bond issuance. The magnitude of the coefficients declines steadily with maturity, and estimates become less precise at longer horizons (4–5 years), where endogeneity concerns are also weaker. While the direction of the effect remains negative across all maturities, the weaker statistical precision at longer horizons suggests that markets incorporate structural credit risk more gradually, consistent with the idea that credibility builds over time through sustained issuance rather than a single financing event.

This maturity gradient is economically informative. Short-dated CDS contracts primarily reflect investors' assessments of near-term creditworthiness, liquidity conditions, and refinancing risk. The stronger effects at the 1–3 year horizon therefore suggest that green bond issuance is interpreted by markets as improving banks' short-to-medium-term funding stability, transparency, and risk management practices. Entering the green bond market may broaden the

investor base, enhance disclosure, and signal commitment to disciplined balance-sheet management, all of which can reduce perceived credit risk in the near term.

At longer maturities, CDS spreads embed expectations about structural solvency, long-run business models, and macro-financial uncertainty. The smaller and less precisely estimated effects at the 4–5 year horizon suggest that while green bond issuance contributes to credibility, its immediate impact is more closely tied to funding conditions and investor sentiment than to deep structural changes in long-run default risk. This interpretation is consistent with the heterogeneity results and marginal effects analysis, which indicate that longer-horizon benefits become more pronounced only as issuance is sustained over time.

In summary, the term-structure evidence points to a dynamic adjustment process in market perceptions. Investors appear to respond first through a reassessment of near-term funding and credit conditions, while longer-term credibility effects emerge gradually as banks accumulate issuance experience. This pattern aligns with the broader interpretation of green bond issuance as a signaling mechanism: initial participation improves perceptions of short-run stability, whereas repeated engagement strengthens longer-run confidence in banks' transition strategies and balance-sheet resilience. Bank Green Bond Issuance and Capital Adequacy

5.2.5. Entropy Balancing

A remaining concern is that banks issuing green bonds may differ systematically from non-issuers along observable dimensions such as size, leverage, and funding structure. While the baseline specification restricts the sample to banks with bond market access and includes bank fixed effects, residual cross-sectional differences could still influence both issuance decisions and CDS pricing. To address this concern, we apply entropy balancing to reweight the control group so that the first three moments of key balance-sheet covariates match those of issuing banks (Hainmueller, 2012).

We balance on core characteristics closely linked to funding access and credit risk, including bank size, deposit reliance, leverage, and loan intensity. Appendix Table A.3. reports covariate balance before and after reweighting. Prior to weighting, treated banks are substantially larger, more leveraged, and rely less on deposit funding than non-issuing banks. For example, the average log asset size is 25.92 for issuers compared to 23.64 for non-issuers, while leverage differs by more than five percentage points. After entropy balancing, these differences are almost eliminated. The weighted control group closely replicates the treated

group across all matched covariates, with differences in means reduced to near zero. This indicates that the reweighting procedure successfully constructs a counterfactual group that is observationally comparable to issuing banks.

We then re-estimate the baseline models using the entropy-balanced weights. The results remain qualitatively and quantitatively similar to the main specifications, indicating that the observed reduction in CDS spreads is not driven by systematic differences in observable bank characteristics. Appendix Table A.4 reports the CDS results using the entropy-balanced sample. The findings remain strongly consistent with the main baseline estimates. In Panel A, the fixed-effects coefficients are negative across all maturities, ranging from −0.087 for one-year CDS to −0.026 for five-year CDS. The term-structure pattern is preserved, with larger effects at shorter maturities and gradually declining magnitudes at longer horizons, mirroring the unweighted results.

Panel B further reinforces the causal interpretation. The 2SLS estimates remain large, negative, and highly significant across all maturities, with coefficients of −1.556 for one-year CDS, −1.368 for two-year CDS, −1.190 for three-year CDS, −1.042 for four-year CDS, and −0.917 for five-year CDS (all $p < 0.01$). Instrument strength remains high (KP F-statistic ≈ 55 across specifications), and the Anderson–Rubin and Stock–Wright tests confirm the statistical significance of the IV estimates. The Durbin–Wu–Hausman tests continue to reject exogeneity, supporting the IV framework.

Importantly, the magnitudes under entropy balancing are slightly larger than those obtained in the main sample. This pattern suggests that observable differences between issuers and non-issuers, if anything, bias the baseline estimates toward zero. Once banks are balanced on observable characteristics, the reduction in market-perceived credit risk following green bond issuance becomes even more pronounced.

As a result, the entropy-balanced results provide strong evidence that the CDS response is not driven by pre-existing differences in bank size, leverage, or funding structure. Instead, the effect reflects changes associated with green bond issuance itself. Combined with the bank fixed-effects design and the IV strategy, this robustness test substantially strengthens the identification of a causal relationship between green bond issuance and lower market-perceived credit risk.

From an identification perspective, the results indicate that the findings are robust to three distinct sources of bias: time-invariant bank heterogeneity (addressed by fixed effects),

reverse causality (addressed by IV estimation), and observable selection into issuance (addressed by entropy balancing). This layered approach provides a high degree of confidence that the observed decline in CDS spreads reflects a genuine funding- and credibility-based effect of green bond issuance rather than underlying issuer characteristics.

5.2.6. Placebo Test

To assess whether the observed CDS effects reflect genuine post-issuance changes rather than pre-existing trends, we conduct placebo tests using leads of green bond issuance.

We construct two placebo indicators equal to one in the one-year and two-year periods prior to a bank's first green bond issuance and re-estimate the baseline CDS5Y specification. If the main results were driven by anticipation effects or underlying improvements in bank fundamentals, these placebo variables would be expected to exhibit significant coefficients.

The results are reported in Appendix Table A.2. Across both placebo specifications, the coefficients are small and statistically insignificant. The one-year placebo estimate is −0.057 ($p = 0.234$), while the two-year placebo estimate is −0.045 ($p = 0.386$). These null effects indicate that CDS spreads do not decline prior to issuance, providing reassurance that the baseline results are not driven by pre-existing downward trends in perceived credit risk.

We further conduct a lead specification that includes a two-year lead indicator alongside the contemporaneous issuance dummy. The coefficient on the lead term is close to zero (0.012, $p = 0.816$), confirming the absence of systematic pre-trends. This finding is particularly important because CDS spreads are forward-looking measures; if markets anticipated future issuance based on improving fundamentals, a decline would be expected before issuance occurs.

Overall, the placebo and lead tests support the identifying assumption that the observed reductions in CDS spreads occur after, rather than before, green bond issuance. This strengthens the interpretation that the main estimates capture a causal shift in market-perceived credit risk associated with green bond financing rather than selection on improving fundamentals.

5.3. Cost of Capital and Its Components

This section examines whether green bond issuance affects banks' funding costs and overall cost of capital. Building on the CDS results, which indicate a decline in market-perceived credit risk, we next investigate whether these risk perceptions translate into

measurable changes in financing conditions. Specifically, we consider three outcomes: the cost of debt, the weighted average cost of capital, and the cost of equity. These measures capture distinct channels through which sustainable financing activity may reshape banks' funding structures and investor perceptions.

5.3.1. Baseline Effects on Funding Costs

[Insert Table 5 here]

Table 5 reports fixed-effects and IV estimates of the relationship between green bond issuance and banks' funding costs to test Hypothesis H3a (Funding Cost Effect) and Hypothesis H4a (Equity Risk Compensation Effect). Panel A presents baseline fixed-effects estimates, while Panel B reports 2SLS results that address potential endogeneity.

The fixed-effects results show a clear and economically meaningful pattern. Green bond issuance is associated with a statistically significant decline in the cost of debt. The estimated coefficient of −0.261 ($p < 0.01$) indicates that, conditional on bank and year fixed effects, banks experience lower borrowing costs following entry into the green bond market. This result is consistent with the interpretation that green issuance improves funding conditions by expanding the investor base, enhancing transparency, and signalling stronger environmental commitment.

In contrast, the effect on the overall cost of capital is small and statistically insignificant in the fixed-effects specification. This suggests that while debt financing becomes cheaper, the total cost of capital may not immediately decline due to offsetting movements in equity financing conditions.

Indeed, the fixed-effects estimates indicate that green bond issuance is associated with a positive and weakly significant increase in the cost of equity (0.411, $p < 0.10$). This pattern is consistent with standard capital structure theory. In the Modigliani–Miller framework with taxes and financial distress costs, the expected return on equity increases with leverage because equity holders bear greater residual risk as debt financing expands. Formally, the cost of equity can be expressed as $r_e = r_a + (D/E)(r_a - r_d)$, where r_a is the return on assets, r_d is the cost of debt, and D/E is the leverage ratio. As green bond issuance lowers borrowing costs and potentially facilitates additional debt financing, the resulting increase in leverage raises the risk borne by equity holders, who in turn require higher expected returns (Hamada, 1972; Modigliani & Miller, 1963). This mechanism is consistent with the trade-off theory of capital structure, which predicts that cheaper debt can lead firms to substitute toward debt financing

until the marginal benefits of tax shields are offset by higher expected distress and agency costs (Kraus & Litzenberger, 1973). In this context, the observed rise in the cost of equity reflects a rebalancing of risk between debt and equity investors rather than a deterioration in overall firm fundamentals.

The IV results in Panel B reinforce these findings and suggest that endogeneity is a central concern in the funding-cost channel. The Durbin–Wu–Hausman tests strongly reject exogeneity across all three outcomes, while the Kleibergen–Paap F-statistics confirm that the instruments are sufficiently strong. Under the 2SLS specification, the negative effect on the cost of debt becomes substantially larger in magnitude (-9.215, $p < 0.01$), and the cost of capital also declines significantly (-7.310, $p < 0.05$).

This pattern points to a clear economic mechanism behind the endogeneity. Green bond issuance is not a random event; rather, it is a strategic financing decision that is likely to occur when banks anticipate favourable market conditions, improvements in credit quality, or strong investor demand. For example, a bank expecting a decline in borrowing costs due to strengthening fundamentals, regulatory support, or enhanced market visibility may choose to issue a green bond precisely at that time. In such cases, the observed reduction in funding costs would partly reflect underlying improvements in creditworthiness rather than the causal effect of green bond issuance itself. This creates a downward bias in the fixed-effects estimates, as issuance and funding-cost improvements are jointly determined by forward-looking expectations.

The larger magnitudes obtained under 2SLS are consistent with this interpretation. By isolating the exogenous component of green bond issuance driven by country-level climate vulnerability and energy transition conditions, the IV approach removes the portion of issuance decisions that is correlated with anticipated funding advantages. The resulting estimates therefore capture a cleaner causal effect, suggesting that the true funding-cost benefit associated with green bond issuance is stronger than what is implied by the within-bank fixed-effects results.

Interestingly, the 2SLS results indicate a negative effect on the cost of equity as well (-7.132, $p < 0.10$). Taken together, the evidence suggests that once endogeneity is addressed, green bond issuance is associated with a broad improvement in financing conditions across both debt and equity markets.

Overall, the results support Hypothesis H3a, which predicts a reduction in the cost of debt and total cost of capital following green bond issuance. The mixed evidence on the cost of equity in fixed-effects models, combined with the negative IV estimates, suggests that equity market responses may depend on the extent to which green issuance strengthens credibility and reduces perceived risk.

5.3.2. Alternative Measures of Green Bond Activity

[Insert Table 6 here]

To examine whether funding advantages reflect the scale of green financing rather than merely the act of issuing, Table 6 replaces the issuance dummy with continuous measures of outstanding green bond exposure to test Hypothesis H3b & H4b (Intensity Effect). The evidence points to a clear scale effect. The amount-based measure (lnGBamount) is consistently negative and statistically significant in both fixed-effects and 2SLS specifications, indicating that banks with larger outstanding green bond volumes enjoy progressively lower debt financing costs. This pattern suggests that investor demand strengthens as banks deepen their presence in green capital markets.

By contrast, the number-based measure produces weaker fixed-effects estimates but remains strongly negative and significant under 2SLS. This divergence implies that markets place greater weight on the economic magnitude of green funding rather than the frequency of issuance. In other words, what matters is not how often banks issue, but how substantial and sustained their green financing commitment becomes. These results reinforce the baseline findings and highlight an important mechanism: the funding-cost benefits of green bonds appear to scale with the depth of engagement in green capital markets, consistent with a credibility and investor-recognition effect.

5.3.3. Heterogeneity by Issuance Exposure

[Insert Table 7 here]

To examine whether the funding-cost effects depend on the depth of engagement in green bond markets, Table 7 introduces interaction terms between green bond issuance and two cumulative exposure measures to test Hypothesis H3c & H4c (Exposure Effect). Panel A uses issue-based exposure, defined as the logarithm of the cumulative number of issuance years by a bank up to year t, while Panel B uses amount-based exposure, measured as the logarithm of cumulative outstanding green bond volume.

The interaction results reveal an important nuance in how markets price green financing activity. Under issue-based exposure (Panel A), the interaction term is positive but statistically insignificant for both the cost of debt and the cost of capital. This suggests that simply accumulating issuance experience over time does not systematically strengthen or weaken the funding-cost benefits. In other words, repeating issuance across years may build familiarity, but does not by itself materially alter how investors price bank funding.

In contrast, Panel B shows a more structured pattern when exposure is measured by the scale of cumulative issuance. The coefficient on GBdummy remains negative and significant, indicating that the initial entry into green bond markets is associated with lower funding costs. However, the interaction term between GBdummy and amount-based exposure is positive and statistically significant for both outcomes. This implies that the marginal funding benefit declines as the scale of cumulative green bond issuance grows.

This pattern is consistent with a diminishing-returns mechanism. Early green bond issuance may generate strong credibility gains, broaden the investor base, and signal improved transparency and risk management, leading to lower borrowing costs. Over time, as green issuance becomes a routine and well-understood component of a bank's funding strategy, additional issuance conveys less incremental information to investors. As a result, the marginal reduction in funding costs gradually weakens.

To further clarify this mechanism, Figures 5 and 6 plot the marginal effect of green bond issuance on the cost of debt across the distribution of cumulative exposure.

[Insert Figure 5 here]

[Insert Figure 6 here]

Figure 5 (issue-based exposure) shows that the marginal effect of green bond issuance on the cost of debt is most negative at low levels of issuance experience, but steadily converges toward zero as the number of issuance years increases. This indicates that the strongest funding benefits are concentrated at the early stages of market participation. As banks become repeat issuers, the incremental impact of each additional issuance year becomes smaller.

Figure 6 (amount-based exposure) reinforces this interpretation from a scale perspective. The marginal effect of green bond issuance is strongly negative when cumulative issuance amounts are low, but the effect attenuates as total outstanding green bond volume increases. At high levels of cumulative issuance, the marginal effect approaches zero,

suggesting that once green financing is fully embedded in a bank's capital structure, additional issuance provides limited new funding advantages.

Additional marginal-effect plots for the cost of equity and WACC (Appendix Figures A.1 – A.4) reveal a similar pattern. The equity premium associated with initial issuance declines as cumulative exposure increases, while WACC effects converge toward zero, consistent with a gradual normalization of capital-structure adjustments.

As a result, the exposure-based evidence complements the CDS results but highlights a different transmission channel. While sustained issuance strengthens credibility and reduces perceived credit risk in CDS markets, the direct funding-cost advantage appears strongest at the initial adoption stage and diminishes as green bond issuance becomes a standard funding practice. This suggests that the primary funding benefit operates through market entry and signaling effects, rather than through indefinite scale expansion.

5.4. Leverage and Capital Structure Adjustments

This section examines whether green bond issuance is associated with systematic changes in banks' balance-sheet structure, focusing on regulatory capital ratios and leverage. While earlier results show that green bond issuance lowers funding costs and reduces market-perceived credit risk, these benefits may be accompanied by adjustments in capital structure. In particular, if green bonds provide relatively cheaper debt financing, banks may respond by increasing leverage while maintaining adequate regulatory capital buffers. This channel is consistent with corporate finance theory (Modigliani & Miller, 1963), where firms rebalance toward debt when its marginal cost declines, subject to regulatory constraints.

5.4.1. Capital Adequacy and Tier 1 Capital

[Insert Table 8 here]

To test Hypothesis 2a (Capital Structure Effect), Table 8 reports the relationship between green bond issuance and regulatory capital strength using two complementary measures: the total capital adequacy ratio and the Tier 1 capital ratio. Across specifications, the binary issuance indicator (GBdummy) is not statistically associated with either capital ratio in both fixed-effects and IV models. This suggests that simply entering the green bond market does not mechanically alter banks' regulatory capital buffers.

However, a different picture emerges when using issuance intensity measure to test Hypothesis 2b (Issuance Intensity Effect). In Panel A, the 2SLS estimates indicate that larger

cumulative issuance amounts and higher issuance frequency are associated with significantly higher capital adequacy ratios. The coefficients on lnGBamount (0.686, $p < 0.01$) and lnGBnumber (8.376, $p < 0.01$) suggest that banks with deeper engagement in green bond markets tend to hold stronger overall capital buffers relative to risk-weighted assets. Similar patterns appear in Panel B for Tier 1 capital ratios, where the 2SLS coefficients on lnGBamount (0.357, $p < 0.01$) and lnGBnumber (4.320, $p < 0.01$) are positive and statistically significant.

These results point to an important distinction between the presence of issuance and the scale of engagement. While the act of issuing a green bond does not immediately alter capital ratios, sustained participation in green capital markets is associated with gradual strengthening of regulatory capital positions. One interpretation is that banks issuing green bonds at larger scale tend to be more capital-intensive institutions with stronger balance-sheet discipline and greater regulatory scrutiny. Alternatively, banks may build capital buffers over time to support expanding green lending portfolios and meet evolving supervisory expectations related to climate risk.

The endogeneity tests further reinforce this interpretation. Exogeneity cannot be rejected for the GBdummy specifications, suggesting that fixed-effects estimates are appropriate for the issuance indicator. In contrast, endogeneity is detected for the continuous issuance measures, and the stronger 2SLS estimates indicate that fixed-effects results may understate the relationship between sustained issuance and capital strength. Taken together, the evidence suggests that deeper engagement in green bond markets is associated with gradual improvements in regulatory capital adequacy rather than immediate structural shifts following initial issuance.

5.4.2. Leverage Dynamics

[Insert Table 9 here]

We next examine Hypothesis H5a (Leverage Effect) whether green bond issuance is associated with changes in leverage, measured as the debt-to-equity ratio. In contrast to the capital ratio results, Table 9 shows a strong and consistent relationship between green bond activity and leverage.

In the baseline specification, GBdummy is positively and significantly associated with leverage in both fixed-effects and IV models. The fixed-effects estimate indicates that leverage increases by 0.169 ($p < 0.01$) following green bond issuance, while the 2SLS estimate is larger

at 0.470 ($p < 0.01$). This pattern suggests that the availability of green debt financing encourages banks to expand debt funding relative to equity.

The issuance intensity measures reinforce this conclusion (Hypothesis 5b – Intensity Effect). Both lnGBamount and lnGBnumber are positively and significantly associated with leverage across fixed-effects and IV specifications. The magnitude of the IV estimates is particularly notable, indicating that banks with larger cumulative green issuance positions exhibit systematically higher leverage ratios. The Durbin–Wu–Hausman tests strongly reject exogeneity, confirming that endogeneity is an important concern and supporting the use of the IV framework.

In summary, these results indicate that green bond issuance is associated with a gradual shift toward more debt-intensive capital structures. This finding is consistent with the funding-cost results documented in Section 5.2: if green bonds lower borrowing costs, banks have an incentive to rely more heavily on debt financing. At the same time, the capital ratio results suggest that this increase in leverage does not come at the expense of regulatory solvency buffers. Instead, banks appear to adjust both sides of the balance sheet, increasing debt funding while maintaining or even strengthening capital adequacy as issuance becomes more sustained.

5.4.3. Interpretation: Capital Structure Trade-offs

The capital and leverage results point to a systematic reconfiguration of banks' balance sheets following entry into the green bond market. Rather than reflecting isolated financing decisions, the evidence is consistent with a dynamic adjustment process in which banks rebalance their funding mix in response to changes in the relative cost of capital.

A natural lens through which to interpret this pattern is the capital structure trade-off framework (Kraus & Litzenberger, 1973; Myers & Majluf, 1984). In this setting, firms choose leverage by balancing the marginal benefits of debt, primarily lower financing costs and potential tax advantages, against the marginal costs associated with financial distress, regulatory constraints, and agency frictions. When access to green bond markets reduces the marginal cost of debt, the trade-off shifts: the optimal leverage ratio increases, making debt financing more attractive relative to equity.

Our results align closely with this mechanism. The funding-cost analysis shows that green bond issuance is associated with materially lower debt financing costs, while the leverage regressions indicate a corresponding increase in debt-to-equity ratios. This combination suggests that banks respond to cheaper debt by tilting their capital structure toward greater

reliance on debt funding. At the same time, the capital adequacy results indicate that regulatory capital ratios are not eroded, and, if anything, strengthen as issuance becomes deeper and more sustained. This pattern is consistent with a constrained trade-off in which banks expand leverage but remain disciplined by regulatory capital requirements under the Basel framework, which effectively place a floor on risk-taking.

From a corporate finance perspective, this resembles a movement toward a new interior optimum rather than a simple expansion of balance sheets. Lower debt costs shift the marginal benefit curve outward, encouraging greater use of debt, but supervisory pressure, market discipline, and internal risk management prevent excessive erosion of capital buffers. In equilibrium, banks appear to adopt a funding structure characterized by higher leverage combined with maintained or gradually improving regulatory capital strength.

Importantly, the adjustment is driven more by the depth of engagement in green bond markets than by the initial issuance decision itself. Continuous measures of issuance activity, capturing cumulative amounts and repeated access, are more strongly associated with capital strengthening than the binary issuance indicator. This suggests that sustained participation in green capital markets may be accompanied by strategic balance-sheet management, including capital planning and risk-weight optimization, to support expanding green asset portfolios and maintain credibility with investors and regulators.

These findings reinforce and extend the earlier evidence on CDS spreads and funding costs. If green bond issuance lowers perceived credit risk and reduces the cost of debt, theory predicts a shift toward greater leverage (Modigliani and Miller with taxes; trade-off theory). The simultaneous rise in leverage alongside stable or improving capital ratios suggests that banks are not substituting prudential strength for cheaper funding. Instead, they appear to be integrating green bonds into a broader capital structure strategy, using them to optimize funding costs while preserving regulatory resilience.

6. Conclusion

This study examines how bank-issued green bonds reshape banks' risk profile, funding costs, and capital structure. Using a large international panel and exploiting within-bank variation over time, we document a consistent pattern: green bond issuance is associated with lower market-perceived credit risk, cheaper debt financing, and measurable adjustments in balance-sheet composition. Together, these findings suggest that green bond markets are not merely symbolic financing channels but have tangible financial implications for issuing banks.

We begin by showing that green bond issuance is associated with a reduction in bank CDS spreads across maturities, with particularly strong effects at shorter horizons. This pattern indicates that markets interpret green bond issuance as a signal of improved near-term funding stability, transparency, and risk management capacity. IV estimates confirm that these effects are not driven by reverse causality or selection into issuance by stronger banks. In addition, the exposure-based analyses show that the credit-risk benefits strengthen with sustained issuance experience, consistent with a credibility mechanism whereby repeated engagement in green finance enhances investor confidence and monitoring.

Turning to funding conditions, we find robust evidence that green bond issuance reduces banks' cost of debt. The effect is economically meaningful and becomes stronger once endogeneity is addressed, suggesting that baseline estimates may understate the true funding advantage. Continuous measures of issuance further indicate that the scale of engagement matters: larger cumulative green bond positions are associated with progressively lower borrowing costs. At the same time, we observe a modest increase in the cost of equity, consistent with capital structure trade-off theory. As debt becomes cheaper and more attractive, equity holders may demand higher returns to compensate for increased leverage and risk exposure.

Finally, the balance-sheet results provide a coherent picture of capital structure adjustment. Green bond issuance is associated with higher leverage, reflecting greater reliance on debt financing. Yet this shift does not appear to weaken capital buffers. Instead, banks that engage more deeply in green bond markets tend to maintain or strengthen regulatory capital ratios over time. This combination of increased leverage alongside stable or improving capital adequacy suggests that banks are not substituting prudential strength for cheaper funding. Rather, they appear to be moving toward a new equilibrium in which green bond financing supports funding optimization while remaining constrained by regulatory discipline.

The evidence points to a unified mechanism. Green bond issuance lowers perceived credit risk and reduces funding costs, which in turn encourages greater use of debt financing. At the same time, regulatory requirements and market scrutiny ensure that capital strength is preserved. Sustained participation in green bond markets further amplifies credibility effects, reinforcing the risk and funding benefits over time.

Contributions

This paper makes several contributions to the literature. First, it provides systematic evidence on how green bond issuance affects issuing banks themselves, rather than focusing solely on bond pricing or investor outcomes. By linking green bond activity to CDS spreads, funding costs, and capital structure, the study offers a comprehensive view of how sustainable finance interacts with core banking fundamentals.

Second, the paper contributes to the growing literature on the financial consequences of climate-related financial instruments by showing that green bonds can influence market perceptions of credit risk. The results suggest that green issuance acts as a signal of risk management quality and long-term strategic orientation, which is reflected in lower CDS spreads and improved funding conditions.

Third, the study extends capital structure theory into the context of sustainable finance. The findings are consistent with trade-off models in which changes in the cost of debt shift optimal leverage, while regulatory constraints shape the adjustment path. The evidence that banks increase leverage but maintain capital adequacy highlights the role of prudential regulation in mediating the financial effects of green financing.

Policy and practical implications

The results carry important implications for policymakers, regulators, and market participants. For regulators, the evidence suggests that green bond markets can support financial stability by lowering funding costs and strengthening market confidence, provided that capital requirements continue to anchor balance-sheet discipline. For banks, the findings indicate that sustained engagement in green bond markets may yield strategic funding advantages and reputational benefits, particularly when issuance is consistent and credible over time. For investors, the results imply that green bond issuance may contain information about issuers' risk management practices and funding resilience, beyond the environmental label itself.

More broadly, the findings highlight that the financial benefits of green bonds are not purely symbolic. Instead, they operate through standard financial channels, risk perception, funding costs, and capital structure decisions, suggesting that sustainable finance can become embedded in the core functioning of banking systems.

Limitations and future research

While the empirical strategy addresses key endogeneity concerns, identification ultimately relies on institutional and cross-country variation in climate-related conditions.

Future work could build on this by exploring bank-level shocks, regulatory interventions, or natural experiments that further isolate causal effects. In addition, extending the analysis to loan pricing, asset allocation, or real-economy lending outcomes could provide deeper insight into how green financing translates into broader economic impact.

Overall, the evidence suggests that green bond issuance is not merely a financing label but a mechanism that shapes how banks are perceived, how they fund themselves, and how they structure their balance sheets. As sustainable finance continues to expand, understanding these internal effects will be essential for assessing its role in both financial stability and the transition to a low-carbon economy.

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List of Tables

Table 1. Descriptive Statistics and Correlations

Variable	Obs.	Mean	Std. Dev.	Min	Max
Panel A: Dependent variables					
WACC Cost of capital (%)	14,594	6.341	3.465	.419	18.398
Cost of Debt (%)	14,594	2.582	2.588	-.061	11.612
Cost of Equity (%)	14,594	10.033	4.158	1.891	23.926
Debt to Equity (%)	14,393	4.752	1.982	0	7.116
Tier 1 Capital ratio (%)	7,753	14.673	5.523	6.800	49.230
Capital Adequacy ratio (%)	9,358	17.191	7.090	8.400	64.350
1 year CDS spread (bp) (log)	12,493	2.150	1.801	-6.327	5.433
2 year CDS spread (bp) (log)	12,493	2.473	1.513	-4.759	5.386
3 year CDS spread (bp) (log)	12,493	2.636	1.343	-3.827	5.322
4 year CDS spread (bp) (log)	12,493	2.730	1.232	-3.062	5.297
5 year CDS spread (bp) (log)	12,493	2.788	1.156	-2.484	5.298
Panel B: Green bond (GB) variables					
GB dummy	15,854	.075	.263	0	1
GB amount (log)	15,854	1.490	5.261	0	24.421
GB number (log)	15,854	.062	.346	0	5.598
Panel C: Bank specific control variables					
Size Total assets (log)	15,658	22.136	2.958	5.984	27.952
ROAA (%)	15,383	1.546	5.497	-39.567	29.046
Firm value to Market capital ratio (%)	12,565	2.832	4.674	.089	34.301
NPL to Net loans ratio (%)	10,185	.996	2.503	0	16.796
Stock Volatility (stdv)	15,481	.278	.255	0	2.194
Leverage Debt to Total assets ratio (%)	13,245	20.070	22.729	0	94.977
Deposit to Total assets ratio (%)	10,159	44.104	33.065	0	99.151
Cash Short Term Investment (log)	15,334	19.170	3.230	8.286	25.387
Reserves for Loan losses (log)	8,490	18.782	2.355	12.541	23.783
Cost to Total revenue ratio (%)	15,440	68.525	25.820	5.539	141.014
Board Size (number)	5,531	11.589	3.711	1	33
Board Gender Diversity (%)	5,499	18.966	13.475	0	66.667
Independent Board Members (number)	5,039	57.919	26.478	0	100
Environmental Pillar Score (number)	5,557	51.814	27.850	0	99.142
Panel D: Macro control variables					
GDP (%)	94	2.928	1.701	-1.583	6.812
WGI (number)	90	63.755	24.906	8.258	99.889
Yield Slope (%)	94	1.236	2.031	-2.781	9.614
Bank Concentration (%)	92	62.847	16.810	29.873	100
Panel E: Instrumental variables					
NDGAIN (number)	94	51.878	16.883	0	75.364
RE Consumption (%)	90	23.378	22.770	0.072	91.892

Notes: This table reports descriptive statistics (mean, standard deviation, minimum, and maximum) for all variables used in the analysis. Variable definitions are provided in the Appendix. Financial outcome variables related to funding costs, cost of debt, cost of equity, CDS spreads, and capital structure measures) are computed only for bank–year observations with access to bond markets, ensuring comparability across issuing and non-issuing banks. Continuous bank-level variables are winsorized to mitigate the influence of extreme outliers. Green bond variables are constructed from cumulative bank-year issuance activity. CDS spreads are expressed in natural logarithms. All monetary values are in constant terms where applicable.

Table 2. Green Bond Issuance and Bank CDS Spreads

Variables	(1) CDS1Y	(2) CDS2Y	(3) CDS3Y	(4) CDS4Y	(5) CDS5Y
Panel A: Fixed-effect Model					
GBdummy	-0.0356	-0.0383	-0.0352	-0.0311	-0.0274
SE	(0.0651)	(0.0547)	(0.0481)	(0.0437)	(0.0405)
Controls	Yes	Yes	Yes	Yes	Yes

Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	6,661	6,661	6,661	6,661	6,661
Number of banks	665	665	665	665	665
Adj. R^2	0.249	0.211	0.182	0.161	0.147
Panel B: 2-Stage Least Square					
GBdummy (IV)	-1.358***	-1.327***	-1.205***	-1.061***	-0.913***
SE	(0.417)	(0.360)	(0.322)	(0.292)	(0.268)
Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	6,348	6,348	6,348	6,348	6,348
Number of banks	634	634	634	634	634
KP F-stat	82.96	82.96	82.96	82.96	82.96
Anderson-Rubin Wald	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Stock-Wright	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Endogeneity test	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$

Notes: This table reports fixed-effects (Panel A) and two-stage least squares (2SLS, Panel B) estimates of the relationship between green bond issuance and bank CDS spreads across maturities from 1 to 5 years. The dependent variables are the natural logarithm of CDS spreads (in basis points). GBdummy equals one from the first year a bank issues a green bond onward, and zero otherwise. Standard errors (in parentheses) are clustered at the bank level.

The Kleibergen–Paap F-statistics indicate that the instruments are strong. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the IV estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test reject the null of exogeneity, supporting the use of the 2SLS specification.

**** p<0.01, ** p<0.05, * p<0.10.*

Table 3. Alternative Green Bond Measures and Bank CDS Spreads (5-Year)

Variables	**(1) FEM**	**(1) 2SLS**	**(2) FEM**	**(2) 2SLS**
(1) lnGBamount	-0.00156	-0.025**	-	-
	(0.00205)	(0.011)	-	-
(2) lnGBnumber	-	-	-0.0270	-0.303**
	-	-	(0.0244)	(0.129)
Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6,661	3,098	6,661	3,098
Number of banks	665	402	665	402
Adj. R^2	0.147	-	0.147	-
KP F-stat	-	26.54	-	24.30
Anderson-Rubin Wald	-	$p < 0.05$	-	$p < 0.05$
Stock-Wright	-	$p < 0.05$	-	$p < 0.05$
Endogeneity test	-	$p < 0.05$	-	$p < 0.10$

Notes: This table reports fixed-effects (FEM) and two-stage least squares (2SLS) estimates using alternative measures of green bond activity and 5-year CDS spreads as the dependent variable. The dependent variable is the natural logarithm of 5-year CDS spreads (in basis points). Columns (1) use the log of cumulative green bond issuance amount (lnGBamount), while Columns (2) use the log of the cumulative number of green bond issues (lnGBnumber), both measured up to year t.

The Kleibergen–Paap F-statistics indicate that the instruments are sufficiently strong. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the IV estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test suggest the presence of endogeneity, supporting the use of the 2SLS specification.

**** p<0.01, ** p<0.05, * p<0.10.*

Table 4. Issuance Exposure Heterogeneity

VARIABLES	**(1) CDS1Y**	**(2) CDS2Y**	**(3) CDS3Y**	**(4) CDS4Y**	**(5) CDS5Y**

Panel A: Issue-based Exposure					
GBdummy	0.198	0.198	0.194	0.185	0.171
SE	(0.199)	(0.172)	(0.155)	(0.143)	(0.133)
Issue-based Exposure	-	-	-	-	-
GB × Exposure	-0.279*	-0.240*	-0.213*	-0.191*	-0.172*
	(0.159)	(0.134)	(0.118)	(0.107)	(0.0997)
Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,293	3,293	3,293	3,293	3,293
Number of banks	437	437	437	437	437
Adj. R^2	0.346	0.288	0.242	0.211	0.189
Panel B: Amount-based Exposure					
GBdummy	1.693*	1.568**	1.450**	1.336**	1.224**
SE	(0.921)	(0.791)	(0.702)	(0.635)	(0.584)
Amount-based Exposure	-	-	-	-	-
GB × Exposure	-0.0896**	-0.0812**	-0.0740**	-0.0676**	-0.0617**
	(0.0448)	(0.0383)	(0.0338)	(0.0305)	(0.0281)
Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,293	3,293	3,293	3,293	3,293
Number of banks	437	437	437	437	437
Adj. R^2	0.347	0.290	0.244	0.213	0.191

Notes: This table examines heterogeneity in the relationship between green bond issuance and CDS spreads by issuance exposure. The dependent variables are the natural logarithm of CDS spreads (in basis points) across maturities from 1 to 5 years. GBdummy equals one from the first year a bank issues a green bond onward, and zero otherwise.

Panel A measures exposure using cumulative issuance experience, proxied by the (log of) the cumulative number of years a bank has issued green bonds up to year t, capturing the depth of participation over time. Panel B measures exposure using the (log of) cumulative total green bond issuance amount up to year t, reflecting the scale of activity. These exposure variables are interacted with GBdummy to test whether the effect of green bond issuance strengthens as banks gain greater experience in the green bond market. Standard errors (in parentheses) are clustered at the bank level.

**** p<0.01, ** p<0.05, * p<0.10.*

Table 5. Green Bond Issuance and Bank's Cost of Debt, Cost of Capital & Cost of Equity

Variables	**(1) Cost of Debt**	**(2) Cost of Capital**	**(3) Cost of Equity**
Panel A: Fixed-effect Model			
GBdummy	-0.261***	-0.0121	0.411*
SE	(0.0904)	(0.164)	(0.227)
Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,175	4,928	4,928
Number of banks	588	600	500
Adj. R^2	0.358	0.398	0.268
Panel B: 2-Stage Least Square			
GBdummy	-9.215***	-7.310**	-7.132*
SE	(2.918)	(2.843)	(3.666)
Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,678	4,678	4,678
Number of banks	556	556	556
KP F-stat	13.28	13.28	13.28
Anderson-Rubin Wald	$p < 0.01$	$p < 0.01$	$p < 0.05$

Stock-Wright	p < 0.01	p < 0.01	p < 0.05
Endogeneity test	p < 0.01	p < 0.01	p < 0.05

Notes: This table reports the relationship between green bond issuance and banks' funding costs. The dependent variables are the cost of debt, weighted average cost of capital, and cost of equity (all in percentage terms). GBdummy equals one from the first year a bank issues a green bond onward, and zero otherwise. Panel A presents bank and year fixed-effects estimates, while Panel B reports two-stage least squares (2SLS) results addressing potential endogeneity in green bond issuance. Standard errors (in parentheses) are clustered at the bank level. The Kleibergen–Paap F-statistic indicates that the instrument is sufficiently strong. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the 2SLS estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test reject the null of exogeneity, supporting the use of the IV specification.
**** p<0.01, ** p<0.05, * p<0.10.*

Table 6. Alternative Green Bond Measures and Bank's Cost of Debt

Variables	**(1) FEM**	**(1) 2SLS**	**(2) FEM**	**(2) 2SLS**
(1) lnGBamount	-0.0123***	-0.407***	-	-
	(0.00443)	(0.097)	-	-
(2) lnGBnumber	-	-	-0.0496	-4.567***
	-	-	(0.0642)	(1.117)
Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	4,928	4,678	4,928	4,678
Number of banks	600	556	600	556
Adj. R^2	0.398	-	0.396	-
KP F-stat	-	11.70	-	11.28
Anderson-Rubin Wald	-	p < 0.01	-	p < 0.01
Stock-Wright	-	p < 0.01	-	p < 0.01
Endogeneity test	-	p < 0.01	-	p < 0.01

Notes: This table reports fixed-effects (FEM) and two-stage least squares (2SLS) estimates using alternative measures of green bond activity and banks' cost of debt as the dependent variable (in percentage terms). Columns (1) use the log of cumulative green bond issuance amount (lnGBamount), while Columns (2) use the log of the cumulative number of green bond issues (lnGBnumber), both measured up to year t*. Standard errors (in parentheses) are clustered at the bank level.*
The Kleibergen–Paap F-statistics indicate that the instruments are sufficiently strong. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the IV estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test reject the null of exogeneity, supporting the use of the 2SLS specification.
**** p<0.01, ** p<0.05, * p<0.10.*

Table 7. Issuance Exposure Heterogeneity

VARIABLES	**(1) Cost of Debt**	**(2) Cost of Capital**
Panel A: Issue-based Exposure		
GBdummy	-0.473	-0.159
SE	(0.319)	(0.466)
Issue-based Exposure	-	-
GB × Exposure	0.290	0.119
	(0.231)	(0.321)
Controls	Yes	Yes
Bank FE	Yes	Yes
Year FE	Yes	Yes
Observations	4,175	4,175
Number of banks	558	558
Adj. R^2	0.359	0.204
Panel B: Amount-based Exposure		
GBdummy	-2.378*	-3.177*
SE	(1.336)	(1.892)
Amount-based Exposure	-	-

GB × Exposure	0.110*	0.153*
	(0.0631)	(0.0894)
Controls	Yes	Yes
Bank FE	Yes	Yes
Year FE	Yes	Yes
Observations	4,175	4,175
Number of banks	558	558
Adj. R^2	0.360	0.205

Notes: This table examines heterogeneity in the relationship between green bond issuance and banks' funding costs by issuance exposure. The dependent variables are cost of debt and weighted average cost of capital, expressed in percentage terms. GBdummy equals one from the first year a bank issues a green bond onward, and zero otherwise.
Panel A measures exposure using cumulative issuance experience, proxied by the (log of) the cumulative number of years a bank has issued green bonds up to year t*, capturing sustained participation over time. Panel B measures exposure using the (log of) cumulative total green bond issuance amount up to year* t*, reflecting the scale of activity. The interaction term (GB × Exposure) tests whether the effect of green bond issuance varies with the depth of a bank's involvement in the green bond market.*
Standard errors (in parentheses) are clustered at the bank level.
**** p<0.01, ** p<0.05, * p<0.10.*

Table 8. Green Bond Issuance and Banks' Capital Adequacy & Tier 1 Capital

Panel A: Capital adequacy ratio						
Variables	**(1) FEM**	**(1) 2SLS**	**(2) FEM**	**(2) 2SLS**	**(3) FEM**	**(3) 2SLS**
(1) GBdummy	0.273	5.272	-	-	-	-
	(0.210)	(6.126)	-	-	-	-
(2) lnGBamount	-	-	0.0144	0.686***	-	-
	-	-	(0.0107)	(0.218)	-	-
(3) lnGBnumber	-	-	-	-	0.199	8.376***
	-	-	-	-	(0.166)	(2.821)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,070	2,987	3,070	2,987	3,070	2,987
Number of banks	417	378	417	378	417	378
Adj. R^2	0.218	-	0.218	-	0.218	-
KP F-stat	-	3.593	-	7.904	-	6.661
Anderson-Rubin Wald	-	p > 0.10	-	p < 0.01	-	p < 0.01
Stock-Wright	-	p > 0.10	-	p < 0.01	-	p < 0.01
Endogeneity test	-	p > 0.10	-	p < 0.01	-	p < 0.01
Panel B: Tier 1 capital ratio						
Variables	**(1) FEM**	**(1) 2SLS**	**(2) FEM**	**(2) 2SLS**	**(3) FEM**	**(3) 2SLS**
(1) GBdummy	0.179	0.543	-	-	-	-
	(0.208)	(7.393)	-	-	-	-
(2) lnGBamount	-	-	0.00941	0.357***	-	-
	-	-	(0.0104)	(0.127)	-	-
(3) lnGBnumber	-	-	-	-	0.0680	4.320***
	-	-	-	-	(0.134)	(1.612)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,909	2,808	2,909	2,808	2,909	2,808
Number of banks	396	357	396	357	396	357
Adj. R^2	0.227	-	0.227	-	0.227	-
KP F-stat	-	2.87	-	13.76	-	10.53
Anderson-Rubin Wald	-	p > 0.10	-	p < 0.01	-	p < 0.01
Stock-Wright	-	p > 0.10	-	p < 0.01	-	p < 0.01
Endogeneity test	-	p > 0.10	-	p < 0.01	-	p < 0.01

Notes: This table reports fixed-effects (FEM) and two-stage least squares (2SLS) estimates of the relationship between green bond issuance and banks' capital strength. Panel A uses the capital adequacy ratio, and Panel B

uses the Tier 1 capital ratio as dependent variables (both in percentage terms). Column (1) uses a binary indicator (GBdummy) equal to one from the first year a bank issues a green bond onward. Column (2) uses the log of cumulative green bond issuance amount (lnGBamount), and Column (3) uses the log of the cumulative number of green bond issues (lnGBnumber), both measured up to year t.
The Kleibergen–Paap F-statistics assess instrument strength. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments. Reported p-values from the Durbin–Wu–Hausman endogeneity test indicate that endogeneity is not detected for GBdummy specifications but is present for issuance-based measures, supporting the use of the 2SLS approach in those cases.
**** p<0.01, ** p<0.05, * p<0.10.*

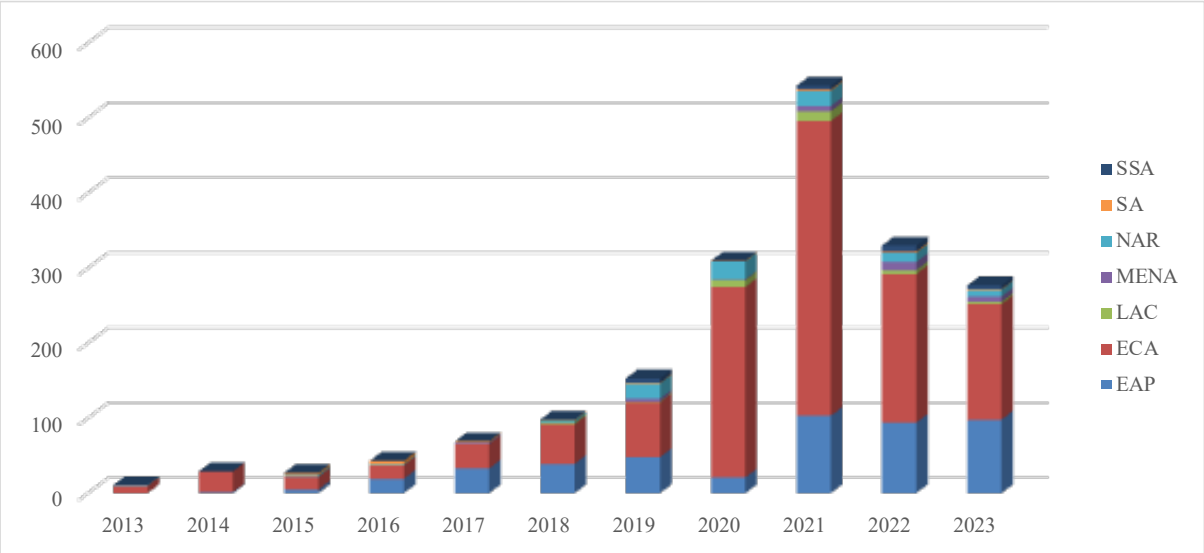
Table 9. Green Bond Issuance and Issuance Intensity and Bank's Leverage

Variables	**(1) FEM**	**(1) 2SLS**	**(2) FEM**	**(2) 2SLS**	**(3) FEM**	**(3) 2SLS**
(1) GBdummy	0.169***	0.470***	-	-	-	-
	(0.0462)	(0.123)	-	-	-	-
(2) lnGBamount	-	-	0.00868***	0.057***	-	-
	-	-	(0.00236)	(0.017)	-	-
(3) lnGBnumber	-	-	-	-	0.123***	1.238***
	-	-	-	-	(0.0338)	(0.435)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,875	2,772	3,293	2,772	3,293	2,772
Number of banks	394	359	437	359	437	359
Adj. R^2	0.201	-	0.201	-	0.201	-
KP F-stat	-	40.59	-	21.92	-	8.558
Anderson-Rubin Wald	-	$p < 0.01$	-	$p < 0.01$	-	$p < 0.01$
Stock-Wright	-	$p < 0.01$	-	$p < 0.01$	-	$p < 0.01$
Endogeneity test	-	$p < 0.01$	-	$p < 0.01$	-	$p < 0.01$

Notes: This table reports fixed-effects (FEM) and two-stage least squares (2SLS) estimates of the relationship between green bond issuance and banks' leverage, measured as the debt-to-equity ratio. Column (1) uses a binary indicator (GBdummy) equal to one from the first year a bank issues a green bond onward. Column (2) uses the log of cumulative green bond issuance amount (lnGBamount), and Column (3) uses the log of the cumulative number of green bond issues (lnGBnumber), both measured up to year t.
The Kleibergen–Paap F-statistics indicate that the instruments are sufficiently strong. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the IV estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test reject the null of exogeneity, supporting the use of the 2SLS specification.
**** p<0.01, ** p<0.05, * p<0.10.*

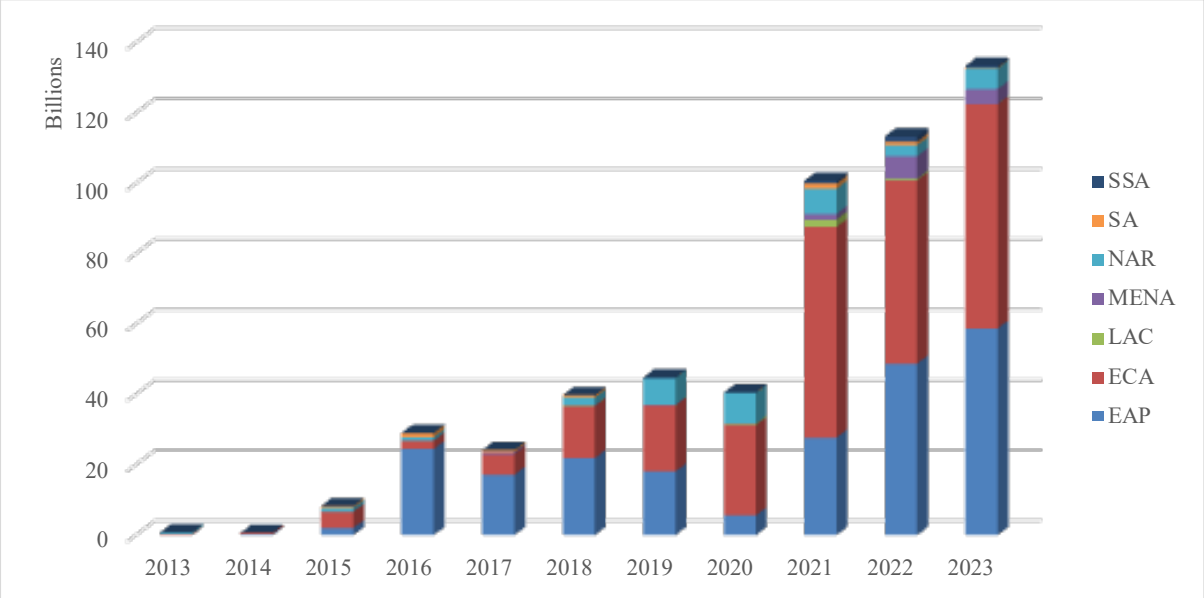
List of Figures

Figure 1. Number of bank green bonds issued by region and year



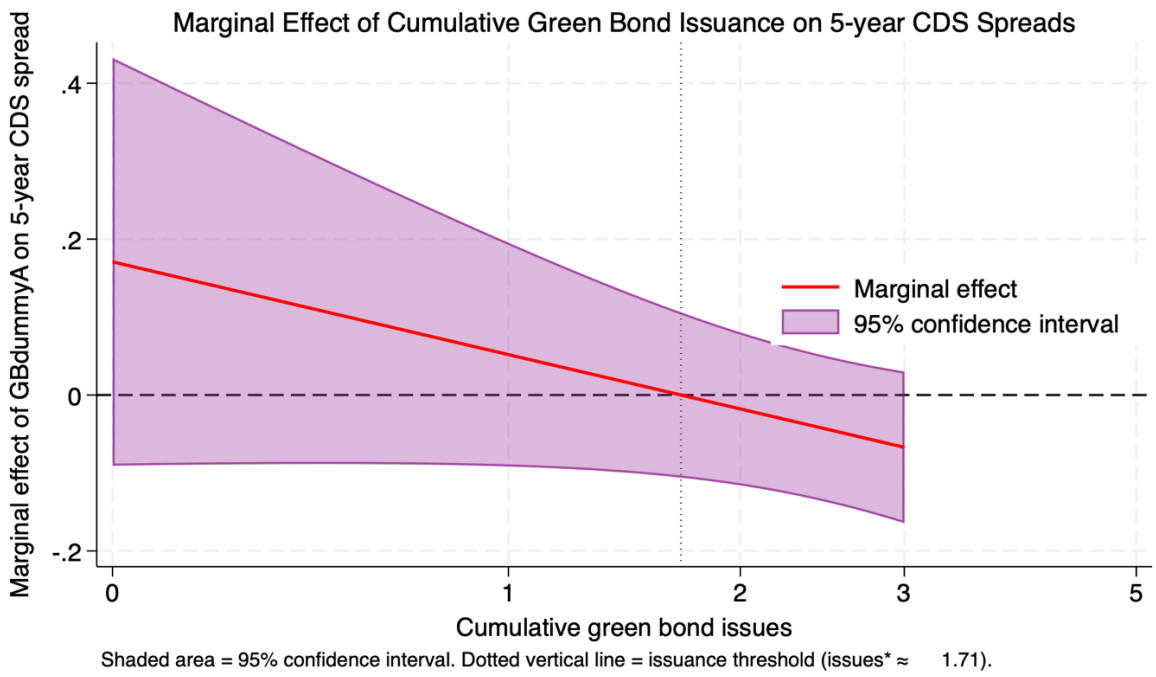
Notes: This figure shows the annual number of green bonds issued by banks across regions from 2013 to 2023. Regions are defined as follows: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; NAR = North America; SA = South Asia; SSA = Sub-Saharan Africa. Issuance activity accelerates markedly after 2017, with Europe and East Asia accounting for the largest share of transactions. Data are sourced from Workspace and matched to banks in our sample.

Figure 2. Value of bank green bond issuance by region and year



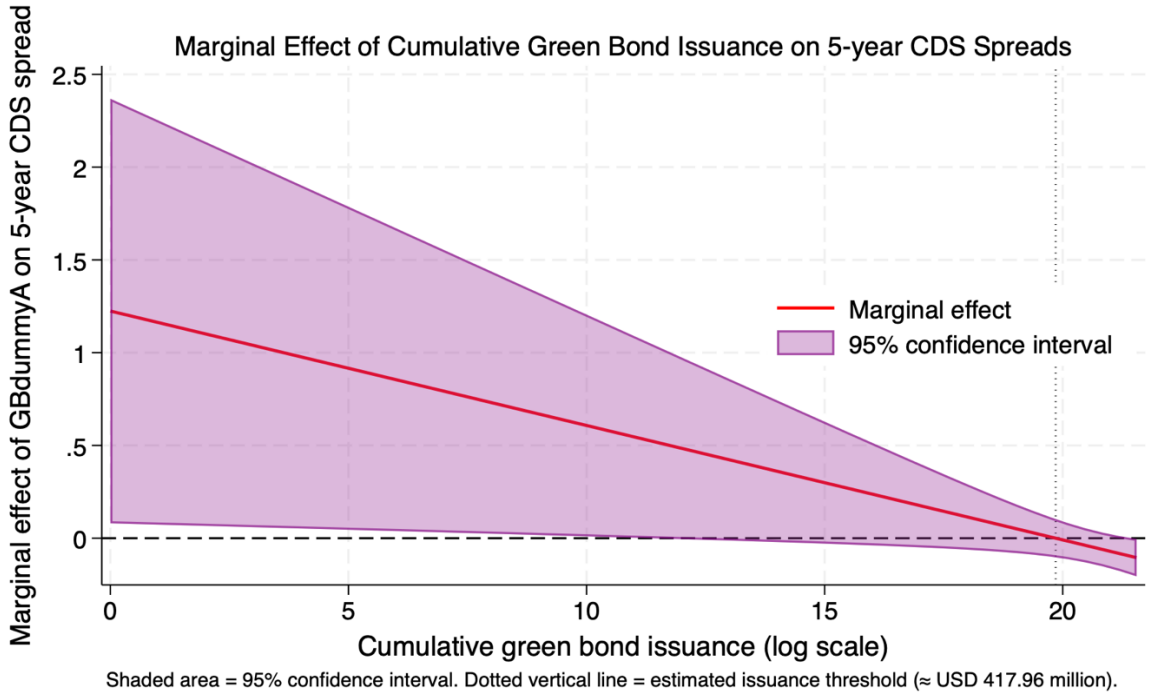
Notes: This figure reports the annual value of green bond proceeds (USD) issued by banks across regions. Regions are defined as follows: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; NAR = North America; SA = South Asia; SSA = Sub-Saharan Africa. Total issuance increases substantially after 2018, peaking in the early 2020s, driven primarily by European and East Asian banks. Data are sourced from Workspace and matched to banks in our sample.

Figure 3. Marginal Effect of Green Bond Issue-based Exposure on 5-Year CDS Spreads



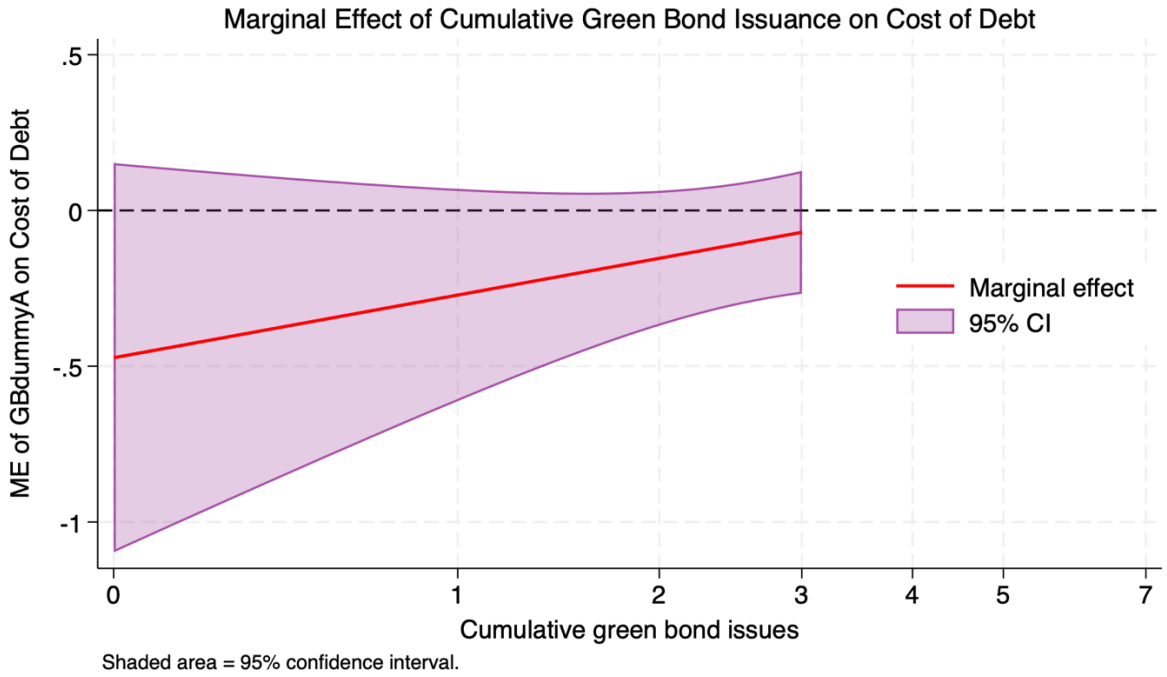
Notes: This figure plots the marginal effect of green bond issuance (GBdummy) on 5-year CDS spreads as a function of cumulative green bond issuance experience, measured as the number of years since a bank first issued a green bond (cumulative issuance years). The red line shows the estimated marginal effect, and the shaded area represents the 95% confidence interval. The horizontal dashed line indicates the zero-effect benchmark. The vertical dotted line marks the estimated threshold level of issuance experience (approximately 1.71 cumulative years), beyond which the effect of green bond issuance on CDS spreads becomes negative. Estimates are based on the baseline fixed-effects specification with bank and year fixed effects and the full set of controls.

Figure 4. Marginal Effect of Green Bond Amount-based Exposure on 5-Year CDS Spreads



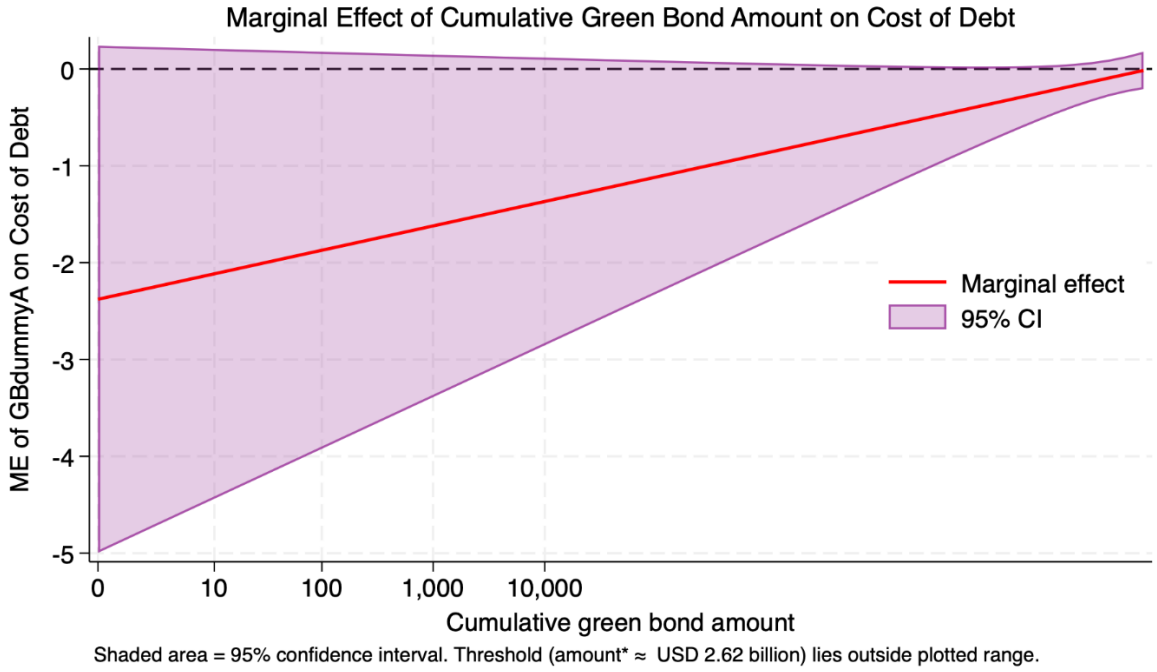
Notes: This figure illustrates the marginal effect of green bond issuance (GBdummy) on 5-year CDS spreads as a function of cumulative green bond issuance volume, measured as the log of the total amount issued by a bank up to year t. The red line represents the estimated marginal effect, and the shaded area denotes the 95% confidence interval. The horizontal dashed line marks the zero-effect benchmark. The vertical dotted line indicates the estimated threshold level of cumulative issuance (approximately USD 418 million), beyond which the effect of green bond issuance on CDS spreads turns negative. Estimates are based on the baseline fixed-effects specification including bank and year fixed effects and the full set of controls.

Figure 5. Marginal Effect of Green Bond Issue-based Exposure on Cost of Debt



Notes: This figure presents the marginal effect of green bond issuance (GBdummy) on banks' cost of debt as a function of cumulative green bond issuance experience, measured as the number of years since a bank first issued a green bond (cumulative issuance years). The red line shows the estimated marginal effect, while the shaded area represents the 95% confidence interval. The horizontal dashed line indicates the zero-effect benchmark. The upward-sloping pattern suggests that the reduction in cost of debt associated with green bond issuance becomes smaller as banks accumulate more issuance experience over time. Estimates are based on the baseline fixed-effects specification including bank and year fixed effects and the full set of controls.

Figure 6. Marginal Effect of Green Bond Amount-based Exposure on Cost of Debt



Notes: This figure shows the marginal effect of green bond issuance (GBdummy) on banks' cost of debt as a function of cumulative green bond issuance amount, measured as the total value issued by a bank up to year t (log scale). The red line represents the estimated marginal effect, and the shaded area indicates the 95% confidence interval. The horizontal dashed line marks the zero-effect benchmark. The positive slope indicates that the reduction in cost of debt associated with green bond issuance weakens as cumulative issuance amount increases. The estimated threshold level (amount ≈ USD 2.62 billion), at which the marginal effect converges to zero, lies outside the plotted range. Estimates are based on the baseline fixed-effects specification with bank and year fixed effects and the full set of controls.

Appendix Table

Table A.1. Variables Description

Variables		Abbreviation	Definition	Source
Panel A: Explained variables (Y)				
Market-perceived risk	Credit Default Swap spread	CDS	The annual premium (in basis points) paid to insure against default on a bank's senior debt, measured for maturities from 1 to 5 years.	NUS Credit Research Initiative https://nuscri.org
Cost of Fundings	Cost of Capital	Cost of Capital	The weighted average cost of financing a bank's assets from both debt and equity sources.	Bloomberg
	Cost of Debt	Cost of Debt	The cost of financing a bank's assets from debt sources.	Bloomberg
	Cost of Equity	Cost of Equity	The cost of financing a bank's assets from equity sources.	Bloomberg
Capital Structure	Capital Adequacy ratio	Capital Adequacy ratio	Ratio of total capital to risk weighted assets.	Workspace
	Tier 1 Capital ratio	Tier 1 Capital ratio	Ratio of Tier 1 capital to risk weighted assets.	Workspace

	Debt to Equity ratio	DE	Ratio of total debt to total equity.	Workspace & calculated
Panel B: Explanatory variables				
(i) GB issuance				
Green bonds issuance decision	GBdummy	A dummy variable equals one from the first year a bank issues a green bond onward, and zero otherwise.		Workspace
Green bonds issuance intensity	GBamount	Natural log of the cumulative par value of green bond issued by bank i up to year t.		Workspace
	GBnumber	Natural log of the cumulative numbers of green bond issued by bank i up to year t.		Workspace
Green bonds issuance exposure	Issue-base exposure	Natural log of the cumulative number of years in which bank i has issued green bonds up to year t.		Workspace & calculated
	Amount-based exposure	Natural log of the cumulative par value of green bond issued by bank i up to year t.		Workspace & calculated
(ii) Bank governance				
Board size	BRDSIZE	Total number of members on a Board		Workspace
Female on Board	FEMDIR	Percentage of female on the Board.		Workspace
Independent Board Members	INT	Number of independent, non-executive directors on the board.		Bloomberg
Environmental Pillar Score	ESG	ESG environmental pillar rating reflecting a bank's environmental performance, policies, and disclosure practices (higher values indicate stronger environmental performance).		Workspace
(iii) Control variables - Standard bank characteristics				
Size	SIZE	Natural log of total assets in million USD		Workspace
Profitability	ROAA	Ratio of net income divided by average total assets		Workspace
Customer deposit ratio	DEP	Ratio of total customer deposits over total assets		Workspace & calculated
Leverage	LEV	Ratio of total debt to total assets		Workspace & calculated
Firm value to Market capital ratio	FTM	Ratio of firm value to market capitalization, where firm value is measured as the sum of market value of equity and book value of debt.		Workspace
Non-performing loan ratio	NPL	Ratio of non-performing loans to total net loans		Workspace
Stock Volatility	VOL	Standard deviation of a bank's stock returns over a given period (typically annual).		Workspace & calculated
Cash & Short-Term Investments	CASH	Natural logarithm of cash and short-term investments held by the bank.		Workspace
Loan loss reserves	LLR	Natural log of total loan loss reserves in million USD		Workspace
Cost to revenue ratio	COST	Ratio of total cost to total revenue		Workspace & calculated
(iv) Control variables - Country variables				

GDP growth rate	GDP	GDP growth rate = $(GDP_t - GDP_{t-1})/GDP_{t-1}$ (%)	World Development Indicator
Inflation	INF	Inflation rate = $(CPI_t - CPI_{t-1})/CPI_t$ (%)	World Development Indicator
World Governance Indicator	WGI	Governance score calculated by the World Bank using six country-level governance indicators	World Development Indicator
Bank Concentration	CON	Market share of the largest banks in the country (e.g., assets held by the top 3 or top 5 banks as a percentage of total banking sector assets).	World Development Indicator
Yield Slope	SLOPE	Difference between long-term and short-term government bond yields (10-year minus 1-year).	Calculated
(v) Instrumental variables			
ND-GAIN index	NDGAIN	Measures a country's current vulnerability to climate disruptions and its readiness to leverage private and public sector investments for adaptive actions.	Notre Dame Global Adaptation Initiative https://gain.nd.edu
Renewable energy consumption	RE_GEN	The share of renewable energy in a country's total final energy consumption	World Development Indicator

Table A.2. Placebo Test

VARIABLES	(1) Placebo t−1	(2) Placebo t−2	(3) Lead test
GB_placebo1	-0.057		
	(0.048)		
GB_placebo2		-0.045	
		(0.052)	
GB_lead2			0.012
			(0.052)
GBdummyA			-0.050
			(0.042)
Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	12,493	12,493	10,543
Banks	1,032	1,032	1,027
Adj. R^2	0.051	0.051	0.048

Notes: This table reports placebo and lead tests examining the relationship between green bond issuance and CDS spreads. Columns (1) and (2) present placebo specifications using lagged indicators of green bond issuance (GB_placebo1 and GB_placebo2), which take the value of one and two years prior to actual issuance, respectively. Column (3) reports a lead test using a forward indicator (GB_lead2) equal to one two years before issuance, alongside the baseline issuance indicator (GBdummyA). The absence of statistically significant coefficients on the placebo and lead variables supports the validity of the identification strategy and suggests that pre-trends do not drive the main results.
**** p<0.01, ** p<0.05, * p<0.10.*

Table A.3. Entropy Balancing

Variable	Treated Mean	Control Mean	Difference
Panel A. Pre-weighting balance			
Total Assets	25.92	23.64	+2.28
Deposit/TA	44.06	49.66	−5.60
Leverage	20.17	14.65	+5.52
Net Loans/TA	57.06	63.61	−6.55
Panel B. Post-weighting balance			
Total Assets	25.92	25.91	0.01
Deposit/TA	44.06	44.06	0.00
Leverage	20.17	20.17	0.00
Net Loans/TA	57.06	57.07	−0.01

Notes: This table reports covariate balance statistics before estimation using entropy balancing. "Treated" refers to bank–year observations in which banks issue green bonds, while "Control" refers to non-issuing bank–year observations. Reported values are sample means for each group, along with the mean difference after applying entropy balancing weights. The balancing procedure reweights the control group so that its distribution of observable characteristics matches that of the treated group across key bank-level and macroeconomic variables used in the main analysis. This ensures comparability between issuing and non-issuing banks and mitigates selection bias prior to regression estimation. Variable definitions are provided in the Appendix.

Table A.4. Green Bond Issuance and Bank CDS Spreads on Entropy Balanced Sample

Variables	(1) CDS1Y	(2) CDS2Y	(3) CDS3Y	(4) CDS4Y	(5) CDS5Y
Panel A: Fixed-effect Model					
GBdummy	-0.0872	-0.0650	-0.0472	-0.0345	-0.0257
SE	(0.0746)	(0.0634)	(0.0562)	(0.0513)	(0.0477)
Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4,585	4,585	4,585	4,585	4,585
Number of banks	541	541	541	541	541
Adj. R^2	0.299	0.247	0.206	0.178	0.160
Panel B: 2-Stage Least Square					
GBdummy	-1.556***	-1.368***	-1.190***	-1.042***	-0.917***
SE	(0.429)	(0.360)	(0.316)	(0.286)	(0.264)
Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4,432	4,432	4,432	4,432	4,432
Number of banks	501	501	501	501	501
KP F-stat	55.27	55.27	55.27	55.27	55.27
Anderson-Rubin Wald	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Stock-Wright	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Endogeneity test	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$

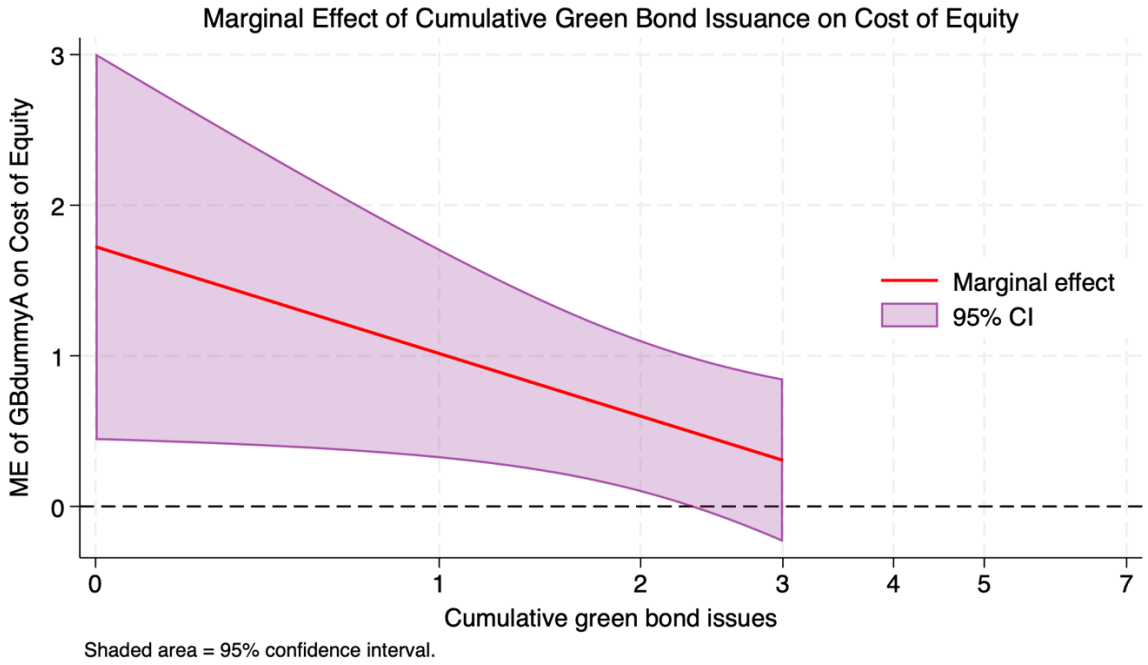
Notes: This table reports fixed-effects (Panel A) and two-stage least squares (2SLS, Panel B) estimates of the relationship between green bond issuance and bank CDS spreads across maturities from 1 to 5 years using an entropy-balanced sample. Entropy balancing is applied to reweight observations so that treated and control banks are comparable along key observable characteristics prior to estimation. The dependent variables are the natural logarithm of CDS spreads (in basis points). GBdummy equals one from the first year a bank issues a green bond onward, and zero otherwise.

The Kleibergen–Paap F-statistics indicate strong instruments. Anderson–Rubin Wald and Stock–Wright tests provide inference robust to weak instruments and confirm the statistical significance of the IV estimates. Reported p-values from the Durbin–Wu–Hausman endogeneity test reject the null of exogeneity, supporting the use of the 2SLS specification.

*** p<0.01, ** p<0.05, * p<0.10.

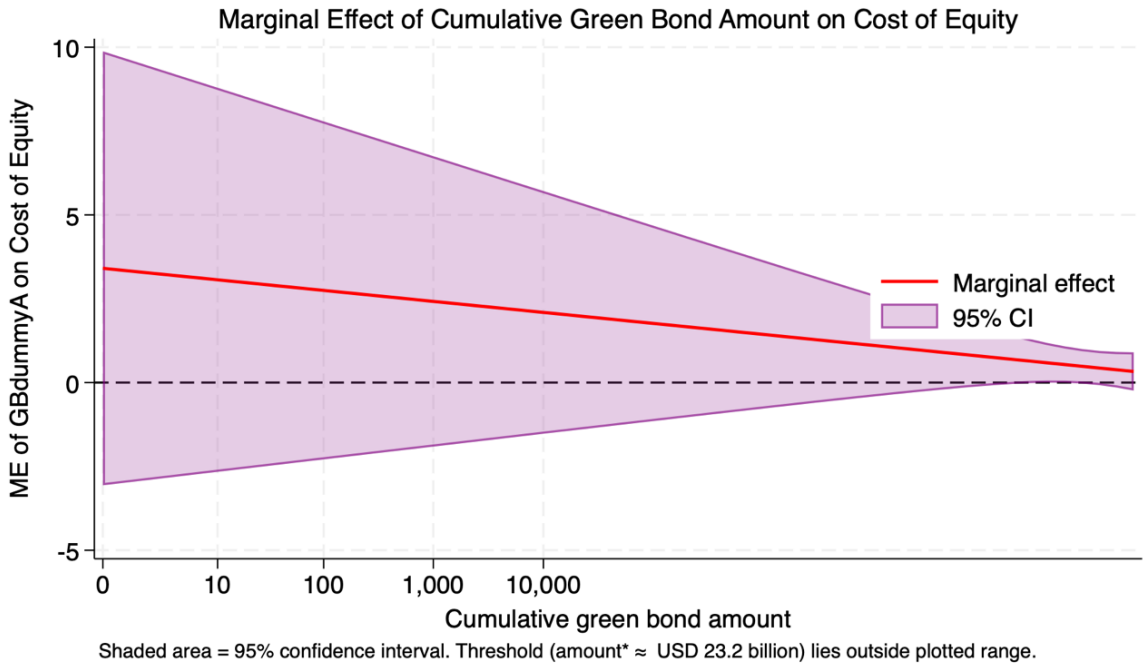
Appendix Figures

Figure A.1. Marginal Effect of Green Bond Issue-based Exposure on Cost of Equity



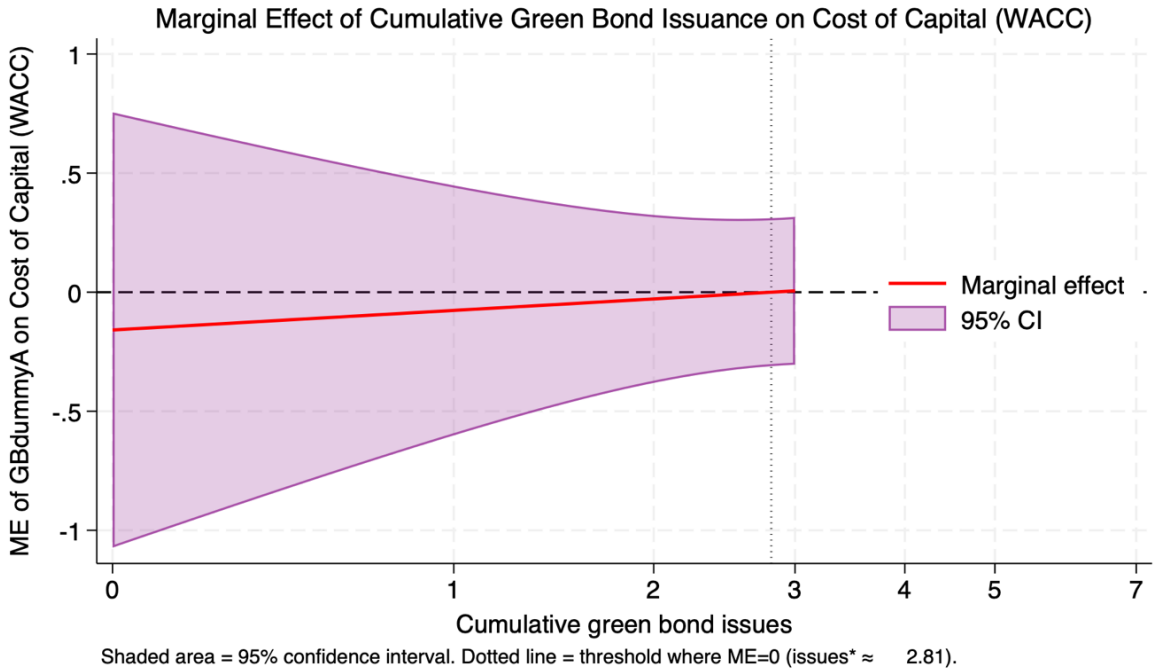
Notes: This figure presents the marginal effect of green bond issuance (GBdummy) on banks' cost of equity as a function of cumulative issuance experience, measured as the number of years since a bank first issued a green bond (cumulative issuance years). The red line shows the estimated marginal effect, while the shaded area indicates the 95% confidence interval. The horizontal dashed line marks the zero-effect benchmark. The downward-sloping pattern suggests that the initial increase in cost of equity associated with green bond issuance declines as banks accumulate more issuance experience. Estimates are based on the baseline fixed-effects specification with bank and year fixed effects and the full set of controls.

Figure A.2. Marginal Effect of Green Bond Amount-based Exposure on Cost of Equity



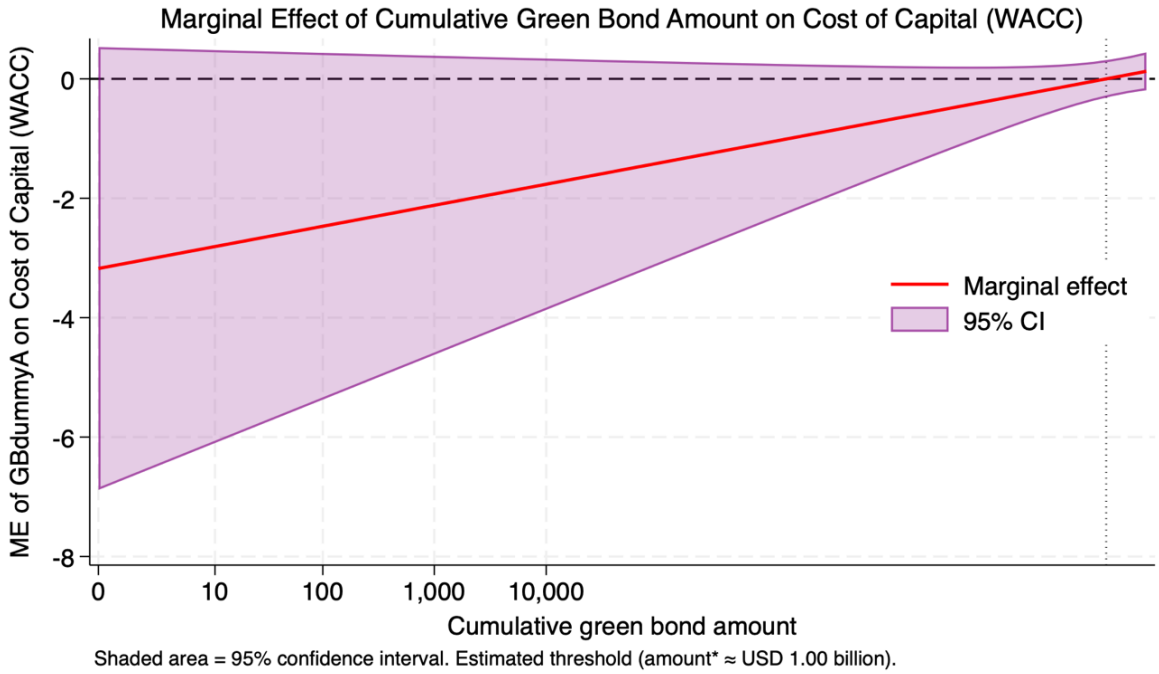
Notes: This figure plots the marginal effect of green bond issuance (GBdummy) on banks' cost of equity as a function of cumulative green bond issuance volume, measured as the total amount issued by a bank up to year t *(log scale). The red line represents the estimated marginal effect, and the shaded area denotes the 95% confidence interval. The horizontal dashed line marks the zero-effect benchmark. The downward-sloping pattern indicates that the positive association between green bond issuance and cost of equity weakens as cumulative issuance increases. The estimated threshold level (amount ≈ USD 23.2 billion), at which the marginal effect approaches zero, lies outside the plotted range. Estimates are based on the baseline fixed-effects specification with bank and year fixed effects and the full set of controls.*

Figure A.3. Marginal Effect of Green Bond Issue-based Exposure on Cost of Capital



Notes: This figure illustrates the marginal effect of green bond issuance (GBdummy) on WACC as a function of cumulative issuance experience, measured as the number of years since a bank first issued a green bond. The red line represents the estimated marginal effect, and the shaded area denotes the 95% confidence interval. The horizontal dashed line indicates the zero-effect benchmark. The vertical dotted line marks the estimated threshold level of issuance experience (issue years ≈ 2.81 years), where the marginal effect approaches zero. Estimates are derived from the baseline fixed-effects specification including bank and year fixed effects and the full set of controls.

Figure A.4. Marginal Effect of Green Bond Amount-based Exposure on Cost of Capital



Notes: This figure shows the marginal effect of green bond issuance (GBdummy) on the weighted average cost of capital as a function of cumulative green bond issuance volume, measured as the total amount issued by a bank up to year t *(log scale). The red line indicates the estimated marginal effect, and the shaded area represents the 95% confidence interval. The horizontal dashed line denotes the zero-effect benchmark. The positive slope suggests that the negative impact of green bond issuance on WACC diminishes as cumulative issuance increases. The vertical dotted line marks the estimated threshold level (amount* ≈ USD 1.00 billion), where the marginal effect converges to zero. Estimates are based on the baseline fixed-effects specification including bank and year fixed effects and the full set of controls.*

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