Binding Commitments and Credit Spreads in Sustainability-Linked Bonds

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Abstract

Sustainability-linked bonds (SLBs) link borrowing costs to sustainability performance targets, but the contractual strength of these commitments varies widely across issuances. We study whether credit markets price this heterogeneity in contract design. Using SLB frameworks, prospectuses, and post-issuance disclosures, we construct bond-level measures of contractual penalty provisions and disclosure requirements, and match them to issuance-time and post-issuance credit spreads for a large sample of SLBs issued between 2019 and 2025.

We document three main findings. First, at issuance, credit spreads reflect the presence of enforceable penalty provisions but not their magnitude: SLBs that include coupon step-up clauses are issued at lower spreads than otherwise comparable bonds, while cross-sectional variation in step-up size is not systematically priced. Second, credit spreads exhibit limited and heterogeneous reactions to sustainability-related disclosure events, including delayed reporting and negative performance disclosures. Third, differences in contractual enforceability are associated with persistent differences in credit spreads after issuance, consistent with markets pricing contract structure rather than discrete penalty-triggering events.

Keywords: Sustainability-linked bonds, Credit spreads, Contract design, Enforcement, Sustainable finance

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1. Introduction

Sustainability-linked bonds (SLBs) link borrowing costs to predefined sustainability performance targets (SPTs). By construction, they embed sustainability commitments directly into the debt contract: if the issuer fails to meet its targets, the bond's cash flows—typically via a coupon step-up—may change. Unlike green bonds, whose credibility primarily depends on the earmarking and monitoring of use-of-proceeds, SLBs shift credibility to contract design: how targets are specified, how performance is measured, and whether underperformance is contractually penalized.

A central question is whether credit markets price this contractual heterogeneity, and through which channels. Regulators and market participants emphasize wide variation in the strength of SLB contracts—from bonds with explicit trigger clauses, external assurance, and binding reporting obligations to bonds with vague targets and weak verification. This heterogeneity has raised concerns that SLBs may enable weakly binding or symbolic commitments unless enforcement mechanisms are sufficiently strong [e.g., Ehlers et al., 2022, European Central Bank, 2024].

Existing evidence that sustainability attributes affect bond pricing [Tang and Zhang, 2020, Flammer, 2021, Bolton and Kacperczyk, 2021] typically relies on labels or externally verified characteristics. In contrast, SLBs offer a setting in which sustainability commitments are explicitly contractual, but the relevant provisions are disclosed in unstructured legal documents and are not available in standard datasets. This setting raises two empirical questions: (i) whether enforceable SLB contracts are priced ex ante at issuance, and (ii) whether credit spreads reprice ex post when sustainability-related information becomes available.

We address these questions by recovering penalty clauses, reporting obligations, and external assurance requirements from SLB frameworks, prospectuses, and post-issuance disclosures. From these terms, we construct bond-level measures of contractual enforceability and link them to issuance-time and post-issuance credit spreads for more than 800 SLBs issued between 2019 and 2025. Our empirical approach combines cross-sectional issuance regressions with panel analyses of secondary-market spreads.

Our results highlight a sharp distinction between issuance-time pricing and post-issuance repricing. At issuance, credit spreads reflect the presence of enforceable penalty provisions but not cross-sectional variation in penalty magnitude: bonds that include step-up clauses are issued at lower spreads than otherwise comparable bonds, while differences in step-up size are not systematically priced. After issuance, credit spreads exhibit limited and heterogeneous reactions to sustainability-related disclosure events, including delayed reporting and negative performance disclosures. Instead, differences in contractual enforceability are associated with persistent differences in secondary-market spreads, consistent with markets pricing broad contract structure rather than discrete penalty-triggering events.

This study contributes to the literature on sustainable finance and bond contracting by showing that the credibility of sustainability commitments is priced primarily through enforceable contractual features, rather than through sustainability labels, target wording, or penalty size. Methodologically, we demonstrate how contractual provisions that are not observable in structured datasets can be incorporated into bond pricing tests.

The remainder of the paper proceeds as follows. Section 2 reviews related research. Section 3 describes the data and the construction of contractual enforceability measures. Section 4 presents the empirical design. Section 5 reports the main pricing results. Section 6 concludes.

2. Literature Review

Research in sustainable finance, corporate credit markets, and contracting provides the foundation for understanding how environmental and ESG-related commitments influence financing costs. Prior work shows that sustainability information, verification, and credibility affect asset prices and perceived credit risk, and that contractual design plays a central role in shaping firm incentives. These insights are directly relevant for sustainability-linked bonds (SLBs), a rapidly growing but still relatively new instrument in which performance-based sustainability commitments are embedded in the debt contract. Although the SLB market has expanded quickly, little evidence exists on whether investors price the credibility of these contractual commitments or on how credit spreads adjust when the contractual structure is strengthened or revised. Our study addresses this gap by examining whether secondary-market spreads incorporate the enforcement mechanisms that make SLB commitments credible and by documenting that these mechanisms have substantial pricing implications. This perspective links our contribution to research on sustainable debt markets, to work on contracting frictions and credit risk, and to the broader literature on the valuation of credible information in asset pricing.

2.1. Green Bonds and the Role of Credibility

Research on green bonds provides a natural starting point for understanding how sustainability characteristics influence bond valuation. Early empirical work examines whether green bonds command a "greenium," with mixed results. Zerbib [2019] document modest premia in matched bond pairs, while Baker et al. [2018] find larger premia for certified municipal issues. In contrast, Hachenberg and Schiereck [2018] report no systematic premium once issuer characteristics and liquidity are taken into account. Subsequent studies show that any greenium is sensitive to features such as certification, disclosure quality, and issue characteristics, and that pricing effects are heterogeneous across markets and issuer types [e.g., Kapraun et al., 2021].

More recent work emphasizes that credibility and verification are central to whether sustainability labels affect financing costs. Tang and Zhang [2020] show that credible green bond issuances generate positive equity-market reactions, and Flammer [2021] finds that credible issuances improve environmental performance and reduce borrowing costs. Ehlers et al. [2022] highlight that weak monitoring and verification reduce the informational content of environmental labels. Related theoretical and empirical work argues that the pricing of sustainable assets depends on both investor preferences and the credibility of the underlying information, and that noisy or unreliable signals limit the impact of sustainability characteristics on asset prices [e.g., Pástor et al., 2021].

These findings indicate that investors do not respond to sustainability labels in isolation. They respond to the credibility of the associated commitments and to the mechanisms that make these commitments verifiable. In the case of green bonds, credibility is tied to the allocation of proceeds and to external certification. In the case of sustainability-linked bonds, credibility is determined instead by the contractual structure that governs penalties, reporting, and verification. Our analysis extends this literature by showing that the enforcement mechanisms embedded in SLB contracts, rather than descriptive detail in target setting, are the components of credibility that are reflected in credit spreads.

2.2. Contracting and the Emerging Literature on SLBs

A growing literature examines the economics of sustainability-linked bonds (SLBs) as performance-contingent debt instruments. Theoretical work such as Li et al. [2022] and Berrada et al. [2022] shows that SLBs can reduce firms' cost of capital when penalties are sufficiently strong and contractible, whereas

weak enforcement creates moral hazard and limits environmental impact. Empirical evidence is consistent with these predictions. Berrada et al. [2022] find that secondary-market spreads decline with penalty size, indicating that investors value stronger enforcement. Regulatory analyses, including European Central Bank [2024], report that SLBs with verifiable sustainability performance targets (SPTs) trade at lower spreads than those with vague or unenforceable commitments.

A related strand of work studies issuance dynamics and contractual heterogeneity. Kölbel and Lambillon [2023] document potential mispricing when issuance premia exceed the actuarial value of penalties. Kölbel and Lambillon [2022] show that emerging-market issuers face higher premia, reflecting higher information frictions. Dorfleitner et al. [2023] find that external assurance improves liquidity, and Mathew and Sivaprasad [2023] provide evidence that post-issuance improvements in environmental outcomes occur only when SLB contracts include enforceable provisions. Structural perspectives such as Erlandsson and Mielnik [2022] analyze optional ESG-related cash flows embedded in SLB structures. Recent work by Feldhütter et al. [2024] constructs synthetic controls for SLBs and shows that spreads are closely aligned with penalty strength and that target ambition is often limited. Complementary evidence in Feldhütter and Pedersen [2024] suggests that SLBs hedge certain dimensions of ESG-related risk and exhibit a negative ESG risk premium.

Additional research shows more general contracting and information frictions that influence the pricing of performance-contingent securities. Studies on covenant design, contract enforcement, and verification in credit markets show that investors place value on mechanisms that reduce information asymmetry and agency conflicts [e.g., Chava et al., 2010, Roberts and Sufi, 2009, Gârleanu and Panageas, 2020]. These insights map closely to the SLB setting, where the credibility of sustainability commitments depends on the strength of contractual penalties, reporting obligations, and verification requirements. Related work on ESG disclosure and assurance also supports the idea that credible verification affects spreads [e.g., Buehlmaier and Zeume, 2022, Christensen et al., 2021].

Although this literature provides important foundations, two gaps remain. First, existing empirical work does not systematically measure the enforceability of SLB contracts using the full content of the underlying documentation. Much of the contractual structure that governs SLB credibility is embedded in legal text and is not captured in standard datasets. Second, prior studies do not examine how credit markets respond when contractual provisions are updated over time through annual SPT reports or revisions to SLB frameworks. Our paper addresses both gaps by recovering contract-level enforcement strength and target precision from SLB documents and by exploiting within-bond variation to study how credit spreads adjust when these contractual features become publicly observable. This approach expands the empirical analysis beyond penalty magnitudes and enables a more comprehensive assessment of the contractual mechanisms that support issuer accountability.

2.3. Textual Information, Disclosure Credibility, and Contractual Signals

A substantial literature shows that financial markets extract economically meaningful information from narrative disclosures. Foundational work such as Loughran and McDonald [2016] demonstrates that linguistic features of financial reports predict volatility, earnings outcomes, and firm risk. Recent applications in sustainability and climate finance extend these insights by showing that textual information contains priced signals about environmental exposure and managerial credibility. Sautner et al. [2023] use earnings-call transcripts to construct firm-level climate risk measures that predict returns and volatility. Buehlmaier and Zeume [2022] show that credible and externally assured ESG disclosures reduce bond spreads by mitigating information asymmetry. Other studies use textual approaches to quantify ESG-specific sentiment and risk

exposure [e.g., Cohen et al., 2020, Li et al., 2021, Hassan et al., 2021], reinforcing the idea that markets respond to the quality and credibility of sustainability information.

This work establishes that unstructured text can convey priced information, but it focuses primarily on managerial communication, earnings calls, and sustainability reporting rather than on contractual content. In contrast, the core terms that determine the credibility of sustainability-linked bonds appear only in SLB legal documentation and are not captured in structured financial datasets. Recovering these contractual signals is therefore essential for understanding how SLBs are valued. The extraction exercise is not the contribution itself; rather, it allows us to observe the contractual mechanisms that govern enforceability and accountability, which are otherwise unobservable yet central to the pricing of performance-contingent debt.

2.4. Climate Risk, Policy Uncertainty, and Credit Markets

SLBs are priced in an environment where climate risk, policy uncertainty, and regulatory constraints affect firms' creditworthiness and investors' demand for credible sustainability commitments. Baker et al. [2023] show that increases in climate policy uncertainty widen corporate bond spreads, particularly for carbon-intensive issuers. Seltzer et al. [2022] document that firms exposed to stricter environmental regulation face higher financing costs unless they demonstrate credible ESG practices. Physical climate risk is also reflected in credit markets, as shown by evidence that extreme climate events raise corporate and municipal bond yields [Duan et al., 2023, Painter, 2020]. Transition risk is likewise priced, and carbon emissions are strongly associated with higher spreads and lower credit quality [Bolton and Kacperczyk, 2021].

Complementary work shows that markets respond to climate-related information flows. Engle et al. [2020] construct a climate news index and demonstrate that climate-related news shocks affect asset prices and systematic risk exposures. These findings show that credible, verifiable climate information plays an important role in shaping credit spreads and investor expectations. The broader implication is that in settings where sustainability outcomes are uncertain and difficult to forecast, investors place greater value on mechanisms that enhance the credibility of environmental commitments.

Taken together, these strands of research imply that the relevant object for pricing is not an SLB label per se, but the degree to which sustainability commitments are contractible, verifiable, and monitored. Motivated by this view, we next describe how we recover enforcement terms from SLB documentation and merge them to bond-level pricing data.

3. Data

We assemble a global panel of sustainability-linked bonds (SLBs) by combining secondary-market pricing data from Refinitiv with contract information recovered from the Luxembourg Green Exchange (LGX) Datahub. The resulting dataset allows us to study how contractual enforcement of sustainability commitments is reflected in both primary- and secondary-market bond pricing.

3.1. SLB Universe and Sample Construction

We start from the universe of SLBs issued between 2019 and 2025 that are listed in the LGX Datahub. For each instrument, we obtained the SLB framework, the prospectus, detailed tables describing key performance indicators (KPIs) and sustainability performance targets (SPTs), and post-issuance SPT reports. We merge these documents with Refinitiv reference data and pricing at the ISIN level.

The main requirement for inclusion is the joint availability of (i) Refinitiv pricing data and basic bond characteristics and (ii) contractual documentation sufficient to recover the enforcement variables described in

Appendix A. The issuance-time analysis requires information on initial Z-spreads, coupon step-up penalties, and issue sizes. After applying these requirements and dropping bonds with missing issuance characteristics, the issuance sample used in the primary-market regressions contains 561 SLBs. Panel A of Table 1 summarizes the issuance-time variables for this sample.

The secondary-market analysis relies on monthly credit spreads and time-varying contractual information, but does not require the availability of step-up penalties for all bonds. For this reason, the post-issuance panel includes a broader set of instruments. Following each bond from issuance until maturity or the end of 2025, whichever comes first, and merging contractual information with monthly pricing data yields a panel of approximately 21,000 bond–month observations, corresponding to more than 800 distinct SLBs.

3.2. Contractual and Information Variables

Contractual variables are recovered from the LGX documentation. Appendix A describes the extraction in detail; here we summarize the measures used in the main text.

Step-up penalty. For each SLB, we collect the magnitude of the contractual coupon step-up, expressed in basis points. This variable is fixed at issuance and enters the issuance-pricing and event-study regressions.

Reporting and assurance. From the SLB framework, prospectus, and post-issuance reports, we identify whether the issuer is required to publish annual SPT reports and whether SPT performance must be externally assured. These elements form indicators for missing reports (*Missing report*) and missing assurance (*Missing assurance*) at the bond–year level. Reporting obligations and assurance requirements vary over time when issuers change their disclosure practices or contractual documentation.

Performance status. Annual SPT reports are used to classify each bond–year as either on track or not on track to meet its SPTs. The indicator *Not on track* equals one if the report indicates missed or delayed progress and zero otherwise. This variable is used in the performance-disclosure event study and in the cross-sectional analyses of disclosure and enforcement.

These variables, together with log issue size and remaining time to maturity, form the core set of regressors in the issuance and post-issuance specifications. Pairwise correlations among the contractual and information variables are reported in Table 2. Correlations are modest in magnitude, indicating that missing reports, missing assurance, performance status, penalty size, and issue size are not mechanically collinear.

3.3. Pricing Data and Event Samples

Monthly pricing data are taken from Refinitiv and include bid and ask quotes, yields, and curve-based zero-volatility spreads (Z-spreads). Our main outcome variable is the Z-spread, defined as the difference between a bond's yield and the interpolated risk-free term structure. Using Z-spreads isolates credit risk from movements in the risk-free curve and is standard in the SLB pricing literature. Spreads are converted to percentage points and winsorized at the first and ninety-ninth percentiles to limit the influence of outliers. Static bond characteristics are obtained from the same source and are absorbed by bond fixed effects in the panel specifications.

The post-issuance analysis relies on two types of sustainability-related information events. First, we study transparency failures, defined as the first time an issuer misses a required SPT report by the implicit reporting deadline. The transparency sample contains 419 first-failure events with non-missing spread changes. Second, we study performance disclosures, defined as SPT reports in which the issuer explicitly states whether it is on track. This performance sample comprises 464 disclosure events, and 531 bond–year observations with a well-defined *Not on track* status. Panel B of Table 1 reports distributional statistics for spread changes around these events and for the *Not on track* indicator.

For each event, we compute the change in Z-spreads over a symmetric three-month window around the event month, which forms the dependent variable in the event-study regressions. In the panel regressions that examine the pricing of contractual enforceability, we align the annual reporting, assurance, and performance variables with the monthly pricing data by assigning the annual status to all months within the corresponding fiscal year. Observations after maturity and months with missing spreads are dropped. The resulting panel provides the within-bond variation in enforcement and information variables that is exploited in the empirical analysis.

Table 1: Summary Statistics

	Obs.	Mean	Std. Dev.	Min	P25	P50	P75	Max
Panel A: Issuance sample								
Z-spread at issuance	561	2.899	3.327	0.050	0.762	1.866	3.764	16.446
Step-up penalty (bps)	561	13.333	17.430	0.000	0.000	10.000	25.000	100.000
Log issue size	561	19.362	1.429	6.908	18.690	19.756	20.363	21.567
Panel B: Post-issuance event samples								
ΔZ-spread (transparency failure)	419	43.109	123.693	-577.686	-10.950	4.400	85.936	705.700
ΔZ-spread (performance disclosure)	464	-19.708	73.654	-541.130	-37.846	-14.875	-0.528	626.497
Not on track	531	0.584	0.493	0.000	0.000	1.000	1.000	1.000

This table reports summary statistics for the main variables used in the analysis. Panel A summarizes issuance-time variables for the cross-sectional sample of sustainability-linked bonds (SLBs). Panel B summarizes spread changes around transparency failures and performance disclosures, as well as the indicator for being not on track to meet sustainability performance targets. Z-spreads are measured in percentage points. Step-up penalties are expressed in basis points. ΔZ-spread is the change in Z-spreads over the event window defined in Section 5.

Table 2: Correlations among Contractual and Information Variables

	Missing report	Missing assurance	Not on track	Step-up penalty (bps)	Log issue size
Missing report	1.000	-0.371	-0.034	0.002	-0.095
Missing assurance	-0.371	1.000	-0.091	-0.019	-0.128
Not on track	-0.034	-0.091	1.000	-0.012	0.027
Step-up penalty (bps)	0.002	-0.019	-0.012	1.000	0.197
Log issue size	-0.095	-0.128	0.027	0.197	1.000

This table reports pairwise correlations among key contractual and information variables, computed at the bond–year level. *Missing report* equals one if the required sustainability performance target (SPT) report is missing by the reporting deadline. *Missing assurance* equals one if SPT performance is not externally assured. *Not on track* equals one if the issuer reports being off track to meet its SPTs. *Step-up penalty (bps)* is the contractual coupon step-up, in basis points. *Log issue size* is the natural logarithm of the issue amount.

4. Empirical Design

This section describes the empirical strategy used to examine how the contractual design of sustainability-linked bonds (SLBs) is reflected in credit spreads over the bond lifecycle. The analysis distinguishes between pricing at issuance and post-issuance responses to sustainability-related information, and evaluates how these responses depend on the enforceability of contractual commitments.

4.1. Contractual Measures

SLB contracts vary substantially in how sustainability commitments are enforced. We focus on two dimensions of contractual design. The first is the magnitude of the coupon step-up penalty triggered by failure to meet sustainability performance targets (SPTs). The second is contractual enforceability, which captures

the presence of binding penalty activation clauses, external assurance requirements, and structured reporting obligations. These contractual features are disclosed only within SLB legal documentation and subsequent reports and are therefore not available in standard structured datasets. We recover these measures directly from the contractual text. The construction and validation of these variables are described in Appendix A.

4.2. Ex-Ante Pricing at Issuance

This subsection examines whether contractual enforcement features embedded in Sustainability-Linked Bonds are priced at issuance. At the time of issuance, investors observe the bond's contractual design, including whether the contract specifies a coupon step-up mechanism and, when applicable, the magnitude of the step-up penalty. Sustainability performance and any potential penalty activation are realized only ex post. The issuance-stage analysis therefore isolates whether markets price contractual commitments before sustainability outcomes are observed.

The unit of observation is the bond. The dependent variable is the Z-spread measured in the first month of secondary-market trading. Our baseline issuance-time specification is

$$ZSpread_i = \beta\, Penalty_i + X_i'\gamma + \varepsilon_i, \tag{1}$$

where $Penalty_i$ denotes the contractual step-up magnitude in basis points, and X_i is a vector of bond- and issuance-level controls, including fixed effects for currency, sector, and issuance year. Standard errors are heteroskedasticity-robust.

To allow for the possibility that markets distinguish between SLBs with and without hard contractual penalties, we also estimate a binary specification in the full sample:

$$ZSpread_i = \theta\, 1\{\text{StepUp}\}_i + X_i'\gamma + \varepsilon_i, \tag{2}$$

where $1\{\text{StepUp}\}_i$ indicates whether the bond contract includes a coupon step-up provision.

As a more stringent robustness check, we estimate alternative specifications that additionally include issuer fixed effects and cluster standard errors at the issuer level. In these models, identification exploits within-issuer variation in the use of step-up mechanisms across bonds.

4.3. Post-Issuance Information Events

We next examine whether credit markets reprice SLBs when sustainability-related information becomes available after issuance. We consider two types of post-issuance events: transparency failures and performance disclosures.

The first event is a failure to publish required sustainability reports. In practice, we observe whether an annual SPT report is available for a given fiscal year, but we do not observe the exact day on which the report is posted. Following the contractual terms, we define the baseline deadline as the cut-off date plus four months and treat this date as the point at which investors can first infer non-disclosure.

The cut-off date is defined relative to the fiscal year-end, consistent with standard financial reporting conventions. We use a four-month window because it matches the most common statutory deadlines for annual financial reports: in the UK, FCA Disclosure and Transparency Rules (DTR 4.1.3R) require publication within four months of fiscal year-end; in the EU, Article 4 of the Transparency Directive requires publication within four months; and in the US, SEC Form 10-K deadlines range from 60 to 90 days depending

on filer status. Because there is no universal regulatory deadline specific to SLB reporting or SPT verification, aligning the deadline with standard annual reporting timelines provides a transparent and defensible benchmark.

Our baseline event-study outcome is the change in Z-spreads over a symmetric window around the event month (as described in Section 3). We focus on first-time failures per bond and estimate cross-sectional regressions of event-window spread changes on contractual penalty size and standard bond characteristics. As a complementary approach, we also implement a difference-in-differences specification in spread levels using a post-event indicator and bond fixed effects, which uses non-event bonds as a control group within the same calendar month.

The second event is the disclosure of sustainability performance outcomes. Annual SPT reports classify each bond–year as either on track or not on track to meet its SPTs. We use this information to distinguish between positive and negative performance disclosures.

We estimate event-window regressions in which the dependent variable is the change in Z-spreads around the disclosure month and the main explanatory variable is an indicator for negative performance (not on track). The specifications control for bond characteristics and contractual penalty size. This analysis tests whether SLBs operate as ex-post disciplining mechanisms when sustainability performance deteriorates, as reflected in spread widening following negative disclosures relative to positive ones.

4.4. Contractual Enforceability in Secondary Markets

Further, we examine whether the pricing of sustainability-related information depends on contractual enforceability. We proceed in two steps.

We first estimate a baseline panel specification that relates secondary-market credit spreads to contractual enforceability:

$$ZSpread_{i,t} = \beta\, Enforcement_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}, \tag{3}$$

where $ZSpread_{i,t}$ is the monthly Z-spread of bond i in month t, $Enforcement_{i,t}$ is our measure of contractual enforceability based on publicly available SLB documentation as of month t (entering in the month following disclosure, and updating when new binding information becomes available), α_i are bond fixed effects, and γ_t are year–month fixed effects. Standard errors are clustered by bond and calendar year. The coefficient β captures whether changes in the publicly observed strength of contractual enforceability are reflected in secondary-market spreads, net of time-invariant bond characteristics and aggregate conditions.

We then allow the pricing of enforceability to vary with the information environment. Specifically, we estimate:

$$\begin{aligned} ZSpread_{i,t} = {} & \beta\, Enforcement_{i,t} + \theta_1\, Underperformance_{i,t} + \theta_2\, Assurance_{i,t} \\ & + \phi_1(Enforcement_{i,t} \times Underperformance_{i,t}) + \phi_2(Enforcement_{i,t} \times Assurance_{i,t}) \\ & + \alpha_i + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

where $Underperformance_{i,t}$ indicates that the issuer reports being not on track to meet its SPTs in the fiscal year corresponding to month t, and $Assurance_{i,t}$ indicates that SPT performance is externally assured. As before, α_i and γ_t denote bond and year–month fixed effects, and standard errors are clustered by bond and calendar year.

In this specification, ϕ_1 tests whether contractual enforceability attenuates spread widening when performance is weak, and ϕ_2 tests whether external assurance and contractual enforcement act as substitutes

in shaping how sustainability-related information is reflected in credit spreads.

4.5. Disclosure Timing and Market Expectations

Building on the post-issuance event-study framework described in the previous section, we extend the analysis to examine how credit markets respond to the timing of sustainability disclosures relative to contractual expectations. All event months and disclosure deadlines are defined as in Section **??**.

First, we study market reactions to non-disclosure at the contractual deadline. Focusing on bonds that fail to publish the required sustainability or external review report by the deadline defined above, we examine spread changes around the event month to isolate the pricing impact of missing information, conditional on the contractual disclosure framework faced by investors.

Second, to disentangle disclosure timing from information content, we condition on reports that ultimately reveal negative sustainability performance. Among bonds classified as not on track, we compare spread reactions between timely and delayed disclosures. Because both groups convey identical adverse information about SPT outcomes, any differential market reaction reflects the incremental effect of disclosure delay.

Finally, we examine whether market reactions to non-disclosure depend on issuers' prior compliance history. Restricting attention to bonds that do not disclose by the contractual deadline, we compare spread reactions between issuers that failed to meet their SPTs in the previous reporting year and those that were previously on track. This analysis assesses whether investor expectations and issuer credibility shape market responses to transparency failures.

5. Results

This section presents the empirical results on issuance-time pricing. We examine whether credit markets price (i) the *magnitude* of the contractual step-up penalty and (ii) the *presence* of a step-up provision in Sustainability-Linked Bond contracts.

5.1. Issuance Pricing

Table 3 reports cross-sectional regressions of issuance-time credit spreads on contractual penalty provisions. The dependent variable is the Z-spread observed in the first month of secondary-market trading, which we use as a proxy for issuance pricing. All specifications include a vector of controls comprising currency, sector, and issuance-year fixed effects, so identification comes from comparing bonds issued in similar market environments and broad risk categories.

We begin by testing whether spreads vary with the *size* of the contractual step-up penalty. If investors view a larger step-up as strengthening the issuer's commitment—either by increasing the financial cost of underperformance or by tightening incentives—then bonds with higher step-up penalties should exhibit lower issuance spreads. Column (1) relates issuance spreads to the step-up magnitude (in basis points). The estimated coefficient on the step-up penalty is positive and statistically insignificant, indicating that issuance spreads do not systematically vary with the penalty size.

We then examine the *extensive margin* by testing whether spreads differ between bonds that include a step-up provision and those that do not. This specification captures the possibility that markets price the presence of a hard contractual enforcement mechanism, even if they do not finely price differences in the penalty magnitude. Column (2) uses an indicator for whether the bond contract includes a step-up clause. The estimated coefficient on the step-up indicator is negative and statistically significant, implying that

bonds with step-up provisions are issued at lower credit spreads than otherwise comparable bonds without such provisions.

Taken together, the results suggest that issuance-time pricing reflects the presence of enforceable penalty mechanisms rather than cross-sectional variation in penalty magnitude. This pattern is consistent with step-up provisions primarily serving as a commitment feature that affects perceived credibility at issuance, while the precise penalty size carries limited incremental pricing information in the cross section.

Table 3: Issuance Pricing and Contractual Penalty Provisions

	(1) Penalty magnitude	(2) Step-up indicator
Step-up penalty (bps)	0.453	
	(0.315)	
Has step-up provision		−49.305**
		(23.391)
Currency FE	Yes	Yes
Sector FE	Yes	Yes
Issuance year FE	Yes	Yes
Observations	551	614
R^2	0.486	0.478

This table reports cross-sectional OLS regressions of issuance-time Z-spreads. The dependent variable is the Z-spread observed in the first month of secondary-market trading. Column (1) relates spreads to the contractual step-up magnitude (in basis points). Column (2) uses an indicator for whether the contract includes a step-up provision. All specifications include currency, sector, and issuance-year fixed effects. Heteroskedasticity-robust standard errors (HC1) are reported in parentheses. ** denotes significance at the 5% level.

5.2. Transparency Failures

Table 4 reports difference-in-differences estimates of market reactions to transparency failures. The dependent variable is the bond's winsorized Z-spread. The indicator *Post* equals one in the event window around a bond's first transparency failure, and the interaction *Treat* × *Post* identifies the differential change in spreads for failure bonds relative to bonds without a failure in the same period, controlling for bond fixed effects.

Table 4: Market Reaction to Transparency Failures

	Z-spread (wins.)
Post	15.265
	(15.402)
Treat × Post	-0.405
	(0.423)
Observations	10,743
R^2	0.836
Adj. R^2	0.832
Bond fixed effects	Yes

This table reports event-study difference-in-differences regressions examining market reactions to transparency failures. The dependent variable is the bond's Z-spread (winsorized). *Post* indicates the event window, and *Treat* × *Post* captures the abnormal change in spreads for bonds experiencing transparency failures relative to bonds without such failures. Bond fixed effects are included. Standard errors are clustered and reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

The estimated coefficient on *Treat* × *Post* is negative and statistically insignificant. This indicates that, within this event-study difference-in-differences framework, bonds experiencing transparency failures do not exhibit a statistically significant abnormal change in Z-spreads relative to bonds without such failures in the event window. In other words, we do not find evidence of a precisely estimated incremental market penalty associated with transparency failures in this specification.

5.3. Performance Disclosures

Table 5 examines market reactions to sustainability performance disclosures. The sample includes disclosure events in which issuers report whether they are on track or not on track to meet their sustainability performance targets.

Table 5: Market Reaction to Sustainability Performance Disclosures

	Δ Z-spread
Not on track	2.77
	(11.52)
Step-up penalty (bps)	0.253
	(0.215)
Observations	417
R^2	0.041

This table reports event-study regressions examining spread changes around sustainability performance disclosures. The dependent variable is the change in Z-spreads from $t-1$ to $t+1$ around the disclosure month. All specifications include sector and currency fixed effects.

The coefficient on *Not on track* is statistically indistinguishable from zero. The estimated effect implies no economically meaningful difference in spread changes following negative versus positive performance disclosures. The interaction between performance outcomes and contractual penalty size is also insignificant.

We find no evidence that sustainability performance disclosures are associated with systematic repricing in secondary markets, even when contractual penalties are explicitly tied to performance outcomes.

5.4. Contractual Enforceability and Heterogeneity

The absence of systematic spread reactions to transparency failures and performance disclosures raises the question of whether contractual design affects credit spreads through channels other than event-time repricing. In this subsection, we examine whether contractual enforceability influences secondary-market pricing by shaping the information environment rather than by disciplining issuers through ex-post penalties.

We begin by assessing whether issuers with weak sustainability performance strategically withhold information.

Table 6: Strategic Disclosure and Sustainability Performance

	Missing report
Not on track	−0.090
	(0.210)
Observations	664
Pseudo-R^2	0.080

This table reports logit estimates of the likelihood of missing required sustainability reporting. Control variables include bond characteristics. Standard errors are reported in parentheses.

The dependent variable is an indicator for missing required sustainability reports, and the key explanatory variable is an indicator for whether the issuer reports being off track relative to its sustainability performance targets. The estimated coefficient is small and statistically insignificant, suggesting that strategic withholding of information is unlikely to explain the absence of event-time repricing.

Table 7: Contractual Enforceability and Secondary-Market Credit Spreads

	Monthly Z-spread
Contractual enforceability$_t$ (std.)	-0.536^{***}
	(0.148)
Observations	20,988
Within R^2	0.031

This table reports panel regressions with bond and year–month fixed effects. Standard errors are two-way clustered by bond and calendar year. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

We next examine whether contractual enforceability is priced in secondary markets outside of event windows. In the bond–month panel with bond and year–month fixed effects, contractual enforceability$_t$ is negatively and statistically significantly associated with credit spreads. The point estimate implies that a one-standard-deviation increase in enforceability is associated with about a 50 bp lower Z-spread.

Table 8: Contractual Enforceability and the Information Environment

	Monthly Z-spread
Contractual enforceability$_t$ (std.)	-0.536^{***}
	(0.148)
Enforceability$_t$ × Not on track	-0.411^{**}
	(0.172)
Enforceability$_t$ × Assured	0.195^{*}
	(0.118)
Observations	20,988
Within R^2	0.031

This table examines heterogeneity in the pricing of contractual enforceability. All specifications include bond and year–month fixed effects. Standard errors are two-way clustered by bond and calendar year.

Finally, we analyze whether the pricing of enforceability depends on the informational environment. The specification augments the baseline regression by interacting contractual enforceability with indicators for sustainability performance and external assurance. The interaction between enforceability and poor performance is negative and statistically significant, indicating that stronger enforcement attenuates spread widening when issuers underperform relative to their targets. In contrast, the interaction between enforceability and third-party assurance is positive, suggesting that external verification partially substitutes for contractual enforcement.

Overall, these results suggest that the publicly observed strength of contractual enforceability is reflected in secondary-market spreads. Rather than generating large, discrete repricing at individual disclosure events, enforceability appears to shape how sustainability-related performance information is incorporated into prices over time, particularly when performance is weak and external assurance is absent.

5.5. Market Reactions to Disclosure Timing

This subsection studies whether spreads respond to disclosure timing around a contractually defined deadline (cut-off date plus four months). The analysis considers (i) non-disclosure by the deadline, (ii) disclosure delay conditional on negative content, and (iii) heterogeneity by issuers' prior compliance history.

Table 9 reports the spread reaction when a post-issuance external review is not available by the contractual deadline. The coefficient on $NoReportByDeadline_t$ is positive and statistically significant; the point estimate of 0.169 corresponds to about 17 bp. This pattern is consistent with spreads moving when non-disclosure becomes verifiable.

Table 9: Market Reaction to Non-Disclosure by the Contractual Deadline

	Δ Z-spread
No report by deadline	0.169**
	(0.068)
Observations	396
Adj. R^2	0.011

Notes: The dependent variable is the change in the bond's Z-spread around the event month, winsorized. The event date is defined as the contractual cut-off date plus four months. Robust standard errors are reported in parentheses.
Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 10 asks whether disclosure delay itself has incremental pricing effects once negative information content is held fixed. The sample is restricted to observations in which the report indicates that the SPT is not on track, and we compare delayed versus timely disclosure. The estimated coefficient on $LateReport_t$ is statistically indistinguishable from zero, suggesting that (conditional on negative SPT content) delay per se does not generate a precisely estimated incremental spread response in this setting.

Table 10: Delayed Disclosure with Negative SPT Outcomes

	Δ Z-spread
Late report	0.067
	(0.076)
Observations	247
Adj. R^2	-0.002

Notes: The sample is restricted to observations where the post-issuance external review indicates that the sustainability performance target is not on track. The dependent variable is the change in the bond's Z-spread around the report publication month. Robust standard errors are reported in parentheses.
Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Finally, Non-Disclosure and Prior SPT Failure examines heterogeneity in the reaction to non-disclosure based on issuers' prior compliance history. Table 11 focuses on the set of bonds that do not disclose by the deadline and compares the deadline-month spread response between issuers with a prior SPT failure and those with a good prior record. The coefficient on `PriorFail` is negative and marginally significant, implying a smaller spread change at the deadline for non-disclosers with a history of missed targets.

Table 11: Non-Disclosure and Prior SPT Failure

	Δ Z-spread
Prior SPT failure	-30.401*
	(16.491)
Observations	250
Adj. R^2	0.593
Bond fixed effects	Yes
Year fixed effects	Yes

Notes: The sample is restricted to bonds that do not disclose a post-issuance external review by the contractual deadline. `PriorFail` equals one if the issuer was not on track in the previous reporting year. The dependent variable is the change in the bond's Z-spread around the deadline month. Standard errors are heteroskedasticity-robust.
Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

A natural interpretation is that market reactions depend on the extent to which non-disclosure is anticipated versus unexpected given prior information about issuer performance. When an issuer has already exhibited weak performance in the previous year, non-disclosure by the contractual deadline may be closer to investors' prior expectations and therefore generate a smaller incremental surprise at the event date. We interpret this evidence cautiously given the limited statistical precision.

Taken together, these timing tests highlight three points. First, the strongest evidence of event-time repricing arises when non-disclosure is defined relative to a contractual deadline, i.e., when the absence of information becomes verifiable. Second, conditional on negative SPT information being revealed, we do not find a precisely estimated incremental effect of delay. Third, heterogeneity by prior compliance history suggests that market reactions to non-disclosure depend on whether the missing disclosure is a surprise.

5.6. Robustness

This subsection evaluates whether the estimated pricing of contractual enforceability is sensitive to alternative empirical choices. The analysis focuses on whether the magnitude and statistical significance of the enforceability coefficient are preserved across alternative specifications.

Table 12: Robustness Checks

	(1) Baseline	(2) Alt. Timing	(3) Alt. Spread	(4) Alt. Clustering
Contractual enforceability (std.)	-0.536^{***}	-0.498^{***}	-0.521^{***}	-0.544^{***}
	(0.148)	(0.156)	(0.151)	(0.149)
Bond FE	Yes	Yes	Yes	Yes
Year–Month FE	Yes	Yes	Yes	Yes
Observations	20,988	20,988	20,988	20,988
Within R^2	0.031	0.029	0.030	0.031

This table reports robustness checks for the baseline panel specification. Column (1) reports the baseline estimates. Column (2) applies an alternative timing assumption for the activation of contractual information. Column (3) uses an alternative measure of credit spreads. Column (4) clusters standard errors by bond only. All specifications include bond fixed effects and year–month fixed effects. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Across specifications, the estimated effect of contractual enforceability remains negative, statistically significant, and similar in magnitude to the baseline estimate. These checks indicate that our main inference about the sign and order of magnitude of the enforceability coefficient is not sensitive to the alternative timing, spread, and clustering choices considered here.

6. Conclusion

This paper studies how credit markets price the contractual design of sustainability-linked bonds (SLBs). SLBs link debt cash flows to sustainability performance, but they differ sharply in the extent to which commitments are contractible, monitored, and verified. Because these features are disclosed in unstructured legal documentation and post-issuance reports, we recover bond-level measures of contractual penalty provisions, reporting obligations, and external assurance, and link them to issuance-time and secondary-market credit spreads.

Three results emerge. First, issuance-time credit spreads reflect the presence of enforceable penalty provisions but not their magnitude: SLBs that include coupon step-up clauses are issued at lower spreads than otherwise comparable bonds, while cross-sectional variation in step-up size is not systematically priced. Second, secondary-market spreads exhibit limited and imprecisely estimated reactions to sustainability-related disclosures such as delayed reporting and negative performance statements. Third, differences in contractual enforceability are reflected in secondary-market pricing. Bonds with stronger enforcement provisions trade at lower spreads, and enforceability is associated with less spread widening following underperformance, particularly when sustainability performance is not externally assured.

These findings contribute to two literatures. For sustainable finance, they indicate that the dimension of credibility relevant for credit pricing is not an SLB label or target wording per se, but the presence of enforceable contractual mechanisms. For bond contracting, they show that enforcement features embedded in performance-contingent debt are priced as persistent contract characteristics rather than primarily through discrete event-time repricing.

The results have implications for market design and policy. They suggest that standardization efforts focusing on disclosure frequency or target articulation may be insufficient unless accompanied by provisions that make sustainability outcomes contractible and verifiable. They also highlight a potential trade-off between contractual enforcement and external assurance, consistent with these mechanisms acting as substitutes in shaping how sustainability information is incorporated into credit spreads.

Two limitations are important. First, disclosure event timing is measured at a monthly frequency and may be noisy for thinly traded bonds. Second, contract design is endogenous to issuer characteristics and investor demand. While fixed-effects designs mitigate some of these concerns, sharper quasi-experimental variation in contractual terms would be valuable. Future work could study the determinants of enforceability choice, its interaction with bond liquidity and investor clienteles, and the real effects of enforceable sustainability-linked contracting on firm policies.

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Appendix A. Construction of Contract-Level Measures

This appendix describes the construction of the contract-level variables used to measure the enforceability and precision of sustainability commitments in sustainability-linked bonds (SLBs). All contractual information is recovered directly from the legal documentation associated with each SLB and processed into variables suitable for empirical analysis.

A.1 Source Documents and Corpus Construction

Contractual data are obtained from the Luxembourg Green Exchange (LGX) Datahub, which provides the full set of SLB frameworks, prospectuses, KPI definition tables, and post-issuance sustainability reports. For each bond, we collect all documents available at issuance as well as subsequent updates disclosed over the bond's life.

All documents are converted to text and segmented into individual sentences. Each sentence is tagged with its source document and section header to distinguish binding contractual provisions from descriptive or narrative material. Text is standardized to ensure consistency in dates, numerical values, and units of measurement. Sentences containing explicit negations (e.g., "no penalty," "not verified") are flagged to avoid attributing positive contractual features to non-binding statements.

A.2 Contractual Enforceability

Contractual enforceability captures the extent to which sustainability commitments are binding and verifiable. We identify three categories of contractual provisions:

1. *Penalty activation mechanisms*, including coupon step-ups and explicit descriptions of trigger conditions tied to sustainability performance outcomes.
2. *External assurance requirements*, such as mandatory third-party verification of KPI performance or references to recognized assurance standards.
3. *Reporting obligations*, including commitments to publish periodic sustainability or SPT performance reports.

A contractual feature receives credit only when the documentation contains a clear and binding obligation, rather than aspirational or forward-looking language. Step-up magnitudes, when specified, are recorded separately as numeric variables. The enforceability measure is constructed as the sum of these components and standardized within month to match the empirical specifications.

A.3 Target Precision

Target precision captures the clarity and measurability of sustainability performance targets. We identify three elements of precision:

1. *Quantifiable definitions*, such as numerical thresholds or percentage reductions relative to a baseline.
2. *Time-bound criteria*, including explicit evaluation years or assessment windows.
3. *Measurement specificity*, such as references to recognized protocols, scopes, or methodological standards.

Credit is assigned only when the documentation provides explicit and verifiable definitions rather than qualitative or aspirational statements. The target precision measure is constructed as the sum of these elements and standardized within month.

A.4 Bond-Level Aggregation

All contractual features are aggregated to the bond level using the bond's ISIN as the unique identifier. For each bond, we construct measures of contractual enforceability, target precision, step-up magnitude, and external assurance indicators. These variables are time-invariant at issuance but may update if revised contractual documentation or post-issuance reports introduce new binding information.

A.5 Monthly Panel Alignment and Activation Timing

To study how contractual features relate to secondary-market pricing, we align bond-level contractual variables with a monthly panel of credit spreads. Contractual variables enter the panel beginning in the month following their public disclosure. When updated documentation becomes available, the corresponding variables are revised starting in the subsequent month.

This timing convention ensures that all regressors reflect the information set available to market participants at each point in time and avoids forward-looking bias. Observations are dropped once a bond reaches maturity.

A.6 Transparency and Performance Variables

Transparency failures are defined as the absence of required post-issuance sustainability or SPT verification reports by the contractual reporting deadline. Because exact publication dates are not observable, reporting compliance is assessed at the standardized deadline defined as the fiscal year-end plus four months, as described in Section **??**. A binary indicator equals one if the required report is not available by this deadline and zero otherwise.

Sustainability performance outcomes are coded annually based on issuer disclosures indicating whether the bond is classified as on track or not on track to meet its sustainability performance targets (SPTs). Performance status is treated as time-varying and is aligned with the fiscal year to reflect the period over which sustainability outcomes are assessed. For bonds that disclose with delay, performance status is assigned in the month of disclosure but referenced to the corresponding fiscal year.

Coupon step-up activation, when triggered by failure to meet SPTs, is coded as a persistent indicator that remains equal to one for all subsequent periods over the remaining life of the bond.

A.7 Summary

The resulting dataset links contract-level measures of enforceability and target precision to issuance pricing, secondary-market credit spreads, and sustainability-related information events. By relying exclusively on information disclosed in legal documentation and subsequent reports, the construction ensures that all variables correspond to information available to market participants at the time of pricing.