

Validating a Quantitative Discrepancy Index Between ESG Debt Covenants and Realized Capital Allocation

Authors

John Moose, Hammed Hammed, Abi Cit

Date: October 8, 2026

Abstract

Sustainability-linked debt instruments have proliferated rapidly, yet a critical gap persists between contractual ESG commitments and the actual deployment of capital. This study develops and validates a novel quantitative discrepancy index—the Covenant-Allocation Gap Index (CAGI)—designed to measure the divergence between ESG debt covenant specifications and realized capital allocation patterns. Drawing on a multi-source dataset of corporate debt issuances and capital expenditure disclosures, the research employs a design-based quantitative methodology integrating natural language processing of covenant documents, financial statement analysis, and predictive modeling. The CAGI demonstrates strong predictive validity, correctly identifying 89.4% of firms subsequently subject to regulatory inquiry for sustainability-related disclosure irregularities. The index reveals that covenant specificity and third-party verification requirements are the strongest predictors of allocation alignment, while sector-level effects show that energy and utilities exhibit the widest gaps. The findings offer a replicable framework for investors, regulators, and corporate governance scholars to move beyond binary greenwashing detection toward continuous, quantitatively grounded monitoring of sustainability-linked debt integrity.

Keywords: ESG debt covenants, capital allocation, greenwashing index, sustainability-linked finance, covenant compliance

1. Introduction

1.1 Background

The integration of environmental, social, and governance (ESG) criteria into corporate debt markets has fundamentally transformed the architecture of sustainable finance. Sustainability-linked loans (SLLs) and sustainability-linked bonds (SLBs) now represent a substantial and growing share of global corporate financing, with the self-declared SLB market alone exceeding \$300 billion in cumulative issuance. Unlike green bonds, which employ a use-of-proceeds structure restricting capital to pre-specified eligible projects, sustainability-linked instruments embed performance-based pricing mechanisms into general-purpose debt. These instruments tie coupon adjustments or fee modifications to the achievement of predefined sustainability performance targets (SPTs), measured through key performance indicators (KPIs) selected by the borrower. This structural innovation creates a legally enforceable financial incentive for sustainability performance: covenant failure triggers measurable economic penalties, typically in the form of coupon step-ups or fee adjustments.

The theoretical appeal of this architecture is substantial. By embedding sustainability performance directly into the cost of capital, sustainability-linked debt ostensibly aligns corporate financial interests with environmental and social objectives. The International Capital Market Association (ICMA) Sustainability-Linked Bond Principles and the Loan Market Association (LMA) Sustainability-Linked Loan Principles provide voluntary guidelines governing KPI selection, target calibration, and verification requirements. These frameworks emphasize that KPIs should be relevant, core, and material to the borrower's business strategy, with targets calibrated ambitiously and verified by independent third parties.

However, the rapid expansion of sustainability-linked debt has outpaced the development of robust mechanisms for evaluating whether contractual commitments translate into substantive capital allocation. The critical question is not merely whether firms report meeting their stated KPIs—a question susceptible to selective disclosure and metric manipulation—but whether the capital raised through sustainability-linked instruments is actually deployed in a manner consistent with the sustainability commitments embedded in the debt covenants. This distinction between reported performance and realized allocation represents the conceptual frontier of greenwashing detection in debt markets.

1.2 Problem Statement

Existing approaches to detecting greenwashing in corporate finance rely predominantly on measuring the gap between ESG disclosure and ESG performance, typically operationalized as the difference between a firm's ESG communication score and its assessed ESG performance score. This disclosure-performance gap methodology has been extended to debt market contexts, with studies demonstrating that firms exhibiting larger discrepancies face higher borrowing costs when controversies emerge. Okeke (2026) developed validated constructs for measuring corporate environmental misrepresentation, identifying dimensions including misleading claims, selective disclosure, symbolic environmentalism, and ESG metric manipulation. Okeke and Rahim (2026) advanced this work through a triangulated Greenwashing Index (GWI) that integrates linguistic deception analytics, verified performance data, and stakeholder credibility assessments, successfully identifying 83% of regulator-sanctioned firms.

Despite these advances, a significant measurement gap persists. Existing greenwashing indices focus on the alignment between what firms *say* and what third-party raters *assess* about their overall ESG performance. They do not directly measure the alignment between what firms *contractually commit to* in debt covenants and what they *actually do* with the capital raised through those instruments. This is a consequential omission. A firm may maintain consistent ESG ratings and disclosure practices while systematically deploying capital from sustainability-linked debt in ways that fail to advance—or even actively undermine—the specific sustainability objectives referenced in its covenant KPIs. The covenant-allocation gap is conceptually distinct from the disclosure-performance gap and requires a separate measurement apparatus.

Furthermore, the contractual heterogeneity of sustainability-linked instruments complicates any attempt at standardized assessment. SLLs and SLBs differ systematically in disclosure quality, target rigidity, and penalty structures. Approximately 96% of SLBs disclose KPIs in detail, compared with only 58% of SLLs, and SLBs overwhelmingly employ penalty mechanisms (91%) whereas SLLs are more likely to use reward structures (35%). These structural differences suggest that the covenant-allocation gap may vary systematically across instrument types, yet no validated index exists to measure this variation quantitatively.

The unsolved issue, therefore, is the absence of a validated quantitative framework that measures the discrepancy between ESG debt covenant specifications and realized capital allocation, enabling investors and regulators to assess whether sustainability-linked debt generates substantive change in corporate resource deployment or merely reproduces symbolic compliance.

1.3 Objectives of the Study

General objective:

To develop and validate a quantitative index measuring the discrepancy between ESG debt covenant specifications and realized capital allocation patterns.

Specific objectives:

1. To identify the covenant-level, firm-level, and instrument-level predictors most strongly associated with covenant-allocation gaps in sustainability-linked debt issuances.
2. To design a composite discrepancy index (CAGI) that integrates natural language processing of covenant documents with quantitative capital allocation analysis.
3. To validate the CAGI framework against regulatory enforcement outcomes and independent sustainability assessments using retrospective data.

1.4 Research Questions

1. What combination of covenant characteristics, issuer attributes, and instrument features most accurately predicts divergence between ESG covenant commitments and realized capital allocation?
2. How does the proposed Covenant-Allocation Gap Index (CAGI) perform in identifying firms subsequently subject to regulatory inquiry, compared with existing disclosure-based greenwashing measures?
3. What implementation barriers—data availability, verification standards, methodological limitations—constrain the operationalization of covenant-allocation gap measurement in practice?

1.5 Significance of the Study

For practitioners and institutional investors: The CAGI framework offers a replicable screening tool for assessing the integrity of sustainability-linked debt instruments. Portfolio managers and credit analysts can integrate the index into due diligence processes, identifying issuers whose covenant commitments are most likely to be decoupled from actual capital deployment.

For policymakers and regulators: The study provides empirical evidence supporting the development of standardized disclosure requirements for capital allocation in sustainability-linked instruments. Current regulatory frameworks, including the EU Corporate Sustainability Reporting Directive and India's SEBI BRSR Core, emphasize disclosure verification but do not mandate post-issuance allocation tracking. The CAGI demonstrates the feasibility of such tracking.

For academic literature: This research extends greenwashing measurement theory beyond the disclosure-performance paradigm, introducing a covenant-behavior dimension that captures a distinct form of sustainability misalignment. It bridges literatures on debt covenant governance, corporate capital allocation, and ESG measurement.

For future researchers: The methodology provides a template for extending covenant-allocation analysis to sovereign debt, project finance, and private credit markets where disclosure regimes differ.

1.6 Scope and Limitations

This study focuses on publicly listed corporate issuers of sustainability-linked loans and bonds in North American and European markets between 2018 and 2025. The analysis draws on covenant documents, capital expenditure disclosures, and regulatory enforcement records available through public sources. Key boundaries include: (1) exclusion of private company issuances where allocation data are unavailable; (2) reliance on reported capital expenditure categorizations, which may not perfectly capture actual deployment; (3) focus on environmental KPIs, excluding social and governance-linked covenants; and (4) a retrospective design that validates the index against historical outcomes rather than predicting future enforcement. These limitations are addressed in detail in Section 5.3.

2. Literature Review

2.1 Conceptual Review

ESG Debt Covenants. Debt covenants are contractual provisions that constrain borrower behavior to protect lender interests. Traditional financial covenants specify minimum liquidity ratios, maximum leverage thresholds, or interest coverage requirements. ESG debt covenants extend this architecture to sustainability performance, linking pricing mechanisms or default triggers to the achievement of environmental or social targets. Sustainability-linked instruments differ from green use-of-proceeds bonds in that they impose no restrictions on how capital is deployed; instead, they create conditional pricing adjustments based on KPI performance. This structure theoretically preserves borrower flexibility while incentivizing sustainability improvement.

Realized Capital Allocation. Capital allocation refers to the deployment of financial resources across investment categories, operational expenditures, and strategic initiatives. For the purposes of this study, realized capital allocation is operationalized through capital expenditure (CapEx) categorizations disclosed in financial statements and sustainability reports. The relevant dimension is not total capital deployment but the *composition* of that deployment: whether capital flows toward activities consistent with covenant sustainability objectives (e.g., renewable energy infrastructure, emissions reduction technologies, sustainable process improvements) or toward activities that maintain or expand carbon-intensive operations.

Covenant-Allocation Gap. The covenant-allocation gap is defined as the divergence between the sustainability orientation specified in ESG debt covenants and the actual composition of capital allocation. This construct differs fundamentally from disclosure-performance gaps. A firm may accurately disclose its ESG performance and maintain consistent third-party ratings while still exhibiting a wide covenant-allocation gap if its capital deployment patterns contradict the

sustainability objectives its debt covenants ostensibly advance. The gap captures *behavioral* misalignment rather than *reporting* misalignment.

2.2 Theoretical Framework

Prospect Theory. Prospect theory posits that decision-makers evaluate outcomes relative to reference points and exhibit asymmetric risk preferences in gains versus losses. In the context of sustainability-linked debt, prospect theory explains why firms may contract for ambitious ESG targets while maintaining capital allocation patterns that prioritize short-term financial returns. The psychological framing of covenant compliance—as a potential loss (coupon step-up) to be avoided rather than a gain to be achieved—may incentivize firms to manage reported metrics rather than transform underlying capital deployment. The covenant-allocation gap emerges as a rational response when the perceived cost of genuine capital reallocation exceeds the expected penalty for covenant failure.

Agency Theory. Agency theory addresses conflicts of interest between principals (lenders, investors) and agents (corporate managers). ESG debt covenants function as monitoring and bonding mechanisms designed to reduce agency costs associated with information asymmetry regarding sustainability behavior. However, if covenant specifications are sufficiently flexible—relying on self-selected KPIs, soft targets, or unverifiable metrics—the monitoring function is attenuated. The covenant-allocation gap represents a residual agency cost that persists when contractual monitoring fails to capture substantive behavioral alignment.

Legitimacy Theory. Legitimacy theory explains organizational behavior as motivated by the desire to maintain social acceptance within institutional frameworks of norms and expectations. Research on Brazilian thematic bond issuers demonstrates that firms often pursue symbolic legitimacy through adherence to voluntary frameworks while avoiding the costs of substantive compliance. This pattern—decoupling formal commitment from material accountability—provides the institutional context within which covenant-allocation gaps emerge and persist.

2.3 Empirical Review

Okeke (2026) developed and validated multidimensional constructs for measuring corporate environmental misrepresentation, identifying five key dimensions: misleading environmental claims, selective disclosure, symbolic corporate environmentalism, ESG metric manipulation, and digital greenwashing. The study employed rigorous scale development procedures including item generation, expert validation, and statistical refinement. However, the validated constructs capture *communication* misalignment rather than *behavioral* misalignment in capital deployment, leaving the covenant-allocation gap unmeasured.

Okeke and Rahim (2026) introduced the Greenwashing Index (GWI), a triangulated framework integrating BERT-based natural language processing of corporate disclosures, verified performance data (ESG scores, EPA violations), and stakeholder credibility assessments. The GWI identified 83% of regulator-sanctioned firms and demonstrated that NGOs rate

greenwashing severity more punitively than investors. The study's cluster analysis revealed four behavioral archetypes, with "Dual-Gap Deceivers"—firms exhibiting high linguistic deception scores and high performance-gap scores—showing the strongest association with enforcement risk. While methodologically sophisticated, the GWI measures the gap between *claims* and *assessed performance*, not the gap between *covenant commitments* and *realized allocation*.

Research on sustainability-linked loan contractual features reveals systematic differences between loan and bond instruments. An analysis of contractual terms found that 96% of SLBs disclose KPIs in detail, compared with 58% of SLLs; 71% of SLB targets are quantitative, versus 19% for loans; and 91% of SLBs use penalty mechanisms whereas only 18% of loans do. These structural differences suggest that covenant-allocation gaps may be systematically wider in loan instruments, yet no study has directly measured this gap or its instrument-type variation.

A study of Brazilian green, social, and sustainability bond issuers found that while 85% of issuers claimed adherence to ICMA principles, only 26% had publicly available frameworks, 21% published allocation reports, and 27% published impact reports. The finding that voluntary commitments fail to drive substantive disclosure without associated sanctions supports the theoretical expectation that covenant-allocation gaps are largest where enforcement mechanisms are weakest.

2.4 Research Gap

The empirical literature on greenwashing measurement has produced validated instruments for assessing disclosure-performance gaps and linguistic misrepresentation, yet no validated framework exists for measuring the gap between ESG debt covenant specifications and realized capital allocation. Existing measures capture what firms *say* relative to what raters *assess*; they do not capture what firms *contract to do* relative to what they *actually do* with capital. This gap is particularly consequential in sustainability-linked debt markets, where the entire mechanism of influence operates through covenant-based incentives rather than use-of-proceeds restrictions. Without a validated covenant-allocation discrepancy index, investors and regulators cannot assess whether sustainability-linked debt generates substantive behavioral change or merely symbolic compliance. This study fills that gap by developing and validating the Covenant-Allocation Gap Index (CAGI).

3. Methodology

3.1 Research Design

This study employs a quantitative, design-based research design combining retrospective data analysis with prospective index validation. The design is appropriate because the research objective is twofold: (1) to develop a measurement instrument (CAGI) grounded in theoretical constructs, and (2) to validate that instrument against criterion outcomes (regulatory

enforcement, independent sustainability assessments). Design-based research is particularly suited to instrument development where no established measurement precedent exists. The validation component follows a retrospective cohort design, where the index is computed using data available at the time of debt issuance and assessed against subsequent enforcement outcomes.

3.2 Study Area / Population

The target population comprises corporate issuers of sustainability-linked loans and sustainability-linked bonds in North American and European markets. The sampling frame includes publicly listed firms with: (1) at least one self-declared SLB or SLL issuance between January 2018 and December 2024; (2) publicly available covenant documentation specifying KPIs and SPTs; (3) capital expenditure disclosures disaggregated by activity type; and (4) availability of post-issuance data on regulatory inquiries or enforcement actions. Private company issuances are excluded due to data availability constraints.

3.3 Sample Size and Sampling Technique

A stratified random sampling approach yielded a final sample of 214 debt issuances from 156 unique corporate issuers. Stratification was applied across three dimensions: instrument type (SLB vs. SLL), sector (energy/utilities, manufacturing, financial services, technology), and issuance year. The sample size was determined through power analysis for logistic regression models with moderate effect sizes (odds ratio ≥ 1.8), achieving 0.80 power at $\alpha = .05$. Post hoc analysis confirmed adequate statistical power for all primary analyses.

3.4 Data Collection Methods

Data were collected from four sources. First, covenant documents were obtained from issuer filings, lender disclosures, and the Bloomberg SLB database, with KPIs and SPTs extracted through a combination of automated parsing and manual coding. Second, capital expenditure data were extracted from annual reports (Form 10-K, annual reports) and sustainability reports, categorized using a standardized taxonomy distinguishing sustainable versus conventional capital deployment. Third, regulatory enforcement records were compiled from SEC, FCA, ESMA, and EPA databases. Fourth, ESG controversy data were obtained from Refinitiv and Bloomberg, capturing incidents that became publicly known after issuance. No simulated data were used in the validation sample; however, the index development phase employed synthetic data for algorithm testing prior to application to the empirical sample.

3.5 Research Instruments

The technical architecture of the CAGI integrates three analytical components. First, natural language processing of covenant documents employed a fine-tuned Bidirectional Encoder Representations from Transformers (BERT) model to extract KPI specificity scores, following the methodological approach validated in Okeke and Rahim (2026). Second, capital allocation

classification used a keyword-based taxonomy applied to expenditure descriptions, with manual validation of a 20% subsample achieving 94.2% agreement. Third, the composite index was computed as a weighted function of covenant specificity, allocation alignment, and verification intensity. The weighting scheme was derived through exploratory factor analysis, with factor loadings used to assign relative weights. All analyses were conducted in Python 3.11 using scikit-learn, transformers, and statsmodels libraries.

3.6 Validity and Reliability

Content validity was established through expert review by seven domain experts (three sustainable finance researchers, two credit analysts, two regulatory specialists) who rated the relevance of each index component on a 7-point scale (mean = 5.9, indicating high perceived relevance).

Predictive validity was assessed by testing whether CAGI scores at issuance predicted subsequent regulatory inquiry within 24 months. The index achieved 89.4% classification accuracy (AUROC = 0.87), substantially outperforming disclosure-based greenwashing measures in comparative tests.

Inter-rater reliability for manual coding of capital allocation categories was assessed using Cohen's κ , yielding $\kappa = 0.89$ (95% CI: 0.84–0.93), indicating strong agreement beyond chance. For covenant KPI extraction, automated parsing against manual validation produced $F1 = 0.91$.

3.7 Data Analysis Techniques

Model performance was evaluated using logistic regression, random forest, and gradient boosting classifiers, with hyperparameters tuned through 5-fold cross-validation. Performance metrics included accuracy, precision, recall, F1, and AUROC. Feature importance was assessed through permutation importance and SHAP values for the gradient boosting model. Comparative analysis against baseline measures (disclosure-performance gap, ESG controversy count) employed paired-sample tests of AUROC differences. Statistical significance was set at $\alpha = .05$ with Bonferroni correction for multiple comparisons.

3.8 Ethical Considerations

This study used only de-identified, publicly available data. No protected health information was accessed. All data sources comply with institutional research ethics requirements. The study protocol was reviewed and determined to be exempt from IRB oversight under 45 CFR 46.104(d)(4), as it involves analysis of publicly available data and does not involve intervention or interaction with human subjects.

4. Results

4.1 Data Presentation

Descriptive statistics for the analytical sample are presented in Table 1. The sample includes 214 issuances stratified across SLB (n = 98) and SLL (n = 116) instruments.

Table 1. Key Indicators by Instrument Type

Indicator	SLB (n = 98)	SLL (n = 116)
Covenant specificity score (0–10)	7.8 (1.4)	5.9 (1.9)
Third-party verification (proportion)	0.92	0.61
CAGI score (0–100)	34.2 (18.7)	48.6 (22.3)
Post-issuance regulatory inquiry	0.14	0.27
Mean issuance size (\$ millions)	487.3	612.8
Mean maturity (months)	89.4	55.2

Note. Values in parentheses are standard deviations. CAGI = Covenant-Allocation Gap Index. SLB = sustainability-linked bond; SLL = sustainability-linked loan.

Table 1 presents the core comparison between instrument types. SLBs exhibit higher covenant specificity scores (M = 7.8, SD = 1.4) than SLLs (M = 5.9, SD = 1.9), $t(212) = 8.14$, $p < .001$. Third-party verification is nearly universal for SLBs (92%) but less common for SLLs (61%), $\chi^2(1) = 26.4$, $p < .001$. Critically, CAGI scores are significantly lower (indicating narrower gaps) for SLBs (M = 34.2, SD = 18.7) than for SLLs (M = 48.6, SD = 22.3), $t(212) = 5.12$, $p < .001$, Cohen's $d = 0.70$. Regulatory inquiry rates are approximately double for SLL issuers (27%) compared with SLB issuers (14%).

4.2 Analysis of Results

The gradient boosting classifier achieved the strongest predictive performance among the three models tested. Model comparison results are presented in Table 2.

Table 2. Model Performance in Predicting Regulatory Inquiry

Model	Accuracy	Precision	Recall	F1	AUROC
Logistic regression	0.831	0.794	0.712	0.751	0.82
Random forest	0.864	0.847	0.763	0.803	0.85
Gradient boosting	0.894	0.882	0.811	0.845	0.87

Note. AUROC = area under the receiver operating characteristic curve. Bold indicates best performance.

The gradient boosting model achieved 89.4% accuracy in classifying issuers subsequently subject to regulatory inquiry, with AUROC = 0.87. This substantially exceeds the performance of the disclosure-performance gap baseline (accuracy = 0.762, AUROC = 0.73) and ESG controversy count baseline (accuracy = 0.714, AUROC = 0.68). Paired comparison of AUROC values indicates that the CAGI model significantly outperforms both baselines (difference = 0.14 and 0.19, respectively; both $p < .001$).

Feature importance analysis, conducted through permutation importance on the gradient boosting model, identified the strongest predictors of covenant-allocation gap. Covenant specificity ranked highest (importance = 0.241), followed by third-party verification requirement (0.198), allocation alignment ratio (0.176), KPI quantifiability (0.142), and penalty magnitude (0.118). Firm-level characteristics including leverage (0.067) and profitability (0.041) exhibited weaker predictive contributions.

5. Discussion

5.1 Interpretation

The finding that covenant specificity is the strongest predictor of allocation alignment extends agency-theoretic accounts of debt governance. Prior research has demonstrated that specific, verifiable covenants reduce agency costs by constraining managerial discretion. The present results suggest that this logic applies with particular force to ESG covenants: vague or qualitative KPIs permit wide latitude in capital deployment, whereas quantitatively specified targets create measurable thresholds against which allocation patterns can be assessed. The 89.4% classification accuracy of the CAGI demonstrates that this informational channel is both theoretically coherent and empirically powerful.

The instrument-type differences observed—SLBs exhibiting narrower covenant-allocation gaps than SLLs—are consistent with research documenting that bond covenants impose more rigid

constraints than loan covenants. SLBs' greater reliance on penalty mechanisms (rather than rewards) and near-universal third-party verification create structural incentives for substantive compliance that SLLs, with their relationship-based monitoring and reward-oriented structures, do not replicate to the same degree. This finding challenges the assumption that borrower-lender relationships substitute for contractual specificity; in the ESG domain, relational monitoring appears insufficient to ensure allocation alignment.

The CAGI's superior performance relative to disclosure-based greenwashing measures confirms the conceptual argument that covenant-behavior misalignment is a distinct phenomenon from disclosure-performance misalignment. Okeke's (2026) validated constructs for measuring environmental misrepresentation and Okeke and Rahim's (2026) triangulated GWI provide valuable tools for detecting communication-based greenwashing. The present study demonstrates that a separate measurement apparatus is required for behavioral misalignment in capital allocation. The two approaches are complementary rather than substitutive: the GWI captures what firms *say*, while the CAGI captures what firms *do* with the capital their covenants govern.

5.2 Implications

Academic implications: This study extends greenwashing measurement theory by introducing a covenant-behavior dimension that bridges debt governance and sustainability accountability literatures. The CAGI operationalizes a construct—the covenant-allocation gap—that has been implicit in policy discussions but never quantitatively validated. The finding that covenant specificity mediates allocation alignment provides a mechanism-level explanation for why some sustainability-linked instruments generate behavioral change while others do not.

Practical implications: Credit analysts and portfolio managers can integrate CAGI scores into ESG risk assessment processes, prioritizing issuers with covenant specificity scores above 7.0 and mandatory third-party verification. Regulators developing post-issuance monitoring frameworks should focus on allocation reporting requirements, which current frameworks omit. A practical takeaway for administrators: when negotiating sustainability-linked debt, insist on quantified KPIs with defined allocation thresholds rather than qualitative commitments. The expected lead time for regulatory inquiry detection using CAGI screening is approximately 18–24 months after issuance, providing a decision window for pre-emptive engagement.

5.3 Limitations

1. **Sample size and generalizability.** The sample of 214 issuances, while adequate for the statistical analyses conducted, limits generalizability to smaller issuers and non-Western markets where disclosure regimes differ.
2. **Reliance on reported allocation data.** Capital expenditure categorizations depend on issuer disclosure practices, which may themselves be subject to strategic manipulation. The CAGI measures gaps between covenant commitments and *reported* allocation, not verified physical capital deployment.

3. **Assumption of historical pattern stability.** The predictive model assumes that relationships between covenant characteristics and allocation behavior remain stable over time. Structural changes in sustainable finance regulation could alter these relationships.

5.4 Future Research Directions

1. Extension of the CAGI framework to sovereign and sub-sovereign debt instruments, where covenant structures and allocation accountability mechanisms differ from corporate contexts.
2. Longitudinal research examining whether CAGI scores at issuance predict changes in subsequent covenant design, testing whether market learning drives convergence toward higher-specificity contracting.
3. Integration of satellite-based or physical asset-level data to validate reported capital allocation, addressing the reliance on self-reported expenditure categorizations.
4. Comparative analysis of CAGI performance across regulatory regimes to assess whether mandatory verification requirements, such as those in the EU Corporate Sustainability Reporting Directive, reduce covenant-allocation gaps.

6. Conclusion

This study developed and validated the Covenant-Allocation Gap Index (CAGI), a quantitative measure of the discrepancy between ESG debt covenant specifications and realized capital allocation. The index achieved 89.4% accuracy in identifying issuers subsequently subject to regulatory inquiry, substantially outperforming disclosure-based greenwashing measures. Covenant specificity and third-party verification emerged as the strongest predictors of allocation alignment, with sustainability-linked bonds exhibiting significantly narrower gaps than sustainability-linked loans. The CAGI offers a replicable framework for investors, regulators, and scholars seeking to move beyond binary greenwashing detection toward continuous, quantitatively grounded monitoring of sustainability-linked debt integrity. Administrators negotiating or monitoring ESG debt should prioritize quantified KPIs with defined allocation thresholds, recognizing that vague commitments invite allocation drift. As sustainability-linked finance continues to expand, the capacity to measure whether contractual commitments translate into substantive capital deployment will determine whether these instruments fulfill their transformative promise or become another mechanism of symbolic compliance.

References

1. Okeke, A. (2026). Measuring greenwashing: Validating constructs for corporate environmental misrepresentation. *Innovation and Green Development*, 5(3), Article 100363. <https://doi.org/10.1016/j.igd.2026.100363>
2. Okeke, A., & Rahim, L. J. (2026). Deconstructing deception: A triangulated greenwashing index for precision sustainability governance. *Organization & Environment*. Advance online publication. <https://doi.org/10.1177/10860266261477310>
3. Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, 142(2), 499–516.
4. Berrada, T., Engelhardt, N., & Gibson Brandon, R. (2024). Sustainability-linked bonds: The role of contractual features in driving decarbonization. *Journal of Corporate Finance*, 102687.
5. Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–291.
6. Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305–360.
7. Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review*, 20(3), 571–610.
8. Delmas, M. A., & Burbano, V. C. (2011). The drivers of greenwashing. *California Management Review*, 54(1), 64–87.
9. Lyon, T. P., & Montgomery, A. W. (2015). The means and end of greenwash. *Organization & Environment*, 28(2), 223–249.
10. Yu, E. P., Van Luu, B., & Chen, C. H. (2020). Greenwashing in environmental, social and governance disclosures. *Research in International Business and Finance*, 52, 101192.
11. Birindelli, G., Chiappini, H., & Jalal, R. N. U. D. (2024). Greenwashing and cost of debt: Empirical evidence from European listed firms. *Journal of Cleaner Production*, 141892.
12. Berg, F., Kölbel, J. F., & Rigobon, R. (2022). Aggregate confusion: The divergence of ESG ratings. *Review of Finance*, 26(6), 1315–1344.
13. Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 61, 101427.

14. Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, 98, 39–60.
15. Christensen, H. B., & Nikolaev, V. V. (2012). Capital versus performance covenants in debt contracts. *Journal of Accounting Research*, 50(1), 175–206.