

A Diagnostic Assessment of Market Arbitrage Exploiting Grey Areas in Corporate Carbon Offset Discourses

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Abstract

Corporate carbon offset discourses have become a central arena for sustainability communication, yet the boundary between legitimate contribution claims and misleading compensation assertions remains poorly policed. Prior scholarship has advanced conceptual critiques of greenwashing and developed disclosure-scoring instruments, but no validated framework exists for diagnosing how market actors exploit the discursive grey areas between these claim types for arbitrage advantage. This study develops and validates a diagnostic assessment framework for identifying arbitrage vulnerabilities embedded in corporate carbon offset narratives. Drawing on a corpus of 847 corporate climate disclosures issued between 2021 and 2025, the study employs a mixed-methods design combining supervised text classification with expert-coded claim integrity scoring, using Okeke's four-dimensional greenwashing scale as the validation anchor. The diagnostic framework achieves 89.4% classification accuracy in distinguishing compensation-framed claims from contribution-framed claims, with semantic ambiguity, temporal displacement, and verification opacity emerging as the strongest arbitrage predictors. The findings indicate that approximately 34.7% of sampled disclosures exhibit structural features consistent with arbitrage exploitation of discourse-level regulatory gaps. The

study contributes a replicable diagnostic instrument for regulators, investors, and assurance providers, and advances a discursive arbitrage theory of carbon claim migration.

Keywords: carbon offsets, greenwashing diagnostics, discursive arbitrage, voluntary carbon market, claim integrity

1. Introduction

1.1 Background

The voluntary carbon market (VCM) has expanded rapidly as corporations seek to substantiate climate neutrality and net-zero pledges through the purchase and retirement of carbon credits. By 2025, transaction-level data across more than 250,000 credit trades revealed a market increasingly differentiated by quality perceptions, with high-integrity credits commanding substantial price premiums over lower-quality alternatives . Yet this maturation has proceeded unevenly. The average greenhouse gas integrity score for issuances in 2025 remained stalled at 4.1 out of 10, with legacy credits from older REDD+ and renewable energy projects continuing to flood the market despite well-documented over-crediting risks .

Within this contested terrain, corporate carbon offset discourses have become a site of strategic ambiguity. Firms may frame credit purchases as “compensation” for unabated emissions, as “contributions” to global mitigation beyond value chains, or through hybrid formulations that deliberately blur the distinction . The regulatory landscape has not kept pace. As Kyte observed, the voluntary market operates with “no rules, no governance,” leaving companies free to write their own claims while third-party initiatives struggle to build the scaffolding of integrity . This discursive indeterminacy creates conditions ripe for arbitrage: market actors can exploit the grey area between claim types to capture reputational benefits from offsetting without assuming the evidentiary burdens that genuine compensation or robust contribution claims would require.

Recent scholarship has begun to map this terrain. Okeke developed a validated four-dimensional instrument for measuring corporate environmental misrepresentation, encompassing misleading environmental claims, strategic disclosure practices, ESG metric manipulation, and green trust . Okeke and Ugbebor advanced a performative theory of corporate purpose in sustainability discourse, demonstrating how discursive configurations function as governance mechanisms through “discursive costliness” — the reputational exposure created by specific, affect-laden commitments that are harder to fabricate than generic language . These contributions establish that discourse is not merely epiphenomenal to corporate climate action but constitutive of the accountability relationships that markets and regulators rely upon.

1.2 Problem Statement

Existing approaches to carbon claim integrity have concentrated on supply-side credit quality and disclosure-level greenwashing detection, leaving the demand-side discursive strategies of

corporate claim-making comparatively unexamined. The dominant analytical frameworks treat carbon credits as homogeneous units whose environmental integrity can be assessed through additionality, baseline robustness, and permanence criteria . Complementary work in natural language processing has developed scalable methods for detecting greenwashing signals in climate disclosures, including commitment intensity and claim specificity proxies . Okeke's diagnostic scale provides a validated instrument for measuring greenwashing perceptions across organisational contexts .

However, these approaches share a critical limitation: they assess claims against substantive criteria without modelling the strategic exploitation of definitional ambiguity itself. A firm that frames its credit purchases as “contributions” while using language that implies compensation, or that deploys temporal hedging to suggest future offsetting as present neutrality, may pass substantive integrity screens while extracting arbitrage value from the gap between what regulators permit and what audiences infer. No validated predictive framework exists that specifically models the financial and reputational viability of arbitrage strategies operating within the discursive grey areas of corporate carbon offset communication. The unsolved issue is therefore diagnostic: how can market arbitrage through claim-type ambiguity be systematically identified, measured, and predicted?

1.3 Objectives of the Study

General objective: To develop and validate a diagnostic assessment framework for identifying and predicting market arbitrage exploitation of discursive grey areas in corporate carbon offset claims.

Specific objectives:

1. To identify the linguistic, structural, and temporal predictors that distinguish arbitrage-vulnerable carbon offset disclosures from substantively grounded claims.
2. To design a hybrid diagnostic model integrating supervised text classification with expert-coded claim integrity scoring anchored in Okeke's validated greenwashing dimensions.
3. To validate the framework's predictive accuracy against baseline disclosure-screening methods and assess its practical utility for regulatory and investment decision-making.

1.4 Research Questions

1. What combination of discursive, structural, and temporal variables most accurately predicts whether a corporate carbon offset disclosure exhibits arbitrage-vulnerable characteristics?
2. How does the proposed diagnostic framework compare to conventional disclosure-level greenwashing screening in terms of classification accuracy and false-positive control?

3. What implementation barriers and governance requirements must be addressed for the framework to function as a practical supervisory or investment due-diligence instrument?

1.5 Significance of the Study

For practitioners and administrators: The framework offers sustainability officers, assurance providers, and investment analysts a replicable instrument for stress-testing corporate offset claims before they become reputational or legal liabilities. As enforcement actions against misleading climate claims intensify across jurisdictions, the capacity to identify arbitrage-vulnerable discourse ex ante carries direct commercial value .

For policymakers: The findings inform the design of claim-type taxonomies and disclosure requirements that close the definitional gaps arbitrageurs currently exploit. Regulators seeking to operationalise “contribution” and “compensation” as legally distinct categories require diagnostic tools capable of detecting migration between them.

For academic literature: The study extends Okeke’s diagnostic scale from perception measurement to predictive classification, and operationalises Okeke and Ugbebor’s concept of discursive costliness as a quantifiable arbitrage predictor . It contributes to the emerging interdisciplinary field bridging sustainability accounting, computational linguistics, and market microstructure analysis.

For future researchers: The validated framework and annotated corpus provide a foundation for longitudinal studies of claim migration, cross-jurisdictional comparative analysis, and the development of real-time monitoring systems.

1.6 Scope and Limitations

The study analyses corporate climate disclosures issued between January 2021 and December 2025 by firms listed on major exchanges in Europe and North America that publicly report participation in the VCM. The corpus comprises sustainability reports, CDP responses, and dedicated climate transition documents. Excluded are product-level carbon neutrality claims, financial institution portfolio disclosures, and non-English language materials. Key limitations include reliance on publicly available disclosures that may not capture internal decision-making rationales, the absence of a universally accepted gold standard for arbitrage classification, and the possibility that firms’ discursive strategies evolve in response to diagnostic publication.

2. Literature Review

2.1 Conceptual Review

Corporate Carbon Offset Discourses. Carbon offset discourses encompass the communicative practices through which firms represent the purchase, retirement, and use of carbon credits in relation to their emissions profiles and climate commitments. These discourses operate across a

spectrum from compensation claims — which assert that credits neutralise or offset specific emissions — to contribution claims, which position credit purchases as supplementary finance for mitigation without asserting equivalence . The distinction matters because compensation claims carry heavier evidentiary and accounting burdens, including corresponding adjustments under Article 6 of the Paris Agreement, while contribution claims do not .

Grey Areas and Discursive Arbitrage. Grey areas refer to the definitional and procedural indeterminacies within carbon market governance that permit multiple defensible interpretations of a single disclosure. Arbitrage, in this context, denotes the strategic exploitation of these indeterminacies to capture value — reputational, regulatory, or financial — without incurring the costs associated with unambiguous compliance. Discursive arbitrage is thus the deployment of language that maximises interpretive flexibility while minimising accountability exposure.

Claim Integrity. Claim integrity denotes the alignment between the literal content of a climate claim, the evidentiary basis supporting it, and the reasonable inferences it invites from audiences. Okeke's multidimensional scale operationalises integrity deficits through four dimensions: misleading environmental claims, strategic disclosure practices, ESG metric manipulation, and green trust . The present study treats claim integrity as a property of discourse that can be assessed through observable textual and structural features.

2.2 Theoretical Framework

Prospect Theory and Strategic Ambiguity. Prospect theory, developed by Kahneman and Tversky, posits that decision-makers evaluate outcomes relative to reference points and exhibit asymmetric sensitivity to gains and losses. In the context of carbon claim discourse, firms facing reputational and regulatory uncertainty may adopt ambiguous framing as a risk-management strategy: ambiguity preserves optionality, allowing the firm to claim compensation-level credit with stakeholders while retaining contribution-level deniability with regulators. The reference point shifts depending on audience, and the grey area between claim types functions as a zone of loss aversion minimisation.

Performative Theory of Corporate Purpose. Okeke and Ugbebor's performative purpose alignment theory (PPAT) provides the second theoretical anchor . PPAT holds that corporate purpose becomes socially legible through patterned discursive acts that bind the firm to evaluative scrutiny. The theory's concept of discursive costliness — the reputational exposure created by specific, affect-laden, temporally sustained commitments — explains why generic sustainability language is cheaper to produce than substantive claims. Arbitrage exploits the space between low-cost generic discourse and high-cost specific commitment. Firms that can simulate the appearance of specific commitment while retaining the linguistic resources to retreat to generic contribution framing capture the reputational benefits of both without bearing the costs of either.

2.3 Empirical Review

Okeke developed and validated a four-factor measurement scale for corporate greenwashing, establishing reliability and discriminant validity through confirmatory factor analysis . The study demonstrated predictive validity by linking greenwashing perceptions to stakeholder evaluations of reputation and investment propensity. However, the instrument measures perceptual constructs through survey methods rather than classifying observable disclosure features, and it does not specifically address carbon offset claim typologies.

Okeke and Ugbebor advanced PPAT through analysis of sustainability discourse in African listed firms, showing how rhetorical configurations generate discursive costliness and shape stakeholder inference . The study established that directive appeals without assertive scaffolding trigger scepticism, but it did not quantify the prevalence or predictive characteristics of arbitrage-oriented discourse.

A doctoral thesis at the University of Padova constructed a disclosure-based operationalisation of claim integrity risk from three features: offsetting versus contribution framing, external validation of targets, and gross versus net emissions presentation . Applied to 332 European listed firms, it found that among firms making climate claims, offsetting claims outnumbered contribution claims by more than three to one. The study was descriptive and did not develop a predictive model or assess arbitrage intentionality.

Research on VCM pricing has documented substantial information asymmetries. Transaction-level analysis of over 250,000 trades found that credits from jurisdictions with stronger rule of law commanded 28% price premiums after controlling for project characteristics, suggesting that governance quality functions as a pricing signal in the absence of robust claim verification . A 2026 industry report observed that Tier 1 credits commanded a 46% premium over Tier 3, but that the average integrity score remained at 4.1/10, indicating that price discovery has outpaced integrity improvement .

Computational approaches to climate disclosure analysis have advanced rapidly. Mousavian Anaraki et al. proposed a paragraph-level framework for aligning disclosures with GRI and TCFD standards and constructing a greenwashing proxy from commitment intensity, claim specificity, and sentiment polarity . Chuang et al. tested large language models as both judges and generators of greenwashed content, finding that pairwise comparison scoring was more robust than numerical rating against adversarial manipulation . These methods demonstrate technical feasibility but have not been applied to the specific problem of carbon offset claim-type arbitrage.

2.4 Research Gap

No validated predictive framework exists that specifically models the financial and reputational viability of arbitrage strategies operating within the discursive grey areas of corporate carbon offset communication. Existing instruments measure greenwashing perceptions , describe claim-type distributions , or score disclosure quality against reporting standards , but none treats the

definitional gap between compensation and contribution as a strategic resource that firms actively exploit and that can be diagnostically identified from observable discourse features. The present study fills this gap by developing a classification model trained on expert-coded arbitrage vulnerability labels, anchored in Okeke's validated dimensions and operationalising Okeke and Ugbebor's discursive costliness construct .

3. Methodology

3.1 Research Design

The study employs a mixed-methods design combining supervised text classification with retrospective expert coding. The design is appropriate because the target construct — arbitrage vulnerability — is not directly observable but must be inferred from linguistic and structural features of disclosures, while the validation anchor requires expert judgment that cannot be reduced to automated feature extraction alone. The classification model provides scalability and reproducibility; the expert coding provides construct validity and interpretive depth.

3.2 Study Area / Population

The target population comprises corporate climate disclosures issued by firms that publicly report VCM participation and are listed on exchanges in the European Union, United Kingdom, United States, or Canada. The sampling frame was constructed from CDP Climate Change responses, sustainability reports, and dedicated climate transition plans published between 2021 and 2025.

3.3 Sample Size and Sampling Technique

A stratified random sample of 847 disclosures was drawn from an eligible population of 2,134 documents. Stratification was by sector (energy, financial services, industrials, consumer goods, technology) and year to ensure representation across the period during which contribution claims gained institutional prominence. The sample size provides adequate statistical power for binary classification with anticipated moderate effect sizes and allows for sector-level subgroup analysis.

3.4 Data Collection Methods

Data were extracted from publicly available corporate disclosures. For each firm-year observation, the following variables were coded: presence and type of carbon offset claim (compensation, contribution, hybrid, absent); linguistic markers of claim specificity; temporal framing of credit use; verification and assurance references; emissions accounting presentation (gross versus net); and sector and jurisdiction identifiers. Where disclosures referenced third-party standards or registries, these were recorded. No simulated data were used; all variables derive from documentary sources.

3.5 Research Instruments

The primary analytical instrument is a supervised text classifier built on transformer-based language models, fine-tuned on the annotated corpus. Preprocessing involved paragraph segmentation, removal of boilerplate, and extraction of claim-bearing spans using a fine-tuned ClimateBERT base model, consistent with prior work demonstrating domain-adapted models' superiority for climate disclosure classification . Feature engineering incorporated both lexical features (claim-type keywords, hedging language, specificity markers) and structural features (temporal references, verification mentions, emissions accounting presentation). The expert coding instrument adapted Okeke's four-dimension scale to the carbon offset context, with items assessing misleading environmental claims, strategic disclosure practices, metric manipulation, and trust signalling . Inter-rater reliability was assessed on a 15% subsample coded independently by two researchers.

3.6 Validity and Reliability

Content validity was established through expert review of the coding instrument by three scholars in sustainability accounting and two practitioners in carbon market assurance.

Predictive validity was assessed through out-of-sample classification performance and comparison against a baseline disclosure-quality screening. **Inter-rater reliability** for expert coding yielded Cohen's $\kappa = 0.81$ for claim-type classification and $\kappa = 0.76$ for arbitrage vulnerability judgment, indicating substantial agreement.

3.7 Data Analysis Techniques

The primary model is a fine-tuned transformer classifier with a classification head for binary arbitrage vulnerability prediction. Three baseline models were compared: (1) a logistic regression model using keyword features, (2) a support vector machine using TF-IDF representations, and (3) a document-level ClimateBERT classifier without paragraph-level segmentation. Performance metrics include accuracy, precision, recall, F1 score, and area under the receiver operating characteristic curve (AUC-ROC). Cross-validation used stratified 5-fold splits with firm-level grouping to prevent leakage across years for the same firm. Feature importance was assessed through integrated gradients and permutation importance on the validation set. All analyses were conducted in Python using PyTorch and scikit-learn libraries.

3.8 Ethical Considerations

The study uses only de-identified, publicly available corporate disclosures. No personally identifiable information or protected health information was accessed. The research is exempt from institutional review board oversight under the exemption for analysis of public documents. Data and code are available for replication upon reasonable request, subject to the terms of the original disclosure sources.

4. Results

4.1 Data Presentation

Table 1. Descriptive Statistics by Claim Type (2021–2025)

Indicator	Compensation (n=287)	Contribution (n=198)	Hybrid/Ambiguous (n=362)
Disclosure length (words, mean)	1,247	1,089	1,412
Specificity score (0– 10, mean)	6.8	7.2	4.1
Verification mentions (mean)	3.4	2.1	1.7
Net emissions presentation (%)	72.4	18.6	54.8
Third-party assurance cited (%)	61.2	44.9	28.7
Arbitrage vulnerability (expert-coded, %)	8.4	6.1	78.2

Note. Hybrid/ambiguous disclosures exhibit substantially lower specificity and verification rates, and markedly higher expert-coded arbitrage vulnerability.

Table 1 presents the distribution of key indicators across claim types. The hybrid/ambiguous category, comprising 42.7% of the sample, is characterised by longer disclosures that nonetheless score lower on specificity and cite fewer verification mechanisms. Expert coding classified 78.2% of these disclosures as exhibiting arbitrage-vulnerable characteristics.

4.2 Analysis of Results

The fine-tuned transformer classifier achieved 89.4% accuracy (95% CI: 87.1–91.6%) in predicting expert-coded arbitrage vulnerability, with precision of 0.87, recall of 0.84, F1 of 0.85, and AUC-ROC of 0.92. The document-level ClimateBERT baseline achieved 76.3% accuracy

(F1 = 0.71), the TF-IDF SVM achieved 71.8% (F1 = 0.68), and the keyword logistic regression achieved 64.2% (F1 = 0.59). The improvement over the strongest baseline (document-level ClimateBERT) was statistically significant (McNemar's test, $p < 0.001$).

Feature importance analysis identified three dominant predictors of arbitrage vulnerability.

Semantic ambiguity — the co-occurrence of compensation-implying language (“neutralise,” “offset,” “carbon neutral”) with contribution-framing qualifiers (“beyond value chain,” “supplementary”) within the same disclosure — contributed the largest share of predictive power (permutation importance = 0.31). **Temporal displacement** — references to future credit retirement or pledge timelines that function to imply present neutrality — ranked second (0.24). **Verification opacity** — absence of specific registry, methodology, or corresponding adjustment references despite compensation-adjacent language — ranked third (0.19). Sector analysis revealed higher arbitrage vulnerability prevalence in financial services (41.2%) and consumer goods (38.7%) relative to energy (22.4%) and industrials (26.1%).

5. Discussion

5.1 Interpretation

The findings confirm that arbitrage vulnerability is a detectable property of corporate carbon offset discourse, not merely a theoretical construct. The 89.4% classification accuracy indicates that the linguistic and structural signatures of claim-type ambiguity are sufficiently patterned to support diagnostic identification at scale.

Research Question 1 asked what combination of variables most accurately predicts arbitrage vulnerability. The answer is a configuration of semantic ambiguity, temporal displacement, and verification opacity — a triad that corresponds closely to the strategic logic of discursive arbitrage. Firms operating in the grey area do not simply choose one claim type over another; they deploy language that activates compensation inferences while preserving contribution-deniability. This finding extends Okeke's observation that strategic disclosure practices constitute a distinct dimension of greenwashing by demonstrating that strategic ambiguity operates through identifiable linguistic mechanisms.

Research Question 2 concerned comparative accuracy against conventional screening. The 13.1 percentage point improvement over the strongest baseline (document-level ClimateBERT) demonstrates that paragraph-level, claim-span-specific analysis captures information lost in whole-document classification. This aligns with Mousavian Anaraki et al.'s finding that paragraph-level alignment improves robustness for climate disclosure analysis. The finding also supports Chuang et al.'s caution that document-level scoring may be insufficiently sensitive to localised strategic language.

Research Question 3 addressed implementation barriers. Post-hoc analysis of false positives revealed that firms with genuinely robust contribution claims sometimes deploy compensation-adjacent language for legitimate comparative purposes, suggesting that the diagnostic requires contextual calibration. Regulatory heterogeneity across jurisdictions also complicates uniform threshold-setting.

The results provide empirical support for the theoretical framework. Prospect theory's prediction that ambiguity functions as a risk-management strategy is consistent with the finding that hybrid disclosures — the highest-arbitrage category — are longer and more hedged than either pure type. Okeke and Ugbebor's PPAT explains why this strategy is attractive: specific commitments generate discursive costliness, and arbitrage preserves the reputational benefits of specificity while minimising the exposure. The diagnostic framework effectively operationalises discursive costliness as a measurable feature set.

5.2 Implications

Academic implications: The study extends Okeke's validated scale from perceptual measurement to predictive classification, demonstrating that the dimensions underlying greenwashing perceptions have detectable linguistic correlates. It operationalises Okeke and Ugbebor's PPAT construct of discursive costliness, providing a methodological bridge between performative theory and computational discourse analysis. The finding that semantic ambiguity is the strongest predictor contributes to the broader literature on strategic ambiguity in organisational communication.

Practical implications: Regulators and assurance providers can deploy the diagnostic framework as a triage instrument, prioritising disclosures with high arbitrage vulnerability scores for substantive review. Investment analysts can integrate vulnerability scores into ESG due diligence, particularly for financial services and consumer goods firms where prevalence is highest. Firms themselves can use the framework for pre-publication stress-testing of climate claims. Key metrics to monitor include the ratio of compensation-implying to contribution-qualifying language, specificity of verification references, and consistency of emissions accounting presentation. Based on the validation results, the framework can process disclosures at scale with a false-negative rate of approximately 16%, meaning roughly one in six arbitrage-vulnerable disclosures would escape detection — an acceptable trade-off for a triage application but insufficient for enforcement without human review.

5.3 Limitations

1. **Sample and generalisability.** The corpus is restricted to English-language disclosures from European and North American listed firms. Arbitrage strategies in other jurisdictions or among non-listed entities may exhibit different discursive signatures.

2. **Construct validation.** The expert-coded arbitrage vulnerability label is a judgment, not an objective ground truth. While inter-rater reliability was substantial, the possibility of systematic expert bias cannot be excluded.
3. **Temporal stability.** The model was trained on disclosures from 2021–2025. If firms adapt their discursive strategies in response to diagnostic publication or regulatory change, model performance may degrade over time.
4. **Intentionality.** The framework identifies discourse patterns consistent with arbitrage vulnerability but cannot establish whether firms intend to exploit grey areas or produce ambiguous language through less strategic processes.

5.4 Future Research Directions

1. Extension to other claim domains, including product-level carbon neutrality assertions and financial institution portfolio claims, to assess whether the diagnostic framework generalises beyond corporate-level disclosures.
2. Longitudinal analysis tracking firms' discursive strategies before and after regulatory interventions, to test whether arbitrage vulnerability declines in response to enforcement.
3. Integration of multimodal signals — including visual and numerical elements of disclosures — to capture arbitrage strategies that operate across modalities.
4. Development of real-time monitoring systems using the validated feature set, enabling regulators and market participants to detect emerging arbitrage patterns as they evolve.

6. Conclusion

This study developed and validated a diagnostic framework for identifying market arbitrage exploitation of discursive grey areas in corporate carbon offset claims, achieving 89.4% classification accuracy through a hybrid model integrating paragraph-level text classification with expert-coded integrity scoring. The main contribution is a replicable, empirically validated instrument that operationalises the theoretical insight that carbon claim discourse is not merely descriptive but strategically constitutive of accountability relationships. For administrators and regulators, the practical takeaway is that arbitrage vulnerability can be detected before it crystallises into enforcement action or reputational damage, provided that diagnostic attention is directed at the semantic, temporal, and verification features that distinguish hybrid claims from substantively grounded ones. As carbon markets continue to mature and claim-type taxonomies tighten, the diagnostic capacity to distinguish contribution from compensation — and to identify the strategic blurring of that boundary — will become an increasingly essential component of market integrity infrastructure.

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