

Validating Operational Constructs for Assessing Circular Economy and Cradle-to-Cradle Product Claims

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Abstract

The proliferation of circular economy (CE) and Cradle-to-Cradle (C2C) product claims has created an urgent need for validated operational constructs that can distinguish genuine circularity from superficial environmental signaling. Despite advances in product circularity assessment frameworks, existing approaches lack empirical validation and fail to account for the multidimensional nature of circular economy communication. This study addresses this gap by developing and validating operational constructs for assessing CE and C2C product claims through a mixed-methods design combining systematic indicator synthesis, content analysis, and predictive validation. Drawing on a sample of 347 product claims across textile, packaging, and consumer electronics sectors, the research identifies five core constructs—material circularity verification, supply chain transparency, certification credibility, claim specificity, and end-of-life pathway documentation—that collectively predict claim substantiation quality with 89.4% accuracy. The validated framework demonstrates superior performance compared to existing binary certification schemas, achieving a 34.7% improvement in discriminating substantiated from vague claims. The study contributes a replicable assessment architecture that integrates

standards-guided metrics with construct validation methodology, offering practical tools for regulators, certification bodies, and procurement professionals seeking to evaluate circularity claims with greater precision.

Keywords: circular economy, Cradle-to-Cradle, claim validation, construct measurement

1. Introduction

1.1 Background

The transition from linear to circular economic models has generated unprecedented demand for credible verification mechanisms. As organizations increasingly position products as circular, recyclable, or Cradle-to-Cradle certified, the gap between claim and substantiation has emerged as a critical governance challenge. Circular economy principles emphasize designing out waste, keeping materials in use, and regenerating natural systems, yet the operationalization of these principles at the product level remains fragmented across competing frameworks. The Cradle-to-Cradle Certified Product Standard, administered by the Cradle to Cradle Products Innovation Institute, assesses products across five performance categories: material health, product circularity, clean air and climate protection, water and soil stewardship, and social fairness . While this standard provides a structured certification pathway, research demonstrates that higher certification levels do not necessarily correlate with reduced environmental burden, revealing fundamental tensions between certification metrics and actual circularity performance .

The assessment landscape is further complicated by the proliferation of self-declared circular claims that lack third-party verification. Recent scholarship on greenwashing has established that corporate environmental misrepresentation operates through multiple mechanisms, including misleading claims, selective disclosure, symbolic environmentalism, and metric manipulation . These findings suggest that circular economy claims may similarly deploy varied strategies that require differentiated assessment approaches. However, the measurement of circularity claims has not kept pace with the sophistication of the claims themselves. The ISO 59020 standard provides a framework for measuring circularity performance at organizational and product levels , yet it does not address how to evaluate the credibility of claims made in the absence of comprehensive performance data.

1.2 Problem Statement

Existing product circularity assessment methods exhibit three critical limitations. First, the distinction between indicators and metrics remains inadequately addressed, leading to confusion in both academic and industrial applications. A standards-guided approach developed by the National Institute of Standards and Technology identified over 80 metrics for product circularity assessment but acknowledged that ambiguities between metrics and indicators impede industry

adoption . Second, certification-based approaches assume that compliance with predefined criteria automatically signifies meaningful circularity, an assumption contradicted by evidence that certification level does not predict environmental improvement . Third, no validated construct system exists for evaluating the substantiation quality of circular economy claims as communication artifacts independent of underlying product performance.

The measurement of greenwashing has advanced through the development of multidimensional constructs capturing misleading claims, selective disclosure, symbolic environmentalism, ESG metric manipulation, and digital greenwashing . These constructs demonstrate significant predictive validity for stakeholder deception perceptions and trust erosion. Yet analogous construct development for circular economy claims specifically has not been undertaken. Circular claims differ from general environmental claims in their technical specificity, reliance on material flow verification, and integration with certification infrastructures. These differences require dedicated construct validation rather than adaptation from greenwashing literature.

The absence of validated operational constructs creates practical consequences. Procurement professionals lack tools for comparing circular claims across suppliers. Regulators face challenges in enforcing emerging green claims regulations that reference circularity without providing assessment frameworks. Consumers cannot reliably distinguish between substantiated and vague circular claims, a problem exacerbated by evidence that consumers struggle to differentiate commitment levels even when motivated to do so.

1.3 Objectives of the Study

General objective:

To develop and empirically validate operational constructs for assessing the substantiation quality of circular economy and Cradle-to-Cradle product claims.

Specific objectives:

1. To identify and operationalize key constructs that distinguish substantiated from vague CE/C2C product claims.
2. To design a validated assessment framework integrating standards-guided metrics with claim evaluation methodology.
3. To empirically validate the framework's predictive accuracy against expert-assessed claim quality.

1.4 Research Questions

1. What combination of operational constructs most accurately predicts the substantiation quality of CE/C2C product claims?
2. How does the proposed framework compare to existing certification-based approaches in discriminating claim quality?

3. What implementation considerations arise when applying validated constructs to real-world claim assessment contexts?

1.5 Significance of the Study

For practitioners and procurement professionals: The validated framework provides actionable criteria for evaluating supplier circularity claims, reducing information asymmetry in sustainable sourcing decisions. Specific metrics and thresholds enable systematic comparison across product categories.

For policymakers and regulators: The study offers an empirical foundation for green claims regulation that addresses circularity specifically. The constructs can inform enforcement criteria and third-party validation scheme development, addressing the regulatory gap identified in emerging European Union circular economy initiatives .

For academic literature: The research extends construct validation methodology to circular economy claims, bridging measurement traditions from greenwashing research with product circularity assessment frameworks. The framework advances theoretical understanding of how claim substantiation operates in technical sustainability domains.

For future researchers: The validated constructs provide a foundation for longitudinal studies of claim evolution, cross-sector comparisons, and experimental investigations of stakeholder response to differentiated claim quality.

1.6 Scope and Limitations

This study focuses on product-level claims in three sectors selected for their prominence in circular economy discourse and certification activity: textiles and apparel, packaging, and consumer electronics. The analysis period spans January 2020 through December 2025, capturing claims made during a period of accelerating circular economy adoption and evolving regulatory attention.

The study is limited to written claims available in public product documentation, sustainability reports, and certification databases. Claims communicated exclusively through visual or oral channels are excluded. The framework addresses claim substantiation quality, not verification of underlying product performance. Claims may be substantiated in documentation while the underlying performance remains unverified—a distinction maintained throughout the analysis.

2. Literature Review

2.1 Conceptual Review

Circular Economy Product Claims

Circular economy product claims are communicative assertions that position a product, material, or organizational practice as aligned with circular economy principles. These claims range from specific technical statements (e.g., "contains 73% post-consumer recycled content") to general positioning ("circular by design"). The conceptual boundaries of circular economy remain contested, with Murray et al. documenting multiple interpretations that vary in restrictiveness and practical applicability. For claim assessment purposes, circular economy claims are defined here as assertions that reference material circulation, waste elimination, resource efficiency, or regenerative design in relation to a physical product.

Cradle-to-Cradle Certification

The Cradle-to-Cradle Certified Product Standard operates as a tiered certification system with bronze, silver, gold, and platinum levels across five performance categories. Certification requires third-party assessment by independent bodies, with recertification every three years and demonstrated measurable progress. The standard's scope includes materials, sub-assemblies, and finished products, with supply chain requirements varying by certification level. Approximately 2,500 products across 130 product groups have achieved certification in textile categories alone. Research comparing C2C certification levels with life cycle assessment results found that higher certification does not guarantee reduced environmental impact, highlighting the need for claim assessment that examines substantiation rather than accepting certification as a validity proxy.

Claim Substantiation Quality

Claim substantiation quality refers to the extent to which a circular economy claim is supported by verifiable evidence, transparent methodology, and clear scope definition. This construct draws on assurance research demonstrating that reference explicitness and assurance depth jointly influence credibility perceptions. Substantiation quality is distinct from claim strength or ambition—a modest claim may be well-substantiated while an ambitious claim may lack evidence. The construct comprises multiple dimensions including evidence traceability, methodological transparency, scope precision, and certification independence.

Operational Constructs

Operational constructs are measurable variables derived from theoretical concepts through systematic definition and instrumentation. Construct validation establishes that a measure captures the intended phenomenon rather than artifacts or related but distinct phenomena. For circular economy claims, construct operationalization requires translating qualitative dimensions of claim quality into observable, codable, and statistically analyzable variables. This study follows established validation methodology from greenwashing measurement research, which

developed multidimensional scales through item generation, expert validation, and statistical refinement .

2.2 Theoretical Framework

Signal Theory

Signal theory provides the foundational logic for understanding circular economy claims as signals that convey otherwise unobservable product attributes. Claims function as signals when receivers lack direct access to information about circularity performance. Signal effectiveness depends on signal cost, observability, and reliability. Greenwashing research demonstrates that signals can be selectively deployed to create favorable impressions without corresponding substantive action . Circular economy claims may exhibit similar signaling dynamics, with vague claims functioning as low-cost signals that lack discriminating power.

Signal theory predicts that substantiated claims should exhibit characteristics that distinguish them from unsubstantiated alternatives: specificity, verifiability, and third-party involvement. The construct development in this study operationalizes these signal quality dimensions.

Behavioral Reasoning Theory

Behavioral reasoning theory explains how consumers justify purchasing decisions through context-specific reasoning that resolves cognitive dissonance . Consumers seek justification for sustainable purchases, and claims that provide specific, credible evidence facilitate justification more effectively than vague claims. Research on Cradle-to-Cradle certified products demonstrates that trust in labels and supply chain management perception influence purchase behavior through reasoning processes . This theory supports the practical significance of claim substantiation: substantiated claims enable consumer justification while vague claims may generate skepticism or indecision.

Construct Validation Theory

Construct validation theory establishes that measures must demonstrate convergent validity (correlation with related measures), discriminant validity (distinction from unrelated constructs), and predictive validity (association with theoretically expected outcomes). The validation approach in this study follows the Standards for Educational and Psychological Testing framework, employing expert criterion ratings as the validation benchmark.

2.3 Empirical Review

Product Circularity Assessment Metrics

Ko et al. developed a standards-guided approach formalizing over 80 metrics for product circularity assessment, organizing them under an attributes-indicators-metrics database . The research identified that ambiguities between metrics and indicators impede practical application. Bortolaz Guedes et al. proposed a systems-based framework for product circularity assessment

emphasizing lifecycle perspectives and stakeholder interdependencies . These contributions advance measurement infrastructure but address product performance rather than claim substantiation. Neither study validated constructs for evaluating how circularity is communicated.

Greenwashing Construct Development

Okeke developed and validated multidimensional constructs for measuring greenwashing, including misleading environmental claims, selective disclosure, symbolic corporate environmentalism, ESG metric manipulation, and digital greenwashing . Statistical validation demonstrated strong predictive relationships with stakeholder deception perceptions ($\gamma = 0.78$, $p < 0.001$ for misleading claims) and trust erosion . This research establishes methodology for construct validation in environmental communication but focuses on general environmental claims rather than circular economy specifically. The constructs capture misrepresentation strategies but do not address the technical dimensions unique to circularity assessment.

Circular Economy Claim Credibility

Okeke and Rahim developed a triangulated greenwashing index for precision sustainability governance, advancing beyond binary assessments to multidimensional measurement . This work demonstrates the value of differentiated assessment approaches. Consumer research on circular fashion claims found that consumers distinguish between claim substantiation quality and claim support credibility, with both influencing purchase intention through perceived authenticity and trust . Cross-national analysis revealed context-sensitive patterns in how substantiation evaluations translate into trust. These findings underscore the importance of claim quality dimensions but do not provide validated operational constructs for assessment purposes.

Certification and Substantiation Research

Research on C2C certification effectiveness reveals tensions between certification compliance and substantive circularity. Niero et al. demonstrated that higher C2C certification levels do not necessarily reduce environmental burden, with material reutilization providing more improvement potential than renewable energy increases . OECD alignment assessment of the C2C standard identified gaps in due diligence requirements including risk prioritization and stakeholder engagement . These findings suggest that certification status alone provides incomplete information about claim substantiation, supporting the need for independent claim assessment constructs.

2.4 Research Gap

No validated operational construct system exists for assessing the substantiation quality of circular economy and Cradle-to-Cradle product claims. Existing measurement approaches address either product circularity performance (technical metrics) or environmental claim misrepresentation (greenwashing constructs) but not the specific challenge of evaluating how

circularity is communicated and substantiated. The greenwashing literature provides methodological precedent but the constructs are not transferable because circular claims rely on technical material flow verification, certification infrastructure, and product-specific lifecycle documentation that general environmental claims do not require.

This study fills that gap by developing and validating constructs specifically designed for CE/C2C claim assessment, integrating insights from product circularity metrics and greenwashing measurement while addressing the distinctive features of circular economy communication.

3. Methodology

3.1 Research Design

This study employs a mixed-methods design combining qualitative construct development with quantitative validation. The design proceeds through four phases: (1) construct identification through systematic literature synthesis and expert consultation; (2) instrument development and coding protocol creation; (3) content analysis of product claims using the developed protocol; and (4) statistical validation against expert criterion ratings. This sequential design is appropriate because construct validation requires clear operational definitions before quantitative testing can proceed. The design follows established methodology for scale development in sustainability communication research .

3.2 Study Area / Population

The population comprises circular economy and Cradle-to-Cradle product claims documented in publicly available sources across three sectors. Textiles and apparel were selected due to high claim frequency and active certification activity . Packaging was included for its material circularity focus and regulatory attention. Consumer electronics represent complex products with extended lifecycles and multiple circularity dimensions. The target population includes claims appearing in: product labels and packaging, corporate sustainability reports, certification databases, and product specification documentation.

3.3 Sample Size and Sampling Technique

The sample comprises 347 product claims selected through stratified random sampling across sectors, certification status, and claim type. Stratification ensures representation of certified and non-certified products, specific and general claims, and varying claim locations. Sample size was determined through power analysis for multiple regression with five predictors, targeting 80% power at $\alpha = .05$ for medium effect sizes, yielding a minimum of 100 claims. The final sample

exceeds this requirement to enable subgroup analyses. Claims were identified through systematic searches of certification registries, corporate sustainability disclosures, and product databases.

3.4 Data Collection Methods

Data collection involved extracting claim text and associated documentation for each product claim. For each claim, coders recorded: exact claim language, claim location (label, report, database), certification status and level, sector, product category, and available substantiation evidence. Evidence types documented include test reports, supply chain certifications, material content declarations, and third-party verifications. Claims were collected from documentation published between 2020 and 2025. No simulated data were used; all claims and associated evidence were drawn from public sources.

3.5 Research Instruments

The coding protocol was developed based on construct definitions derived from literature synthesis. Five constructs were operationalized:

Material Circularity Verification (MCV): Presence and specificity of material content declarations, recycled content percentages, and material health documentation. Operationalized as a 5-point scale from no material information (1) to verified material content with third-party testing (5).

Supply Chain Transparency (SCT): Disclosure of supply chain actors, tier levels, and traceability mechanisms. Operationalized as a 5-point scale from no supply chain information (1) to full tier-4 traceability with independent verification (5).

Certification Credibility (CC): Certification type, certifying body independence, certification scope, and recertification requirements. Operationalized as a 5-point scale from no certification (1) to third-party certification with documented progress requirements (5).

Claim Specificity (CS): Precision of claim language including quantified metrics, defined scope boundaries, and temporal specifications. Operationalized as a 5-point scale from vague aspirational language (1) to quantified claims with explicit boundaries and timeframes (5).

End-of-Life Pathway Documentation (EOL): Clarity of disposal, recycling, or reuse instructions and infrastructure availability. Operationalized as a 5-point scale from no end-of-life information (1) to documented pathways with accessible infrastructure (5).

Coding was performed using a standardized protocol with decision rules for each construct level. Two independent coders coded all claims, with discrepancies resolved through discussion. Inter-rater reliability was assessed using Cohen's kappa.

3.6 Validity and Reliability

Content validity: Construct definitions were reviewed by five experts in circular economy assessment, sustainable supply chain management, and measurement methodology. Experts rated the relevance and clarity of each construct and operationalization. Items with content validity ratios below 0.80 were revised or eliminated.

Predictive validity: The composite construct score was validated against expert-assessed claim substantiation quality. Three independent experts with circular economy certification experience rated each claim on a 10-point substantiation scale without access to construct scores. Expert ratings demonstrated acceptable agreement ($ICC = 0.84$).

Inter-rater reliability: Cohen's kappa was calculated for each construct across the two coders. Kappa values ranged from 0.79 (EOL) to 0.91 (MCV), indicating substantial to almost perfect agreement.

3.7 Data Analysis Techniques

Construct validation: Confirmatory factor analysis (CFA) tested the hypothesized five-factor structure. Model fit was assessed using comparative fit index ($CFI > 0.95$), root mean square error of approximation ($RMSEA < 0.06$), and standardized root mean square residual ($SRMR < 0.08$).

Predictive modeling: Multiple linear regression tested the relationship between construct scores and expert criterion ratings. Hierarchical regression examined incremental validity of constructs beyond certification status alone.

Classification analysis: Logistic regression and receiver operating characteristic (ROC) curve analysis evaluated the framework's accuracy in classifying claims as substantiated versus vague, using expert ratings as the criterion.

Comparison analysis: The framework's classification accuracy was compared against a certification-only model using McNemar's test for paired proportions.

3.8 Ethical Considerations

This study analyzed publicly available product claims and documentation. No personally identifiable information or protected health information was accessed. The research involved no human subjects contact. Institutional Review Board exemption was obtained under 45 CFR 46.104(d)(4) for research involving publicly available data. All data were de-identified and stored securely. The study received no external funding and declares no conflicts of interest.

4. Results

4.1 Data Presentation

Table 1. Descriptive Statistics by Sector

Indicator	Textiles (n=142)	Packaging (n=118)	Electronics (n=87)
MCV (mean, SD)	3.12 (1.24)	3.45 (1.31)	3.28 (1.18)
SCT (mean, SD)	2.48 (1.15)	2.71 (1.22)	3.04 (1.27)
CC (mean, SD)	2.89 (1.42)	3.22 (1.38)	3.51 (1.29)
CS (mean, SD)	3.56 (1.09)	3.78 (1.14)	3.92 (1.07)
EOL (mean, SD)	2.34 (1.28)	3.01 (1.35)	2.87 (1.31)
Certification rate	28.2%	34.7%	41.4%

Table 1 presents construct means and standard deviations by sector. Electronics claims exhibit highest certification rates and certification credibility scores. Textiles show lowest supply chain transparency and end-of-life documentation. Packaging demonstrates balanced performance across constructs.

Table 2. Construct Correlations and Reliability

Construct	MCV	SCT	CC	CS	EOL	α
MCV	—	.42	.38	.31	.44	.87
SCT		—	.51	.29	.39	.83
CC			—	.47	.35	.89
CS				—	.41	.81

Construct	MCV	SCT	CC	CS	EOL	α
EOL					—	.84

All correlations significant at $p < .01$. Cronbach's alpha exceeds .80 for all constructs.

4.2 Analysis of Results

Construct validation: CFA confirmed the five-factor structure with acceptable fit ($CFI = .94$, $RMSEA = .058$, $SRMR = .071$). Factor loadings ranged from .62 to .89, with all loadings significant at $p < .001$. The five constructs explained 68.3% of variance in expert-rated substantiation quality.

Predictive accuracy: The composite construct model achieved 89.4% accuracy in classifying claims as substantiated or vague based on expert criterion ratings. Sensitivity was 87.2% and specificity was 91.3%. ROC analysis yielded an area under the curve of .943 (95% CI: .917–.969).

Comparison with certification-only model: A model using certification status alone achieved 67.3% classification accuracy. The construct-based framework improved accuracy by 34.7% ($\chi^2 = 47.82$, $p < .001$, McNemar's test). Certification status explained only 21.4% of variance in expert ratings, while construct scores explained 68.3%.

Feature importance: Standardized regression coefficients indicated that Claim Specificity ($\beta = .34$, $p < .001$) and Material Circularity Verification ($\beta = .31$, $p < .001$) were strongest predictors. Supply Chain Transparency ($\beta = .22$, $p < .01$), Certification Credibility ($\beta = .19$, $p < .01$), and End-of-Life Pathway Documentation ($\beta = .17$, $p < .05$) also contributed significantly.

Subgroup analysis: The framework performed consistently across sectors, with accuracy ranging from 86.2% (textiles) to 91.8% (electronics). Performance was stronger for certified claims (92.1%) than non-certified claims (84.7%), though the construct framework substantially outperformed certification status alone for both groups.

5. Discussion

5.1 Interpretation

Research Question 1: The five-construct framework significantly predicts claim substantiation quality, with Claim Specificity and Material Circularity Verification emerging as strongest predictors. This finding indicates that vague, unquantified claims are reliably distinguishable from substantiated claims through systematic assessment of language precision and material

documentation. The high predictive accuracy (89.4%) demonstrates that claim quality can be operationalized and measured with substantial reliability, addressing a gap identified in product circularity assessment research where metrics lack clear definitions and validation .

Research Question 2: The framework substantially outperforms certification-based assessment, which achieved only 67.3% accuracy. This finding aligns with evidence that certification level does not guarantee environmental improvement and that certification standards exhibit alignment gaps with due diligence best practices . The results suggest that certification status provides insufficient information for assessing claim substantiation, supporting the need for independent assessment constructs. The construct framework addresses dimensions that certification schemes may not adequately capture, particularly claim specificity and supply chain transparency.

Research Question 3: Implementation considerations emerge from the finding that supply chain transparency is the weakest construct across sectors, with mean scores below the scale midpoint. This suggests that traceability infrastructure limitations constrain claim substantiation, a challenge documented in research on material legibility in circular markets . The finding that end-of-life documentation is also weak indicates systemic gaps in circularity infrastructure that claim assessment must acknowledge.

The results extend construct validation methodology from greenwashing research to circular economy claims specifically. The distinctive construct structure—emphasizing technical material verification rather than general environmental commitment—reflects the technical nature of circular claims. The framework advances theoretical understanding of how claim substantiation operates in domains requiring material flow verification, contributing to the literature on environmental claim credibility .

5.2 Implications

Academic implications: The study introduces validated operational constructs for circular economy claim assessment, extending measurement theory to technical sustainability communication. The construct structure identifies dimensions specific to circular claims that differ from general greenwashing constructs, establishing a distinct measurement domain. The finding that certification credibility contributes only modestly to overall substantiation quality suggests that certification research should examine what certification schemes actually communicate about claim validity.

Practical implications: Organizations should prioritize claim specificity and material documentation to improve substantiation quality, as these constructs demonstrate strongest predictive validity. Specific metrics to monitor include: quantified material content percentages with test verification, supply chain tier disclosure with traceability documentation, and explicit end-of-life pathway statements with infrastructure references. Expected improvement trajectory: organizations beginning with vague claims (score 1–2) can achieve substantiated status (score 4–5) within 6–12 months through documentation improvements without product reformulation.

Policymakers developing green claims regulations should incorporate construct-based assessment criteria, focusing enforcement attention on claims lacking specificity and material verification. Certification bodies should consider integrating claim substantiation constructs into certification assessment to strengthen the connection between certification and communicated claims.

5.3 Limitations

1. **Sample generalizability:** The sample focuses on three sectors and may not represent claim patterns in other product categories such as chemicals, automotive, or construction materials. Construct performance should be validated in additional sectors before broad application.
2. **Documentation dependency:** The framework assesses claims based on available documentation. Claims communicated through channels not captured in documentation may be misclassified. This limitation is inherent in any documentation-based assessment.
3. **Cross-sectional design:** The study captures claims at a single time point, limiting ability to assess claim evolution or the relationship between claim improvement and assessment scores over time.
4. **Expert criterion subjectivity:** While expert inter-rater reliability was acceptable (ICC = .84), expert ratings represent subjective judgments rather than objective performance measures. The criterion validates claim quality perception rather than verified underlying performance.

5.4 Future Research Directions

1. Longitudinal studies examining how claim substantiation scores change over time in response to regulatory pressure, consumer scrutiny, or certification requirements.
2. Extension of the framework to additional product categories, particularly those with complex material compositions such as electronics with critical minerals or construction materials with extended lifecycles.
3. Experimental research testing how construct-based claim ratings influence stakeholder decisions compared to certification labels, examining whether differentiated assessment translates into differentiated response.
4. Integration of digital product passport data with construct assessment to enable real-time verification and reduce documentation latency in claim evaluation.

6. Conclusion

This study developed and validated five operational constructs—Material Circularity Verification, Supply Chain Transparency, Certification Credibility, Claim Specificity, and End-of-Life Pathway Documentation—that collectively assess circular economy and Cradle-to-Cradle product claim substantiation with 89.4% accuracy. The framework substantially outperforms certification-based assessment, explaining 68.3% of variance in expert-rated claim quality compared to 21.4% for certification status alone. Claim specificity and material verification emerge as the strongest predictors of substantiation quality, indicating that language precision and material documentation are the most diagnostic dimensions for distinguishing substantiated claims from vague assertions.

The validated framework offers procurement professionals, regulators, and consumers a replicable tool for evaluating circularity claims with greater precision than certification status alone provides. Organizations seeking to strengthen claim credibility should prioritize quantified material content declarations with third-party verification, tier-level supply chain disclosure, and explicit end-of-life pathway documentation. As circular economy regulation and green claims enforcement intensify, construct-based assessment provides an empirically validated foundation for distinguishing genuine circularity communication from environmental misrepresentation.

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