

Article

Beyond the eco-label: Consumer psychology, greenwashing traps, and supply chain transparency in sustainable material communication

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Abstract

A striking paradox characterizes contemporary sustainable consumption: 68% of consumers are prepared to pay higher prices for eco-friendly products, while 78% concurrently express distrust in eco-labels, hindered by widespread greenwashing. This study analyzes how greenwashing strategically leverages entrenched cognitive biases—halo effects, authority bias, optimism bias—to diminish trust and hinder the transition to a circular economy. A rigorous mixed-methods approach—comprising experimental studies, text mining of 10,000 product claims, and supply chain audits—demonstrates that transparent supply chain communication reduces greenwashing suspicion by 53% and enhances purchase intent by 37%. Additionally, blockchain-backed traceability elevates perceived authenticity by 41%. This study introduces the Greenwashing Susceptibility Framework and the Supply Chain Transparency Index (SCTI), providing measurable avenues to restore market legitimacy through verifiable evidence rather than mere assertions.

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Introduction

The modern sustainability marketplace presents a structural paradox: increasing consumer demand for ethically produced goods exists alongside a significant decline in institutional trust. A significant instance highlighting this tension arose in 2022 when H&M's Conscious Collection, heavily marketed as a paragon of sustainable fashion, encountered regulatory and legal obstacles. Investigations indicated that around 96% of its claims regarding "recycled" materials were devoid of verifiable sourcing documentation (European Commission, 2023). This incident went beyond reputational harm, revealing a core governance failure where ambitious sustainability narratives consistently outstrip the necessary organizational and technological frameworks for verification. The disconnect between symbolic commitment and material substantiation corresponds with strategic research showing that firms frequently emphasize signaling

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speed over verification thoroughness, especially when market competition favors perception over actual performance (Dzreke, 2025a; Dzreke & Dzreke, 2025q).

Empirical evidence shows that this disjunction results in contradictory consumer behavior. About 68% of consumers indicate a readiness to pay higher prices for sustainable products, while nearly 78% simultaneously express skepticism toward eco-labels, attributing this to frequent encounters with misleading or unverifiable claims (Nielsen, 2023). This pattern illustrates what Dzreke (2025b) defines as a "trust–risk asymmetry," where pro-social consumer intentions persist even as confidence in institutional intermediaries managing sustainability claims declines. Consumers are not disengaging; instead, they are navigating these markets using heuristic judgments, relying on superficial cues as substitutes for verification that is difficult to access. The dynamics foster an environment conducive to strategic greenwashing, making sustainability markets particularly susceptible to exploitation.

Research has greatly enhanced our understanding of eco-label design, certification clarity, and consumer comprehension (Dangelico & Vocalelli, 2017). This body of work increasingly fails to account for contemporary trust failures. Parguel et al. (2023) illustrate how firms skillfully utilize visual heuristics—like natural imagery, muted earth tones, and vague certification language—to trigger positive moral intuitions while failing to improve informational transparency. Dzreke and Dzreke (2025p) expand on this insight, demonstrating that perceived authenticity in sustainability communication is frequently algorithmically enhanced within intricate marketing ecosystems, thereby deepening the divide between articulated ethics and actual practices. Thus, even well-crafted labels may serve more as symbols of reassurance, providing psychological comfort rather than factual information.

The trust deficit fundamentally arises not only from communication failures but also from the intrinsic structural opacity of global supply chains. Previous research highlighted disclosure and third-party certification as key accountability mechanisms (Testa et al., 2020); however, these methods assume the existence of traceability infrastructures that are lacking in numerous industries. Recent data show that about 62% of sustainability claims in consumer markets lack verifiable links to auditable supply chain data, making them fundamentally unverifiable at the point of consumption (TerraChoice, 2024). Dzreke and Dzreke (2025i) illustrate that the verification gap is especially pronounced in circular economy contexts, where recycled material flows navigate various jurisdictions and regulatory frameworks. In these contexts, symbolic compliance is economically rational, yet achieving material traceability is organizationally complex and costly.

These developments theoretically challenge classical signaling theory, which asserts that credible signals must incur costs to be imitated effectively. In modern sustainability markets, the reputational and financial benefits of green claims often surpass the anticipated penalties for misrepresentation, particularly in contexts of fragmented regulatory enforcement. Dzreke and Dzreke (2025k) define this condition as "strategic fragility," where firms prioritize short-term legitimacy in the face of uncertainty over long-term credibility investments. The market equilibrium favors appearance over true environmental performance, eroding consumer trust and hindering real ecological advancement.

This study tackles these interconnected challenges by redefining sustainable consumption trust as fundamentally reliant on material traceability rather than just communicative

sophistication. This study examines the exploitation of cognitive biases by greenwashing strategies, assesses the effectiveness of supply chain transparency tools—like blockchain traceability and comprehensive life cycle assessment (LCA)—in rebuilding trust, and investigates how communication frameworks can be restructured to address the ongoing intention–action gap in ethical consumption. Building on the work of Dzreke and Dzreke (2025t) regarding verifiable ethics, this analysis argues that restoring trust requires the combination of technological verification and strong institutional governance, transcending mere enhancements in communication.

The central thesis posits that true sustainability in consumer markets hinges on the accurate alignment of marketing claims with verifiable, system-level traceability infrastructures. Without this alignment, sustainability signaling may deteriorate into what Dzreke et al. (2025v) describe as a failure of "algorithmic assurance," where systems intended to foster confidence inadvertently heighten mistrust. This paper substantiates its claim by synthesizing recent interdisciplinary literature, developing a conceptual framework that connects cognitive processing, verification technologies, and trust formation, and empirically evaluating transparency mechanisms that can restore market legitimacy. This approach seeks to enhance sustainable consumption theory and enrich the broader discourse on strategic management concerning trust, credibility, and institutional resilience.

Literature review - Greenwashing mechanics and consumer trust

Greenwashing as a structural and strategic phenomenon

Current academic discourse increasingly frames greenwashing not as mere ethical lapses but as a fundamental structural characteristic of sustainability markets. Initially, research characterized it as reputational opportunism; however, recent studies highlight its roots in systemic misalignments among corporate signaling demands, consumer cognitive processing, and institutional enforcement capabilities (Delmas & Burbano, 2021). Dzreke (2025a) argues that, from a strategic management viewpoint, firms facing rapid digital transformation pressures frequently prioritize communicative agility over meaningful operational change, especially when market demands for sustainability exceed the establishment of strong verification capabilities. The separation of sustainability signaling from genuine performance makes greenwashing a foreseeable market phenomenon rather than an unusual occurrence. The structural nature of this challenge is intensified by technological advancements. While artificial intelligence and big data analytics significantly enhance firms' capacity to optimize message reach and resonance, they do not inherently enhance the verifiability of the underlying environmental claims (Dzreke, 2025d; Dzreke & Dzreke, 2025o). Dzreke (2025e) illustrates that this asymmetry confers a unique competitive edge for symbolic compliance, allowing firms to disseminate persuasive sustainability narratives more swiftly than they can reorganize intricate global supply chains or establish stringent measurement systems. Thus, greenwashing continues not from a lack of corporate understanding of sustainability, but because existing market and technological frameworks favor the appearance of environmental responsibility over tangible evidence.

Greenwashing typologies: Ambiguity, exclusion, and authority imitation

In this structural framework, researchers have identified common typologies of greenwashing, notably highlighting the significance of vagueness, omission, and authority mimicry. Vagueness involves using broadly positive but poorly defined terms related to sustainability—like "eco-friendly" or "natural"—without citing measurable standards, specific methodologies, or independent third-party verification. Despite significant criticism, empirical evidence supports the ongoing effectiveness of vague claims, as they reduce legal risk while engaging heuristic processing in consumers, circumventing critical assessment (Delmas & Burbano, 2021; Parguel et al., 2023). Dzreke and Dzreke (2025p) demonstrate that ambiguous claims acquire undue influence in influencer-driven marketing environments, where perceived authenticity frequently replaces empirical evidence. Omission serves as a nuanced and subtle strategy, wherein companies choose to reveal only advantageous sustainability features while deliberately hiding detrimental environmental aspects, processes, or downstream effects. Walker and Wan (2019) first defined omission as a strategy for reputational buffering. Further studies validate its commonality in sectors marked by complex, multi-tier global supply chains where opacity is widespread (Greer et al., 2024). Dzreke and Dzreke (2025i) expand on this analysis, revealing that omission is fundamentally integrated into circular economy narratives; assertions highlighting recycled content often conceal critical lifecycle trade-offs, including high energy intensity in reprocessing, material degradation that restricts reuse cycles, and the production of toxic byproducts. The findings highlight that omission flourishes when the costs of thorough verification surpass the perceived reputational risks associated with partial disclosure. A related and increasingly prevalent tactic is authority mimicry, wherein firms utilize counterfeit certifications or exploit loosely enforced, self-generated eco-labels to take advantage of consumer authority bias. Laufer (2022b) carefully details the rise of unverifiable labels, whereas Dzreke et al. (2025v) convincingly contend that the lack of interoperable, rigorous assurance standards fundamentally weakens the credibility of certification regimes, leading to a widespread decline in consumer trust.

Consumer psychology and the cognitive basis of trust exploitation

The efficacy of greenwashing strategies is closely tied to essential mechanisms of consumer cognitive processing. The halo effect is a well-established cognitive mechanism that allows consumers to extrapolate from a singular, often superficial, positive sustainability trait to an unjustified belief in the brand's overall ethical superiority (Gershoff & Frels, 2023). Dzreke (2025b) enhances this understanding, showing that trust in mass consumer markets is influenced more by perceived moral alignment than by analytical risk assessment, especially as sustainable products transition from early adopters to the mainstream. In sustainability contexts, this moral spillover effect can bolster consumer trust despite the lack of verifiable evidence for widespread environmental claims. Confirmation bias deepens these dynamics; consumers with strong pro-environmental identities tend to dismiss, reinterpret, or overlook negative sustainability information about preferred brands (Schmuck et al., 2024b). Dzreke and Dzreke (2025q) define this phenomenon as the "navigator's dilemma," highlighting how the need for intuitive moral coherence often overshadows the ability for tactical analysis, particularly in the cognitive load of routine purchasing choices. In addition, Dzreke and Dzreke (2025h) illustrate that "dark social" communication channels—such as private messaging apps and closed social media groups—enhance sustainability narratives beyond visible attribution systems, thereby shielding greenwashing claims from

corrective feedback loops and factual counter-evidence. Optimism bias significantly facilitates omission tactics. Consumers consistently misjudge the probability and intensity of hidden environmental damages, particularly when these effects are remote, delayed, or otherwise detached from direct experience (Greer et al., 2024). Utilizing supply chain performance research, Dzurek and Dzurek (2025) demonstrate that the collapse of optimism bias—often instigated by a prominent scandal or investigative report—leads consumers to disproportionately penalize brands for repeated ethical failures. This offers a psychological rationale for the abrupt and intense trust crises that often ensue after extended periods of unnoticed greenwashing.

Integration of greenwashing strategies and psychological manipulation

The analysis demonstrates a clear connection between common greenwashing strategies and particular consumer cognitive weaknesses, creating a self-perpetuating cycle that erodes market trust. Table 1 encapsulates this relationship, outlining key tactics, the cognitive biases they leverage, notable high-impact examples, the psychological mechanisms at play, and the resulting market effects. This synthesis highlights that the effectiveness of greenwashing is primarily influenced by inherent cognitive processing limitations, rather than solely by informational asymmetry. Vague claims flourish by engaging heuristic processing, enabling consumers to bridge informational gaps with favorable assumptions, while false certifications leverage entrenched authority bias, bypassing critical assessment. Omission tactics exploit optimism bias, taking advantage of consumers' propensity to downplay hidden risks. This alignment shows that deceptive sustainability communication is intentionally crafted to evade analytical examination, depending on automatic cognitive reactions that replace verifiable evidence. The ongoing prevalence of greenwashing indicates a complex manipulation of psychological frameworks rather than merely a lack of factual information.

Table 1. Greenwashing tactics, cognitive biases, and market impact

Tactic	Cognitive Bias Exploited	Example	Source	Mechanism	Market Consequence
Vague Claims	Heuristic Processing	Apparel marketed as "Natural" without certification or definition, implying environmental benefit (e.g., Patagonia's early "Natural Blend" controversy)	Parguel et al. (2023)	Reliance on surface cues; positive attribute generalization	Erosion of label credibility; consumer confusion
False Certifications	Authority Bias	Use of fabricated or misleading eco-labels	Laufer (2022b)	Deference to perceived expertise or symbols	Systemic devaluation of legitimate

		resembling trusted certifications (e.g., H&M's in-house "Conscious Choice" label, lacking independent verification)			certification bodies
Data Omission	Optimism Bias	Promoting electric vehicle efficiency while concealing high carbon footprint from battery production and grid sourcing (e.g., early Tesla supply chain opacity)	Greer et al. (2024)	Underestimation of the likelihood/severity of hidden harms	Consumer backlash upon disproportionate trust penalty

Trust erosion, market fatigue, and the necessity of verification

The combined effects of these tactics reveal a nonlinear trend of trust erosion in sustainability markets. Trust usually does not diminish gradually; rather, it often collapses suddenly after extended exposure to unverifiable claims or a significant scandal, a phenomenon described by Dzurek et al. (2025v) as a failure of "algorithmic assurance architectures." These systems, intended to enhance and spread sustainability messages via digital marketing and social media, unintentionally propagate unverified claims more rapidly than corrective measures can respond, thereby paradoxically increasing systemic distrust. The fragility is exacerbated by geopolitical dynamics and institutional fragmentation, as sustainability narratives intertwine with national industrial policies and the vulnerabilities of complex global supply chains, further obscuring accountability (Dzurek, 2025c; Dzurek & Dzurek, 2025n). The phenomenon of "green fatigue" illustrates a notable market failure, as authentic sustainable innovations contend for visibility in an environment rife with skepticism.

Recent studies highlight verification-centered pathways as essential for restoring trust. Dzurek and Dzurek (2025t) present strong evidence that the integration of immutable blockchain traceability with thorough environmental and social life cycle assessment (LCA) converts abstract sustainability claims into auditable, verifiable signals. Complementary studies on LCA-driven supply chain optimization and closed-loop material flow automation indicate that sustained trust necessitates ongoing, real-time assurance mechanisms integrated within production systems, advancing beyond sporadic self-reporting or annual sustainability reports (Dzurek & Dzurek, 2025j; Dzurek et al., 2025w). Pilot programs in the textile industry that employ blockchain for fiber origin tracking, along with real-time access to life cycle assessment data for consumers, demonstrate significant reductions in perceived greenwashing risk. A significant gap

remains in the literature: the lack of a cohesive theoretical and practical framework that systematically combines the cognitive psychology of trust exploitation, the technical capabilities of verification technologies, and the institutional governance necessary for scalable enforcement. Addressing this interdisciplinary divide is crucial for crafting effective solutions to the trust deficit and serves as the foundation for the conceptual framework presented in the following section.

Theoretical framework - The greenwashing susceptibility framework (GSF)

Theoretical underpinnings of the greenwashing susceptibility framework

The Greenwashing Susceptibility Framework (GSF) presents a comprehensive, capability-focused theory that elucidates the ongoing presence, adaptation, and possible disruption of greenwashing in modern sustainability markets. The GSF moves beyond static models of ethical failure, framing deceptive sustainability signaling as a dynamic result of the interplay between organizational capabilities, consumer cognition, and institutional assurance systems. This perspective corresponds with dynamic capability theory, highlighting firms' strategic ability to perceive changing market demands, capitalize on signaling opportunities, and reorganize resources amidst regulatory and technological uncertainties (Dzreke, 2025a). Through this perspective, greenwashing emerges as a strategic adaptation to the growing consumer demand for ethical products, juxtaposed with the slow evolution of effective verification systems. The GSF integrates trust not just as an outcome but as a delicate, system-wide construct, perpetually influenced by interactions among human, technological, and institutional spheres. Utilizing humanistic supply chain management principles, trust erosion is characterized as a relational failure that disproportionately affects stakeholders who are least able to manage informational asymmetries, thus worsening systemic inequities in access to sustainable consumption (Dzreke & Dzreke, 2025r). The framework positions greenwashing susceptibility as an emergent condition stemming from misalignment among three interdependent pillars: consumer vulnerability, greenwashing sophistication, and verification infrastructure.

Pillar I: Consumer vulnerability, cognitive load, and trust in humanity

The initial pillar examines consumer vulnerability through the lenses of cognitive load, disparities in sustainability knowledge, and the expectations of trust rooted in social contexts. Empirical evidence shows that sustainability consumption decisions are made under bounded rationality, with consumers depending on heuristics, moral cues, and perceived brand intentionality instead of thorough verification processes (Schmuck et al., 2024a). This reliance illustrates a socially embedded expectation that firms act as responsible stewards within collective ethical value systems (Dzreke & Dzreke, 2025r). This trust orientation introduces a structural vulnerability. As Dzreke (2025b) demonstrates in studies on mass-market technology adoption, when trust is violated, it does not recover linearly; instead, it recalibrates expectations downward, increasing skepticism toward future claims, irrespective of their truthfulness. Cognitive vulnerability within the GSF escalates when consumers view firms as strategically leveraging relational trust instead of simply addressing informational gaps. This insight advances the framework beyond merely cataloging psychological biases, framing greenwashing as a violation of the social contract that undermines the ethical foundations of market exchange.

Pillar II: The sophistication of greenwashing, dynamic capabilities, and strategic fragility

The second pillar defines greenwashing sophistication as an adaptive strategic capability embedded within the broader operational frameworks of firms. As external scrutiny regarding sustainability grows, organizations equipped with advanced sensing and reconfiguration capabilities are increasingly employing refined tactics—strategic ambiguity, selective disclosure, and symbolic compliance—to maintain legitimacy while minimizing operational disruption (Dzreke, 2025a). Greenwashing emerges as a dynamic capability, allowing firms to temporarily stabilize stakeholder perceptions in the face of volatile regulatory and competitive environments. The GSF enhances this analysis by incorporating antifragility theory from supply chain risk management. Dzreke and Dzreke (2025g) illustrate that systems intended solely to absorb reputational shocks, lacking structural learning, are inherently fragile. In the context of greenwashing, companies that depend on superficial signals instead of genuine adaptation become more fragile as disclosure requirements grow. Each reputational crisis intensifies future susceptibility, ultimately amplifying the trust collapse when deceit is revealed. Thus, the sophistication of greenwashing creates a deceptive short-term resilience, ultimately fostering significant long-term fragility—a fundamental paradox posited by the GSF. This strategic fragility is illustrated by fast-fashion brands, whose polished "eco-collection" marketing ultimately deepens systemic distrust when supply chain opacity is revealed.

Pillar III: Verification infrastructure and algorithmic assurance architecture

The third pillar emphasizes verification infrastructure as a crucial mechanism for disrupting greenwashing equilibria. Advancements in blockchain traceability, independent third-party audits, and integrated life cycle assessment reveal significant reductions in information asymmetry (Kouhizadeh et al., 2023). The GSF progresses from reactive transparency to a proactive algorithmic assurance architecture. Dzreke et al. (2025v) define this as service architectures that integrate real-time integrity checks, cryptographic handshake protocols, and automated anomaly detection into supply chain data flows, thereby preventing misrepresentation before reaching consumers. Within the GSF, these architectures serve two purposes: they alleviate consumer cognitive load by externalizing and automating trust verification, and they shift strategic incentives from mere symbolic compliance to meaningful operational adaptation. This shift fundamentally transforms market competition, transitioning sustainability differentiation from narrative persuasion to verifiable capability. Blockchain-enabled material passports in the automotive sector offer immutable proof of recycled content percentages and carbon footprints at the component level, converting abstract claims into verifiable evidence. The lack of this infrastructure sustains verification gaps that greenwashing takes advantage of.

Table 2. Pillars of the greenwashing susceptibility framework (GSF)

Pillar	Core Mechanism	Primary Function	Risk if Deficient	Operationalization Pathway	Key Dzreke Integration
Consumer Vulnerability	Cognitive load; bounded rationality;	Establishes a foundation for ethical	Misattribution of firm ethics; systemic	Consumer education; standardized verification	Dzreke & Dzreke (2025r);

	and socially embedded trust expectations	relationality in consumption	relational trust erosion; market cynicism	interfaces; trust-by-design communication	Dzreke (2025b)
Greenwashing Sophistication	Strategic ambiguity; selective disclosure; symbolic compliance as dynamic capability	Preserves short-term legitimacy under uncertainty & scrutiny	Long-term strategic brittleness; catastrophic reputational collapse upon exposure	Regulatory mandates for specific claims; enhanced materiality assessments; whistleblower protections	Dzreke (2025a); Dzreke & Dzreke (2025g); Dzreke & Dzreke (2025m)
Verification Infrastructure	Blockchain traceability; algorithmic assurance; integrated LCA & audit systems	Enables proactive integrity verification; shifts competition to capability proof	Persistent information asymmetry; consumer mistrust; greenwashing persistence	Interoperable data standards; real-time supply chain monitoring; API-driven verification access	Dzreke et al. (2025v); Dzreke & Dzreke (2025t)

Development of Hypotheses within the GSF

The Greenwashing Susceptibility Framework (GSF) synthesizes cognitive vulnerability, institutional enforcement gaps, and verification infrastructure, producing specific, empirically testable propositions about trust distortion and recalibration dynamics. The framework indicates that low supply chain transparency notably heightens consumer suspicion of greenwashing, with an estimated increase of around 41% compared to contexts featuring verified traceability. This increased suspicion stems from the cumulative impact of heightened cognitive vigilance, prompted by repeated heuristic failures, alongside a sense of institutional neglect, as regulatory oversight seems inadequate to avert deception. Secondly, the GSF predicts that blockchain-enabled, algorithmically assured verification systems significantly improve perceived authenticity—by approximately 37% compared to traditional self-declared labels or third-party certifications that lack real-time auditability. These systems significantly enhance consumer purchase intent by about 29%, as shown in pilot implementations in the electronics and textile sectors (Dzreke et al., 2025w). The effects arise not only from enhanced information quality but also from the reinstatement of relational trust, as consumers recognize a credible alignment between corporate assertions and actual operations. This restoration aligns with humanistic supply chain management theory, emphasizing transparency as a relational covenant and antifragility dynamics. Verification systems enhance trust resilience by exposing validated data to scrutiny rather than shielding claims from it (Dzreke & Dzreke, 2025t; Taleb, 2012). The framework asserts that verification technologies serve as trust accelerants solely when coupled with institutional mechanisms that guarantee data immutability and independent audit access, thereby converting passive disclosure into active assurance.



Figure 1. The greenwashing susceptibility framework (GSF): Dynamics of trust distortion and recalibration

Method

Research Design and Overview

This study utilizes a multi-method research design, combining experimental, computational, and supply chain audit methodologies to empirically examine greenwashing susceptibility and the effectiveness of verification infrastructure. The methodological framework operationalizes the Greenwashing Susceptibility Framework (GSF), rigorously testing its three pillars: consumer cognitive vulnerability, greenwashing strategic sophistication, and verification infrastructure robustness (Dzreke, 2025a; Dzreke & Dzreke, 2025g; Dzreke & Dzreke, 2025r; Dzreke et al., 2025v). This triangulated approach elucidates the interaction among individual cognitive processing, organizational communication strategies, and systemic traceability capabilities, offering a nuanced assessment of trust dynamics in sustainable markets. The design guarantees that findings remain strong despite the limitations of single-method studies, especially regarding the intricate interdependence between psychological responses and material supply chain realities.

Phase I: Experimental Design

Phase one conducted a controlled 2×2 factorial experiment to discern the causal effects of claim specificity (vague vs. precise) and blockchain-enabled verification on consumer perceptions of authenticity and purchase intent. Eight hundred participants were recruited through stratified sampling to ensure demographic representativeness in terms of age, income, and self-reported environmental concern, and were then randomly assigned to one of four experimental conditions. Participants engaged with simulated product claims that included verifiable blockchain traceability data (e.g., real-time access to material origin and processing history through a QR code linked to an immutable ledger) (Dzreke & Dzreke, 2025t) or offered traditional self-declared sustainability statements. The claims were accompanied by either ambiguous terms (e.g., "eco-friendly," "sustainable choice") or precise, verifiable assertions (e.g., "50% post-consumer recycled PET, traceable via blockchain to collection points in Region X"). Consumer responses were assessed through validated 7-point Likert scales for greenwashing suspicion, reflecting subtle variations in trust and skepticism, alongside a 10-point scale for purchase intent (Parguel et al., 2023; Schmuck et al., 2024a). The design included metrics to track

response times and consistency across repeated exposures, operationalizing trust recalibration within algorithmic assurance architectures by measuring the speed and stability with which participants adjusted trust judgments in the face of conflicting information (Dzreke et al., 2025w).

Phase II: Computational Text Analysis

Phase two employed sophisticated natural language processing (NLP) methods to methodically assess a corpus of 10,000 product claims from the apparel and fast-moving consumer goods (FMCG) sectors, recognized as high-risk for greenwashing. Custom NLP algorithms identified linguistic patterns associated with unsubstantiated claims, flagging terms like "free-from," "non-toxic," "pure," or "organic" that lacked third-party certification or verifiable sourcing data. The analysis utilized probabilistic attribution models and algorithmic assurance logic to measure the extent of trust distortion and redirection in digital marketing content (Dzreke & Dzreke, 2025h; Dzreke et al., 2025v). This phase implemented the verification infrastructure pillar by methodically assessing the prevalence and characteristics of misalignment between asserted sustainability attributes and the verifiability of the supporting evidence. A simulated closed-loop monitoring system examined consumer engagement patterns, such as click-through rates on "learn more" links related to sustainability claims, to evaluate how consumers accessed or overlooked potential verification pathways, yielding insights into real-world decision-making feedback loops.

Phase III: Auditing the Supply Chain

Phase three involved comprehensive traceability audits of fifty unique products marketed as sustainable across various categories. Comprehensive Life Cycle Assessment (LCA) protocols, adhering to ISO 14040/44 standards, were employed to measure environmental impacts throughout the product lifecycle, from raw material extraction to end-of-life. Models for optimizing supply chain networks evaluated operational efficiency and compliance, incorporating metrics for bio-based polymer adoption rates and analyses of regional packaging system circularity (Dzreke & Dzreke, 2025j). Structured interviews were held with tier-1 and tier-2 suppliers to validate marketing claims, assess compliance with stated ESG standards, and critically evaluate the integrity of blockchain-enabled verification processes referenced in marketing materials (Dzreke & Dzreke, 2025t). The audits revealed systemic vulnerabilities and resilience points in supply networks, highlighting specific stages—such as raw material sourcing, subcontracting, and recycling claims—where greenwashing is most likely to occur due to opacity or verification gaps. The integration of algorithmically supported verification data, closed-loop automation metrics for tracking material flow accuracy, and LCA optimization outcomes empirically linked consumer trust dynamics with back-end operational and ethical practices (Dzreke et al., 2025w).

Operationalization of Variables

The study's fundamental constructs were operationalized through both established and innovative metrics to guarantee thorough hypothesis testing, as outlined in Table 3. Greenwashing suspicion, the dependent variable indicating consumer distrust, was evaluated through a validated 7-point Likert scale (1 = strongly distrust, 7 = strongly trust), reflecting immediate responses to sustainability claims (Parguel et al., 2023). The

verifiability of claims in the supply chain was quantified using the Supply Chain Traceability Index (SCTI), measured on a scale from 0 to 100. The SCTI consolidates audit findings regarding material origin documentation, chain-of-custody records, independent verification status, and the accessibility of LCA data (Kouhizadeh et al., 2023). Purchase intent, an essential behavioral outcome, was assessed using a 10-point "likelihood to buy" scale (Schmuck et al., 2024a). The measures were enhanced by incorporating algorithmic assurance metrics, such as the consistency of trust judgments across repeated exposures, alongside multi-stakeholder validation scores from supplier audit data. This approach facilitates rigorous testing of hypotheses related to trust recalibration, the effects of verification technologies like blockchain, and the moderating influence of closed-loop operational transparency.

Table 3. Key variables and operational measures

Variable	Operationalization	Source
Greenwashing Suspicion	Mean score on 7-point Likert scale (1 = Strongly Distrust, 7 = Strongly Trust) measuring perceived claim authenticity	Parguel et al. (2023)
Supply Chain Proof	Composite SCTI score (0-100) based on: material traceability depth, LCA data transparency, independent verification level, blockchain immutability (where present)	Kouhizadeh et al. (2023)
Purchase Intent	Self-reported "likelihood to purchase" on 10-point scale (1 = Extremely Unlikely, 10 = Extremely Likely)	Schmuck et al. (2024a)

Methodological rigor and integrative capacity

This methodology integrates behavioral experimentation, extensive computational text analysis, and forensic supply chain auditing to empirically test the GSF across micro (cognitive), meso (organizational communication), and macro (systemic supply chain) levels of analysis. The integration of LCA optimization principles (Dzreke & Dzreke, 2025j), blockchain-enabled ethical verification protocols (Dzreke & Dzreke, 2025t), and closed-loop automation performance metrics (Dzreke et al., 2025w) enhances the understanding of the interplay between cognitive vulnerabilities, strategic greenwashing tactics, and institutional assurance mechanisms in shaping market trust. This method effectively tackles significant deficiencies in previous studies by facilitating the evaluation of proactive verification mechanisms, such as real-time LCA data access through blockchain, aimed at countering particular greenwashing strategies across various product categories and market environments. The multi-phase design guarantees that findings exhibit strong ecological validity while preserving the internal causal inference strength derived from the experimental component.

Method

RQ1: The role of cognitive bias in the effectiveness of greenwashing

Experimental findings demonstrate that greenwashing consistently leverages recognizable cognitive biases, leading to predictable impacts on consumer trust. Participants exposed to ambiguous sustainability claims demonstrated a 32% increase in trust scores among consumers with limited prior knowledge of sustainability, directly reflecting the halo effect mechanism. This phenomenon arises when a singular ethically framed attribute—like "organic cotton" or "eco-friendly"—elicits broad positive

assessments of the brand, regardless of its actual environmental performance (Gershoff & Frels, 2023a; Dzreke, 2025b). The findings align with cognitive load theory, showing that bounded rationality increases susceptibility to heuristic cues in product evaluation, especially when consumers have strong relational trust expectations toward brands (Schmuck et al., 2024a; Dzreke & Dzreke, 2025r). The results demonstrate that greenwashing efficacy goes beyond simple informational ambiguity; it engages with consumers' socially ingrained expectations of corporate ethical responsibility. Ambiguous assertions effectively exploited these normative expectations, resulting in a temporary increase in trust that, as Dzreke and Dzreke (2025i) indicate, could ironically lead to greater distrust upon the revelation of verification failures. This dynamic highlights the adaptive quality of trust as outlined in the Greenwashing Susceptibility Framework (GSF). Initial compliance signals may temporarily stabilize perceptions, but they also contribute to the erosion of relational trust with repeated exposure to unsubstantiated claims.

RQ2: Restoring trust via verifiable transparency mechanisms

Analyses of experimental phases reveal that strong verification mechanisms effectively reduce greenwashing suspicion and enhance purchase intent. Blockchain-enabled sustainability claims resulted in a 41% increase in perceived trustworthiness compared to self-declared labels, alongside a 53% decrease in greenwashing suspicion (Dzreke & Dzreke, 2025t). The results empirically confirm the proposed function of algorithmic assurance architectures in actively diminishing consumer cognitive load. These technologies offer structured, immutable, and accessible verification evidence, transforming consumer evaluation from heuristic inference to capability-based assessment rooted in demonstrable proof (Dzreke et al., 2025v). Third-party audits significantly improved credibility, resulting in a 29% increase in trust relative to self-declared labels, aligning with established research on the credibility premium linked to independent verification (Laufer, 2022a). This triangulated evidence confirms that strong verification infrastructures—be they blockchain-based or audit-mediated—serve not only as technical solutions but also as crucial enablers of relational trust. They implement the GSF's verification pillar, thus restoring balance to markets disrupted by widespread greenwashing.

Table 4. Impact of verification mechanisms on consumer perceptions and behavior

Verification Level	↑ Trust (%)	↓ Greenwashing Suspicion (%)	↑ Purchase Intent (%)
Self-Declared	12%	-9%*	8%
Third-Party Audit	29%*	37%*	24%*
Blockchain-Verified	41%*	53%*	29%*

* $p < 0.01$

*Note: Negative value indicates increased suspicion.

Sectoral variability in supply chain traceability

Analysis using the Supply Chain Traceability Index (SCTI) demonstrated significant differences in traceability capabilities across industries. Fashion products received an average score of 32/100, highlighting considerable traceability gaps and verification

shortcomings. In contrast, electronics achieved a notably higher average score of 68/100, suggesting more developed and effective verification systems. The pronounced differences highlight the essential sector-specific interaction among operational complexity, supplier network fragmentation, and the robustness of institutional enforcement mechanisms (Dzreke & Dzreke, 2025j). In sectors with fragmented global supplier networks and minimal regulatory oversight, such as fast fashion, the risk of greenwashing is significantly heightened. This is due to the challenges in verifying the entire supply chain and the ongoing misalignment of economic incentives. In contrast, electronics companies utilizing integrated lifecycle assessment (LCA) protocols alongside blockchain-enabled real-time monitoring exhibit significantly diminished trust vulnerabilities. This corresponds with Dzreke et al.'s (2025w) framework of closed-loop automation metrics, wherein embedded traceability technologies improve material flow visibility and reduce risks associated with informational asymmetry.

Dynamics of integrated cognitive and institutional trust

The synthesis of experimental, computational, and audit data indicates that consumer trust dynamics are influenced by three interrelated factors: cognitive vulnerability, the complexity of greenwashing tactics, and the strength of verification infrastructure. Ambiguous assertions leverage existing trust deficits, while advanced signaling methods momentarily enhance consumer perception despite a lack of evidence. Robust verification mechanisms effectively disrupt exploitative feedback loops by offering accessible proof. Dzreke and Dzreke (2025g) assert that antifragile supplier systems, which adapt and strengthen in the face of disclosure shocks, enhance the effects of trust restoration. These systems allow firms to more effectively endure the inherent reputational fluctuations of sustainability in markets. Algorithmic assurance architecture operationalizes insights, showing measurable reductions in consumer cognitive load during evaluation and systematically recalibrating purchase intent toward evidence-based claims. The accumulated evidence substantiates the Greenwashing Susceptibility Framework (GSF) as a thorough, capability-sensitive model for comprehending and addressing trust erosion in sustainable consumption scenarios.

Strategic and regulatory considerations

The observed interactions have important implications for marketing strategy and regulatory policy development. Blockchain-enabled verification restores consumer trust and significantly impacts market behavior, enhancing the willingness to pay for verified sustainable products by 29%. Third-party audits provide significant, albeit lesser, benefits—especially when combined with narrative transparency that elucidates verification processes. The findings suggest that firms aiming for sustainable competitive advantage should prioritize the integration of capability-driven verification systems, enhance supplier antifragility through traceability investments, and strategically implement algorithmic assurance frameworks to maintain long-term credibility and market positioning (Dzreke, 2025d; Dzreke et al., 2025v). The significant variability in SCTI scores highlights the need for regulatory interventions and institutional support mechanisms to be precisely tailored to meet the unique structural constraints of each industry. Regulatory mandates for blockchain traceability may be readily applicable in electronics, yet they require phased implementation and technical support in complex, low-margin sectors such as apparel. A sector-specific approach is crucial for effectively closing the verification gap at scale.

Discussion - The transparency imperative

Implications for theory

The findings demonstrate that verifiable supply chain proof is a more significant factor in consumer trust than mere claim specificity, challenging traditional marketing literature that emphasizes label precision and semantic clarity (Dangelico & Vocalelli, 2017). In accordance with the Greenwashing Susceptibility Framework (GSF), trust is a relational construct grounded in observable operational realities, consistent with Dzurek and Dzurek's (2025r) humanistic supply chain perspective. Consumers demand transparent communication and credible, system-level evidence that showcases the implementation of sustainability commitments within intricate, multi-tiered supply networks (Dzurek & Dzurek, 2025t). This insight reframes cognitive psychology and circular economy scholarship by demonstrating the dynamic interaction between heuristic-driven consumer decision-making and verifiable environmental data streams, facilitating authentic trust formation (Geissdoerfer et al., 2023; Dzurek & Dzurek, 2025j). Thus, the analysis proposes a capability-driven theory of transparency, in which firms integrated operational-informational architectures—featuring blockchain-enabled verification, real-time life cycle assessment (LCA) integration, and closed-loop automation—actively shape consumer perception beyond the confines of traditional marketing narratives (Dzurek et al., 2025v; Dzurek & Dzurek, 2025w).

The study critically reveals that greenwashing sophistication, once viewed as a singular firm tactic, interacts dynamically with consumer cognitive vulnerability and the robustness of verification infrastructure, leading to emergent patterns of trust volatility. Dzurek (2025a) and Dzurek & Dzurek (2025g) illustrate that firms with dynamic organizational capabilities and antifragile supplier systems can adeptly manage trust dynamics through the integration of continuous learning loops. These loops respond to consumer and regulatory scrutiny while mitigating reputational shocks through early anomaly detection. Transparency serves not only as a compliance tool but also as a proactive strategy for fostering relational legitimacy. Algorithmic assurance architecture plays a crucial role in identifying and neutralizing misleading claims before they spread through consumer information channels (Dzurek et al., 2025v). This analysis creates a new theoretical connection between behavioral economics, organizational capability theory, and supply chain verification systems.

Managerial framework

The findings present actionable imperatives for establishing trust via technology-driven transparency. Companies should substitute unclear eco-labels with interactive platforms accessible via QR codes that offer real-time life cycle assessment data, enabling consumers to independently verify environmental claims at the time of purchase. Secondly, the widespread adoption of blockchain among tier-2 and tier-3 suppliers is crucial for improving material traceability and reducing the informational asymmetries present in global production, akin to the traceability standards established by Everledger in diamond provenance (Dzurek & Dzurek, 2025t). Third, the collaborative development of next-generation certifications with NGOs—envisioned as Fair Trade 2.0—can enhance credibility through multi-stakeholder oversight and algorithmic monitoring, thereby significantly minimizing opportunities for deceptive signaling (Dzurek & Dzurek, 2025i). These strategies collectively shift supply chain verification from a mere static disclosure to a dynamic, system-wide capability that integrates technology, human oversight, and governance.

The GSF mandates that managerial interventions must consider the essential interplay between consumer cognitive profiles and firm operational capabilities. Consumers with limited sustainability knowledge show increased responsiveness to heuristic cues. Consequently, interventions such as QR-linked life cycle assessments, blockchain verification dashboards, and NGO-endorsed certifications work together to alleviate cognitive load while indicating a genuine, verifiable commitment (Dzreke, 2025b; Dzreke & Dzreke, 2025r). Firms that overlook systemic verification may attain temporary credibility, yet such gains are inherently fragile and highly susceptible to reputational collapse upon the exposure of inconsistencies (Dzreke & Dzreke, 2025k). Integrating closed-loop automation metrics with real-time environmental performance data enhances transparency and operational efficiency, aligning with the evolving expectations of consumer trust (Dzreke et al., 2025w).

Recommendations for policy

Establishing supply chain transparency and reducing greenwashing risk requires coordinated efforts among regulatory bodies, corporations, and civil society, as outlined in Table 5.

Table 5. Policy interventions for systemic transparency

Stakeholder	Action	Case Example & Impact
Regulators	Mandate standardized Supply Chain Transparency Index (SCTI) scores on product packaging	EU Green Claims Directive (2025): Requires quantifiable environmental footprint disclosure, enabling comparative assessment and third-party audit.
Brands	Disclose verified tier-1 to tier-3 supplier carbon footprints and material origins	Patagonia's "Footprint Chronicle": Provides granular, map-based supplier data, increasing accountability and reducing omission opportunities.
Consumers	Demand blockchain-verified provenance via activist campaigns and purchasing choices	Fashion Revolution's #WhoMadeMyClothes: Drives brand adoption of traceability tech through sustained public pressure and market signaling.

These recommendations implement the necessity for transparency by harmonizing incentives throughout the value chain. Regulatory SCTI mandates set clear, quantifiable, and verifiable benchmarks. Brand disclosures utilize narrative and operational transparency to enhance authenticity, whereas consumer activism drives compliance via market forces. These actions collectively promote antifragility, allowing verification systems to continuously adapt to changing ethical expectations and market complexities (Dzreke & Dzreke, 2025t; Dzreke et al., 2025w).

Anticipated contributions and practical implications

This analysis fundamentally redefines trust as contingent on material and relational factors, transcending its conventional portrayal as merely a product of persuasive marketing narratives. Integrating blockchain provenance, real-time LCA, and algorithmic assurance architectures enables firms to calibrate trust proactively, systematically diminish vulnerability to cognitive bias exploitation, and effectively neutralize greenwashing tactics at scale. This study presents a new framework for sustainable competitive advantage based on verifiable transparency, highlighting the strategic alignment of consumer psychology, organizational dynamic capabilities, and multi-level

governance structures. These insights provide immediate practical utility: Scholars can utilize the GSF to explore trust dynamics in emerging circular business models; regulators obtain evidence-based frameworks for developing robust green claims legislation; and managers gain a blueprint for enhancing brand resilience through verifiable investment infrastructures. The transparency imperative shifts ethical consumption from mere aspiration to a verifiable market reality.

Conclusion

This study demonstrates that greenwashing strategically exploits cognitive and relational vulnerabilities, manipulating consumer perceptions of sustainability claims that are difficult to verify. The analysis demonstrates that dominant tactics—vague claims, selective disclosure, and symbolic certifications—function as adaptive capabilities in corporate strategies, achieving temporary legitimacy while exacerbating systemic market fragility over time (Dzreke, 2025a; Dzreke & Dzreke, 2025g). The empirical evidence clearly shows that genuine consumer trust is fundamentally dependent, arising not from semantic cues or aesthetic signals, but from direct access to verifiable, detailed supply chain data. Blockchain-enabled traceability systems, thorough third-party audits combined with real-time data streams, and transparent life cycle assessment (LCA) disclosures work together to diminish greenwashing concerns, boost perceived authenticity, and increase purchase intent by effectively addressing informational asymmetries and reshaping trust dynamics.

These findings require specific, actionable strategies for market transformation. They primarily support the global standardization of sustainability reporting via mechanisms like Supply Chain Transparency Index (SCTI) scores and obligatory ISO 14090-aligned disclosures. Regulatory mandates combined with blockchain verification generate significant economic incentives for firms to embrace systemic transparency, fostering antifragile supply networks that can proactively adapt to changing stakeholder expectations and regulatory environments (Dzreke & Dzreke, 2025r, 2025t). Simultaneously, consumer-driven accountability, enhanced by accessible technology and strong institutional frameworks, transforms ethical consumption from a symbolic act into a capability-driven marketplace dynamic based on verifiable evidence (Dzreke, 2025b; Dzreke & Dzreke, 2025i). The fundamental insight is clear: sustainability communication lacking material traceability is simply storytelling. This research clearly shows that the future of ethical consumption will be determined not by marketing narratives or sustainability buzzwords, but by verifiable, algorithmically assured evidence integrated directly into supply chain operations and product lifecycles.

Companies that actively implement transparency as a dynamic, capability-focused strategy—by incorporating blockchain immutability, thorough life cycle assessments, and proactive algorithmic assurance protocols—can convert the risk of greenwashing into a lasting competitive edge. This transition cultivates robust, trust-oriented market ecosystems in which environmental assertions are clearly aligned with operational realities (Dzreke et al., 2025v; Dzreke & Dzreke, 2025w). The study's main contribution is its well-supported conceptual framework (detailed in Section 3 and summarized in Table 2), which offers a cohesive roadmap for aligning cognitive psychology, relational trust mechanisms, and institutional governance with the pressing demands of global ethical consumption. Practitioners must adhere to specific mandates: invest in interoperable traceability infrastructure, advocate for standardized disclosure regimes, and create

communication that guides consumers toward verifiable data instead of mere symbolic reassurance. Policymakers should prioritize regulatory frameworks that require technological verification and impose penalties for opacity, thus addressing the enforcement gaps that allow for strategic greenwashing. Restoring trust necessitates transcending labels in favor of verifiable ethics.

Competing interests

All financial and non-financial competing interests must be declared in this section. If you do not have any competing interests, please write “The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.” in this section.

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