The Verification Economy: Building Audit-Ready Sustainable Supply Chains in the Age of Digital Product Passports and the EU Circular Economy Act

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Abstract

Across product-based industries, sustainability is no longer framed primarily as a matter of voluntary disclosure or reputational positioning. It is becoming a matter of substantiated proof. This paper conceptualizes this structural shift as the *Verification Economy*: a market environment in which supplier qualification, market participation, and access to capital depend increasingly on the capacity to defend sustainability attributes with evidence that withstands procurement scrutiny and third-party assurance.

The underlying mechanism is risk reallocation. Claims that are unsupported or weakly supported generate contractual, reputational, and enforcement risks. When firms are unable to provide robust and traceable evidence, they become risk signals within procurement systems. The consequences are tangible: audit escalations, delayed approvals, additional documentation cycles, and intensified price pressure.

Europe accelerates this transformation through a layered policy architecture that links industrial competitiveness, ecodesign, circularity, and corporate disclosure. Digital Product Passports (DPPs) indicate a structural move from entity-level reporting toward product-level, supply-chain-transmissible information. In parallel, the anticipated EU Circular Economy Act (CEA) is positioned as a market-shaping instrument intended to strengthen circular supply chains and to stimulate demand for secondary raw materials. In doing so, it increases the economic relevance of traceable circularity claims.

Drawing on institutional theory, the resource-based view and dynamic capabilities, as well as signaling and transaction-cost economics, this paper defines *verification readiness* as a higher-order organizational capability. This capability reduces what is termed *assurance friction*: the delays, costs, and disputes that arise when sustainability claims cannot be verified in an efficient and standardized manner. Four propositions are formulated, linking verification readiness to market access, lifecycle verification costs, circular value capture, and resilience under geopolitical stress.

The paper develops an evidence taxonomy, proposes a verification-readiness maturity model, and outlines an empirical research design combining policy-stack analysis, comparative case studies, and survey-based measurement. Its contribution lies in a capability-oriented theory of green-transition competition, shifting analytical attention from reporting outputs toward proof architectures within supply chains and product-level transparency systems.

The Verification Economy is a market in which business outcomes depend on reliable, detailed, and transferable sustainability evidence. It features product-specific proof, integrated supply-chain validation, and standardized auditability. In this system, sustainability is treated like quality or safety-measurable, documented, and open to review.

The transformation is driven by risk reallocation, where regulatory enforcement, litigation, and reputational risks shift to claim points. When claims are unsubstantiated, procurement systems react defensively, creating assurance friction, repeated requests, legal escalation, third-party verification costs, and delays. Verification gaps, therefore, create economic costs.

Keywords: verification economy; audit-ready sustainability; proof supply chain; verification readiness; assurance friction; digital product passport; circular economy act; sustainable procurement.

1. Introduction: From Sustainability Narratives to Auditable Proof

The field of sustainability management is undergoing a transformative shift. Where organizations once relied on broad commitments and reputation-driven narratives, today's landscape demands rigorous, auditable proof for every sustainability claim. Stakeholders now expect more than aspirational goals, they require credible, traceable evidence that demonstrates genuine progress. This evolution compels organizations to move beyond rhetoric and adopt systematic approaches to data collection, governance, and assurance that are woven into the fabric of their operations.

Managers face a new set of challenges, both technical and strategic, as they transition from communicating intentions to establishing processes that ensure reproducibility and defensibility. The ability to link sustainability assertions directly to primary data, governed by robust controls and independently verified, is now a hallmark of organizational competitiveness. This shift is reshaping supply chain management, information systems, and cross-functional collaboration, making audit-ready evidence a prerequisite for success at every tier.

In many industries, sustainability has evolved into a discipline of evidence. The central managerial task is no longer merely to communicate policies or targets but to ensure every claim can be traced, governed, and defended. This paper introduces the concept of the Verification Economy—a competitive environment in which sustainability attributes matter only to the extent they are verifiable. In this context, proof becomes the currency of market access and reputation.

The Verification Economy fundamentally changes the rules of the game: only substantiated sustainability attributes carry economic weight. Organizations unable to provide verifiable proof face real consequences, delayed supplier approvals, heightened price pressure, and increased procurement friction. Those that can efficiently demonstrate compliance, traceability, and circularity gain a clear competitive edge. Verification readiness emerges as a strategic asset, redefining how organizations compete and collaborate.

This transition is not simply the result of more regulation; it is driven by a fundamental reallocation of risk. Unsupported sustainability claims create contractual and enforcement risks for downstream partners; weak evidence triggers procurement friction and audit escalation; and the inability to provide verifiable information signals supplier risk, resulting in delays and increased pressure. Sustainability has become an operational capacity requirement, much like quality management or financial control, rather than just a reporting exercise.

Risk reallocation is at the heart of this shift. The burden of proof now migrates through supply chains, buyers and regulators transfer risk to suppliers, who must demonstrate compliance and traceability or face contractual disputes, regulatory scrutiny, and operational setbacks. Verifiable

information is now central to supplier qualification, contract negotiation, and audit programs, making assurance processes and evidence management critical investments for organizations seeking to remain in key markets.

Europe is accelerating this shift with a unique policy stack that connects product policy, circularity, and corporate disclosure. Digital Product Passports (DPPs), introduced under the EU's Ecodesign Directive, signal a move from entity-level disclosure to product-specific transparency. These passports require detailed information about product composition, origin, and lifecycle impacts, enabling traceability and accountability across supply chains. The forthcoming EU Circular Economy Act further stimulates demand for secondary raw materials and incentivizes traceable circularity claims, pushing the market from generic sustainability reporting toward granular, auditable evidence.

The European policy landscape is especially influential in shaping the Verification Economy. DPPs and the Circular Economy Act drive the transition from generic reporting to detailed, audit-ready proof, raising the stakes for compliance and verification. These innovations reinforce the economic value of proof, making verification readiness not only a compliance requirement but a source of competitive advantage.

This paper champions a capability-based perspective on green-transition competition, defining verification readiness as a higher-order organizational capability for efficiently and reproducibly producing audit-ready evidence. By reducing assurance friction—delays, costs, and disputes resulting from insufficient verification, organizations enhance market access, cost-to-serve efficiency, circular value capture, and supply chain resilience. The paper introduces an evidence taxonomy and maturity model, offering a robust framework for empirical analysis and actionable insights for academics, practitioners, and policymakers navigating the new dynamics of sustainability verification.

By providing a capability-based account of green-transition competition, this paper positions verification readiness as a key to reducing assurance friction and achieving superior outcomes across market access, cost-to-serve, circular value capture, and resilience. The evidence taxonomy, maturity model, and empirical design presented here lay the foundation for understanding and advancing competitive advantage in the Verification Economy.

The move from sustainability storytelling to verifiable evidence is not just altering how organizations operate; it is redefining the terms of competition. The Verification Economy rewards those who are prepared with credible, traceable proof, while European policy accelerates this transition and raises the stakes for verification readiness. The capability-based framework and empirical design outlined here invite further research and strategic action, setting the stage for innovation in sustainable supply chain management. Readers can look forward to a deep exploration of these challenges and opportunities in the chapters that follow.

1.1 Research gap, scope, and structure

Although the sustainability literature has extensively examined disclosure, reporting quality, and the credibility of voluntary claims, a narrower set of studies has addressed the operational conditions that make sustainability attributes verifiable at the point of transaction. Much of the debate still treats verification as an external after-step (assurance added to a report) rather than as an internal production system for evidence. In practice, however, the binding constraint for many firms is neither ambition nor intent, but the ability to assemble defensible proof under time pressure, across multiple products, and through multi-tier supply networks where data ownership and definitions are fragmented.

This paper focuses on product-based value chains in which sustainability information is increasingly embedded in procurement decisions, ecodesign compliance, and customer qualification. The objective is not to propose yet another reporting framework, but to explain why proof systems are becoming a competitive factor and to specify the organizational capabilities that reduce verification frictions. The analysis is intentionally positioned at the intersection of management theory and emerging European policy because Europe combines disclosure requirements, product rules, and circular-economy measures in ways that turn verification from a reputational concern into a market-access condition.

Conceptually, the argument is built in three steps. First, the paper defines the Verification Economy and explains its underlying mechanism: risk reallocation through procurement and regulatory liability. Second, it develops verification readiness as a higher-order capability and introduces assurance friction as an observable, measurable mechanism linking capability to outcomes. Third, it situates these constructs within the European policy stack, highlighting how product-level transparency (via DPPs) and circular market-making (via the anticipated CEA) are expected to raise the value of traceable circularity claims and the penalties for weak evidence.

To guide empirical work, the paper proposes a maturity model and an evidence taxonomy, and outlines a mixed-methods research design that links policy diffusion points to firm-level capability development and measurable commercial outcomes.

1.2 Contributions and managerial relevance

The paper contributes to the sustainability and operations management literature in three ways. First, it reframes sustainability competition as a dual contest over performance and proof. When performance is necessary but not sufficient, proof serves as a second-order differentiator, determining whether environmental attributes are recognized in contracts and tenders. Second, it specifies verification readiness as an integrative capability, extending resource-based and dynamic capability perspectives into the domain of audit-ready sustainability. Third, it introduces assurance friction as a practical mechanism through which verification constraints translate into time, cost-to-serve, and risk outcomes.

For managers, the implication is that verification cannot be treated as an isolated ESG function. Proof requirements must be translated into governance routines, data architecture, and supplier agreements. The most durable advantages are likely to come from building reusable evidence packs and product records that travel across customers, rather than from bespoke responses to questionnaires. This managerial logic aligns with the direction of European product policy: once product-level information becomes standardized and reusable, the marginal cost of verification declines for prepared firms but can become prohibitive for those that rely on ad hoc manual work.

2. Research Questions

RQ1. How do converging regulatory and procurement requirements drive the transformation of sustainability from narrative assertions to verifiable, audit-ready evidence throughout supply chains, contributing to the development of the Verification Economy?

This research question examines how regulatory frameworks and procurement standards are shifting organizational practices away from generic sustainability claims and toward robust, evidence-based verification. Increasingly, legislative mandates and buyer expectations require organizations to substantiate sustainability assertions with primary data, governed by internal controls and validated by third-party assurance. This transformation extends beyond compliance reporting and permeates every tier of the supply chain, demanding audit-ready documentation and traceability. The question aims to illuminate how these converging pressures foster the emergence of the Verification Economy—a market environment in which the economic value of sustainability attributes is contingent on their verifiability. It also seeks to understand how supply chain management, information systems, and interorganizational collaboration evolve to meet these new standards, ultimately making verification readiness a core operational and strategic capacity.

RQ2. Which organizational and interorganizational capabilities define verification readiness, and how do these competencies influence competitive outcomes, including supplier approval, market access, contract terms, resilience, and cost-to-serve?

This question delves into the specific capabilities, both within organizations and across their networks, that underpin verification readiness. It considers verification readiness as a higher-order capability that coordinates a range of lower-level competencies, including data governance, lifecycle measurement, supplier engagement, chain-of-custody management, and audit alignment. The research investigates how these capabilities enable organizations to efficiently produce audit-ready evidence, thereby reducing assurance friction, including delays, costs, and disputes. Furthermore, it examines the impact of verification readiness on key competitive outcomes: the ability to secure supplier approvals, access markets with stringent sustainability requirements, negotiate favorable contract terms, enhance supply chain resilience, and optimize cost-to-serve. By analyzing these relationships, the question seeks to define a capability-based framework for understanding competitive advantage in the Verification Economy.

RQ3. How is the European circular economy policy package, especially product policies enabled by DPPs and the anticipated EU Circular Economy Act, expected to reshape value creation and bargaining power across global supply chains in the context of geopolitical challenges and critical materials dependencies?

This question investigates the anticipated impact of Europe's evolving policy landscape on global supply chain dynamics, with a focus on the Digital Product Passport (DPP) initiative and the forthcoming EU Circular Economy Act. These policies represent a structural shift from entity-level sustainability disclosures to product-specific transparency, requiring detailed data on composition, origin, and lifecycle impacts. The research explores how such measures strengthen circular supply chains, stimulate demand for secondary raw materials, and increase the economic value of traceable circularity claims. In addition, the question considers how these regulatory innovations may alter the distribution of value creation and bargaining power among supply chain participants, especially given ongoing geopolitical challenges and dependencies on critical materials. By examining these factors, the research aims to provide actionable insights into the strategic implications of policy-driven verification requirements for global supply chain actors.

3. Literature Review and Theoretical Foundations

3.1 Institutional theory: coercive and normative pressures toward auditable sustainability

Institutional theory offers a powerful lens for understanding why organizations increasingly adopt auditable sustainability practices. The theory contends that organizations tend to converge in their behaviors and processes due to three types of pressures: coercive (external mandates), normative (industry expectations), and mimetic (imitation of leading practices). In the context of sustainability verification, coercive pressures have become more pronounced as governments and regulatory bodies implement stricter laws, enforce mandatory disclosure standards, and require transparent reporting of environmental impacts. These legal and regulatory demands force organizations to develop systems capable of producing audit-ready evidence, not just narrative claims.

Normative pressures arise from evolving buyer expectations, industry standards, and professional assurance practices. As major buyers and industry consortia set higher sustainability benchmarks, such as requirements for product-level carbon footprints, traceable origin information, and recycled content, these norms cascade through supply chains. Procurement functions play a critical role as intermediaries, translating external requirements into supplier qualification criteria, contract clauses, and audit programs. This transmission means that even suppliers not directly regulated feel compelled to comply, as their customers increasingly demand verifiable sustainability evidence.

Furthermore, mimetic pressures contribute to the diffusion of auditable sustainability practices. Organizations often emulate the strategies and systems of industry leaders, particularly when facing uncertainty or when such practices become associated with competitive advantage. Once a pioneering buyer operationalizes product-level requirements, suppliers at multiple tiers—regardless of their regulatory status, are incentivized to adopt similar verification capabilities to remain competitive and eligible for contracts. This collective movement accelerates the transition from sustainability narratives to robust, audit-ready proof across entire supply networks.

Institutional theory shows that auditable sustainability involves more than compliance; it is a systemic change influenced by laws, industry standards, and imitation. The result is a growing expectation that sustainability claims must be substantiated with primary data, governed by controls, and validated through third-party assurance, fundamentally reshaping organizational practices and the dynamics of market competition.

3.2 Resource-Based View and Dynamic Capabilities: Verification Readiness as a Higher-Order Capability

The resource-based view (RBV) and dynamic capabilities framework together provide a robust theoretical foundation for understanding how organizations achieve verification readiness in the context of sustainability assurance. RBV contends that not all resources are equal—those that are valuable, rare, inimitable, and non-substitutable underpin sustainable competitive advantage. In sustainability verification, key resources include sophisticated data systems, proprietary measurement tools, and strong supplier relationships that enable the seamless collection and validation of audit-ready evidence. However, the mere possession of such resources is insufficient in a rapidly evolving regulatory and market environment.

Dynamic capabilities build on RBV by emphasizing an organization's capacity to adapt, orchestrate, and reconfigure its resource base in response to external changes, such as new regulatory requirements or shifting buyer demands. In the Verification Economy, dynamic capabilities are exemplified by the ability to integrate disparate data sources, continuously improve

lifecycle measurement methodologies, engage suppliers proactively, manage chain-of-custody across multiple tiers, and align internal processes with evolving audit standards. These actions are not static; they require ongoing learning, innovation, and cross-functional coordination. Verification readiness thus emerges as a higher-order capability, a meta-competence that leverages and synchronizes underlying skills and systems, enabling the organization to consistently generate credible, audit-ready sustainability evidence. Such higher-order capability is especially critical as verification demands intensify, driven by institutional pressures, regulatory mandates, and market expectations for traceable claims. Organizations with strong verification readiness can respond more efficiently to audit requests, reduce assurance friction, and differentiate themselves in supplier approval processes, market access negotiations, and contract terms. Moreover, they are better positioned to build resilience and lower cost-to-serve, as verification processes become embedded and scalable. Ultimately, verification readiness becomes a strategic asset, reinforcing the organization's ability to sustain competitive advantage in a landscape where proof of sustainability is not just a compliance requirement but a source of market differentiation and trust.

In summary, the resource-based view and dynamic capabilities perspective highlight that verification readiness is more than a collection of tools or processes, it is an integrated, adaptive capability that coordinates data governance, lifecycle measurement, supplier engagement, chain-of-custody management, and audit alignment. This higher-order capability enables organizations to thrive in the Verification Economy, where the ability to reliably and efficiently produce audit-ready evidence is a prerequisite for competitive success.

3.3 Signaling and Transaction Cost Economics: Proof as a Market Mechanism

Signaling theory and transaction cost economics jointly provide a compelling explanation for the increasing centrality of audit-ready proof in sustainability markets. In many supply chains, buyers and procurement teams face significant information asymmetry; they cannot directly observe or verify the internal sustainability practices of their suppliers. This asymmetry creates a trust gap, where buyers must rely on supplier claims that may be difficult to substantiate. Signaling theory posits that, under such conditions, suppliers can use credible signals, actions or evidence that are costly or difficult to falsify, to convey their true level of commitment to sustainability and differentiate themselves from less diligent competitors. Audit-ready proof, such as third-party verified data, traceable documentation, and robust internal controls, serves as such a signal. When producing and maintaining audit-ready evidence requires significant investment in systems, processes, and assurance, only suppliers genuinely committed to sustainability are likely to incur these costs, making the signal both credible and valuable.

From the perspective of transaction cost economics, the presence of information asymmetry and uncertainty in sustainability claims increases the costs associated with transactions. Buyers must engage in extensive due diligence, ongoing monitoring, renegotiation of contract terms, and, in some cases, dispute resolution—all of which add friction and expense to supplier relationships. Audit-ready proof transforms this dynamic by reducing ambiguity and making the verification of sustainability claims more straightforward and efficient. When suppliers present verifiable, standardized, and independently assured data, buyers can more quickly and confidently evaluate compliance, reducing the need for repeated audits or protracted negotiations. This reduction in "assurance friction" lowers transaction costs, streamlines procurement processes, and enables more fluid market exchanges. Over time, the expectation of audit-ready proof shifts market norms, incentivizing all participants to invest in verification capabilities and further embedding proof as a prerequisite for participation in the Verification Economy.

In summary, signaling theory explains why audit-ready proof acts as a mechanism for building trust and establishing market credibility, while transaction cost economics demonstrates how such proof reduces operational inefficiencies and barriers to exchange. Together, these theories underscore the pivotal role of verifiable evidence in aligning incentives, lowering risk, and fostering more efficient, transparent, and trustworthy sustainability markets.

3.4 Assurance practice and auditability as governance technology

Beyond the broad theoretical lenses of institutions, resources, and transaction costs, the sustainability assurance literature provides a more operational account of how credibility is produced. Assurance is not simply a label attached to an output; it is a structured evaluative process that relies on evidence, defined criteria, sampling strategies, and documented judgments. In this sense, auditability is an attribute of the underlying data and control environment as much as it is an attribute of a published statement.

Two implications follow. First, as sustainability information moves closer to financial decision-making, the logic of internal control becomes more relevant. Claims must be supported by documented procedures, segregation of duties, change control, and traceable data lineage. When these conditions are absent, assurance providers must expand testing effort, increase sampling, or qualify conclusions, which raises verification cost and reduces the usability of claims for downstream procurement or finance.

Second, assurance expectations vary with intended use. Entity-level reporting may tolerate aggregation, materiality judgments, and periodic correction cycles. Product-level and transaction-level claims, by contrast, often require precision, traceability to batches, and the ability to explain deviations in real time. This difference matters because many sustainability claims now function as contractual terms (for example, minimum recycled content, restricted substances compliance, or footprint thresholds). Where claims become contractual, the practical threshold for evidence moves upward: the cost of a disputed or retracted claim is no longer only reputational but also legal and operational.

Accordingly, verification readiness can be interpreted as an internalization of assurance logic into operational routines. Firms that pre-align their data models, documentation, and controls with assurance practice effectively shift verification from a bespoke external event to a repeatable internal process. This shift is analogous to the historical development of quality management: once measurement systems and controls are institutionalized, audits become faster and less disruptive.

3.5 Information infrastructure, interoperability, and the economics of evidence reuse

A further stream of relevant work concerns information infrastructures and the conditions under which data becomes reusable across organizational boundaries. Sustainability verification is frequently characterized by duplication: suppliers respond to similar questionnaires in slightly different formats, customers request overlapping datasets, and the same calculations are reproduced repeatedly because inputs are not standardized or trusted. This duplication is not only inefficient; it also increases error risk and undermines comparability.

Interoperability therefore becomes a central economic variable in the Verification Economy. When evidence can be packaged, transmitted, and re-used across customers and auditors, the marginal cost of verification declines and investments in proof systems become scalable. Conversely, when standards fragment, firms face continuous reconciliation work, and SMEs in particular may be forced into labor-intensive compliance that does not translate into market advantage.

From an operational perspective, interoperability requires more than a shared file format. It requires shared semantics (consistent definitions of indicators), shared identifiers (product and supplier identities that persist across systems), and governance rules (who is allowed to update, approve, and access data). Product-centric systems such as PLM and ERP can provide the backbone for such governance, but only if sustainability data is treated as controlled master data rather than as an ad hoc reporting overlay.

The importance of evidence reuse also reshapes bargaining power. Buyers that can standardize proof requirements and integrate supplier data into their own product records reduce their exposure and accelerate procurement cycles. Suppliers that can provide reusable evidence packs reduce buyer effort and can position themselves as lower-risk partners. Under product-level regimes such as DPPs, this dynamic intensifies: the ability to populate a product record with validated sustainability information becomes a condition for participation, and data interoperability becomes a direct driver of switching costs and competitive differentiation.

4. Conceptualizing the Verification Economy

4.1 Definition

Verification Economy (definition): A Verification Economy describes a market landscape where the economic value of sustainability claims hinges entirely on their verifiability. This means that attributes such as recycled content, ethical sourcing, or carbon footprint are recognized only if they can be traced to reliable primary data, are governed by robust internal controls, and withstand rigorous scrutiny from procurement teams and independent third-party auditors. In this context, proof is not merely a retrospective communication tool; it becomes a core input to every critical transaction, including supplier qualification, contracting, and financing. Organizations must embed verification processes into their operations so that evidence is audit-ready from the outset, enabling seamless and defensible exchanges between buyers and suppliers. The expectation is that sustainability information is managed with the same discipline as financial data: traceable, governed, controlled, interoperable, and aligned with assurance standards. As a result, participation in the market increasingly depends on the ability to produce credible, defensible proof, fundamentally reshaping business practices, procurement logic, and risk allocation. In the Verification Economy, sustainability claims drive value only when they are backed by verifiable evidence, making proof a prerequisite for both market access and competitive advantage.

4.2 Why verification becomes decisive: risk reallocation and procurement logic

The Verification Economy emerges as the cost of being wrong about sustainability attributes rises for downstream actors. Procurement, brand owners, and regulated entities increasingly face liability for misstatements, greenwashing allegations, and noncompliance. Therefore, they pass verification demands upstream. When suppliers cannot provide evidence, buyers rationally respond by treating them as higher risk: more audits, more conditions, slower onboarding, and potentially price discounts to compensate for risk.

4.3 Audit-ready sustainability: operational criteria

Audit-ready sustainability requires (1) traceability from claim to source data, (2) governance with named owners and approval workflows, (3) internal controls including versioning and audit trails, (4) interoperability across tiers so evidence can be exchanged in reusable formats, and (5) alignment with assurance expectations on scope, sampling, and documentation. These criteria mirror finance and quality disciplines.

5. Europe's Policy Stack and the Shift to Product-Level Proof

Digital Product Passports (DPPs) institutionalize product-level transparency by making product information portable and reusable across transactions. Even where technical details evolve, the economic implication is stable: once product-level records become part of supplier qualification and compliance, firms must treat product data as a controlled asset. In parallel, the anticipated Circular Economy Act (CEA) is positioned as a market-making package intended to strengthen circular supply chains and increase the economic value of traceable circularity. A key policy objective is to enable a Single Market for secondary raw materials, which raises the importance of verified recycled-content and circularity claims.

5.1 Latest state of play (as of early 2026)

The Circular Economy Act (CEA) remains in preparation. The European Commission launched a public consultation and call for evidence on 1 August 2025, with the consultation open until 6 November 2025, and stated that the initiative is due for adoption in 2026. The Commission frames the CEA as an industrial and resilience measure: it is intended to establish a Single Market for secondary raw materials, increase the supply of high-quality recycled materials, and stimulate EU demand for these materials.

A European Parliament research briefing (EPRS) characterises the upcoming act as a central pillar of the Clean Industrial Deal and the Commission's competitiveness agenda for the 2024–2029 mandate, and reports that the Commission is expected to table the legislative proposal in the third quarter of 2026. The same briefing notes that possible measures may be organised around three pillars: amendments to the Waste Framework and Landfill Directives, amendments to the Waste Electrical and Electronic Equipment (WEEE) Directive, and additional measures to address bottlenecks and market fragmentation.

5.2 Expected impact on the Green Economy, traceability, and audit-proof data

The Circular Economy Act (CEA) is poised to fundamentally reshape the landscape of the Green Economy by reinforcing the importance of traceability, data integrity, and verifiable sustainability claims. Its anticipated adoption signals a move from fragmented and inconsistent regulations toward a unified, market-driven framework that incentivizes circular business models and enhances the competitiveness of secondary raw materials. This shift is not merely regulatory; it is a structural transformation that demands operational change from firms across supply chains.

From a 'Verification Economy' perspective, the CEA should be interpreted as market-making legislation: it aims to make circular models and secondary raw materials economically competitive by reducing structural frictions (fragmented waste rules, inconsistent quality, weak demand signals). If successful, this will amplify the commercial relevance of verified circularity attributes (e.g., recycled content, secondary material quality, take-back participation, and end-of-life pathways).

The CEA's impact extends beyond compliance; it actively creates new market opportunities for firms that can demonstrate credible, audit-ready evidence of circularity. By tackling barriers such as fragmented waste management rules and inconsistent standards for recycled materials, the Act encourages the development of robust traceability systems and reliable data exchange. As a result, companies that invest in verification capabilities—such as chain-of-custody tracking, batch-level material composition analysis, and comprehensive end-of-life documentation—will be better positioned to capture value in emerging markets for secondary materials.

Three channels are particularly relevant for green-economy outcomes and proof requirements:

Traceability as infrastructure for secondary-material markets: Establishing a Single Market for secondary raw materials is contingent on trust in the identity, quality, and legal status of materials. Firms must adopt rigorous chain-of-custody systems, ensure batch-level material composition is accurately recorded, and maintain documentation that proves compliance with end-of-waste and shipment regulations. This transforms traceability from a reporting obligation into a foundational operational capability, essential for participation in new circular markets.

Audit-proof data shifts from annual reporting to transaction-ready evidence: As circularity becomes a prerequisite for market access and procurement, evidence of sustainable practices must be available on demand, during tenders, supplier onboarding, and customer audits. Firms will need to create controlled evidence packs, maintain meticulous data lineage, and embed internal controls that ensure claims are reproducible and verifiable. This real-time readiness will be critical for demonstrating compliance and securing business in a verification-driven economy.

Integration with Digital Product Passports and ecodesign requirements: The CEA aligns with broader European policy trends that mandate product-level transparency and interoperability. Digital Product Passport (DPP) architectures will carry verified circularity information, enabling downstream stakeholders to access and reuse data efficiently. Firms should design data models that integrate Bill of Materials (BOM), material declarations, Product Carbon Footprint (PCF), Life Cycle Assessment (LCA) results, and circularity attributes, ensuring consistency and version control across customers and auditors. This integration supports scalable, audit-proof verification and enhances the value of circular products.

In summary, the Circular Economy Act is likely to strengthen the economic logic of the Green Economy by lowering barriers to circular business models and by increasing the commercial value of verified secondary-material and circularity attributes. For firms, the strategic response is to build verification readiness that treats traceability and audit-proof data as core operational infrastructure—integrated into product design, procurement, and quality systems, rather than as an after-the-fact reporting exercise.

The transition to a Verification Economy means that proof of sustainability is no longer a passive, retrospective task. Instead, it becomes a dynamic, proactive requirement embedded in every transaction, procurement decision, and product innovation. Firms that prioritize verification readiness will not only meet regulatory demands but also gain a competitive edge—accelerating supplier qualification, reducing assurance friction, and capturing premium value in circular business models. This approach fosters resilience, operational excellence, and credible market positioning in a rapidly evolving regulatory and commercial environment.

6. A Capability Model of Verification Readiness

6.1 Construct definition

Verification readiness is defined as a firm's preparedness to provide credible evidence of compliance and performance, thereby minimizing delays and disputes during audits. It is conceptualized as a higher-order capability composed of governance and accountability, data architecture and quality management, methodological discipline for footprints and lifecycle metrics, supplier engagement and chain-of-custody management, and assurance alignment.

6.2 Assurance friction

Assurance friction denotes inefficiencies, delays, or added costs when buyers or auditors face obstacles in verifying a supplier's sustainability claims. Typical sources include incomplete data, inconsistent definitions, missing chain-of-custody evidence, manual and repetitive questionnaire handling, weak internal controls, and poor interoperability across tiers. Verification readiness reduces friction by standardizing evidence, improving traceability, and aligning documentation with assurance expectations.

6.3 Evidence taxonomy

This paper proposes an evidence taxonomy ordered by audit strength: (1) primary measured data (metered energy, mass balance logs, lab results), (2) controlled operational records (batch records, ERP traceability entries, chain-of-custody logs), (3) validated models and calculations (PCF/LCA with transparent assumptions), (4) third-party attestations (assurance statements, EPDs, certifications), and (5) narrative statements (policies and commitments) that provide context but require linkage to stronger evidence classes.

6.4 Verification-readiness maturity model

A four-level maturity model is proposed. Level 1: ad hoc evidence (spreadsheets and reactive questionnaires). Level 2: standardized evidence (templates, metric ownership, partial traceability). Level 3: controlled proof system (claim-to-evidence mapping, finance-like controls, supplier data contracts, audit trails). Level 4: interoperable proof supply chain (DPP-ready product records, reusable evidence packages, automated workflows, and cross-tier interoperability).

7. Sector Exemplar: Filtration as a Hard Case for Circular Proof and Ecodesign

Filtration illustrates verification and circularity challenges because products are multi-material, performance-critical, and often contaminated at end-of-life. Circularity claims are difficult unless product design anticipates separability, reuse/refurbishment pathways, and data capture. Ecodesign principles such as mono-material strategies, reduced use of glues and toxic additives, modular reuse (frames reused, media replaced), and design for disassembly can simultaneously improve circular feasibility and reduce the evidentiary burden. Moreover, operational energy use often dominates lifecycle impacts, shifting verification requirements toward performance-linked lifecycle metrics such as pressure drop and maintenance cycles.

8. Propositions and Testable Implications

P1: Market access and supplier qualification

Higher verification readiness is positively associated with supplier qualification speed and market access because it reduces perceived procurement risk and lowers assurance friction. Indicative measures include onboarding duration, number of audit rounds, number of corrective actions, conditional approvals, and share of revenue with regulated or ESG-intensive buyers.

P2: Cost and productivity dynamics

Verification readiness increases fixed costs initially (systems, controls, supplier engagement) but reduces total verification cost over time through standardization, automation, and fewer audit iterations. Measures include cost-to-serve for questionnaires, hours per audit, response time, and rework rates.

P3: Circular value capture via evidence-linked ecodesign

Firms that link ecodesign choices to evidence, material traceability, durability/repairability documentation, and feasible end-of-life pathways, capture disproportionate value from circular business models because they can demonstrate compliance and performance more credibly. Measures include preferred supplier status, eligibility for public procurement, and pricing outcomes in closed-loop contracts.

P4: Resilience under geopolitics and disruption

Verification readiness improves supply-chain resilience under geopolitical stress by enabling faster qualification of alternative suppliers and more credible risk communication to customers and financiers. Measures include time to requalify suppliers, continuity of supply under disruption, and audit escalations during shocks.

9. Managerial Architecture: Building a Proof Supply Chain

The Verification Economy requires operational instruments that make evidence reusable and auditable. Three instruments are emphasized: a claim-to-evidence matrix that maps each claim to sources, methods, owners, and controls; a verification dashboard tracking evidence completeness, response time, and escalation rates; and a supplier proof playbook that defines minimum evidence requirements, exchange formats, and remediation pathways across tiers.

10. Methodology and Empirical Design

The paper proposes a mixed approach: (1) a structured policy-stack analysis mapping instruments to proof obligations and diffusion points across tiers; (2) comparative case studies across sectors, stratified by maturity levels; and (3) survey measurement of verification readiness and assurance friction to test relationships with market access, cost-to-serve, circular value capture, and resilience outcomes.

Table 1. Integrated Policy & Market Driver Evidence Matrix

Instrument / Driver	Core Objective	Proof Objects (What Must Be Evidenced)	Typical Data Sources	Assurance / Audit Touchpoints	Value Chain Propagation
Digital Product Passport (DPP)	Product-level transparency and traceability	Material composition, origin, product carbon footprint (PCF), repairability, end-of-life information	PLM / BOM, supplier declarations, LCA/PCF models, technical specifications	Product record validation, traceability checks, data integrity verification	OEM → Tier 1 → Tier 2+
Circular Economy Act (anticipated)	Market creation for secondary materials and circular pathways	Recycled content, circular pathways, secondary raw material quality, end-of-life feasibility	Chain-of-custody logs, recycled content certificates, waste contractor records, take-back logs	Verification of circularity claims, data lineage controls, mass-balance checks	Product stewardship → suppliers
Customer procurement requirements	Supply chain compliance and risk mitigation	Scope 3 emissions data, certifications, and regulatory compliance proofs	Supplier evidence packs, certifications, and third-party audits	Supplier qualification audits, corrective action tracking	Buyer → direct suppliers
Buyer procurement (Scope 3 + brand risk)	Emissions transparency and reputational risk control	Footprint metrics, compliance documentation, claims integrity evidence	Questionnaires, audit evidence packs, and internal control documentation	Contractual obligations, supplier performance monitoring	Procurement contracts → suppliers
Voluntary standards (ISO, GHG Protocol)	Method consistency and comparability	Method documentation, boundary definitions, datasets, and calculation logic	Emission factor databases, internal data systems, LCA tools	Method review, sampling, recalculation, limited/reasonable assurance	Company-wide → value chain reporting

Table 1 maps policy instruments to proof objects and where requirements propagate through the supply chain. This helps readers see why verification demands increase even for non-regulated suppliers.

Table 2. Evidence & Control Maturity Model

Level	Evidence Handling	Controls & Governance	Supplier Interoperability	Typical Outcomes
1 – Reactive	Ad hoc spreadsheets; fragmented documentation; evidence created on request	Minimal controls; unclear data ownership; no formal review logic	Low; bilateral email exchanges; non-standard formats	Slow supplier onboarding; repeated data requests; inconsistent submissions
2 – Structured Manual	Standardized templates; recurring KPI collection; partial documentation reuse	Basic approval workflows; limited traceability; role-based responsibilities emerging	Moderate for key suppliers; template-based exchange	Fewer clarification loops; improved consistency; still largely manual effort
3 – Controlled & Reusable	Formal claim-to-evidence mapping; centralized evidence repository; reusable supplier packs	Audit trails; change control procedures; validation testing; defined data lineage	Contractual data requirements; structured data exchange protocols	Faster audits; reduced friction in procurement; improved defensibility of claims
4 – Integrated & DPP-Ready	DPP-ready structured product records; automated data flows; system-integrated LCA/PCF models	Controls embedded in IT systems; automated validation; continuous monitoring	High interoperability; standardized digital exchange (API/PLM integration)	Preferred supplier status; scalable proof across customers; audit-ready by design

Table 2 maps the transition from reactive compliance to system-embedded, value-chain-integrated proof infrastructure.

11. Discussion

The argument advanced in this paper is that sustainability competition is increasingly mediated not only by environmental performance itself, but by the capacity to render such performance verifiable under conditions of procurement scrutiny, regulatory oversight, and assurance review. The Verification Economy thus denotes more than a rhetorical shift from narrative claims to auditable proof; it reflects a broader reconfiguration of market selection mechanisms in which sustainability attributes acquire economic relevance only insofar as they can be substantiated through credible, reproducible, and transferable evidence. Within this setting, verification readiness is best understood as a higher-order organizational capability that enables firms to convert dispersed sustainability information into transaction-ready proof.

This perspective extends existing debates on sustainability reporting and assurance in two respects. First, it relocates analytical attention from disclosure outputs to the organizational conditions under which claims become defensible across value-chain relationships. Second, it suggests that the competitive consequences of sustainability are increasingly shaped by the architecture of proof production rather than by reporting ambition alone. Firms may exhibit comparable environmental intent or even similar underlying performance, yet differ substantially in their ability to document, validate, and communicate that performance in forms that reduce buyer uncertainty and withstand third-party review. In this sense, proof does not merely accompany sustainability performance; it conditions its recognition in markets.

11.1 Bargaining power and commercial differentiation

One important implication of this argument concerns bargaining power within supply chains. Verification readiness does not only reduce exposure to compliance-related risk; it may also alter the relative positioning of suppliers and buyers in commercial negotiations. Suppliers able to provide structured, reusable, and audit-aligned evidence reduce the evaluative burden placed on customers. Such suppliers become easier to qualify, easier to integrate into procurement systems, and less costly to monitor over time. The result may be preferential treatment in qualification processes, shorter contracting cycles, and, in certain market contexts, more favorable commercial terms.

By contrast, weak proof systems create a form of informational vulnerability. Even where environmental performance is substantively strong, suppliers whose claims are difficult to verify may be treated as higher-risk counterparties. This increases the likelihood of repeated evidence requests, supplementary audits, delayed decisions, and contractual caution. The implication is that sustainability proof can operate as a mechanism of commercial differentiation: it reduces uncertainty, lowers transaction costs, and strengthens the supplier's strategic position. This is consistent with the earlier discussion in the paper of interoperability and evidence reuse, both of which increase the scalability of proof systems across multiple customers and audit contexts. Verification readiness therefore has distributive consequences: it influences not only compliance outcomes, but also the allocation of value and bargaining leverage across the supply chain.

11.2 Assurance friction as a measurable mechanism

The paper introduces assurance friction as the key mechanism linking verification capability to organizational and market outcomes. Conceptually, assurance friction captures the operational burdens that arise when sustainability claims cannot be verified efficiently, consistently, or with sufficient evidentiary strength. Unlike abstract notions of credibility, assurance friction is observable in concrete transactional phenomena: elongated questionnaire cycles, repeated clarification requests, corrective-action loops, escalations to legal or audit functions, and disputes concerning boundaries, methods, or data provenance.

The importance of this construct lies in its capacity to render the effects of verification readiness empirically tractable. It translates a broad institutional demand for credibility into measurable organizational costs and delays. In doing so, it clarifies why proof systems matter strategically. Where assurance friction is high, the cost of participating in sustainability-sensitive markets rises for both buyers and suppliers. Where it is low, claims become easier to evaluate, reuse, and rely upon. The concept therefore provides a bridge between institutional pressure, organizational capability, and competitive outcome.

More broadly, the notion of assurance friction suggests that firms compete not only on environmental outcomes, but on the reliability and efficiency with which those outcomes can be rendered auditable. This is why the paper analogizes proof systems to quality systems: both institutionalize process discipline, reduce variability, and support scalable forms of trust. In the Verification Economy, therefore, the ability to produce low-friction evidence may become as important as the underlying environmental attribute being claimed.

11.3 Boundary conditions and risks

The benefits associated with verification readiness are unlikely to be uniform across all sectors, firms, and regulatory settings. Rather, their magnitude is shaped by several important boundary conditions. First, buyer verification intensity varies considerably. Markets characterized by public procurement, high reputational exposure, or direct regulatory accountability are likely to impose more demanding proof requirements than markets in which sustainability attributes remain secondary to price or delivery considerations. Under such conditions, the returns to verification capability may be substantial in some sectors yet more modest in others.

Second, the value of verification readiness may be weakened by methodological fragmentation. Even where firms possess robust data and internal controls, inconsistent customer requirements, divergent calculation rules, and incompatible claim definitions may generate reconciliation costs that erode the benefits of capability development. In such environments, firms remain exposed to duplicative verification work despite internal preparedness. This suggests that the scalability of proof systems depends not only on firm-level investment, but also on the degree of standardization in the wider institutional environment.

Third, the paper’s framework raises distributional concerns for SMEs. Verification systems often require fixed investments in data architecture, governance, supplier engagement, and assurance preparation. Where evidence requirements remain highly fragmented and non-reusable, smaller firms may face disproportionate compliance burdens relative to their organizational capacity. This creates a risk that verification regimes, while intended to improve trust and transparency, may also function as barriers to participation. These boundary conditions reinforce the paper’s policy argument that interoperability, proportionality, and evidence reuse are not peripheral design choices, but central conditions for an effective and inclusive Verification Economy.

12. Implications

12.1 Managerial implications: organizing for verification capability

From a managerial perspective, the findings suggest that verification readiness should not be approached as a narrow reporting function, nor as a purely downstream response to audit requests. Rather, it should be treated as an organizational capability rooted in governance, information architecture, methodological discipline, supplier coordination, and assurance alignment. Firms seeking to build this capability will need to define ownership of claims and evidence, formalize approval and escalation processes, establish data lineage and version control, standardize methodological assumptions, and strengthen contractual and operational arrangements for supplier evidence exchange. The key managerial challenge is therefore not simply to produce more sustainability data, but to institutionalize the conditions under which that data becomes reusable, defensible, and decision-relevant across multiple transaction contexts.

This has implications for organizational design. Sustainability functions must be connected more closely to finance, quality, procurement, and product-data management rather than operating as stand-alone communication or reporting units. In practical terms, firms are likely to derive the greatest benefit from verification investments when evidence production is embedded in routine operating systems and product records, rather than assembled retrospectively through manual and fragmented processes. Verification readiness, in this sense, is less a matter of disclosure sophistication than of organizational integration.

12.2 Policy implications: interoperability, proportionality, and evidence reuse

The policy implications of the paper follow directly from its central claim that the value of sustainability information depends on its verifiability and transferability. If policy instruments such as Digital Product Passports and circular-economy measures are to strengthen transparency without generating excessive duplication, they must promote interoperable data structures, consistent claim definitions, and conditions for evidence reuse across organizational boundaries. Interoperability lowers the marginal cost of verification by reducing repeated translation and reconciliation work. Evidence reuse increases efficiency by enabling suppliers to respond to multiple buyers and assurance contexts through common proof architectures rather than bespoke submissions.

At the same time, proportionality remains essential. In performance-critical sectors, circularity and traceability requirements must be designed in ways that preserve safety, hygiene, technical reliability, and other essential product functions. An effective verification regime must therefore balance rigor with feasibility. This is especially important for SMEs, whose participation may depend on whether compliance systems are modular, standardized, and scalable. On this view, the success of the emerging European policy stack will depend not only on the ambition of

substantive sustainability requirements, but on whether the institutional infrastructure of verification is sufficiently harmonized to allow credible proof to circulate without excessive friction.

12.3 Implications for green finance and risk pricing

The framework also carries implications for green finance. Where investors and lenders increasingly rely on sustainability-related information to assess transition exposure, financed emissions, or the credibility of transition plans, the quality of proof systems becomes economically consequential beyond product markets alone. Verification readiness may reduce financing frictions by increasing confidence in the methodological robustness and auditability of disclosed sustainability information. Firms capable of producing structured, comparable, and defensible evidence are likely to face lower internal costs in responding to due diligence processes and may contribute to more precise forms of risk pricing.

This does not imply that verification readiness alone determines financing outcomes. Rather, it suggests that proof capability may increasingly function as an enabling condition for credible interaction with capital providers. In settings where sustainability information is used to support investment decisions, the distinction between reported ambition and auditable substantiation becomes materially significant. The framework developed here therefore opens an additional avenue for future research at the intersection of sustainability assurance, disclosure quality, and financial-market response.

13. Conclusion

This paper has defined the Verification Economy as a market condition in which sustainability performance creates economic value only when it can be rendered demonstrable, traceable, and auditable. The paper's central contribution is to shift the analytical focus from sustainability reporting as an output toward verification readiness as an organizational capability. In doing so, it argues that the strategic importance of sustainability increasingly depends on the capacity to produce proof architectures that can withstand procurement scrutiny, regulatory review, and third-party assurance.

The European policy context gives this shift particular urgency. Product-level transparency requirements associated with Digital Product Passports, together with the anticipated Circular Economy Act and related circular-economy measures, indicate a movement away from generalized narrative disclosure toward structured, product-specific, and supply-chain-transmissible evidence. These developments increase the market value of data lineage, traceability, methodological consistency, and control robustness. They also create stronger incentives for firms to organize sustainability information in ways that are reusable across transactions rather than assembled reactively for isolated reporting exercises.

Against this backdrop, the paper conceptualizes verification readiness as a higher-order capability and assurance friction as the mechanism through which that capability affects commercial and organizational outcomes. The proposed evidence taxonomy, maturity model, and proof-supply-chain architecture provide a basis for both empirical investigation and managerial application. The broader implication is that competitive differentiation in the green transition will depend not solely on the environmental ambition of firms, but on the extent to which that ambition can be translated into verifiable and transferable proof.

Future empirical research should test the propositions developed here across sectors, firm sizes, and policy settings. In particular, there is a need to examine how proof capability affects supplier qualification, cost-to-serve, circular value capture, and resilience under disruption, as well as how standardization and interoperability condition these effects. The main conclusion, however, is already evident at the conceptual level: in an economy increasingly structured by verification demands, sustainability claims matter commercially only when they can be substantiated with evidence that is credible, reusable, and audit-ready.

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Abbreviation

CEA	Circular Economy Act (EU; anticipated legislative package)
CSRD	Corporate Sustainability Reporting Directive (EU)
DPP	Digital Product Passport
EPD	Environmental Product Declaration
ESG	Environmental, Social, and Governance
ESRS	European Sustainability Reporting Standards
EU	European Union
GHG	Greenhouse Gas
LCA	Life Cycle Assessment
PCF	Product Carbon Footprint
RBV	Resource-Based View

Uploaded the co	Small and Medium-sized Enterprise
SME	
SOP	Standard Operating Procedure
TCO	Total Cost of Ownership
TCE	Transaction Cost Economics