Blockchain as a Governance Infrastructure for ESG Compliance in European Supply Chains

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This paper examines how blockchain technologies are reshaping governance and transparency in European supply chains and assesses whether these changes can enhance ESG compliance under the Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDDD). Drawing on a structured conceptual synthesis of academic literature, EU regulatory documents, and publicly documented industry cases, the paper argues that blockchain can support more data-driven, traceable, and auditable oversight by replacing fragmented documentation with continuous, tamper-resistant information flows. These capabilities are particularly relevant to the environmental and governance dimensions of ESG, as they can enhance emissions tracking, chain-of-custody verification, and audit-trail reliability. However, blockchain's contribution remains uneven and depends on the governance of permissioned consortia, the quality of input data, interoperability challenges, and firms' willingness to share information. Its contribution to social sustainability is more limited, as many labor-related risks are difficult to capture solely through digital records. The paper concludes that blockchain can serve as an enabling governance infrastructure for European ESG regulation, but not as a standalone solution. Its effectiveness depends on regulatory clarity, interoperable digital standards, and sustained collaboration across supply chain actors.

Keywords:
blockchain governance,
ESG compliance,
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1 Introduction

Businesses find it challenging to monitor environmental, social, and governance (ESG) issues across multiple tiers of suppliers because of the increasing fragmentation, geographical dispersion, and operational opacity of global supply chains. According to Zamfir (2020), this structural complexity has widened information gaps between firms and their upstream partners. The European Union enacted a comprehensive legislative framework to improve corporate accountability and transparency. The Corporate Sustainability Reporting Directive (CSRD), which introduces the double materiality principle and requires companies to disclose both financial, material ESG information and sustainability impacts relevant to society, is a key component of this framework. It also extends mandatory sustainability reporting to a much broader set of companies (European Commission, 2025). Europe is becoming one of the most demanding regions for ESG-related supply chain governance due to these regulatory developments, which signal increased expectations for traceability, data quality, and disclosure accuracy.

Traditional governance methods have inherent limitations that undermine their effectiveness in complex global supply chains, despite the widespread use of sustainability audits, certifications, supplier questionnaires, and voluntary reporting schemes. OECD (2018) notes that voluntary due diligence often relies on self-reported and selectively verified information, resulting in persistent transparency gaps. European Commission (2023) defines greenwashing as a widespread practice in which businesses exaggerate, misrepresent, or fabricate environmental claims to appear more sustainable than they are. These shortcomings directly contribute to the persistence of greenwashing. Greenwashing is a structural governance failure that distorts market transparency, misleads investors and customers, and undermines the credibility of ESG reporting systems. It is not merely a communication issue.

Regulatory agencies have increasingly issued warnings about the dangers of making false sustainability claims. According to ESMA (2024), false ESG disclosures threaten both investor protection and market integrity, and greenwashing can occur at any stage of the sustainable investment value chain. ESMA's (2024) findings indicate that sustainability statements often omit valuable information, use vague language, or lack verifiable evidence– issues that are difficult for traditional audits and certifications to detect. As the European Union shifts from voluntary corporate social responsibility to mandatory due diligence under measures such as the Corporate Sustainability Due Diligence Directive (CSDDD), these limitations become even more significant. Under this new regulatory framework, businesses must demonstrate ongoing, evidence-based oversight of environmental and human rights impacts throughout their entire value chains. Traditional governance tools were not designed to meet the demands for continuous, legally enforceable ESG oversight.

In this context, blockchain technology has attracted increased attention as a potential solution to ongoing accountability and transparency challenges in international supply chains. Conceptually, blockchain functions as a distributed and immutable ledger, enabling decentralized transaction verification and ensuring that recorded data cannot be altered retroactively. According to the European Commission (2022), these characteristics make blockchain particularly suitable for situations where multiple parties need to share information without relying on a single trusted intermediary. The integration of smart contracts, self-executing code embedded within the blockchain, further enhances governance by automating compliance checks, generating alerts, and enforcing predetermined rules without human intervention. This technical architecture supports end-to-end traceability, allowing businesses to track the origin, movement, and transformation of items at every stage of the supply chain.

Recent studies suggest that blockchain may reduce information asymmetries and support more reliable ESG data flows. Blockchain technology can provide reliable records of social and environmental performance, support more credible sustainability claims and reduce the risk of greenwashing. Similarly, the World Economic Forum (2020) argues that blockchain-enabled traceability can improve risk management, enable real-time monitoring, and encourage more ethical sourcing practices. Because blockchain enables the creation of tamper-resistant, auditable, and interoperable ESG data, it is increasingly considered in the European regulatory landscape as a technical supplement to CSRD-aligned reporting and CSDDD-aligned due diligence procedures. As regulatory demands for transparency increase, blockchain offers a viable, though challenging, path toward stronger and more verifiable ESG governance in European supply chains.

Despite significant excitement, conflicting empirical evidence remains regarding blockchain's actual impact on ESG outcomes. Systematic studies of blockchain implementations in sustainable supply chains often find that its theoretical advantages are not realized in practice. For example, Paliwal et al. (2020) identify persistent challenges, including data quality limitations, interoperability issues, and organizational readiness, which hinder the effective use of blockchain technology in real-world supply chains. Similarly, Munir et al. (2022) argue that while blockchain may enhance traceability and transparency, its ESG impact is often constrained by inadequate data inputs, inconsistent stakeholder engagement, and the absence of standardized sustainability indicators. Governance challenges further complicate implementation. European Commission (2022) reports that integrating blockchain into existing corporate reporting systems is obstructed by fragmented digital infrastructures, unclear data ownership rules, and a lack of harmonized regulatory guidance.

The European regulatory context is notably underexplored in the literature. Few studies specifically examine how blockchain's capabilities align with the reporting and due diligence requirements set by the CSRD and the CSDDD, even though blockchain is widely theorized as a tool for enhancing transparency. Most existing evaluations focus on conceptual benefits rather than assessing whether blockchain can generate auditable, standardized, and regulator-ready ESG data required by EU law. Similarly, the European Commission (2022) notes that blockchain's effectiveness largely depends on broader institutional and governance frameworks, suggesting that technological solutions alone cannot address systemic transparency shortcomings. This gap between conceptual promise and regulatory reality highlights the need for a more comprehensive, evidence-based assessment of blockchain's role in ESG-oriented supply chain governance, especially given Europe's increasingly stringent sustainability regulations.

This paper addresses the following research question: How can blockchain-based systems support sustainability-oriented supply chain governance within the European regulatory framework? This inquiry highlights the increasing need to assess both the technological potential of blockchain and its capacity to meet the evolving reporting and due diligence requirements in the European regulatory environment. The paper aims to clarify how blockchain can support more reliable, verifiable, and interoperable ESG-related data flows by synthesizing recent scholarly literature and analyzing the changing institutional framework shaped by instruments such as the CSRD and CSDDD. At the same time, the investigation critically examines the constraints, implementation challenges, and unresolved governance issues that continue to limit blockchain's effectiveness in real-world supply chain scenarios. In doing so, the paper presents blockchain as a contingent and context-dependent governance tool, whose usefulness depends on broader institutional, organizational, and technological conditions, rather than as a deterministic solution.

The paper is structured as follows. Section 2 presents the theoretical and regulatory background, focusing on supply chain governance, information visibility, and the European ESG framework. Section 3 reviews the literature on traditional governance mechanisms and blockchain applications in supply chains, highlighting key limitations and contextual conditions. Section 4 describes the methodological approach, which is based on a structured conceptual synthesis. Section 5 discusses the implications of blockchain for sustainability-oriented supply chain governance and outlines directions for future research. Section 6 concludes by answering the research question, summarizing implications for policymakers, companies, and researchers, and outlining limitations and directions for future research.

2 Theoretical and regulatory background

2.1 Governance, Information Visibility, and ESG Requirements in European Supply Chains

In the academic literature on global production networks, governance refers to the institutional configuration through which firms coordinate interdependent activities, allocate responsibilities, and enforce standards across dispersed supplier ecosystems. Rather than a narrow managerial function, governance includes the rules, monitoring arrangements, and decision-making structures that determine how authority and risk are distributed along the chain. Classic global value chain theory emphasizes that these arrangements arise in response to transaction complexity, the codifiability of information, and supplier capabilities, resulting in varying degrees of oversight and control (Gereffi et al., 2005). Within European supply chains, these challenges are heightened by regulatory expectations that firms maintain continuous, evidence-based supervision of environmental and social impacts. As OECD (2018) notes, conventional due diligence practices often rely on self-reported or selectively verified information, exposing systemic weaknesses in the mechanisms firms use to ensure responsible conduct.

A central difficulty arises from limited visibility into information across multi-tier networks. Scholars argue that without reliable access to upstream data, including production conditions and emissions metrics, firms struggle to identify risks or substantiate sustainability claims (Mol, 2015). This lack of verifiable information creates vulnerabilities that go beyond operational inefficiencies: it undermines the credibility of corporate reporting and enables misleading environmental or social assertions. European Commission (2023) explicitly links these informational gaps to the persistence of greenwashing, noting that unverifiable claims distort markets and erode stakeholder trust. Consequently, the ability to generate accurate, consistent, and auditable data has become a foundational requirement for effective oversight in European supply chains.

The European Union's evolving ESG regulatory framework formalizes these expectations. The CSRD expands mandatory sustainability disclosures and introduces the principle of double materiality, requiring firms to report both financially relevant ESG risks and their broader societal impacts (European Commission, 2025). The CSDDD further requires companies to identify, prevent, and mitigate adverse environmental and human rights impacts throughout their value chains, transforming due diligence from a voluntary practice into a legally enforceable obligation. Complementing these measures, the EU Taxonomy Regulation establishes a standardized classification system for environmentally sustainable activities, shaping how firms substantiate environmental performance and how investors assess sustainability risks. Scholars argue that the EU's recent sustainability regulation marks a shift from largely voluntary, sometimes symbolic CSR (CSR) commitments toward more substantive accountability, where firms must support sustainability reporting and due-diligence claims with verifiable, audit-ready evidence rather than intent alone (Hadro et al., 2025; Pantazi, 2024).

This regulatory framework highlights the structural interdependence between ESG compliance and firms' ability to generate reliable, high-quality data and maintain strong verification mechanisms throughout their supplier networks. Without systems that ensure data integrity, continuous monitoring, and credible audit trails, firms cannot meet the evidentiary standards required by CSRD, CSDDD, or the EU

Taxonomy. Regulatory bodies have emphasized this point. ESMA (2024) warns that insufficient information reliability and weak oversight structures create conditions in which greenwashing proliferates, threatening investor protection and undermining the legitimacy of sustainable finance markets. Academic research highlights that market-based sustainability governance–especially audit- and certification-centered oversight–often delivers only partial visibility and uneven accountability in multi-tier supply networks, limiting the ability to detect evolving risks and to demonstrate substantive improvements (LeBaron & Lister, 2021). These challenges have prompted growing interest in technological infrastructures that support more rigorous data assurance. In this context, blockchain has emerged as a potential tool for enhancing the reliability, auditability, and regulatory readiness of ESG-related information in European supply chains.

2.2 Basic Blockchain Concepts in Supply Chains

Blockchain is best understood as a distributed ledger architecture that restructures how information is recorded, validated, and exchanged across organizational boundaries. Unlike centralized databases, a distributed ledger is maintained collectively by multiple nodes, each holding synchronized copies of the same dataset. This structure reduces reliance on a single authority and enhances the resilience of information systems. A defining feature of blockchain is immutability: once a record is validated and appended to the ledger, it cannot be altered without leaving a detectable revision history. This integrity is enforced through consensus mechanisms, which allow participating nodes to agree on the validity of new entries before they are added. In supply chain applications, consensus typically relies on efficient algorithms suited to controlled environments rather than the open, energy-intensive protocols used in public networks. Smart contracts, self-executing code embedded within the ledger, extend these capabilities by automating predefined rules, enabling conditional payments, compliance checks, and event-triggered notifications without manual intervention (European Commission, 2022; World Economic Forum, 2020).

These technical properties provide several capabilities directly relevant to ESG-oriented supply chain oversight. First, blockchain enables comprehensive product and process monitoring by linking each logistical or production event to a tamper-resistant digital record. This allows firms to reconstruct the complete history of an item's movement and transformation, enhancing the verifiability of sustainability claims. Second, the immutability of blockchain entries creates a secure audit trail for ESG-relevant data, such as emissions measurements, certifications, or due diligence findings. Because records cannot be retroactively modified, blockchain reduces opportunities for data manipulation and strengthens the evidentiary basis required for regulatory reporting. Third, smart contracts enable automated enforcement of contractual or regulatory obligations by embedding compliance logic directly into operational workflows. This can include automatic validation of supplier documentation, real-time alerts when environmental thresholds are exceeded, or the release of payments only after verified completion of sustainability-related milestones (Saberi et al., 2018).

A central design distinction is the difference between public and permissioned blockchains. Public networks allow unrestricted participation and full visibility of transactions, features generally incompatible with commercial confidentiality, competitive sensitivities, and data protection requirements. As a result, most supply chain implementations use permissioned systems, where participation is limited to vetted organizations and data access is governed by consortium-level rules. Although permissioned architecture provides greater control, scalability, and alignment with privacy regulations, they also reintroduce elements of centralized coordination and limits the radical openness often associated with blockchain. Empirical studies show that firms frequently adopt consortium-based models that balance data accessibility with confidentiality, resulting in hybrid arrangements that enhance auditability and data integrity but do not provide full public transparency (European Commission, 2022; Lustenberger & Spychiger, 2025).

Clarifying these foundational concepts is essential for assessing whether blockchain's technical properties can support the evidentiary and procedural requirements imposed by CSRD and CSDDD.

3 Literature Review

3.1 Traditional Governance and Information Management in Supply Chains

Research on conventional supply chain oversight consistently highlights audits, certifications, supplier codes of conduct, and corporate reporting as the primary mechanisms firms use to monitor upstream practices. These tools emerged as standardized responses to growing concerns about labor abuses, environmental degradation, and ethical misconduct in global production networks. Scholars note that third-party audits and certification schemes were designed to provide external assurance and reduce information gaps between buyers and suppliers, while codes of conduct formalized expectations regarding labor, environmental, and ethical performance (LeBaron & Lister, 2021). Corporate sustainability reports became the main vehicle through which firms communicated their commitments and performance to external stakeholders. Together, these instruments formed the backbone of traditional supply chain governance throughout the 2000s and early 2010s.

Despite their widespread adoption, a substantial body of literature questions their effectiveness. Numerous studies argue that audit-based oversight struggles to detect systemic risks because it relies on periodic inspections, pre-announced visits, and documentation that can be selectively curated or falsified (LeBaron & Lister, 2021; OECD, 2018). Researchers have documented persistent information asymmetries between lead firms and upstream suppliers, noting that suppliers often have much more knowledge about production conditions than buyers, creating opportunities for opportunistic behavior and misrepresentation. Certifications and reporting schemes face similar challenges: they depend heavily on self-reported data, lack standardized metrics across industries, and often fail to capture conditions beyond first-tier suppliers. These weaknesses contribute to well-documented cases of fraud, concealment of labor violations, and inaccurate environmental disclosures. Scholars also highlight the technological limitations of traditional systems, which rely on siloed databases, fragmented IT infrastructures, and manual data collection processes, hindering real-time monitoring and reducing the reliability of reported information (Mol, 2015).

A recurring theme in this literature is that traditional governance instruments were not designed to meet the heightened expectations now imposed by ESG-oriented regulation, particularly in the European Union, where firms must demonstrate ongoing, evidence-based oversight rather than periodic compliance (Hadro et al., 2025; Mol, 2015; Pantazi, 2024).

3.2 ESG Pressures and the European Regulatory Context

Recent literature highlights a significant increase in expectations surrounding ESG performance within global supply networks. Analysts note that sustainability has shifted from a voluntary corporate initiative to an area shaped by investor scrutiny, civil society pressure, and increasingly stringent regulatory requirements. This change reflects a broader transformation in how firms are evaluated: stakeholders now require verifiable evidence of responsible conduct rather than general commitments or narrative reporting. Studies on the development of non-financial disclosure frameworks emphasize that European companies face growing demands for structured, comparable, and audit-ready sustainability information, driven by both market pressures and regulatory intervention (Hadro et al., 2025; Pantazi, 2024).

Within this changing landscape, the European Union has positioned itself at the forefront of institutionalizing ESG obligations. The EU's regulatory approach is distinctive because it integrates reporting, due diligence, and sustainable finance into a unified policy framework. The CSRD significantly increases the number of firms required to make mandatory sustainability disclosures and introduces detailed European Sustainability Reporting Standards (ESRS), which require companies to provide granular, verifiable data on environmental impacts, human rights risks, and governance practices (European Commission, 2025). In addition, the CSDDD requires firms to identify, prevent, and mitigate adverse impacts throughout their value chains, making due diligence a legal duty rather than a voluntary exercise. Researchers examining these developments note that the EU has moved decisively away from earlier soft-law approaches, replacing voluntary corporate social responsibility models with binding obligations that require demonstrable oversight of upstream operations (LeBaron & Lister, 2021).

Across the literature, there is broad recognition that these regulatory changes reflect a structural need for more reliable and interoperable sustainability data. Traditional reporting systems, built around self-disclosure, periodic audits, and fragmented IT infrastructures, struggle to meet the evidentiary standards required under CSRD and CSDDD. Studies consistently highlight persistent challenges such as inconsistent data formats, limited visibility beyond first-tier suppliers, and the absence of continuous monitoring mechanisms, all of which hinder firms' ability to produce the high-quality information demanded by regulators (Mol, 2015; OECD, 2018). While some authors view the EU's regulatory push as a catalyst for innovation in sustainability data management, others caution that compliance will remain difficult without significant technological and organizational transformation.

Debate continues over the feasibility of the EU's ambitions. Some commentators argue that the regulatory framework may outpace firms' operational capacities, especially in sectors with complex, multi-tier supply networks. Others contend that the move toward mandatory oversight is necessary because voluntary approaches have failed to achieve meaningful improvements in environmental and social outcomes. Despite these differing views, the literature agrees on one point: the EU's focus on verifiable, high-quality sustainability information creates strong incentives for firms to adopt new tools that enhance data integrity, monitoring capacity, and regulatory readiness.

3.3 Blockchain in Supply Chains (Global Evidence)

Research on blockchain applications in supply chains has expanded rapidly over the past decade, driven by the promise of more reliable information flows, enhanced auditability, and improved coordination across multi-tier networks. Early work focused on conceptualizing blockchain as a distributed ledger capable of recording product movements and transactional events in a tamper-resistant manner, thereby reducing opportunities for fraud and data manipulation (Saberi et al., 2018). Subsequent studies documented a wide range of pilot projects across sectors such as food, pharmaceuticals, luxury goods, and logistics, where blockchain was used to verify product origins, authenticate certifications, and streamline documentation processes. These applications are often presented as solutions to long-standing problems of information asymmetry and fragmented data systems, with proponents arguing that blockchain can accelerate audits, reduce counterfeiting, and strengthen the evidentiary basis of sustainability claims (World Economic Forum, 2020).

Despite these optimistic narratives, empirical findings are mixed. Several studies report that blockchain pilots often struggle to scale beyond initial testing due to interoperability challenges, inconsistent data inputs, and difficulties coordinating participation across diverse supply chain actors (Kouhizadeh et al., 2019). Network effects present a significant barrier: blockchain systems deliver value only when a critical mass of suppliers, logistics providers, and certification bodies adopt the same platform; a condition rarely met in fragmented global industries. Research also highlights that many blockchain deployments rely on permissioned consortia rather than open networks, which can limit data accessibility and reintroduce centralized control structures that blockchain was originally intended to circumvent (Lustenberger & Spychiger, 2025). These findings suggest that while blockchain can enhance data integrity within controlled environments, its broader governance implications remain uncertain.

On the one hand, blockchain is widely promoted as a transformative technology capable of reshaping supply chain oversight; on the other hand, empirical studies show that many implementations remain prototypes, with limited evidence of long-term operational impact. Some authors argue that blockchain's benefits are most pronounced in sectors with high regulatory pressure or strong incentives for verifiable provenance, such as food safety or pharmaceuticals. Others caution that blockchain alone cannot resolve underlying issues such as poor data quality, lack of supplier engagement, or misaligned incentives across the chain (Treiblmaier, 2018). These critiques underscore that blockchain's effectiveness depends not only on its technical architecture but also on the institutional, organizational, and economic conditions in which it is deployed.

These insights reinforce the view that blockchain should be examined as a context-dependent governance tool rather than a universal solution, particularly in regulatory environments such as the European Union.

3.4 Blockchain, Governance, and ESG Performance

A growing body of research examines blockchain not only as a logistical tool but also as a governance mechanism that can strengthen the credibility and reliability of sustainability information. Much of this work argues that blockchain's core attributes, tamper-resistant recordkeeping, decentralized validation, and automated rule enforcement, can enhance the evidentiary basis of environmental and social claims. Studies exploring sustainability-oriented blockchain applications suggest that distributed ledgers can support more reliable emissions accounting, verifiable labor documentation, and improved monitoring of resource use, thereby contributing to more robust ESG performance indicators (Park & Li, 2021; Qian et al., 2023). These contributions are often framed as responses to long-standing weaknesses in traditional oversight systems, particularly the reliance on self-reported data and the difficulty of verifying conditions beyond first-tier suppliers.

Several authors propose conceptual frameworks that integrate blockchain into broader sustainability governance models. For example, Saberi et al. (2018) describe how blockchain can reinforce responsible sourcing by improving data integrity and reducing opportunities for opportunistic behavior among suppliers. Similarly, Nikolakis et al. (2018) present the Evidence, Verifiability, and Enforceability (EVE) framework, which positions blockchain as a tool for strengthening the credibility of sustainability claims in global value chains. These frameworks agree that blockchain can enhance the reliability of ESG-related information by creating secure audit trails and enabling more consistent monitoring of environmental and social impacts. Other studies highlight the potential of smart contracts to automate compliance processes, such as verifying certifications or triggering alerts when sustainability thresholds are breached, thereby reducing the administrative burden associated with due diligence (World Economic Forum, 2020).

Despite these theoretical contributions, empirical evidence remains uneven. Many studies reporting positive ESG outcomes rely on simulations, prototypes, or single-case demonstrations rather than large-scale, longitudinal data. Research on real-world deployments frequently highlights persistent challenges, including high implementation costs, limited interoperability between blockchain platforms, and firms' reluctance to share sensitive information within distributed networks

(Lustenberger & Spychiger, 2025). These constraints often lead companies to adopt permissioned blockchain consortia, which provide greater control over data access but also reintroduce hierarchical governance structures that limit the openness and decentralization originally associated with blockchain. As a result, the extent to which blockchain improves sustainability outcomes varies significantly across contexts, and many projects do not progress beyond pilot stages.

The literature also reveals ongoing debate about blockchain's actual contribution to ESG performance. Some authors argue that blockchain can meaningfully reduce greenwashing by providing verifiable evidence of sustainability claims, particularly in sectors where provenance and certification are central to market value. Others caution that blockchain cannot compensate for poor data inputs, weak regulatory enforcement, or insufficient supplier engagement. Without reliable upstream data, blockchain risks becoming a sophisticated repository for inaccurate or incomplete information, a problem often summarized as "garbage in, garbage out." These critiques underscore that blockchain's effectiveness depends not only on its technical architecture but also on the institutional and organizational conditions in which it is embedded.

Taken together, this body of research highlights both the promise and the limitations of blockchain as a tool for ESG-oriented supply chain governance. The literature suggests that blockchain can enhance data integrity, strengthen verification mechanisms, and support more credible sustainability reporting, but its real-world impact remains contingent on adoption dynamics, regulatory alignment, and the quality of underlying data.

4 Methodology

This study uses a qualitative, concept-driven research design, grounded in a structured conceptual synthesis, to clarify how blockchain technologies intersect with emerging ESG obligations in European supply chains. Instead of conducting primary data collection, the analysis synthesizes insights from peer-reviewed scholarship, EU regulatory instruments, and publicly available industry materials to construct an integrated understanding of blockchain's governance implications. This approach is appropriate given the rapid evolution of both blockchain applications and European sustainability regulation, as well as the need for a framework that brings these developments into dialogue.

The review draws on three categories of secondary sources selected for their direct relevance to the research question. First, peer-reviewed academic publications establish the theoretical foundations of blockchain, supply chain governance, transparency, and sustainability oversight. Second, EU regulatory and policy documents capture the institutional requirements shaping ESG reporting and due diligence in the European context, particularly those related to the CSRD and CSDDD. Third, publicly available industry reports, white papers, and implementation examples illustrate how blockchain-enabled traceability and monitoring have been framed or applied in practice.

Source identification followed a structured but non-systematic review approach. Relevant material was identified through targeted searches in Google Scholar, Scopus, and open-access repositories using combinations of terms such as "blockchain," "supply chain," "traceability," "auditability," "ESG," "sustainability reporting," "CSRD," "CSDDD," and "Europe." The review focused primarily on material published between 2015 and 2025, reflecting the period when blockchain applications in supply chains expanded, and the European ESG regulatory framework became significantly more developed. Additional sources were identified through backward citation tracing from highly relevant academic and institutional publications.

Selection was based on thematic relevance rather than exhaustive coverage. Academic sources were prioritized when they offered conceptual clarity, theoretical framing, or synthesis of implementation challenges. Regulatory and institutional documents were prioritized when they clarified reporting, assurance, and due diligence expectations relevant to European firms. Industry materials were used more selectively, mainly for illustrative purposes rather than as independent evidence of effectiveness, to avoid overstating the empirical maturity of blockchain deployments.

The analytical process followed three steps. First, the literature was reviewed to identify blockchain's core capabilities relevant to supply chain oversight, including secure recordkeeping, improved data verifiability, and automated rule enforcement.

Second, these capabilities were conceptually mapped to the environmental, social, and governance (ESG) dimensions to assess how blockchain could support compliance with CSRD and CSDDD requirements. Third, the study compared blockchain's theoretical potential with evidence from real-world deployments, highlighting the gap between conceptual claims and operational outcomes. Illustrative examples from publicly documented implementations clarify how blockchain functions in practice, without using a formal case study methodology.

This methodological approach allows the paper to connect the technological characteristics of blockchain with the institutional evolution of European sustainability governance. By integrating regulatory analysis with technological and organizational perspectives, the study provides a structured foundation for evaluating whether blockchain can enhance the reliability, auditability, and regulatory readiness of ESG-related information in European supply chains.

The aim of this approach is therefore not to provide a formal systematic review or a case-based evaluation, but to develop a transparent, analytically structured synthesis of how blockchain's governance capabilities align with the evidentiary demands of emerging European ESG regulations.

5 Analysis and Discussion: Governance Implications of Blockchain for ESG Compliance

5.1 Blockchain as a Governance Infrastructure in European Supply Chains

Blockchain introduces a series of structural changes in how firms coordinate, monitor, and verify activities across supply networks, with direct implications for ESG-oriented governance in the European regulatory environment. Traditional oversight mechanisms in supply chains rely primarily on ex post audits and fragmented documentation, offering limited visibility into upstream operations and delayed detection of ESG-related risks (OECD, 2018).

A second governance transformation involves the shift from siloed, paper-based information systems to shared digital infrastructures. In many supply chains, sustainability-relevant data remain dispersed across incompatible databases and proprietary platforms, limiting firms' ability to reconstruct a reliable chain of custody. Blockchain-based architectures address this fragmentation by enabling authorized participants to access a synchronized ledger, reducing duplication and strengthening the consistency of recorded information. For European firms operating under CSRD requirements, such consolidation is particularly relevant, as it supports audit-ready disclosures and improves the interoperability of ESG-related data across organizational boundaries. Smart contracts add a governance layer by embedding rules directly into digital workflows. By automating the validation of documentation, issuing threshold-based alerts, or enabling conditional execution of contractual obligations, smart contracts can implement due diligence requirements more consistently and traceably. In the context of the CSDDD, where firms are expected to demonstrate proactive risk mitigation rather than reactive compliance, such automated mechanisms may support more systematic enforcement of sustainability requirements across supplier networks. However, their effectiveness ultimately depends on the quality of input data and the governance arrangements that define how rules are designed, monitored, and revised.

Blockchain also enhances the verifiability of the chain of custody information by generating tamper-resistant records of product movements and process-level events. Each transaction or transformation is time-stamped and cryptographically secured, creating a durable audit trail that can substantiate claims related to origin, environmental performance, or labor conditions. This capability addresses a central weakness of traditional governance systems, which often rely on unverifiable supplier declarations or documentation that can be selectively curated. In contrast, blockchain-based records provide a more robust evidentiary foundation for sustainability reporting and reduce the risk of greenwashing, an issue repeatedly highlighted by European regulators (ESMA, 2024).

However, blockchain does not eliminate governance challenges; rather, it reconfigures them. Most supply chain implementations rely on permissioned blockchain consortia rather than open public networks. These consortia introduce new forms of network governance in which participating firms collectively determine membership rules, data-access rights, and validation procedures. While this model enhances confidentiality and aligns with European data-protection requirements, it also recentralizes authority within a smaller group of dominant actors. Decisions about who controls validator nodes, who can view specific data fields, and how consensus is reached become critical governance questions in their own right. Power asymmetries may persist if lead firms dictate consortium rules or restrict access to sensitive information, potentially limiting the democratizing potential often attributed to blockchain technologies (Lustenberger & Spychiger, 2025).

Overall, blockchain enables more continuous monitoring, improved data integrity, and automated rule enforcement, but it also introduces new governance arrangements that require careful institutional design. These dynamics are central to evaluating blockchain's contribution to ESG compliance under the CSRD and CSDDD, where regulatory alignment depends not only on technological capability but also on control, access, and accountability structures.

5.2 Blockchain and Transparency as a Governance Outcome

Blockchain's contribution to information visibility is often cited as one of its most significant governance effects in supply chains. By enabling more integrated and auditable records of product movements and sustainability-related events, blockchain addresses long-standing transparency challenges associated with fragmented documentation systems. This capability is particularly important in the European context, where firms must provide reliable, audit-ready ESG data under the CSRD and CSDDD.

A useful example is provided by blockchain-based food traceability initiatives, which use distributed ledgers to record product origin, batch movements, certification events, and handovers across multiple supply chain stages. In these settings, blockchain does not merely store documentation; it creates a shared, time-stamped chain of custody that allows firms and auditors to reconstruct product provenance more quickly and consistently than fragmented paper-based systems. This example is particularly relevant to the European ESG context because it demonstrates how blockchain can enhance auditability, reduce information gaps among supply chain participants, and strengthen the evidentiary basis for sustainability-related claims. At the same time, these initiatives show that the benefits of traceability depend on reliable upstream data entry, agreed participation rules, and interoperability with existing organizational systems.

A central mechanism is the creation of end-to-end traceability across supply networks. When logistical movements, transformations, and handovers are recorded on a shared ledger, firms can reconstruct a product's provenance with much greater precision. Such visibility is particularly relevant in sectors where provenance is linked to regulatory compliance or market value, including food safety, pharmaceuticals, and ethically sourced commodities. By consolidating these events into a synchronized ledger, blockchain reduces informational gaps and strengthens the verifiability of sustainability claims (Saberi et al., 2018).

Blockchain also enables tamper-resistant audit trails for environmental and social data. Certifications, emissions measurements, due diligence findings, and inspection results can be recorded in an immutable form, creating a durable evidentiary base for sustainability reporting. Because entries cannot be altered retroactively without leaving a detectable trace, blockchain reduces opportunities for data manipulation and enhances the credibility of disclosures submitted under European reporting standards. This immutability is particularly valuable for regulators and certifiers, who can access consistent, time-stamped records rather than relying on self-reported information or periodic audits. As a result, verification processes become more efficient, with reduced administrative burden and greater confidence in the underlying data (World Economic Forum, 2020).

However, blockchain does not automatically ensure full transparency. In most supply chain applications, visibility remains selectively distributed through permissioned networks, where access rights and validation procedures are governed by consortium rules rather than open participation. Moreover, blockchain preserves data integrity after entry, but it does not guarantee that upstream inputs are accurate or complete. Its transparency benefits, therefore, depend on data quality, governance design, and the willingness of supply chain participants to engage in shared information systems.

Another limitation concerns data quality at the point of entry. Although blockchain preserves records in an immutable form, it does not guarantee the accuracy of information provided by upstream actors. Without reliable data collection processes, verification mechanisms, and credible third-party oversight, distributed ledgers risk preserving flawed or misleading information instead of improving sustainability governance (Kouhizadeh et al., 2019). Taken together, blockchain enhances transparency by strengthening data integrity, increasing information visibility, and supporting more efficient verification processes. However, its effectiveness depends on data quality, the governance design of permissioned networks, and the willingness of supply chain actors to participate in shared information systems. These conditions ultimately determine the extent to which blockchain can meet the evidentiary requirements of European ESG regulation and reduce the information asymmetries that have historically undermined sustainability oversight.

5.3 Mapping Blockchain Capabilities to ESG Pillars

The relationship between blockchain and ESG performance becomes clearer when the technology's core capabilities are mapped onto the environmental, social, and governance dimensions that structure European sustainability regulation. This section translates the conceptual model developed earlier into a structured analysis aligned with the reporting and due-diligence expectations embedded in the CSRD and CSDDD. Across all three pillars, blockchain offers mechanisms that can strengthen data integrity and verification capacity; however, the extent to which these mechanisms translate into substantive ESG outcomes varies significantly across the environmental, social, and governance domains.

5.3.1 Environmental Capabilities

Blockchain can enhance environmental performance primarily by increasing the granularity of emissions and resource-use data. Several pilot projects show that distributed ledgers can record carbon footprints at the level of individual products or shipments, enabling firms to calculate embedded emissions with greater precision. When combined with IoT devices and sensor networks, blockchain can capture real-time environmental metrics such as energy consumption, temperature control in cold chains, or fuel usage in transport.

Similar logic applies in logistics and cold-chain settings, where blockchain can be combined with sensor-generated records of temperature control, transport conditions, and delivery events. In these contexts, the governance value of blockchain lies less in automation alone and more in creating tamper-resistant environmental records that support verification of handling conditions, spoilage reduction, and emissions-related reporting.

Enhanced information visibility also supports green logistics and waste reduction. More reliable chain-of-custody records enable firms to optimize inventory flows, reduce spoilage, and identify inefficiencies in transport routes. These operational improvements align with CSRD requirements for detailed disclosures on resource efficiency, emissions, and environmental impacts across the value chain.

From a regulatory perspective, blockchain's immutability strengthens the auditability of environmental disclosures. CSRD requires companies to provide verifiable, assurance-ready environmental data; blockchain's tamper-resistant logs offer a mechanism for demonstrating the provenance and reliability of such information. However, the extent of realized improvement varies. While some deployments show measurable gains in emissions tracking and waste reduction, others remain limited to pilot phases or face integration challenges with legacy systems.

5.3.2 Social Capabilities

Blockchain's contribution to the social pillar is more complex. The technology can record labor-related certifications and compliance documentation, including fair trade labels, no child labor attestations, and occupational safety audits, in a tamper-resistant format. This creates a more durable record of supplier commitments and can support CSDDD-aligned due diligence processes by documenting social audits across multiple tiers.

Blockchain also facilitates multi-tier monitoring of supplier practices. Because distributed ledgers can capture events beyond the first tier, they provide a mechanism for tracking whether subcontractors comply with required labor standards. This is particularly relevant for CSDDD, which obliges firms to identify and mitigate adverse human-rights impacts throughout their value chains.

Yet significant limitations remain. Social risks are often qualitative, context-specific, and locally embedded conditions that cannot be fully captured through digital records. Blockchain can log the existence of a certification, but it cannot independently verify whether a factory inspection was rigorous, whether workers were interviewed freely, or whether coercive practices were concealed. There is also a risk of superficial compliance logging, where firms upload certificates without addressing underlying labor issues. As a result, blockchain's contribution to the social pillar should be understood as complementary to, rather than a substitute for, substantive social governance and enforcement mechanisms.

5.3.3 Governance Capabilities

Blockchain's strongest alignment with ESG objectives is in the governance pillar. Distributed ledgers can enhance anti-corruption controls and oversight by recording payments, approvals, and contractual milestones in a tamper-resistant format. This reduces opportunities for unauthorized transactions, retrospective alterations, and selective disclosure, thereby strengthening procurement integrity and internal control systems in global supply chains. Immutable transaction histories also provide a more reliable evidentiary base for boards, auditors, and regulators, supporting CSRD requirements for demonstrable data reliability and verifiable sustainability disclosures. Furthermore, blockchain enhances the credibility of ESG reporting by limiting firms' ability to selectively disclose or conceal information. This is particularly relevant in the European context, where regulators have expressed concern about greenwashing and the opacity of sustainability claims. By providing a secure record of data inputs and verification events, blockchain can help ensure that reported information reflects actual performance rather than narrative framing.

5.3.4 Uneven Effects Across ESG Pillars and Scaling Challenges

Across all three pillars, blockchain offers greater potential to support ESG compliance, particularly in the environmental and governance domains where data structures are more quantifiable and verification needs are clearer. However, the actual impact remains partial and uneven. Many deployments are still in the pilot stage, with limited long-term evidence of sustained improvements. Adoption gaps, interoperability challenges, and regulatory frictions, especially regarding data protection and consortium governance, continue to constrain scalability. In the social domain, blockchain's contribution is inherently limited by the qualitative nature of many labor-related risks.

Overall, blockchain can strengthen the institutional foundations of ESG compliance under CSRD and CSDDD; however, its effectiveness ultimately depends on data quality, network participation, and alignment with broader organizational and regulatory infrastructures rather than on technological adoption alone.

5.4 Limitations, Risks, and Open Issues

Although blockchain offers significant opportunities to enhance oversight and improve the reliability of sustainability-related information, its adoption in European supply chains remains limited by technical, regulatory, organizational, and ESG-specific challenges. A critical assessment of these limitations is essential to avoid deterministic narratives and to situate blockchain within the broader institutional transformations required by the CSRD and CSDDD.

5.4.1 Technical and Economic Constraints

A first set of limitations concerns the technical and economic feasibility of blockchain deployment. Interoperability remains a persistent challenge, as supply chain actors often operate heterogeneous IT systems, and blockchain platforms themselves are fragmented across competing architectures (Kouhizadeh et al., 2019; Treiblmaier, 2018). Scalability presents a related constraint. Even permissioned blockchains can encounter performance bottlenecks when processing large volumes of transactions, particularly in data-intensive sectors. These technical challenges are compounded by significant implementation and maintenance costs, which may discourage small and medium-sized enterprises from participating in blockchain-enabled networks (World Economic Forum, 2020). Consequently, the economic burden of adoption risks reinforcing existing asymmetries between large lead firms and smaller suppliers.

Another practical constraint is the uneven digital maturity of supply chain participants. Blockchain-based systems are often discussed as if all firms can connect to shared infrastructures under similar conditions, but in practice, suppliers differ significantly in data management capacity, IT integration, and readiness to comply with standardized reporting requirements. This heterogeneity is especially important in cross-border supply chains, where smaller firms may still rely on manual documentation, fragmented enterprise systems, or low-cost digital tools that are not easily interoperable with blockchain platforms. Therefore, the technical feasibility of distributed ledgers depends not only on the platform's architecture but also on the broader digital preparedness of the surrounding network.

5.4.2 Regulatory and Legal Tensions

Blockchain also raises regulatory and legal tensions that are particularly significant in the European context. The immutability of distributed ledgers is at odds with the General Data Protection Regulation (GDPR), which grants individuals the right to rectification and erasure of personal data. Finck (2019) and European Commission (2022) note that this tension is structural rather than incidental: immutable ledgers challenge core GDPR principles, and proposed workarounds, such as off-chain storage or hashed identifiers, introduce additional complexity and may undermine the integrity of the ledger. Cross-border data transfer rules further complicate blockchain deployments in global supply chains, especially when nodes are distributed across jurisdictions with differing data protection regimes (Casino et al., 2019). Questions of liability also remain unresolved: if incorrect or fraudulent data are recorded on-chain, responsibility may be ambiguous, creating legal uncertainty for firms relying on blockchain for CSRD- or CSDDD-related disclosures.

Regulatory uncertainty extends beyond data protection in a narrow sense. In the European context, firms must ensure that digital governance systems are not only technically functional but also compatible with evolving expectations for assurance, accountability, and evidentiary reliability. This raises unresolved questions about the legal status of blockchain records in audit and compliance procedures, the admissibility of smart contract–generated actions as evidence of due diligence, and the allocation of responsibility when multiple actors contribute to a shared ledger. Until these issues are clarified, many firms may remain cautious about relying too heavily on blockchain as a primary compliance infrastructure.

5.4.3 Organizational and Political Dynamics

Beyond technical and legal issues, blockchain adoption is influenced by organizational and political dynamics within supply networks. Many firms are reluctant to share operational data due to concerns about competitive advantage, exposure of sensitive information, or reputational risk. Khan et al. (2023) and Karaduman & Gülhas (2025) show that organizational reluctance to share operational data–rooted in concerns about trust, information misuse, and technology governance–remains a significant barrier to blockchain adoption in supply chains, and that the design of permissioned blockchain networks can both mitigate some of this resistance and introduce new governance challenges related to control, access rights, and stakeholder power dynamics. Lustenberger & Spychiger (2025) and Saberi et al. (2018) argue that these dynamics can undermine the collaborative potential of blockchain and limit the extent to which information visibility is truly distributed across the supply chain.

These organizational dynamics are particularly significant in multi-tier supply chains, where smaller suppliers often lack the technological capabilities, financial resources, or administrative capacity needed to participate in blockchain-enabled reporting systems. While lead firms may see distributed ledgers as tools to improve compliance and visibility, upstream suppliers may regard them as additional reporting burdens with little proportional benefit. This results in an uneven distribution of compliance costs, especially when suppliers are expected to invest in digital infrastructure, data standardization, or staff training to meet the information requirements of dominant buyers. In such contexts, blockchain may reinforce rather than reduce structural asymmetries, as firms with greater bargaining power define the technical architecture, access conditions, and reporting expectations for the broader network.

A related issue concerns the institutional legitimacy of blockchain-based governance arrangements. Even when supply chain actors formally agree to participate in a permissioned consortium, trust in the system is not generated automatically by technology. Participants must also perceive the rules for data access, validation, dispute resolution, and platform oversight as fair and credible. If consortium governance is seen as opaque or disproportionately controlled by a small group of lead firms, other actors may engage only minimally, share data selectively, or treat the platform as a compliance formality rather than a meaningful coordination mechanism. This suggests that the success of blockchain in ESG-oriented supply chain governance depends not only on technical robustness but also on procedurally legitimate governance structures that distribute responsibilities, rights, and incentives in ways perceived as acceptable across the network.

5.4.4 ESG-Specific Risks and Symbolic Adoption

A final set of concerns relates to ESG-specific skepticism. Critics warn that blockchain may be used to signal technological sophistication without addressing underlying governance failures–a phenomenon sometimes described as "blockchain-washing." Nikolakis et al. (2018) caution that blockchain can entrench superficial certification practices by recording the existence of labels or audits without ensuring their substantive quality. LeBaron & Lister (2021) similarly show that certification systems often mask underlying labor issues, suggesting that blockchain may digitize rather than resolve these structural weaknesses. ESMA (2024) further warns that unverifiable sustainability claims remain a systemic risk, even when supported by digital tools. Without robust verification processes, blockchain risks becoming a technologically sophisticated repository for flawed information rather than a mechanism for improving sustainability governance.

This risk is particularly relevant in regulatory environments where firms face increasing pressure to demonstrate visible compliance with sustainability standards. In such contexts, blockchain may be adopted not because it transforms underlying governance practices, but because it offers a convincing appearance of control, innovation, and traceability. The symbolic value of blockchain can thus become disconnected from substantive improvements in environmental or social performance. In this sense, the danger is not only technological overstatement but also institutional complacency: once digital traceability tools are implemented, firms and external stakeholders may overestimate the extent to which underlying risks have actually been reduced.

5.4.5 Integrated Assessment

Taken together, these limitations show that blockchain should be understood as a contingent governance instrument rather than a self-sufficient compliance solution. Its value lies in improving traceability, auditability, and procedural consistency, but these benefits depend on regulatory alignment, interoperable infrastructure, organizational cooperation, and credible data-generating practices across the supply chain.

From this perspective, the central issue is not whether blockchain can contribute to ESG governance, but under what conditions such contributions become credible, scalable, and institutionally meaningful. Its value is likely greatest where verification demands are high, data points are relatively codifiable, and participating actors share sufficient incentives to maintain common standards. In contrast, in fragmented supply chains marked by weak trust, uneven digital capabilities, and ambiguous accountability, blockchain may add complexity without resolving the underlying governance deficit. A balanced assessment therefore requires attention not only to technological potential, but also to the institutional fit between blockchain architectures and the broader regulatory and organizational environments in which they operate.

6 Conclusion and Implications

6.1 Direct Answer to the Research Question

This paper examines how blockchain reshapes governance and information visibility in European supply chains and to what extent these changes enhance ESG performance under the CSRD and CSDDD. The analysis demonstrates that blockchain introduces a measurable shift towards more data-driven, traceable, and auditable governance structures, replacing fragmented documentation systems and periodic inspections with continuous, tamper-resistant information flows. These changes strengthen firms' ability to monitor upstream activities, verify sustainability claims, and maintain reliable audit trails. However, these governance transformations occur predominantly within permissioned blockchain consortia, where access rights, validation rules, and data visibility remain subject to consortium-level control. As a result, blockchain reconfigures rather than eliminates existing power asymmetries, and transparency remains selectively distributed rather than universal.

Regarding ESG enhancement, the findings suggest that blockchain is most useful in the environmental and governance pillars, where verification needs are clearer and data structures are more easily codified. It can improve emissions tracking, documentation reliability, and the auditability of due diligence processes, thereby supporting the evidentiary requirements of the CSRD and CSDDD. However, its contribution remains partial: social risks are often less amenable to digital codification, and implementation outcomes continue to vary across sectors and organizational settings. Blockchain, therefore, strengthens the institutional foundations of ESG compliance but does not replace broader governance, enforcement, or supplier engagement mechanisms.

6.2 Implications for Policymakers, Companies, and Researchers

The findings of this study have several implications for the key actors shaping the future of ESG-aligned supply chain governance in Europe. For policymakers, the analysis highlights that regulatory ambition increasingly depends on data infrastructures that support it. The analysis also underscores the need for clearer institutional guidance on integrating blockchain into the CSRD and CSDDD compliance landscape. Interoperability standards remain underdeveloped, and without common technical protocols, blockchain networks risk fragmentation and incompatibility. Regulators may therefore need to promote standardized data models, shared taxonomies, and certification frameworks that enable cross-platform communication. In addition, the persistent tension between blockchain's immutability and the GDPR suggests a need for regulatory clarification or interpretive guidance to help firms navigate data protection obligations when using distributed ledgers. Policymakers may also consider incentives for responsible data sharing, particularly in sectors where supply chain opacity has historically undermined sustainability oversight.

For companies, blockchain adoption requires strategic decision-making rather than technological enthusiasm. Firms must assess where blockchain meaningfully improves oversight, such as emissions tracking, auditability, or multi-tier supplier monitoring, and where alternative digital tools may be more appropriate. Effective implementation also depends on collaboration across supply chain partners, as blockchain's value emerges only when a critical mass of actors participates in the network. This means that firms must invest not only in technology but also in supplier engagement, capacity building, and data quality assurance. The analysis further highlights the importance of addressing governance questions within permissioned consortia, including node control, access rights, and decision-making procedures, to avoid reproducing existing power asymmetries.

For researchers, the study identifies several avenues for future inquiry. Much of the existing evidence on blockchain's ESG impact is conceptual or based on early-stage pilots. There is a clear need for empirical, longitudinal research examining how blockchain performs in mature deployments, particularly within European regulatory contexts. Comparative studies evaluating blockchain alongside other digital technologies, such as IoT systems, cloud-based traceability platforms, or

AI-enabled risk analytics, would also help clarify where blockchain offers distinctive advantages. Finally, more work is needed on the social dimension of ESG, where blockchain's contributions remain limited and where qualitative, context-specific risks challenge the assumptions of digital traceability.

6.3 Limitations of the Study

The contributions of this paper must be interpreted in light of several methodological limitations. First, the analysis is conceptual and literature-based, relying on secondary sources rather than primary empirical data. While this approach is suitable for synthesizing emerging insights across technology, governance, and regulation, it limits the ability to assess how blockchain performs in fully operational, large-scale European supply chain settings. Many of the cases referenced in the literature remain pilot projects or early-stage deployments, and the evidence base is therefore uneven across sectors and ESG dimensions.

Second, the study draws primarily on published and publicly documented cases, which may overrepresent successful or well-publicized implementations while underrepresenting failed, abandoned, or commercially sensitive projects. This introduces a degree of publication bias that cannot be fully eliminated. Third, the analysis focuses on the European regulatory environment, particularly the CSRD and CSDDD. While this provides a coherent institutional framework, it also means that findings may not be directly generalizable to jurisdictions with different regulatory architectures, data-protection regimes, or supply chain structures.

Finally, mapping blockchain capabilities to ESG pillars necessarily simplifies the complexity of real-world sustainability challenges. Environmental and governance metrics are more amenable to digital traceability than many social issues, which are qualitative, context-specific, and resistant to codification. Therefore, the conclusions should be interpreted as analytically indicative rather than empirically definitive, especially regarding large-scale operational performance and the social dimensions of ESG.

6.4 Final Reflection

Taken together, the findings of this study suggest that blockchain represents a meaningful, though not definitive, step towards more accountable and transparent supply chain governance in Europe. The technology's capacity to generate tamper-resistant audit trails, support continuous monitoring, and strengthen the evidentiary basis of sustainability disclosures aligns closely with the institutional demands introduced by the CSRD and CSDDD. Yet blockchain's impact is neither automatic nor universal. Its effectiveness depends on the quality of underlying data, the governance structures of permissioned networks, and the willingness of firms to collaborate across organizational and competitive boundaries. These conditions highlight that blockchain is best understood not as a standalone solution but as one component within a broader socio-technical system that includes regulatory frameworks, organizational practices, and human judgement.

The broader implication is that technological innovation alone is insufficient to resolve the structural challenges of sustainability governance. Blockchain can enhance visibility, reduce information asymmetries, and support more credible reporting, but it cannot substitute for robust due diligence processes, meaningful supplier engagement, or strong regulatory enforcement. As European supply chains adapt to increasingly stringent ESG expectations, blockchain may serve as valuable enabling infrastructure, improving the reliability of sustainability information and supporting more consistent oversight. Its long-term contribution, however, will depend on how effectively it is integrated into the institutional, organizational, and social arrangements that underpin responsible business conduct.

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