

Decentralised Supply Chain Reputation: A Privacy and Self-Sovereign Identity Perspective

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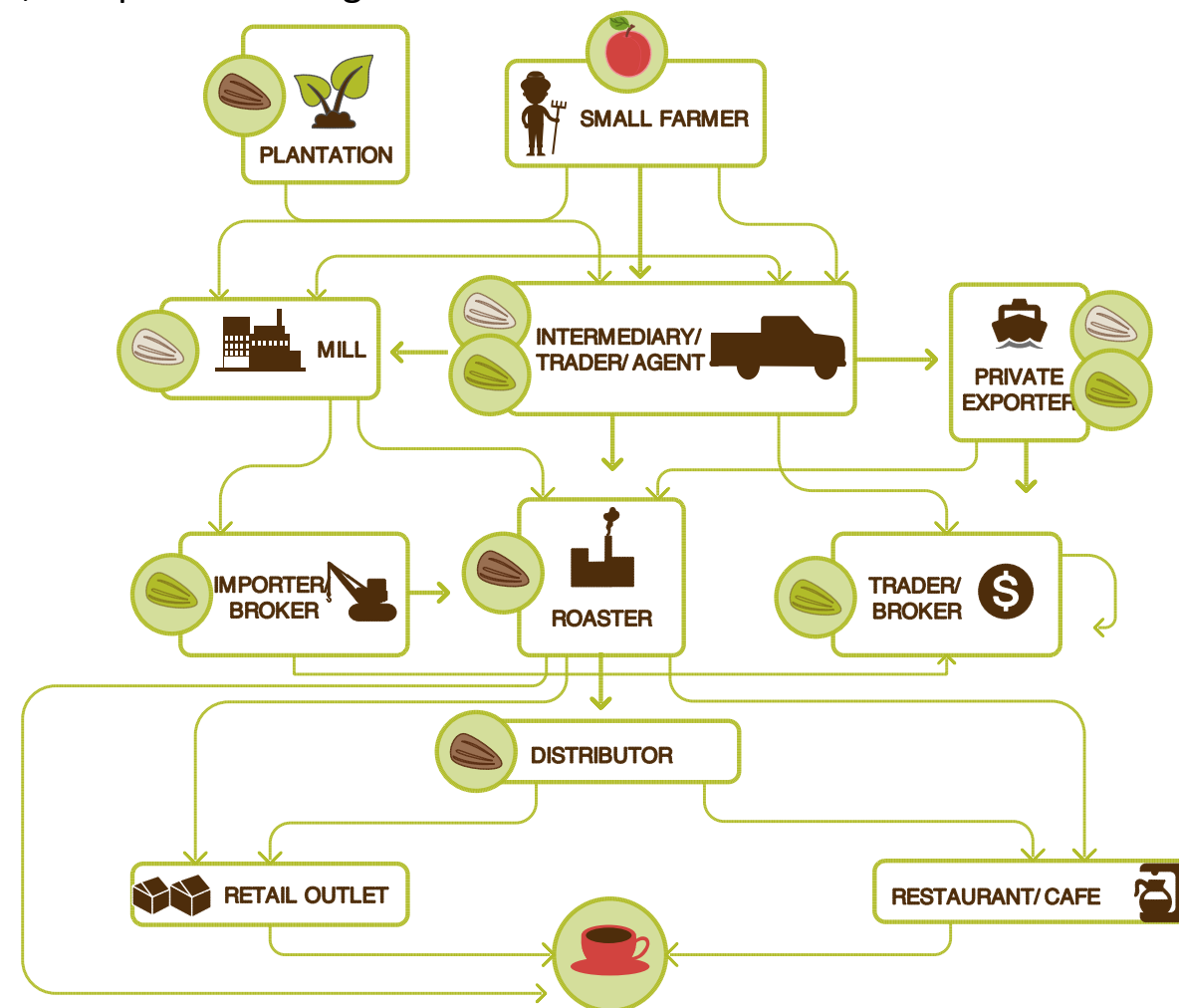


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Supply Chain Use-Case

- Supply chain is the interconnected journey that raw materials, components and goods take before their sale to customers (McKinsey & Company)
 - Supply chain management is a large area of study
 - Significant complexity
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- Controlling the processes and movement of goods involves policies and methods

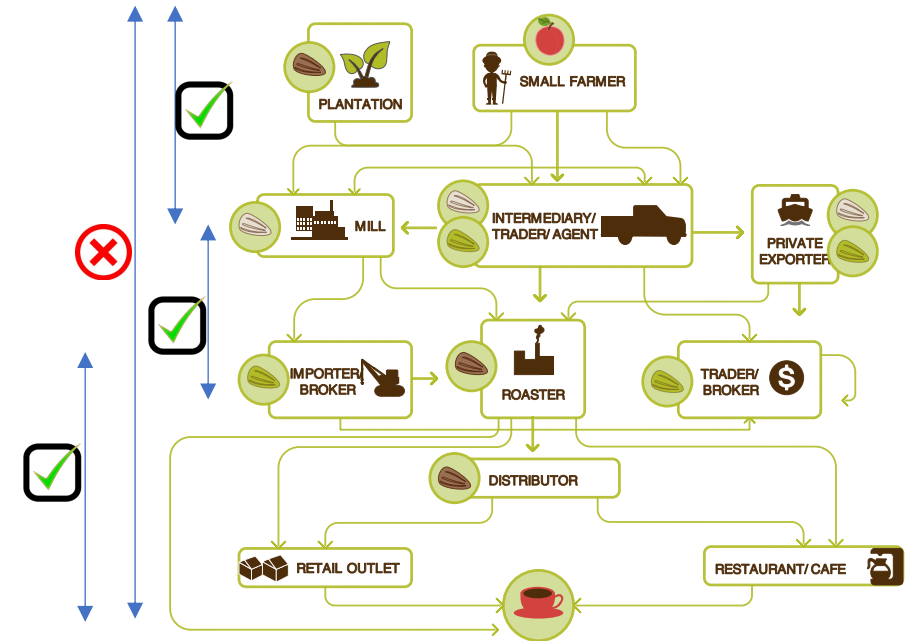


Problem Context & Motivation

- Supply chain vulnerabilities
 - Fragmented trust, data silos, regulatory gaps
 - Leading to blind spots and compliance risks



- Core challenge
 - Achieving end-to-end accountability while balancing transparency and privacy
 - Social sustainability concerns
 - Inconsistent quality assurance
 - Inadequate interoperability across systems and compliance registries



Research Objectives and Contributions

- Objectives
 - How does the literature address trade offs in transparency vs. privacy?
 - To what extent do these works integrate decentralisation for identity verification/audits?
 - How are compliance records/incentives embedded for accountability?
- Contributions
 - **Identify gaps** in supply chain reputation system design
 - **Examine alignment** with digital identity verification
 - **Analyse SSI requirements** integration
 - **Investigate compliance** records integration

Methodology

Systematic Review

Period: January 2022 - January 2025

Language: English only

Selection Process

Initial pool: 1,437 documents

After screening: 21 studies selected

Tool used: Rayyan systematic review platform

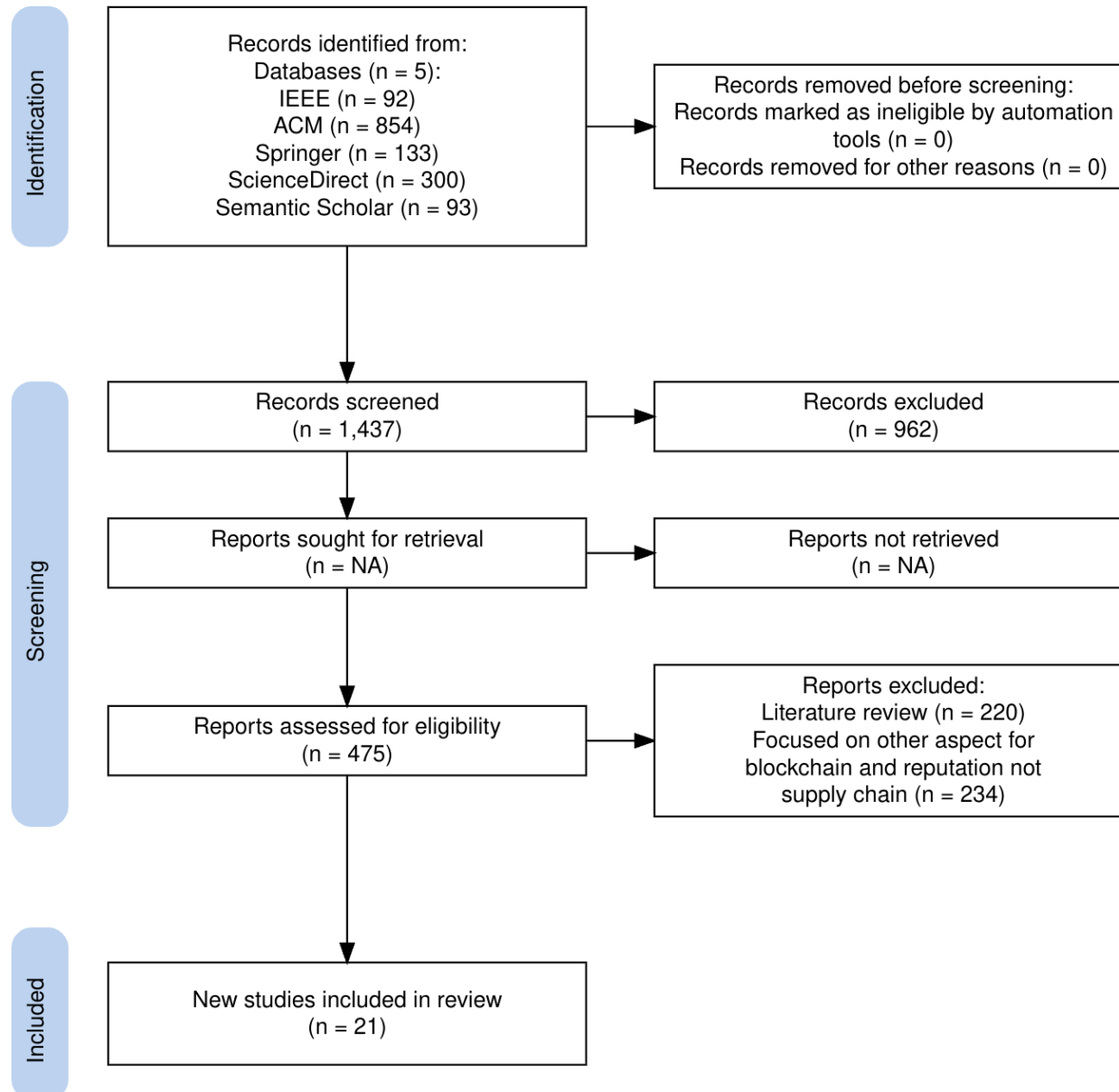
Analysis Framework

Blockchain technology adoption

Supply chain issues addressed

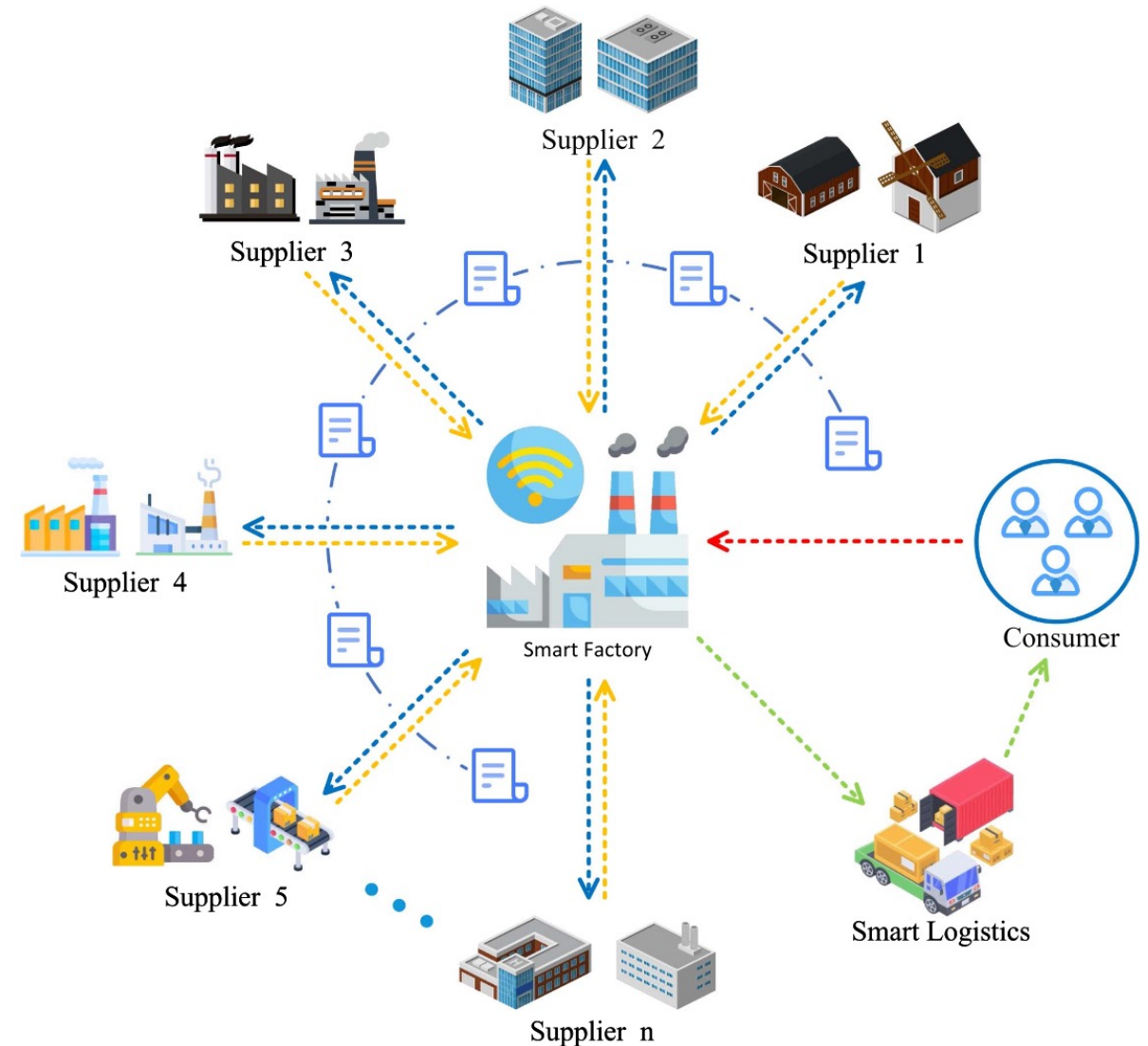
Proposed solutions

Reputation system roles



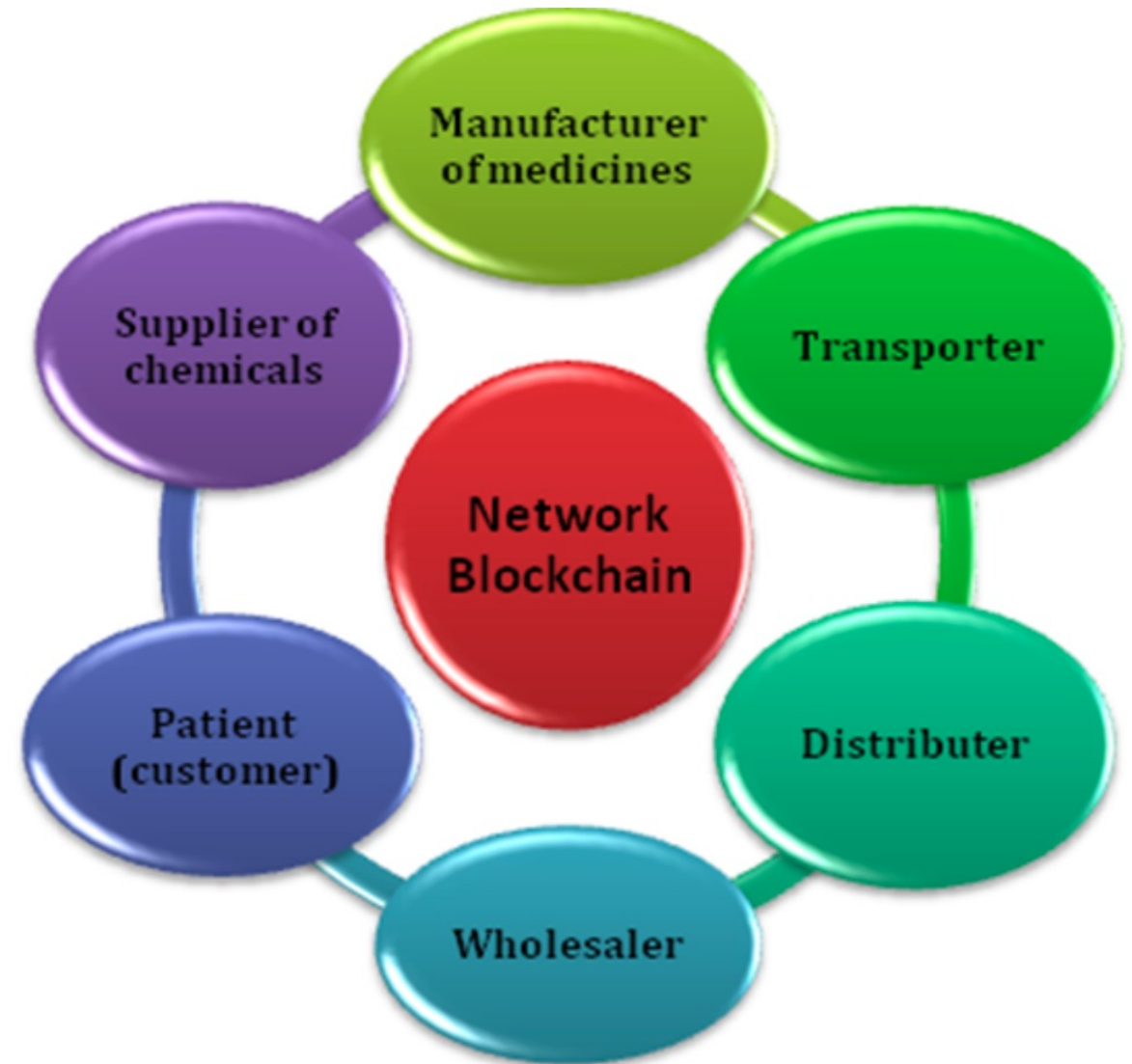
Transparency vs. Privacy

- Approaches in the literature
 - **Consortium blockchains** with weighted scoring
 - **Smart contracts** for objective feedback
 - **IoT integration** linking physical to digital
 - **Hybrid approaches** combining blockchain + hardware security
- Limitations/Challenges
 - Oversimplified scoring e.g binary/weighted, ignores compliance
 - Partial centralisation of trusted authorities
 - Interoperability barriers e.g IoT/blockchain data silos.



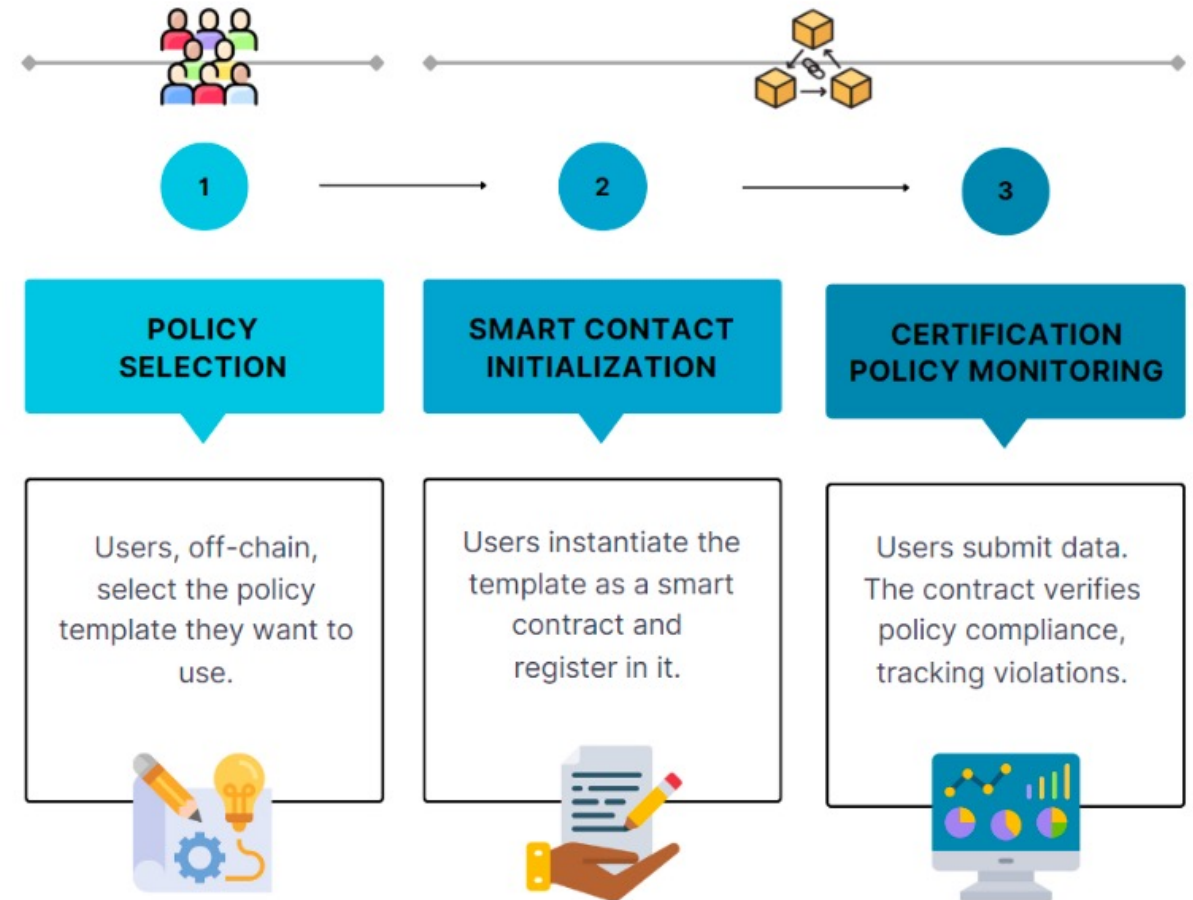
Digital Identity in Supply Chain

- Approaches in the literature
 - **QR codes** for product authentication
 - **Federated identities** with IoT integration
 - **Immutable records** for traceability
- Limitations/challenges
 - Limited scoring methods (credential authorities)
 - Fragmented interoperability (No cross system collaboration standards).
 - Inadequacy in privacy controls (user control, minimal disclosure).



Compliance and accountability in Supply Chain

- Approaches in the literature
 - **IoT sensor validation** with smart contracts
 - **Game-theoretic models** for fraud mitigation
 - **Blockchain integration** for traceability
 - **Cross-chain frameworks** for interoperability
- Limitations/Challenges
 - No proactive compliance incentives (tokenised rewards)
 - Limited real-time penalty enforcement
 - Poor integration with industry standards and legal frameworks



Domains Covered



Domain	Technology	Key Contribution
Agriculture	Blockchain + IoT/RFID	Cost-efficient traceability
Pharmaceutical	Ethereum + QR codes	Anti-counterfeit authentication
Transportation	Consortium blockchain	Tamper-proof supplier ratings
Manufacturing/Logistics	Permissioned BC + digital twins	Physical-digital alignment
Energy/Electronics	Blockchain HSM + trust algorithms	Dynamic security frameworks
Cross-Domain	ZKP + MPC	Privacy-preserving compliance

Signature	Year	Domain	Technology	Key Contribution
Blockchain for supply chain traceability [1]	2016	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [2]	2017	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [3]	2018	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [4]	2019	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [5]	2020	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [6]	2021	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [7]	2022	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [8]	2023	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [9]	2024	Supply Chain	Blockchain	Traceability and provenance
Blockchain for supply chain traceability [10]	2025	Supply Chain	Blockchain	Traceability and provenance

Privacy Principles Incorporated

(GDPR, SSI & Proposed Principles)

Privacy Principles	Fulfillment
Integrity, Confidentiality/Security	19/21
Transparency	18/21
Accuracy	14/21
Storage control	11/21
Persistence	7/21
Accountability	6/21
Interoperability	6/21
Sovereignty	5/21
Purpose limitation	4/21
Data minimisation	3/21
Existence	2/21
Portability	0
Lawfulness/Fairness	0
Recovery	0

Gaps Identified

1. Reputation System Limitations

- Oversimplified scoring: Binary or limited-factor models
- Centralisation paradox: Blockchain systems still relying on trusted authorities
- Compliance blind spots: Missing certification and regulatory metrics

2. Digital Identity Fragmentation

- Interoperability failures: No cross-system standards
- Privacy vs transparency conflicts unresolved
- SSI integration gaps: Limited user-centric designs

3. Accountability Mechanisms

- Passive detection focus: Lack of proactive compliance incentives
- Legal framework disconnect: Poor integration with enforceable regulations
- Scalability challenges: Multi-tier global supply chain complexity

Conclusion

- Decentralised transformative potential enables transparency but gaps in privacy/accountability persist.
- Work is ongoing to address some of the gaps identified in this study

Key Contribution:

- First systematic review linking SSI, privacy, and decentralised SC reputation.
 - Roadmap for resilient, user-centric Industry 4.0 supply chains.

Questions!

Thank you for your attention

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