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Blockchain + AI: The New Era of Transparent Supply Chains

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Introduction



Since the 1990s, global supply chains have shifted from static, linear models to dynamic, technology-enabled networks. They have become more agile and increasingly focused on real-time responsiveness to demand and disruption.

Companies like Walmart and Procter & Gamble led the move toward integrated information systems, deploying enterprise resource planning (ERP) to enhance coordination and control. These systems have resulted in major efficiency gains, but visibility across the supply chain still remains fragmented. It is not a surprise, given the complex nature of global supplier networks.

However, this cannot be treated like a norm anymore. Today, visibility is not something that is 'good-to-have'. It is not simply an operational benefit, but a strategic necessity. The ability to monitor inventory, shipments, production, and warehouse conditions in real time helps companies respond faster, minimize risk, and build stronger supply chains. This capability also lays the foundation for compliance with regulatory frameworks, supports operational sustainability, and enables better cross-partner coordination.

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The importance of visibility is underlined by the growth of the global supply chain management market, which was valued at USD 23.58 billion in 2023. It is projected to reach USD 63.77 billion by 2032, growing at a CAGR of 11.7%. North America led the market with a 32.49% share in 2023.

When speaking of visibility, one cannot ignore transparency. Often confused with each other, these two do not mean the same thing. Companies are being held accountable for what happens deep inside their supply networks.

That is what transparency entails: the active disclosure of business practices, ethical sourcing, environmental impact, and financial accountability.

For true supply chain shift, both visibility and transparency must be achieved together.

Supply Chain Visibility vs. Transparency

Characteristic	Visibility	Transparency
Tracking	Real-time tracking of inventory, shipments, and assets	Willingness to disclose supplier practices and impacts
Purpose	Informs operational decisions and risk responses	Builds trust with consumers, regulators, and stakeholders
Benefit	Enables partner coordination and faster execution	Supports ESG compliance and brand integrity
Technology	Powered by IoT, sensors, AI, and analytics	Enhanced with AI, blockchain and ERP systems
Focus	External Operational focus	External disclosure focus

Blockchain and AI technologies are now enabling a new level of visibility that directly supports transparency. **Blockchain offers an immutable ledger where every action, from raw material sourcing to delivery, can be recorded and verified.** Smart contracts automate business rules, enforcing compliance without manual oversight. This means traceable provenance of goods, accurate tracking, and controlled access to critical data.

AI strengthens this by analysing vast datasets, detecting anomalies, predicting disruptions, and ensuring the right insights reach the right stakeholders. Combined, these technologies can remove the blind spots that have long challenged global supply chains.

This whitepaper will explore three critical areas where blockchain and AI deliver transparency that traditional systems cannot:

- 1. Conventional Record Keeping vs Blockchain:** Why distributed, tamper-proof records outperform traditional ledgers in securing trust.
- 2. ESG Tracking and Traceability:** How transparency tools support environmental and ethical standards with verifiable data.
- 3. Enhanced Security Across Supply Chains:** How AI and blockchain reduce fraud, prevent counterfeiting, and secure sensitive information.

How Blockchain and AI can Outperform Conventional Record Keeping for Better Transparency

Traditional supply chains were built for stability, not agility. To protect against delays, shortages, or disruptions, supply chain leaders often relied on redundancy. This included carrying excess inventory, duplicating vendors, or stockpiling critical materials. This reactive model still dominates many industries today. But with rising complexity and global interdependence, such redundancy is no longer sustainable on its own. Businesses now need systems that offer real-time clarity and proactive risk mitigation. The static nature of conventional record-keeping exposes the loopholes when it comes to obtaining better visibility and accountability that are needed in a transparent supply chain.

Blockchain (in some cases, along with AI) is changing the game.

Since 2019, some of the world's largest enterprises have begun investing in blockchain-powered supply chain systems. While many made public announcements, others moved quietly. One example is Target. As early as mid-2018, the Minnesota-based retailer began developing ConsenSource, a blockchain-based supply chain management system designed to improve traceability and data integrity. Target has also pledged support for Hyperledger Grid, a Linux Foundation project aimed at building cross-industry supply chain tools on top of distributed ledger infrastructure.

These moves represent a pivot toward a new foundation for record keeping. The traditional systems are no longer enough.

Suitable for Simple and Complex Systems

Even a basic supply chain transaction, say, a shipment of 500 units from supplier to warehouse to retailer, involves inventory data, shipping documents, payment entries, and confirmation from all parties. In most cases, this is managed through ERP systems and financial ledgers. But these systems are siloed. Supplier, buyer, and logistics provider rarely have simultaneous access to the same version of the truth. As a result:

- Duplicate payments might go unnoticed
- Shipment mismatches are caught too late
- Journal entries are disconnected from inventory records
- Dispute resolution becomes expensive and time-consuming

Blockchain eliminates this. Every movement, update, and financial transaction is recorded in an immutable, shared ledger. No single party controls the data and everyone sees the same version, with access governed by permissions. AI systems, when integrated with blockchain, can monitor these entries in real time to detect anomalies, flag inconsistencies, and predict downstream impacts before they escalate.

Practical Benefits: Blockchain and AI in Supply Chain Record Keeping ...

1. Data Consistency Across Stakeholders

Blockchain ensures that all authorized parties see the same record in real time. No reconciliation needed between systems.

Actionable Outcome: Less time resolving disputes, faster invoice approvals, stronger vendor relationships.

2. Automated Contract Enforcement

Smart contracts can enforce terms such as delivery timelines, quality thresholds, and payment conditions.

Actionable Outcome: Reduced errors, instant payment releases upon fulfillment, zero manual oversight needed.

2. End-to-End Traceability

Blockchain assigns a digital fingerprint to every product and transaction. AI maps relationships between events.

Actionable Outcome: Product recalls are faster, fraud is harder, and compliance audits are simplified.

2. Predictive Risk Management

AI models trained on blockchain data can forecast disruptions, detect fraud patterns, and highlight operational bottlenecks.

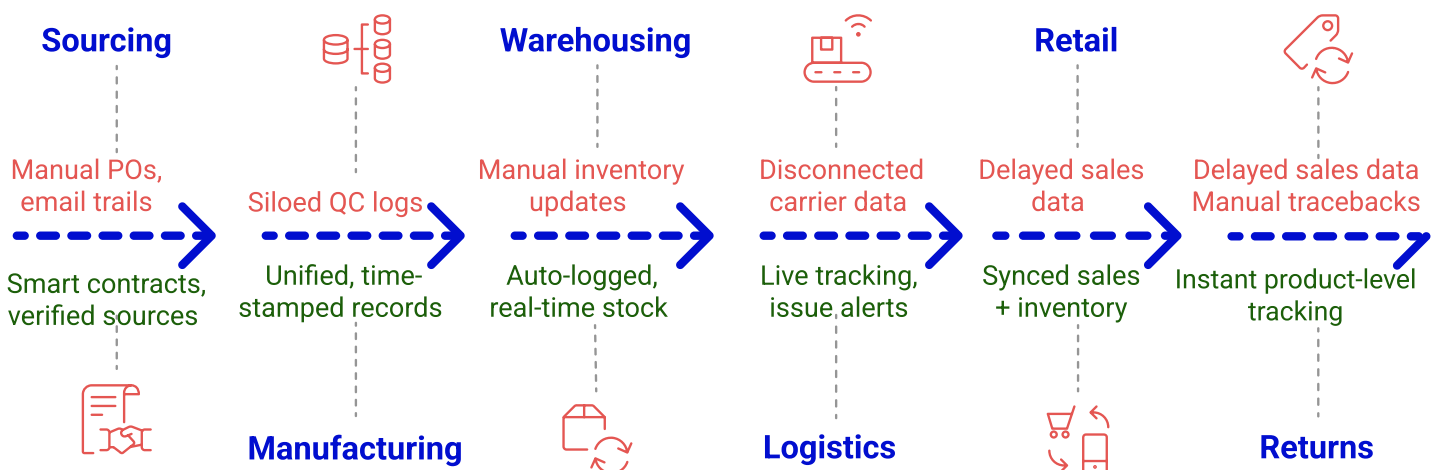
Actionable Outcome: Faster response to exceptions, fewer unplanned delays, improved supply chain resilience.

2. Immutable Proof of Activity

Every update or transaction logged on blockchain is timestamped and tamper-proof.

Actionable Outcome: Reliable audit trails, enhanced trust, and long-term data integrity.

Supply Chain Process Transformation



Legacy record keeping systems weren't built to handle the speed, scale, or complexity of modern supply chains. Blockchain and AI solve this by creating verifiable, unified, and intelligent records that are available to all the right players, at the right time. For organizations aiming to operate leaner, faster, and more transparently, these technologies are going to become foundational.

Compliance of ESG Standards with Digital Proof

True and transparent compliance of environmental, social, and governance (ESG) standards requires verifiable data and end-to-end supply chain visibility. Customers, regulators, and investors now expect **clear evidence of ethical sourcing, reduced emissions, and supplier accountability**. Traditional methods, such as manual audits, static reports, and supplier self-assessments often fall short. They are slow, disconnected, easy to falsify, and fail to give decision-makers real-time visibility.

Blockchain and AI technologies directly address this gap by turning ESG claims into verifiable, tamper-proof records. They **support end-to-end supply chain traceability, automate compliance reporting, and enable near-instant feedback on sustainability performance**.

1. Supply Chain Traceability: Tracking from Origin to End Use

Blockchain allows companies to track raw materials, production processes, and shipment movements in real time. Every event is recorded in an immutable ledger, accessible only to authorized parties, with precise timestamps and location data.

This directly supports:

- Ethical sourcing by verifying that materials come from approved, conflict-free sources
- Labor rights monitoring by documenting supplier practices and working conditions
- Fraud prevention through real-time inventory validation and tamper-proof certificates

Case Example:

Sainsbury's is using Everledger's blockchain technology to monitor the full lifecycle of its diamonds—from extraction to sale. This ensures ethical sourcing and gives customers clear, verifiable insight into the origin of their purchase.

2. Carbon Credit Verification: Eliminating Double Counting and Fraud

Managing carbon credits involves multiple parties, registries, and transactions. Without a shared system of record, double counting, fraudulent entries, and data loss are common. Blockchain digitizes carbon credits as traceable, non-duplicable tokens. It links them to actual energy use or offset projects, verified using data from IoT sensors and AI-based validation systems.

Key outcomes are:

- Authenticity, as every credit has a unique, trackable digital signature
- Transparency, since stakeholder can verify how credits were issued, transferred, and retired
- Real carbon offsetting due to transparent credits trading

Platform Example:

DCarbonX enables secure and auditable carbon trading. It combines blockchain-based tokenization with automated verification protocols to avoid double-spending and falsified offsets.

3. Automated ESG Reporting: From Periodic to Real-Time

Traditional ESG reporting is time-consuming. It requires data from multiple systems, manual consolidation, and time lag between activity and disclosure. Blockchain simplifies this by capturing ESG-relevant data at the point of activity. AI processes this data to produce insights and generate reports with minimal human intervention. ...

Benefits include:

- Faster compliance cycles
- Higher data accuracy
- Automated anomaly detection
- Continuous stakeholder engagement through live dashboards

This improves transparency for investors, regulators, and consumers—and reduces internal reporting burden.

4. Managing Supplier Performance Across Complex Networks

Supply chains rarely consist of just one supplier tier. Brands must evaluate dozens or hundreds of partners. Conventional methods, like paper audits or disconnected spreadsheets, make holistic ESG oversight difficult.

Blockchain resolves this by storing supplier declarations, certifications, and activity logs in a single, unified ledger. AI identifies gaps, flags inconsistencies, and measures actual performance over time. This makes supplier evaluation proactive, not reactive.

Example:

Canadian apparel brand Tentree uses blockchain to track the journey of raw fibers through to finished clothing. This includes environmental impact data and third-party certifications. The result is a product-level record of ESG compliance.

5. Quantifying Emissions and Environmental Impact

AI and IoT-powered smart sensors can monitor factory emissions, energy usage, and transportation data in real time. Blockchain then records this data chronologically and securely. Unlike spreadsheets or self-reporting, this method prevents manipulation and provides granular, timestamped proof of compliance...

Blockchain + AI support:

- Accurate emission reporting
- Granular energy audits
- Verification of energy savings or offsets
- Baseline-to-improvement tracking across facilities

This combination ensures environmental claims can be backed by measurable, objective data, not estimates or self-declared values.

Enabling Accountability with Proof

Speaking with suppliers about their ESG policies or receiving documentation is not enough. Many brands rely on what partners report. But as third parties play a critical role in production and distribution, relying on unverifiable input leads to ESG risk exposure.

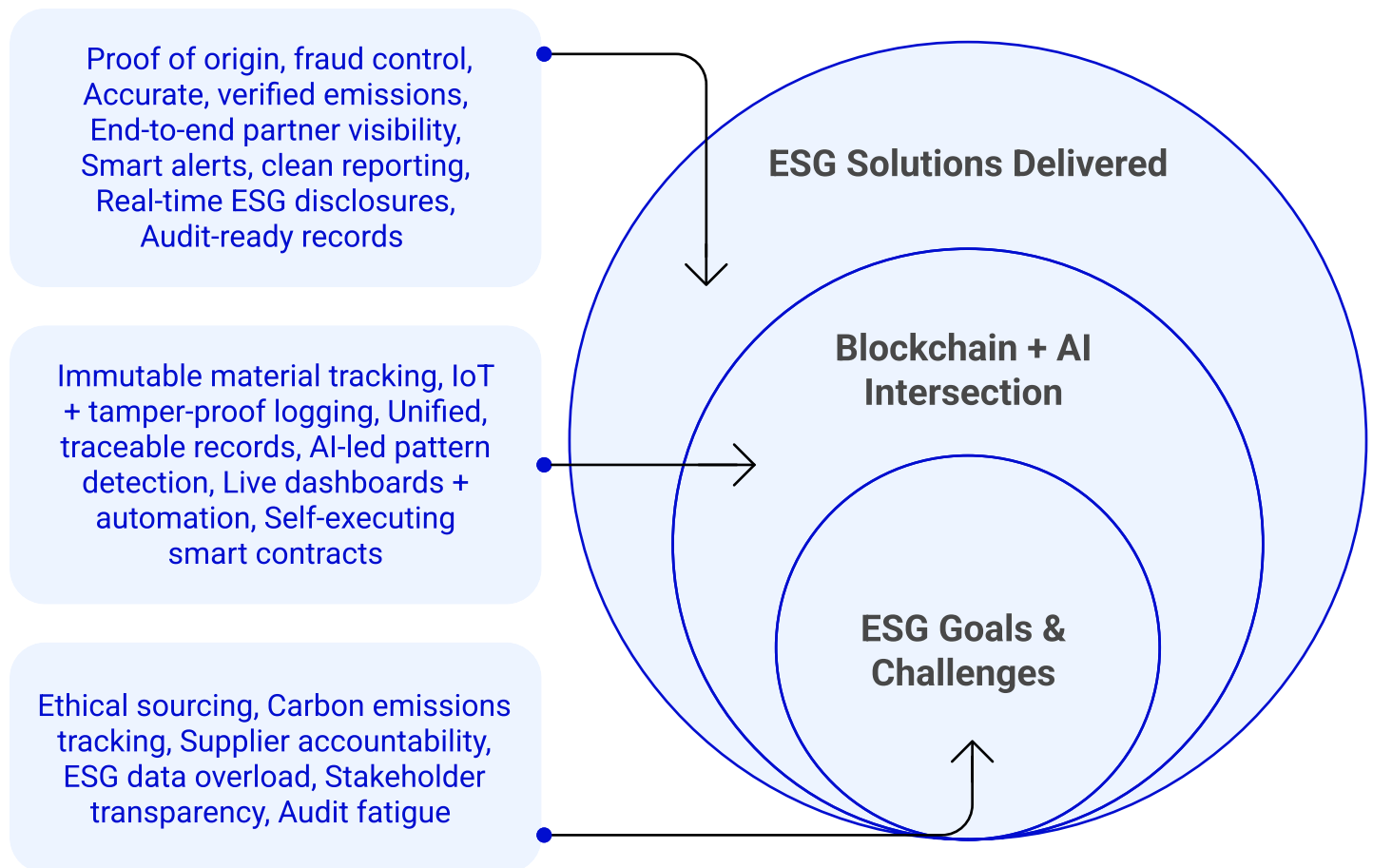
Blockchain resolves this by ensuring that:

- Supplier performance is recorded not just reported
- Certificates and audits are linked to the actual product or process
- Activities are logged chronologically, without alteration
- Insights are available to every authorized partner, not locked inside silos

AI tools layered on this data detect if real activities match reported commitments.

This means ESG tracking is no longer just a checkbox exercise. It becomes a continuous, automated function of the supply chain.

How AI and Blockchain Close the Gap Between ESG Goals and Execution



Blockchain and AI spell out a lot of possibilities in the ESG space. This is aptly summed by Michael Meehan, Chief Executive of the Global Reporting Initiative (GRI), who stated, “We are now on the cusp of a new era: The way we capture, analyze and use sustainability data is about to be transformed.”

What’s more, as part of GRI’s Sustainability and Reporting 2025 project, three key trends have been identified: dynamic sustainability data exchange, a stronger focus on critical global issues, and near-real-time interactions becoming the norm. Blockchain and AI are central to enabling all three, offering scalable, verifiable, and real-time infrastructure to make ESG data reportable and actionable.

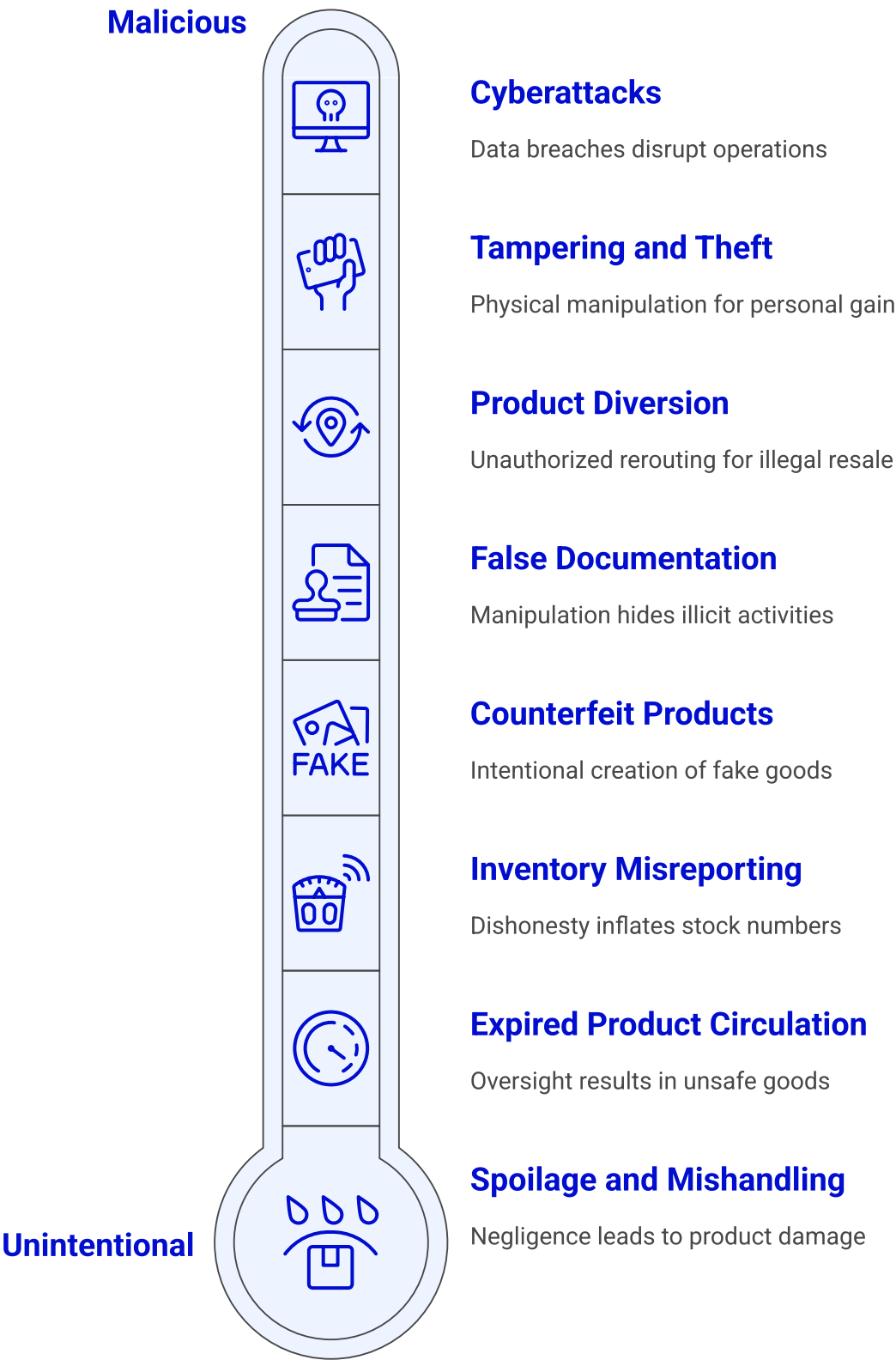
Protecting Supply Chains: AI and Blockchain Against Fraud and Tampering

Transparent supply chains depend on trusted data. But without a secure foundation, that transparency becomes unreliable. Weak links in data handling, information sharing, or inventory tracking create space for fraud, tampering, and misreporting. This not only erodes trust but can have severe consequences, especially when dealing with sensitive products like pharmaceuticals, fresh produce, or high-value goods.

As supply chains become more interconnected and digitized, the risks are also evolving. Manual systems and siloed databases can't provide the level of traceability or tamper resistance needed in today's environment. Blockchain and AI fill this gap by offering security, data integrity, and anomaly detection at scale.



Common Fraud and Security Threats in Supply Chains



Use Case 1: Cold Chain Tracking for Pharmaceuticals

Many vaccines and temperature-sensitive drugs must be stored under strict cold chain conditions, often between 2°C and 8°C. Even slight deviations in temperature can render them ineffective. Manual logs and disconnected systems are prone to error and delay, which can lead to missed incidents or falsified records.

With blockchain, every temperature reading (recorded through IoT-enabled cold chain sensors) is time-stamped and written to a tamper-proof ledger. This ensures all parties can verify the product has remained within required parameters throughout transit.

For example, during COVID-19 vaccine distribution, cold chain failures were a critical concern. A study published by PubMed Central analysed global vaccine supply chain issues and found that blockchain could address key security, communication, and efficiency failures. The issues identified included:

- Physical limitations: Shortages in production and medical infrastructure
- Communication issues: Poor coordination between manufacturers, distributors, and clinics
- Security concerns: Counterfeit vaccines, public misinformation, and data breaches
- Efficiency challenges: Manual processes, outdated systems, and missing data

The study proposed that blockchain can significantly mitigate communication gaps, prevent counterfeit activity, and improve supply chain efficiency, thus boosting public trust and reducing operational costs.

Real-World Adoption: FDA's BRUINchain

As part of the FDA's DSCSA Pilot Project Program, UCLA and LedgerDomain developed BRUINchain: a blockchain system designed to track pharmaceuticals through the supply chain down to the point of patient delivery. The system scans 2D barcodes, flags expired or suspect drugs, and verifies product legitimacy with manufacturers in real time. This creates a secure chain of custody for each drug unit, from producer to pharmacist.

Use Case 2: Perishable Goods and Expiry Management

Fresh produce like blueberries, kiwis, or mangoes often travel across borders, requiring weeks of transport and multiple handlers. These products have short shelf lives, and even small errors in handling or documentation can lead to spoilage or expired items reaching retailers.

Blockchain can log harvest dates, storage temperatures, handling events, and transit duration for each batch. Combined with AI, predictive models can forecast spoilage risk and flag inconsistencies, such as delayed shipments or incorrect expiration dates.

Because blockchain uses one-way hashing to secure data inputs, any modification to the original entry breaks the hash, making tampering immediately detectable. Once data is written, it cannot be changed retroactively, only appended with a new transaction. This ensures data integrity throughout the lifecycle of the product.

Real-World Adoption by Walmart

In 2017, Walmart announced a blockchain partnership with several major players in the food and supply chain industry, including Dole, Kroger, McCormick, Nestlé, Tyson Foods, and Unilever. The goal of this collaboration was to explore and develop applications of blockchain technology to enhance food traceability and improve the overall reliability of supply chain data.

By leveraging blockchain's ability to provide immutable, time-stamped records of every transaction or movement, the initiative aimed to bring greater transparency to food supply chains. This allowed participants to trace the origin of food products in seconds rather than days, helping to quickly identify sources of contamination, reduce waste, and build consumer trust through verified sourcing and handling practices.

How AI Supports Supply Chain Security

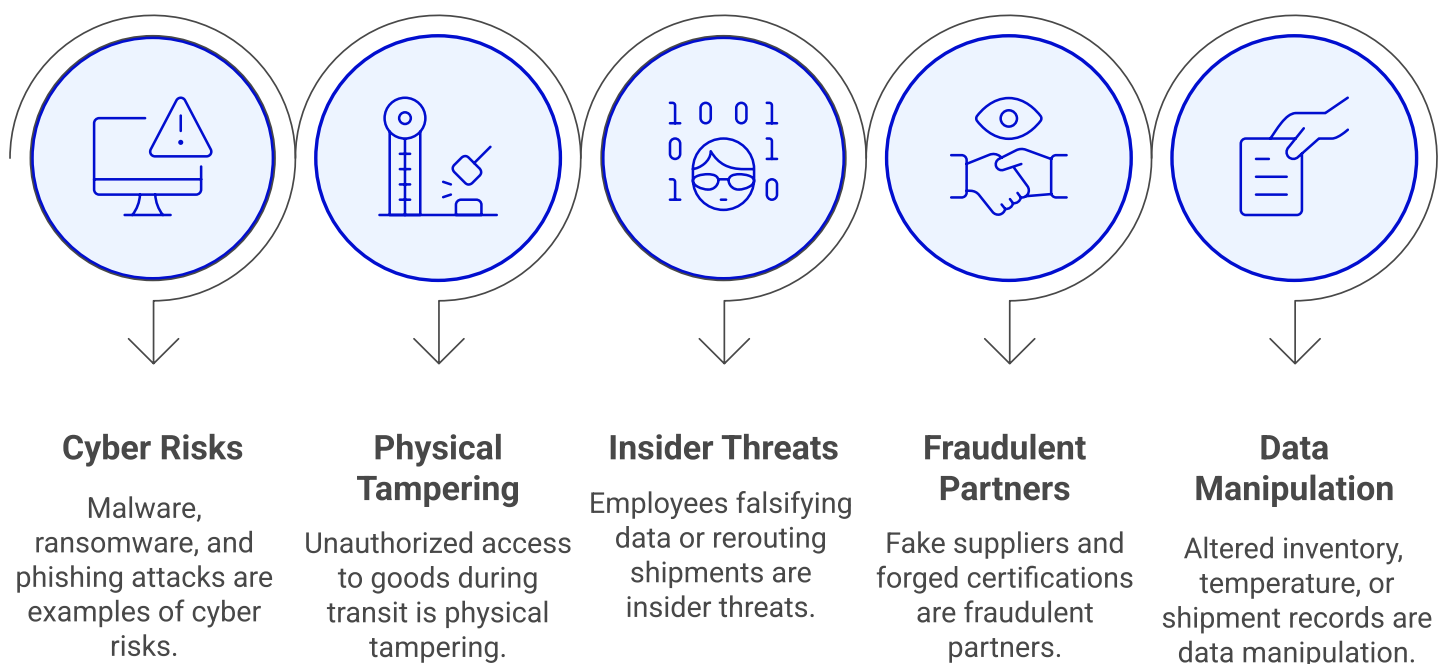
AI plays a complementary role to blockchain by actively monitoring and analysing the data captured in the supply chain. While blockchain ensures the integrity of the data, AI provides intelligence on how to act on it.

AI does this by:

- **Anomaly Detection:** AI systems can monitor incoming data (e.g., temperature logs, inventory counts, delivery times) and detect deviations from expected patterns.
- **Predictive Maintenance:** AI can predict where a failure (in cold storage or transport systems) is likely, reducing downtime and loss.
- **Risk Scoring:** Suppliers and distribution routes can be scored based on historical performance, flagging weak links before they cause disruptions.
- **Automated Alerts:** When data points fall outside acceptable thresholds, such as a vaccine shipment hitting 10°C, AI can trigger real-time alerts for immediate action.

Security Risks in Supply Chains

Digital and Physical Vulnerabilities



4 Ways Blockchain and AI Mitigate Security Risks

1. Immutable Records (Blockchain)

Every supply chain event, whether it's a shipment departure or a cold storage reading, is stored permanently, blocking any unauthorized changes or erasures.

2. Real-Time Verification (Blockchain + IoT)

Combined with sensors and smart tags, blockchain confirms that data points, such as delivery time, route, or condition, are captured at source and can't be retroactively changed.

3. Intelligent Pattern Recognition (AI)

AI continuously scans the network for deviations, suspicious behaviours, or previously unseen attack patterns, allowing for pre-emptive action.

4. Zero-Trust Architecture (Blockchain)

Every participant in the network is treated as untrusted by default. Only verified, permissioned users can interact with data, and every action is logged and traceable.

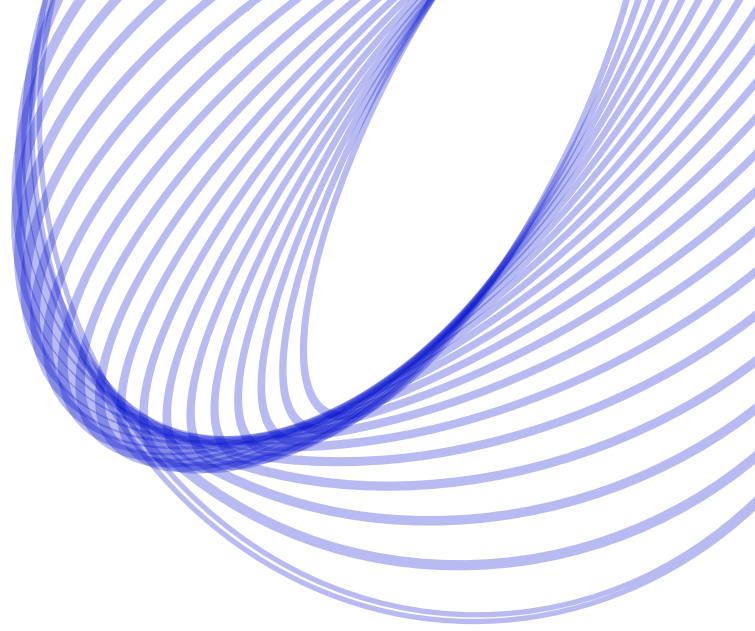
Together, AI and blockchain enable a security loop where accurate data is both protected and actionable.

Building a More Reliable, Accountable Supply Chain...

AI and blockchain are practical tools to solve long-standing supply chain challenges. From tracking materials down to their source to preventing counterfeiting and automating ESG reporting, these systems bring structure, accuracy, and shared visibility across complex supplier networks. Their value lies in making supply chain data traceable and secure while eliminating gaps that often lead to fraud, inefficiency, and non-compliance.

What does this mean for businesses? Well, the next step is not experimentation, but implementation. Organizations should begin by auditing their current systems for weaknesses in traceability, data integrity, and compliance reporting and then pilot blockchain and AI-based solutions in high-impact areas like cold chains, ESG tracking, and supplier performance management. The cost of delay can be higher than the cost of adoption.

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US +1 (442) 319-7124

UK +44 (20) 3769 0051

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sales@perimattic.com



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