

## Supply Chain Transparency and Traceability in the Textile Sector

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### Abstract

The textile sector operates through complex, multi-tiered global supply chains that span raw material production, spinning, weaving, dyeing, garment manufacturing, and international distribution. While this structure enables cost efficiency and rapid production, it often limits visibility across production stages, increasing risks related to labor exploitation, environmental harm, and regulatory non-compliance. In response, supply chain transparency and traceability have emerged as critical mechanisms for improving accountability and strengthening stakeholder trust within the textile industry. The role of transparency and traceability systems in enhancing ethical governance and sustainability performance in the textile sector. Transparency refers to the disclosure of sourcing practices, supplier relationships, and environmental impact data, while traceability involves the ability to track materials and processes across each stage of production. Digital tools such as blockchain, radio-frequency identification (RFID), and data analytics platforms are increasingly used to verify origin, monitor compliance, and improve information accuracy.

**Keywords:** Supply chain transparency; Traceability; Textile sector; Ethical sourcing; Sustainable supply chains

### Introduction

The textile sector is one of the most globally interconnected industries, characterized by fragmented production networks that span multiple countries and regulatory environments. From cotton cultivation and fiber production to dyeing, stitching, and final retail distribution, apparel products typically pass through numerous intermediaries before reaching consumers. While this structure enables cost efficiency and rapid scalability, it also reduces visibility across supply chain tiers. Limited transparency has contributed to recurring concerns related to labor exploitation, environmental degradation, unsafe working conditions, and regulatory non-compliance. High-profile industrial accidents and reports of environmental damage have intensified public scrutiny of textile supply chains. Consumers, civil society organizations, and regulatory authorities increasingly demand accountability from brands regarding sourcing practices and production standards. In response, transparency and traceability have become central themes in sustainable supply chain management within the textile industry. Supply chain transparency refers to the disclosure of relevant information about sourcing locations, supplier relationships, production processes, and environmental impacts. It involves proactive communication of data that allows stakeholders to assess ethical and sustainability performance. Traceability, on the other hand, focuses on the technical capability to track materials and components throughout the supply chain. Effective traceability systems enable

companies to identify the origin of raw materials, monitor compliance at each production stage, and respond rapidly to disruptions or violations. Technological advancements have expanded the tools available for improving transparency and traceability. Digital platforms, blockchain systems, radio-frequency identification (RFID), and advanced data analytics allow real-time tracking and verification of supply chain information. However, implementation remains uneven across regions and company sizes. Smaller suppliers may lack the technological infrastructure or financial capacity to participate fully in traceability systems. Beyond technological challenges, transparency initiatives must also navigate issues of data accuracy, confidentiality, and coordination among multiple stakeholders. Regulatory developments in several regions now require mandatory disclosure of supply chain risks, further increasing the importance of reliable monitoring mechanisms.

### **Structure and Complexity of Global Textile Supply Chains**

Global textile supply chains are among the most fragmented and geographically dispersed production networks in the world. A single garment may involve multiple countries, dozens of suppliers, and numerous subcontractors before reaching the final consumer. This complexity enables cost efficiency and specialization but significantly limits visibility and accountability across production stages.

#### **1. Multi-Tiered Production Structure**

Textile supply chains typically operate through a tiered structure. Tier 1 suppliers assemble finished garments, often located in major apparel-exporting countries. Tier 2 suppliers handle fabric production, including weaving, knitting, and dyeing. Tier 3 suppliers are responsible for spinning fibers into yarn, while Tier 4 suppliers provide raw materials such as cotton, wool, or synthetic inputs derived from petrochemicals. As production moves upstream, transparency often decreases, making monitoring more difficult.

#### **2. Geographic Dispersion and Cost Optimization**

Production processes are frequently distributed across countries based on comparative advantages such as labor costs, resource availability, or trade agreements. Cotton may be grown in one region, spun into yarn in another, woven into fabric elsewhere, and finally assembled in a separate manufacturing hub. This geographic dispersion complicates coordination and increases the risk of regulatory inconsistencies.

#### **3. Subcontracting and Informal Networks**

To meet tight production timelines and fluctuating demand, primary suppliers often subcontract portions of work to smaller factories. These subcontracting arrangements can extend beyond formal contractual relationships, creating layers of informal production networks. Such practices reduce direct oversight and increase the risk of labor violations or environmental non-compliance.

#### **4. Global Value Chain Dynamics**

The textile sector operates within a global value chain framework where brands and retailers typically control design, branding, and distribution, while manufacturing activities are outsourced. This buyer-driven structure places significant pressure on suppliers to reduce costs and accelerate production, sometimes at the expense of transparency and sustainability standards.

#### 5. Information Asymmetry and Limited Visibility

Complex supply networks generate information asymmetry between brands, suppliers, regulators, and consumers. Brands may have limited insight into upstream raw material sourcing, and consumers rarely have access to detailed production data. This lack of visibility increases reputational risk and complicates efforts to verify ethical practices.

#### 6. Logistical and Coordination Challenges

Managing international logistics, compliance documentation, quality control, and regulatory requirements across multiple jurisdictions adds operational complexity. Disruptions such as political instability, trade policy shifts, or transportation bottlenecks can quickly impact supply continuity.

#### 7. Implications for Transparency and Traceability

The structural complexity of textile supply chains underscores the importance of robust transparency and traceability mechanisms. Without digital tracking systems, standardized reporting, and coordinated governance frameworks, monitoring multi-tiered global networks remains highly challenging.

global textile supply chains are characterized by layered production tiers, geographic dispersion, subcontracting practices, and buyer-driven governance structures. While this complexity supports economic efficiency and scalability, it also presents significant challenges for accountability, ethical oversight, and sustainable management. Addressing these structural realities is fundamental to strengthening transparency and traceability across the textile sector.

### **Technological Innovations: Blockchain, RFID, and Digital Platforms**

Technological innovation has become central to improving transparency and traceability in the textile sector. As global supply chains grow more complex, digital tools provide mechanisms to track materials, verify compliance, and reduce information asymmetry. Among the most prominent technologies are blockchain systems, radio-frequency identification (RFID), and integrated digital platforms that enable real-time data sharing across stakeholders.

#### 1. Blockchain for Immutable Record-Keeping

Blockchain technology offers a decentralized ledger system in which transaction records are securely stored and cannot be altered retroactively. In textile supply chains, blockchain can document each stage of production, from raw material sourcing to final retail distribution. Every transaction or certification entry becomes time-stamped and traceable. This enhances trust by reducing the risk of data manipulation and enabling verification of sustainability claims. For example, brands can use blockchain to confirm the origin of organic cotton or to track compliance with labor standards.

#### 2. RFID and Product-Level Tracking

RFID technology uses embedded electronic tags to monitor the movement of goods throughout the supply chain. These tags transmit data through radio waves, allowing automated tracking of inventory across warehouses, distribution centers, and retail stores. In the textile sector, RFID improves stock accuracy, reduces theft, and enhances visibility of product flows. At a traceability level, it allows companies to track individual garments, linking them to production batches and supplier information.

### 3. Digital Supply Chain Platforms

Cloud-based digital platforms integrate data from suppliers, manufacturers, logistics providers, and retailers into centralized systems. These platforms enable real-time monitoring of production timelines, compliance documentation, environmental metrics, and shipment status. Advanced analytics tools within these systems can identify risks, forecast disruptions, and support regulatory reporting requirements.

### 4. Data Integration and Interoperability

Effective technological adoption requires interoperability between systems across multiple supply chain tiers. Standardized data formats and shared protocols ensure that information from blockchain, RFID, and enterprise resource planning (ERP) systems can be integrated seamlessly. Without coordination, fragmented digital systems may limit the effectiveness of transparency initiatives.

### 5. Enhancing Compliance and Audit Efficiency

Digital traceability tools simplify audit processes by providing accessible documentation of supplier certifications, environmental performance metrics, and labor compliance records. Automated alerts can notify companies of non-compliance risks or missing documentation, enabling faster corrective action.

### 6. Challenges in Implementation

Despite their benefits, these technologies involve significant investment in infrastructure, training, and cybersecurity safeguards. Smaller suppliers may face financial or technical barriers to adoption. Additionally, ensuring data accuracy at the point of entry remains critical, as technology cannot eliminate misinformation if initial inputs are unreliable.

### 7. Strategic and Sustainability Implications

When effectively implemented, blockchain, RFID, and digital platforms strengthen accountability, reduce fraud, and enhance consumer confidence. They support regulatory compliance and provide measurable evidence of sustainability performance. Over time, digital traceability can evolve from a compliance tool into a strategic asset that reinforces brand reputation and competitive advantage.

technological innovations are transforming transparency and traceability in the textile sector. By integrating secure digital systems and real-time tracking technologies, companies can improve oversight, strengthen stakeholder trust, and support more responsible global supply chain management.

## Conclusion

Supply chain transparency and traceability have become essential pillars of responsible governance in the textile sector. The industry's multi-tiered and geographically dispersed structure creates significant challenges for monitoring labor standards, environmental performance, and sourcing practices. Without systematic visibility across production stages, brands face heightened reputational, legal, and operational risks. Technological innovations such as blockchain, RFID, and integrated digital platforms offer practical mechanisms to address these structural complexities. By enabling real-time tracking, secure data storage, and improved audit efficiency, these tools strengthen accountability and reduce information asymmetry. However, technology alone cannot guarantee transparency. Effective

implementation requires standardized data protocols, cross-tier collaboration, regulatory oversight, and sustained investment in supplier capacity building. Consumer expectations and regulatory pressures are increasingly pushing textile companies toward greater disclosure and traceability. Transparent reporting and verified sourcing practices enhance brand credibility and foster long-term trust. At the same time, adoption challenges persist, particularly for smaller suppliers facing financial and technical constraints. Ultimately, strengthening supply chain transparency and traceability is not merely a compliance exercise but a strategic imperative. When embedded into core operational frameworks, visibility across textile supply networks supports ethical sourcing, environmental stewardship, and resilient global value chains. Sustainable transformation in the textile sector depends on integrating technological innovation with governance reform and collaborative stakeholder engagement.

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