

2025-11

The convergence of traceability and sustainability in modern supply chains

Selvaraj, Manikandan

School of Business and Entrepreneurship, Independent University, Bangladesh (IUB)

<https://icebtm.iub.edu.bd>

Downloaded from IUB Academic Repository

The Convergence of Traceability and Sustainability in Modern Supply Chains

Manikandan Selvaraj¹, Rohit Raman²

¹Amazon Inc., USA

²Senior Associate, PricewaterhouseCoopers (PwC) Advisory Services LLC, USA

mani.in@hotmail.com

Paper ID: ICEBTM-25-1048

Abstract - Global supply chains are transforming due to regulations, consumer demands, and market disruptions, all pushing for greater transparency. Serialization and traceability are key to this, creating a digital record of a product's journey from source to consumer. This convergence is vital for supply chain sustainability. Traceability helps verify environmental and social claims, builds consumer trust, and supports the circular economy by tracking product flows for reuse and recycling. It also minimizes waste during recalls and improves resource use, lowering carbon footprints. Technologies like IoT sensors, blockchain, and AI enhance data accuracy, security, and insights. Case studies in pharmaceuticals, food, and apparel show how traceability boosts safety, ethical sourcing, and compliance. However, adoption challenges—ranging from integration costs to partner alignment—must be addressed to realize its full potential. This paper argues that integrating traceability and sustainability is a strategic imperative. Organizations that embed these capabilities will achieve compliance, resilience, efficiency, and long-term competitive advantage.

Keywords - Traceability, Sustainability, Supply Chains, Serialization, Circular Economy, Regulatory Compliance, Ethical Sourcing, Blockchain

I. INTRODUCTION

Global supply chains are experiencing unprecedented pressure from regulators, consumers, and market volatility. Increasing demands for transparency, accountability, and ethical conduct have made supply chain sustainability a business imperative rather than a voluntary initiative. The traditional focus on cost and efficiency is being replaced by a broader framework that emphasizes environmental responsibility, social equity, and regulatory compliance. In this context, traceability and serialization have emerged as critical enablers of sustainable supply chains. Serialization—the process of assigning unique identifiers such as serial numbers, QR codes, or RFID tags to individual products—creates the foundation for granular visibility. Traceability builds upon this foundation by using these identifiers to monitor and document the movement, transformation, and condition of goods throughout the supply chain. Together, they form a digital thread that provides a verifiable history of products from raw material sourcing to end-of-life disposal. The convergence of traceability and sustainability addresses multiple challenges facing supply chains today. First, it allows companies to substantiate environmental and social claims, thereby reducing the risk of greenwashing and enhancing stakeholder trust. Second, it enables circular economy practices such as recycling, remanufacturing, and reuse by ensuring that materials and products are accurately tracked across reverse logistics channels. Third, it reduces

waste and improves operational efficiency by facilitating precise recalls and providing real-time insights into inventory and logistics management. Finally, it ensures compliance with increasingly stringent regulations such as the U.S. Food Safety Modernization Act (FSMA 204), the Drug Supply Chain Security Act (DSCSA), and the European Union's Digital Product Passport (DPP). The purpose of this paper is to explore how serialization and traceability serve as strategic drivers of sustainability in modern supply chains. It synthesizes insights from academic literature, industry practices, and regulatory frameworks to highlight the opportunities, challenges, and future directions for integrating these capabilities. The paper argues that organizations that embed traceability into their sustainability strategies will not only achieve compliance but also build resilience, efficiency, and long-term competitive advantage.

II. LITERATURE REVIEW

Supply Chain Sustainability

The concept of supply chain sustainability extends beyond operational efficiency to encompass environmental stewardship, social responsibility, and long-term resilience [10]. Scholars emphasize that sustainability in supply chains involves balancing the “triple bottom line” of people, planet, and profit [28]. Companies are increasingly judged not only on financial performance but also on their ability to minimize environmental harm and uphold ethical labor practices. In practice, however, achieving sustainable supply chains has proven challenging due to limited visibility across multi-tier networks and the prevalence of opaque practices in global sourcing [11]. Recent studies argue that digital technologies are critical to bridging this visibility gap [15]. Transparency, underpinned by traceability systems, enables stakeholders to verify compliance with sustainability goals and regulatory mandates. Without traceability, sustainability claims remain unverifiable, leaving firms vulnerable to reputational risks.

B. Serialization as a Foundational Capability

Serialization is the assignment of unique identifiers to individual products, typically in the form of alphanumeric codes, barcodes, or RFID tags [5]. Initially developed for inventory management and anti-counterfeiting in industries such as pharmaceuticals, serialization has since become a cornerstone of modern supply chain management. For example, the DSCSA mandates unit-level serialization of prescription drugs in the U.S. to ensure patient safety and combat counterfeit medicines [6]. Academic literature underscores serialization as a prerequisite for granular traceability [9]. By creating item-level identities, serialization enables precise tracking, targeted recalls, and improved forecasting. Beyond compliance, serialization also supports

sustainability by allowing firms to monitor product lifecycles and assess environmental impacts more accurately.

C. Traceability as a Strategic Enabler

Traceability is broadly defined as the ability to track and trace the history, application, or location of an item through recorded data [14]. Researchers distinguish between forward traceability (tracking products through the supply chain to the consumer) and backward traceability (tracing back from consumer to origin) [25]. Both forms are essential for sustainability: forward traceability enables targeted recalls and efficient resource use, while backward traceability ensures accountability in sourcing practices. Several studies link traceability directly to sustainability outcomes. For example, in the food sector, traceability systems have been shown to reduce food waste by isolating contaminated batches and preventing unnecessary recalls [22]. In the apparel industry, traceability enhances transparency in labor practices and material sourcing, thereby addressing social and environmental concerns [14]. Despite these benefits, researchers highlight challenges such as data interoperability, cost of implementation, and partner adoption [25].

D. Digital Technologies Powering Traceability

The literature highlights a range of enabling technologies that enhance traceability systems:

1. Internet of Things (IoT): IoT devices monitor environmental conditions such as temperature, humidity, and location in real-time, critical for ensuring product integrity and reducing spoilage [16].
2. Blockchain: Blockchain provides an immutable, decentralized ledger for recording supply chain transactions. It ensures trust among stakeholders and prevents data manipulation [21].
3. Artificial Intelligence (AI) and Data Analytics: AI enables predictive insights, anomaly detection, and demand forecasting using the vast data generated by traceability systems [24].
4. Cloud Platforms: Cloud-based systems facilitate scalability, interoperability, and global accessibility of traceability data [23].

These technologies not only strengthen compliance and risk management but also amplify sustainability outcomes by optimizing logistics, reducing waste, and enabling verifiable claims.

E. Gaps in Existing Research

While significant work has been conducted on supply chain sustainability and traceability, integration between the two remains underexplored. Much of the literature treats traceability as a compliance or risk management tool rather than as a strategic driver of sustainability [12]. Few studies provide holistic frameworks linking serialization, traceability, and circular economy practices. Moreover, empirical research quantifying the sustainability benefits of traceability remains limited, particularly in multi-tier and cross-border supply chains. This paper aims to address these gaps by framing traceability as both a compliance necessity and a sustainability enabler, supported by case studies and cross-industry insights.

III. TRACEABILITY AS A SUSTAINABILITY DRIVER

A. Enhancing Transparency and Preventing Greenwashing

Consumers and investors are increasingly skeptical of generic sustainability claims [22]. Traceability systems enable firms to substantiate these claims with verifiable evidence, such as proof of recycled content, certified ethical sourcing, or carbon reduction measures. This transparency mitigates reputational risks associated with “greenwashing” and enhances stakeholder trust [14]. For example, blockchain-enabled traceability in coffee supply chains allows consumers to confirm farm-level sustainability certifications, reinforcing brand credibility.

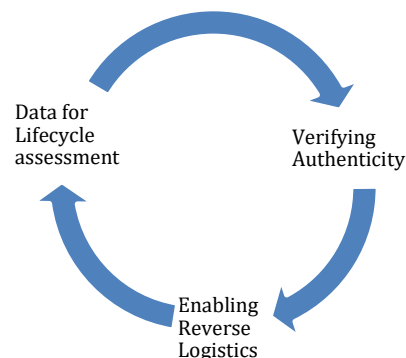
B. Enabling Circular Economy Practices

The transition from a linear “take–make–dispose” model to a circular economy requires accurate tracking of products and materials across multiple life cycles [10]. Traceability supports circularity by:

1. Verifying the authenticity of recycled or remanufactured materials.
2. Enabling reverse logistics for product take-back programs.
3. Providing data for lifecycle assessments (LCAs) and extended producer responsibility (EPR) reporting.

Industries such as electronics and apparel have begun embedding digital identifiers to facilitate reuse and recycling. For example, the EU’s Digital Product Passport initiative will require manufacturers to provide traceability data that supports product repairability and recyclability [28].

Fig.1 Enabling Circular Economy



C. Reducing Waste and Optimizing Resources

One of the most tangible sustainability benefits of traceability is waste reduction. Traditional recall processes often cause the disposal of entire product batches, even when only a small subset is affected. Serialization and traceability enable targeted recalls, reducing both cost and environmental impact [27]. Similarly, real-time inventory visibility minimizes overproduction, spoilage, and obsolescence, particularly in food and pharmaceutical sectors where product integrity is time-sensitive [5].

D. Improving Operational Efficiency and Reducing Carbon Footprints

Beyond waste reduction, traceability generates data that can be used to optimize logistics networks. By analyzing transportation routes, companies can identify inefficiencies and reduce fuel consumption [7]. IoT-enabled monitoring ensures compliance with cold-chain requirements while minimizing unnecessary energy expenditure. These

efficiencies not only lower operational costs but also contribute directly to carbon reduction targets [8].

E. Ensuring Regulatory Compliance and Ethical Sourcing

Governments worldwide are enacting stricter supply chain regulations addressing food safety, forced labor, and deforestation. Traceability provides the documentary evidence needed to comply with these mandates [7]. For example, under FSMA 204, food companies in the U.S. must maintain records of Key Data Elements (KDEs) and Critical Tracking Events (CTEs) to trace products in case of contamination [8]. Similarly, the EU Deforestation Regulation (EUDR) requires proof of non-deforestation in agricultural supply chains. By ensuring compliance, firms reduce legal risks while demonstrating their commitment to ethical and sustainable practices. This alignment strengthens brand reputation and creates long-term business resilience.

IV. ENABLING TECHNOLOGIES FOR TRACEABILITY

Traceability ecosystems are built on a combination of identification, data capture, and data-sharing technologies. These technologies not only ensure compliance but also amplify sustainability outcomes by improving efficiency, reducing waste, and enhancing trust.

A. Unique Identifiers

Serialization begins with unique identifiers such as QR codes, RFID tags, and NFC chips. According to GS1, over 10 billion items globally are scanned daily using GS1 standards [6]. QR codes have gained prominence in consumer-facing industries due to their low cost and ease of adoption, while RFID tags offer advantages in bulk scanning and automated data capture. For example, Walmart's RFID mandate for apparel suppliers reduced inventory inaccuracies by over 25%, leading to fewer stockouts and waste [9].

B. Internet of Things (IoT)

IoT sensors embedded in packaging and logistics assets enable real-time monitoring of conditions such as temperature, humidity, and shock. This is critical for perishable products like food and pharmaceuticals. A World Health Organization report estimated that up to 25% of vaccines are degraded due to poor cold chain management, a challenge IoT traceability directly addresses [18]. By preventing spoilage, IoT reduces both financial losses and environmental waste.

C. Blockchain

Blockchain offers an immutable, decentralized ledger for capturing supply chain transactions. IBM Food Trust, one of the largest blockchain traceability platforms, reduced the time to trace a product's origin from 7 days to 2.2 seconds in pilot programs with Walmart and Nestlé [11]. Beyond speed, blockchain ensures tamper-proof sustainability claims, enabling companies to combat greenwashing and enhance trust among stakeholders.

D. Artificial Intelligence and Data Analytics

AI leverages the massive data generated by traceability systems to deliver predictive insights. Applications include anomaly detection for counterfeit identification, demand forecasting, and logistics optimization. A McKinsey study estimated that AI-driven supply chain optimization can

reduce forecasting errors by 30–50% and inventory costs by 20–50% [15]. When applied to traceability, these efficiencies directly translate into sustainability gains by minimizing waste and reducing unnecessary transportation.

E. Cloud-Based Platforms

Cloud computing underpins scalability and global accessibility. Platforms such as AWS Supply Chain, SAP Leonardo, and Oracle SCM enable real-time data integration across multi-tier networks. According to Gartner, 70% of supply chain organizations are investing in cloud-based solutions to improve transparency and collaboration [25]. Cloud platforms are also critical for aligning with regulatory mandates such as FSMA 204 and the EU Digital Product Passport, which require standardized data exchange across global stakeholders.

V. CASE STUDIES IN PRACTICE

To illustrate the real-world impact of traceability, this section presents case studies across three industries: pharmaceuticals, food and beverage, and apparel. These examples demonstrate how traceability contributes to both compliance and sustainability outcomes.

C. Pharmaceuticals: Patient Safety and Cold Chain Integrity

Pharmaceutical supply chains are highly regulated due to risks associated with counterfeit drugs and product degradation. Under DSCSA, all prescription drugs in the U.S. must be serialized by 2024. Serialization has already improved recall precision: during a pilot by the U.S. FDA, companies were able to isolate defective medicines at the unit level, reducing the volume of recalled products by over 80% compared to batch-level recalls [12]. Cold chain management is another critical area. IoT-enabled traceability ensures vaccines and biologics remain within specified temperature ranges. Pfizer's COVID-19 vaccine distribution relied on GPS-enabled thermal sensors that transmitted location and temperature data every five minutes [27]. This prevented spoilage and reduced waste in one of the most complex pharmaceutical supply chains ever executed.

A. Food and Beverage: Farm-to-Fork Transparency

Foodborne illness outbreaks highlight the importance of rapid traceability. The 2018 E. coli outbreak linked to romaine lettuce in the U.S. took weeks to trace, leading to the disposal of millions of pounds of safe produce. In contrast, Walmart's blockchain pilot with IBM Food Trust enabled the origin of mangoes to be traced in 2.2 seconds [22]. By isolating only affected batches, blockchain traceability reduces food waste, enhances consumer safety, and protects brand reputation.

Sustainability claims are also supported by traceability. Nestlé and Carrefour implemented blockchain-based transparency for their organic milk supply chain in France, allowing consumers to scan a QR code and verify farming practices, animal welfare, and carbon footprint metrics [14]. This not only builds consumer trust but also incentivizes suppliers to adopt more sustainable practices.

B. Fashion and Apparel: Combating Greenwashing

The apparel industry faces criticism for opaque supply chains, poor labor conditions, and high environmental impact. Traceability is increasingly being used to verify material origins and sustainability claims. For example, H&M's "Conscious Collection" includes QR codes that allow customers to see the country of production and supplier information for each garment [19]. Circularity initiatives are also gaining traction. Fashion for Good, a global sustainability initiative, has piloted digital tracers embedded in textiles to verify the use of recycled fibers [20]. Blockchain platforms such as TextileGenesis enable brands like Adidas and Stella McCartney to trace fibers like organic cotton and recycled polyester through multi-tier supply chains, addressing the industry's greenwashing challenges.

Fig 2. Case study comparison table

Industry	Use Case	Technology	Outcomes
Pharmaceuticals	Serialization & supply chain	Blockchain, serialization	Reduced recalls, less waste
Food and Beverage	From farm to fork transparency	Blockchain, QR codes	Reduced recalls, waste reduction
Apparel	Material origin verification	Blockchain, Digital tracers	Combating greenwashing

VI. CHALLENGES AND BARRIERS

While traceability delivers clear benefits in transparency, compliance, and sustainability, its widespread adoption faces several challenges. These barriers are both technical and organizational, reflecting the complexity of global supply chains.

A. High Implementation Costs

The initial investment in serialization equipment, IoT sensors, blockchain infrastructure, and integration with enterprise systems is significant. For small and medium-sized businesses (SMBs), these costs can be prohibitive. A Deloitte study found that over 60% of SMBs cite cost as the primary barrier to traceability adoption [5]. Without scalable and affordable solutions, adoption may remain concentrated among large multinational firms.

B. Integration with Legacy Systems

Many supply chain stakeholders continue to rely on outdated enterprise resource planning (ERP) and warehouse management systems. Integrating modern traceability technologies with these legacy platforms is technically complex and resource intensive [6]. Incompatibility often leads to fragmented data, limiting the effectiveness of traceability initiatives.

C. Data Accuracy and Interoperability

Traceability systems rely on accurate and standardized data. Inconsistent data entry, lack of adherence to global standards (e.g., GS1, EPCIS 2.0), and absence of interoperability across platforms reduce data reliability [9]. Without harmonized standards, achieving full visibility across multi-tier supply chains remains challenging.

D. Supply Chain Partner Resistance

Effective traceability requires collaboration among all supply chain actors, including raw material suppliers, manufacturers, distributors, and retailers. However, smaller partners may resist adoption due to cost, lack of technical expertise, or concerns over data privacy [12]. Trust and governance frameworks are needed to encourage participation and equitable data sharing.

E. Data Governance and Privacy Concern

Questions around who owns traceability data and how it can be shared create governance challenges. Suppliers may be reluctant to share sensitive data with downstream partners for fear of losing bargaining power. Moreover, regulatory frameworks like GDPR introduce additional complexity in ensuring privacy and data security [27].

F. Complexity of Multi-Tier Global Supply Chains

Global supply chains often span dozens of countries and involve hundreds of intermediaries. Traceability across such complex networks requires harmonization of standards and cross-border regulatory cooperation. Without coordinated international frameworks, companies risk fragmented compliance obligations and incomplete visibility [7].

VII. THE PATH FORWARD

Despite these challenges, the trajectory of global supply chains points toward increasing adoption of traceability as both a compliance requirement and a strategic differentiator. Several emerging trends and opportunities highlight the future direction of this field.

A. Regulatory Momentum

Governments are accelerating the adoption of mandatory traceability requirements. The U.S. Food Safety Modernization Act (FSMA 204) mandates the capture of Key Data Elements (KDEs) and Critical Tracking Events (CTEs) for high-risk foods by 2026 [8]. Similarly, the European Union's Digital Product Passport (DPP), set to launch under the Ecodesign for Sustainable Products Regulation, will require manufacturers to disclose product-level environmental data [7]. These regulations signal a future where traceability is no longer optional but compulsory.

B. Rising Consumer Demand for Transparency

Consumers are increasingly motivated by sustainability in purchasing decisions. A 2022 IBM survey found that 71% of consumers are willing to pay a premium for brands that demonstrate supply chain transparency [25]. Companies that provide verifiable traceability data are more likely to differentiate themselves and secure customer loyalty.

C. Advances in Technology

Emerging technologies are expanding the capabilities of traceability: Digital Twins create virtual models of physical supply chains, enabling predictive insights and scenario planning.

1. AI and Machine Learning enhance demand forecasting, fraud detection, and sustainability reporting.

2. Blockchain-IoT Convergence provides immutable, real-time data streams for high-risk supply chains such as pharmaceuticals and food.

These innovations will reduce costs, improve scalability, and increase adoption across industries [18].

D. Business Model Innovation

New commercial models are making traceability more accessible. Pay-per-trace or subscription-based platforms lower barriers for SMBs by replacing upfront capital expenditures with scalable operational costs [30]. Collaborative industry platforms—such as IBM Food Trust in food and TextileGenesis in fashion—demonstrate how shared infrastructure can accelerate adoption.

E. Toward Circular and Ethical Supply Chains

Traceability will increasingly underpin circular economy initiatives by enabling material reuse, recycling, and extended producer responsibility (EPR) schemes. Similarly, it will support compliance with labor and environmental regulations by providing verifiable evidence of ethical practices [16]. Companies that embrace traceability not only reduce regulatory risks but also future-proof their supply chains against environmental and social disruptions.

VIII. CONCLUSION AND FUTURE RESEARCH

The convergence of traceability and sustainability marks a fundamental transformation in modern supply chain management. What once began as tools for compliance and operational efficiency—serialization, unique identifiers, and record-keeping—has evolved into a strategic framework for resilience, transparency, and ethical responsibility. By creating a digital thread that links products across their lifecycle, traceability enables organizations to substantiate sustainability claims, reduce waste, support circular economy practices, and optimize resource use.

The evidence from pharmaceuticals, food and beverage, and apparel industries demonstrates the tangible value of traceability. Targeted recalls reduce waste and protect consumer safety, blockchain systems deliver farm-to-fork transparency, and textile tracers combat greenwashing. At the same time, enabling technologies such as IoT, blockchain, and AI are reshaping the economics of traceability by lowering costs and improving scalability. Despite these advances, adoption barriers remain significant. High implementation costs, legacy system integration, data governance, and multi-tier complexity hinder progress, particularly for small and medium-sized enterprises. Overcoming these barriers will require regulatory clarity, harmonized standards, shared infrastructure, and innovative business models that distribute costs equitably across the value chain. Looking ahead, regulatory initiatives such as FSMA 204 and the EU Digital Product Passport, coupled with rising consumer demand for verifiable transparency, will make traceability non-negotiable. Companies that treat traceability not merely as a compliance tool but as a strategic enabler of sustainability will gain long-term competitive advantage by building trust, efficiency, and resilience into their supply chains.

Future Research Directions

This paper highlights the need for further academic inquiry in several areas:

1. Quantifying Impact: Empirical studies measuring the environmental and financial benefits of traceability across industries.
 2. Consumer Behavior: Research on how traceability data influences consumer trust, purchasing decisions, and brand loyalty.
 3. Cross-Border Frameworks: Comparative studies on traceability regulations across regions to develop globally harmonized models.
 4. SMB Adoption Models: Exploration of scalable, cost-effective traceability solutions tailored for smaller firms.
 5. Technology Integration: Investigation of digital twins, AI, and blockchain–IoT convergence in enabling predictive and adaptive supply chains.
- By addressing these gaps, future research can strengthen the academic and practical foundations for traceable and sustainable supply chains. The path forward is clear: transparency, once optional, is now a defining characteristic of supply chain excellence in the twenty-first century.

REFERENCES

- [1] Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. *International Journal of Physical Distribution & Logistics Management*, 38(5), 360–387.
- [2] Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), 1699–1710.
- [3] Olsen, P., & Borit, M. (2013). How to define traceability. *Trends in Food Science & Technology*, 29(2), 142–150.
- [4] Dabbene, F., Gay, P., & Tortia, C. (2014). Traceability issues in food supply chain management: A review. *Biosystems Engineering*, 120, 65–80.
- [5] U.S. Food and Drug Administration (FDA). (2013). Drug Supply Chain Security Act (DSCSA).
- [6] U.S. Food and Drug Administration (FDA). (2022). Food Safety Modernization Act (FSMA) 204 Rule on Food Traceability.
- [7] European Commission. (2022). Ecodesign for sustainable products regulation: Digital product passports.
- [8] European Parliament. (2023). EU regulation on deforestation-free products.
- [9] GS1. (2022). EPCIS and CBV standards release 2.0.
- [10] Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. *Computer Networks*, 54(15), 2787–2805.
- [11] Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, 57(7), 2117–2135.
- [12] Hardgrave, B. C., Aloysius, J. A., & Goyal, S. (2013). RFID-enabled visibility and retail inventory record inaccuracy: Experiments in the field. *Production and Operations Management*, 22(4), 843–856.
- [13] Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232.
- [14] Testa, F., Iraldo, F., Vaccari, A., & Ferrari, E. (2015). Why eco-labels can be effective marketing tools: Evidence from a study on Italian consumers. *Business Strategy and the Environment*, 24(4), 252–265.
- [15] Kamath, R. (2018). Food traceability on blockchain: Walmart's pork and mango pilots with IBM. *Journal of the British Blockchain Association*, 1(1), 3712.

- [16] IBM. (2018). Walmart and IBM: Blockchain for food safety.
- [17] Nestlé. (2019). Nestlé and Carrefour give consumers blockchain access to milk supply chain.
- [18] Pfizer. (2021). Pfizer-BioNTech COVID-19 vaccine distribution and cold chain.
- [19] H&M Group. (2020). Sustainability performance report 2020.
- [20] Fashion for Good. (2021). Textile tracing pilots for circular fashion.
- [21] McKinsey & Company. (2019). Smartening up with artificial intelligence (AI): What's in it for Germany and its industrial sector?
- [22] Deloitte. (2021). The future of traceability in supply chains: Opportunities and challenges.
- [23] Capgemini. (2020). The digital supply chain's missing link: Unlocking the value of data sharing.
- [24] Gartner. (2021). The 2021 Supply Chain Technology User Wants and Needs Survey.
- [25] IBM. (2022). Sustainability at a turning point: Consumer expectations demand action.
- [26] Elkington, J. (1997). Cannibals with forks: The triple bottom line of 21st century business.
- [27] TerraChoice. (2010). The sins of greenwashing: Home and family edition.
- [28] World Health Organization (WHO). (2017). WHO guidelines on the international packaging and shipping of vaccines.
- [29] Walmart. (2020). RFID adoption and supply chain visibility results.
- [30] TextileGenesis. (2021). Blockchain for sustainable fiber traceability in fashion.