

Digital Systems and Technology

A Blockchain-Based Framework for Apparel & Footwear Supply Chain Traceability

Distributed ledger technology solutions enable fashion brands and retailers to improve supply-chain visibility across their diverse ecosystems, helping them to communicate product provenance to partners and customers, as well as mitigate environmental and reputational risk.

Executive Summary

The fashion industry is strutting its stuff. On one hand, shoppers can access an attractive assortment of products made accessible by mobile, personalization, immediate delivery and convenient returns. On the other hand, manufacturing is more efficient and effective than ever before, due to increased automation and computerization in areas such as patternmaking, sewing and knitting.

Apparel and footwear companies have exceptionally competitive capabilities to design, develop and deliver products to retailers in lead times that can be measured in days. Despite these efficiencies, apparel and footwear manufacturing processes pose significant environmental and reputational risks, which can potentially impact a retailer's profitability, brand equity and operational capabilities.

Shoppers, particularly millennials, are increasingly conscious about the environmental footprint of the clothes they buy. As a result, key purchasing influences now pivot around consumer knowledge of who produced the clothes, where they were made and what they are made of. These changing demand patterns and factors are pushing clothing manufacturers and retailers to alter their practices and business models to produce more ethically and environmentally conscious products.

However, the complex nature of apparel and footwear product manufacturing processes has resulted in a lack of trust along the supply chain. The journey of these products, from raw material to finished goods, often spans multiple geographies, manufacturing sites and agents, and very often courses through opaque and distrustful networks. Although databases do exist, they are often fragmented and do not provide a single view of product provenance. For these reasons, traditional centralized approaches, solutions and technologies are incapable of keeping pace with this increasingly fragile ecosystem.

One emerging solution is distributed ledger technology (DLT), which can provide greater transparency, traceability and auditability along the supply chain and can provide the consumer a lens for ethically sourced products. Underpinning evolving blockchain

networks, DLT is quickly proving itself to be a reliable and well-invested technology stack. (See “Retail: Opening the Doors to Blockchain” and “Blockchain in Manufacturing: Enhancing Trust, Reducing Costs, Lubricating Processes Across the Value Chain” for deeper insights.) As pilot projects and proofs of concepts give way to live production environments, blockchain initiatives must be complemented with the right implementation approach.

This white paper delves into a blockchain-driven supply chain traceability framework, tailored for the apparel and footwear industry. We look at fashion manufacturing supply-chain characteristics — its actors, risks and peculiarities. Lastly, we conclude with challenges and future directions related to this model.

Fashion retailing’s blockchain participants



Figure 1

A blockchain/distributed ledger technology primer

A subcategory of DLT, blockchain¹ is defined by its ability to record transactions on a ledger held by each peer in a network; such transactions can be easily verified and are accessible to all parties on a blockchain network without the need of a central authority. Blockchain's unique attributes (i.e., records immutability, consensus algorithms and strong cryptography) can help incorporate transparency and traceability so that multiple participants in the network can create, update and audit data. This would simultaneously ensure security, proof of identity and privacy, and forestall malicious transactions, document forgery, etc.

The apparel and footwear supply chains represent the perfect environment² to track suppliers spread across various geographies that process and transact as untrusting entities along the supply chain. With a blockchain/DLT solution, end users, regulators and supply chain participants can drill down and obtain greater levels of detail on the origins, purity and authenticity of the product, while also providing traceability in the event of product recalls. The distributed ledger elements will also increase process efficiency and lower the costs of producing the final product.

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Fashion industry growth drivers

The fashion industry is simultaneously transforming across multiple dimensions in the way products are made, sold and bought. The convenience of online shopping has led to a significant increase in demand, and new digital partnerships are emerging to reach and serve shoppers essentially on-demand.³

Fashion & footwear supply chain characteristics & complexities

Manufacturing supply chains are typically based on factors such as accessibility to raw material, cost-effective labor, trade policies, production costs, transportation networks, industrial modernization, law and order framework, etc. Supply chain traceability is a function of these parameters and varies from industry to industry.

Production-centric industries such as pharmaceuticals, aerospace and automobile manufacturing have long product lifecycles, and require modern manufacturing practices to operate in a highly regulated environment. In the food and beverage industry, regulations, labelling standards and audits make traceability a mandatory objective.

Due to the nature of its products and consumer consumption patterns, supply-chain product traceability is a low priority in the apparel and footwear industry. The key characteristics of fashion and footwear manufacturing include:

- Very short product lifecycles and small manufacturing batches.
- Highly fragmented processes accomplished in complex global supply networks.
- Raw material production and processes occur in countries with low-cost centers of operation, primarily manual operations, and easily accessible material and labor inputs.
- Transformation of plant- and animal-based raw materials that extinguishes the original biological structure.



Figure 2 illustrates the high-level lifecycle in the apparel and footwear industry.

The apparel and footwear manufacturing network

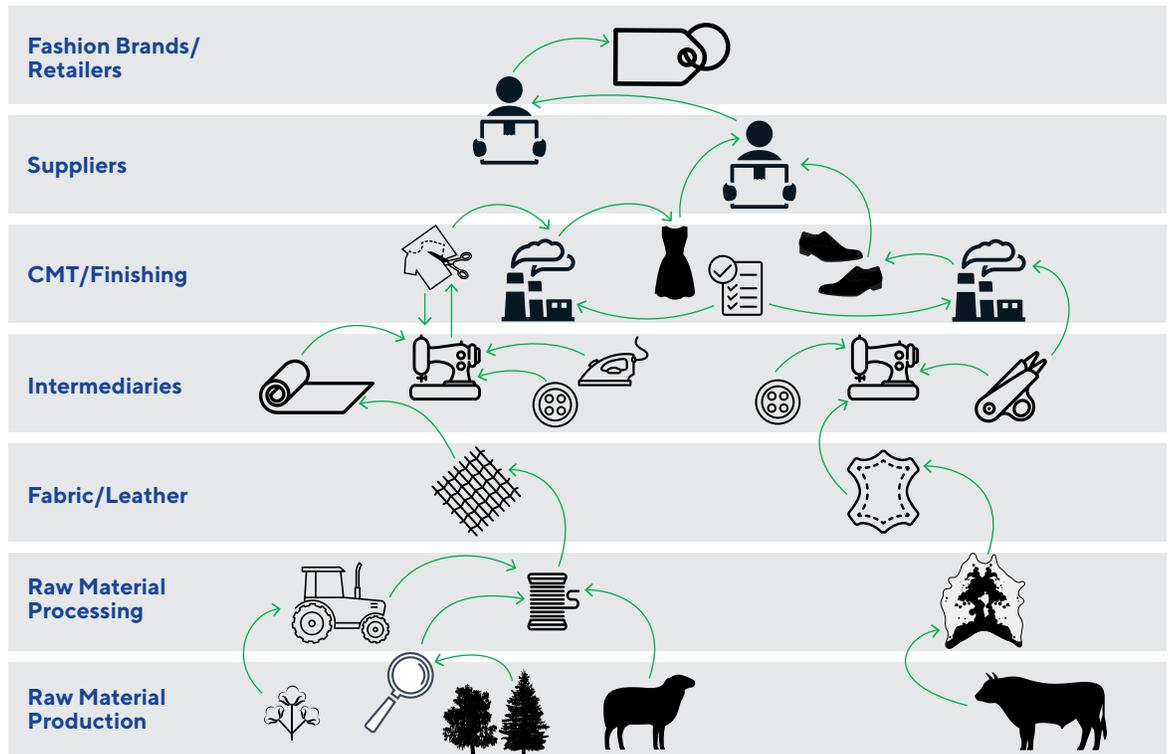


Figure 2

The rapid growth in fashion manufacturing did not face a commensurate surge in regulatory scrutiny. As a result, serious social and environmental issues have surfaced in the apparel and footwear supply chain. Some major brands have suffered incidents where subcontracting sites have caused damage to human life and the environment. Modern slavery continues to be a large issue. And incidents of gender discrimination, subminimum wages, child labor and migrant worker use have been gaining prominence (see Figure 3, next page).

Reported incidents impacting the fashion retail supply chain

	Issues	Incidents
Social	<ul style="list-style-type: none"> █ Worker health and safety. █ Human trafficking. █ Below minimum wage. █ Child labor. 	<ul style="list-style-type: none"> █ Rana Plaza collapse – Bangladesh.^{4,5} █ Migrant worker exploitation – Turkey.⁶
Environmental	<ul style="list-style-type: none"> █ Discharge of untreated toxic chemicals into the ground and water bodies. █ High level of water consumption to produce cotton fabric. █ Production of wood-based fibers leading to deforestation. 	<ul style="list-style-type: none"> █ Independent analysis of water around viscose-producing factories in India, China and Indonesia, where severe water pollution was detected.⁷ █ Desertification of the Aral Sea.⁸
Quality	<ul style="list-style-type: none"> █ Spurious or inferior raw materials. █ Presence of harmful chemicals. 	<ul style="list-style-type: none"> █ A large U.S. retailer where the use of Egyptian vs. Indian cotton was in question.⁹ █ Significant levels of cadmium found in jewelry at major U.S. fashion retailers.¹⁰ █ A large UK fast fashion retailer had to recall thousands of flip-flops after discovering a carcinogenic chemical used in the dye.¹¹

Figure 3

Supply chain risks and issues remained opaque for many years,¹² thus obscuring accountability, until recently. Consumer awareness, relentless activism and engagement have forced brands to raise their consciousness on these issues to not only protect brand equity but to avoid penalties in the countries in which they operate.

Therefore, it has become imperative for fashion companies to lead the change by embracing supply chain transparency as a strategic objective, in order to:

I Manage risks:

- I Identify, address and prevent violations, adopt best practices and achieve supply chain visibility as a means to maintain full disclosure on material and process origins.

I Realize efficiencies:

- I Improve gross margins through better product design and processes with reduced lead times; control the critical path of the products from fabric to finished goods.

I Create sustainable products:

- I Build better products that are closed loop and switch to sustainable raw materials and manufacturing practices to reduce total environmental impact.

Footwear and apparel players need to extend an arm into the depth of their supply chains to retrieve information on processes, providers and materials for each product in-store and on a website. This data should power visualization, verification, provenance and risk prediction within internal departments and external agencies, as well as suppliers and customers

I Improve brand equity:

- I Create collaborative conversations in the industry and governments to improve conditions for the entire ecosystem.
- I Engage with customers to increase awareness and adoption of ethical and sustainable fashion products.

Challenges & limitations: why a fresh approach is needed

The market measures of fashion brands and retailers establish the foundations of their business strategies and objectives:

- I Buying efficiency:** Lower purchasing price and higher gross margins.
- I Better and consistent quality:** Design and quality collaboration to reduce returns.
- I Faster design to shelf lead times:** To maintain freshness and seasonality.
- I Improved supplier capability, capacity and reliability:** To reduce risks and increase capacity.

Predictably, these objectives have set the prevalent guideposts for the fashion industry's supply chain IT strategy and roadmap, resulting in solutions that emphasize better buying, merchandising, logistics and product lifecycle management.

However, to meet corporate social responsibilities and sustainability mandates, retailers and manufacturers need a different approach. Footwear and apparel players need to extend an arm into the depth of their supply chains to retrieve information on processes, providers and materials for each product in-store and on a website. This data should power visualization, verification, provenance and risk prediction within internal departments and external agencies, as well as suppliers and customers.

Strategic Pathway Business Model: overview

Our Strategic Pathway Business Model acts as a framework to provide higher levels of visibility and traceability initiatives across all departments of a fashion organization. We begin this section with setting the business expectations, followed by an explanation of our approach to technology evaluation. From there, we delve into the strengths and essentials of blockchain to reveal how it can effectively complement related processes and systems.

The Strategic Pathway Business Model

	1. Scene-Setting	2. Assess & Evaluate	3. Prepare & Model	4. Build & Operate	5. Measure & Communicate
Summary	Business stakeholders achieve a context of risks and impacts, to establish objectives.	Evaluate the current state and accuracy of capabilities, information and systems.	Model a process, information and technology, framework and principles.	Build, integrate, pilot, evaluate and iterate to achieve incremental value.	Realize, visualize and measure for the benefit of all stakeholders, including external partners.
Recommended Activities	<ul style="list-style-type: none"> Gain a perspective on the environmental and social footprint of the products. Establish and agree upon definitions of commonly used terms – visibility, traceability, etc. Quantify the impact of not being sustainable on profitability, revenue and customer sentiment. Establish tangible environmental and social objectives, measures and benefits. 	<ul style="list-style-type: none"> Assess level of accuracy, verifiability and reliability of current processes and information related to: <ul style="list-style-type: none"> Product manufacturing facilities. Raw material origins. Material quantities and environmental impact. Gather sentiment and assess impact from: <ul style="list-style-type: none"> Customers. Suppliers. Internal departments. Agencies. Assess capabilities and limitations of systems and data sources, internal and external. 	<ul style="list-style-type: none"> Model the sourcing supply chain with a focus on: <ul style="list-style-type: none"> Supplier selection. Material and process consolidation. Procurement operations. Sourcing cost optimization. Information model to record, measure and report transparency and traceability. Technology model that depicts the flow of information through the chain, from farm to customer. 	<ul style="list-style-type: none"> Build blockchain-based product traceability and reporting engine. Onboard and verify supply-chain stakeholders down to raw material processors. Capture, verify and improve material flow data. Integrate and scale the information flow into the larger technology landscape. 	<ul style="list-style-type: none"> Create and generate reports to embed traceability and transparency data for internal and external stakeholders. Measure quality and usability of information. Measure sourcing and supply-chain value. Improvise. Incrementalize.
Unlock Quick Wins Through a Pilot	<ul style="list-style-type: none"> Form a core working group and develop hypotheses, pilot objectives and metrics. 	<ul style="list-style-type: none"> Identify merchandise and material categories that can be pilots. Initiate a pilot with a few initial suppliers, across a mix of geographies. 	<ul style="list-style-type: none"> Create initial process framework to identify information elements that need to be captured. Organize supplier and factory communications to facilitate onboarding. 	<ul style="list-style-type: none"> Prioritize the features that are most critical for the use case, and these are where blockchain will create the maximum impact to build a bare-bones testable technology framework. 	<ul style="list-style-type: none"> Deliver provenance information to all stakeholders, including customers shopping on product pages.

Figure 4



Strategic Pathway Business Model: deep dive

1. Scene-Setting

To successfully execute a strategy, it is essential to articulate the context and the impact of maintaining the status quo. It is recommended for all stakeholders to address the following key questions:

What is your organization’s definition of visibility and traceability?

Guiding examples include:

- **Visibility:** Knowing the name and location of factories involved in the processing and manufacturing of clothing and footwear.
- **Traceability:** Achieve accurate and verifiable information on the path that each product has taken through the supply chain from raw materials to finished goods.

How does lack of visibility and traceability impact everyone around the table?

What should you commit to achieve?

- Establish high-level objectives, measures, stakeholder commitment and a course of action.

The impact of limited traceability on all stakeholders

Board, Finance & Legal	<ul style="list-style-type: none"> ■ Overall impact on revenue and profitability, legal impact and risk to brand perception.
Product Design & Sourcing	<ul style="list-style-type: none"> ■ Cost inefficiencies and administrative overheads because of operating with a large supplier base. ■ Restricted material and design innovation.
Buying & Merchandising	<ul style="list-style-type: none"> ■ Negative impact on gross margins
Logistics, Supply Chain Percentage Quality	<ul style="list-style-type: none"> ■ Lead times impacted by low visibility. ■ High cost of product recalls.
Content, Creative & Customer Service	<ul style="list-style-type: none"> ■ Impact on customer engagement, and negative customer and social sentiment as a reaction to incidents.

Figure 5

2. Assess & Evaluate

Assessing the current state of the supply chain is an important step at this stage. More often than not, best practices, operating procedures and technology components can be enhanced and scaled to meet present and future needs. Obviously, this would be a preferred approach over building everything from the ground up. Therefore, it is recommended to walk across all departments to assess:

- Availability of information related to suppliers, factories, processes and materials.
- External sources of information related to sustainability and ethical trade.
- Accuracy and verifiability of information provided.
- Supplier participation and collaboration in the capture of information.

Fashion companies can find this stage to be the ideal starting point to conceptualize and model the supply chain, information flow and the technology landscape. What follows are strategic options available to determine the course of action.

3. Prepare & Model

Traceability initiatives never succeed unless all stakeholders are woven into a string of processes where expectations, objectives and value are clearly articulated. There is no better way to achieve this than creating models which give form and structure to define processes, input information and integrate systems.

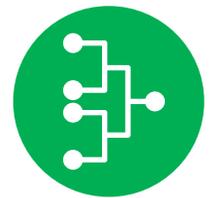
Operations model

Traceability can be established only if there is a structure within the supply chain. In the apparel and footwear industry, lower-tier factories will not be in direct control of fashion brands. It is recommended to adopt a supply chain model where the participants are known and preferably consolidated.

Supply chain model alternatives

Ad hoc	Declared	Consolidated	Nominated	Captive
<p>A fashion company has direct visibility and control only of their immediate suppliers.</p> <p>Lower tier sites are selected and managed by higher tier sites.</p> <p>Tier relationships are transactional and volatile.</p>	<p>Each supplier in the chain declares who their process providers are.</p> <p>This activity continues down to the raw materials.</p> <p>The fashion company is responsible to facilitate data capture and verification.</p>	<p>Fashion company consolidates its supply chain to nominated providers at a level (e.g., mills or tanneries).</p> <p>All tiers above the consolidated level are required to obtain materials or processes from any of the nominated providers.</p>	<p>Fashion entity nominates a preferred supplier for each activity.</p> <p>Each nominated process provider operates on guidelines and policies agreed upon with the fashion company.</p>	<p>All stages are owned and managed by a single entity.</p>

Figure 6



To capture all the data points to record, measure and report transparency, a supply chain mapping exercise should be initiated. This is the stepping stone to traceability, as all participants need to be recorded and verified. Figure 7 illustrates the key elements that need to be performed.

Key process elements for mapping the existing supply chain

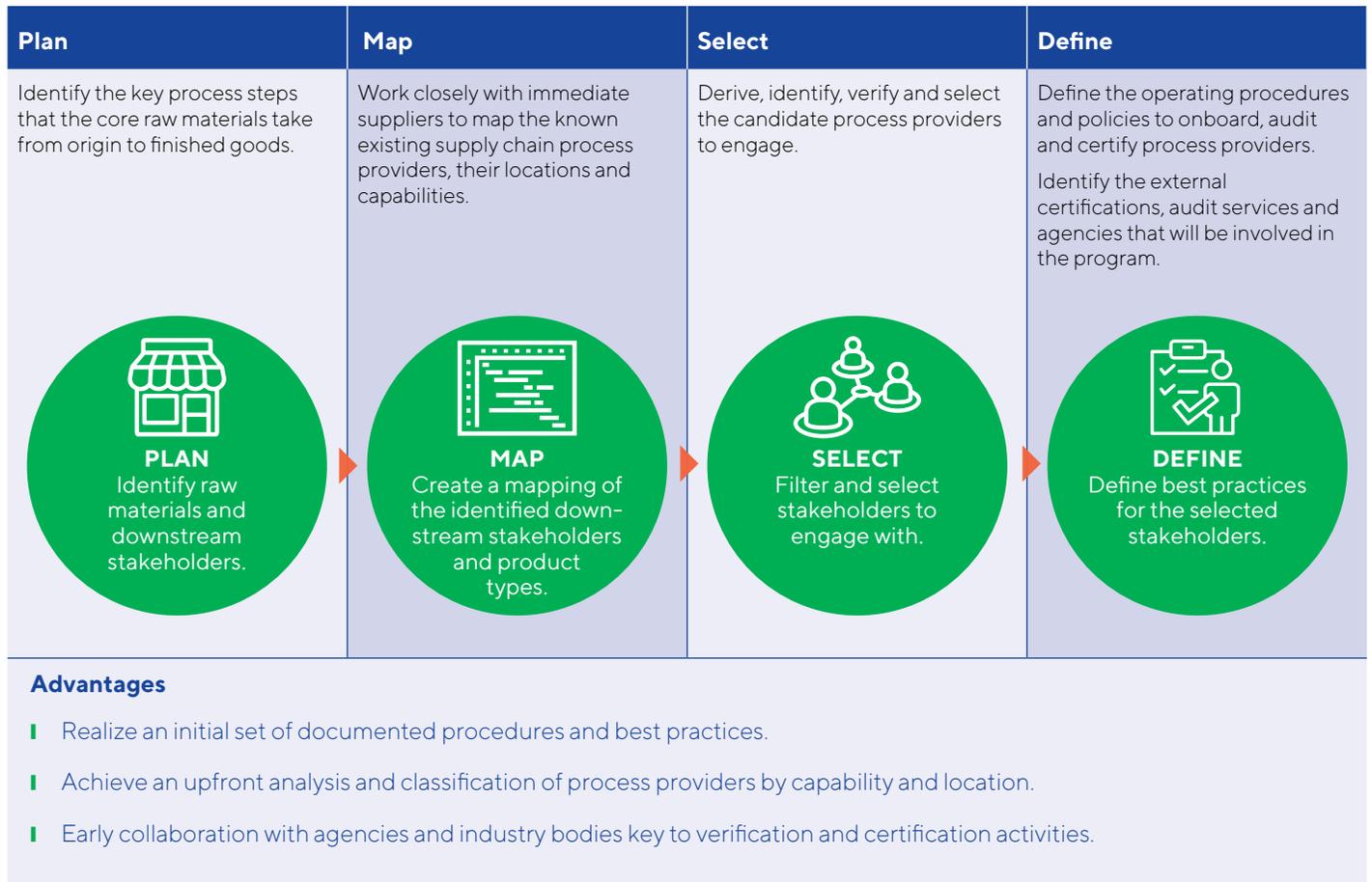


Figure 7

Information model

The level of visibility and traceability that can be achieved is a function of the information that can be captured, verified and reported from all stakeholders in the supply chain. Therefore, it is very important to take steps toward modeling the underlying information entities (see Figure 8).

An illustrative information model

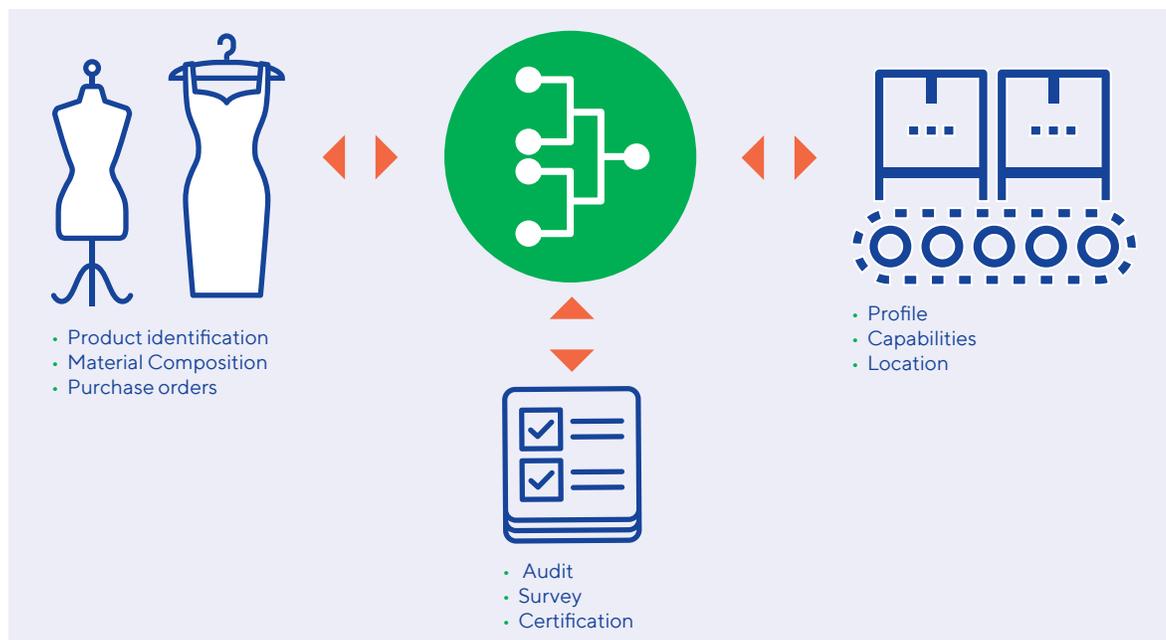


Figure 8

Each of these entities will have further sub-attributes that need to be modelled depending on the organizational context and complexity.

Technology model

Currently, the industry is managing the supply chain, product, sales and purchase data through a web of bespoke solutions such as enterprise resource planning (ERP) packages, traditional databases and client/server applications. However, each of these solutions has led to partial, unverified, unauthenticated data scattered among numerous players in the supply chain. As data is handed from one participant to another, the disparity and lack of a standardized technological infrastructure causes data to degrade with every transaction (i.e., due to manual reformatting and reinterpretation). As a result, the end user only sees a tiny bit of the full picture of the purchased product, and it is often rife with errors.

Systems and application can access the ledger which can read and write more directly to enable physically disparate supply chain partners to see data that is often of interest to interrelated parties. It also enables more efficient data extraction for further downstream analysis and reporting, both internally and externally.

Traceability and transparency initiatives extend far beyond the boundaries of the retail organization and into supplier sites and raw material providers, which need to be audited by agencies or third-party providers.

Therefore, the solution calls for an engine that would traverse the length and breadth of the supply chain landscape. Information collected across the chain needs to be consumed and verified by internal and external agencies, and applied for reporting and analytics.

Blockchain's data immutability, consensus and traceability can provide a verifiable system of data which provides a single source of truth. Systems and application can access the ledger which can read and write more directly to enable physically disparate supply chain partners to see data that is often of interest to interrelated parties. It also enables more efficient data extraction for further downstream analysis and reporting, both internally and externally.



4. Build & Operate

A constantly shifting supply chain environment makes cross-industry product traceability exceedingly complex. Products, suppliers, factories and processes are always in motion. Given the operational intensiveness of constantly onboarding new sites and rapidly gathering information on products with ultra-short lifecycles, footwear and apparel companies need an extensible solution.

Figure 9 (next page) depicts process flows that demonstrate how the blockchain/DLT can be used to capture and manage digital identities, as well as input to output states in the production of a cotton garment. This is a logical continuation of establishing the operations and process model.

Blockchaining the apparel supply chain

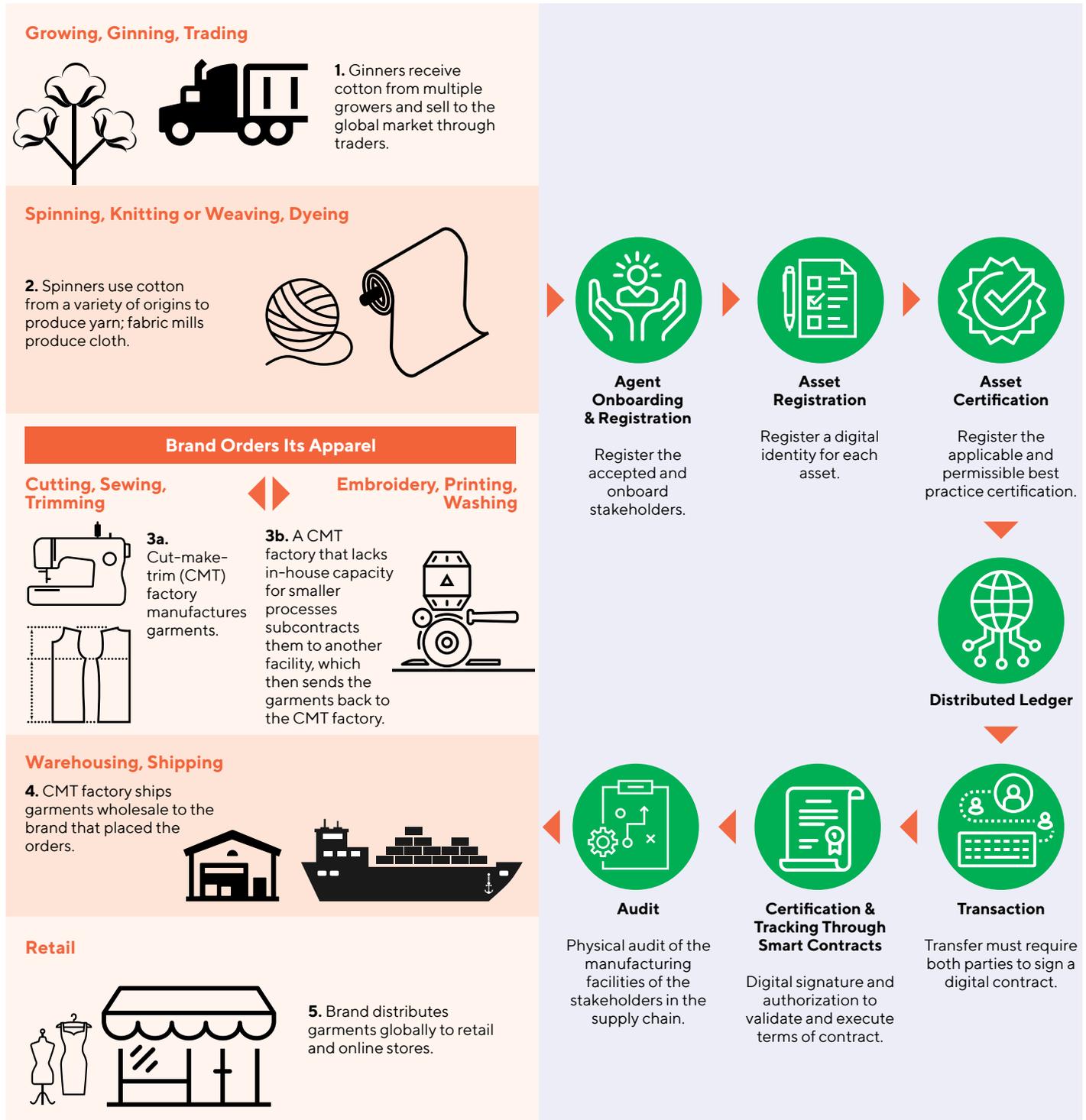


Figure 9

This type of blockchain network also provides certification and audit, which verify the end-to-end supply chain process. Figure 10 shows how information flows can be built in the blockchain/DLT to safeguard the business interests of all the participants on the network.

Process steps to integrate blockchain/DLT into the apparel supply chain

Process	Agent Onboarding & Registration	Asset Registration	Asset Certification	Transaction	Certification & Tracking Through Smart Contracts	Audit
Description	<p>All participants are onboarded and registered.</p> <p>They will be provided with a public/private key to reflect their digital identity on the blockchain by a registry.¹³</p> <p>Records are now available for inspection on the blockchain by the entire community.</p> <p>It is this level of transparency which forms the trust element to enhance their reputation on the network.</p>	<p>This process creates a token or digital identity for the asset.</p> <p>This digital identity of the assets is the key to transacting on the network.</p>	<p>The onboarded certification authority will inspect and verify the asset and provide a certification for the asset in adherence to best practice standards.</p> <p>Specific attributes such as fair trade and fair labor certificates can be achieved.</p>	<p>Transaction of assets between parties takes place from one manufacturing process provider to another.</p>	<p>Smart contracts can help enforce the validation of certification.</p>	<p>Independent auditors can audit the flow of materials through manufacturing tiers.</p> <p>This additional layer provides a greater level of credibility and verification of the processes.</p>
Example	<p>All mapped raw material producers, process intermediaries and manufacturers are registered onto the network and assigned a digital signature to sign their transactions.</p>	<p>A farmer yarn spinner processes 10 tons of cotton fiber and registers it on the blockchain.</p> <p>The recorded information includes material grade along with the facility name, location, and membership ID of a standards and certifications body such as Better Cotton Initiative (BCI).</p>	<p>The cotton can be certified by standards and certifications bodies such as BCI.</p>	<p>Spinner sells yarn to fabric mill.</p> <p>The mill sells fabric to the trim provider.</p> <p>Each party records the transaction on the blockchain.</p> <p>A digital signature provides authenticity of the transaction between participants.</p>	<p>10 tons of certified cotton can be entered into a smart contract.</p> <p>A spinner's sale of six tons of cotton is updated to recalculate and record four tons of certified cotton remaining on the smart contract.</p> <p>If the spinner engages in malpractice and tries to merge a different batch of cotton, the smart contract triggers a red flag, indicating an attempt to sell uncertified cotton.</p>	<p>The auditor inspects the manufacturers' facilities and updates the results on the blockchain.</p>

Figure 10

More process steps to integrate blockchain/DLT into the apparel supply chain

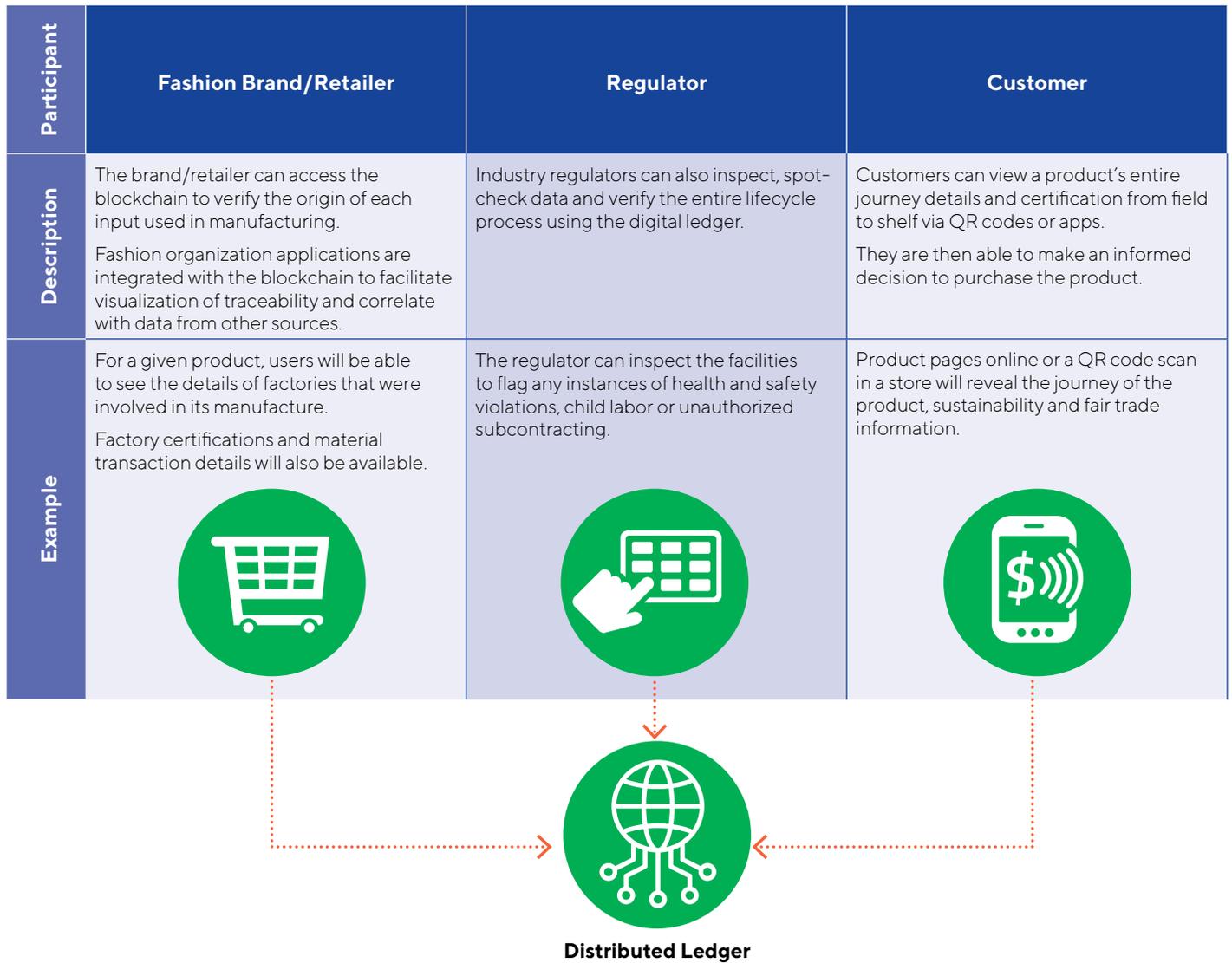


Figure 11

Smart contracts & certification

Certification is the most important aspect of provenance which proves that every material input and process has been performed to acceptable standards. Figure 12 illustrates the different types of certification for each actor and smart contract logic to validate and track supply chain data for the raw material producer, manufacturer and retailer.

How smart contracts validate & monitor certifications

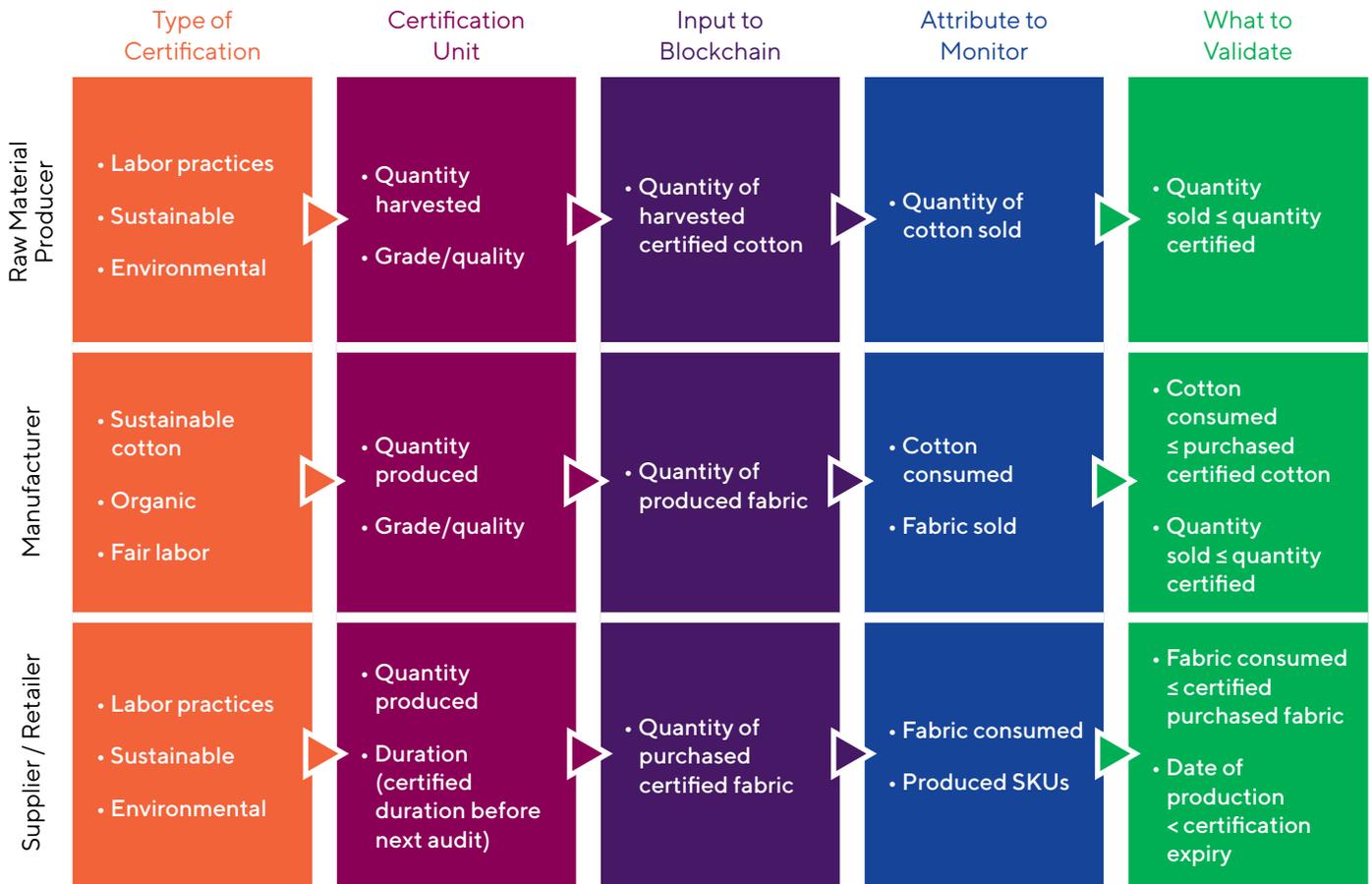


Figure 12

Scaling

The industry supply chain is a complex ecosystem and there will most certainly be multiple raw materials used in the manufacturing of a garment. To illustrate how this can be scaled up at a retail level, Figure 13 (next page) shows the digital profile of the information. This can be used to trace the provenance of the product using a hierarchical parent/child-like structure.

A hierarchical representation of product-level provenance data capture

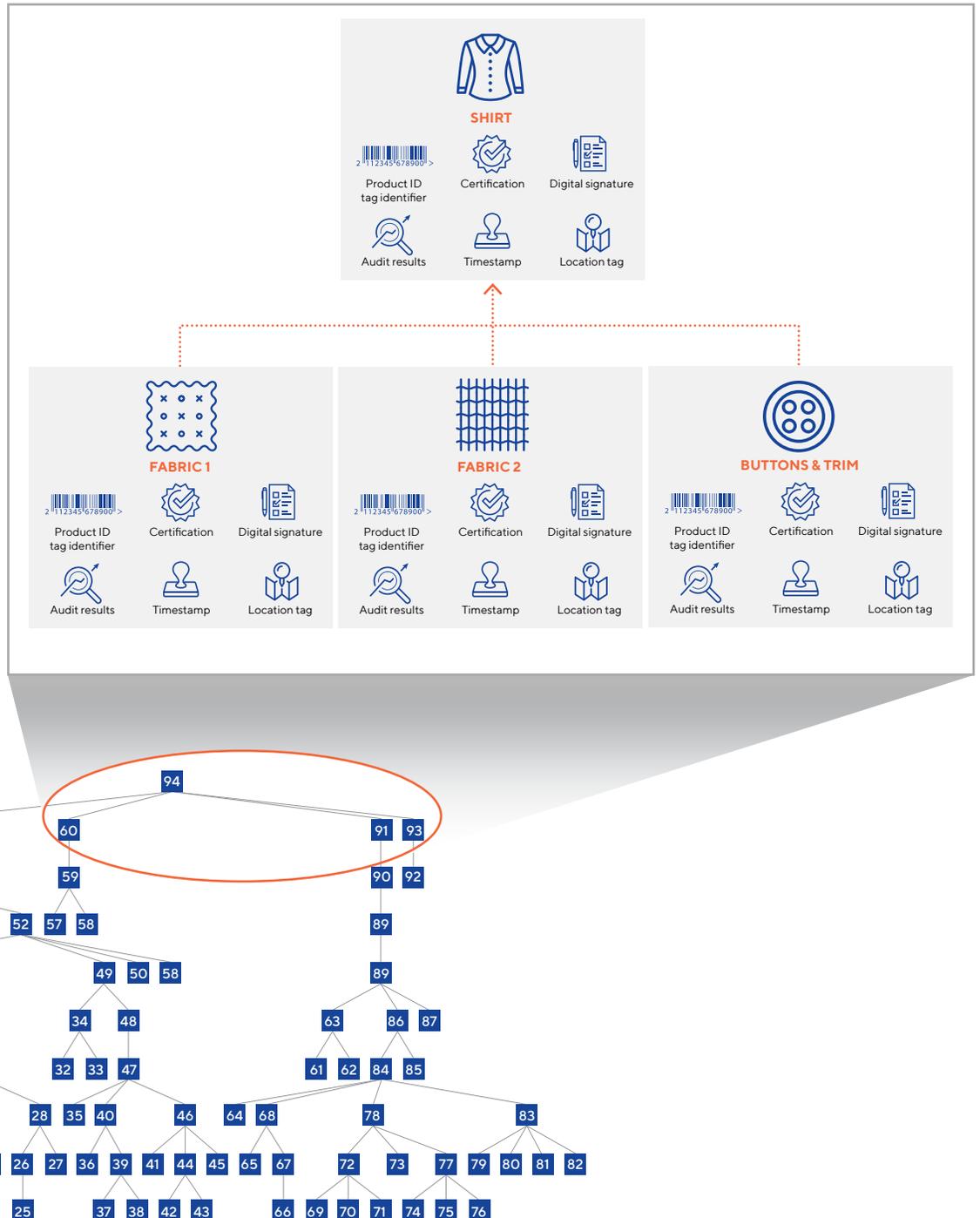


Figure 13



5. Measure & Communicate

Tracking data across the supply chain

Traceability across the supply chain presents unique challenges. Data must be collected not only from a retailer's direct suppliers, but also across sub-suppliers until the raw material providers have been found. To efficiently capture data, some level of classification will need to be considered (e.g., batches or standardized quantities) in order to adhere to the industries' norms. Although this is a developing area, the digitization of the product element can be used by incorporating bar codes, serial numbers, radio-frequency identification (RFID), near field communication (NFC) and Internet of Things (IoT) sensors.

Privacy: managing commercially sensitive information and blockchain types

While supply chain partners want full transparency, the fact of the matter is that a majority of participants are competitors. Manufacturers A and B may not want the selling price of a shirt, or their relationship with producers to be revealed through transactions on a common network. Hence, the ongoing blockchain debate: public, private or consortium-led blockchain alternatives. A public blockchain (e.g., Bitcoin, Ethereum) is open, and anyone with computing capacity can contribute to the network and manage the ledger. While, in a private blockchain, one or more businesses have authority to decide who can join and which members can write, edit or view information in the digital ledger. The consortium provides a hybrid between the public and private models.

Moreover, most industries are heading in the consortium direction (e.g., financial services with R3, energy companies, with Shell, BP and Statoil, and retail, with Walmart and Nestle leading the way). However, the decision to join a blockchain consortium or set up a stand-alone network often comes down to relative market power and strategic intent. Motivation to join includes understanding what the competition is doing, remaining competitive, preparing to implement the technology, or joining consortiums on the fear of missing out (FOMO).

Despite the many challenges organizations confront in unlocking DLT's full potential, forming a consortium can help individual companies overcome the trust barrier and encourage stronger collaboration to solve deep-seated industry challenges.

Various industry organizational bodies such as Better Cotton Initiative (BCI)¹⁴ and The Sustainable Apparel Coalition along with a number of start-ups (Provence, Sourcemap and Skuchain) are exploring ways to integrate and implement blockchain technology into the supply chain through their POCs. We suggest that all supply-chain participants proactively engage with these groups to stay abreast of DLT developments.

Blockchain/DLT’s implementation challenges

Our analysis suggests the industry faces numerous blockchain implementation challenges. Figure 14 groups the challenges into three primary categories and offers potential remedies.

Blockchain problems & solutions

Ecosystem Challenges	Business Challenges	Industry Challenges
<ul style="list-style-type: none"> █ Regulatory uncertainty and perceived legal risk. █ Data protection laws vary across geographies. █ Implementing evolving blockchain platforms.¹⁵ █ Interoperability between platforms and lack of standards. 	<ul style="list-style-type: none"> █ Providing participant incentives to perform best standard practices. █ Need for ground audits and recertification to ensure real world compliance of best practices. █ Increased cost to the supply chain for producers and the customer. 	<ul style="list-style-type: none"> █ Providing incentives to each supply chain partner for agreement to onboard onto the network. █ Each player has their own unique way to map the supply chain. Reluctance of these players to share these details can possibly hamper the formation of a consortium.
<p>We recommend the following to address challenges:</p> <ol style="list-style-type: none"> ① Reduce complexities through operationalizing some level of consolidation in the supply chain. ② Onboard audit, certification and industry bodies into the platform. ③ Communicate objectives through industry forums and supplier events. ④ Use the platform for incentives and penalties, which will benefit all parties on the chain. ⑤ Present the success stories to the customers and take customer feedback back to the factories. 		

Figure 14

Looking forward

Digital thinking and technology have made exceptional customer experience a must have, but it comes with significant investment. Compared with the customer journey, the product journey has received far less attention and investments. To balance the ledger, we believe blockchain/DLT can deliver enhanced product authenticity at a reasonable cost.

This white paper proposes a new business framework where certification plays a crucial element for advocating the ethical, sustainable property of the supply chain models.

In order to make ethical sourcing simple and ensure that transparency becomes ingrained in the supply chain, we believe the first phase should focus on using a blockchain network to manage a single product type for piloting and testing purposes, before embarking on different products and supply chain scenarios.

We recognize the complexity of the supply chain; getting it right has immense benefits to the brand and reaffirms trust to customers, retailers, manufacturers and providers across the ecosystem. But with shifting consumer patterns and supplier relationships, and a growing need to secure orders and remain competitive in the global market, we believe the fashion apparel and footwear market is rife for disruption.

Although there remain many technological, business and industry challenges, we believe the benefits of establishing higher levels of transparency and traceability will outweigh all the costs over the longer run. We recognize that for the blockchain/DLT to be implemented successfully in the supply chain, it must work and interoperate with other evolving technologies such as artificial intelligence, machine learning, the Internet of Things and digital identity systems.

Finally, our relationship with products and how they are produced is changing, and the blockchain/DLT models will definitely evolve across the supply chain to eventually reduce counterfeiting, improve labor practices and establish higher levels of ethical sourcing standards.

Endnotes

- ¹ Blockchain has three unique properties representing special characteristics for the supply chain: immutability (once data is transferred, it cannot be changed or altered); consensus (how members come together to adopt the protocols); and cryptography (how to receive and send data in a secure way using public/private-key mechanisms).
- ² That is, multiple untrusting participants exist where data is being entered in multiple databases to manage the business process. There are trusted third parties that facilitate interactions between multiple parties and there is an objective to capture or log facts, and an immutable history for parties.
- ³ The Boston Consulting Group predicts a rise of 63% in overall fashion consumption between 2017 and 2030, with increasing demand from developing countries. At this rate, over 100 million tons of apparel and footwear will soon be purchased annually. *Pulse of the Fashion Industry 2017*, BCG & GFA.
- ⁴ *Pulse of the Fashion Industry 2017*, BCG & GFA.
- ⁵ www.bbc.co.uk/news/world-asia-22525431.
- ⁶ www.bbc.co.uk/news/business-37716463.
- ⁷ www.theguardian.com/sustainable-business/2017/jun/13/hm-zara-marks-spencer-linked-polluting-viscose-factories-asia-fashion.
- ⁸ www.washingtonpost.com/news/capital-weather-gang/wp/2015/09/25/watch-the-aral-sea-disappear-one-torrid-year-at-a-time/?noredirect=on&utm_term=.1226dc905455.
- ⁹ <http://uk.businessinsider.com/egyptian-cotton-sheets-may-be-fake-2016-8>.
- ¹⁰ www.ceh.org/news-events/press-releases/content/toxic-fashion-new-testing-finds-major-retailers-selling-jewelry-loaded-cadmium/.
- ¹¹ www.bbc.com/news/business-40632891.
- ¹² In a recent Gartner survey, 30% of the respondents said that they have no or low-maturity sustainability initiatives. “How to Lead Supply Chain in the Big Shift to Sustainable Business.” March 2018. ID G00350699, www.gartner.com/doc/3869185/lead-supply-chain-big-shift.
- ¹³ The registry defines a process for the registration of the identified participants and assigns a digital identity which links their real-world identity with their blockchain-based digital identity. This digital identity will be representative of them on the blockchain, which can be verified by the registry upon request.
- ¹⁴ BCI is a nonprofit that promotes better standards in cotton farming and practices across 24 countries. The initiative now represents around 12% of global cotton production and partner retailers include H&M, Gap, IKEA and Levi Strauss. As of 2016, BCI has more than 50 retailers and over 700 suppliers.
- ¹⁵ Blockchain is evolving rapidly and new technology developments and discoveries are leaving earlier implemented versions dated. Hence firms are cautioned on undertaking investments when new developed protocols are expected to develop.

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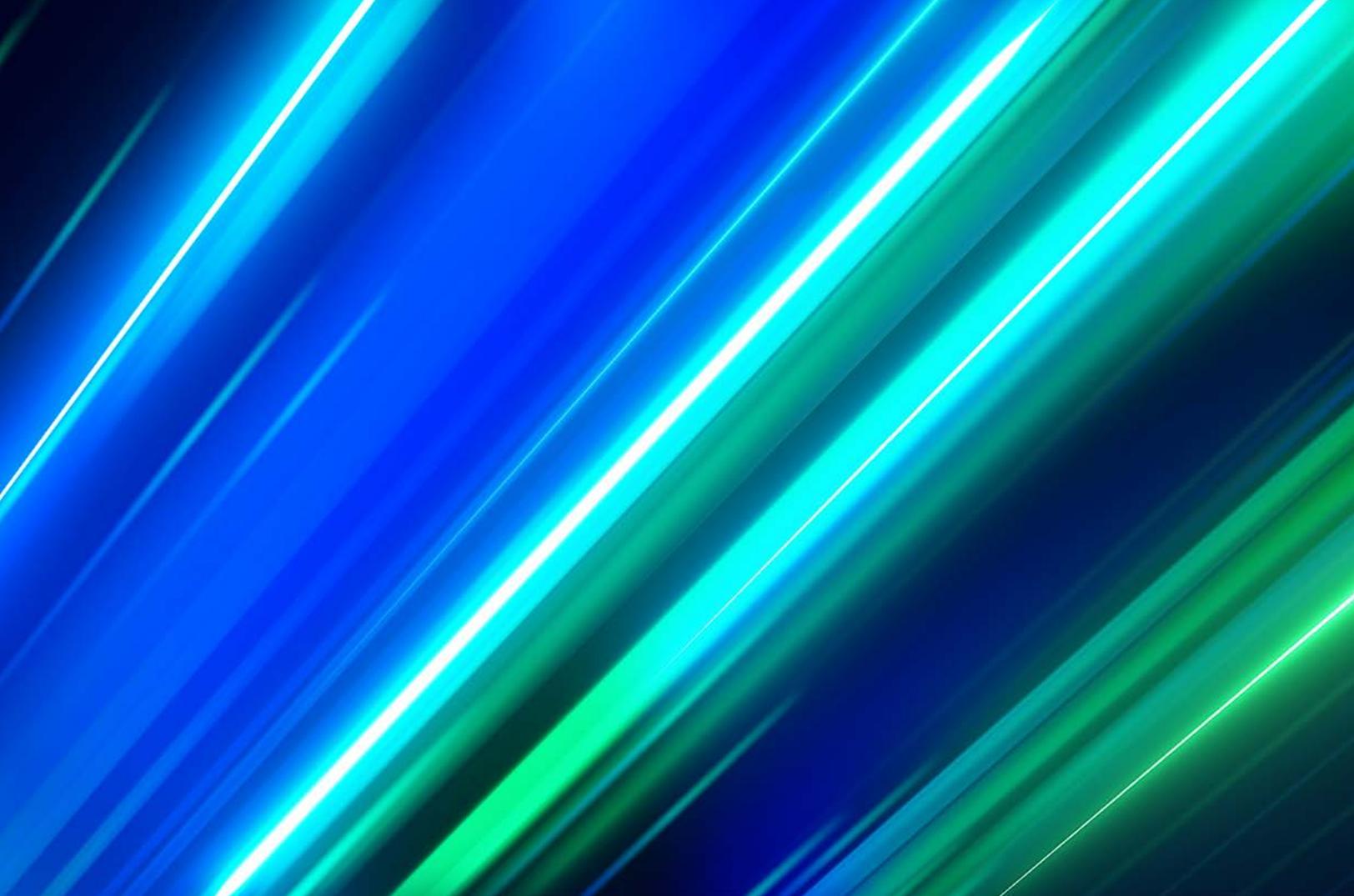
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Cognizant's Blockchain and Distributed Technologies Practice offers advisory, consulting and blockchain implementation services to organizations across industries. We uniquely bring together deep industry experience, extensive blockchain technical expertise, and intimate knowledge of the enterprise IT environment to guide our clients' journeys from prototype and pilot through production. Our collaboration with the industry's leading lights, combined with hands-on expertise with both open source and proprietary frameworks, gives us the business and technological capabilities to assist organizations industry-wide in their efforts to make blockchain a value-yielding and dependable shared infrastructure solution across the extended enterprise. For more information, please visit www.cognizant.com/blockchain.

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