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Using blockchain to drive supply chain transparency

Use cases and future outlook on blockchain in supply chain management

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Introduction

The COVID-19 pandemic gave the world a close-up view of the key factor determining the effectiveness of an organization—its supply chain management. Using blockchain can improve both supply chain transparency and traceability as well as reduce administrative costs.

Current supply chain landscape

Until COVID struck in 2020, consumer expectations revolved around a two-hour delivery model. But when the pandemic disrupted that model, consumers soon discovered the implications of the term "supply chain" as they confronted delays in the delivery of household goods — everything from toilet paper, mobile phones, and entertainment equipment to gaming consoles and home office furniture. With knowledge comes new expectations. And now both consumers and organizations alike are looking to technology to enhance supply chains and alleviate, or at least mitigate, any bottlenecks in the system. Nevertheless, technology is no silver bullet. Supply chains are often hostage to a host of factors including geopolitical tensions, cyberattacks, inflation, droughts that disrupt shipping by lowering water levels, and critical product stockouts, as well as the many unforeseen effects of global warming.

Given all these disruptions, many companies, and those responsible for supply chain effectiveness, are rethinking their lean and just-in-time planning as well as issues related to source, make, deliver, and return processes and systems. Moreover, supply chain executives are increasingly required to predict, and proactively mitigate, vulnerabilities in the supply chain. For that reason, these executives are focusing their strategic investments on three key effectiveness drivers:[1]

1. Predicting supply chain risk

2. Enabling environmental, social, and governance (ESG) tracking through supply chain traceability

3. Enhancing trust in a complex, multi-stakeholder environment

Enhancing these three drivers can help executives and their enterprises achieve transparency, track provenance and compliance, and enhance brand loyalty. For many organizations seeking to master their supply chains, this is where blockchain enters the picture. Blockchain is a record of transaction data that relies on a shared ledger. This ledger is inherently tamper-evident and provides a trusted shared and reliable way to record, validate, and view transactions across a complex system with many participants, some of whom may not inherently trust each other.

In the past, supply chain leaders had to rely on redundancy to mitigate supply chain disruptions. While some redundancy may always be necessary—especially for critical materials—solutions like blockchain can help companies proactively detect and mitigate supply chain risks before any severe impact occurs. For example, to increase transparency and traceability, companies in resource-intensive industries have turned to blockchain solutions to help control Scope 3 emissions.[2] Finally, because global supply chains involve many discrete entities that are frequently separated by several degrees in terms of their interests, the quality and opacity of information invariably degrades trust among parties. Technologies like blockchain can help offset such detrimental effects by ensuring the authenticity of information and transparency during upstream transactions.

How can blockchain help?

When thinking about how best to apply blockchain technology in the supply chain, it is important to remember that supply chains are, at their core, a network of interlinked companies. In that network, each business adds value to a product or service before it reaches the end user. This exchange and accumulation of value is recorded through a series of transactions, or flows, of information, goods, services, and finances.[3] A "permissioned blockchain" offers the potential of recording these transactions (both physical and virtual) on a shared and immutable ledger, which enables the capture, validation, and sharing of data across these interlinked companies. Ultimately, all parties have access to a seamless exchange of value and a single source of truth that was previously impossible. For more and more use cases (e.g., predicting risk; enhancing visibility and traceability for critical product components; increasing data accuracy, immutability, and trust among value partners), blockchain strengthens global supply chains. Moreover, blockchain technology is mature enough to interface with, and take advantage of, other emerging technologies such as Internet of Things (IoT), smart contracts (pieces of code stored on a blockchain), and artificial intelligence (AI) to provide an enhanced and secured supply chain.

The next section discusses the potential benefits of blockchain in each of these areas.

Potential benefits of using blockchain in supply chain

As noted earlier, blockchain has the potential to unlock significant value for organizations by reducing supply chain risk, increasing visibility, and enhancing trust across a complex ecosystem. Additionally, since blockchain does not displace a company's legacy systems, blockchain technology can serve as an add-on enterprise solution that increases value while still maintaining existing enterprise resource planning (ERP) software systems or other current systems. Let's consider three examples of how blockchain can deliver tangible benefits.

Reduced risk

The issue: Most supply chain risks fit within one of four categories—sourcing, transport, facility, or distribution. Each potential risk arises at a different step in the traditional source, make, and deliver process.

1. Sourcing risks occur upstream when a supplier suddenly fails to provide goods or services on time.

2. Transport risks occur with a disruption to a company's inbound or outbound logistics.

3. Facility risks coincide with interruptions in warehousing and manufacturing operations.

4. Finally, distribution risks manifest downstream when demand spikes or flatlines.

Opportunity for blockchain: Access to reliable data can help mitigate all these risks thanks to the timely identification of issues and potential alternatives. Yet, accessible, complete, and accurate data is not always easy to come by in a supply chain. The sheer number of parties involved, such as suppliers, manufacturers, distributors, retailers, and logistics providers, complicates matters. Moreover, since parties in a supply chain typically store data in silos, there is a lack of data sharing among them, and the accuracy of that data can vary considerably. Blockchain helps address all these issues by creating a trusted, shared, and decentralized ledger that eliminates silos and guarantees all parties access to that ledger thanks to tamper-proof records that help ensure the data's trustworthiness.

Consider this example. Blockchain, integrated with AI and data shared across cellular networks via Internet of Things (IoT) devices, can help companies monitor and expedite the identification of bottlenecks in the supply chain, thereby mitigating transport risks. This, in turn, can allow businesses to better anticipate the possibility and extent of delays.

Within the different facilities of a business, participants can reduce specific facility risks by leveraging satellites, IoT devices, and cellular networks connected to the blockchain. This allows them to monitor and provide real-time alerts about inventory levels and any disruptions at key inbound or outbound handoff points to upstream and downstream partners. Blockchain captures the collected data points as immutable records, which managers can access to trace and identify points of disruption and plan any necessary product reroutes. Blockchain also helps mitigate potential insurance disputes between parties by embedding insurance policies within smart contracts that will automatically execute their terms when triggered by a given event (e.g., weather-related disasters, cybersecurity attacks).

Finally, downstream, blockchain can help mitigate distribution risk. It allows organizations to build digital inventories that are accurate and immutable by implementing AI to obtain real-time insights into demand shifts, patterns, and potential disruptions. All that helps companies make informed planning and inventory management

decisions and more effectively manage the flow of goods down to the last mile.

Real-life example: Multiple entities within the Mitsubishi Group decided to explore the value of blockchain for various stages of their supply chain. As the world's largest producer of methacrylates (a basis for the polymers used in the manufacture of a wide range of medical equipment, from intravenous tubes to heart valves), Mitsubishi Chemical Group conducted a pilot project. Its goal? To enhance sourcing capabilities and provide both the enterprise and consumers with trustworthy data on the true origins of all its products.[4] The pilot provided the group with the ability to trace the full chain of custody and distinguish between the origins of the material (conventional versus recycled materials) through the use of colorized tokens (red versus green). As a result, Mitsubishi was able to assemble the necessary evidence in cases where the materials received did not meet contractual standards.[5]

Meanwhile, Mitsubishi Logistics also implemented its ML Chain platform. It allows the entity to sustainably manage facility, transportation, and distribution risks for its outsourced pharmaceutical shipments. It also provides clients with quality assurance guarantees that products are stored under proper conditions (e.g., proper temperatures) during transport from pharmaceutical factories and logistics hubs to wholesalers. The platform's distributed ledger technology helps ensure that data is tamper-proof and easily accessible to Mitsubishi Logistics' client base so all parties can flag potential issues at their source of origin along the blockchain.[6]

Enhanced visibility

The issue: Many companies struggle with a lack of end-to-end visibility and transparency in their supply chains.[7] Despite the growing ESG expectations of consumers and governments alike, many organizations are still unable to provide irrefutable information regarding provenance and chain of custody. That's especially true of large organizations with complex, multitiered supply chains. It can be particularly difficult for anchor companies (i.e., large global businesses with a lot of market power and a high-profile brand) at the downstream end of a supply chain to ensure that small businesses (i.e., companies that are more than 10 tiers upstream) are treated fairly and ethically.

Opportunity for blockchain: By implementing a blockchain-based supply chain, businesses can effectively digitize physical assets and create a decentralized, immutable record of all transactions across the end-to-end value stream.[8] Paired with IoT devices and radio-frequency identification (RFID) tags, participants can monitor the real-time conditions and movements of both perishable (e.g., vaccines and agricultural products) and non-perishable goods (e.g., gold and diamonds) on the blockchain thereby making it possible to track a product from origin to delivery … all the way to consumption. The blockchain creates an irrefutable product history that anchor companies can use to enforce ethical and sustainable business practices upstream more effectively. Enhanced supply chain visibility can be particularly effective in industries involving materials prone to unethical sourcing such as "conflict diamonds." The mining of these rare stones often occurs in countries with corrupt or weak regimes, where there is a significant risk of human rights abuses, including forced labor and child labor.

In the case of diamonds, it is, therefore, important for consumers to be able to trace the origin of their purchase to ensure that it has been ethically sourced. Another case in point is lithium batteries. Given their huge global demand, they are prone to counterfeiting. But thanks to blockchain, manufacturers can counter that by assigning barcodes to products and by generating unique tokens (i.e., digital twins). Each token contains cryptographic seals that denote the certification, originator, registry, and other data that prove the authenticity of each battery.[9]

Real-life example: De Beers, one of the largest diamond producers in the world, has implemented a blockchain-based tracking system called Tracr. Tracr allows De Beers to track diamonds from the point where they are mined, through the cutting and polishing process, and ultimately to the end consumer. This technology provides tamper-proof source assurance at scale, encourages consumers' confidence in the ethical sourcing of their diamonds, and helps to combat the trade in conflict diamonds.[10]

Improved trust

The issue: In a large, global supply chain that encompasses many parties, anchor companies may find it difficult to trust their upstream counterparts. Visibility and trust recede rapidly for most companies, even after the second tier of relationships. Such lack of trust has been warranted in the past, given counterfeit and gray market trade, the mistreatment of workers, and inconsistencies in sustainability practices among partners in the supply chain.[11]

Opportunity for blockchain: By recording all supply chain transactions on a shared and immutable ledger, blockchain provides a level of trust previously impossible. Importantly, it offers this level of trust to all participants (big and small) in the network. It does so by giving them access to the same information passed along the supply chain (thereby reducing fraud), by potentially minimizing communication or data transfer errors, by allowing businesses to maintain oversight on outsourced manufacturing contracts, and, ultimately, by saving businesses time previously spent validating data.[12] Finally, it is worth noting that smart contracts provide yet another mechanism for enhancing trust. By automatically executing a verifiable code that implements contract terms and conditions, smart contracts guarantee that participants in the supply chain adhere to the terms defined in their contract. That helps radically reduce the risk of incorrect or inconsistent contract execution.[13]

Real-life example: FedEx developed a prototype system to enable real-time tracking and monitoring of shipments. The blockchain-based system provides a secure, tamper-proof, and decentralized database that records every step of the shipment process—from the point of origin to the final delivery destination. The system uses

smart contracts to automate the transfer of ownership/possession of goods between different parties, such as the shipper, carrier, and receiver, and to ensure that all parties are aware of the current status and whereabouts of the shipment. That, in effect, eliminates the need for participants to trust each other. Moreover, this system helps enhance the customer experience and reduces the likelihood of disputes among various participants. In the event a dispute should arise, the smart contract can automatically trigger a resolution process, such as the return of the shipment to the original shipper.[14]

Key challenges for using blockchain in the supply chain

Beyond potentially enhancing supply chain resilience and viability, blockchain technology also presents several challenges that supply chain enterprises should consider during the decision-making process.

Interoperability

Overview: As blockchain technology continues to mature, its networks will require universal interoperability standards.[15] Those will help ensure compatibility across different types of blockchain platforms and decentralized applications, as well as existing legacy technological ecosystems. These measures will enable cross-communications and verification of end-to-end transactions throughout the supply chain networks.

Potential mitigation: Currently, "bridges" help achieve cross-chain interoperability. They are typically a combination of on-chain smart contracts and off-chain "relayers" that work in tandem to transmit information from one chain to another. While this facilitates interoperability, it may present certain trade-offs depending on the nature of the bridges. Ideally, the off-chain relayers should be decentralized. And on-chain smart contracts should auto-validate all the transferred information to eliminate the need to trust any intermediaries. However, this on-chain validation can be resource-intensive and prohibitively expensive. To offset that, certain trusted entities can be permitted to transfer information (instead of utilizing a decentralized network of relayers). While this can help mitigate the resource issues, it does require that all the participants trust the bridge relayers. Ecosystem participants need to assess these matters collectively to arrive at common standards based on acceptable levels of risk, performance, and trust among the participants.

Scalability

Overview: Scalability considerations—notably, processing power, high-speed internet connectivity, energy consumption, and proficient storage space—are the key factors affecting public blockchains.[16] Given the size and growth potential of public networks compared to the more exclusive private blockchain networks, enterprises are more likely to leverage the latter for their business needs. However, given the increasing globalization and interconnectivity of end-to-end supply chains across sectors,[17] enterprises may need to evaluate the scalability of their private blockchains so they can maximize the inclusion of supply chain partners and help mitigate the common supply chain risks noted above.

Potential mitigation: Currently, supply chain enterprises, and their internal IT functions, can explore a variety of possible scaling solutions. For public chains, popular solutions include high-capacity layer 1 blockchains and scaling solutions such as layer 2 blockchains. High-capacity layer 1s are chains that allow high throughput of transactions; however, they may make compromises on decentralization. Layer 2s are scaling solutions that build on top of existing layer 1s to bundle transactions before posting them back to layer 1. That way, they retain decentralization as they still rely on the base layer's security.

For private chains, scalability is less of a concern. That's because the permissioned participants can choose to rely on high-performing hardware and lighter-weight consensus mechanisms to support transactions throughout the network. Each industry needs to decide on what best suits its needs based on the nature of its supply chain network. If it needs to rely on a public chain, however, then it can use various layer 1 and layer 2 protocols depending on their ability to scale appropriately. If it needs to deploy a permissioned chain, then it should forecast network usage as accurately as possible to determine hardware requirements and the appropriate consensus mechanism.

Security and privacy

Overview: Every technological solution presents a set of potential security and privacy risks. Enterprises should bear these in mind across the exploration, design, adoption, and implementation phases of the solution life cycle. For blockchain technology, these security and privacy risks exist across four high-level categories: confidentiality, integrity, consensus mechanism, and smart contracts.[18]

Potential mitigation: Supply chain and enterprise leaders should be sure to incorporate their IT and cybersecurity partners into strategic discussions early and often throughout the entire solution exploration, adoption, and implementation life cycle. By doing so, they can help educate supply chain network participants on the best practices, key technological risks, and potential workarounds. Additionally, this collaboration facilitates the development of comprehensive IT strategic plans that can help mitigate potential risks as early as possible. Figure 1 provides an overview of security and privacy risks along with an example of a risk evaluation matrix across different types of blockchain.[19]

Figure 1. Risk evaluation matrix: Security and privacy risks

Cybersecurity risk area	Risk overview	Public permissionless	Private permissioned
Confidentiality	Information stored on-chain is accessible to all network participants. Hence, best practices avoid storing sensitive/private data on public chain; if there is an absolute need to do so, encrypt the data. For private chains, be sure that only honest participants join the network.	**High risk** All on-chain data is publicly accessible	**Low risk** Only allowed network participants can access on-chain data
Integrity	The immutable nature of blockchains protects data integrity by design; however, smaller-sized blockchains with fewer nodes are more prone to data compromises if a malicious actor gains access to a majority of the nodes.	**Low risk** Most prominent public chains have a high number of nodes	**Medium risk** Private chains typically have fewer nodes and a need for robust access measures to participate in the network
Consensus mechanism	Consensus denotes the mechanism by which network participants agree upon the status of the ledger. Smaller chains with fewer nodes are at a higher risk of attack. Such attacks can suppress transactions, validate fraudulent transactions, or cause a network outage.	**Low risk** Most prominent public chains have a high number of nodes	**Medium risk** Private chains typically have fewer nodes and a need for robust access measures to participate in the network
Smart contracts	Smart contracts are on-chain programs that automatically execute orders according to a code that captures agreed-upon terms. These smart contracts are immutable. Once deployed, they cannot be changed even in case of a bug. The only solution for a bug is to "kill" the current contract, deploy a new one, and then route users to the new smart contract. Hence, the audit of smart code is vital.	**Critical risk** If a "buggy" smart contract is deployed and used, it cannot be updated; moreover, it may be exploited once its vulnerability is found	**Medium risk** If a "buggy" smart contract is deployed, it's easier to kill it, deploy a new one, and have all the participants use a new smart contract

Source: Adrien Ogée et al., *Inclusive deployment of blockchain for supply chains: Part 5 – A framework for blockchain cybersecurity*, World Economic Forum, December *2019*.

Stakeholder buy-in and adoption

Overview: For global supply chain networks, the adoption of blockchain is still in its infancy. To spark further investment and encourage organizational buy-in, supply chain leaders should clarify the direct business value of blockchain technology to the C-suite of their enterprises. Leaders must also support further discussion on industry standardization of blockchain as well as the allocation of resources to develop critical internal blockchain expertise. Only then will leaders be in a position to advise on potential solutions, implementation, and integration with existing ERP systems and frameworks[20] so they can minimize operational disruption.

Potential mitigation: Supply chain leaders should facilitate discussions with internal and external stakeholders within the organization and across supply chain networks. That way, they can collectively explore the potential value-add of blockchain technology and conduct cost-benefit analyses that can inform future investment decisions.[21]

Case studies: Three Deloitte-led blockchain projects

Deloitte's world-class Supply Chain practice helps enterprises imagine, deliver, and run their digital supply networks to address tomorrow's challenges and opportunities. This section provides three examples of how Deloitte teams helped clients tackle some of their most complex supply chain issues using blockchain.

Case 1: Using blockchain and IoT for shipment tracking

OVERVIEW

Tracking parcels or shipments in real time is possible with modern delivery services; however, data is often tied to a specific company that manages the delivery chain. Valuable insights from collected data often end up in a centralized repository. But that limits their availability for analysis by multiple parties and represents a lost opportunity to optimize the management of the supply chain.

APPROACH

Deloitte worked with a client to develop real-time shipment tracking. To do that, Deloitte teams brought together a common blockchain platform—Hyperledger Fabric—which underpins Deloitte's supply chain prototype "Track and Trace," together with Thingstream, a real-time positioning tracker, and AWS technology. Strapped on to a pallet, a sensor records the location of a shipment over any GSM network, internationally. By tracking all data on a single ledger, the sender, shipper, and receiver can build a trusted and immutable history of the shipment's life cycle.

IMPACT

The prototype allows real-time tracking of any object as it is shipped across borders and without the need for human intervention to update its location. Data is recorded immutably on a distributed ledger. And in a network at scale, that prevents a single actor from tampering with any data. This process is the first step in the creation of integrated end-to-end blockchain solutions for supply chains—solutions that can enable greater collaboration between parties and increased transparency throughout the value chain.

Case 2: A blockchain-based proof of concept focused on simplifying patient consent and biological samples management in clinical trials

OVERVIEW

The complexity of biological sample (biosample) collection and management raises many challenges for clinicians who lead trials and who need to guarantee patients' consent throughout the process.

APPROACH

To demonstrate the value of blockchain in solving these pain points, Deloitte teams developed a proof of concept (PoC) called BioTrack & Trace. The PoC brings consent, biosample collection, biosample storage, biosample sharing, and analysis processes all on to the blockchain. This brings together the too often isolated processes as they are managed by doctors, clinical trial sites, biobank managers, and researchers. By tracking these processes on a single blockchain, operations teams and scientists can track a sample's location, understand how it was collected and used, and verify the level of consent the trial participant provided. Similarly, it allows trial participants to have greater control over their biosamples and gain insights into the results of their participation in the study. BioTrack & Trace ultimately improves tracking mechanisms, traceability, and consent management across the clinical trial's value chain.

IMPACT

BioTrack & Trace allows for any actor on the blockchain to track and trace biosamples and the consent provided by each trial participant. This is the first step in the development of a broader, industrywide blockchain ecosystem that enables greater collaboration and alignment between the needs and demands of pharmaceutical companies, data standardization, analytics, patient-centricity and retention, process simplification, and cost reduction.

Case 3: Supply chain tracking solution developed on Hyperledger to track medical products across different stages and actors in the clinical supply chain

OVERVIEW

A large pharmaceutical and biotechnology corporation had relied on paper-based manual processes, disparate systems, and external organizations to transport drugs being developed in clinical trials. These disjointed processes and systems lacked real-time transparency and end-to-end auditability of data.

APPROACH

Deloitte created a PoC to track drugs across different stages and among different actors in the clinical supply chain. That facilitated the traceability of individual samples that were dispensed to participants in clinical trials. The solution leveraged AWS Blockchain services, iOS and Android mobile technology, and Hyperledger blockchain fabric landscape. The mobile application, with Android and iOS versions, enabled barcode scanning functionality, status filters and counts, and blockchain connectivity.

IMPACT

This supply chain tracking application improved transparency for all users in the supply chain. Digitization of key processes also reduced the number of manual steps while streamlining the tracking of various data sources. Most importantly, it helped the company reduce the costs of regulatory reporting thanks to new data audit capabilities.

Conclusion: Future outlook for blockchain in supply chains

Imagine a world where you can replace the currently fragmented tracking of your supply chain with an interoperable solution, one that can significantly reduce the risk of unethical sourcing, shipping delays, inadequate storage, or ineffective distribution of your goods. Imagine a world where you can provide visibility into your supply chain to your customers and regulators and furnish irrefutable proof that you are meeting supply chain standards and expectations. And imagine a world, where, by addressing these considerations, you foster deeper trust and efficiency among all the stakeholders within your supply chain.

Blockchain can help address some of the key challenges that the supply chain industry faces today. While some technological and operational challenges remain in implementing blockchain solutions, Deloitte continues to work with enterprises to overcome these roadblocks and deliver the robust and effective solutions they need to forge superior supply chains. Given the current economic headwinds, and as corporations and consumers alike entertain high expectations of supply chains with fewer risks, greater visibility and transparency, and enhanced trust, Deloitte encourages enterprises to consider blockchain solutions as a possible antidote to their supply chain challenges.

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About Blockchain & Digital Assets at Deloitte

At Deloitte, our people work globally with clients, regulators, and policymakers to understand how blockchain and digital assets are changing the face of business and government today. New ecosystems are developing blockchain-based infrastructure and solutions to create innovative business models and disrupt traditional ones. This is occurring in virtually every industry and in most jurisdictions globally. Our deep business acumen and global industry-leading Audit & Assurance, Consulting, Tax, and Risk and Financial Advisory services help organizations across industries achieve their various blockchain aspirations.

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