Blockchain in the Supply Chain

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Introduction

This paper assesses to what degree blockchain technology is part of corporate supply chain management practitioners' domain expertise, as well as if there is any useful impact of blockchain-based applications on supply chain processes. A significant roadblock is, however, the extremely poor understanding corporate people have about blockchain. The first step of the journey is therefore to align on terms and definitions.

Blockchain is a distributed database network that maintains a continuously growing list of "blocks" with data records. A block records some or all of recent transactions, and once completed, it goes into the blockchain as a permanent database. It makes transactions recordable and trackable, providing a system that is transparent, efficient and market-oriented. The most significant features of the blockchain are briefly summarized below.

Notarization (Reputation): The process of securely keeping track of the creation and modification time of a document. It allows interested parties to know, without a doubt—and without the need of an intermediary, e.g., a notary—that a document in question existed at a particular date and time.

Title transfer: It allows smart property, a property whose ownership is controlled via the blockchain. Examples could include physical property such as cars, phones or houses.

Chain of possession (Provenance): Provenance enables every physical product to come with a digital 'passport' that proves authenticity (e.g., is this product what it claims to be?) and origin (e.g., where does this product come from?), creating an auditable record of the journey behind all physical products.

Smart contracts: Perhaps the most relevant blockchain feature, smart contracts are self-executing contractual states, stored on the blockchain, which nobody controls and therefore everyone can trust. With blockchain, not only can no party change history, but no party can bi-pass the smart contract permissioning logic. So a smart contract enables restrictions to be placed around which accounts can create or update the data.

Irrevocability/ Immutable (Time Stamping/History of transactions): The validation of any recording on the blockchain isn't centralized, eliminating the need of a third-party to intermediate. There is an irrevocable trail of all the transactions that have ever been made, which makes attempts of hacking or fraud unsuccessful.

Ownership and uniqueness of separately held documents: Blockchain participants may exchange documents with the certainty that they are sharing true and validated originals.

Where do we go from here?

Blockchain characteristics are particularly apt to transferring asset ownership. A pallet of goods, a bill of lading, a purchase order, or a certificate of origin are all examples of assets. Candidate supply chain processes to take advantage from the blockchain are those devoted to transferring these assets:

- "Procure Materials and Services"
- "Produce/Manufacture/Deliver Product"
- "Manage Logistics and Warehousing"

Procure Materials and Services

During the certification and validation of suppliers it is important to rely on a single source of truth that validates the qualification claimed by the supplier. Certification agencies will release and time-stamp the credentials that will remain irrevocable and immutable until the next audit. The collected information will form integral part of the negotiated contract that will be encrypted, signed, and time-stamped to become irrevocable. The agreed clauses will be coded in a smart contract and controlled in the blockchain during the execution of the pertinent business processes. The execution of the contract can be managed from within the smart contract. Only auditors- after being properly authorized- may check transactions that trigger the execution of the contract, while nobody else will access sensitive information protected by confidentiality.

During the ordering process it is important to compare vendor quotes, and the certainty that the original information collected from suppliers remains irrevocable and immutable allows to avoid future complaints from rejected suppliers. Similarly, confidentially concealed data may form part of eventual

internal audits to prove that the short-listed, and then winning, vendors conformed to the buying company's protocols and requisition criteria.

Once created, the purchase order can be time-stamped to become a valid (and legally binding – a blockchain feature not yet available today but most likely to become in the near future) document, whose clauses can be executed only if valid thanks to the programming features of smart contracts. When goods arrive at the buyer's factory, blockchain offers the possibility to time-stamp and control the provenance of goods, ensuring they correspond to contractual conditions and render irrevocable the recorded delivery data (e.g., date and time of arrival; condition of goods; correspondence with purchase order). Blockchain allows to control the existence and verification of completeness of the accompanying shipping documents. Ownership of goods may change at that moment depending on the agreed contractual terms. The ability of blockchain to secure the transfer of title triggered by a smart contract well fulfils this need.

Inevitable disputes from unmatched deliveries should be fast resolved by retrieving data collected throughout the order-receipt processes and adequately time-stamped, recorded, activated, and supported with documents all living in the blockchain.

Irrevocable and time-stamped exchange of supplier documentation and information allows to have all relevant data points necessary for a correct and unbiased vendor assessment.

Produce/Manufacture/Deliver Product

Material in inventory changes hands and for certain material (e.g., precious metals, expensive commodities, and price-sensitive items) it may be useful to prove the ownership of the goods and track their life cycle throughout the supply chain. This is especially important if the company has to prove to auditors that materials come from environmentally and socially responsible certified areas. Similarly important is to prove that the company ships finished goods with components and raw materials that comply with controls and criteria set either by the client or by regulatory bodies. The transactions relative to the movement of goods can be shared on the blockchain, but confidential data (e.g., price, value of goods, quantities) remain protected.

Fully operational production assets secure business continuity and reliability of delivered goods. In some industry sectors this represents an indispensable business discriminator (e.g., aerospace, medical devices). Data about how the maintenance was executed and who did it (e.g., was it a qualified agent? Was the process executed following the right procedures? Was it done at the right time?) may be stored to become irrevocable and indisputable. Signed maintenance schedules, list of used components,

pictures of operated parts, certifications of completed work, and skills certificates of maintenance operators are all documents subject to levels of trust that blockchain's notarization feature can ensure. If external teams are engaged to perform the necessary maintenance controls, it is advantageous to codify the expected activities using a smart contract. External contractors can share unique valid documents that produce evidence that utilized staff possess valid certificates of expertise and used components comply with required specifications.

Quality tests must produce valid and incontrovertible documents. Details of lab verifications and results of exams must be original, without risk of manipulation or counterfeit. The added complexity that they may come from various sources can be elegantly resolved by blockchain's capability to assign ownership and uniqueness of separately held documents. Customers or auditors may require true and unquestionable information on production execution (i.e., used components, tools and assets adopted, dedicated operators). Components and ingredients can be traced to supplier's raw material lots. Tracking products across the supply chain determines the source and destination of the material flows.

Manage Logistics and Warehousing

Inventory flows are associated with possession of goods and the ability to uniquely prove their ownership makes this blockchain feature relevant. Similarly, the possibility to track the possession of the products and determine their provenance becomes a must-have for any company that wants (or must) prove the origin of goods to contrast counterfeiting and strict health/ safety regulatory directives. The activities that add value to the goods (e.g., receiving, inspecting, picking and packing) may relate to contractual clauses that trigger payment of handling and logistics services. All activities may be made visible to external viewers, but sensitive data remains strictly confidential to authorized parties. Products shipped to clients may require certification of origin documents that can be best created, validated, and secured with blockchain's notarization characteristics. Change of ownership is made possible, as well as the possibility to trace back the provenance of all components of the finished goods' bills of material. The use of third party logistics service providers, of shipping carriers, and freight forwarders is fully regulated and automatically controlled by irrevocable and immutable smart contract execution. Shipping documents (e.g., bill of lading, advance shipping note, customs clearance papers) find the finest repository in the blockchain that takes care of the proprietorship and uniqueness of documents that belong to different owners.

Returned goods are managed with dedicated processes that must ensure that repairs follow strict rules and that- once refurbished- the products are compliant with specifics and criteria that blockchain's notarization best resolve. The possession of items moving backwards may be subject to warranty clauses that require changing the title of possession. Similarly, malfunctioning goods must be reverse-engineered and traced all the way back to the origin of components, to perform a root-cause analysis and identify the source of defect. The flows of warranties, repairs, and associated costs are excellently controlled via smart contracts, and the irrevocability of the transactions throughout the product's lifecycle together with the possibility to access valid and notarized documents make blockchain the perfect fit for this set of extremely important supply chain activities.

Conclusion

Blockchain is certainly not the panacea for all problems and the hype surrounding this innovative and potentially disruptive technology must be reduced and put in the right perspective. Applying blockchain features to operational supply chain processes however suggests that a good number (according to our research, at least one-third) of these could strongly benefit from the features offered.

This document suggests as next steps to create use cases with supply chain practitioners that test the assumptions and establish the true potential of the blockchain in the supply chain, into what can be defined 'Supply Blockchain Management'.