APPLICATION OF BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

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Abstract: The supply chain industry is a multi-party network of logistics, shipping, manufacturing and retail businesses coordinating with one another to take a product from manufacture all the way through the supply chain to the consumer or end user. Since distributed ledger technologies are generally immutable and tamper-resistant, they can help reduce the occurrence of fraud and increase transparency across every point in the supply chain. A further benefit that blockchain brings to the supply chain is increased data veracity and security. However, there are still many open questions regarding how to bridge events and assets living in the real world with blockchains. The goal of this paper, based on recently published literature, is a critical presentation of some theoretical and practical cases on the issue of how blockchain can function as a protocol that can offer a layer of interoperability across the supply chain industry.

Keywords: blockchain, supply chain, management.

1. Introduction

According to the Official Newsletter of the European Union's Blockchain Observatory & Forum, blockchain is one of the major breakthroughs of the past decade (Official Newsletter EU, 2018). A technology that allows large groups of people and organizations to reach agreement on and permanently record information without a central authority, it has been recognized as an important tool for creating trust online, potentially providing the infrastructure for a fair, inclusive, secure and democratic digital economy. This has significant implications for how we think about many of our economic, social and political institutions. As a key component of the next generation World Wide Web, often referred to as Web 3.0, blockchain is also expected to become an important industry in its own right. By providing trust in information without using third parties, blockchain can greatly facilitate peer-to-peer transaction platforms, potentially catalyzing new, decentralized and highly automated digital

markets that will create new businesses and be an ongoing source of innovation and economic growth (Chen, 2018).

Presently, it is well known that supply chains has become complicated. It takes days to make a payment between a manufacturer and a supplier, or a customer and a vendor. Contracts must be handled by lawyers and bankers, which means extra cost and delay. Products and parts are often hard to trace back to suppliers, making defects difficult to eliminate. Whether for industrial equipment, consumer goods, food products, or digital offerings, supply chains have many headaches. Friction in supply chain is a big problem. There are too many go-betweens. The rise in uncertainty stops supply chains from working well. Suppliers, providers and clients must deal via central third-party entities, instead of directly with each other. What should be simple transactions turn into lengthy procedures with many steps.

Supply chain is one of the industries where blockchain has the greatest potential to make a difference (Mire, 2018a). Part of the reason is that the supply chain industry is a multi-party network of logistics, shipping, manufacturing and retail businesses coordinating with one another to take a product from manufacture all the way through the supply chain to the consumer or end user. Unfortunately, the multi-party nature of supply chain tends to result in quite a few inefficiencies and opportunities for fraud. Blockchain promises to function as a protocol that can offer a layer of interoperability across these disparate systems. Another benefit blockchain brings to the supply chain is increased data veracity and security. Since distributed ledger technologies are generally immutable and tamper-resistant, they can help reduce the occurrence of fraud and increase transparency across every point in the supply chain. Data reliability is essential to supply chain systems. Blockchains are great for managing digital assets and ensuring their integrity (O'Byrne, 2017). However, there are still many open questions regarding how to bridge events and assets living in the real world with blockchains.

On the first of February 2018, the European Commission launched, with the support of the European Parliament, a two-year project (European Commission launches, 2018) – the EU Blockchain Observatory and Forum. The Blockchain Observatory and Forum will highlight key developments of the blockchain technology, promote European actors and reinforce European engagement with multiple stakeholders involved in blockchain activities. Blockchain technologies, which store blocks of information that are distributed across the network, are seen as a major breakthrough, as they bring about high levels of traceability and security in economic transactions online. They are expected to impact digital services and transform business models in a wide range of areas, such as healthcare, insurance, finance, energy, logistics, intellectual property rights management or government services. This has made supply chain one of the most promising early use cases for blockchain, and one in which one can see a lot of activity. In the frames of the EU Blockchain Observatory and Forum's first theme of 2019 (Lyons, 2019), they are looking into the current state of global supply chains and how blockchain can be applied, as well as looking at some of the projects and approaches currently being developed to meet this challenge.

Additionally, companies from around the world are exploring applications of blockchain technology in their own supply chain networks. A recent study by Capgemini Research Institute (Does Blockchain hold the key, 2018) that surveyed 731 organizations regarding their existing and planned blockchain initiatives, found that 447 organizations are currently experimenting with or implementing blockchain. Out of these organizations, manufacturers were found to have the most at-scale deployments of blockchain today, leading all industries included in the study.

Taking advantage of the developing potential of the blockchain technology as far as its transparency and quick, secure, and immutable nature is concerned, in this paper, we present research results and use cases described in the literature and concerning the blockchain technology as an important tool, especially in the supply chain management.

2. Transformation of the supply chain management

A blockchain is a distributed, digital ledger (Chen, 2018). The ledger records transactions in a series of blocks. It exists in multiple copies spread over multiple computers, which are also called 'nodes'. The ledger is secure because each new block of transactions is linked back to previous blocks in a way that makes tampering practically impossible. As it is decentralized, it does not depend on any single entity (like a bank) for safekeeping. The nodes connected to the blockchain network get updated versions of the ledger as new transactions are made. The multiple copies of the ledger are the "truth" about every transaction made so far in the blockchain. Trying to falsify the ledger would mean having to falsify the copies at precisely the same moment. The chances of being able to do this in blockchain networks of any useful size are negligible.

A typical supply chain (O'Byrne, 2018) has procurement, production, storage, and distribution. It has supplier, partner, subcontractor, and customer relationships. It also has an internal organization by function or department. In silo mode, each department or partner uses its own systems to track products and services. That means friction goes up and transparency goes down. Blockchain can help supply chains get out of silo mode. As a digital, distributed ledger, blockchain increases transparency and efficiency. The same information on transactions can be available to all. Smart contracts (Tapscott, D., and Tapscott, A., 2016, pp. 101-103) can then integrate with the blockchain as software programs. As events are recorded, the smart contracts can automatically trigger actions. For example, a delivery recorded on the blockchain can trigger payment.

Some ways that the blockchain can benefit supply chain managers and their companies include greater transparency and accountability between suppliers; near-immediate transactions using smart contracts; a tamper-proof ledger of manifests, departure and arrival times, etc.;

and a reduction in human error across the board thanks to more widespread automation (Mire, 2018b) – see the Figure 1.
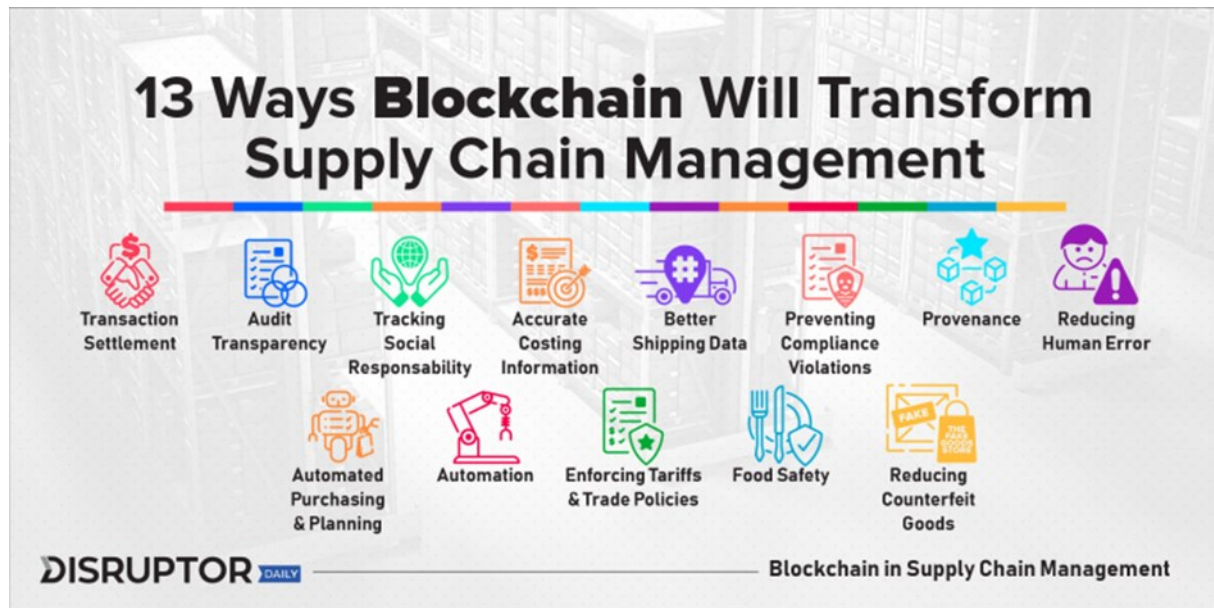

Figure 1. Transformation of supply chain management. Adapted from: (Mire, 2018b).

The deployment process for blockchain in a supply chain may be presented in the six following steps (O'Byrne, 2018):

Step 1: Identify the expected benefits. The link should be clear to improved profitability, or to generate customer satisfaction, or to both. For example, using blockchain might allow a cut out of multiple reconciliation steps after the return of a product. Measurable savings are then made.

Step 2: Pick the right blockchain consensus method. All users of the blockchain must agree on the existing blocks in the chain and the new blocks that are added. The "proof of work" method (Tapscott, D., Tapscott, A., 2016, pp. 31-35) used by bitcoin (Tapscott, D., Tapscott, A., 2016, pp. 5-10) is just one software mechanism to get consensus. The proof is hard to produce, although checking the result is easy. Other technical options exist. Or one can securely identify participants and trust them to behave, as described above.

Step 3: Pick the appropriate platform. Depending on the factors above and possibly others, choose a suitable platform (Tapscott, D., Tapscott, A., 2016, p. 136-138). Many blockchain platforms are open source technologies that are free to use. If there is a cost issue, it is more likely to be in the engineering resources required to make the platform do what one needs.

Step 4: Configure the platform. As blockchain solutions multiply, ease of use is also improving. The technology inside is still complex. However, it can often be accessed and configured through simple interfaces for administrators and other software applications.

Step 5: Write the smart contracts One could limit the use of blockchain to just making payments, for example. But the potential of smart contracts for enhancing supply chains in many other ways, is then ignored. Remember however, smart contracts live on a blockchain.

Once a smart contract to a blockchain is written, it cannot be altered. Therefore, bugs that were not discovered before cannot be corrected. Writing smart contracts is likely to be the biggest and the most complex step.

Step 6: Make a suitable user interface Blockchain system users may not be technically minded, but a good web interface can make it simple for participants to ask for admission to the system. Via the same interface, they may then enter transaction requests or confirmations to update the ledger and trigger execution of smart contracts.

In the opinion of A. Back (Back, 2018), a researcher and analyst at The Blockchain Review – a Business Journal on Cryptocurrency & Blockchain Technology (The Blockchain Review, 2018), using blockchain technology can deliver system-wide visibility across supply chains enabling companies to meet the transparency, traceability, accountability and efficiency imperatives required for competitiveness. By replacing rigid centralized supply chain systems with a dynamic, decentralized infrastructure, the blockchain technology supercharges the ability to track and immutably record the movement of both goods and information across entities on a supply chain. Transactions that occur on a blockchain powered supply chain can involve the transfer of anything of value from physical assets, to legal documents. These asset exchanges (transactions) are grouped together in an encrypted block with other recent transactions. Once validated, each transaction within the latest block of transactions is timestamped (Meaning of 'timestamp, 2018) and added to an unchangeable chain of blocks in chronological order. With each time-stamp including a previous time-stamp, an immutable audit trail is created that is visible to all members of the blockchain network, in real time, on an openly shared ledger.

Using blockchain in supply chain management provides a unique infrastructure that gives companies the capacity to link physical goods to serial numbers and digital tags and record them on a shared platform. Granular traceability and auditability of physical goods and an efficient method of identifying problems, criminal activities and assigning accountability become possible (The Blockchain Review, 2018).

3. Workshop report – supply chain and traceability

As mentioned in the Introduction, since February 2019, the EU Blockchain Observatory & Forum has been running a project on the current state of global supply chains and how blockchain can be applied. In the first workshop report, K. Timist and L. Courcelas (Lyons, 2019) presented the following issues to be tackled by the participants:

- … Today's global supply chains are immensely complex and long, involve a great number of actors, and rely often on outdated – often paper-based – processes.
- This has resulted in increasing demand from stakeholder groups for improvements.

o   Buyers (consumers) want more and better information about the provenance and quality of the projects they purchase.

o   Merchants want to unlock value by gaining efficiencies in their supply chains, but also in serving the demand of their customers for more granular, trustworthy information on their products - and so potentially commanding a premium.

o   Enforcement bodies want to more accurately and efficiently track and manage supply chains and their attendant market activities.

- The purpose of the workshop was to examine what projects have accomplished so far, how they have or have not scaled, and what hurdles they have faced and/or overcome. It was also to try and understand the role that Europe and Europeans can play in shaping blockchain-based supply chain innovations.

- At the moment, the US and China are at the start and end point of many global trade corridors and are in a good position from which to set standards. The question is what place Europe can have in setting norms and standards, as well as in developing its own regional champions.

One of the biggest challenges remains how to create a link between the physical product and the on-chain data. During the workshop discussions it was stressed that one has to be clear that blockchain was not a technology that washes data. It is garbage in/garbage out. So one needs accountability at the point of data entry. With blockchain, one could use tokenization (Tokenization (data security), 2019) as an incentivization tool to drive people to input data correctly, but how to ensure quality? Some standards could help. But standards cannot solve everything. Blockchain could be used as a tool to help, for instance, by having another person as a validator who could step in and review the transaction and validate it. There is a whole new industry evolving of blockchain-enabled devices in which a cryptographic chip is a standard component, like, for example, in a phone. Real-time data integrity, including secure protocols that allow physical devices to record data on the chain are needed. With granular transparency, it will be easier for people to understand what they are really buying (Voshmgir, 2019).

4. Present practices and the future of supply chain solutions

During numerous EU Blockchain Observatory & Forum workshop discussions, it was stressed that blockchain is expected to become an important industry in its own right. By providing trust in information without using third parties, blockchain can greatly facilitate peer-to-peer transaction platforms, potentially catalyzing new, decentralized and highly automated digital markets that will create new businesses and be an ongoing source of innovation and economic growth.

Y. Wang et al. (Wang, et al., 2019) recently explored how blockchain technology can potentially influence future supply chain practices and policies. Basing on a systematic review of both the academic and practitioner supply chain literature, they identified the main drivers of blockchain deployment within supply chains, as well as within areas in which this emerging technology may provide the most value for supply chain management. They demonstrated not only some of the technology's latest applications, but also a range of technological, organizational and operational challenges that are likely to affect its further diffusion. An important observation of blockchain initiatives in practice is that most of them deploy permissioned blockchain (Tapscott, D., Tapscott, A., 2016, pp. 67-68) solutions. Given the sensitivity of supply chain information, this is not surprising, as revealing proprietary details, such as demand, capacities, orders and prices, at all points of the supply chain to unknown participants is unwise. Permissioned blockchains are also more effective at controlling the consistency and integrity of the data that are appended to the blockchain, which is critical for decision-making. There tends to be a network orchestrator, who is likely one of the funding members, facilitating coordination and cooperation among the different stakeholders in a blockchain-based supply chain network. This orchestrator plays a critical role in future-oriented value creation, appropriation and distribution among network members. In addition to pursuing socio-economic gains, some consortia have broader aims. By design, the blockchain enables multiple supply chain stakeholders to transact with one another without requiring an intermediary. Therefore, it seems to be best applied when a problem across multiple parties exists, and these parties can each benefit from addressing the problem. This shared value encourages participation and incentivizes collaborative behaviors among participating members. Blockchain technologies also allow competing organizations to become involved in the same network (Wang, et al., 2019). Technically, most blockchain projects in supply chains are developed on either Ethereum (Home/Ethereum, 2019) or Hyperledger Fabric (About Hyperledger, 2019). The former is an open, generic platform (but has recently started to offer private blockchain solutions) that is well-known for its ability to execute smart contracts and allow monetary transactions. By contrast, the latter is a private modular platform led by Linux Foundation and it aims to advance cross-industry blockchain developments. A major difference between the two is their consensus mechanism. Ethereum relies on mining-based "proof of work" to validate transactions, meaning that all participants need to reach consensus on the order of all transactions that have taken place. It uses a built-in cryptocurrency ("ether") to reward miners and pay transaction fees. Hyperledger, in contrast, provides a more fine-grained access control, and only those parties participating in a transaction need to reach consensus.

In the recently book published by Blockchain Hub Berlin, written by Sh. Voshmgir under the title: "Token Economy. How Blockchains and smart contracts revolutionize the Economy", the author formulates in the final 'Outlook' (Voshmgir, 2019, p. 287) the following opinion: "When talking about Blockchain and derived tech, most people seem to focus on the positive potentials. Too little focus seems to lie on the negative implications of this new technology and

its applications. But any technology is always just a tool. How we use that tool is almost never a technological question, but a governance question. The question of how we design these new protocols and smart contracts like tokens is much more of a socio-political-economic issue than a technological one. Discussing potential negative aspects at such an early stage is therefore crucial. One of the most important aspects of criticism will revolve around developing and deploying privacy preserving cryptography in blockchains, otherwise, what was designed to be a free P2P (person-to-person) value exchange, can soon become an effective control machine and a perfect tool for totalitarian regimes"

5. Legislation on the blockchain technology

In the frames of 'Technological Innovation and Economic Growth – A Legislative Toolkit for State Legislators', the American Chamber of Digital Commerce recently published a paper entitled 'State-legislators-toolkit for blockchain technology' (Chamber of Digital…, 2018), where the transformative power of blockchain was described. In the opinion of authors of the paper and in the context of global supply chains, blockchain technology could provide businesses and individuals with an increased ability to track a product's entire path from manufacturer to consumer. The opportunities that blockchain can provide for the supply chain are not limited to one entity or activity. Business processes can achieve cost-reduction and higher levels of efficiency through a streamlined supply chain. Consumers will be able to better determine the quality, safety, and legality of their purchases. Lawmakers can harness this information to more effectively enforce and prevent child labor, forced labor, counterfeit goods, poor working conditions, or other criminal activities. Of particular note is the impact on food safety tracking. Less of the food supply would have to be destroyed if the source of food contamination can be more accurately pinpointed as the first signs of contamination arise. A blockchain-based supply chain would allow for this level of accurate tracking (Chamber of Digital…, 2018, p. 20).

The Toolkit describes the general transformative power of blockchain in the following way: "The transformative possibilities of blockchain and its tremendous positive impact for economic advancement have been recognized by policymakers on local, state, and federal levels. Its ability to improve business processes, increase efficiency, and promote transparency in numerous industries is reforming the ways in which companies conduct business. Its quick, secure, and immutable nature is helping retail giants such as Walmart, using IBM technology, trace produce back to its source within seconds, rather than days or weeks…"

Conclusions

1. Companies from around the world are exploring applications of blockchain technology in their supply chain networks.
2. Since the supply chain industry is a multi-party network of logistics, shipping, manufacturing, and retail businesses, blockchain promises to function as a protocol that can offer a layer of interoperability across these disparate systems.
3. The developing potential of the blockchain technology as far as its transparency and quick, secure, and immutable nature is concerned, was taken into consideration.
4. There are many open questions regarding how to bridge events and assets living in the real world with blockchains.

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