# Improving Supply Chain Transparency using Blockchain: Enablers and challenges

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**Introduction**

Bitcoin was the first system to utilise blockchain technology at a large scale. With the growing popularity of Bitcoin, blockchain systems have found a new audience within the business environment. The unique decentralized ledger technology that allows creation of verifiable transactions has extraordinary applications within business. In this paper the authors have attempted to identify the core benefits of using blockchain technology to improve supply chain management. The authors also have also briefly described the technological underpinnings of the blockchain system.With industry 4.0 transformation in its preliminaries stage, a discussion on how blockchain systems can benefit SCM is important. The authors also have identified the enablers and challenges of blockchain implementation.Like any other information system blockchain implementation is not just infrastructure changes but also requires organisational wide changes to reap the benefits of the new system. The inherent technological issues are preventing many organisations from adopting blockchain systems at a large scale.

The Global Supply Chain Forum (GSCF) defines supply chain management as "the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders" (Lambert & Cooper, 2000). In their work Lambert & Cooper (2000) were able to identify a framework to list out the issues that are faced in supply chain management.Chief among which was the issue of business process links.This business process links have a significant impact on the performance of the supply chain. To achieve a truly integrated supply chain, commitment from all the members is essential. Additionally the creation of such an integrated supply chain often puts the buying organisation at the risk of being captive to its supply chain partners since there is an overwhelming reliance on the partners(Keah Choon, 2002).The sheer complexity of managing business partners through the entire supply chain is compounded by the fact that there is often limited willingness to create anintegrated supply chain process(Lambert & Enz, 2017).

The contemporary literature identifies various methods to implement and sustain an integrated supply chain. There is consensus that supply chain integration requires both managerial and technical components(Gunasekaran, Subramanian, & Rahman, 2017; Lambert, Cooper, & Pagh, 2000; Turkulainen, Roh, Whipple, & Swink, 2017).To create an integrated supply chain the buying organisation has to invite its business partners into their organisation. This goes beyond just sharing information about the products and requirements thereby including them into their business activities. This integration does come with the challenge since there is no reciprocity from the business partners. The business partners are provided extensive information about the inner workings of the buying organisation while they can choose to remain firewalled.This is a unique problem since the objectives of both parties may not be always in line with each other.

There is also an issue of transparency which needs to be addressed. The question of "how much can I actually trust the information coming from my supply chain partner?" is a difficult question for any organisation to answer. One of the solutions to such a conundrum is the use of modern technology such as blockchain. Many organisations are now looking at blockchain to ensure the validity of the information shared across organisations. Recently Walmart had implemented blockchain in collaboration with IBM to track the movement of produce from Chinese farms to shelves(Jing, 2017).

In this article the authors have tried to discuss the impact of blockchain technology on supply chain management. In the first section the paper,blockchain is described and its impact on supply chain processes of modern digital supply chain is discussed in the second section. The paper concludes with a discussion on the enablers and challenges of a blockchain implementation.

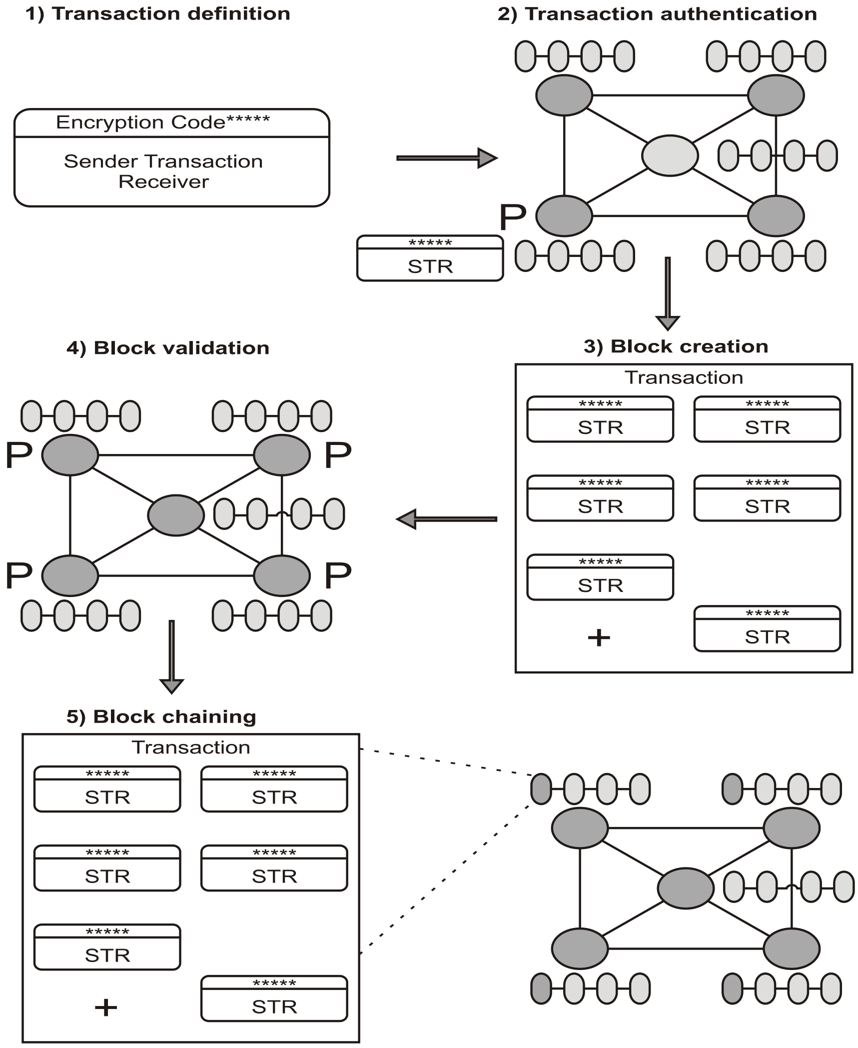
**Blockchain Technology**

The last two decades of technological innovations in the arena of peer-to-peer (P2P) networks and cryptography has led to the development of the blockchain. The fundamental technological principle of blockchain is the distributed, encrypted database, which cannot be reversed and is incorruptible. The following four technological concepts form the underpinnings of Blockchain technology;Decentralized Databases,Blockchain, Proof of Work/Stake and Smart Contracts(Morabito, 2017). Bitcoin was the first system to utilise the blockchain data structure and has become the blueprint for future blockchain implementations.

The starting point of the blockchain is the concept of Distributed Ledger Technology in which each participant of the P2P network has access to a shared ledger. This provides a secure environment to perform transactions without relying on a third party service provider (Ølnes, Ubacht, & Janssen, 2017). Every transaction performed in the network uses public key cryptography and digital signatures to validate the transaction.

The process of validation of the transaction is based on decentralized consensus. Instead of the traditional centralised consensus which was built on database rules; authority and trust of ensuring validity of recording transaction is moved to the decentralized network. Each node in the network is enabled to record transactions continuously and sequentially in a public "block" creating a unique "chain". Each successive block contains the unique fingerprint of the previous code in an encrypted format (hash). This combination of cryptography and blockchain system removes the need for a centralised intermediary for authentication of transactions(Mougayar, 2016).

In order to ensure the validity of information being created by the nodes, blockchain can use the network security protocol called "proof of work". This protocol essentially prevents attackers from creating transactions which are not authenticated. This protocol uses computational power from all the nodes to solve a complex mathematical function which forms the prerequisite for the proof of work scheme. Proof of stake scheme serves as an alternative to proof of work scheme which revolves around the entities that holds stake within the network. In certain conditions a hybrid of both the schemes can also be used to authenticate the transaction(Morabito, 2017). The generalised overview of the blockchain transaction is depicted below.




Adapted from :Morabito, V. (2017). Business Innovation Through Blockchain. Cham: Springer International Publishing.

This decentralized ledger technology has already found use in smart contracts. smart contract has been defined in the work of Ølnes et al.(2017) as a "mechanism involving digital assets of two or more parties where some or all parties put the assets in and assets are automatically redistributed among those parties according to a formula based on certain data that is not known at the time of the contract is initiated". Use of blockchain in smart contracts enables the correct execution of the contracts when the pre-conditions are validated by all parties in the network.

The use of blockchain systems has also fundamental economic benefits as well. With no centralised intermediary involved there is no cost of verification. For example every time there is a transfer of funds using banks, both the involved banks take a service charge which is considerably minuscule. However with blockchain this cost of verification (service charge) will be zero. Blockchain can also be considered as a general purpose technology i.e. it can be used to create a platforms without a powerful intermediary wherein the privacy risk and censorship risk is drastically reduced thereby reducing the cost of networking (Catalini & Gans, 2016; Chen, 2018).

Contemporary literature is littered with examples of how blockchain systems can be used to create a digital platform where authenticated transactions and records could be created(Lemieux, 2016). Sullivan & Burger (2017)detailed the efforts of the Estonian government to create a blockchain based e- residency program. In the Indian context, the Government of Andhra Pradesh has launched an ambitious scheme to use blockchain technology to manage land records and streamlining vehicle registrations(Haridas, 2018). The works of Guo & Liang (2016) and Petersen & Jansson (2017)have detailed the impact of blockchain technology on financial services industry beyond cryptocurrencies. Basden & Cottrell (2017)also talk about how blockchain could modernize the utilities grid to create a new era of decentralized power. Whereas Sun, Yan, & Zhang (2016) have identified the benefits of using blockchain based sharing services that can benefit smart cities.In all the above examples the traditional centralised intermediary based authentication is replaced with blockchain. In all cases the authors have identified that the ability to create transaction which are authenticated increases the transparency of the transaction and the underlying service as well.

Supply chain 4.0

Introduction of cyber-physical system in production and operations environment with the aim of interconnecting human beings and machines in a globally accessible network is referred to as industry 4. 0. The technologies involved in industry 4. 0 include Advanced Robotics, Artificial Intelligence, Hi-Tech Sensors, Cloud Computing, Internet of Things (IoT), Data Capture and Analytics, digital fabrication, mobile devices, Software As A Service and blockchain(Tjahjono, Esplugues, Ares, & Pelaez, 2017).Supply chain 4. 0 is the application of the above mentioned technologies in supply chain management to improve performance and customer satisfaction(Alicke, Rachor, & Seyfert, 2016). Supply chain 4. 0 creates a disruption in the traditional supply chain environment which requires organisations to radically rethink and redesign their supply chain.Alicke et al. (2016) and Tjahjono et al. (2017)also identified the potential cost reduction in various domains of supply chain. The summary of the same is presented below.

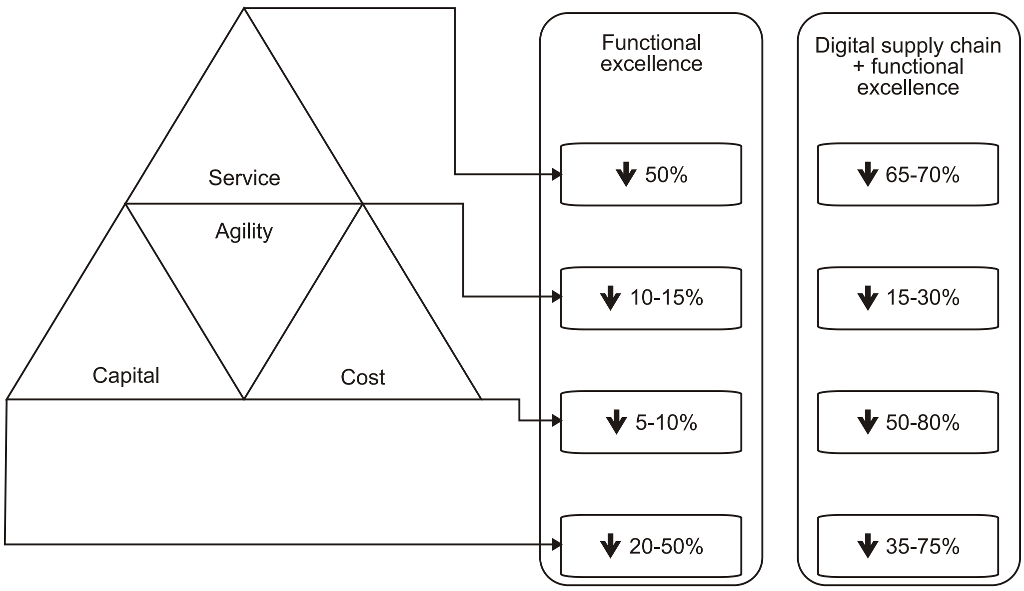



Figure 1: Adapted from Alicke, K., Rachor, J., &Seyfert, A. (2016). Supply Chain 4.0 - the next-generation digital supply chain. McKinsey & Company, (June).

The supply chain 4. 0 benefits have been achieved on the traditional data infrastructure for business intelligence. The traditional infrastructure relies on centralised data repositories which connects all the partners of the supply chain. However centralised system could be easily manipulated by any of the business partners rendering the data untrustworthy. With the use of blockchain in supply chain management an organisation can create decentralized platform for recording transactions that cannot be manipulated. The transparency that the blockchain system provides will enable organisations to improve the supply chain itself.

The following three studies are of particular interest for this article. The first study done by Bocek, Rodrigues, Strasser, & Stiller (2017) explains the use of blockchain system in Pharma supply chain. In their work, the authors were able to present the case of a start-up that uses IoT sensor devices to leverage blockchain technology to bring about the benefits of fraud detection and identity management. The second study conducted by Tian (2016)details the utilisation and development of RFID based blockchain system to build agri-food supply chain traceability. A similar conceptual study conducted by Tieman & Darun (2017)detailing how blockchain system could be used to modernize the halal supply chain.All three studies look into the different parts of the supply chain's transparency issue. The benefits of blockchain technology are not limited to transparency alone but also include durability, immutability and process integrity(Abeyratne & Monfared, 2016). For example, use of blockchain makes it much more difficult for illicit or counterfeit products to enter an otherwise legitimate supply chain(Apte & Petrovsky, 2016; Lu & Xu, 2017).Having a transparent supply chain enables an organisation to plan better. In a typical supply chain, multiple parties are involved and this generates extensive amounts of documentation. Small error in the paper documents may result in delays or hold up of payments. Using blockchain eliminates this chance of error thereby reducing the extra price of verification which is required for paper based documents. Blockchain based systems can also reduce the procure-to-pay gaps with the use of smart contracts. This validated data storage provides organisations to create better data analysis platforms which can reduce the inventory cost by better forecasting(Ernst and Young, 2017; IBM Insitute for Business Value, 2016).

**Enablers and challenges**

To understand the enablers for blockchain implementation within a supply chain we can consider the work of Wang, Chen, & Xu (2016) where the authors attempt to map blockchain implementation with the capability maturity model. Wang, Chen, & Xu (2016) identified four categories and their corresponding maturity levels.This model can be used to understand the enablers within the blockchain implementation. The first of the categories is network; with the blockchain, organisations will have to transform their existing centralised networks to enable peer to peer communication. Second category is the information systems wherein the authors have identified both technical and managerial parameters. The chief among the technical parameters is the requirement of upgrading the infrastructure which includes the computer systems, interfaces and storage. There is also requirement that blockchain system should not be standalone which requires extensive integration across the legacy systems. Third category deals with the computing methodologies. With blockchain, generating standards that are acceptable across companies is a challenge (Alicke, Davies, Leopoldseder, & Niemeyer, 2017). The computational complexity involved in managing a complex blockchain is not just limited to the volume and the speed it extends to ensuring data accuracy as well. Fourth category is the security and privacy category. Using a public blockchain would render confidential information at risk of exposure. The complexity of securing all the nodes in the network is also extensive.

To add to the work previously done byWang, Chen, & Xu (2016), we can also add the fifth category of skills. With the complete redesign of the supply chain environment the employees within all the participating organisations have to develop new skills to leverage the benefits blockchain. Better cross functional communication and leadership skills would strengthen the collaboration between the relevant parties and prepare the organisation for the digital transformation which is required.

While considering blockchain for adoption it's important for an organisation to understand what is the problem that they are trying to solve. Digital transformation of the entire supply chain involves both high complexity as well as high novelty whereas single use systems require far less effort from the organisations (Iansiti, Lakhani, & Mohamed, 2017).Hence to have a successful implementation of blockchain systems, organisations need to have maturity in all categories described above along with a clear business rationale for the implementation.

One of the critical challenges involved in the implementation of blockchain systems is the cost. As discussed before blockchain systems require complete overhauling of the IT infrastructure which is expensive (Alicke et al., 2017). The second challenge is with the technology itself; the network based validation reduces the throughput of blockchain transactions as well as latency. With the current setup of blockchain achieving the performance parameters of centrally controlled systems is extremely difficult (Mendling et al., 2018). The regulatory uncertainty is definitely a challenge within the Indian context as India government has recently decided not to recognise cryptocurrencies which is based on blockchain. The fact that blockchain implementation involves multiple business partners is a barrier to the implementation of the project. Combined with the lack of acceptance within the industry driven primary by the uncertainty of benefits makes the implementation project extremely challenging (Kersten, Blecker, Ringle, Hackius, & Petersen, 2017). Even with these challenges the benefit of creating a transparent supply chain is pushing major players in the market to adopt blockchain as a viable alternative to traditional information systems.

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