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Applications of Blockchain to Improve Supply Chain Traceability

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Abstract

Blockchain has been emerged as a promising technology for a traceability system in industry. It can also be applied to many functions of a Supply Chain Management (SCM) system, such as logistics, quality assurance, inventory management, and forecasting. One of the most important functions of the SCM is to improve the transparency, traceability and auditability of materials flow throughout the supply chain from suppliers, manufacturing facilities, warehouses/distribution centers, to customers. This research especially focuses on the impact of blockchain on supply chain traceability through the current industry applications, and its future direction.

Keywords: Blockchain; Digital Supply Chain; Supply Chain Innovation; Industry 4.0

1. Introduction

The improvement of operations and supply chain functions in any industry has become a core heart of business operations and strategy. To support right decisions of the supply chain operations, firms need accurate and on-time/real-time information about inventory, in-transit movements of materials and products, and many others. Information and Communication Technologies (ICTs) have been rapidly advanced to allow firms to access, obtain, analyze those data, and then make more timely decisions and predict customer demands and necessary further operations. Thus, traceability, i.e., the enabler of making right and timely decisions, has become one of the key topics of Supply Chain Management.

Researches and projects have been done to find ways to improve the transparency, traceability and auditability of materials flow alongside the chain of suppliers to customers. More and more ICT based Supply Chain (SC) traceability solutions have been implemented. For instance, the GLOB-ID project sponsored by the Italian

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government [1] employed a cloud based unified platform to integrate legacy enterprise information systems to enhance SC traceability and transparency of supply chain. Supply chain traceability also means improved environmental sustainability as it was illustrated by a real business case of a leather shoe supply chain [2].

This research has studied the current industry applications of blockchain to the trace of supply chain operations in various industries, and then discussed its benefits and issues for further industry applications.

2. Blockchain as an Enabler of Improving Supply Chain Traceability

2.1. Immutability in Blockchain

Blockchain, in short, is a record-keeping system. It stores information about transaction records shared peer-to-peer across all computers within its network. As transaction records, notably blockchain ledgers, are managed by multiple nodes, blockchain virtually eliminates the possibility of manipulating the transaction records. This feature, called immutability, is indeed one of the most critical advantages of blockchain many industry applications aim to benefit from. This immutability, however, comes with a critical implication: blockchain ledgers are by principle, stands for "public." All such records are managed in the chain, where dependencies between transactions are created, and shared across multiple nodes in the blockchain network. The ledger it provides does not belong to any centralized entity but is managed by a group of computers, miners, as they are otherwise known.

2.2. Wider adoption of Private or Consortium Blockchain

Based on the degree of being "public", blockchain is categorized into three types - public, or permissionless, blockchain where anyone in the network can read, write, or audit chains; private, or permissioned, blockchain where only one entity has full control; and consortium, or federated, blockchain where the rights to read, write, or audit chains are shared amongst members in the consortium. Public blockchain is often found impractical for its high cost and slowness. It is also highly hindered by the "everyone-can-read-everything" problem as noted by [3].

Private blockchain is also criticized for its non-democratized control weakening its value vis-a-vis one of the key design goals of blockchain, but it is understood as a more realistic option in addition to consortium blockchain. While public blockchain, at least theoretically when its limitations are well addressed, could "reinvent" business processes, private and consortium blockchain can be adopted to "complement" business processes. In particular, we would like to examine its "complementary" application to enhance the traceability of supply chain.

2.3. Impact of Blockchain on Supply Chain transparency

[4] described how blockchain could improve traceability and transparency for a 4PL company. In all, SC meets all decision criteria for adopting blockchain technology as set forth by [5], namely, SC is operating in a multi-party value chain; SC needs a shared system of records; There exist conflicting interests and/or no trust in the SC; There exist varying governing policies for entities in the SC; and SC needs immutable event logs. For this reason, the application of this 'nascent' blockchain technology on SCM has gained some good tractions.

2.4. Literatures on Supply Chain Traceability

From the SC perspective, innovation implies an improvement in the flows of products and/or services and information within a SC network. Recently, the concept of Supply Chain Innovation (SCI) has been increasingly

discussed in both practice and academic circles, e.g., [6 - 7]. The literature has described SCI as an interaction of multiple components [8]. Among others, [9] highlighted the importance of i) process and ii) technology as the main components of SCI. The effective and efficient process is defined as a set of activities that facilitates transactions across all SC members including consumers [10] and the technology is considered as a mean that builds the processes by improving traceability and transparency in a SC [11], [9]. Recent literature characterizes the direction of SCI as the digitalization [12]. For example, [13] explore the implications of digitalization which can offer opportunities that will transform a conventional SC toward innovative SC. [14] consider Digital Supply Chain as the base concept for establishing end-to-end information integration in an innovative SC, and they explain the requirements and functionalities of this direction of SCI.

2.5. More Opportunities and business cases of blockchain in Supply Chain Traceability

As it was reviewed above, distributed blockchain ledger system has already been proven to become a very practical SC traceability system. Its adoption is rapidly growing especially in industries where conventional centralized system has faced with technical challenges such as:

- Complex chain of actors. Traceability requires the active engagement and well-concerted collaboration of many participants or actors in the entire SC. Building and operating a centralized system across the complete SC often becomes impractical.
- Ensuring trustworthy. In a complex SC with many actors, a good SC can not be built without strong trust in the entire chain. Partners in the SC highly welcome the democratized and tamper-proof record keeping system.
- High cost entry barriers. Many legacy centralized systems have been implemented with expensive ERP systems from companies like Oracle, SAP, and IBM, raising entry barriers for small farmers, truck drivers, or fisherman, etc. Blockchain based new SC traceability systems allow them to join the SC system simply by a smartphone.

2.6. Challenges and risks of blockchain in SC Traceability

All these said, however, blockchains do not have perfectly rosy roads ahead. As [3] listed, the adoption of blockchain as a SC traceability system should go over the key challenges of:

- Challenge in linking physical to digital. Significant investment is needed to link non-digitized and physical elements to the digital space by the use of various communication technologies such as RFID, NFC, and IoT.
- Cultural adoption to decentralized network. It should go over the cultural barrier to convince stakeholders in SC who are yet new and resistant to the new model of democratized processing.
- Perception & trust of general public. Likewise, wider trust of the general public will play a key role for SC actors to agree with and move on this new technology.

3. **Summary**

Blockchain has already proven to become a good Supply Chain traceability system, and it will inevitably expand its adoption to improve the transparency, traceability and auditability of materials flow along the parties in the Supply Chain. The heat map and velocity of adoption vary per each vertical segment of the industry, mainly based on how critical it is to trace materials flow.

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