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An exploration of blockchain technology in supply chain management

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Abstract

Day by day new technologies are applied to the business environment. Since the start of the fourth industrial revolution, the digital tools allow productivity improvement. Different kinds of technologies have been used to support companies in tasks of sending and receiving information. The information exchanged between companies has always being a concern when having in mind trust, speed, and safety. During few decades, EDI (electronic data exchange) was the main technology supply chain professionals used to send and receive information. Recently, with the rise of the fourth industrial revolution and the Internet of Things (IoT), many aspects of the business environment have changed. Individuals and organizations are required to be more productive. One of the mainstreams for the business environment is blockchain. Some researches argued that bitcoin is the pioneer of blockchain technology. Financial companies joined forces to build a technological infrastructure to use the cryptocurrency on the market. The first blockchain conceived in 2008, in the wake of the global financial crisis and it has never been hacked. Supply chains are complex networks of distant, separate entities that exchange goods, payments, and data across a dynamic, continuously evolving landscape. Blockchain technology allows visibility providing the customer the opportunity to understand how the supply chain works and how to get more information about products traceability. However, there are some challenges to implement blockchain in logistic and supply chain. The paper presents a theoretical review including the principles of the blockchain operations and the required infrastructure to implement it. The paper does not cover the technology architecture applied to the blockchain. The potential benefit of the blockchain will be covered to understand how to apply it in logistics and in the supply chain environment, presenting some examples already implemented or identified.

Keywords: blockchain, smart contract, supply chain, traceability

1. Introduction

Since its creation in 1990, companies are using the World Wide Web to exchange information. The revolutionary system opened the doors for the business productivity improvement and competitiveness. Nowadays, new technologies like the ones applied in social media, machine learning, robotic process automation, and blockchain are improving the business environment and bringing a large way to exchange information

One of the newcomers is blockchain. Initially, blockchain was focused on money exchange. Bitcoin, the electronic money exchange created by Satoshi Nakamoto (2008) opened the possibility to send and receive money without any financial intermediary. The “peer-to-peer electronic cash system” (Nakamoto, 2008), sends payments from one peer to other through a very high safety model using data encrypted that cannot be modified.

Blockchain has grown in popularity due to its characteristic features such as immutability, incorruptible and the capability to enable absolute transactional transparency. It is no doubt that blockchain has the power to transform every aspect of the logistics and supply chain industry. Currently, developments are underway to ensure that blockchain systems will be able to work in tandem with data drawn from IoT devices used in logistics and supply chain.

The inefficiencies of the current data exchange systems and the trust of the information allow the identification of the value of blockchain in supply chain management. The opportunity of paperless bureaucracy and cost reduction accelerate the identification of the new challenges.

Unlike traditional centralized database systems, blockchain validates the data in the ledger using a cryptographic consensus mechanism. The proposal of blockchain is to encourage trust across peers and create safety networks to exchange information. It means no authority or participant can control or manipulate what is recorded by blockchain technology (Mougayar,2016).

The transparency was initially considered as the important aspect of adopting the technology, as well as improving the data exchange, disrupting the traditional way of sending and receiving information. Another important feature clearly recognized is the speed of transactions that also contribute to reduce costs. There is also a growing trend of consumers demanding information about the provenance of products.

The facilities identified in Blockchain are quickly adapted to supply chain operations, mainly due to the product traceability. One of the best examples is the food chain, where the customer can be confident about the authenticity of goods, including the environmental impacts and workers conditions during the entire production process (Kshetri, 2018).

Other examples are medicine and cosmetics, where blockchain improves the value percept from the customer side and give better business results (Aptea & Petrovskyb, 2016).

Other benefits already identified include the simplification of the settlement of claims, increasing transaction security, accelerating payments and reducing fraud, reducing the cost of compliance and regulatory requirements, elimination intermediaries thereby cutting costs and improving tracking of items throughout the supply chain.

To support blockchain implementation in logistic and supply chain management, a smart contract is required. A smart contract is a condition of the operation written on a code. The smart contract automatically executes the transactions and record the information onto the ledger without any human intervention. The aim of smart contracts is to provide security, which

is superior to traditional contract law and to reduce other transaction costs associated with contracting (Tapscott 2016: 105-108).

Buterin explains it as:

> " then we can cut costs to near-zero with a smart contract." (Parker 2016).

Networked members mutually agree on the smart contract. It is a key component for establishing trust and efficiency between parties. Smart contract eliminates all the paperwork, streamlining the entire process and saving time and money.

The scope of this paper is restricted to discuss the blockchain application to the supply chain world and the benefits that can be obtained in such application. It is not an intention of this paper to evaluate the blockchain technology and the different kinds of software used for its implementation.

2. Definition of supply chain

Lummuns and Albert (1997) conceptualize the supply chain as a network of entities in which material flows. Those entities may include different suppliers, transformers or processors, distribution center, retailers and final customers.

According to Slack et al. (1999), a set of interconnected companies whose function is to supply goods and services to a company or to final customers is called "supply chain" (Slack et at., 1999).

The general idea behind supply chain management (SCM) is to manage the flow of goods, services, and information in an effective way in order to achieve high performance and decrease risks (Tan, 2001).

On the other hand, Christopher (1997) defines supply chain as the set composed by a particular leader company and all the other companies with whom they interact, directly or indirectly, through its suppliers and customers, upstream and downstream, that is, from the point of origin of the basic materials and/or services, to the point of effective consumption of the products and/or services.

There are billions of products being manufactured every day globally, through complex supply chains that extend to all parts of the world. However, there is very little knowledge of how, when and where these products were originated, manufactured, and used through their life cycle. Even before reaching the end consumer, goods travel through an often-vast network of retailers, distributors, transporters, storage facilities, and suppliers that participate in the design, production, delivery, and sales, yet in almost every case these journeys remain an unseen dimension of our possessions. (Jessi, et al., 2016)

Day by day, supply chains are getting increasingly more complex, more extended, and more global. An event on one side of the world can stop the production or delivery of a service on

the other side. The event may be a natural or man-made cause, the event may be large or small, but if the supply of a critical component or service is disrupted, the consequences can be severely harmful to companies further along the supply chain, both financially and in terms of reputation (Punter, 2013).

3. What is Blockchain?

Blockchain, the technology underlying bitcoin, is a type of Distributed Ledger Technology that has been defined as a "distributed, shared, encrypted database that serves as an irreversible and incorruptible repository of information" (Wright, 2017).

Nakamoto (2008) argued that bitcoin is a peer-to-peer electronic cash system:

> "A pure version about peer-to-peer electronic cash exchange that allows online payments from one side to other without any financial institution".

According to DTCC (2016), blockchain is both the network and database, secure and integrate. The blockchain is able to build the transactions based on rules defined mathematically and enforced mechanically.

A technical definition based on Linux Foundation is a peer-to-peer distributed ledger forged by consensus, combined with a system for "smart contracts" and other assistive technologies."

Mougayar (2016) argue that blockchain is a kind of technology that can record transactions in a secure and permanent way. It can save the all history of the transaction without any risk. It is a networking technology, similar to world-wide-web (www) that enables a decentralized exchange of data. In a wider sense, blockchain is a distributed database (ledger), which maintains a continuously growing list of timestamped and encrypted transaction records organized in blocks, with each block being linked to a previous block, forming an overview of the overview adapted on the figure 1 by Abeyratne & Monfarej 2016).

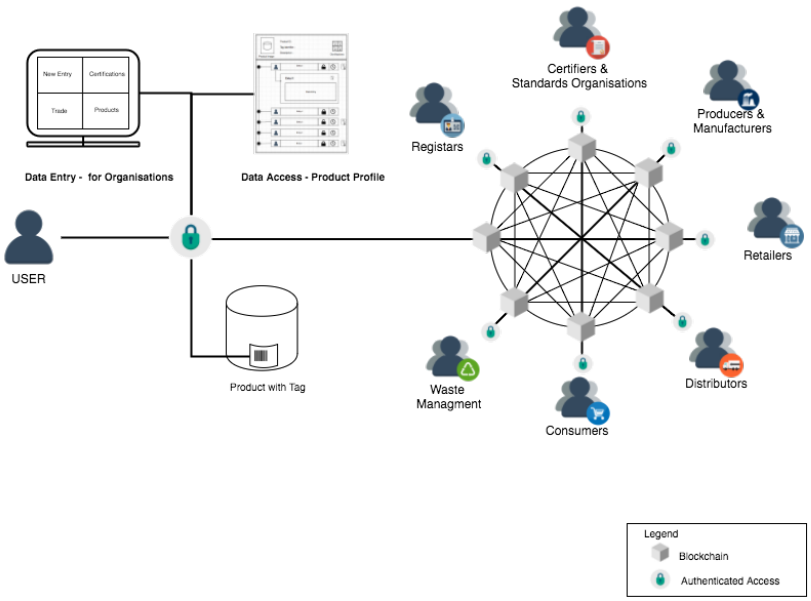

Figure 1: Overview of the proposed concept, adapted from Abeyratne & Monfared, 2016

4. What is behind blockchain?

Mougayar (2016) also argues that smart contract is the key technology that allows Blockchain application on several businesses. It is a contract between parties that is coded and uploaded to the blockchain. The smart contract does not rely on the third party authorities. All processes in dealing with such contracts are automatically controlled. The clauses of a contract are executed after all parties have accomplished their duties. This function removes all ambiguity regarding the execution of contract conditions concerning the existence of external dependencies.

Smart contracts are simply computer programs that execute predefined actions when certain conditions within the system are met.

According to Kakavand et al., (2016):

> "Smart contracts may make the negotiation process and performance of a contract easier and more efficient. Usually, the interface of a smart contract is clear and it imitates the logic of contractual clauses. The main aim is to secure the contractual processes and reduce the cost related to contracting".

Swan (2015) describe a smart contract as one of the main features of blockchain that enabling "trustless" transactions. This type of transaction defines as validated, monitored and bilaterally enforced transactions over a digital network. Smart contracts can incorporate multiple digital signatures for necessary approval of participants. If the conditions of a smart contract depend upon real-world data, systems called "oracles" can be implemented to monitor and verify this data.

Smart contracts are simply computer programs that execute predefined actions when certain conditions within the system are met. Smart contracts provide the language of transactions that allow the ledger state to be modified. They can facilitate the exchange and transfer of anything of value (e.g. shares, money, content, property).

The smart contract is signed by the parts to create a transaction and place them into a block that will be saved immutably into the Blockchain ledger on figure 2 by Szabo (1996)

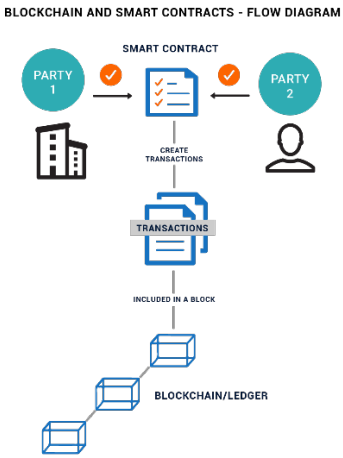

Figure 2: Blockchain and Smart Contract - adapted from Szabo (1996)

As the terms of a Smart Contract are executed during a transaction, the blocks are created per the agreed upon business rules, and the chain is constructed. Of particular importance, each block is digitally verified against the clauses in a Smart Contract, thus assuring the sharing of, and visibility into what becomes a "single version of the truth." (Amber Road, 2018)

Smart Contracts truly are the driving force behind blockchain for supply chain because the business rules they contain are what assures that actual transaction are carried out pursuant to the original agreement. Whether a Smart Contract represents a product licensing agreement, bill of material requirements or some other agreement between the parties, the sequencing of blocks in a transaction can only take place if a given step in the process is consistent with the Smart Contract.

According to Linux Foundation (2018), a smart contract can be provided:

a. Autonomy: can be developed by anyone, no need intermediaries such as lawyer, brokers or auditors

b. Efficiency: removing process intermediaries often results in significant process efficiency gains

c. Backup: a Blockchain and smart contract deployed to it can provide a permanent record, allowing for auditing, insight, and traceability even if the creator is no longer in business

d. Accuracy: replacing human intermediaries with executable code ensures the process will always be performed the same

e. Cost saving: replacing intermediaries often provides significant cost reduction

5. Applicability of Blockchain in supply chain

The Blockchain Trust Accelerator (2018) understands that blockchain is well suited for use in supply chains in part because the technology has the potential to provide an unprecedented level of transparency. Unlike traditional centralized databases, Blockchain systems validate entries or changes in the ledger through a cryptographic consensus mechanism, thereby circumventing the need for intermediaries. This enables otherwise trust-less parties, such as individuals and firms that do not know each other, to engage in near frictionless peer-to-peer transactions.

According to Kshetri (2018), blockchain applications are further explained as a solution for trust issues in supply chains. Enthusiasts of the decentralized application are therefore promoting an early adoption of the technology for companies to stay competitive in the market.

Multiple companies such as Maersk (Jackson, 2017) and Walmart in cooperation with IBM (Popper & Lohr, 2017) have started to plan the implementation of the technology by creating pilot projects to achieve the benefits of the technology already at an early stage. Furthermore, both Walmart and Maersk, have assured that a full version will be ready to implement in the organizational operations in the near future (Popper & Lohr, 2017). In the field of logistics, researchers see many possibilities for the blockchain technology to improve for instance track, trace, and quality measurement solutions.

An example of a supply chain system can be demonstrated in the figure below, where several kinds of information can be saved into Blockchain structure support by smart contract (Gupta, 2018). According to Kshetri (2018), blockchain applications are further explained as a solution for trust issues in supply chains. Enthusiasts of the decentralized application are therefore promoting an early adoption of the technology for companies to stay competitive in the market.

The figure 3 demonstrate an example of Blockchain applied on supply chain management to track the product from the “farm to fork”, including examples of information added on the smart contract and Blockchain recorded.

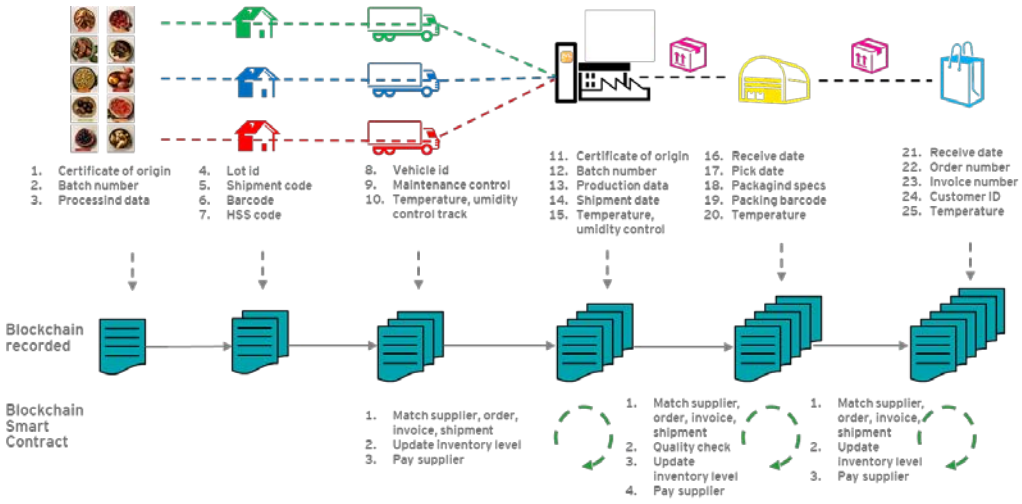

Figure 3: Adapted from Harnessing Blockchain in the SCM & Logistics Space - Gupta (2018)

In general, the development and implementation of blockchain solutions in supply chains are still at an early stage. Thus, there are many opportunities for companies in the future when the technology is further developed (Nowiński & Kozma, 2017). Particularly for the improvement of collaboration between supply chain partners, the blockchain technology could offer different solutions.

Depending on context, different definitions of traceability exist from organizations, legislation or researchers (Aung and Chang, 2014). In a study on different traceability definitions, Olsen and Borit (2013) conclude, "even in scientific papers there is a lot of confusion and inconsistency" regarding the definition of traceability. The researchers' study shows that scientific papers often use the ISO definition of traceability, and the most commonly cited definition from academic sources is the definition from Moe (1998) (Olsen and Borit, 2013).

Besides the adoption of this technology in powering cryptocurrency networks, there are open questions about where blockchain is headed, when it will yield positive results, and who will benefit the most from it. What is clear at this point is that blockchain applications may have one of the most profound impacts on the logistics industry, especially the supply chain. Vipul Goyal (2018), an associate professor at Carnegie Mellon University, states:

> "A lot of companies are interested in blockchain for creating more efficient workflows, but supply chain management is one of the big killer apps".

Awaysheh & Klassen (2010) identify transparency as the extent to which information is readily available to both counterparties in an exchange and to outside observers. In a supply chain context, transparency refers to information available to companies involved in a supply network. Supply chain traceability leverages transparency to operationalize organizational goals related to raw material origins and provide context to a final product or service. Blockchain technologies indeed provide increased supply chain transparency but more

importantly create an immutable and distributed aspect of the custody record by nature of the protocol, which lends itself well to traceability applications.

A very good opportunity to control the inventory was presented during Blockchain Summit in April 26 th., in San Francisco by Ernst Young (EY), where they demonstrated how the visibility of inventory can be improved on supply chain management. The supply chain operations efficiency impacts an organization’s competitiveness and is shaped by numerous factors. Information sharing methodologies such as vendor managed inventory (VMI) create efficient replenishment models without the need for traditional orders (Småros et al., 2003).

In theory, the blockchain can work, but supply chains are very hard to change and adapt (Mougayar, 2016). Mougayar thinks, that companies spend years putting supply chains in place and refining them. It is not very easy to insert a new technology inside established supply chain systems because the integration challenges are not to be underestimated." (Mougayar, 2016).

6. Conclusion

The blockchain is a technology under Bitcoin's core that possesses the key features enabling to solve various current problems in financial and nonfinancial spheres.

This technology faces different ups and downs in the current world. People are divided into two parts: those are truly interested in Blockchain based application and those are sceptical concerning that kind of innovation. Therefore, the adoption of blockchain faces many challenges. The most significant of them, arguably, is the ability of blockchain to displace people from work, but all of us should understand that blockchain is an innovative technology that improves the efficiency in different sectors and enhances globalization in general. As a consequence, a large number of financial and non-financial companies is investing money in the creation of Blockchain based applications and start to implement them in their business in order to enhance several metrics and performance in general.

Supposedly, the adoption of blockchain in the supply chain and logistics is slow at present because of associated risks and some companies appear to be sceptical about this technology, but it is very likely that soon it will earn the confidence of them and will be spread through all industry.

This is the age of empowered customers who demand more information about the products they purchase, including supply sources and complete manufacturing history. Meeting this requirement is often either too difficult, not cost effective, or even impossible given traditional supply chain information technology; however, blockchain contains the possibility of addressing this challenge. This new technology provides a level of supply chain transparency that allows supply chain managers to obtain the information consumers are demanding and thus contribute to their companies' competitive advantages.

The development and implementation of novel technology do not guarantee that it will be used and otherwise succeed. A theoretical insight is required to better understand the underlying

motivators and barriers that will lead companies, or discourage them, from adopting blockchain technologies for supply chain traceability. Previous work has pointed to the importance of behavioural intention and its antecedents in influencing technology use.

At the end of the day, blockchain protected supply chain framework when the product ledger will hold the key properties of – components, quality, quantity and custody at a given point in time. These attributes are stored in a secure infrastructure and can be represented in consumer-facing applications. It will be readable and linked from pre-existing datasets.

Every relevant participant will also be an interested party to perform the quality assessment, audit network and get verification from a relevant performing party. Participants are producers, manufacturers, registrars, standards organization, customers, certifiers, and auditors.

For the foods, medicine, cosmetic chain, blockchain can provide information about the origin of goods including:

- immutable trusted and shared a record of transaction data
- with its verifiable and decentralized nature, retailers and manufacturers can track the origin and location of a product at any point along the supply chain at any given time
- blockchain could eliminate the burden on one trusted centralized party when dealing with multiple parties in multiple jurisdictions exchanging multiple physical goods and multiple documents and settlements by decentralizing the authority

It is clear that the blockchain applications on supply chain management are not completely applied and in the following years, new opportunities will be identified. This article cannot end the discussion but proposal a broad discussion about the new technology to network and database.

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