



BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

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I. a) Research Objectives

The primary object of this paper is to perform a critical analysis on the use of blockchain in supply chains with the help of existing research on the subject. In doing so, one of the major obstacles that the researcher faces, is to filter out the application, use, scope and theoretical research on blockchain as a separate and independent concept from bitcoin as most of the studies on blockchain have been conducted in relation to the cryptocurrency (Crosby et al., 2016). Secondly, the paper intends to give, through real examples, a glimpse of how blockchain is being adopted by major multinational conglomerates around the world. The paper also intends to keep a certain technical aspect of the concept rather than replacing it with simpler terminology and therefore concepts like “decentralised ledger system” and “encrypted peer to peer transaction” will be used without defining each and every preliminary concept. Another objective of the paper is to present the shortcomings of using the technology for supply chain management, under the contemporary circumstances (Golosova and Ramanovs, 2018).

b) Research Questions

The following research questions have been formulated for the objectives of this paper.:

1. What is blockchain technology and what are its features?
2. What good is Blockchain for businesses, especially in supply chain management?
3. What are the different uses of blockchain in supply chains?
4. What are the contemporary developments in private sector and are there any initiatives undertaken to develop blockchain's use in supply chain?
5. What are the shortcomings or disadvantages of using blockchain in Supply chains?
6. What are the prospects for development in blockchain technology and potential uses?

c) Research Methodology

In order to find the most appropriate answers for the above-mentioned research questions, the author has adopted a systematic literature review. The research method employed is of descriptive and analytical research. The literature reviewed in the paper is contemporary and relevant to the current realities of the subject. The author first gives an overview of the subject of discussion and consequently delves deeper into the role of blockchain in supply chain management by providing relevant research articles and journal publications relating to the topic. The paper does not intend to answer all these questions in a definitive

sense but seeks to provide a holistic understanding of the concept to the reader. The paper presents also the advantages, disadvantages and the potential of blockchain in the sphere of supply chains. It is pertinent to state here that due to lack of academic and literary development on the subject, a limited number of peer-reviewed journals were analysed. However, the researcher has intentionally excluded technical reports, theoretical formulas, comments, consultation papers and editorials out of the purview of this research.

The paper is divided into six major parts. Section II provides an overview of the two concepts involved in the subject, blockchain and supply chain. Section III pertains to the intermingling of the two concepts, that is, using blockchain in and for supply chains and the impact blockchain has had. Section IV presents three major industries that have started adopting blockchain technology. Section V talks about the shortcomings or disadvantages of using blockchain and lastly, Section VI provides an analysis of the findings of the paper along with the conclusion

I. Introduction

Blockchain- Overview

Blockchain may aptly be described as one of the most influential and transforming pieces of technology created in the 21st Century, right beside the transformative capabilities that the creation of the Internet brought about. Though still in its rudimentary stages, the concept of blockchain is understood as a “Distributed Ledger Technology” or in simple words, a decentralised form of ledger (Masters et al., 2017) with immutable recording and unprecedented transparency. Blockchain is tamper-proof method of transacting (each transaction is called as a block), as it uses peer-to-peer form of digital transactions that are “time-stamped, encrypted and linked to its preceding transaction” thereby making a chain of blocks (hence, called as blockchain). As is commonly known, Bitcoin and other crypto currencies in the global financial sphere work on blockchain technology, however, what still remains relatively unknown is that blockchain technology can be applied and used in a plethora of immensely complex commercial sectors.

There are essentially four types of blockchain structures, namely, public, private, consortium and hybrid (Pieters and Smith, 2021). Though the latter two are only recent advancements in the technology, the former two have been at the foundation of many new platforms, currencies and institutional systems. In Public Blockchain, such as the one used in Bitcoin, there can be “unlimited number of anonymous parties” that can transact privately without the need of any third-party intermediary such as banks or agents (Dutta et al., 2020). Whereas, private blockchain allows only a “limited number of known parties” to transact among themselves and is the one which is mostly used in supply chains by businesses seeking privacy of their logistical and supply information (Gaur and Gaiha, 2020). The technology can be applied in various stages of a commercial enterprise, right from developing and planning to sourcing and delivering products and services. The blockchain system is highly transparent and substantially reduces transaction time as well as the margin for error in record-keeping (Chen et al., 2022) , besides having a number of other advantages for business which would be discussed in the succeeding chapter.

Blockchain is world renowned for its transparency and risk-reduction features and is one technology that holds disruptive potential for the different aspects of supply chain management (Rao et al., 2021), especially in the post-pandemic times when the economies across the globe have been through uncertain and volatile economic situations causing disruption to business operations in almost every sector. The simplest form of the process of transacting on blockchain is as follows. A block is said to be created when two parties initiate a transaction and the same is assigned an encryption by blockchain, which in turn helps in cross-checking the validity of the transaction by computer nodes and by broadcasting it to the entire network (for providing authenticity to the transaction) (Back et al., 2014).

Supply Chain Management – Overview

Supply Chain Management means the management of a complex system of interconnected organisations (such as the manufacturers, suppliers, wholesaler, logistic companies and retailers) which are engaged with one another for producing or processing the goods through vertical and horizontal scales of operation, in varied processes and activities with the common end goal being selling and delivering the product to the consumer (Chandra and Kumar, 2000). Supply chain is generally understood as a metaphorical chain of processes set up by a giant company operating in multiple countries, a task that entails carrying out complexing coordination, financial and informational exchanges across the different locations at which the different processes are being undertaken, this is usually referred to as an intra-organisational supply chain (Cousins and Spekman, 2003). On the other hand, a broader concept of supply chain means a system involving a number of organisations and is referred to as inter-organizational supply chain (Humphreys et al., 2001). However, irrespective of the form of supply chain, it is a magnanimous task to manage the supply chains and the companies have to spend a lot of its resources on the same (Janvier-James., 2012).

II. Blockchain in Supply Chain Management

Introduction

In most industries, the complex task of managing a supply chain presents a number of obstacles, despite modern advancements in Information and Communication Technologies (ICT) and a major chunk of the difficulties (such as tracking of the good, double-spending, fraud/counterfeiting, administrative or legal paperwork issues) emerge at lower levels of the supply chain, hence requiring companies undertaking the supply chain management to delve into intricate details of the transaction in order to solve the issue. One small glitch or problem arising at the operational levels of the supply chain can have its effect on the whole supply chain, prolonging the ideal time in which the transaction was to be finished (Kleindorfer and Saad, 2005).

Another major problem arising in international supply chains is that tracing the origins (or provenance) of the product becomes an obstacle in cases where source of production or supplier is based in underdeveloped and developing countries. For multinational conglomerates, there is also the major issue of grey and black market of products (that is directly attributable to certain discrepancies and loopholes in the supply chain), which takes out a major chunk of the demand of the product, a problem that leeches on to the company's goodwill and revenue (Gereffi et al., 2010).

One of the initial obstacles that new and upcoming businesses face is that international transactions are difficult to enter into, due to the necessity of third parties or intermediaries such as banks to establish credibility and trust (Werback, 2018), depriving the company of the global demand for the product. Most, if not all of the afore-mentioned problems that businesses face in their supply chains can be solved by adoption of the blockchain technology. In blockchain, as transactions on intra-organisational blockchain are peer to peer encrypted and time-stamped, it becomes relatively easy to identify the product's authenticity, provenance and the supply chain's efficiency at different stages of the chain. Since it is possible to digitize physical assets on blockchain (Pundir et al., 2019), companies can easily track and monitor the assets right from the production stage to delivery to the customer, improving transparency in supply chain and brand-image. There being no necessity of intermediaries and third parties to validate and authenticate transactions, it becomes easier for new businesses to gain exposure to global demand for their products. As blockchain is gaining credibility, more and more companies are adopting the blockchain in supply chain management.

Impact of Blockchain in Supply Chain management

Global blockchain market has exploded in the past five years despite global economic downfall due to the pandemic. With almost every software company and even the U.S Navy experimenting with the technology, Blockchain market is worth an approximately \$5 Billion Industry as of 2021 and is predicted to be worth around \$163 Billion by 2029 (Fortune Business,2021).

As it would be expected, the IT sector is the sphere-header in advancing blockchain. Companies such as IBM, Ezetech, Accenture have started providing private blockchains having special features such as one-up/one-down visibility and permissioned participance for organisational blockchains, streamlining the supplier's records, bringing much more transparency and efficiency to the process. International giant Amazon (through Amazon Web Services AWS) has rolled out its own "Amazon Managed Blockchain" especially for global supply chain networks providing the supply chain participants a "unified view of data, while still being able to independently and privately verify transactions such as production and transport updates" (AWS, n.d). Amazon's technology enables identification of the provenance and current location of products that travel multiple geographical locations that each in turn have different types of legal compliances. Amazon, besides employing the blockchain based supply chain management in its own operations, already has a number of multinationals using its blockchain platform (like Nestle, AT&T, Guardian Life Insurance etc.).

The Coronavirus pandemic brought into light the harsh realities of operating supply chains by the conventional methods, particularly pertaining to the supply, integration of data, demand planning, supplier management, data exchange and order delivery capabilities of the supply chain in case of significant disruptions in supply and volatility of demand in the market (IBM, 2020). To resolve most of these issues, companies adopting blockchain technology can now get digitalised tokens for their physical assets and can have a record of all types of informational flows, financial flows and product supply chains relating to a specific product (wang et al., 2019). The DLT also acts as credible documentary proof of compliance and legal formalities between the company and the national/governmental regulators.

b) Benefits of Blockchain in Supply Chain Management over Conventional Methods

Provenance Traceability

In some developed countries such as the USA, the laws of the countries mandate certain industries (for instance "U.S Drug Supply Chain Security Act of 2013") to trace and identify the medicines right from the original producer of the drug in order to make the medical system safe from counterfeit or harmful products that could potentially cause more damage than treatment. Similarly, a recent trend has begun in the collective consumer demand for inquiring about the provenance of the product. Many companies especially in the perishable items industry face this obstacle of identifying and tracking the product from its very origins as in most cases the products are sourced from small producers and micro enterprises (such as, sourcing in agricultural and poultry products). Companies providing provenance details to its consumers have to face large costs for setting up systems for the same. Through Blockchain and its digital token for digitalising physical assets in the system (or simply, tagging the products with electronic product codes), the process can be made much simpler as whenever the inventory would flow from one organisation to the other, the products' tag would only be needed to be scanned and a record of it could be automatically updated on the blockchain, creating a streamlined flow of supply chain that is easily accessible by the permissioned users (Cole et al., 2019).

Accurate Cost Analysis – Reduction of unnecessary Costs

In cases of intra-organisational supply chain, through the tagging and identifying process in blockchain, the company operating the whole supply chain would be able to identify all the stages where the process is lagging or where obstacles are arising, enabling the company to resolve the particular issue right where it begins. Adopting this tagging method with blockchain technology would also a) prevent any unnecessary delays in delivery and procurement, b) curb the scope for corruption, c) verifying the authenticity of the product and d) checking the counterfeiting of products/ raw materials in the supply chain. The company can also easily perform cost analysis for substituting or replacing some component of the product that causes any of the four aforementioned issues the use of blockchain intends to curb (Rehman et al. 2021).

Effective Auditing of Supply Chain Process & Increased Efficiency

It is often the case that companies run multiple supply chains for a plethora of products and therefore, it becomes very difficult to maintain their supply chain accounts for each of them, that then have to be compulsorily audited and stored for regulatory and administrative purposes. Through the application of Blockchain, this process would be completed in no time as whenever transactions occur, they are verified and updated on the decentralised ledger at the same time and therefore, these ledgers act as an audit trail which is readily available. Using smart applications can further ease business operations relating to release of payments as well as sending receipts and invoices.

These clear supply chain records can also immensely help companies in smooth flow of products in cases of cross-border trade wherein a number of manual processes and documentary requirements (ex: requirements of having a letter of credit, bill of lading, warehouse receipts, and invoices on entry into a state) are involved at varied stages. Complying with the requirements stated above also take up costs and time of the company thereby reducing overall efficiency. Using blockchain helps reduce such costs as well as there could be one common system on which these documentary databases could be uploaded and stored, accessible to both, the regulator and the company (Suominen et al. 2018).

Another major advantage of using blockchain is that the records once updated into the distributed ledger system are immutable, meaning they cannot be deleted, hence, this ensures complete accountability and transparency in the auditing process as compared to the conventional manual auditing in which there lies huge scope for errors and discrepancies (Francisco, 2018).

III. Uses of Blockchain in Industry Specific Supply Chains

a) *Mining Industry*

One of the most highly valuable industries since the past many centuries has been the mining industry but until now, the private mining industry has a bad reputation for violating human rights of workers and making them work as forced or indentured laborers, particularly in under-developed countries where there are huge natural resources. This makes it next to impossible for companies in other sectors to do ethically responsible sourcing of the components/raw material needed in their supply chain. However, through the help of tagging process under blockchain technology this issue can be resolved to a great extent.

Ford Motor Company presents one such example of using Blockchain in supply chain management in the sphere of Cobalt sourcing. Tracking the Cobalt supply chain was the problem that the company aimed to address that would, in turn increase the company's efficiency of tracking their supply of the essential component used in the making of Electric Vehicles and therefore, in 2019 Ford partnered with IBM and a couple of other companies to use "blockchain technology to trace and validate ethically sourced minerals" (Wolfson, 2019). Though it is currently a pilot project aimed at creating a system conducive for producing responsibly sourced minerals, it seeks to ultimately establish an "open and industry wide network to trace and validate minerals and other materials for the automotive and consumer electronics" (Blockdata, *n.d.*). This could potentially lead to trading of products similar to that of commodity trading on the blockchain platform (Lakkakula et al., 2020)

b) *Perishable Goods Industry*

As reflected from the discussion in the previous chapter, blockchain is of immense use for the companies engaged in trading of perishable goods. Besides satisfying consumer demand for verifiable provenance of products, the most important role blockchain could play in this sector is of curbing the spread of food-borne diseases, as highlighted by Kim and Marek (2018) in their work in “Agriculture on the blockchain: Sustainable solutions for food, farmers, and financing”. One such perishable-goods/ food company using blockchain in its supply chain is Walmart, in order to prevent spoiled or harmful food from spreading Food-borne illnesses, by identifying the source of the product and subsequently taking measures to prevent the supply from the location the spoiled product is being sourced from. Currently, with the help of the Hyperledger Platform (permissioned blockchain technology) created by the Linux Foundation, Walmart is creating a traceability system for the entire food supply eco-system (Makridakis and Christodoulou, 2019) through which it would be able to tag and trace provenance of most of the food being sold by the company, being sourced through their network of global suppliers.

c) *Logistics, Transport and Shipping Industry*

In the global market, the transport and shipping industry is indispensable. In this industry, there is always a high change of fraud and/or theft in transit, especially when the supply chain goes through multiple states and jurisdictions. For addressing these issues along with increasing the accuracy of product tracing, blockchain can come into play. Recently, FedEx, one of the largest logistics and transportation companies in the world, joined the “Blockchain in Transport Alliance (BiTA) and adopted Hyperledger blockchain based supply chain system. Through this initiative, FedEx would be able to avoid delays, mitigate risks, automate agreements, maximise its profit margins and gain competitive advantage (Mearian, 2019).

IV. Disadvantages

a) *Lack of Legal Recognition*

The advancements in Blockchain technology are relatively recent, probably still in its initial stages and therefore, there is no legal validation as to the use and extent of legality of blockchain. Adopting the technology from a legal point of view presents a plethora of barriers because conventional legal systems are designed in the conventional manner wherein the government is thoroughly involved in policy decisions, in legitimizing currencies, accounting and taxation processes as well as in validating the transactions taking place, however, this new system would require many new rules and procedures that allow for peer to peer transactions without any intermediary and even legalising the decentralised ledger itself (De Filippi, 2018).

b) *Lacking in Theoretical developments*

The use of blockchain in supply chain is a new and developing field of study and due to its technicalities, requires more experimentation and academic research, which could prove this technology to be credible for adaptation at a global level. The use of blockchain in supply chain management is still mostly being done in the form of pilot projects (Teodorescu and Korchagina, 2021) in order to pragmatically prove the viability of the technology but as for now, it lacks a proper theoretical foundation (Kummer et al., 2020), which could prove fatal for companies in case of some disruption.

c) Expensive Investment

Developing blockchain based systems is an expensive exercise requiring loads of hardware and energy supply, besides the manpower for operating the platform (Wang et al, 2022) . Therefore, currently only a minute number of companies have been able to adopt blockchain in their supply chains. However, this shortcoming is deemed to get over once the networks and databases are established and economies of scale come into play in this sector.

V. Potential Benefits

Elimination of Intermediaries

As more and more transactions occur on blockchain and business to business (B2B) transactions increase, there is a huge scope of increasing profits for both, the supplier and the company (Gurtu and Johny, 2019). For instance, in today's times, a farmer generally sells his vegetables to a middleman, who in turn sells it at a larger scale to a contractor, who in turn collects the product at even larger scale and then delivers the assignment to the procuring company. Commission gets added on each stage. Through the blockchain technology, it could potentially be possible for the procuring company to fetch vegetables and other perishable items directly from the small farmer (Haji et al., 2020) and eventually making it more economically viable for the company as well to procure from small traders in the industry.

Enhanced Transparency for the Customer

Currently, for most parts of the world, getting to know the provenance of products remains a luxury for the consumer, though due to growing concerns, many companies now provide a time-line or geolocation of the product's journey from the warehouse to the consumer, it might even be that the consumer would be able to trace and verify the product's authenticity and provenance before even buying the product so that he/she could make better choices (Montecchi et al., 2019). For instance, it could be that meat procurement and provenance identification go to the extent of tracing the health of the animal while it was living, from which the meat originates from, in order to assure the customer of his/her ethical and health concerns regarding the meat (Colomberotto, 2020).

Expansion in All E-commerce sectors

It is realistically possible that all sectors of the e-commerce industry would adopt the blockchain system (Mohdhar and Shaalan, 2021) and move away from the conventional system to avoid regulatory issues and the need of third parties that take commission for merely passing on the information/data/ money from one supplier to the other. Blockchain could potentially expand to the micro levels of sectors such as finance, education, healthcare, agriculture, aviation etc. (Goyat et al., 2019).

VI. Analysis & Conclusion

There is no doubt that blockchain is the next technological paradigm, which would completely change the way communication and trading takes place in contemporary economies. In the sphere of supply chain management, blockchain has already started entering the prospective systems that hold immense potential in increasing efficiency and improving supply chain operations around the world. The decentralised, encrypted and highly confidential nature of permissioned blockchain makes it an ideal choice for companies around the globe. One major latent advantage of choosing blockchain in supply chain besides the one discussed above is that it gives a huge competitive advantage to in terms of the enhanced data collection capabilities of blockchain and analysis for better policy and cost-cutting decision making (Gohil and Thakker, 2021) . The blockchain system's records are immutable and the transaction can be

anonymous (Niranjanamurthy et al., 2019), while at the same time there are peer to peer encryption features which ensure data protection and make data accessible to all stakeholders or organisations involved in the supply chain, on the lines of the model propounded by Helo and Hao (2019). However, due to lack of legal recognition to the technology, investing huge sums into such a venture before proper literary foundation on the subject, opens up the such a decision to some reasonable scepticism. While blockchain holds unprecedented potential in terms of its unknown volatilities, loopholes and currently unviable uses, it would be too early to herald blockchain as the game-changer for all commercial supply chains

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