Blockchain Technology in Automobile Supply Chain

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A robust traceability system would help organizations in inventory optimization reduce lead time and improve customer service and quality which further enables the organizations to be a leader in their industry sector. The traceability issues and waiting time at different nodes of the supply chain are considered to be priority issues that affect the overall supply chain efficiency in the automotive supply chain. A new blockchain-based architecture was provided to improve traceability and reduce waiting time for the automotive supply chain.

Keywords: automotive supply chains ; blockchain ; simulation ; Industry 4.0

1. Introduction

As industries around the globe expand, their supply chains have become complex and defragmented [1][2][3]. Despite enormous investments being made to improve the part tracking or value tracking in supply chains, most companies still have a limited amount of part tracking mechanisms [4][5][6]. Many organizations have a significant gap between systems employed within a company and across companies. A traceability system is necessary to obtain a reduction in costs, waiting time, and an overall improvement in quality and customer service, which would further enable organizations to develop a competitive advantage [7][8]. Moreover, consumers nowadays are also interested in knowing whether the product they received comes from an ethical background. In recent days the importance of automation within the supply chain process has increased [9]. To automate the supply chain process, multiple systems need to be integrated which essentially means the volume of data produced. This data is essential to track the products and their status at each point to ensure quality [10].

The automotive industry is an important sector that also drives the economy of a nation [11]. Today, organizations are facing different challenges in this sector. Similar to many sectors, the automotive industry also increased its global presence which resulted in frequent part movements across the globe. Firstly, manufacturers are finding difficulty in tracing the in-transit parts, in-house production, and out for delivery products [12][13]. It remains an important challenge for the entire supply chain. Secondly, overcapacity is another problem that results in overspending that affects the overall efficiency of supply chain operations [14]. Customers are concerned about the sustainability of the parts and interested in knowing the origin of the parts. In the automotive industry, it becomes imperative to trace the components and semi-finished goods used in a particular vehicle or product family [15][16]. All the stakeholders of the supply chain lack a common information access framework, making this process difficult to execute in real-time as well as for them to exchange information in real-time [17][18]. The supply chain organizations also find it challenging to maintain the right Inventory Quality Ratio (IQR) across different nodes of the supply chain and that leads to traceability issues. Further, there is unplanned production downtime due to stock out of raw materials and machine breakdowns. The unplanned downtime affects the lead time and the waiting time for the customer is increased. Thus, impacts the supply chain efficiency [19][20].

One of the technologies that are emerging with Industry 4.0 is blockchain. Blockchain has the potential to address some of the issues faced by the automotive industry. Blockchain is a better solution for traceability issues as it can share information across supply chain networks with increased security of information. Each supply chain member can see the same information on a product's lifecycle [21]. Blockchain can potentially affect supply chain parameters such as waiting time, cost, risk reduction, speed, quality, dependability, flexibility, etc. [22][23]. With today's complex supply chain networks, the interactions and transactions among these stakeholders should exist on an immutable ledger/database system that is shared, secured, and can provide permission accessibility. A shared blockchain-based system facilitates increased transparency which enables seamless transactions and improved visibility [24]. One of the benefits of blockchain in the automotive industry is traceability that includes part provenance, vehicle tracking, improved inbound plant logistics, etc. [25]. However, blockchain adoption in the supply chain is still at its nascent stage.

The blockchain is a decentralized database with a collaborative network that functions as a ledger for maintaining secured transactional data [26]. While the applicability of blockchain technology showcases to have a considerably strong case for

changing many aspects of the working of the automotive industry functioning, the automotive sector has just begun to scratch the surface of blockchain applications about its operations. **Figure 1** shows a simple automotive supply chain depicting how product flow happens in the supply chain from suppliers to customers. Considering the volume of components involved in the automotive supply chain, blockchain can help manage its operations. Companies are still exploring ways to enhance the working of their supply chains as well as embrace the change that blockchain technology has to offer.

Figure 1. A typical automotive supply chain.

In the current supply chain, the trust among the supply chain partners is said to be less even though information systems are deployed. Organizations are focusing on a good relationship with other supply chain members to improve their trust however there is no guarantee to validate the information is accurate as some supply chain members may share false information with or without intention which impacts the entire eco-system. Herein tries to implement blockchain technology in an automotive contemporary organization to improve supply chain operations. The literature shows that blockchain in the automotive supply chain is still in the initial stages and there is scope to study this technology and explore the opportunities to implement it in the automotive sector.

Based on the literature, the automotive supply chain with blockchain is not completely explored to overcome traceability issues and improve efficiency. Besides, the automotive supply chain requires a trustable eco-system as it involves multiple parties and stakeholders. Thus, the study on the automotive supply chain is essential to add more value to manufacturers and explore opportunities with blockchain technology.

2. Blockchain Technology in Supply Chain

The literature on blockchain application with the supply chain was analyzed. Li et al., (2018) developed a framework that employs blockchain for systems in injection mold redesign to improve qualitative aspects such as trust, brand value, etc [27]. A case study for developing and implementing blockchain architecture in a cloud manufacturing environment and it is found that the total time required for the transaction process is significantly reduced [28]. Muzammal et al., (2019) present an application platform with the capabilities of and fast processing of data [29]. Banerjee (2018) described the benefits of integrating ERP with blockchain to improve supply chain effectiveness [30]. Atlam and Wills (2018) provided information about blockchain and IoT [31]. Min (2019) analyzed various areas of risk management and security for employing Blockchain technology [32]. Xu et al., (2019) conducted a study on blockchain and how it can be implemented in various product traceability scenarios [33]. Casado-vara et al., (2018) developed a blockchain model is for integrating it with an existing supply chain in the agriculture sector by employing smart contracts [34]. Costa et al., (2017) discuss the visibility of internal logistical processes using Radio Frequency Identification (RFID) technology. Additionally, this study identifies and discusses the main obstacles that are associated with the implementation of its proposed solution. When compared to the data management frameworks of conventional traceability tools such as RFID tagging and E-Kanban, blockchain has the potential to overcome its limitations and significantly improve supply chain operations. The data management system considering RFID tagging needs to be updated frequently as surplus amounts of variable data are produced. The E-Kanban system is slower to adapt to this changing set of data [35]. Furthermore, this system does not work ahead of schedule. While these traceability systems need their infrastructure to be set up, the data management framework of blockchain can be integrated with conventional traceability tools.

With the advent of disruptive technologies, conventional data management systems could be replaced or integrated into modular and scalable systems. The blockchain, being immutable, distributed, and decentralized in nature with its scalability and modularity, could prove an effective alternative for the replacement of data management systems of conventional traceability tools. Furthermore, it could also be integrated with them, if required. **Table 2** shows the summary of data management methods used in various traceability tools.

Table 2. Summary of data management methods used in various traceability tools.

RFID	E—Kanban	Blockchain	
Features	Provides relatively accurate location over a certain range	Allows visual management	Distributed, decentralized, A system with immutable, tamper-proof nature
	Can be integrated with Enterprise resource planning (ERP) systems	Improves visibility in plant and paperless operation	Enables real-time information and enhances visibility through the entire supply chain
	Improves accuracy in logistical operations	Supports lean and helps to reduce waste	Can be integrated with RFID and E-Kanban
Limitations	Limitations in operating conditions	Need for financial investment	Requires adaption to new tech
	Less accurate/faulty detection	Centralized system	Need for financial investment
	Security and privacy issues	Can easily be tampered/modified	A seamless digital-physical link
	Can be tampered/modified	Limited scalability	Needs acceptance by every supply chain partner

Different techniques have evolved which facilitate the live tracking of parts and goods in a supply chain. However, data management frameworks of current traceability systems such as RFID and E-Kanban are centralized and lack the distributed and scalable architecture that can be used for real-time secure data sharing with all supply chain partners. While the current research on various applications of blockchain technology is still evolving, there is a limited amount of research being carried out on blockchain implementation in an automotive supply chain. Although a variety of relevant blockchain applications are being proposed, the pertinent discussions are mostly conceptual expositions, with very little or no empirical evidence of how to employ this technology at the organizational level. Blockchain-enabled supply chain, if successfully implemented, would have potential advantages because of its tamper-proof nature, the distributed structure which would further enable improvement in visibility on the inventory of the organization. Hence there is a need to develop a framework to embed blockchain in the automotive supply chain.

3. Conclusions

The need for blockchain integration is being endorsed by some organizations, however, this view is still not shared by many companies. Herein aimed at identifying traceability issues at various nodes of an automotive supply chain. A new blockchain architecture for the automotive supply chain is proposed. The results were obtained after optimizing the current supply chain by considering blockchain integration. The results seemed to be promising, as there was improved communication between the partners indicated results in improved traceability in inventory that improves IQR and reduction of mean waiting time thereby improving overall supply chain efficiency. Mean daily costs of the whole supply chain were also seen to be reduced and the traceability on waiting time, inventory can be improved with the help of hyper ledger-based blockchain. The blockchain embedded supply chain is more capable in eliminating the risks and uncertainties associated with the automotive supply chain. These are the benefits of adopting blockchain technology in the automotive supply chain.

Five blockchain experts were further consulted to compare the supply chain and blockchain functionalities identified. Here, traceability was found to be the second most important factor and its blockchain readiness value was significantly higher than supply chain readiness which suggests that the current traceability system can be effective if blockchain is implemented. Blockchain offers a peer-to-peer network with cost-effective transaction and data security, thus making its integration with newer technologies all the more desirable. This would inherently assist any organization in making its supply chain cost-effective in the long run.

In conclusion, herein offered a new perspective on implementing blockchain and further digitizing the organization as reviewed by industry and business experts. However, one limitation of this study is that it offers insight only into the automotive sector. Moreover, the industry experts consulted were also predominantly from a manufacturing background. Further research may include the study of how cloud services may accelerate the integration, blockchain’s integration capability with other tools, and the system’s isolation from inevitable disruptions. The unique contributions of the study are

- A framework for blockchain is developed for the automotive supply chain where stakeholders get visibility into goods movement, inventory status, and waiting time.

- A hyper ledger fabric-based blockchain architecture is designed for an automotive supply chain to track the ownership transfers in inbound and outbound logistics, order readiness to fulfill the demand.

The implementation process for blockchain-enabled supply chain architecture mostly revolves around capital issues, network infrastructure issues, and legal aspects of implementation. Except for bitcoin, other use cases for blockchain have not been explored to an adequate level. For example, there is a limited amount of work done to address supply chain-blockchain integration keeping global context in mind. There is an opportunity to study the effectiveness of blockchain on a variety of supply chain operational parameters. The four core values of blockchain are still being closely researched and more functionalities may also be added in the future. Many governments around the globe have not made any laws or regulations for blockchain implementation. The decentralized database will provide more trust for regulators, and it improves the visibility among supply chain members. Researchers can focus on the security and legal aspects of blockchain-enabled supply chain implementation. With disruptive technologies coming into play and technical advancements being conducted with Industry 4.0, a comprehensive study can be performed to address any possible loopholes and issues in the blockchain network. The hyper ledger architecture developed in this study can also be expanded for advanced features such as geofencing and live location sharing with the help of sensors and IoT integration. It is evident that blockchain is evolving and thorough analysis on limitations also needs to be studied before implementation. This may help the practitioners and academia for further research on it.

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