Impact of Blockchain Technology on Operations and Supply Chain Management Performance

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Abstract. This paper emphasizes exploring the relationships between blockchain technology and operations, and supply chain management, and the impacts of blockchain on the performance of operations, logistics and supply chain management. The study revealed that blockchain has been widely applied in the logistics and supply chain of various industries resulting in better operations and performances. The study also found that usage of blockchain technology in daily business operations can provide operations and supply chain managers with several advantages starting from increased response times, safe and secured data, proper visibility across nodes, transparent transactions, and supply chain members' trust. This paper also contributes to value in the literature by summarizing recent blockchain advancements and analyzing their prospective applications in the supply chain and operations management field.

Keywords: Blockchain · Operations Management · Supply Chain Management · Supply Chain Traceability · IoT

1 Introduction

International Business Machines (IBM) defines Blockchain Technology (BCT) as a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network, which can be tangible, or intangible to reduce risk and minimize costs. BCT provides immediate, shared, and completely transparent information to authorized networks that can track production, accounts, purchase orders, and payment status with end-to-end details of a transaction with efficiencies and opportunities.

According to Brookbanks and Parry (2022), A blockchain-based platform introduces common trust and reduces data duplication and improves supply chain visibility. The key elements of a BCT are immutable records, smart contracts, and data management with the help of distributed technology. The blockchain records maintain information related to multiple choices, such as what, when, who, how much, and where, which takes account of its supply chain conditions and its related information. According to (Asokan et al. 2022), BCT and IoT technology can enable real-time information sharing among entities.

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The BCT maintains a sequence of transactions, and links securely that avoids any block being altered/inserted between two existing blocks, in which all the transactions are maintained through an irreversible chain. It is trustable since it prevents malicious actors. It maintains greater trust, security, and efficiency. With an extensively secured network, the BCT can support operations, logistics, and supply chain management. Detailed planning of the supply chain and operations remains a challenge, which requires flexibility, adaptability, responsiveness, and agility for higher operational efficiency. The primary objective of all commercial organizations is profit maximization, through appropriate capacity utilization and pricing strategy.

At the same time, an effective balance between the internal and external environment, and strategic planning, has become an indispensable prerequisite of the Operation and Supply Chain Management (OSCM) system, which blockchain can support. BCT is an evolving and aggressive massive data technology, which can contribute to managing the supply chain and checking scams. According to Ramos et al. (2022), secure data sharing and transaction transparency could optimize the daily routine and avoid fraud. BCT ensures transparency, with distributed network technology, where data can be assigned on a peer-to-peer basis with certified and verified transactions among the community. According to Kiu et al. (2022), blockchain can make improvements in data security, trust ability, and accountability.

1.1 The Purpose of the Study

Blockchain is an emerging and extensively discussed technology. The research in this area is relatively fragmented which causes it to take up the contribution of BCT on OSCM performance. This study contributes to finding out the influence of BCT on supply chain and operation management. It supported optimizing social upliftment, economic breakthrough, and environmental accomplishment. The blockchain characteristics contain clarity, traceability, and protection in real-time data distribution, which can support the supply chain for its excellence. According to Hijazi et al. (2022), BCT has the potential for ensuring trusted data.

The study is likely to assist researchers in developing a strong foundation for practitioners and academics. It will also guide the direction of future research on BCT for organic production on value chain analysis. Based on the purpose of the study, the research questions are developed.

Research Questions

The following research questions are raised to address the impact of BCT on OSCM and how it can support achieving excellence in the value chain:

a. RQ1: What are the relationships between blockchain technology and operations & supply chain management?
b. RQ2: What are the impacts of blockchain on operations and supply chain performance?

There was a need to find answers to these questions, which could positively affect organizational performance due to enhanced total quality management. According to Magd et al. (2021), total quality management practices will have a strong linkage to

organizational performance. It can further promote the organization in adoption and willingness to invest in BCT for supply chain optimization. In the long term, the organization can achieve supply chain excellence with key objectives of cost-effectiveness, speed, or reliability. According to Ahmad et al. (2022), BCT can influence transaction execution speed, throughput, and latency. This research addresses these questions and proposes a solution for its best fit.

It systematically assesses the current scope of blockchain and supply chain interconnection.

According to Kouhizadeh et al. (2022), four major blockchain capabilities, are transparency and traceability, reliability and security, smart contracts, and incentivization. Blockchain was discovered from the commercial supply chain despite differences, but a few characteristics are carved out by distinguished leaders who are dedicated in efficiently managing blockchain resources. According to Ansari (2022), the right environment with committed leadership and supportive infrastructure can be fruitful corporate dreams.

1.2 The BCT Operation Requires Redesigning the Concepts

Forming long, medium- and short-term strategies in revisiting the concepts such as:

a. The adaptability of blockchain with the agile supply chain.
b. Blockchain and supply chain collaboration for success.
c. Strategic planning and coordinated functions of blockchain technology
d. Long-term objectives of blockchain technology

The rest of the paper is structured in the following manner: Section 2 covers the literature review, the discussion on successful cases of blockchain; and blockchain in logistics, operations and supply chain management and its impact on their performance is included in Section 3. Section 4 highlighted the conclusion of the study and future research directions

2 Literature Review

This research aims to analyze the role of BCT in overcoming supply chain management challenges and how it can impact its operational performance. To do so, the theoretical background must be reviewed first. It provides the needed knowledge from contemporary research and assists with clarifying research questions. This section further organizes establishing the foundations for the primary research. Further, information related to the supply chain is presented, and subsequently, the foundations and development of BCT are examined. The following section critically evaluates the perception of blockchain and the supply chain.

2.1 Why Blockchain?

As the name blockchain suggests, it is a chain of blocks in which each block consists of a block header, body, and footer. Specifically, a block header consists of the address,

timestamps, and hash, which uniquely identifies a block, and a pointer to a previous hash. This interconnection of individual blocks with pointers creates a chain of blocks called a blockchain. The concepts of blockchain were first brought to light with the introduction of Bitcoin in 2008 by Satoshi Namakoto.

The key advantages of blockchain are decentralization, cost reduction, scalability, or execution of efficient transactions, distributed than decentralized. The blockchain protects from attackers since the attackers need massive computational power for altering the data. According to Bajar et al (2022), technology and IT systems and operational efficiency are the most significant factors of BCT. Since it can trace back the events that occurred in the network. The security of a blockchain is based on digital identities and cryptography. BCT can contribute to key supply chain objectives.

The researchers created a framework that evaluates how BCT can help an organization meet key supply chain management objectives. The positive effects of BCT are mainly on supply chain performance, cost optimization, flexibility, receptiveness, compliance, sustainability, improvement, etc. According to Hendayani and Fernando (2022), BCT positively and significantly affects supply chain performance and firm competitiveness. The BCT can improve as well as deteriorate the supply chain performance. According to Markus and Buijs (2022), blockchain can affect supply chain performance.

The BCT identities consist of domination technology that presents transparency as a threat due to privacy issues, increased supply chain segregation, and potential radical shift in the marketplace. Secondly, its identity illustrates the drawbacks of smart contracts and the scalability of blockchain. According to Ebekozien et al. (2022), smart contracts, financial management, and supply chain management reduce transaction costs. However, smart contracts are not flexible enough to fit in this environment, and the question beings, who writes them and who is responsible for their maintenance arises. Moreover, they are difficult to change and adapt to legal frameworks.

2.2 Supply Chain Management

Keith Oliver is a British logistician and consultant known for coining the terms firstly introduced the concept of supply chain management in 1982. There have been numerous definitions from different authors but generally, they have agreed on the main concepts. The modern smart supply chain emphasizes environmentally friendly and is supported by back-end technologies. According to Lerman et al. (2022), a smart supply chain contributes to green performance by managing green relationships. These supply chains are supported by multiple participants mostly not owned by the same entity, in other words, they are legally independent.

According to Fernandez et al. (2022), blockchain-enabled supply chain benefit is considerably larger than in conventional supply chains. The members of the supply chain cooperate to add value to the material flow with the essential objective of satisfying end-customer needs. According to Kouhizadeh et al. (2022), four major blockchain capabilities, are transparency and traceability, reliability and security, smart contracts, and incentivization. Different people perceive the supply chain differently. Some do not care about it unless it causes a problem, but some perceive it as a strategic differentiator, giving a company a competitive advantage.

As understand that a highly competitive environment, increased complexity, demand variability, and reaction to change are examples of factors that organizations and individuals must face when engaging in supply chain management. Due to globalization, supply chains have become, over time, more international, causing a growing number of geographically, different entities, and cooperating. According to Tiwari (2022), BCT can be used to govern countries, public utilities, and global facilities, including corporations.

Various circumstances continuously challenge this field. A good example is the COVID-19 world pandemic, which caused huge disruptions and demonstrated how vulnerable and fragile companies are when a sudden supply chain outage occurs. During this time, global supply chains faltered in supplying goods because of demand and supply ripples, and rather than dealing with leanness and efficiency, it was talked about tension, mistrust, and misgivings.

2.3 Drawback of Blockchain

There are possibilities that in blockchain the processing of transactions per second might be limited and delayed. In addition, the transactions stored on a public blockchain could be read or added by anyone which increases the risk of attacks by the malicious network. The chances of altering the ledger and causing an attack could be minimal, however, it cannot be excluded. According to Oh and Shong (2017), BCT cannot be applied when developing financial services. An attacker can potentially damage the network with an increase in computational power increases, which can be directly proportional to the rate of increase in the output.

According to Wouda and Opdenakker (2019), the major pain point identified concerning the transaction process of an office building is that it is difficult to define the characteristics of a property, due to a lack of data structure and quality. This relates, for example, to throughput, scalability, latency, and storage issues. It is also problematic to change a smart contract, which has been already deployed. According to Wilkie and Smith (2021), the lack of blockchain standards, along with the creation of multiple blockchains, complicates interoperability between the various blockchain platforms. The other limitations such as uncertainty in the regulatory environment, costs of implementation, network integrity, and so on.

According to Garanina et al. (2022), BCT is not yet mainstream as the current literature is in the normative stage. As BCT evolves at a high tempo, governments react separately with unexpected regulations, which creates a lot of uncertainty, fragmentation, and chaos. Environmental costs are related to the substantial electric energy consumption, used for "mining" bitcoin. According to Galati (2022), the social capital theory emerged with a necessary lens to investigate blockchain implementation in supply networks. However, with an ongoing transition towards proof-of-stake, this should be gradually eliminated.

3 Discussion

This section discusses BCT and its applications in operations, logistics, and supply chain management field.

3.1 Blockchain in Operations, Logistics, and Supply Chain Management

The BCT, which has been there since the launch of bitcoins in 2009 (Nakamoto, 2008), has now advanced to the point that it is useful for a broad array of applications. The blockchain is a distributed technology that links operators in a network and keeps transactions among them in a reliable, periodic chain (Risius and Spohrer, 2017).

Every stage of OSCM, from the procurement of raw materials to consumer distribution, might be revolutionized by blockchain (Babich and Hilary, 2019; Goyat et al., 2019). Building a BCT based Business Process Reengineering architecture also makes supply chain and operations reengineering possible (Chang et al., 2019). Using BCT, each transaction may be restructured, developing to a faster and more secure path. The blockchain's organizational structure is set up to guarantee the transparency and security of operations, logistics, and supply chains (Tonnissen and Teuteberg, 2020).

In the era of the industry 4.0 revolution, BCT is suggested as a way out to arrange entries in a dispersed approach using a consensus mechanism (Beni et al., 2019; Gao et al., 2018; Fernández-Caramés et al., 2019). BCT can change operations, logistics, and supply chain management credits to its qualities of cost minimization, decentralization, efficient operations, and reduced waste, as well as authenticity, trust, transparency, security, and trust (Gurtu and Johny, 2019; Philipp et al., 2019). Additionally, all transactions facilitated by BCT are further transparent, economical, secure, and efficient (Queiroz et al., 2019). Therefore, it is generally accepted that blockchain's decentralized nature aids in reducing risks in the OSCM (Arza et al., 2020) related to hacking, piracy, vulnerability, costly compliance with governmental regulations, and contractual issues (Min, 2019).

Numerous angles are now being taken when examining the opportunities that BCT presents for supply chain management, operations management, and logistics, and these applications already abound (Dutta et al., 2020). Lack of transparency and trust characterizes today's complicated and global goods exchanges (Tonnissen and Teuteberg, 2020). Processes that are lengthy and incurs huge cost are a result of the various middlemen brought on by the strict documentation requirements (Chavanne and Pires, 2017). The multiple interests of parties in an OSCM can be resolved in a public registry using the distributed blockchain system, over which no one firm has authority. BCT solves issues with transparency and accountability (Casey and Wong, 2017).

There is lack of middlemen in a logistics chain since there is a peer-to-peer system of the blockchain; resulting to direct interactions with the customers by a manufacturer or the suppliers (Hughes et al., 2019). Due to its peer-to-peer networking system and decentralized data management, BCT has the potential to eliminate intermediaries, a process known as disintermediation. Payments between two parties can be made using the cryptocurrency-Bitcoin without the use of a banking middleman. According to Kursh and Gold (2016), this decreases identity theft and fraud while also lowering transaction costs and improving efficiency (Zheng et al., 2017). By passing middlemen through disintermediation, OSCM aims for flexibility, sustainability, risk reduction, reliability, speed, quality, and cost are promised to be attained (Kshetri, 2018).

Disintermediation is the elimination or lessening of merchants, brokers, dealers and other middlemen in business dealings between consumers and manufacturers, according to Atkinson and Schumpeter (2001). Disintermediation, according to Sampson and

Fawcett (2001), occurs when a manufacturer and an end customer conduct business directly with one other. The functioning of intermediaries in various marketplaces has altered dramatically as a result of growing digitization (Peukert & Reimers, 2017).

3.2 Blockchain Characteristics

The blockchain features that set it apart and make it appealing for operations, logistics, and supply chain applications are as follows:

a. Transparency: Data that has been documented and accumulated on a network with agreement from the network and is always traceable and observable.
b. Autonomy: Every single point on the blockchain can independently retrieve, transmit, store, and update data while remaining protected from any third-party interference.
c. Unalterable: To ensure immutability, BCT offers timestamps and controls.
d. Open source: With a clear structure, blockchain gives everybody in the network access to its code.
e. Ownership and distinctiveness: Each document shared on the BCT records its owners and uniquely identifies each document with a hash code.
f. Privacy: The individuality of the person remains hidden when data is sent between nodes.
g. Irretrievable: Every single blockchain maintains a accurate and supportable record of each transaction ever made.
h. Decentralized: The system's data can be viewed, tracked, saved, and updated on several different systems.
i. Origin: Each product on the blockchain is accompanied by a digital record attesting to its authenticity and place of origin.

3.3 Successful Cases of Blockchain Applications in Operations and SCM

There are numerous examples of OSCM that have successfully undergone BCT changes, but there are still challenges with cost (Choi et al., 2020), privacy, security, and usability (Dutta et al., 2020; Peck, 2017). In addition to reforming the OSCM of various industries, it helps improve the functionality and security of existing digital platforms, such as the Internet of Things and other technologies relevant to Industry 4.0. (Cai et al., 2021). Some of the successful cases of BCT applications are summarized below (Alicke et al., 2017):

a. A UK startup called Provenance just secured $800,000 to use BCT to track food. It has already experimented with tracing the supply of tuna in Southeast Asia.
b. To track samples both externally and internally from a variety of vendors, BHP is proposing a blockchain solution that will take the place of spreadsheets.
c. To increase process efficiency, IBM and Maersk are partnering on cross-party, cross-border operations that make use of BCT.
d. To verify transactions, transaction correctness, and record-keeping efficiency, Walmart tested an application that tracks pork in China that is produced in the US.

3.4 Impact of Blockchain on Operations, Logistics and SCM Performance

"End-to-end visibility and traceability", "knowledge sharing", "end-to-end integration", "improved decision-making", "improved data security", "decentralization", and "management" are some of the main areas of attention for BCTs as they gain traction in the field of OSCM (Dutta et al., 2020; Gurtu and Johny, 2019; Surjandy et al., 2019; Tonnissen and Teuteberg, 2020). Due to the absence of traceability of paint locations throughout the supply chain route, large firms like Toyota have already suffered significant losses. Giants like Walmart, Alibaba, Accenture, and JD.com are trying to incorporate BCT in the supply chain, B2B e-commerce, and further sectors to combat frauds, ease traceability, and get transactions easier with an emphasis on high-valuable goods (Kshetri and Loukoianova, 2019). Therefore, the aim is to adapt the supply chain such that it is agile and scalable considering market developments.

Some of the positive impacts of BCT are discussed as follows:

a. By implementing smart contracts, BCT enables real-time order resolution and manufacturing task automation (Sheel and Nath, 2019). Additionally, BCT ensures that the ripple effect in OSCM is minimized, lessening the disruption brought on by shifting paradigms (Ivanov et al., 2019).
b. BCT's services guarantee data and resource attribution, confidentiality and security systems, privacy, authentication, and integrity (Mackey et al., 2019). BCT is significantly more secure than ordinary IoT systems or conventional security services due to its capability for enhanced cybersecurity and superior performance (Kshetri, 2017).
c. BCT allows effective business process management through smart contracts by combining the flow of control and business logic of inter-organizational business operations. Blockchain can also be integrated with smart contracts for hyperconnected logistics (Betti et al., 2019), in which the mechanisms are backed by triggers and act as a connection between business applications and blockchain.
d. Using digitization and smart contracts to ensure collaboration between all parties concerned, BCT integration changes the OSCM organizational structure (Saberi et al., 2019).
e. Through the integration of BCT with SCs, blockchain enhances quality, productivity, and cycle time creates new business opportunities, and promotes product differentiation. Numerous studies have been conducted on the effectiveness of using BCT to regulate prices and eradicate products (Dutta et al., 2020).
f. Blockchain use in OSCM not merely boosts efficiency and saves costs but also improves interactions among all the participants. Additionally, it increases trust and simplifies associated business procedures (Queiroz et al., 2019).
g. BCT promotes supply chain resilience by minimizing the effects of interruptions, employing a proactive and preventive approach to risk management, and providing multilayer protection for OSCM networks (Liu et al., 2019). The hierarchical structure of blockchain makes it simpler to recognize network and organizational risks associated with each OSCM function.
h. By enabling process automation, removing intermediary, and allowing real-time tracking through confidentiality, traceability, and data management methods—all

Fig. 1. Benefits of Blockchain Technology in Operations and Supply Chain Management

of which are the foundations of OSCM reengineering—blockchains improve the transparency and visibility of the entire OSCM. An OSCM that has been properly reengineered can synchronize tracking data across all business domains. Additionally, using smart contracts can aid cut down on the time and expense needed, supporting OSCM reengineering (Chang et al., 2019; Dolgui et al., 2019; Liang et al., 2019).

The benefits of a blockchain for operations, supply chain, and logistics management are depicted in Figure 1.

4 Conclusion

Blockchain technology has a ton of promise in many industries, which has prompted research on its acceptance, application, technology, and design in numerous industries to boost their productivity and sustainability on a global scale. The usage of BCT in daily business operations can provide OSCM managers with several advantages starting from increased response times, proper visibility across nodes, transparent transactions, supply chain members' trust, and safe and secured data. Supply chain operations, OSCM reengineering, and business process management can all be elevated by blockchain applications, giving them a competitive edge.

Big data management, better connectivity, the protection of intellectual property rights, and effective OSCM interaction would be made possible by the integration of

BCT with IoT and the employment of the proper consensus mechanism in several supply chain echelons.

This paper also contributes to value by summarizing recent blockchain advancements and analyzing their prospective applications in OSCM. In general, this review paper will support academics and professionals in better comprehending and understanding the OSCM fields and business sectors to that BCT may be applied.

In future studies, it is crucial to comprehensively examine the essential success factors that affect the development and deployment of BCT. Both scholars and practitioners are encouraged to conduct empirical studies and case-based studies in this field.

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