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Blockchain technology in supply chain management: transparency, security, and efficiency challenges

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Abstract

Supply chain management (SCM) is a core corporate activity responsible for moving commodities and services from one point to another through a variety of stakeholders. The traditional SCM is based on a centralized approach managed at the central headquarters, with all other sub-offices receiving instructions from the main office. Some major issues with current SCM systems include security, transactional transparency, traceability, stakeholder involvement, product counterfeiting, additional delays, fraud, and instabilities. Blockchain (BC) emerges as a technology capable of efficiently and transparently managing data and building trust. It can facilitate transaction authorization and verification in supply chains or payments without relying on a third party. This review shows the integration of blockchain technology (BCT) within SCM, addressing traditional SCM limitations such as centralization, lack of transparency, and susceptibility to cyber-attacks. Blockchain's key attributes—immutability, security, decentralization, transparency, tamper-resistance, and disintermediation—offer significant improvements in SCM processes by enhancing traceability, security, and efficiency. This paper shows various blockchain implementations in different industries, highlighting practical advantages and addressing future research opportunities, such as blockchain interoperability, Blockchain as a Service (BaaS), and next-generation decentralized ledger technologies like Hashgraph.

Keywords: Blockchain Technology (BCT); Supply Chain Management (SCM); Immutability; Transparency; Decentralization; Security; Blockchain as a Service (BaaS); Hashgraph; Interoperability; Cybersecurity

1. Introduction

SCM is defined as the movement of goods from producer to consumer. It is a network that is made up of independent or semi-independent business entities such as producers, suppliers, retailers, and clients who are involved in the manufacturing and distribution of goods [1]. It covers all from item improvement, sourcing, generation, coordination, and the data frameworks required to facilitate these exercises. Since early times, supply chains have occurred, starting with the first item shaped or service formed and sold. But with industrialization and globalization, SCM got to be more refined, permitting companies to do a more proficient work of creating and conveying merchandise and administrations. Organizations can now identify failure before it occurs and take proactive measures to prevent it. They make an exact estimate that supports meeting client requests and monetary goals simultaneously. Every node in the supply chain network must be concurred upon and flexible in response to the needs of the consumer and competent in dealing with issues such as tracking, exchange approaches, shipping modes, and so on. Consumers also have various options for purchasing products, including in-store, online, and more, putting them in the driver's seat when it comes to defining SCM priorities. So, while discussing the primary issues in today's SCM, we discover that today's supply chain is centralized. However, a centralized supply chain is often time-consuming and expensive to manage, and it lacks essential functionality for market analysis. The complexity of supply chains and value networks adds a high cost to supply chain players, which the customer eventually absorbs. The data in the majority of the documents are kept on BC,

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which is an expensive procedure. The present supply chain architecture does not deliver the requisite level of transparency and traceability.

In the current supply chain, stakeholders and consumers face dilemmas relating to coordination, inventory management, human resource reliance, order management, stock management, expiry date, etc. As a result, stakeholders cannot evaluate demand and hence are unable to optimize output and storage.

The traditional SCM is based on a centralized approach. A single business headquarters and a single warehouse full of departmental managers in different areas like logistics, distribution, and procurement, and these managers are responsible for overseeing their specific location during the complete supply chain. They keep track of the information in a centralized database stored nearby. When the data on the record is not beneficial to the company's growth, it may be misrepresented secretly. As a result, mistrust between ventures has progressively noticeable, resulting in higher communication expenses. Also, there is no pricing transparency in the supply chain because of the middlemen. Furthermore, because of the high risk of data manipulation inside the venture, the data across supply chain entities is incompatible; as a result, the product tracing procedure has been delayed.

In Today's supply chain, there is no encrypted mechanism to store consumers' private information. Cyber-attacks will be able to access this data, revealing important public and personal information. Another key issue is that goods only travel in one direction in today's supply chain management. As a result, if a product is faulty, the customer is responsible for the consequences. He didn't have an option but to accept the chance. As a result, in traditional SCM, enabling the reverse flow of products and transactions for each customer is a major challenge. Supply chain attacks are another key issue in Today's SCM. Instead of directly attacking a single organization, supply chain attacks target vendors and providers. It is a cyber-attack that targets a reputable third-party vendor who provides critical services or software to the SC. Unsecure suppliers in a chain are attacked to obtain access to their bigger trade partners in a supply chain assault.

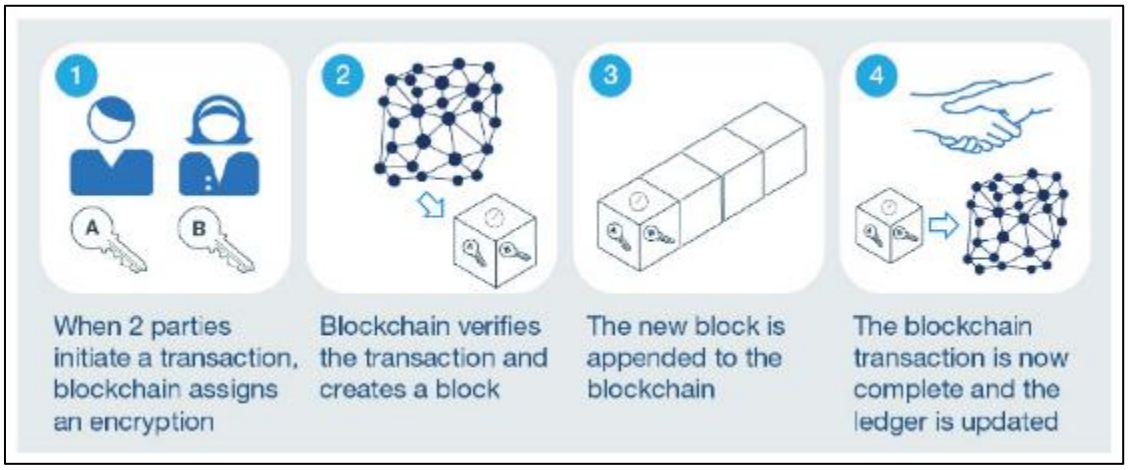

Figure 1 How the transaction works with Blockchain [2, 3]

2. SCM and Blockchain Technology (BCT)

This section focuses on the background of the supply chain and BCT. There are three subsections in this section. First, we'll discuss supply chain management. Second, we'll go through the basics of BCT, including how it works. In the third part, we focused on the usage of BC in supply chain systems.

2.1. A. Supply Chain Management

SCM is a core corporate activity responsible for moving commodities and services from one point to another through a variety of stakeholders. Dissimilar groups, resources, behaviors, and organizations are concerned with converting raw materials into completed products and satisfying consumer orders, which are referred to as supply chains. It is an interconnected network of corporations, individuals, activities, information, and resources that are included in fabricating and transferring a product or service from the seller to the client via a planned flow of information, physical dissemination, and payment. It starts with the delivery of raw materials to a manufacturer and stops with the delivery of the completed product or service to the consumer. Control of the stream of products and services to maintain the quality of sensitive commodities throughout the shipment, eliminate unnecessary expenses, and better satisfy customer

expectations is known as supply chain management [4]. Agri-food sectors, pharmaceutical industry, Textile industry, Automobile industry, manufacturing industry, high-tech industry, service trade, and so on all have supply chain management. Each product in supply chain systems goes through a life cycle that includes states like Processing, Stored, Manufacturing, Shipped, Arrived, and consumed. There are a few issues with present supply chain administration such as the need for straightforwardness (clarity), disturbances, additional delays, data twisting, and instabilities. The present supply chain usually relies on a central entity to maintain data, which could be problematic for transparency and trust. When the data on the ledger is not beneficial to the company's growth, it may be counterfeited tactfully. There's exceptionally minute information about the item's starting point, handling, or distribution to the end customers. The customers were usually only given access to a portion of the information released by big brands. Lack of sufficient knowledge of a product can cause trouble confirming numerous characteristics of a product. Customers could have trouble authenticating many product ingredients claimed by the company. As a result, there is a growing mistrust between ventures, resulting in higher communication expenses. Furthermore, because of the company's high risk of data manipulation, information between supply chains is unpredictable, causing the product traceability process to be easily disrupted. When using a regular supply chain, we might face other issues, including delayed delivery, misplaced shipment, corruption, tampering, and fraud or counterfeiting products. As a result, traditional supply chains have failed to match customer demand for a low-cost, high-quality product [5].

The main aim and challenge of effective SCM is to optimize supply chain presentation containing external effects such as customer focus and internal efficiency, which means analyzing and removing all waste, problems, and complexities across the internal supply chain. Integration of supply chain modules needs Blockchain commitment, confidence, collaboration on decisions, and exchanging true information.

2.2. Blockchain

A Blockchain is a form of database or a storage structure that uses blocks and chaining to store data. As new data is received, it is entered into a new block and then chained to the previous Blockchain. Blocks have specific storage capabilities, and when they are filled, they are linked to the previous filled block, establishing a data chain known as a "Blockchain." tuart Haber and W. Scott Stornetta did the first investigation on the notion of Blockchain in 1991. They wanted to form a system that prohibited altering the contents of the document timestamps. Satoshi Nakamoto, an anonymous individual or group of individuals, originally built the Blockchain in 2008, a peer-to-peer network, and solved the double-spending problem. A year later, Bitcoin, a cryptocurrency, was created based on BCT serving as the distributed ledger. Blocks are the key concept of BCT. To identify the block, a hash value created using the SHA256 hash algorithm is used. The header field of the recent block stores the hash value of the previous block or parent block. The kind and architecture of a BC also influence the structure of a block. Generally, some main attributes can be required for a block in the block header, which is the link to the previous block, i.e., preceding block hash value, the timestamp, the nonce, the Merkle root, with the body of the block, which contains transactions. A nonce is a randomly generated number that is only used once. This number is added to a hashed block to fulfill the difficulty level limitations when it is rehashed. A Merkle tree is a binary tree containing hash pointers named after its creator Ralph Merkle. Data blocks are arranged in pairs in a Merkle tree, and the hash of each of these blocks is kept in a parent node. The hashes of the parent nodes are kept one level up the tree, and they are again arranged in pairs. Continuing in this manner, we reach the root node at the very top of the Merkle tree. Merkle Root refers to the apex of the Merkle tree. Thus, the Merkle root is a hash of all transactions in a block. This implies that instead of checking each transaction individually, just the Merkle root is necessary to validate or verify all transactions in the Merkle tree.

In computing, a BC is a form of distributed ledger that uses a unique technical concept that constructs an immutable ledger of information cryptographically. It is maintained via a decentralized network in which a specific consensus mechanism approves all records. As a distributed ledger, BC does not require a centralized body or an administrator to supervise and control a network. In very easy words, BC is described as a series of blocks that hold information in the form of transactions that are recorded chronologically and openly and that cannot be backdated or tempered. The decentralized nodes verify the transactions (user systems) by a consensus algorithm. The ledgers are spread among all parties involved rather than managed by a single body. It is extremely difficult to change information after it has been stored on a BC. A BC is a sort of database that only allows for reading and adding data [6].

2.3. Types of Blockchain Network

A BC network may be built in a variety of ways. They can be public or private, permissioned or made by a group of individuals (consortium).

Public BC Networks: A public BC, such as Bitcoin, is one that anybody may join and participate in. In this type of BC, significant processing power is required and for transactions, there is little or no privacy, and the security is likewise insufficient.

Private BC Networks: One company manages a private BC network for its customers, deciding who is permitted to participate, running a consensus process, and maintaining the shared ledger, i.e., a private BC network governed by an organization. This may include the use of a BC within the company's firewall. In most cases, a permissioned BC network is put up by a firm that wants to build a private network.

Notably, permissions may also be set on public BC networks. In Public, Permissioned BC network validation of blocks by pre-selected nodes but visible to all users. In private Permissioned BC, validation of the block is controlled by an organization, i.e., in a full centralized manner. As a result, a private or permissioned BC controls who is permitted to join the network and what transactions they may do. Participants must first receive an invitation or permission before they may take part in the activity.

Consortium BC: Several companies can maintain a BC by collaborating. In this type of BC, all transactions and data access are controlled by pre-selected entities. A consortium BC is appropriate when all members require permissions and share responsibilities for the BC.

2.4. Why Do We Need BC?

Here are some of why BC technology has gained so much popularity.

- Unalterable transactions: BC guarantees the inalterability of all operations by registering transactions in chronological sequence. When a new block is added to the existing BC, it cannot be withdrawn or customized. This increases openness and ensures that all transactions are permanent.
- Fraud prevention: The ideas of shared knowledge and consensus help to reduce fraud and embezzlement losses. BC as a monitoring tool reduces expenses in logistics-based companies.
- Reliability: Because a copy of the original BC is available to each participant, the distributed ledger (DLT) technology stays operational even if a substantial number of other nodes fail.
- Time reduction: BC can play a critical role by enabling faster trade settlement since it eliminates the need for a lengthy process of verification, settlement, and clearing because all parties have access to a single version of agreed-upon data from the shared ledger.
- Collaboration: Facilitates direct communication between parties without the need for a third party to serve as a middleman.
- Security: The identities of the interested parties are certified and verified via BC. This eliminates duplicate records, lowers rates, and speeds up transactions.
- Transparency: The BC provides more transparency, and all transactions are irreversible. We can trace everything from orders to payments to accounts to manufacturing with a BC network. So when we look at the BC, we can see everything about a transaction, from beginning to end, providing us more confidence and additional efficiencies and possibilities. Recent advancements in data-driven techniques further underscore blockchain's potential. Maniruzzaman et al. [36] used ML to analyze large-scale unstructured data from social media, demonstrating the power of visualization techniques in extracting meaningful insights from complex information streams.

3. Integration of BC in SCM

Moving to a BC-based solution has just one goal: to provide an immutable, irreversible, distributed, robust, and non-centralized ledger system. Very efficiently, BC can be used to monitor and sign contracts, and it can also be used to verify the provenance of goods. Various BC properties are particularly useful in supply chain case studies, according to systematic research as shown in Table 1.

Table 1 Main Characteristics of BC and Their Potential Contributions to SCM

Characteristics of BC	Description	Contributions to SCM
Immutability	It is also known as irreversibility. The data can hardly be modified or deleted after the nodes have approved the data in BC.	Forged paperwork will no longer be a risk, and auditability is enhanced. Immutability provides security against unfair and fraudulent -Practices [7-10]
Security	BC provides security through the use of encryption protocols and cryptographic algorithms.	Keeping data from trade transactions and other product-related information very resilient and safe [11-14].
Trust	BC creates a trustless network by using sophisticated math.	Business partners can trade together without knowing each other [15-17].
Decentralized	Decentralization means no central institution is needed and every node is equivalent.	It removes the requirement for third-party verification for transactions and their costs [18, 19].
Transparency and Visibility	The data is simultaneously validated and broadcasted to all the nodes. Transactions or records cannot be hidden, creating more trust and adding value to the business system.	BC facilitates firm-to-firm and person-to-person collaboration while also increasing the visibility of organizational procedures and records [20].
Tamper-resistance	Tamper-resistance means that any transaction information stored cannot be tempered during and after block generation.	By tamper resistance, the supply chain helps to ensure dependability and confidence [18].
Disintermediation	Disintermediation is described as a reduction in intermediaries between manufacturers and consumers.	Disintermediation leads to an uninterrupted chain of transactions, increasing speed and trust among stakeholders in the process [18].

4. Advantages of Implementing BC-Based Supply Chain Systems

Since each stakeholder system's ledger contains all records; therefore, the BC platform for the supply chain avoids the uncertainty that comes with traditional supply chain systems' separate databases [21]. According to the interviews conducted by [16], due to automatic data validation, BC lowers the need for double-checking in the supply chain in addition to tracking and tracing services. BC allows transaction monitoring by providing proof of provenance for transactions. BC enables higher volume and data accuracy while speeding up end-to-end supply chain operations. Data is distributed across the whole network in seconds with BC-enabled applications. Consensus techniques provide data truthfulness and intuitive foundations for smart contracts, enabling supply chain automation and operational benefits. So, in supply chain management, BC might improve transparency, traceability, efficiency, and data security [21]. According to [22], using BC to prove provenance could generate US $ 962 billion for global GDP over the next decade. Adding BC to the supply chain system has several advantages, such as:

- Integration and coordination of supply-chain functions should be improved.
- Facilitates the transmission of information between all stakeholders in the supply chain regarding manufacturing, assembling, distribution, and product maintenance.
- By allowing consumers to find out where a shipment or order is in a given time. With BC, the supply chain may be more trustworthy and transparent.
- Continuous monitoring is more clear and precise (Facilitating origin tracking)
- Because BC technology is decentralized and cryptographically secured, data transportation, possession, and ownership may be more safeguarded against manipulation or hacking.
- Improving visibility and product conformity with international standards to increase confidence between the manufacturer and the customer
- lowering administrative and paperwork costs (management and verification costs)
- By checking the authenticity of the product certification, fraud and counterfeit items can be reduced or eliminated. For example, to track if a given item meets quality requirements, this might be utilized.

- Recalling a product promptly (Enables easier trace back to find flaws in products or processes)
- Keeping track of product quantities and their transfer between partners.
- Minimize or eliminate the need for internal systems and business processes to conduct audits. (Easier audit ability)
- Decentralized data distribution
- More flexible system
- Increased data availability
- Improved watch over the data flow (Keeping track of all business-related documents such as purchase orders, modifying orders, paying receipts, etc.)
- By incorporating BC technology into the payment system, it may be possible to reduce friction in commercial finance and therefore eliminate trade disputes.
- Adoption of BC technology in the supply chain systems might help them solve various issues such as cargo insurance, currency risk, and liability for products destroyed during transportation.
- Using BC would significantly reduce the number of errors that occur at various levels of the supply chain and significantly enhance customer service.

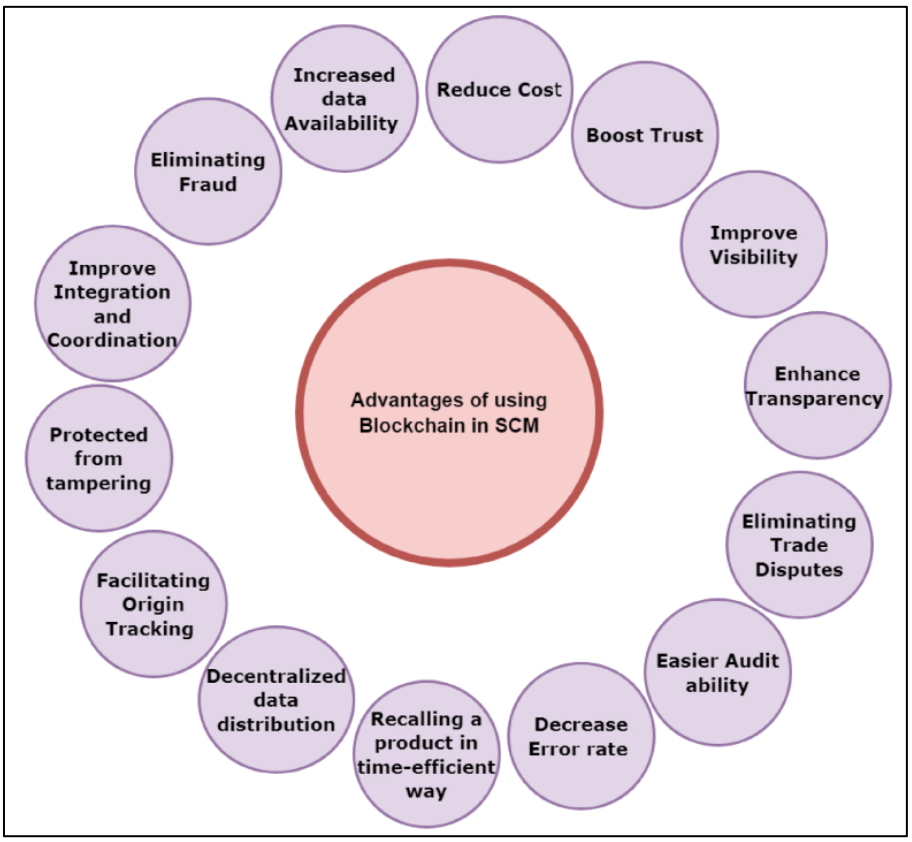

Figure 2 Advantages of using BCT in SCM [2]

5. Blockchain Application Areas

BCT has a wide range of applications, to list a few, logistics field [23, 24], food supply chain and cold chain [23, 25], circular supply chain, healthcare, manufacturing [25], retail [26, 27], and transportation [27]. Some of the famous recent Blockchain solutions under SCM are vaccine distribution, food traceability, supply chain transparency, trade lens container logistics, trusted supplier management [28], recycling, and waste and emissions control. Fig. 3 shows the breakdown of SCM and BCT research by area. SCM is ranked third concerning the frequency of publications, after the health industry and the government sector. SCM, healthcare, and government areas are consistently growing in recent years (2018–2021), while the others (i.e., banking and cyber security) are declining. Overall, 60% of the publications under SCM and BCT are classified under Computer Science, Engineering, and Business. Business, Management, and Accounting represent 12% of the publications. SCM, BCT, and Environmental Sciences-related research (i.e., BCT for

Sustainable SCM, BCT for Circular SCM) or Agriculture-related research (i.e., BCT for Agribusiness, BCT for Food SCM) are potential areas to explore due to the shortage under these areas (Fig. 4).

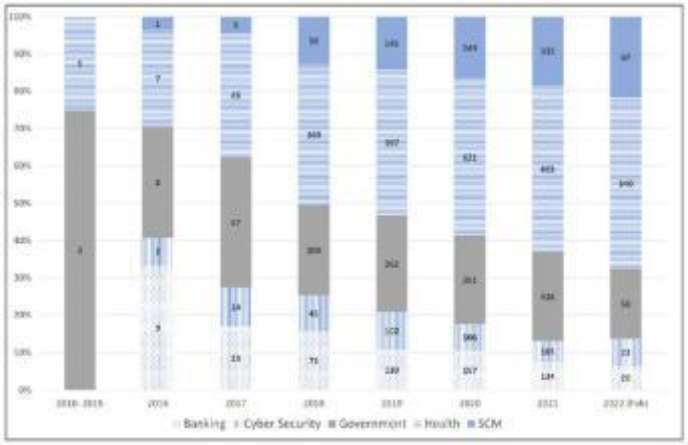

Figure 3 Blockchain publications across areas over the years [2].

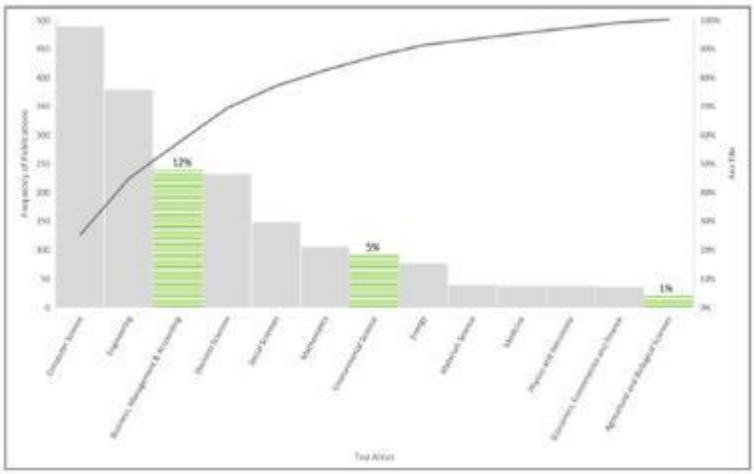

Figure 4 Blockchain publications across areas within the research regime of SCM (2010–2022) [4]

6. Opportunities of BC for Secure SCM

Due to its unique qualities, for instance, real-time data exchange, transparency, reliability, traceability, immutability, and visibility, BC has emerged as the instrument of the modern-day [29]. According to Allied Market Research, BC's global supply chain market will expand at 80.2 percent through 2025. Reports from Market Watch show that the global market for BC-enabled supply chains is estimated to reach $ 9.8 billion by 2025. According to industry estimates, BC's global contribution to the supply chain industry is estimated to reach $ 424 million by 2023. In the near 5 to 10 years, SCM is likely to be among the most successful implementations of BC technology, and BC is likely to become the standard in SCM [30]. Figure 5 shows the SWOT study regarding adoption of BC in supply chain.

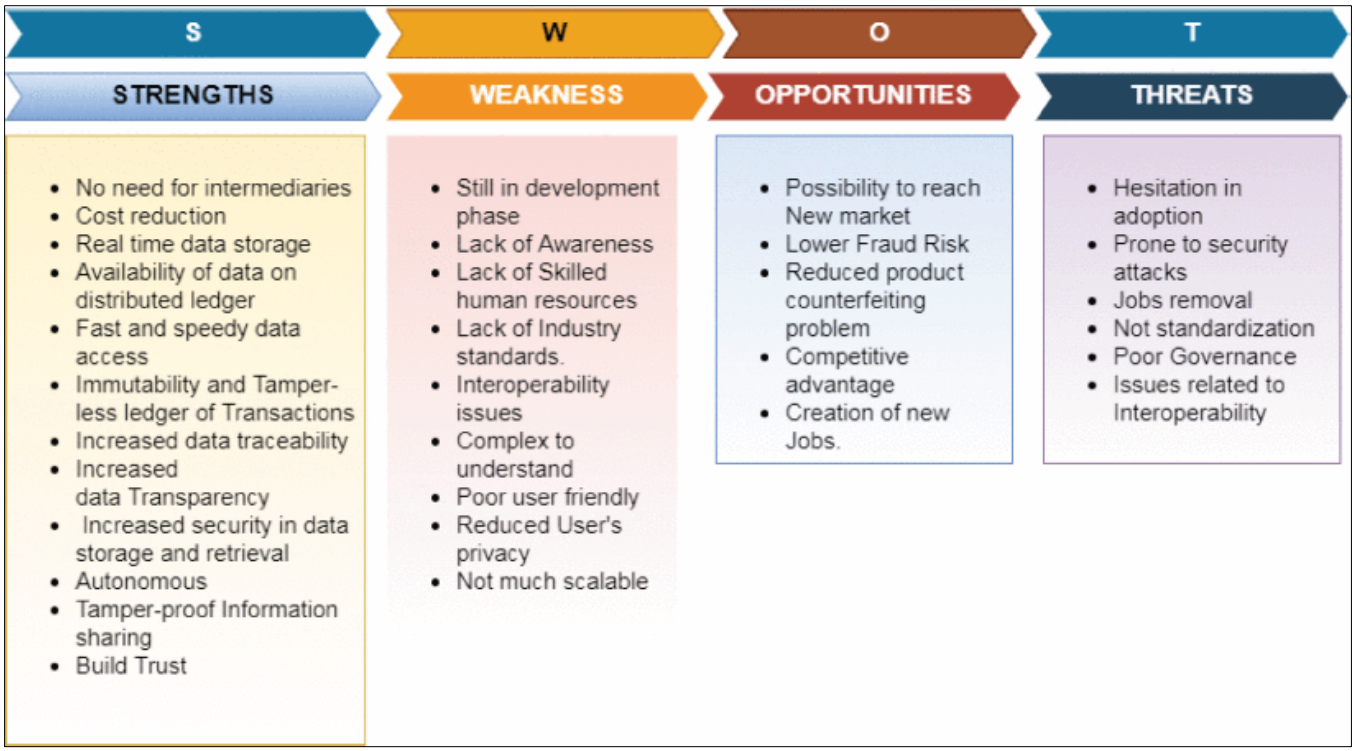

Figure 5 SWOT study regarding adoption of BC in supply industry [1].

Industry 4.0 technologies, encompassing blockchain, significantly enhance manufacturing sustainability through improved traceability and resource optimization. Uddin et al. [37] highlighted these technological integrations, showing how digitization can lead to more sustainable manufacturing processes by promoting transparency, reducing waste, and facilitating better resource management. Efficient resource allocation is another critical domain where blockchain, combined with ML, provides substantial value. Mahmud et al. [38, 39] highlighted how ML-driven blockchain platforms enhance resource management efficiency in cloud computing, offering transparent, automated, and secure decision-making processes.

7. Future Research Opportunities: Next Generation Blockchain

Blockchain has been ever-expanding its potential applications in more and more areas. The evolutionary transformation of BCT can be delineated in Table 2 from Blockchain 1.0 to Blockchain 4.0. This table summarizes the evolution across time based on two BCT-related references [31, 32].

For example, [33] proposed a pallet pooling system based on BCT and IoT (BIoT). They found that the suggested system positively impacts the overall quality of the pooling, increases end-user trust and satisfaction level, facilitates traceability, and minimizes errors. Moreover, this integration leverages cyber security by minimizing system vulnerabilities [34].

Metaverse and NFT are expected to elevate BCT applications across various industries from different spectrums. Furthermore, as the supply chain is typically complex with multiple supply chains connected and intertwined, blockchains serving different supply chains can relate. Therefore, interoperability and chain–chain communication can be a potential research stream, given that it has been raised as a potential challenge in practice.

Blockchain as a Service (BaaS) has been streamlined as a potential trend that will drive the evolution and revolution of technology in the coming years. For example, IBM provides its Hyperledger Fabric blockchain service to several large-scale and medium-scale companies. In addition, there have been several successful business use cases such as Food Trust, World Wire, etc. As a type of SaaS, BaaS will be seen more and more in the new era of business. In this case, BaaS-related research is another tread in the spotlight.

Hashgraph is another decentralized distributed ledger-based technology to address the data storage challenge. Hashgraph is expected to be the next generation BCT because of its fast speed, fairness, and security. For example,

Hashgraph may handle up to half a million transactions per second, while BCT can handle hundreds of thousands of transactions per second [35].

Table 2 Evolutionary transformation of BCT

Topic	**BCT 1.0 Bitcoin—"The Mother of All Blockchain."**	**BCT 2.0 Ethereum**	**BCT 3.0 Hyperledger**	**BCT 4.0 Industry 4.0**
Based on	Distributed Ledger Technology, proof of work [31]	Smart contracts, proof of work consensus mechanisms [32]	Smart contract + decentralized Apps (dApps), proof of stack, proof of authority [32]	BCT + A.I. Proof of integrity [32]
Speed	7 transactions/sec.	30 transactions/sec.	Thousands of transactions/sec.	1 Million Transaction/sec.
Pros	Trusted, reliable, efficient, independent, secure.	Immense application for crowdsourcing. Reduce verification and execution costs. Fraud prevention. Increased Transparency. Increased efficiency.	Higher versatility and modularity. Built-in verification mechanism. More efficient, scalable, and interoperability than the previous generation. Enhanced speed. No single controlling authority. Eliminate dependency on miners for verification and authentication.	Enable smooth integration of different platforms. Highly scalable. Automated Verification (Sharding) Most efficient compared to previous generations.
Cons	Limited Functionality. Inability to support smart contracts. No scalability.	Difficult to write. Errors may lead to adverse effects. Poor scalability.	Complicated. More bugs and updates due to the decentralized nature.	To be determined after progressing with applying it.

8. Conclusion

lockchain significantly enhances supply chain management by increasing transparency, security, traceability, and efficiency. This addresses traditional SCM challenges, such as data manipulation risks, centralization issues, and inadequate stakeholder collaboration. Adoption of blockchain can substantially reduce fraud, streamline operations, and foster trust among supply chain participants. Future research should explore blockchain interoperability, Blockchain as a Service (BaaS), and advanced ledger technologies like Hashgraph. Ultimately, embracing blockchain holds immense potential to revolutionize supply chains, benefiting businesses and society at large.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] U. Agarwal et al., "Blockchain Technology for Secure Supply Chain Management: A Comprehensive Review," in IEEE Access, vol. 10, pp. 85493-85517, 2022, doi: 10.1109/ACCESS.2022.3194319.

[2] Chang, A.; El-Rayes, N.; Shi, J. Blockchain Technology for Supply Chain Management: A Comprehensive Review. FinTech 2022, 1, 191-205. https://doi.org/10.3390/fintech1020015

[3] Macknisy and Company. Blockchain Technology for Supply Chains—A Must or a Maybe? 12 September 2017. Available online: https://www.mckinsey.com/

[4] H. Hellani, L. Sliman, A. E. Samhat and E. Exposito, "On blockchain integration with supply chain: Overview on data transparency", Logistics, vol. 5, no. 3, pp. 46, Jul. 2021.

[5] S. Yadav and S. P. Singh, "Blockchain critical success factors for sustainable supply chain", Resour. Conservation Recycling, vol. 152, Jan. 2020.

[6] J. Yli-Huumo, D. Ko, S. Choi, S. Park and K. Smolander, "Where is current research on blockchain technology?—A systematic review", PLoS ONE, vol. 11, no. 10, Oct. 2016.

[7] J. Kolb, ''Industrial application of blockchains technology—Erasing the weaknesses of vendor managed inventory,'' in Proc. 26th Eur. Conf. Inf. Syst., 2018, pp. 1–17.

[8] C. Antal, T. Cioara, M. Antal, and I. Anghel, ''Blockchain platform for COVID-19 vaccine supply management,'' IEEE Open J. Comput. Soc., vol. 2, pp. 164–178, 2021, doi: 10.1109/OJCS.2021.3067450

[9] J. Aslam, A. Saleem, N. T. Khan, and Y. B. Kim, ''Factors influencing blockchain adoption in supply chain management practices: A study based on the oil industry,'' J. Innov. Knowl., vol. 6, no. 2, pp. 124–134, 2021.

[10] T. Ferdousi, D. Gruenbacher, and C. M. Scoglio, ''A permissioned distributed ledger for the US beef cattle supply chain,'' IEEE Access, vol. 8, pp. 154833–154847, 2020.

[11] J. Moosavi, ''Blockchain in supply chain management: A review, bibliometric, and network analysis,'' Environ. Sci. Pollut. Res., vol. 2021, pp. 1–15, Feb. 2021

[12] K. Behnke and M. F. W. H. A. Janssen, ''Boundary conditions for traceability in food supply chains using blockchain technology,'' Int. J. Inf. Manage., vol. 52, Jun. 2020, Art. no. 101969

[13] L. Wang, L. Xu, Z. Zheng, S. Liu, X. Li, L. Cao, J. Li, and C. Sun, ''Smart contract-based agricultural food supply chain traceability,'' IEEE Access, vol. 9, pp. 9296–9307, 2021, doi: 10.1109/ACCESS.2021.3050112.

[14] C.-L. Chen, Y.-Y. Deng, C.-T. Li, S. Zhu, Y.-J. Chiu, and P.-Z. Chen, ''An IoT-based traceable drug anti-counterfeiting management system,'' IEEE Access, vol. 8, pp. 224532–224548, 2020, doi: 10.1109/ACCESS.2020.3036832

[15] S. Dede, M. C. Köseoğlu, and H. F. Yercan, ''Learning from early adopters of blockchain technology: A systematic review of supply chain case studies,'' Technol. Innov. Manage. Rev., vol. 2021, pp. 19–31, Jul. 2021.

[16] Q. Lin, H. Wang, X. Pei, and J. Wang, ''Food safety traceability system based on blockchain and EPCIS,'' IEEE Access, vol. 7, pp. 20698–20707, 2019, doi: 10.1109/ACCESS.2019.2897792.

[17] F. Tian, ''A supply chain traceability system for food safety based on HACCP, blockchain & Internet of Things,'' in Proc. Int. Conf. Service Syst. Service Manage., Jun. 2017, pp. 1–6

[18] A. Musamih, K. Salah, R. Jayaraman, J. Arshad, M. Debe, Y. Al-Hammadi, and S. Ellahham, ''A blockchain-based approach for drug traceability in healthcare supply chain,'' IEEE Access, vol. 9, pp. 9728–9743, 2021, doi: 10.1109/ACCESS.2021.3049920

[19] M. E. Messiry and A. E. Messiry, ''Blockchain framework for textile supply chain management,'' in Proc. Int. Conf. Blockchain. Cham, Switzerland: Springer, 2018, pp. 213–227

[20] K. Salah, N. Nizamuddin, R. Jayaraman, and M. Omar, ''Blockchainbased soybean traceability in agricultural supply chain,'' IEEE Access, vol. 7, pp. 73295–73305, 2019, doi: 10.1109/ACCESS.2019.2918000.

[21] H. Hellani, L. Sliman, A. E. Samhat, and E. Exposito, ''On blockchain integration with supply chain: Overview on data transparency,'' Logistics, vol. 5, no. 3, p. 46, Jul. 2021

[22] Blockchain Technology: What's Ahead? Assessed: October. 01, 2022. [Online]. Available: https://www.gartner.com/en/informationtechnology/insights/BC

[23] Kouhizadeh, M.; Saberi, S.; Sarkis, J. Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. Int. J. Prod. Econ. 2021, 231, 107831.

[24] Lee, L.H.; Braud, T.; Zhou, P.; Wang, L.; Xu, D.; Lin, Z.; Kumar, A.; Bermejo, C.; Hui, P. All one needs to know about Metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. arXiv 2021, arXiv:2110.05352.

[25] Blossey, G.; Eisenhardt, J.; Hahn, G. Blockchain technology in supply chain management: An application perspective. Comput. Sci. 2019.

[26] Bellare, M.; Kilian, J.; Rogaway, P. The security of cipher block chaining. In Annual International Cryptology Conference; Springer: Berlin/Heidelberg, Germany, 1994; pp. 341–358.

[27] Shen, B.; Dong, C.; Minner, S. Combating copycats in the supply chain with permissioned Blockchain technology. Prod. Oper. Manag. 2022, 31, 138–154.

[28] Queiroz, M.M.; Telles, R.; Bonilla, S.H. Blockchain and supply chain management integration: A systematic review of the literature. Supply Chain. Manag. Int. J. 2019, 25, 241–254.

[29] J. Aslam, A. Saleem, N. T. Khan, and Y. B. Kim, ''Factors influencing blockchain adoption in supply chain management practices: A study based on the oil industry,'' J. Innov. Knowl., vol. 6, no. 2, pp. 124–134, 2021.

[30] R. Alkhudary, X. Brusset, and P. Fenies, ''Blockchain and risk in supply chain management,'' in Dynamics in Logistics. Cham, Germany: Springer, 2020, pp. 159–165.

[31] World Bank. Available online: https://www.worldbank.org/en/home (accessed on 1 October 2022).

[32] Norman, A.T. Blockchain Technology Explained: The Ultimate Beginner's Guide about Blockchain Wallet, Mining, Bitcoin, Ethereum, Litecoin, Zcash, Monero, Ripple, Dash, IOTA and Smart Contracts; Amazon Distribution: Washington, DC, USA, 2017.

[33] Mukherjee, P.; Pradhan, C. Blockchain 1.0 to Blockchain 4.0—The Evolutionary Transformation of Blockchain Technology. In Blockchain Technology: Applications and Challenges; Springer: Cham, Switzerland, 2021; pp. 29–49.

[34] Long, W.; Wu, C.H.; Tsang, Y.P.; Chen, Q. An End-to-End Bidirectional Authentication System for Pallet Pooling Management Through Blockchain Internet of Things (BIoT). J. Organ. End User Comput. 2021, 33, 1–25.

[35] Wu, C.-H.; Tsang, Y.-P.; Lee, C.K.-M.; Ching, W.-K. A Blockchain-IoT Platform for the Smart Pallet Pooling Management. Sensors 2021, 21, 6310.

[36] Md. Maniruzzaman, Md Shihab Uddin, Md Boktiar Hossain, Khandoker Hoque, "Understanding COVID-19 Through Tweets using Machine Learning: A Visualization of Trends and Conversations", European Journal of Advances in Engineering and Technology, 2023, 10(5):108-114.

[37] Md Bahar Uddin, Md. Hossain and Suman Das, "Advancing manufacturing sustainability with industry 4.0 technologies", International Journal of Science and Research Archive, 2022, 06(01), 358-366.

[38] Tanvir Mahmud, "Applications for the Internet of Medical Things", International Journal of Science and Research Archive, 2023, 10(02), 1247-1254.

[39] Tanvir Mahmud, "ML-driven resource management in cloud computing", World Journal of Advanced Research and Reviews, 2022, 16(03), 1230-1238.

[40] Bharati, S., Mondal, M. R. H., Podder, P., & Prasath, V. S. (2022). Federated learning: Applications, challenges and future directions. International Journal of Hybrid Intelligent Systems, 18(1-2), 19-35.