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Beyond the Hype: A Proposed Model Based on Critical Analysis of Blockchain Technology's Potential to Address Supply Chain Issues

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Abstract: This paper explores the proposed solutions based on blockchain technology's potential to solve supply chain management issues. The problems include lack of traceability and transparency, scalability and cost issues, sustainability, efficiency, patchwork logistics, and bullwhip effect issues. In this paper, we have suggested some solutions with the help of blockchain technology. The solutions can solve multiple significant issues in supply chain management. Our blockchain-based solutions can provide a secure and visible record of all transactions and data along the supply chain, which can improve traceability and transparency, a decentralized and efficient method of data processing and exchange that can also increase scalability and reduce cost, a transparent and accountable way to track and verify sustainability-related data. Our method can enable more streamlined and automated tracking and data sharing, helping to reduce the risk of delays and inefficiencies while mitigating the risk of the bullwhip effect by providing real-time visibility and enabling better communication and collaboration between parties. The paper discusses the implications and challenges of implementing blockchain in supply chain management.

Index Terms: Supply Chain, Blockchain, Traceability, Transparency, Decentralize.

1. Introduction

Supply chain management using blockchain technology has become a promising approach for dealing with various issues in the industry. Blockchain technology is a type of distributed ledger technology composed of a series of data

blocks linked through cryptographic methods that provide a permanent digital footprint to all members of the network. As a result, every approved transaction occurring is recorded in a tamper-evidence environment, making it difficult for malicious attempts to alter the information. A supply chain is an interconnected system of businesses that participate in the many processes and activities that produce the goods and services that are ultimately provided to the consumer. Supply chain management is a complex and multifaceted process essential for businesses and organizations' smooth operation.

The main objective of our study is to solve the problems of supply chain management with proper blockchain-based solutions. The main objective of this study will conduct a systematic literature review to thoroughly analyze the potential of blockchain to solve supply chain issues. It also demonstrates the possible advantages of blockchain technology for supply chain management. First, we describe the supply chain and supply chain issues to achieve our main objective before introducing our solution using the blockchain. Hence, the review will analyze the existing literature on blockchain technology and its use in supply chain management, including its advantages, disadvantages, and proper solutions to solve supply chain issues. To attain the main objective, we have suggested blockchain-based solutions to improve supply chain management. According to improved supply chain management, we found many issues that need to be solved. These issues can be raised due to less transparency and traceability in supply chain management. Lack of scalability and efficiency can be another issue of supply chain management. Our blockchain-related solutions can increase the supply chain's transparency and traceability while boosting accountability and security. A tamper-proof and immutable record of the whole supply chain is provided by our method, which can enable end-to-end transparency. To enhance scalability and reduce supply chain costs, our blockchain-based solutions can facilitate secure and efficient data sharing, reducing the need for intermediaries and lowering the cost of supply chain management. Supply chain efficiency can be enhanced using our solutions. The main limitation of our paper lies in the lack of practical implementation due to time and resource constraints. If we get proper time and enough resources, our solutions can be practically implemented. According to achieve our main objective, this paper gives the clear concept of appropriate solutions with blockchain that can help to solve supply chain related problems, which can guide us in future implementations.

The supply chain portion describes the definition of the supply chain, supply chain activities and networks, supply chain management characteristics, supply chain participants, and supply chain benefits. In the supply chain issues part, we describe the problems of the supply chain. The blockchain section describes the definition of blockchain, blockchain mechanism, characteristics of blockchain, and advantages and disadvantages of blockchain. In the solution, we have proposed possible solutions to supply chain issues with blockchain. Next, we discussed our proposed solutions' potential to solve the supply chain issues in the discussion. Finally, we came up with the conclusion that our proposed solutions can potentially solve supply chain issues and the limitations of our research.

2. Supply Chain

Supply chain management is a complex management issue that involves information, capital, logistics, and business flow and creates a dynamic, cooperative interaction between suppliers, manufacturers, retailers, and end users [1]. An efficient and strategic partnership between a buyer and its suppliers is one of the critical success factors in supply chain management (SCM). Supply chain collaboration includes sharing essential information from the market and global network operations, followed by rapid joint decision-making based on such information. Through collaborative efforts to match demand and supply, two trading partners can increase mutual benefits and reduce risks [2].

2.1. Supply Chain Activity and Supply Network

When organizations actively (and collaboratively) manage activities and relationships in the supply chain to maximize customer value and achieve sustainable competitive advantage, one can talk about supply chain management, which represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective & efficient ways possible. The critical supply chain activities are new product development, sourcing, production, logistics, demand management, coordination, and integration. In that sense, logistics is part (although the biggest) of supply chain management. The term "supply networks" (sometimes "supply chain networks" or "distribution networks") is more appropriate since it describes more complex Spatio-temporal structures which emphasize the number, position, the nature of relationships, activities, business objectives, capacity, information services and technology base of its participants. The Supply network of a specific supply chain member (in this case, a manufacturer) consists of the supply side of the network (or supplier network) and the demand side of the network (or distributive network). The supply side encompasses all entities of the supply chain that provide inputs, directly or indirectly, to the focal company. The demand side includes all supply chain members that the product passes through on its way to the end consumer Activities carried out on the supply side of the network are referred to as upstream activities. In contrast, those on the demand side are downstream activities [3].

2.2. Supply Chain Management Characteristics

SCM philosophy suggests that the boundaries of SCM include logistics and all other functions within a firm and a supply chain to create customer value and satisfaction. In this context, understanding customers' values and requirements are essential. In other words, SCM philosophy drives supply chain members to have a customer orientation. SCM as a management philosophy has the following characteristics:

Table 1. Supply chain characteristics

A systems approach to viewing the supply chain as a whole and managing the total flow of goods inventory from the supplier to the ultimate customer.
A strategic orientation toward cooperative efforts to synchronize and converge intra-firm and interfirm operational and strategic capabilities into a unified whole.
A customer focus to create unique and individualized sources of customer value, leading to customer satisfaction [4].

2.3. Participants in the Supply Chain

In any given supply chain, a combination of companies performs different functions. Some companies are producers, distributors or wholesalers, retailers, and companies or individuals who are the customers, the final consumers of a product. Supporting these companies, other service providers will provide a range of needed services.

Table 2. Supply chain participants

Producers	Organizations that manufacture products are known as producers or manufacturers. Both businesses that create raw materials and businesses that manufacture completed goods belong to this category.
Distributors	Distributors are enterprises that purchase inventory in large quantities from manufacturers and ship a collection of relevant product lines to clients. Distributors are also referred to as wholesalers.
Retailers	Retailers hold supplies in stock and sell to the general public in smaller quantities. This company carefully monitors the preferences and requirements of the customers it serves.
Customers	Any organization that buys and uses a product is considered a customer or consumer. A customer company could purchase a good to use in another good that they later resell to other buyers. A customer could also be a product's final consumer, someone who purchases it intending to use it.
Service Providers	These businesses offer services to clients, retailers, distributors, and producers. Service providers have specialized knowledge and abilities focused on a specific task required by a supply chain [5].

Table 3. Supply chain issues

Issues	**Description**
Traceability	Traceability is increasingly vital in various supply chain industries due to a lack of trust caused by inefficient transactions, fraud, and theft. The use of paper certifications and receipts is unreliable in determining the provenance of valuable objects [7].
Transparency	Transparency is vital in supply chains as a lack of it hinders confirmation of the actual value of items, creating competitive challenges in strategy and reputation. Dealing with intermediates adds to the difficulty of managing traceability [7].
Scalability and cost	Supply chain faces challenges in scalability and cost management, as increasing volume of transactions makes maintaining efficiency difficult, while implementing and maintaining these systems can be expensive.
Sustainability	Sustainability certification is crucial in supply chain. Current information systems may not support necessary information for provenance of goods, but improving transparency, security, durability, and process integrity can help [7].
Efficiency	Efficiency is critical in supply chain, achieved by streamlining processes, reducing waste, minimizing delays, and utilizing technology like automation and data analytics. Supply chain optimization is a continuous process that requires constant monitoring and adjustment.
Consumer	Consumer issues in supply chain include safety, quality, and ethics, requiring transparency and sustainability. A comprehensive approach prioritizing quality, safety, and ethics is necessary to meet increasing consumer demands and protect the company's reputation
Security	Security is crucial in supply chain to prevent theft, fraud, and cyber threats. Counterfeiting and piracy are concerns. Strong security measures, such as encryption and authentication protocols, are necessary to safeguard the supply chain.
Coordination	Coordination is crucial in supply chain management to ensure efficient and aligned activities among different entities. This can be achieved through collaboration and communication, including various methods such as contracts, information sharing, and technology. A study proposes a fuzzy logic strategy and AHP to measure the degree of coordination, illustrated with a case study [8].
Patchwork Logistics	The Patchwork Logistics issue in supply chain management is caused by using multiple third-party logistics providers, resulting in a disconnected supply chain that is difficult to integrate and lacks insight or customized services. Conventional 3PLs often offer fixed services with long-term contracts that limit flexibility in responding to changes in supply and demand.
Bullwhip effect	The Bullwhip effect occurs when demand forecasts get distorted as they move up the supply chain, leading to an excess of inventory and financial burdens. Each member of the supply chain creates their own demand forecast based on available orders, resulting in a large amount of safety inventory that slows material flow [3].

2.4. Benefits of Digital Supply Chain

The benefits of a Digital supply chain (DSC) include the cost-effectiveness of services and value-creating activities that are advantageous to many actors in the ecosystem, including firms and their suppliers, employees, and customers. A supply chain is any group of three or more entities (i.e., businesses or people) actively involved in the upstream and downstream movement of goods, services, money, and information from a source to a consumer. The key motivation for supply chain integration is the efficiency associated with minimizing governance costs, including the costs of exchanging with other ecosystem participants and those within the individual organization. When adequately automated, these information flows eliminate the need for manual data entry and reduce human error; current low levels of system

interoperability continues to cause high investment costs, and the potential benefits still need to be realized. Other identified benefits of DSC include reduced product or service costs, creating competitive advantage and barriers to competition, reduced supply chain lead times, and increased flexibility in supply chain design. The critical capability is to deliver the correct information to the right people at the right time for decision-making purposes. Previous research has highlighted how information integration and service automation are important drivers of business value in supply chains [6].

3. Blockchain

3.1. Blockchain Technology

Blockchain is a decentralized, immutable database that makes tracking assets and recording transactions in a business network easier. Formal Definitions, "A decentralized, replicated, immutable, and tamper-proof log that allows users to read data and verify; a distributed database with the ability to operate in a decentralized setting without relying on trusted intermediaries; and a distributed ledger for recording transactions maintained by many nodes without central authority through a cryptographic protocol." [9]

Blockchain is a distributed ledger system used for sharing and organizing digital data developed using various technologies. "A distributed database known as a blockchain is shared and verified by a peer-to-peer network. It consists of a linked series of blocks (a unit of transaction storage), each containing a timestamped transaction that hash-key cryptography has encrypted and has been authenticated by the network community. A blockchain becomes an immutable record of previous activity once a block is added to it and cannot be altered after that [10].

Initially mentioned in 1991 by a group of researchers. Similar to a notary, designed to timestamp documents to avoid manipulation [9]. Mike Hearn first introduced the concept of using the Bitcoin blockchain to track property ownership and transfers in his article on "smart property," the concept of smart property can be traced back to Nick Szabo's 1997 proposal for smart property in a paper on "The idea of smart contracts." [11]

A digital coin, and a well-known use case for blockchain technology, is Bitcoin. Satoshi Nakamoto, who developed Bitcoin, implemented blockchain in 2008 by putting it to work [9].

A transaction will first be started by a user or node and signed with a private key. In short, the private key will generate a unique digital signature and ensure it cannot be modified. The digital signature will drastically change if someone tries to change the transaction details, making it impossible for anyone to authenticate it. As a result, it will be rejected. The transaction will then be broadcasted to the verifying nodes after that. The blockchain platform can utilize a variety of techniques to determine whether the transaction is legitimate or not. These protocols or algorithms are referred to as consensus algorithms. In either case, the transaction will be recorded in the ledger once the nodes have confirmed its authenticity. It will also include a timestamp and a unique ID to further protect it from tampering. After that, the block will connect to the previous blocks, after which a new block will connect to this block, and so on. Furthermore, in doing so, a chain of blocks is formed, giving the concept of "blockchain."

A data structure called "Block" is used to implement the blockchain; it holds the data, the current block's hash, and the preceding block's hash. The data stored inside the block depends on the type and purpose of the blockchain. The sender, the receiver, and the amount are just a few examples of common attributes that may be found in a blockchain typically used for transferring digital currency, such as Bitcoin. To uniquely identify the block, the hash portion hashes the entire block. The blockchain is made up of blocks that are connected by the hash of the previous block. The Open Ledger, or network of Distributed Participants, is the most crucial Blockchain paradigm. These participants are interested in exchanging assets. A block known as the Genesis block maintains the network's original state at the initial state.

Secondly, this ledger is distributed. The ledger is replicated for each participant. Thus, it is a distributed ledger rather than a centralized ledger. Each participant receives a copy of the blockchain's current state when joining the network. A new block is broadcast throughout the network as soon as it is created. When everything checks out, each node links the new block to the blockchain after validating the new block using its copy of the blockchain.

The third rule is to synchronize everyone's copies. Let us say B desires to transfer five assets to C. B, therefore, broadcasts a transaction to the network, informing every node that B wishes to perform a transaction. This is an invalidated transaction to validate this transaction, and there is another concept of the miner. To verify this transaction and record it on the ledger, miners contest with one another. Consider that A and D are also miners.

The miner must perform two tasks in order to validate this transaction.

- Validation involves checking the validity of the transaction by traversing the ledger.
- Locate a key enabling the miner to link a new block to a previous one using the Proof of Work method.

Every other node in the network can link the new block to its ledger when the first successful miner publishes the solution to the network. Others will therefore continue to check other invalidated transactions. The tiny payment miners receive as a reward for their computation power and problem-solving efforts serve as an incentive. If a rogue participant tries to change data in a block, the hash is also changed, which breaks the link between subsequent blocks and previous blocks. Therefore, to alter the blockchain, the malicious participant must recalculate every block after that to create a new,

legitimate chain. Blockchains are virtually unhackable because of this characteristic. For any ordinary machine, recalculating hashes is simple and quick, but PoW slows the creation of new blocks. For instance, calculating a block in Bitcoin takes about 10 minutes. In a blockchain network, all nodes reach a consensus and agree on the ledger's current state. In addition to Proof of Work, more effective and optimized mechanisms have been created recently to address PoW-related issues. They consist of the following: Delegated Proof of Stake, Practical Byzantine Fault Tolerance, Proof of Stake, Proof of Bandwidth, and Proof of Elapsed Time [9].

3.2. Characteristics of Blockchain

Table 4. Blockchain characteristic

Features	Descriptions
Decentralized	Blockchain is a decentralized system where data can be accessed, monitored, stored and updated on multiple systems without the need for central authentication. It addresses key issues of lift resilience, availability, and failover that decentralization requires, which is trust, by utilizing several consensus techniques. It also alleviates performance bottlenecks at the central server and lowers server costs [12,13].
Immutable	Blockchain is considered an immutable distributed ledger due to its ensured immutability via timestamps and restrictions. Any attempt to alter information would require changing the previous blocks' hash data, which is considered astronomically impossible. Blockchain is almost immune to tampering because each block created by a miner is verified by other users on the network [12,13].
Transparent	Blockchain is transparent as the recorded data is visible and traceable throughout its entire lifetime. The network agrees to record and preserve data, making it transparent to all participants [12].
Autonomy	Blockchain's autonomy is characterized by its decentralized system that allows each node to access, transfer, store, and update data without a third party. This feature results in increased privacy, security, and control over data while reducing potential manipulation or corruption by third parties. Additionally, the autonomy of the blockchain network enables it to operate 24/7 without any downtime, making it a highly reliable system [12].
Open source	Blockchain is open source, enabling transparency, collaboration, and community-driven development without a hierarchy. This feature promotes innovation, inclusivity, and greater trust among users [12].
Anonymity	Blockchain provides anonymity as data is transferred between nodes without revealing the user's identity. Users can communicate with the blockchain network using randomly generated addresses, and multiple addresses can be used to prevent identity from being revealed. As a decentralized system, no central authority is keeping track or preserving the private information of its users [12,13].
Ownership and uniqueness	Blockchain ensures ownership and uniqueness of documents through a unique hash code assigned to each document. This hash code preserves ownership information and prevents duplication, ensuring the authenticity and uniqueness of the document [12].
Provenance	Blockchain technology provides provenance characteristics by creating a digital record that testifies to the legitimacy and origin of a product. Every product has a blockchain-based digital record document, which ensures transparency and authenticity in the supply chain [12].
Smart contracting	Smart contracts are typically programmed with terms for the rules, penalties, and activities that will be applied to all parties to the transaction. It is a simple computer code that aids in contract execution. With higher security and reduced transaction costs, it eliminates the requirement for a typical contract [12].
Auditability	A digital distributed ledger and a digital timestamp are used to record and verify each transaction in a blockchain network. As a result, it is feasible to access any network node to audit and track past records [13].

3.3. Type of Blockchain

Blockchain can be categorised into two types:

- Public/Permission less Blockchain
- Private/Permissioned/ Consortium Blockchain

A. Public/Permission Less Blockchain

Anyone can use public blockchains to access and maintain the distributed ledger, with permission to run a consensus mechanism to verify the ledger's integrity. Anyone may join, participate in, and leave the system anytime because it is open and distributed. As a result, this system runs on unidentified and untrusted nodes [9]. Everyone on the network can examine the transaction, confirm it, and participate in the consensus-building process [14]. Participating members may each contribute a new block to the ledger while maintaining their pseudonymous or otherwise unknown identities and names. Each individual or group can manage a blockchain node and participate in transaction verification using the mining algorithm [15].

However, there are disadvantages. In contrast to the current payment systems like Visa and Mastercard, a permissionless blockchain, for example, has a speed restriction for processing high volumes of transactions, which limits its large-scale deployment [16].

Public blockchains frequently use consensus based on proof of work (PoW) and financial incentives, typically involving native cryptocurrency [15]. A permissionless blockchain is an excellent example since Bitcoin is an open platform [17].

B. Private/Permissioned/ Consortium Blockchain

Permissioned Blockchains are a hybrid between private and public Blockchains by incorporating that several participants and the central nodes are initially and strictly selected. Permissioned blockchain is appropriate for semi-

closed systems comprising a few businesses frequently arranged into consortiums. Data transparency varies; access controls are often used to limit access to participants' information and data inside Blockchains, as established by the consortium. A certain level of authentication and identity is needed for private or permissioned blockchains [9]. An individual, an organization, or a set of organizations can rapidly transfer information and record transactions due to the permissioned blockchain. With each participant's identification known to all participants, it provides an additional layer of privilege to control who may participate in the network system. The participant cannot commit fraud in the permissioned blockchain network system because their identity is revealed to the management server [15].

Blockchains in consortiums have numerous owners as opposed to one. Because the number of nodes on private and consortium blockchains is constrained by permissions granted by the owner(s), visibility is restricted at the expense of a minimal degree of immutability, and a system attack would only need to compromise a small number of the blockchain's systems to corrupt the data [14]. A permissioned blockchain offers a means of securing communications between entities that share a common objective but do not entirely trust one another, such as companies that trade money, products, or information. A permissioned blockchain can use conventional Byzantine-fault tolerant (BFT) consensus depending on the peers' identities [15]. Both the Hyperledger and R3CEV Blockchains are consortium-based [14].

3.4. Use of Blockchain

Blockchain technology has found its applications in various sectors, including asset management, trade finance, value-added tax, manufacturing, shipping, healthcare, agriculture and food, e-commerce, education, and entertainment and tourism, etc.

In asset management and trade finance, blockchain has improved by introducing efficiency, transparency, and security through automated transaction processing and operational streamlining. It aims to identify roadblocks, adoption strategies, and success factors for their integration. Its decentralized nature ensures transaction security, reduces operational complexity, and lowers the risk of fraud.

Also, this technology could lead to a new generation of tax systems, which would record tax collections at each and every step of the value chain. This helps avoid arguments and facilitates the calculations of VAT - an important societal impact [14].

The healthcare sector is another area where blockchain technology has found its applications. Healthcare organizations are dealing with an enormous amount of data, and ensuring the accuracy and security of this data is a critical challenge. Blockchain technology can help solve this problem by enhancing data management capabilities and preventing drug counterfeiting. Blockchain technology can ensure that patient data is accurate, secure, and tamper-proof. The patients have the ability to share access to their health information to doctors using this distributed storage platform [16,18].

In the agriculture and food sector, blockchain technology can facilitate end-to-end traceability and reduce food adulteration. By recording the movement of food products from the farm to the table, blockchain technology can help ensure that food products are safe and of high quality. This will help to reduce food waste and enhance the efficiency of the food supply chain.

A credit evaluation system has also been developed based on blockchain technology. The integration of blockchain technology has the potential to greatly benefit the aviation and construction industries too. For aviation, utilizing RFID technology in the supply chain can enable digitization and increased security. There is enormous scope for the integration of blockchain technology with current aviation.

In the construction industry, blockchain can help to manage information and secure payments. However, to fully realize these benefits, both sectors will need to undergo organizational restructuring.

In the e-commerce sector, blockchain technology can simplify and secure e-procurement. By providing a secure platform for online transactions, blockchain technology can help to reduce fraud and increase customer trust. This will help to enhance the efficiency of the e-commerce sector and reduce the cost of doing business.

In the education sector, blockchain technology can help to resolve problems related to reputational management, productivity, peer review processes, and predatory publishing. By providing a secure platform for the sharing of academic data, blockchain technology can help to reduce the cost of education and enhance the quality of education. Data immutability and the elimination of third-party intervention are of utmost importance in the education sector.

The entertainment and tourism sector can leverage traffic, demand, and storage allocation through a decentralized system. By providing a secure platform for the sharing of data, blockchain technology can help to reduce the cost of entertainment and tourism and enhance the efficiency of the industry. In tourism, it can improve the current trend of virtual reality-based tourism and provide an enhanced experience to the firms.

Blockchain technology can prevent fraud in industries such as art, food, and pharmaceuticals. The concept works by using mobile technology to input environmental conditions at the farm level onto a blockchain and then using RFID tags to track products through the supply chain, giving the consumer visibility of product provenance [14].

Finally, Blockchain technology has the potential to revolutionize various sectors including online advertising, spacecraft, governments, postal services, auditing, stock markets, voting, insurance, identity management, and charity [19].

3.5. Pros and Cons

Blockchain technology has decentralization as one of its key benefits, preventing tampering with information and ensuring information validity. A distributed ledger is more secure and resilient against hacking, corruption, and crashing

than a centralized database. A centralized database is more susceptible to hacking, corruption, or crashing. The system's decentralized nature establishes trust; this approach does not require any particular behavior on behalf of the participants but guarantees the system's integrity. Blockchain also provides transparency by allowing participants to view and analyze transactions while preserving anonymity through cryptographic records. They rely on a unique system architecture platform for applications involving multiple parties who require little trust in each other; for example, fragmented supply chains [7]. However, its implementation comes with drawbacks that should not be overlooked. One primary concern is the cost of implementing and maintaining blockchain systems, which can be higher than expected. The non-trivial operations and implementation costs of blockchain systems should never be underestimated. Also, the laws and regulations surrounding the blockchain environment must be clarified, which can lead to confusion among consumers [12]. Furthermore, the regulatory environment surrounding blockchain technology still needs to be clarified, leading to confusion among consumers. As more businesses adopt blockchain-based solutions, concerns about performance and scalability also arise. Slight transaction delays can occur due to the limited capacity of blocks. While blockchain is often considered to provide privacy, recent studies have shown that transaction histories can be linked to reveal users' identities. The lack of a standard protocol for collaboration among industries also challenges the growth of the blockchain industry. The energy consumption required for mining cryptocurrencies is another significant issue, as it contributes to global warming. Selfish mining practices and current regulation problems also pose threats to the security and integrity of blockchain networks. In light of these concerns, it is crucial to find ways to balance the regulatory landscape with the technology's innovative potential, and standardization is necessary for the growth and collaboration of the industry [13,20].

4. Proposed Solution of Supply Chain Issues Using Blockchain

The research paper employed a methodology that consisted of a literature review to understand supply chains and blockchain technology. The literature review studied various aspects of supply chains, including activities, network structures, participants, benefits, and challenges. Similarly, an analysis of blockchain technology covered its history, mechanisms, characteristics, categories, applications, advantages, and disadvantages. Based on the insights gained, the research paper proposed solutions using a step-by-step approach to leverage blockchain for addressing supply chain issues. The methodology involved an in-depth analysis of the literature to develop a comprehensive understanding of supply chains and blockchain technology. The findings and proposed solutions aimed to contribute to the exploration of blockchain's potential in enhancing supply chain management.

4.1. Traceability and Transparency

The supply chain can benefit from the use of blockchain technology by creating a secure and visible record of all transactions and data along the supply chain, which can assist address concerns with traceability and transparency. Using blockchain technology to address concerns with supply chain transparency and traceability requires the following considerations:

Table 5. Supply chain traceability and transparency with blockchain technology

1. Determine the key locations in the supply chain where transparency and traceability are crucial. They might involve the procurement of raw materials, production, movement, storage, and distribution.
2. An appropriate blockchain platform can pick between many blockchain platforms like Ethereum, Hyperledger Fabric, Corda, and others. Pay attention to elements like interoperability, scalability, and security.
3. Create the network architecture for the blockchain, which must include nodes for each of the supply chain's participants, including suppliers, manufacturers, distributors, and retailers. To ensure data privacy and integrity, each node should have permission access to the blockchain network
4. Implement smart contracts to automate and streamline supply chain processes, such as procurement, order fulfillment, and payment
5. Record all supply chain transactions in real-time on the blockchain network, including information on the place of origin, mode of delivery, circumstances surrounding storage, and any quality assurance procedures
6. Access to information on a product's route through the supply chain, including any quality and safety certifications, is made possible via the use of blockchain-based tracking and tracing technologies
7. By using analytics and AI tools, it will be possible for supply chain partners to discover areas for improvement and to make data-driven decisions by drawing insights from blockchain data.

By following these procedures, it will be possible to use blockchain technology to increase the supply chain's transparency and traceability while also boosting accountability, and security. A tamper-proof and unchangeable record of the whole supply chain is provided by blockchain technology, which can enable end-to-end transparency.

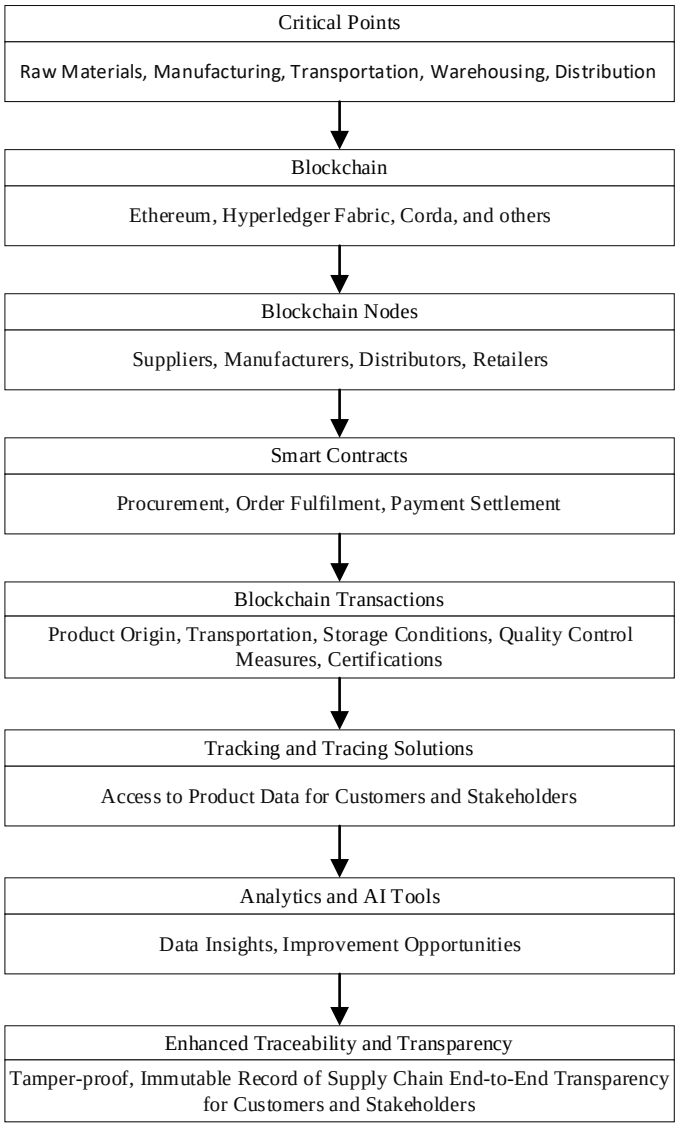

Fig.1. Solution flowchart of traceability and transparency

4.2. Scalability and Cost

Blockchain technology can assist in resolving scalability and cost issues in the supply chain by providing a decentralized and efficient method of data processing and exchange. Consider the following measures when implementing blockchain technology to increase supply chain scalability and reduce costs:

Table 6. Supply chain scalability and cost with blockchain technology

1. Determine the points in supply chain where scalability and cost present the greatest challenges. Examples include high-volume manufacturing facilities and distribution centers.
2. Choose a blockchain platform that can effectively manage high transaction volumes and is inexpensive to operate. Some platforms, including Corda and Hyperledger Fabric, are designed to facilitate enterprise-level applications.
3. Create a blockchain network architecture that minimizes operational expenses. A permissioned network can be used to reduce the quantity of computational power required to operate the network.
4. Implement smart contracts to automate and streamline supply chain processes, including procurement, order fulfillment, and payment resolution. Smart contracts can reduce the expense and duration of these processes.
5. Record all supply chain transactions in real-time on the blockchain network, including information on product origin, transportation, and storage conditions, as well as any quality control measures.
6. Utilize blockchain-based tracking and tracing solutions to reduce supply chain management expenses. These solutions can automate the process of monitoring and tracing, minimizing the need for manual intervention.
7. Utilize analytics and AI tools to extract insights from the blockchain data, enabling supply chain partners to identify areas for improvement and make data-driven decisions. These insights can help optimize the supply chain and reduce costs.

By implementing these measures, blockchain technology can be utilized to enhance scalability and reduce supply chain costs. Blockchain technology can facilitate secure and efficient data sharing, reducing the need for intermediaries and lowering the cost of supply chain management.

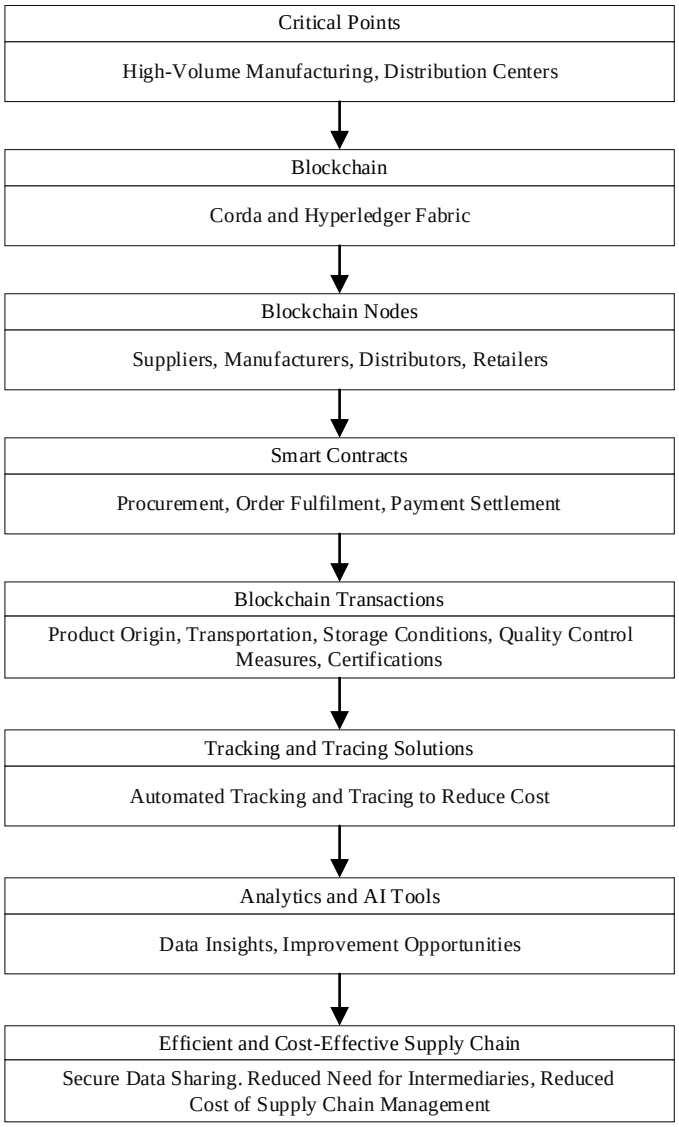

Fig.2. Solution flowchart of scalability and cost

4.3. Sustainability

Blockchain technology can help solve supply chain sustainability issues by providing a transparent and accountable way to track and verify sustainability-related data. Here are some steps to consider when implementing blockchain technology to improve supply chain sustainability:

Table 7. Supply chain sustainability with blockchain technology

1. Determine the sustainability-related data that must be monitored, such as carbon emissions, water consumption, and refuse production.
2. Develop metrics and standards for sustainability that can be implemented throughout the supply chain. These metrics should be based on industry best practices and be measurable, attainable, and relevant to organization.
3. Implement a blockchain-based monitoring and tracing system that records data pertaining to sustainability at every stage of the supply chain. This includes information regarding the origin of basic materials, production processes, transportation, and distribution.
4. Use of smart contracts to automate sustainability-related processes, such as verifying the origin of raw materials or monitoring environmental impact. Smart contracts can be programmed to execute automatically when certain conditions are met, such as reaching a specified level of carbon emissions.
5. Verify sustainability-related information, such as carbon offsets and eco-friendly product claims, with blockchain-based certification systems. This can help prevent fraud and ensure that sustainability-related data is accurate and transparent.
6. Utilize analytics and AI tools to examine data pertaining to sustainability and identify areas for improvement. This can assist in optimizing the supply chain and minimizing environmental impact.

By following these steps can leverage blockchain technology to improve supply chain sustainability. Blockchain technology can enable transparent and accountable tracking of sustainability-related data, helping to reduce environmental impact and ensure that sustainability-related claims are accurate and trustworthy.

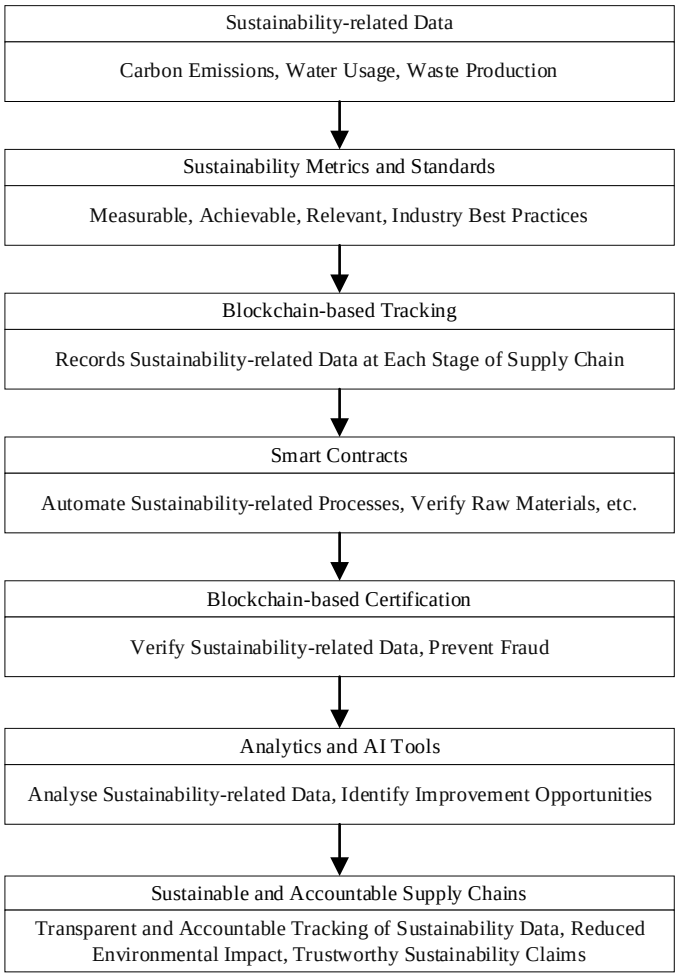

Fig.3. Solution flowchart of sustainability

4.4. Efficiency

Blockchain technology can help solve supply chain efficiency issues by providing a more streamlined and automated way of tracking and sharing data throughout the supply chain. Here are some steps to consider when implementing blockchain technology to improve supply chain efficiency:

Table 8. Supply chain efficiency with blockchain technology

1. Identify the essential data points that must be tracked and shared across the supply chain, such as inventory levels, production schedules, and shipping status.
2. Implement a blockchain-based tracking system that records this data at each stage of the supply chain. This can include data on raw materials, manufacturing, transportation, and distribution.
3. Use of smart contracts to automate processes such as order fulfillment, payment settlement, and contract management. This can help reduce the time and resources needed to manage these processes manually.
4. Use of digital identities based on the blockchain to verify and authenticate supply chain participants. This can help prevent fraud and ensure that only authorized parties have access to shared information.
5. Use of analytics and AI tools to analyze supply chain data and identify areas for improvement. This can help optimize the supply chain and reduce costs.
6. Utilize blockchain-based platforms to facilitate collaboration and communication between supply chain stakeholders. This can reduce the time and resources required to manually manage these relationships.

By following these methods, supply chain efficiency can be enhanced using blockchain technology. Blockchain technology can facilitate the monitoring and sharing of data in a more streamlined and automated manner, thereby reducing costs and increasing overall efficiency.

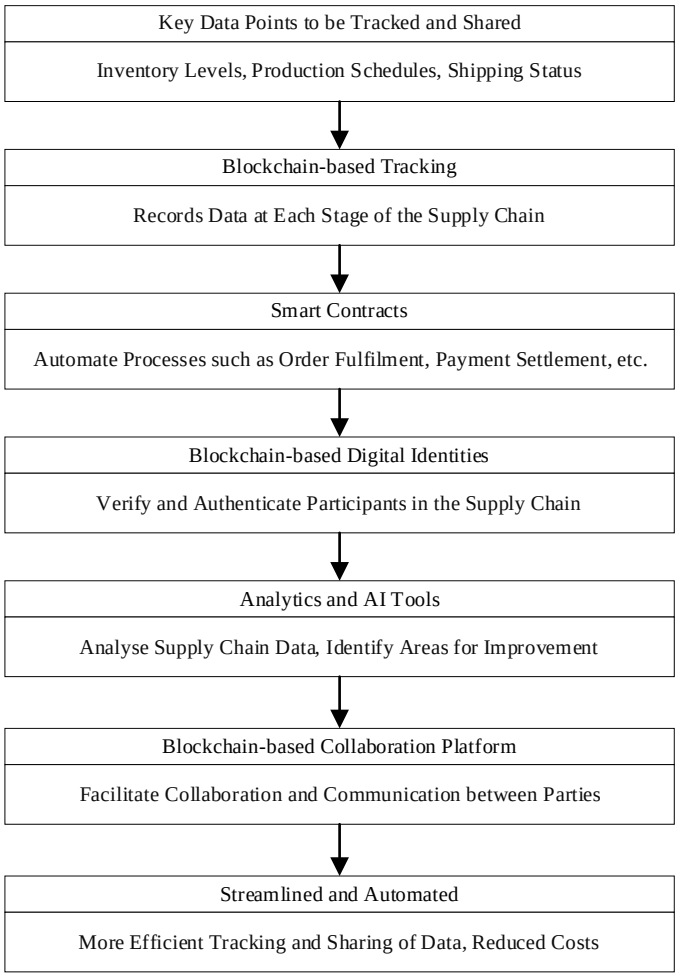

Fig.4. Solution flowchart of efficiency

4.5. Patchwork Logistics and Bullwhip Effect

Using blockchain technology, the following actions can be taken to solve both the Patchwork Logistics and bullwhip effect problems in the supply chain:

Table 9. Supply chain patchwork logistics and bullwhip effect issues with blockchain technology

1. Blockchain-based tracking: Implement a blockchain-based tracking system that records real-time data at each stage of the supply chain. This can include data on inventory levels, production schedules, and shipping status. By using blockchain technology, all parties in the supply chain can have access to the same data, which can reduce the risk of miscommunication and delays.
2. Interoperability: Use blockchain technology to enable interoperability between different logistics systems used by different parties in the supply chain. This can be achieved by developing standardized data exchange protocols that enable different systems to exchange data with each other. By enabling interoperability, we can reduce the complexity of the supply chain and improve communication and collaboration between different parties.
3. Smart contracts: Use smart contracts to automate processes such as order fulfillment, payment settlement, and contract management. This can help reduce the time and resources needed to manage these processes manually and ensure that all parties involved are following the same rules. By automating these processes, we can reduce the risk of errors and delays, which can lead to a more efficient supply chain.
4. Real-time visibility: Provide real-time visibility of supply chain data to all parties involved, including suppliers, manufacturers, distributors, and retailers. This can help improve communication and collaboration, reducing the risk of miscommunication and delays. By providing real-time visibility, we can reduce the likelihood of over- or under-ordering, which can help mitigate the bullwhip effect.
5. Decentralization: Implement a decentralized blockchain network that allows all parties in the supply chain to have equal access to information. This can help reduce information asymmetry and improve decision-making. By having a decentralized network, we can reduce the risk of a single point of failure and ensure that all parties have access to the same information.

By following these steps can leverage blockchain technology to solve both Patchwork Logistics and bullwhip effect issues in the supply chain. Blockchain technology can enable more streamlined and automated tracking and sharing of data, helping to reduce the risk of delays and inefficiencies, while also mitigating the risk of the bullwhip effect by providing real-time visibility and enabling better communication and collaboration between parties.

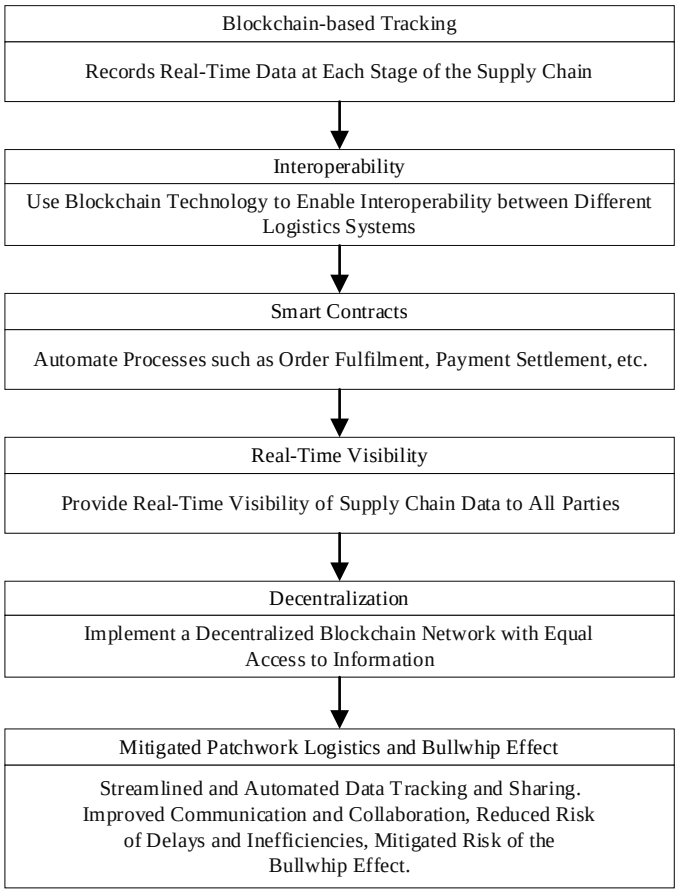

Fig.5. Solution flowchart of patchwork logistics and bullwhip effect

5. Discussion

The issue of supply chain management has become a growing concern for many organizations. However, we have proposed solutions that could revolutionize how supply chain management is handled. Our solutions are based on blockchain, a decentralized network that enables secure and transparent tracking of products throughout the supply chain.

Our solutions address several key issues facing supply chain management. It prevents fraudulent activities and reduces the risk of counterfeit products. Real-time monitoring of product movement ensures timely delivery and prevents supply chain disruptions. Our solutions provide a more sustainable alternative to traditional supply chain management systems by streamlining the supply chain process. It reduces the need for paper-based documentation and minimizes the environmental impact of organizations.

Here are some examples with relevant scenarios that can explain how the advancing features of our proposed method can be used to solve supply chain issues:

5.1. Increasing Traceability and Transparency

In the food industry, traceability is crucial to ensure that food products are safe for consumption to identify the key location. Knowing the source of ingredients, the conditions in which they were produced and transported, and the expiration date can help identify potential contamination issues and ensure food safety. To choose the blockchain platform, corda is a permissioned blockchain platform that is designed for inter-organizational business networks in this case. For creating network architecture, each node such as- food suppliers, manufacturers, distributors, retailers should have permissioned access to the blockchain network to ensure data privacy and integrity. A smart contract could automatically trigger a payment to a supplier once the goods have been delivered and verified. In the food industry, blockchain can be used to track the origin and journey of products, from farm to store. Our blockchain-based solution can be used to authenticate products and prevent counterfeiting. In the retailer sector, blockchain data can be used to optimize inventory management and supply chain efficiency.

5.2. Resolving Scalability and Reducing Cost

A manufacturer may struggle to keep up with demand during peak seasons or a distribution center may experience bottlenecks when handling a large volume of products. Corda and Hyperledger Fabric are both platforms that can handle complex supply chain workflows and are designed to be used by large enterprises. A smart contract that automatically

generates purchase orders when inventory levels reach a certain threshold. A tracking solution could be used to monitor the location of a product as it moves through the supply chain, alerting relevant parties if there are any delays or issues. AI and blockchain can be used to optimize its supply chain, forecasting demand and ensuring optimal inventory levels in real-time.

5.3. Improving Sustainability

If a company wants to improve the sustainability of its supply chain for a clothing line, they may need to monitor factors such as the amount of water used to produce the fabric, the energy used during production, and the carbon emissions produced during transportation and distribution. The company may establish metrics and standards based on industry best practices, such as the Sustainable Apparel Coalition's Higg Index. They could set targets for reducing water usage and carbon emissions and ensure that all suppliers meet these standards. The company could use blockchain technology to create a transparent and secure system for tracking sustainability-related data at every stage of the supply chain. They could set up a smart contract that automatically approves a supplier's invoice only if they can provide documentation showing that they meet the company's sustainability standards. They could use a third-party certification system to verify that a certain amount of carbon emissions has been offset by a supplier, and record this information on the blockchain for transparency and verification. The company could use analytics and AI tools to analyze the sustainability-related data collected.

5.4. Enhancing Efficiency

A manufacturer might need to track inventory levels to ensure they have enough raw materials to produce their products. They might also need to track production schedules to ensure they are meeting demand, and shipping status to ensure timely delivery. By identifying these essential data points, supply chain participants can prioritize their efforts and resources accordingly. Blockchain-based tracking system helps ensure food safety by quickly identifying the source of any contaminated products. A smart contract can automatically release payment to a supplier once the goods have been delivered and verified. This helps reduce the risk of fraud and can save time and resources for both parties. A supplier might be required to provide a digital identity to prove they are a legitimate supplier before being granted access to a manufacturer's supply chain data. A manufacturer might use analytics to identify bottlenecks in their production process and improve efficiency. AI can also be used to predict demand and optimize inventory levels.

5.5. Solving Patchwork Logistics and Bullwhip Effect

A food supply chain where a blockchain-based tracking system is used to record data on the origin, processing, and distribution of the food products. If the company can exchange data seamlessly through blockchain technology, the company can save time and resources, and improve customer satisfaction. The company can use a smart contract to automatically release payment to its suppliers once they have fulfilled their obligations. This can reduce the time and resources needed to manually manage payments and ensure that all parties are paid on time. By knowing exactly how much stock is available and when it will arrive, the retailer can avoid stockouts and reduce the risk of over-ordering. For this a retailer can use real-time data on inventory levels to optimize its ordering process. If the company uses a decentralized blockchain network, the risk of a single point of failure is reduced, and all parties can trust that the data is secure and accurate.

Overall, our proposed solution blockchain technology in supply chains can improve traceability and transparency, enhance efficiency, and reduce costs. Our solutions particularly appeal to organizations seeking ways to improve their supply chain operations while reducing their environmental impact. With our solutions, organizations can enjoy a more transparent, secure, efficient, and sustainable approach to supply chain management. Organizations can take a step towards sustainability by reducing their carbon footprint and minimizing their environmental impact.

6. Conclusions

Supply chains can encounter different problems that make it difficult for things like products, services, and information to move smoothly from suppliers to customers. These problems include not being able to track and trace the processes, inefficiencies that are hard to manage, a lack of clear information, and issues with storing, delivering, and producing goods. To overcome these obstacles, our model utilizes blockchain technology, which offers solutions to enhance transparency and efficiency.

By employing a decentralized system, all participants involved in the supply chain can record and verify transactions, ensuring that information remains unaltered and reliable. Blockchain technology eliminates the need for intermediaries, minimizing the risk of fraud and counterfeiting. Additionally, implementing smart contracts facilitates the automation and enforcement of contracts, streamlining supply chain processes and reducing delays. The adoption of blockchain as a solution to supply chain challenges encourages collaboration and fosters trust by providing an accurate history of each product's journey.

Our study showcases the potential of blockchain to address these supply chain issues comprehensively. As a solution, blockchain technology effectively resolves the lack of transparency, inefficiencies, errors, and fraud prevalent in the industry. Our proposed solutions, based on blockchain technology, improve efficiency, security, and trust by offering

real-time updates, data visibility, tracking capabilities, and transparency. Moreover, blockchain proves to be cost-effective for long-term projects, reducing expenses associated with intermediaries while automating processes. The immutable nature of blockchain ensures the authenticity and integrity of data, addressing trust concerns and mitigating the risk of fraud and counterfeiting.

However, implementing blockchain technology does pose challenges that necessitate customized solutions, stakeholder coordination, and the interoperability and standardization of different blockchain systems. These complexities must be taken into account when considering the adoption of blockchain in supply chains.

A limitation of our research lies in the lack of practical implementation due to time and resource constraints. While our study provides potential solutions for supply chain issues using blockchain technology and offers valuable insights for future research, practical application is essential to fully evaluate the effectiveness of the proposed solutions. Further research emphasizing practical implementation is necessary to validate our findings and ensure their relevance in real-world scenarios.

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