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Blockchain & IOT Applications in Supply Chains, Transparency & Traceability: A Systematic Review of the Literature

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Abstract

The purpose of this paper is to review the existing literature on blockchain technology, present some trends and consider its potential value in different sectors of supply chain management (SCM) using Internet of Things (IoT) for traceability and transparency. The blockchain technology is rapidly making inroads in many industries and there is tremendous potential to eliminate intermediaries and to make SCM more efficient. This paper highlights the imperative role of blockchain technology that has created a discourse in the world of innovation and technology. This work will help academics to further the understanding of blockchain technology. The added role of RFID and IoT in the supply chain along with blockchain is discussed here. The digital transformation of supply chains should revolutionize entire management processes and improve various aspects of sustainability. In particular, the plans of Industry 4.0 aim towards a digitization of several procedures by exploiting emerging technologies such as the Internet of Things, RFID and blockchain.

Keywords
Blockchain; Supply Chain; Ethereum; traceability and IoT.

1. Introduction
Supply chains have become complex networks, and supply chain management systems face various challenges such as lack of visibility between the upstream and downstream parties, lack of flexibility in response to sudden changes in demand, difficulty in controlling operating costs, and insufficient management of supply chain risks. To address these challenges, researchers are exploring the use of blockchain and the Internet of Things (IoT) in supply chain management. This paper reviews the use of blockchain-based IoT technology in supply chain management, including the types of smart devices used and their suitability in the supply chain. It also identifies future research directions and current challenges in the field of IoT supply chain management. The review is based on a systematic literature review of research articles published between 2016 and 2020.

Malicious operators can seriously threaten the security and privacy of supply chains through various malicious exploitations (Su et al. 2018; Saxena et al. 2017; Paul et al. 2017), such as privacy leakage, falsification, node impersonation, and fraudulent money transactions. To provide a secure supply chain for any sector, many innovative mechanisms have been proposed (Wang et al. 2016; Wu et al. 2018), such as trust mechanisms and monetary approaches. However, trust mechanisms are not sustainable and can be susceptible to Sybil attacks and whitewashing attacks, while monetary approaches rely on trusted centers that may not only leak users' privacy for profit but also may be vulnerable to attacks. In this context, blockchain (Novo et al. 2018) offers a unique platform for secure money transactions within a distributed network without trusted agents, using an immutable ledger, cryptocurrency, and the execution of smart contracts.

1.1 Blockchain Technology
Blockchain technology has garnered interest from researchers for its potential use in various management systems due to its decentralized, distributed, and open ledger structure. In a blockchain network, each node holds a copy of the ledger, and the system operates as a peer-to-peer network without the need for third-party intermediaries (Ahmed et al. 2021). The integrity of the blockchain is maintained through strong cryptography and hash functions, which

validate and link together blocks of transactions, making it almost impossible to tamper with a block or individual transaction without detection (Esposito et al. 2018).

1.2 Supply chain management and blockchains

The adoption of blockchain technology in supply chain management (SCM) has the potential to bring about disruptive changes in various industries, leading to the reconfiguration of traditional relationship models due to the disintermediation of transactions. As an example, Figure 2 illustrates the use of a smart contract in a trade between a producer (A) and a supermarket (B). After the terms of the trade have been fulfilled by both parties, a contract is written, coded, and stored in a blockchain structure. The contract is triggered when it meets the negotiated conditions, at which point the money and goods are transferred according to the contract, without the need for an intermediary. This process not only speeds up the transaction but also reduces costs and improves trust, as all participants in the network have a copy of the ledger.

In SCM, it is important to coordinate various parties, processes, and resources, and the permissioned nature of blockchain provides security, authenticity, and ownership to save time. (Malik et al 2019) The Internet of Things (IoT) refers to a network of interconnected devices that share data, such as for automation or monitoring, either privately or publicly. The IoT can assist in detecting malware and DDoS attacks in the network. (Awan et al 2021)

1.3 IoT And Blockchain

The integration of IoT and blockchain technology creates an environment for secure, efficient transactions with lower costs and reusable elements. Security is a key concern for any industrial application, and machine learning approaches have been used in the medical field to diagnose various diseases.(Uddin et. al 2021).These approaches can also be applied for continuous monitoring and alarms for temperature and moisture in supply chain management, particularly for pharmaceuticals and food, by incorporating enterprise resource planning and supply chain solutions. Machine learning and blockchain are used to address security attacks in industrial IoT(Vargas et. al).Machine learning techniques have been effectively utilized in the medical field to identify a variety of illnesses. (Ali et al 2019; Awan et al 2021;Javed et al 2021; Nabeel et al2021;Gupta et al; Nagi et al 2021).Blockchain-based IoT offers several benefits for the supply chain, including improved information flow and traceability, increased information accessibility, the ability to link information flow with material flow, and reduced risks of rule violations and fraud.(Frikha et al 2021; Kouhizadeh et al 2020;) The goal of this paper is to identify current technical research topics, intelligent devices, and future research directions in the use of blockchain-based IoT for supply chain management systems. To the best of our knowledge, there has not been a similar study focused on the use of blockchain IoT in the supply chain.

In section 2 of this paper, we talked about our objectives and driving forces. Then, in section 3, we covered recent research and the conclusions we had drawn from it. We went over our research methods, findings, and conclusions in section 4. In section 5, we went over our research on the use of blockchain in various supply chain industries, as well as our most recent discoveries, the use of IoT in blockchain-based supply chains, and the general enhancement of supply chain traceability and transparency. We covered our conclusion and next focus in section 6.

2. Objectives

Despite the potential of blockchain technology to bring about significant changes in various types of supply chains and new operation models, there is a lack of research in the field of supply chain management (SCM) on the application and impact of blockchains. To address this gap, a systematic literature review (SLR) was conducted to answer the following research questions, (Denyer and Tranfield 2009; Tranfield et al. 2003). The aim of this study is to provide insight into the integration of blockchain and SCM for practitioners and decision makers, as well as to highlight the current journals at the forefront of this topic. It also aims to identify gaps in the literature and provide a research agenda for scholars and practitioners interested in advancing the integration of blockchain and SCM. This is the first investigation to analyze the literature on blockchain and SCM integration from 2019 onwards and it reveals important areas that need further investigation, including managerial implications and a robust research agenda. The results of this study can be useful for scholars and practitioners interested in understanding the current state of blockchain and SCM integration and identifying future research directions.

Table 1. Research Query

SL	Research Query	Motivation
1	What research topics have been addressed in IoT-based Blockchain techniques concerning Supply Chain Management?	To identify which topics are discussed in previous research papers.
2	How effective is the use of Blockchain-based IoT devices in SCM?	To investigate which devices were used in the last documents.
3	Which Blockchain-based IoT device is the most appropriate in SCM?	To recognize the device's importance relative to time.
4	What are the future research directions in Blockchain using IoT in SCM utilizing transparency and traceability?	To identify current issues and challenges for future research directions.

3. Literature Review

Recent studies have investigated the application of blockchain technology in supply chain management, with a particular focus on transparency and traceability. A bibliometric and network analysis by (Weng Chun Tan et al. 2021). found that research on blockchain management is conducted among various research platforms and countries. In a study by (M. Hussain et al. 2021), the authors examine the use of blockchain-enabled IoT devices in supply chain management.

Similarly, (D. M. Vistro and M Faooq 2021) explored the challenges and opportunities presented by blockchain in the food supply chain management. Another study by Sohail Jabbar (2021) conducted an analysis of blockchain-based supply chain management. Justin Sunny Et.al (2020) argues that firms are increasingly incorporating blockchain into their supply chain activities to improve transparency through tracking and tracing events.

The impact of the SARS-CoV-2 pandemic on supply chain failures and how blockchain technology can address these issues is also examined by (A. S. Sangeetha 2020). P. Wan (2020) highlights the potential of blockchain-enabled information sharing in enhancing collaborative work across different types of supply chains. Other studies, such as those (by A. S. Sangeetha 2020) and (S. Madumidha 2019) discuss the opportunities and challenges presented by blockchain technology in the context of open manufacturing and the Industrial Internet of Things (IIoT).

(Y. Tsang 2019) proposes a blockchain-driven IoT solution for food traceability, while (A. Alahmadi 2019) investigates the use of blockchain-based smart contracts for secure and fair IIoT-enabled supply chain management. (S. J. Divey 2019) argues that the supply chain and logistics industry are considered to be the next promising use case for blockchain technology. (Sidra Malik et al 2019) introduced TrustChain, a consortium blockchain to track interactions among supply chain participants and to dynamically assign trust and reputation scores based on these interactions. (Francesco Longo 2019) conducted an experimental study on blockchain-enabled supply chains.A summary of the studies conducted on blockchain-based supply chain management with IoT from 2019 onwards is presented in Table2. The table includes the authors, publication year, outcomes measured, and key finding of each study.

Table 2. A list of Papers containing Blockchain and IoT applications in supply chain from 2019 onwards

Year	**Published Channel**	**Author**	**Intervention**	**Outcomes Measured**
2021	Journal	Weng Chun Tan Et.al	A bibliometric and network analysis conducted on	Identify the influential studies, leading research groups, institutions, and countries.

			Blockchain in supply chain management.	
2021	Journal	M. Hussain et al	A Systematic Literature Review on Blockchain-Based IoT Devices in Supply Chain Management	
2021	Conference	D. M. Vistro, M. Farooq	A Review on Applications and Challenges of Blockchain with IoT in Food Supply Chain Management System	Complete comprehension of blockchain and its possible effects, which won't just can be a valuable control for new specialist in important field
2021	Journal	Sohail Jabbar	Blockchain-enabled supply chain: analysis, challenges, and future directions	• Technical and non technical challenges in the adoption of Blockchain for supply chain applications • The suitability of various consensus algorithms for applications in the supply chain • Tools and technologies in the Blockchain ecosystem • Some key areas as future research directions
2020	Journal	Justin Sunny Et.al	Firms have started incorporating blockchain into their supply chain activities to improve the transparency through tracking and tracing the events	Insight on the capabilities of blockchain-based traceability solutions by reviewing the currently available literature
2020	Conference	A. S. Sangeetha	The SARS-CoV-2 exposed supply chain failures can be tackled by blockchain technology.	Blockchain will increase supply chains' productivity and accountability, and have a positive effect on anything from warehousing to distribution to payment
2020	Journal	P. Wan	The deployment of blockchain-enabled information sharing within a supply chain can add value to enhance collaborative work in different types of supply chains.	Blockchain enabled information sharing can add value to enhance collaborative work in different types of supply chains such as health and medical, construction and smart city
2020	Journal	Jinying Li	Challenges and opportunities in context of open manufacturing and industrial internet of things	
2020	Journal	V. G. Venkatesh	System architecture for blockchain based	Developed a system architecture for monitoring

			transparency of supply chain social sustainability	social sustainability compliances issues, the research has several limitations
2020	Journal	Jacopo Grecuccio	Combining Blockchain and IoT: Food-Chain Traceability and Beyond	Designed and developed a software framework that allows Internet of Things (IoT) devices to interact directly with an Ethereum based blockchain
2020	Conference	Shubham Sahai	Enabling Privacy and Traceability in Supply Chains using Blockchain and Zero Knowledge Proofs	A blockchain based model for the supply chain that provides privacy and traceability with efficient contamination tracing is the intervention.
2019	Conference	S. Madumidha	In Food Supply Chain System using Blockchain Technology with Internet of Things	
2019	Journal	Y. Tsang	Blockchain-Driven IoT for Food Traceability With an Integrated Consensus Mechanism	A proposed system for a blockchain IoT based food traceability system
2019	Conference	A. Alahmadi	Towards Secure and Fair IIoT-Enabled Supply Chain Management via Blockchain-Based Smart Contracts	A blockchain based supply chain management system in the IIoT
2019	Conference	S. J. Divey	The supply chain and logistics industry are considered to be the next promising use case for this fast-evolving technology.	
2019	Conference	Sidra Malik	Trust Management in Blockchain and IoT Supported Supply Chain	TrustChain design uses a consortium blockchain to track interactions among supply chain participants and to dynamically assign trust and reputation scores based on these interactions
2019	Journal	Francesco Longo	An experimental study on Blockchain-enabled supply chain	• Potential of deploying the blockchain in a supply chain • the supply chain overall performance • the negative consequences of information asymmetry over the echelons of a supply chain

4. Methods

In conducting our research on the application of blockchain technology in supply chain management systems, we followed a systematic literature review (SLR) methodology. To begin, we searched for relevant literature in various databases such as Scopus, ScienceDirect, EmeraldInsight, WileyOnlineLibrary, and other sources, using key terms such as blockchain, supply chain, IoT, and so on. We limited our search to recent publications from 2018 to 2022. After conducting an initial screening of the titles and abstracts, we selected a total of 45 papers for further analysis. These papers were chosen based on their relevance to our research topic and were read in full. Finally, after a thorough examination of the literature, we made our final selections and conclusions.

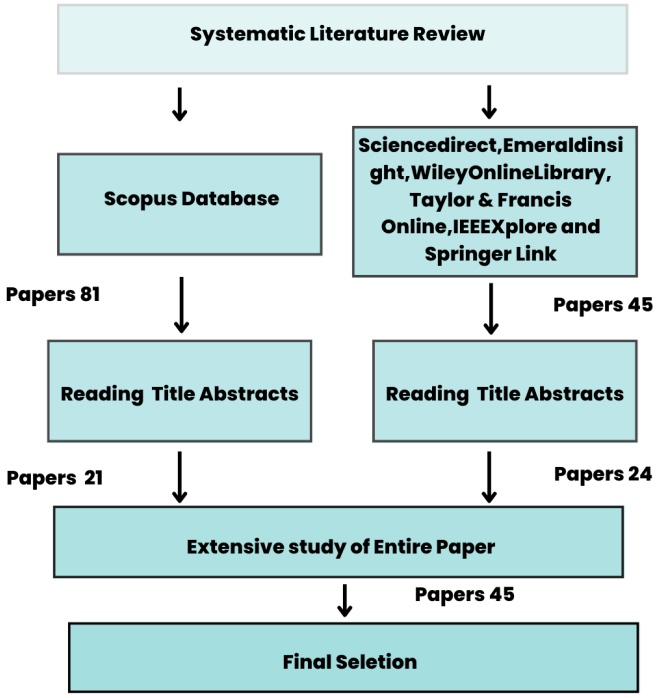

Figure 1. Schematic representation of the systematic review process

4.1 Data Collection

After initial screening of the abstracts and titles, we narrowed down the selection to a total of 45 papers that were deemed most relevant to our research objectives. These papers were then thoroughly examined in full, with the final selection being based on the relevance and pertinence to our research.

As a result of our literature review, we were able to observe the trend of research in this field and to identify key journals and conference proceedings that are at the forefront of this rapidly evolving area of study. We have presented these findings in the form of a chart, as shown in Figure 2.

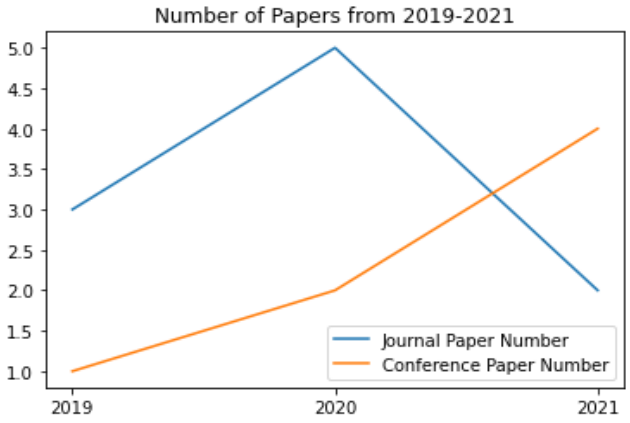

Figure 2. Trend in research of blockchain based supply chain .

5. Results and Discussion

Numerous supply chains have already adopted blockchain to enable traceability and hence foster transparency. In this section, we go over our research on various supply chain segments and how blockchain technology might be applied there. The goal of blockchain traceability in various contexts, its advantages and disadvantages, and the technique used to design the solution are all examined in each use case. Additionally, the distribution network designs of the supply chain scenarios taken into consideration for blockchain traceability solutions are examined.

5.1.1 Food/Agricultural supply chain

The use of blockchain traceability technologies in food and agricultural supply chains is generally accepted. A unique paradigm for the traceability of soybean was recently presented by Salah, Nizamuddin, Jayaraman, and Omar (2019). On Ethereum's open blockchain, a prototype of the framework was created. The framework intends to increase openness along a supply chain that includes a farmer, seed firm, grain elevator, processor, distributor, retailer, and consumer. Tracking and tracing of soybean is made possible with the deployment of the suggested framework, and any quality faults may be quickly fixed by determining the product's source.The architecture includes standardized identifiers like the Global Trade Identification Numbers (GTIN) and the InterPlanetary File System (IPFS). Although merchants buy products in batches, using standard identifiers makes it easier for supply chain actors to track products and transaction-related operations. To add the information right away, participants in the soybean supply chain must communicate with a smart contract that has been set up on the blockchain.

AgriBlockIoT is tested for viability utilizing the "farm to fork " use case, which is implemented using the Ethereum and Hyperledger blockchains. The AgriBlockIoT architecture is designed for a supply chain scenario with six participants: a provider, a producer, a processor, a distributor, a retailer, and a consumer. These participants are required to abide by the requirements and other laws given by the government.

The reach of blockchain technology in smart agriculture is revealed in this work. The palm oil business has come under fire for deforestation, CO2 emissions, and breaches of human rights; as a result, environmental and social sustainability are essential components of palm oil supply chains. Hirbli (2018) suggested a decentralized traceability solution to address this problem by fusing blockchain technology with a strategy known as Roundtable Sustainable Palm Oil (RSPO). Customers are primarily given confidence by RSPO that the production of palm oil is sustainable in terms of quality criteria. Companies must adhere to the RSPO's or comparable guidelines in order to produce certified sustainable palm oil. The proposed traceability system is able to keep track of mass-produced palm oil products throughout their entire path, from the plantation to the customer's doorstep. This study takes into account a conventional supply chain that starts with farmers, moves through manufacturers, oil mill owners, merchants, and ends with consumers.

Additionally, Intel showed how Hyperledger Sawtooth (Hyperledger, 2018), a platform for building and administering blockchains, may make the seafood supply chain's traceability easier in April 2017. Sensory tools were utilized in the study to capture data on the location of the fish and the storage conditions.

Furthermore, certain firms, such as Provenance, Arc-Net, Bart. Digital, and Bext360, empower small farmers by providing solutions that improve product traceability. For instance, the Soil Association Certification recently partnered with Provenance to test a technology that follows the path of organic food (Soil Association Certification, 2018). technology by using it as a credit evaluation system to improve oversight and management efficiency. Additionally, it can be used to strengthen the oversight of international accords pertaining to agriculture, such as those of the World Trade Organization and the Paris Climate Agreement (Tripoli and Schmidhuber 2018).

Finally, blockchain can contribute to increasing awareness of the environmental aspects of food production. The destruction of the land, soil, and water used to produce food is a major issue here. The achievement of the Sustainable Development Goals (SDG) of the United Nations, in particular, depends on the quality of the soil (Keesstra et al. 2016). In this setting, it is crucial to prioritize the sustainable development, good management, and wise use of agricultural fields, water resources, and soils (Keesstra et al., 2018). Making this information transparent to the public and following it through the supply chain is crucial for increasing public pressure on producers and policymakers to produce food in a sustainable manner.

5.1.2 Pharmaceutical supply chain

The proposed architecture by Shimaa Ouf (2021) integrates IoT, blockchain, and semantic web to support pharmaceutical companies in enhancing patient satisfaction, building trust through transparency, preventing drug counterfeiting, and improving supply chains in transit and storage. It also facilitates sharing and reusing knowledge about the pharmaceutical supply chain with other systems. By boosting medication flow transparency and visibility and improving the representation of the growing volumes of data produced by pharmaceutical supply chain transactions, this technology enhances the security of the pharmaceutical supply chain.

PharmaChain is a blockchain-based method for traceability presented by V. Bali et al. in 2021. With the help of the proposed algorithms and application architecture, traceability is made possible. Hyperledger Fabric running on Dockers can be used to create the proposed application. Javascript is used to write the chain codes. The manufacturer, wholesaler, retailer, and customer are the components of the pharmaceutical blockchain proposed in this paper. Only manufacturers have the ability to register a drug onto the blockchain, where the ownership transfer of the drug is maintained.

For effective product traceability in the healthcare supply chain, Ahmad Musamih et al. (2021) describe an Ethereum blockchain-based strategy utilizing smart contracts and decentralized off-chain storage. The smart contract ensures data provenance, does away with the need for middlemen, and gives all stakeholders access to a safe, immutable history of transactions..

Ahmad et al (2020) In this work, we examine the innovative IoT and Blockchain-based pharmaceutical governance. Blockchain technology based on the Internet of Things (IoT) is a sort of distributed ledger (DLT) that keeps an immutable record of all transaction data that cannot be altered and is available to all participants. By implementing an IoT-based blockchain system, the pharmaceutical industry would have the resources necessary to enhance drug governance throughout the supply chain, improving the effectiveness and dependability of healthcare.

In a pharmaceutical supply chain with a single sender, single receiver, and an IoT-based container as players, Hasan et. al (2019) showed an Ethereum-based traceability solution. The Raspberry Pi 3 will be used to process the data collected by the IoT-based container, which may record information about parameters like temperature, pressure, vibrations, location, humidity, etc. When a contract provision is broken, the processing unit will call a smart contract function, and the associated information will be broadcast to the entire blockchain network. This function allows for the tracking of a pharmaceutical product's transportation status. A vaccination supply chain was created to evaluate the intended system's viability.

5.1.3 Courier Express Parcel (CEP) supply chain

Supply chains for Courier Express Parcel (CEP) provide tremendous potential for blockchain. Helo and Hao (2019) reported on the potential applications of blockchain in operations and supply chains and presented the Blockchain-

based Logistics Monitoring System, a cutting-edge system for tracking packages (BLMS). Customers, logisticians, and all other players may track and trace their parcel packages within the ecosystem thanks to the system's capability. The built method will be used and tested on the Ethereum blockchain network. The CEP sector can further use blockchain for managing customer returns as an addition to the framework shown here. However, there are no blockchain frameworks for reverse supply chains in the literature.

5.1.4 Luxury supply chain

Luxury supply chains can use solutions for traceability based on blockchain. The advantages of exchanging jewelry products using Blockchain Technology Supported (BTS) platforms like Everledger were discussed by Choi (2019). Using BTS platforms for certification and authorization of premium goods like diamonds is advantageous for both producers and consumers. Salespeople in retail settings must spend a lot of time explaining the specifics of products to customers. Once more, the clients will be given largely paper-based, easily manipulable proof of purity. All of these problems can be resolved through retail exchange of expensive jewelry through BTS. The information about jewelry goods that is added to the blockchain will always be unchangeable. End users of premium supply chains are going to be very worried about the genuineness and purity of the products.

5.1.5 Consumer electronics supply chain

Jian et al (2021) This work investigates a dual storage block chain model of data on-chain and off-chain based on the hyperledger fabric in order to address the issues of huge quantity of data storage and low query efficiency in home appliance supply chain traceability system. When the total amount of traceable data reaches 100000, the model is put up against the conventional model, and the results show that the model's query efficiency has increased by at least 42.36%. This fixes the issue of the traditional model's poor efficiency with data queries and can guarantee the traceability reliability of supply chain data for manufacturers of home appliances.

5.1.6 Manufacturing supply chain

A blockchain-based architecture for Internet of Things applications is presented by Kamalendu Pal and Ansar-Ul-Haque Yasar (2020), bringing distributed data management to facilitate transactions services within a multi-party garment company supply chain network.

Westerkamp et.al (2019) introduced a blockchain-based method for tracking produced goods and their components/ingredients for the first time. The system was able to detect and trace different input materials that were primarily needed for producing a product, as well as how they changed throughout the production process. The main players in the system as it is constructed are suppliers, producers, logistical service providers, certifiers, and customers. The concept of a token receipt is used in the system to maintain the link between a product and its component. The idea was prototyped and put into practice using smart contracts on the Ethereum network.

Through peer-to-peer replication, the blockchain architecture enables users to share a ledger that is updated each time a block of transactions is decided to be committed. In this manner, the blockchain technology can save operating costs and friction, produce immutable transformation records, and enable transparent ledgers with almost instantaneous updates. Additionally, it may drastically alter how business processes and workflow are created within an organization, creating new possibilities for innovation and expansion.

Using the neutrosophic analytic hierarchy process, Amin Vafadarnikjoo et al. (2021) examined the obstacles to blockchain technology adoption in manufacturing supply chains (N-AHP). For the validation of blockchain technology in a developing economy, they provided a structure for an action plan. The results show that "transaction-level uncertainties" are the biggest obstacle and account for the majority of the final ranking, followed by "use in the underground economy," "managerial commitment," "challenges in scalability," and "privacy threats." This article can help industrial managers and experts in developing nations more precisely pinpoint impediments to blockchain adoption and demonstrate how to properly integrate blockchain technology into supply chains.

5.1.7 Automobile supply chain

PartChain, a decentralized application for the automotive industry, was proposed by Miehle Et. al (2019) to secure the traceability of automobile parts that are produced in diverse areas of the world and distributed over worldwide supply chains. The main players in this supply chain are Original Equipment Manufacturers (OEM), suppliers, and logistic service providers. Although the installation will require a lot of work, this application will make it possible to identify

the problematic components and avert negative outcomes without having to call back the entire batch of already-sold-out automobiles. The use of this application can help get rid of fake components. The supply chain's business logics were integrated with smart contracts. Despite the fact that PartChain is suggested for automotive supply chains, the same remedy can be used for any product made with large number of parts and its supply chains.

5.1.8 Textile supply chain

An exploratory study was conducted by Giulio Caldarelli et al. in 2021 on a well-known fashion company that is based in the Veneto region (Italy). The (CAQDAS) program AQUAD is used to code the data that was taken from interviews and focus groups. The result is then arranged in accordance with an altered TOE perspective. The results of this exploratory study are consistent with the notion that the blockchain solution could be a useful addition to sustainable supply chains.

An industry-specific blockchain-based traceability system was unveiled by Agrawal et. al (2018). The proposed approach takes into account a use case in the textile sector with cotton producer, manufacturer, wholesaler, distributor, customer, registrar, and auditor as the participating entities. This work's blockchain traceability idea can significantly increase visibility because buyers, sellers, and auditors can track a product's history. Such a traceability method can boost clients' trust in purchasing textile items.

5.1.9 Wood supply chain

The nation of origin is the largest predictor of buyer trust, followed by the price level for the timber product, the existence of a certification scheme, and the length of the connection with the supplier, according to research by E.F. Morten Komdeur and Paul T. M. Ingenbleek (2021). Blockchain technology also significantly impacted consumer trust and has the potential to play a big role in fostering trust in forestry products during international trade.

Figorilli et al. (2018) proposed a blockchain-based information-sharing system that uses RFID technology to track the movement of valuable wood along the whole supply chain and to trace it back to assure its quality and authenticity. The simulation followed the path of the timber through the supply chain until it arrived at the customer's side in the form of finished goods. The simulated scenario also includes a prototype implementation of the suggested blockchain architecture. The implementation was carried out using Microsoft Azure Blockchain Workbench.

5.1.10 Dangerous goods supply chain

Supply networks for hazardous materials, such as explosives, need to be managed very securely. Transporting dangerous goods requires careful planning. Imeri and Khadraoui (2018) developed a ground-breaking blockchain-based technique to track and trace dangerous goods while they are in transit. This makes it possible for all parties engaged in the supply chain for dangerous goods to get the necessary information. The hazardous material manufacturer creates the smart contract with all the necessary details about the things that must be transported. This information will be accessible to the regulatory bodies as well as other peers or network members.In the event of an emergency, authorities can act immediately and swiftly pinpoint the causes by looking at what happened in the past. By looking at the past of what occurred, authorities can immediately respond to an incident and pinpoint the causes. In this method, the supply chain for dangerous commodities is made transparent through the use of blockchain technology, which helps manage unsafe situations. Similar concepts can be used to experiment with the weapon supply chain. The military can utilize these techniques to continuously monitor the availability of weapons in various locations.

5.2.1 Blockchain and Iot: Supply Chain Management

The severity of supply chain inefficiencies is rising, which is impeding the development of the industry as a whole and all related economic sectors like distribution, manufacturing, and logistics. For the next generation of IoT devices, the blockchain can offer an automated and secure transaction architecture. Blockchain is a part of the technology portfolios of many startups. The SARS-CoV-2 epidemic has placed a lot of attention on supply chains, which must quickly adapt to demand side shocks (J. E. Hobbs 2020). Customers are afraid to purchase food from the supermarkets, and food purchasing habits have drastically changed. Food supply chains that are managed by a small number of highly concentrated major processors, such as those that pack meat, seafood, dairy products, etc., may be particularly vulnerable.Potential supply-side interruptions include things like: migration to one's hometown, self-quarantine, labor shortages caused by illness, etc..

Transportation and distribution of food supply chains are vulnerable. The World Economic Forum (WEF) said that "blockchain technology can tackle supply chain failures exposed by SARS-CoV-2 and can boost economic recovery". Distributed Ledger Technology or Blockchain Technology is ideal for handling different stakeholders, inter-organizational and cross-border transportations. Contingency plans must be devised with the help of IoT devices and blockchain to continue the businesses during a pandemic situation. Every buyer must be aware of the product's origin, quality, and date of original manufacture. Together with IBM, Wal-Mart is developing a fully transparent digital food system for the twenty-first century. With the development of technologies like Distributed Ledger Technology and the Internet of Things, consumers can now easily verify the informational accuracy of the goods they purchase.

5.2.2 Benefits of Blockchain and IoT Integration

By figuring out the ideal distribution method and cutting down on the time it takes to transport perishable goods, blockchain technology has helped Wal-Mart lessen the problem of food contamination. Food Wal-Mart uses Hyperledger blockchain technology to trace the source of mangoes in the United States in 2.2 seconds (D. Datta Et.al 2020). In the past, it took 7 days to determine the mangoes' provenance. The benefits of utilizing blockchain and IoT together in supply chains are

- Increase administrative efficiency by getting rid of middlemen and intermediaries
- When it comes to the distribution of goods, efficient routing based on real-time traffic data is highly helpful.

The following are the drawbacks of IoT-enabled SCM:

- costly and time-consuming bank fees for the Letter of Credit procedure.
- There is a sizable delay in the processing of insurance claims in the event of product damage.
- It is necessary to rely on the brokers in Customs for accurate documentation.
- The Letter of Credit procedure is automated through real-time tracking and smart contracts.
- In the event of product damage during transit, an immediate insurance claim settlement is offered.
- It is not necessary to rely on brokers in Customs to ensure that the documentation is accurate.

5.3 Traceability/Transparency

Traceability refers to the ability to track products and obtain information about them, such as their origin, components, and movements, during production and distribution. There is increasing interest in traceability and visibility in the supply chain due to customer demand for greater transparency and knowledge of product origins from manufacturers and retailers. This gap in traceability in the supply chain, particularly in relation to ethical, sanction-compliant, and safe production, is a significant economic and social challenge. Traceability involves following products throughout their entire life cycle, from the procurement of raw materials to production, distribution, and consumption, which can be difficult due to the complexity of supply chains and product flows across extended networks. One example of traceability architecture in the supply chain is Origin Chain, which uses private blockchains distributed geographically to traceability service providers to create a reliable traceability platform involving other organizations, such as government-certified laboratories, large suppliers, and retailers with strong connections to the company. Origin Chain stores two types of data on the blockchain as variables in smart contracts: the hash of traceability certificates and the necessary traceability information required by regulations. This platform has better performance and lower costs compared to a public blockchain.

Transparency

Transparency refers to the ease with which information is accessible to both parties involved in an exchange and external observers. It is an important factor in evaluating the performance of the supply chain, especially in the secure environment provided by blockchain. In a supply chain, products pass through a vast network involving various actors, such as extractors, producers, retailers, distributors, conveyors, and storage facilities. Blockchain technology has the potential to increase transparency in the system, leading to fewer failures, and can improve productivity, customer service, and cost-effectiveness by enhancing the transparency of the supply chain. However, improvements to the current system may be necessary in order to increase network speed and processing times. In competitive, complex, and dispersed markets, many companies are adopting these practices and emerging technologies to increase transparency in both forward and reverse supply chain processes.

6. Conclusion

By evaluating the currently available literature, this study primarily offers an insight into the capabilities of blockchain-based traceability systems. Through tracking and tracing, the use of blockchain-based traceability systems

can improve supply chain transparency. In practically all supply chains, blockchain-oriented traceability solutions are becoming more and more popular, according to a review of the articles reported in the literature. According to the literature analyzed for this paper, the bulk of these applications now exist in the supply chains for food and medications. Blockchain applications are being significantly improved by the integration of IoT and smart contracts. Surprisingly, blockchain cannot replace all current technology.

New traceability applications can only be developed with more study as blockchain technology matures. The results of this study must be seen in the context of two restrictions. The selection of the literature was not wholly systematic, to start.

In conclusion, we have conducted an extensive literature review to understand the recent advancements in blockchain-based supply chain management. From our analysis, we found that various sectors are exploring the potential of blockchain technology to improve transparency and traceability in their supply chains. However, many challenges remain in implementing this technology, particularly in the complexity of integrating it into existing systems. Additionally, we found that researchers are increasingly looking to IoT devices as a way to overcome these challenges and improve the efficiency of supply chain management. Despite the current limitations, it is clear that blockchain has the potential to revolutionize supply chain management in the future, and more research is needed to fully realize its potential. As we move towards an increasingly digitalized and connected world, blockchain technology has the potential to play a crucial role in the advancement of industrial 5.0.

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