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Blockchain Technology in Supply Chain Management

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Abstract:. *Blockchain is a record of transaction data that relies on a shared ledger. This ledger is inherently tamper-evident and provides a trusted shared and reliable way to record, validate, and view transactions across a complex system with many participants, some of whom may not inherently trust each other. Blockchain is a special type of database management system that has more features than a regular database*

Keywords: Blockchain

I. INTRODUCTION

Blockchain is a record of transaction data that relies on a shared ledger. This ledger is inherently tamper-evident and provides a trusted shared and reliable way to record, validate, and view transactions across a complex system with many participants, some of whom may not inherently trust each other. Blockchain is a special type of database management system that has more features than a regular database. We describe some significant differences between a traditional database and a blockchain in the following list: Blockchains decentralize control without damaging trust in the existing data.

Definition Of block Chain :- It is known to be a string of encrypted data blocks where the blocks have the information that is the data, and the information is locked so that whoever has the key can access the information [6]. The chain contains many files linked with one another and each of the files includes information such as a timestamp that speaks about when the data is created and the historical information about the blocks in the blockchain [7]. All the blocks together are known as the blockch

Blockchain Use Cases in Supply Chain Management.

Enterprise blockchain technology can transform the supply chain with these three use cases:

Traceability

Transparency .

Tradeability

Traceability improves operational efficiency by mapping and visualizing enterprise supply chains. A c/owing number of consumers demand sourciig information about the products they buy. Blockchain helps organizations understand their supply chain and engage consumers with real, verifiable, and immutable data.

Transparency builds trust by captunng key data points, such as certifications and claims, and then provides cpen access to this data publicly. Once registered on the Ethereum blockchain, it's authenticity can be verified by third-party attestors. The information can be updated and validated h real-time.

Tradeability is a unique blockchain offering that redefines the conventional marketplace concept. Using blockchain, one may "tokenize" an asset by splitting an object into shares that digitally represent ownership. Smilar to how a stock exchange allows trading of a company's shares, this fractional cv/nership allows tckens to represent the value of a shareholder's stake of a given cbject. These tokens are tradeaUe. and users can transfer ownership without the physical asset changing hands.

- The blockchain technology enhance product traceability:

Global supply chains support everything from consumer packaged goods to product recalls. Sometimes consumer products or raw hgredients need to be recalled to prevent hjuryor llness. Between bst sales, replacement costs, and lawsuits; recalls on consumer products negatively in pact millions of individuals around the world. Blockchain technology can enhance product traceability by reducing counterfeiting and by streamlinng product recall

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- How does blockchain technology improve supply chain transparency?

Blockchain technology enhances supply chain management through process tracking, regulatory compliance, reporting.
How does blockchain enhancing supply chain transparency and process tracking?
Supply chain traceability is one of the top use cases for blockchain technology Replacing the traditional processes with distributed ledger technology could hcrease trade volume by 15% and US GDP by up to 5%. Blockchain provides the abiity to track any digital or physical product throughout its lifecycle. Distrbuted ledger technology has the potential to expand the sustainable and ethical production and consumption of any commodity on a global scale.
Almost every industry uses third-party manufacturers a various products from multiple vendors before creating and labeling the final finished goods. In some cases, white-label products are sold before behg repackaged and relabeled under another brand. Transparency in process tracking gives producers a bird-eye view into their value chain, allowing them to guarantee the proper handoff of third-party goods and final product labeling. Blockchah can track the progression of assets, record the information and show previous asset records. Smart contracts are used to enforce the asset tracking processes on the Ethereum blockchain. Anyone can view tfie provenance and journey of an asset in real-time, whether the asset is physical or digital.
•How does blockchain technology bring tradeability to the supply chain?
Blockchain technology enables efficient ownership and licensing. Verifying past ownership through standardized icensing procedures is vital for numerous industries. Additionally, blockchain can be utilized to accurately license services, products, and software through the use of automated smart contract payments.
Blockchain provides consensus, which means there is no dispute in the chain regarding transactions by design. All entities on the chain have the same version of the ledger, giving it the unique potential to track ownership records for real estate, automobiles, and digital assets.
Blockchain can be used as a tool to track waste, emissions, and environmental impact at each stage of the supply chain. Improved supply chain visibility can reveal new opportunities for waste and energy reduction.

Objective :-

When It comes to supply chain management, the blockchain can be a cutting-edge way to streamline ail the moving parts, while also coordinating with multiple points of contact. The benefits of blockchain for supply chain management include improvements to security, visibility, accessibility, as well as transparency
A blockchain consists of a set of protected information blocks chained sequentially to one-another. Together they form an immutable ledger, distributed over the participating nodes. These nodes are computing platforms that interact with the end users. The purpose of the blockchain is to share information amongst all parties that access it via an application. Access to this ledger in terms of reading and writing may be unrestricted ('permissionless'), or restricted ('permissioned'). The shared information is protected against modification, meaning that any al-teration would be easily and immediately detectable. For that reason, once information is rec-orded on the blockchain, it is considered immutable because it is so strongly protected

The Blockchain

There is no such thing as 'the blockchain'. There exist many different blockchains today, some are operated in public, some in private. Without the ambition of being exhaustive, the following are well-known blockhain implementations today. The seminal example is Bitcoin, of whom 667 other cryptocurrencies were derived. Other cryptocurrency families are based on Bytecoin, NXT and XRP. Ethereum, which allows logic to be executed in a distributed way, and which includes its own currency (Ether), is also a blockchain. Venezuela was the first country to issue a government-backed cryptocurrency. It was challenged for its lack of technical clarity and governance.
Non-blockchain based distributed ledgers include HyperLedger Fabric, Corda, BigChainDB and Rchain.
Other blockchain technologies at a glance
Today's most active Blockchain technologies include the pioneers such as Bitcoin, Ethereum and Ripple (a clearing and settlement technology), as well as Ethereum-based follow-ups that apply new approaches for scalability, such as Tendermint, Hydrachain and Hyperledger. There's also a broad category of more scalable designs such as the Lightning Network, Raiden, BigchainDB, RChain and Aeternity. There are also Superchains, which connect multiple Blockchains

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together. These include Interledger and Cosmos. And there are others, such as Cord, which come with separated 'fact' databases, where the data is kept consistent, but not everyone has a copy of everything.

Blockchain overview

Blockchain is an immutable, tamper-proof distributed ledger technology (DLT), which is utilized in a shared and synchronized environment where all the transactions are validated by users and are traceable. It enables a decentralized environment where all the members of the network can interact securely without the need for a trusted authority. Hence it eliminates the need for a central entity by validating and storing all transactions through distributed consensus. To implement blockchain with these functions, it shows the typical "work flow" of using blockchain for a transaction. Note that this work flow is rather standard.

Blockchain is formed through a series of connected blocks, where transactions history can be easily traced through previous blocks making the technology transparent and trustworthy. Each block contains its own unique ID and has the hash of the previous block, thus ensuring transaction security. All transactions are validated and recorded by the users in that network; they are also time stamped, arranged in a chronological order, connected to the previous block and are irreversible once added to the network. This entire structure of blockchain makes it a "trusted technology". One of the most important functionalities which make blockchain trusted, secure and transparent is the so called "consensus mechanism". Records are embedded in blocks linked through hash values and the decision to add a new block to the system is taken through the consensus mechanism. For any alteration of an existing block, the adversary must compete with all the users to construct a longer branch which helps DLT to maintain protection of historical data with collaboration mechanism.

Characteristics of blockchain

The characteristics of blockchain which make it unique and promising for future industrial applications are:

Decentralized: The data on the system can be accessed, monitored, stored and updated on multiple systems.

Transparent: Data is recorded and stored on the network, with consensus from the network and is visible and traceable throughout its lifetime.

Immutable: Blockchain provides timestamps and controls to ascertain
immutability

Irreversible: For every transaction ever made, a certain and verifiable record is kept in each blockchain.

Autoncny: Each node on the blockchain can access, transfer, store and update data by itself safely without third party intervention.

Open source: Blockchain provides open source access to everyone in the network with sense of hierarchy.

Anonymity: As data transfer occurs between nodes, the identity of the individual remains anonymous.

Ownership and uniqueness: Every document exchanged on the blockchain stores its ownership records with a unique hash code

Provenance: Every product has a digital record document in the blockchain which proves its authenticity and origin.

Contract automation (i.e. smart contracting): It is a small computerized program to help execute contract. It replaces the need of a usual contract with providing better security and lower transaction costs. Smart contracts are usually coded to include conditions for rules, penalties and actions that will be applied for all the parties involved in the transaction. Smart contracting supports quick response operations in supply chains.

Blockchain architecture

It consists of five modules that govern the respective operations and create protocols for blockchain applications.

Data source module: It helps create the blockchain in the "distributed and shared databases". It ensures that the data retrieved by the users of the blockchain would be unaltered and uncorrupted. Note that data immutability, tamper-proofed storage with any form and shared data ledger through data "Application Programming Interface (API)" are the key aspects of blockchain.

Transaction module: It monitors, manages, enables and supports the "journey of a transaction in blockchain". It helps to validate and facilitate addition to the blockchain. Though smart contracting transaction gates, data are transferred.

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Along with shared visibility of transactions, the flow of information across the SC is constituted through the bockchain. Transactions are bundled and delivered to each node in the form of a block. Note that transactions once executed are almost impossible to delete or roll back in blockchains. •

Block creation module: Blocks can be regarded as data structures created by the miners. They contain information and details of transactions that

are replicated to all nodes of the network. The block creation module enables the addition of new blocks to an existing SC by providing hash values and connections of the previous block. The sequences of transactions are saved in "chronological blocks" and blocks that store

invalid transactions can be identified and tracked easily.

Consensus module: Proof of work and proof of state algorithms are used to confirm and validate all the transactions to avoid corruption of data. Data consistency is maintained in the distributed network through the carefully designed "consensus algorithms". Distributed concensus helps in both verification of the validity of transactions and link creation among the blocks in the blockchain system. •

Connection and interface module. It monitors the tracking of transactions and helps provide real time data on smart contracts. This module synchronizes all the information technology (IT) platforms, algorithms and software required for blockchain applications. Depending upon the use cases, multiple distributed ledger platforms could be made available in the market that offer consensus algorithms for the blockchain system, no matter whether the blockchain is public, private, permissioned or non-permissioned.

3.3. Major drawbacks of blockchain technology

Blockchain technology can provide a tool to support publicly viewable and secure transactions. However, due to the irreversible nature of transactions in blockchain, the receiver does not get any refunds unless a new transaction is issued. Also, the laws and regulations surrounding blockchain environment are not clear which can lead to confusion among consumers. Finally, blockchain is in fact not as cheap as some people believe. The non-trivial operations cost and implementation cost of blockchain systems should never be under-estimated.

Methodology

The study conducted a systematic Iterature review (SLR) as per the Denyer and Tranfield(2009) and Tranfield et al. (2003) protocol and consequently adapted Dutta et al. (2020) search methodology. We established a rigorous procedure to include and exclude the articles starting with a set of search strings by evaluating the previous iterature. The initial search keyword resulted in the generation of 2934 articles conducted in the Scopus database which is considered to be one of the world's most reliable and comprehensive database for peer reviewed journals (Tandon et al., 2021; Varriale et al., 2021). On further filtering, we set certain inclusion criteria. We only included articles that include discussion about BT in domain, and are published in top-peer reviewed journals, and the number was reduced to 1,382 and by selecting "English" as the only, the number went down to 1346. By limiting the subject areas to Business, Management and Accounting, Computer Science and Decision Sciences, the number went down to 1019. We then Smited the journals to the top peer reviewed journals. We arrived at a ist of 390 articles upon this search category (as of 31 May 2022). Upon ensuring the availability and reading of full text articles, we arrived at the final count of 292 articles. Figure Irepresents the search methodology. Table 2presents the inclusion and exclusion criteria .

Blockchain infrastructure:-

Blockchain can only be accessed over a computer, laptop, server connected to the internet. All the devices when connected are known as nodes of the blockchain. Blockchain is stored by the nodes and permission is given to certain users that will be discussed in the study of blockchain in the supply chain [8]. A ledger is created when the blockchain is stored across the nodes which are recognized as a system where the data is stored and is shared across various sites, countries, or institutions [6]. Traditional databases are used to contrast the distributed ledger where the digital data is enclosed in a centralized location and in blockchain, the nodes store identical data .

Adding to the blockchain

To add data to the block of the blockchain, it is required to send a node out a transition request with the data that is added to other nodes of the network of the blockchain for the creation of the block (7). It is necessary to agree to the addition of the new block to the blockchain before the block is added to the chain. At the time of the validation of the

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new block, the node mist confirms that the block is correctly formatted and there is no duplcate transaction in the block [9). Once the block is validated, an encrypted block is added to the blockchain and n the blockchain network; it is stored by the other nodes. Due to the encryption nature of the blockchain and distributed ledger format, the data on the blockchain is not hackable and thus there is a lot of trust and confidence in the data that is stored on the blockchain [10].

II LITERATURE REVIEW

A. Blockchain in Supply Chain Management

1) Blockchain Technology definition and its boundaries It has been discussed above that blockchain is a distributed ledger database that consists of records or transactions or various digital incidents that are executed by the participants. Some articles have been pubSshed to a clarification on blockchain technology and how it works in the recent past [14]. Cryptocurrencies are one of the most popular examples of blockchain technology has been also named Bitcoin. Apart from these cryptocurrencies, there are also human implications of this blockchain such as supply chain, financial services, and manufacturing. This research paper has focused on the implementation of blockchain in supply chain management rather than concluding the technical mechanism of the blockchain technologies [15]. The paper has not talked about blockchain technology's key aspects like the protocols, algorithm, wallet signature and hash functioa

2) Supply chain management definition and its boundaries The definition of supply chain management is not the same for all others; however, according to [161 supply chain management is a process of handling the entire integrative flow of materials ranging from a raw material supplier to production warehousing and transportation to the users. There are various methods involved h supply chain management and it is important to identify its boundaries [12]. In this research paper, all the supply chain activities rangng from supply to manufacturing, distribution and the activities related to customers has been discussed. Apart from this, supply chain management also discusses the management of the entire chain in the study.

3) Blockchain-based supply chain There is uncertainty about the adoption of blockchain, globally as well as logistically [17]. The reason is the immaturity of blockchain, and it is bokmg to transform the SC activities by helping enhance as well as accountability. Accordng to [1$], transparency is a crucial factor ii the traceability level. However, [19] has come up with 3 types of transparency in an SC. They are a range of transparency products, transparency, and participation transparency. Thus to implement blockchain-based SCs, it is necessary to analyze the SC transparency factor and to correlate it with the opportunity as well as Sst perspective analysis so that it could help h assessing the mystery gains or losses.

4) To understand blockchain technology n the supply chain, it is necessary to consider interdisciplinary investigation so that theories can be buitt and designed for blockchain technology [20], Moreover, the firms can be benefited from blockchairvbased social sustain ability and responsibility to extend visibility and assure due diligence. It has been found that 1here is a lack of experience in understandingand knowledge about blockchain technology and There is also a labour skill gap with this technology that is required to be fixed. Moreover, according to [17], blockchain technology for technology and business needs to be addressed properly because there is a lot of expectation from thistechnology that can lead to the field adoption of this technology in the industry. Blockchain technology can assist in achieving the seven objectr/es of SCM: their cost, quality, speed, dependency,risk reduction,
sustaxability as well as flexibiity [21].

5) As discussed blockchain as a capability to break down data silos and provide one data source h digitization with the help of real-time data control that is requred for all trusted partners n the network. With the help of blockchain trust and security can easily be enhanced and apart fromthis.there also exist business values that would help n buildng trust with the help of blockchain by improving efficiency, reputation, and responsiveness [17]. It can be easiy concluded that the blockchain has a huge impact on the performance of the supply chain however when it comes to operation management, the blockchain provides a lot of advantages over the existing systems. According to [221 enterprise resource planning, radio frequency identification, and the blockchain are regarded as complementary technologies and it is extremely important to analyze their best combination so that we can maximize effect and impact. Accordng to [20], there are four barriers to blockchain development-enabled SCs are interested-organizational organizational,

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technical as well as external variables. There is no doubt friat despite these barriers, blockchain technology is extremely useful as the driver of digitization n theSC [20].

Leading uses of the technology in the supply chain :-

Blockchain technology has the potential to revolutionise supply chain management by providing increased transparency, security, and efficiency. The following are 10 leading uses of the technology in the supply chain.

1) Blockchain in supply chain: Transparency

Blockchain technology can provide real-time visibility and tracking of goods and products throughout the entire supply chain, from production to distribution to end consumers. This helps to increase transparency and trust between different parties in the supply chain.

2) Blockchain in supply chain: Product authentication

Blockchain can be used to verify the authenticity of products and prevent counterfeiting by enabling secure and tamper-proof records of a product's origin and movement throughout the supply chain.

3) Blockcham in supply chain: Quality control

Blockchain can be used to track the quality of products as they move through the supply chain, enabling faster identification and removal of defective products, reducing waste and improving customer satisfaction.

4) Blockchain in supply chain: Finance

Blockchain can be used to facilitate supply chain finance, providing secure and transparent records of transactions between suppliers, manufacturers, and distributors.

5) Blockchain in supply chain: Smart contracts

These are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code. They can be implemented using blockchain technology to automate and streamline supply chain processes, reducing costs and improving efficiency.

6)Blockchain in supply chain: Inventory management Blockchain can be used to track inventory levels and optimise inventory management processes, reducing inventory costs and improving supply chain efficiency.

7)Blockchain in supply chain: Reducing paperwork

By digitising and automating supply chain processes using blockchain technology, administrative costs can be reduced, and paperwork can be eliminated, saving time and resources.

8) Blockchain in supply chain: Food safety

Blockchain can be used to track and monitor food safety, ensuring that food products are safe for consumption by providing a transparent and traceable record of the product's journey through the supply chain.

9)Blockchain in supply chain: Compliance Blockchain can be used to ensure compliance with regulatory requirements by providing a transparent and auditable record of supply chain processes, reducing the risk of non-compliance and associated penalties.

10)Blockchain in supply chain: Sustainable sourcing Blockchain can be used to provide transparency and traceability in the sourcing of raw materials, enabling companies to ensure that their products are ethically and sustainably sourced.

Blockchain platforms for supply chain

The following are some of the most popular blockchain-based supply chain platforms.

IBM Food Trust is for food supply chain management. It enables food producers, distributors, and retailers to track the movement of food products across the supply chain, ensuring transparency and traceability.

Ambrosus is another platform for food supply chain management, but pharmaceuticals. It enables businesses to track the movement of products across the supply chain and ensure their quality and authenticity.

VeChain is a blockchain platform designed for supply chain management and product authentication. It enables businesses to track their products throughout the supply chain and verify their authenticity.

Provenance provides supply chain transparency and traceability. It enables businesses to track products from the source of origin to the end consumer, providing a complete view of the supply chain.

ChainLink helps with supply chain automation, enabling businesses to automate supply chain processes by connecting smart contracts to external data sources and APIs.

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Couses:-

By automating many processes within the supply chain, blockchain technology can increase efficiency and reduce costs. This could include automating payments, tracking inventory levels, or streamlining logistics processes. And it paves way for another critical component: the need for speed

Benefits of Blockchain in Supply Chain Management?

Blockchain technology coupled with the ability to program business logic with the use of smart contracts enables the following:

Transparency into the provenance of consumer goods- from the source point to end consumption

Accurate asset tracking

Enhanced licensing of services, products, and software

Even in today's technologically advanced world, supply chains could dramatically improve efficiency, audible tracking, and limit exploitative behaviors. In the container industry, paperwork can account for half the cost of transport. A nationwide study conducted in the U.S. from 2010 to 2012 by the international ocean advocacy organization Oceana revealed that seafood is mislabeled up to 87% of the time. Mica, which is present in makeup, electronics, and automobile paint is often sourced from illegal mines by child laborers.

Furthermore, consumer goods, especially electronics, pharmaceuticals, and luxury brands, are susceptible to counterfeiting and fraud. In fact, a report from PwC claims that more than 2% of global economic output results from counterfeiting revenues.

The implementation of public, private, and hybrid blockchains will bring traceability, transparency, and accountability to the movement of goods and commodities. The technology can be applied to logistics to make business processes more efficient and to cut costs from supply chain infrastructure.

Managerial implications

Blockcham technology has enormous potential in various sectors which has led to worldwide research on its adoption, implementation, technology and architecture in different sectors Examines the implementation of blockchain in sectors such as energy, healthcare, agriculture and food, finance, education, technology, government services, manufacturing, shipping, e-commerce, automotive sectors and the like to improve their efficiency and scalability. We examine and discuss some related managerial implications, social impacts and challenges in this section.

- Managerial implications

In day-to-day business operations, the use of blockchain can fetch numerous benefits to SC mangers. From secured and tampered-proof storage of data to improve response time, transparency in transactions, clear visibility across the nodes, and trust among SC members. The disintermediation mode of blockchain operations can bring the SC operations, SC reengineering and business process management to new heights and create competitive advantages.

The SC coordination among SC partners are being studied and researched over the decades. Integrating with loT, the use of blockchain technology with appropriate consensus mechanism in various SC echelons would enable big data management, improved connectivity, intellectual property rights and efficient SC contacting.

From secured and tampered-proof storage of data to improve response time, transparency in transactions, clear visibility across the nodes, and trust among SC members. The disintermediation mode of blockchain operations can bring the SC operations, SC reengineering and business process management to new heights and create competitive advantages.

II. CONCLUSION

SCM has entered the big data era, and blockchain technology has emerged as a disruptive technology. It is commonly believed that blockchain has a huge potential to transform the SCs, both global and local, by improving operational efficiency, data management, responsiveness, transparency and smart contract management. With blockchain bursting out on the scene, it can act as a source of competitive advantage for companies, governments and all kinds of organization in the society. Investments are being made by different companies and countries in exploring the new applications with blockchain to achieve a higher operational efficiency. The blockchain industry is also moving toward various areas, including the standardization issue and the way to integrate different blockchain systems together. This article provides a thorough review of 178 research articles and covers several aspects of blockchain technology in SC and logistics management. It starts with a brief overview of blockchain architecture and its characteristics, as well as

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some of the important literature reviews on blockchain in SCs and the uniqueness of the current work. As mentioned earlier, the key benefits of blockchain in SCs, various applications of blockchain in different SC functions and operations, and societal impacts are some of the major aspects being covered in this review article, which are under-examined in the prior review papers.

This work also adds values by summarizing the recent developments in blockchain and examining its potential applications in various sectors like healthcare, finance, technology, energy, agriculture, trade, government services, e*commerce, shipping, aviation and automotive sectors. The work has identified and covered all the pertinent research studies published in this field and will significantly help both academics and practitioners to have a better understanding of the related studies. Nevertheless, the managerial implications and related big theories for future developments of blockchain enabled SCs have been discussed. The societal impacts and various challenges associated with blockchain have been examined. All these could act as valuable references for researchers and supply chain managers. An extensive future research agenda in various SC functions and operations, business process management and SC sustainability including potential research in different industrial sectors has been proposed.

Overall, this review article will help researchers and practitioners to better understand and identify SC areas and industry sectors in which blockchian technology could be used. The current trends, challenges, and potential scope for future research opportunities around the use of blockchain for supply chain operations are also discussed.