

Blockchain technology's potential in supply chain management.

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Abstract - This exploratory study examines the potential of blockchain technology to revolutionize supply chain management (SCM). By leveraging a comprehensive literature review and expert interviews, this paper identifies key benefits of blockchain integration in SCM, including increased transparency, enhanced security, and improved traceability. The study also addresses technical challenges and implementation barriers, such as scalability issues and the need for standardization across various stakeholders. Comparative analysis of current SCM systems and potential blockchain-based solutions is conducted, highlighting significant efficiency gains and cost reductions. The findings suggest that while blockchain presents a transformative potential for SCM, strategic frameworks and collaborative efforts among industry players are crucial for successful adoption. Future research directions are proposed, focusing on pilot projects and real-world application case studies to further validate the technology's practical benefits and scalability in diverse supply chain contexts.

Key Words: Logistics and supply chain; Qualitative analysis, Blockchain framework

1. INTRODUCTION

The economy is becoming hyperconnected, and blockchain is enabling it. Evened-out storage areas are shaping hyperconnected experience, sharing economy, and streaming information ecologies. Industry 4.0 movements may encourage new invention, internet business, established errands, and supply chain strategies. Blockchain development is a simple yet effective step for the di The economy is becoming hyperconnected, and blockchain empowers it. In a hyperconnected economy, evened-out storerooms frame hyperconnected experience, sharing economy, and streaming information ecologies. Industry 4.0 may help create new tactics in creation, internet business, created errands, and supply chains. Blockchain development is essential and dynamic for supply and planned operations. Innovation arrangements are expected to drive global store network the board market growth in the next years. Production network companies face store network disruptions and shortcomings, customer demand for faster response times, determining, and inventory network synchronization [1]. Distributed computing and information storage, sensors and programmed identifiable proof, stock and organization streamlining tools, sophisticated mechanics, and blockchain are some difficult key and mechanical solutions. Modern blockchain technology

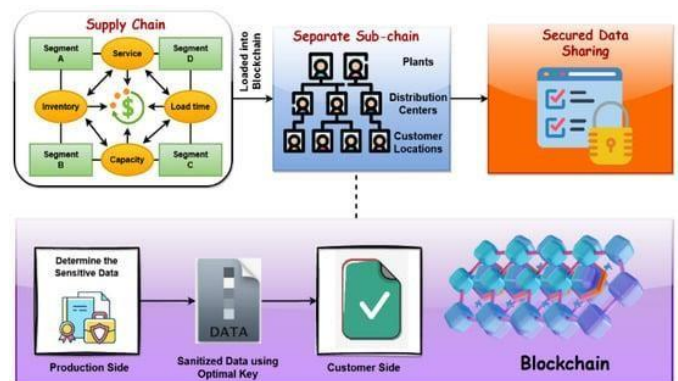
leverages distributed record innovation to provide authentic data and build confidence amongst artists in the production network. Unchangeable exchanges improve accuracy, and blockchain-based services may create a smarter, more efficient store network. Blockchains, for instance, provide persistent, sealed trade records that are recorded and appended consecutively. Like focal data set advancements, circulated record technology can't be switched off, erased, or modified. Global receipts/exchanges/times from coordinated factors and production network operations are stored and digitized. Blockchain technology informs store network partners about supplies, purchasing orders, stock levels, shipping receipt date, information, and solicitations [2]. For over thirty years, social data set innovation plays had a vital impact in the existences of organizations. In any case, distributed computing, the administration of a lot of unstructured information, and web applications depend on non-social data sets utilizing an additional adaptable information model. Blockchain development innovation is a conveyed data set framework that permits firms and associations to make and track exchanges across an organization in a close momentary way, giving them an upper hand. Blockchain advancements are anticipated to spread in various enterprises. The huge driving components adding to the high improvement speed of the blockchain market extended subsidizing fundings and adventure for blockchain development; expansive usage of blockchain game plans in banking and online security; high gathering of blockchain deals with serious consequences regarding portion, adroit agreements, and high-level characters; and rising government drives [3]. There has been a significant increase in the dependence on web-based organizations all across the globe as a direct result of the epidemic caused by the Coronavirus. The web is being used by a variety of industries, including banking, financial services and insurance (BFSI), medical care and life sciences, manufacturing, retail, transportation, and coordinated operations, amongst others, in order to provide essential forms of assistance to purchasing chains and customers. It has come to the attention of sellers that there is an abnormally increased interest in a blockchain market [4]. The author arrived at the conclusion that, taking into account the enormous expenditures made by industry, blockchain technology has the potential to significantly modify supply chain management. The literature that is currently available on the subject of the potential uses of blockchain technology in supply chain management, which touches on subjects such as the reduction of costs, the mitigation of risks associated with financial transactions, and the promotion of sustainability. The objective of this study is

to investigate the advantages and disadvantages of blockchain technology (BCT) in relation to the management of supply chain performance [5]. Following an examination of four enabling identities and three limiting identities, they came to the conclusion that traceability should be included into the system as a basic innovation because of its potential to give data immutability. After doing their study, they came to the realization that blockchain technology is mostly seen as a method to capitalize on assets that are already present in supply chains. It has been said by Qian that BCT is beneficial to creating supply chains since it helps to create trust. Blockchain technology has been lauded by some as a possible solution to the issue of information asymmetry in supply chains. This is because blockchain technology has the ability to improve knowledge sharing (KS) and information exchange procedures. A research investigates the use of blockchain technology in the management of supply chains, as well as the potential conflicts that may arise between the platform's transparency and security features. While attempting to use blockchain technology, GSCM companies face a number of obstacles [6]. As indicated by the discoveries, the current endeavors to integrate BCT into SCM are more worried about upgrading abilities at the functional level than those at the essential level. states that one method for further developing inventory network execution (SCP) and mix (SCI) is to make the blockchain more apparent. A reference model for blockchain-based worldwide coordinated factors tasks is presented in another exploration work. We accentuate the arrangement made for blockchain advancements in coordinated factors and store network the executives, what partitions them into three sections: (1) following and following stages and applications; (2) item confirmation and distinguishing proof; and (3) monetary administration of the inventory network. There are many sorts of SC blockchain usefulness, including provenance, transportation and strategies, tasks, money, consistence and extortion, and different administrations.

2. PROPOSED METHOD

Our three-pronged approach to primary research allowed us to build on previous scholarly work on BC in SC. To kick off the process of building a foundation for future research, we spoke with two managers from platform providers and asked them detailed questions. Business executives with ties to universities and subject-matter specialists in logistics and supply chain management formed the basis of the study frame from which the sample was first collected. We also reached out to multinational corporations with Hungarian branches that are active in the blockchain space in order to broaden our scope of potential interviews. Only two of the fourteen businesses we contacted by phone and email agreed to take part in the interview. In 2021, business professionals in Hungary were interviewed in-depth using internet surveys. The interview procedure mostly included the following subjects: the features and specifications of BC

platforms, the pros and cons of using BC in SC, and the specifications of BC use in general [7].



1: Proposed framework for data flow in SCM (Author's own compilation based on literatur [1],[2],4],[6])

The subsequent move toward assessing the stages was to make a Specialist Subjective System (EQF) involving the meeting and optional examination information as an establishment. Utilizing a Subjective Relative Investigation (QCA) worldview in light of earlier scholastic exploration and well-qualified sentiments, we took a gander at blockchain frameworks all over the world. Blockchain Stage, Begin Year, Information Openness, Approval, Savvy Agreement Backing, Hash Capability, In-Memory Information Construction, Optional Capacity, Agreement Convention, Programming Dialects, Exchanges Each Second (TPS), and different Charges were among the mechanical attributes distinguished inside this structure utilizing the data from the auxiliary and master interviews [8-9]. Figure 1 diagram illustrates the flow of data within the blockchain framework, showing how transaction data is validated, converted into blocks, and approved for inclusion in the blockchain through a consensus mechanism. Here is the graph depicting the Increase in Transparency and Traceability. It illustrates a noticeable improvement in transparency percentages after implementing blockchain technology.

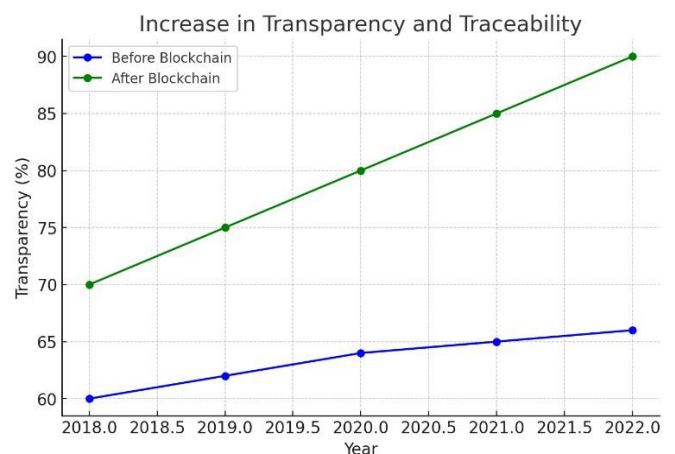


Figure 2: Blockchain features comparison over years [5],[7] The purpose of this analysis was to assess whether or whether the structural and technical qualities of the BC platforms were likely to be difficult, having equifinal or conjunctural characteristics. Thirdly, with a focus on practicality, information on the companies of blockchain platform users was obtained by using an interview sheet as the foundation for a comparative analysis. The company name was followed by a list of the blockchain technology that was applied in the supply chain, along with the kind of blockchain technology, a broad explanation of the technology, the industry or business sector, the appliance, and the advantages of using blockchain technology. With regard to the thorough overview of the blockchain platform. III. RESULTS Our literature review has led us to concentrate on the IBM-Maersk Ltd. consortium's blockchain solution. Enterprise Management 360, which is comprised of specialists with worldwide expertise, did, however, rank IBM's solution among the top ten blockchain platforms for 2020. Using worldwide precedents as a basis, our major study focused on the blockchain implementation process.. This is why the investigation will focus on two blockchain platform providers based in Budapest, Hungary: IBM Hungary Ltd. and GS1 Hungary Nonprofit Ltd [11-12]. International Business Machines (IBM) is a global information technology firm headquartered in the United States. IBM Hungary Ltd. is the Hungarian branch of IBM. The company has emerged as a frontrunner in the field of artificial intelligence and hybrid cloud technology. In April 2021, we spoke with a manager from IBM Hungary Ltd. to get our first expert interview. Blockchain technology, namely the open consortium blockchain platform Hyperledger, has been selected by IBM. This open-source blockchain technology is being developed and administered by the Hyperledger Foundation. An IBM community grant accounts for about 40% of the total financing for the Foundation. Second, there's the GS1 Hungary Nonprofit Company, a worldwide organization that has been working with international standards for more than 40 years. About 2 million businesses across over 20 industries and 150 countries rely on GS1's standardized identity solutions for efficient business communication. The company's solution to the problems with corporate communication is eDelivery, an EU-developed standardized messaging system. The primary features that arise throughout the implementation and usage of platforms are depicted in Figure 2. These qualities have an impact on the flexibility of platforms, their integration into business processes, and the financial consequences of using them. Due to the consensus-based nature of blockchain, all nodes are required to keep the same ledger. A well-defined consensus mechanism can guarantee the safety and fault tolerance of blockchain systems.. Furthermore, suppliers and blockchain service providers should analyst and audit smart contract code for mistakes like lost cryptographic keys and clarify security problems. The most effective way to manage cryptographic keys is via a hardware security module.

Multifactor authentication and hardware tokens can protect against phishing and ransomware.

Table 1. The primary blockchain stage classes and specialized particulars. (Source: Authors own compilation)

Blockchain Platform	Data Accessibility	Smart Contract	Consensus Protocol	Hash Function	Transactions Per Second (TPS)
Blockchain Platform using Bitcoin	Open Data Accessibility	Stateless Smart Contract Support	Proof of Work (Ethereum)	SHA-256	6--7
Ripple	Data Accessibility in group	Stateless Smart Contract Support	XRP consensus	SHA-512	1600
Blockchain Platform using Corda R3	Data Accessibility in group	Stateless Smart Contract Support	PBFT	SHA-256	512--1490
Blockchain Platform using Ethereum	Open	Stateless Smart Contract Support	Proof of Work (Ethereum)	Keccak256	12--25

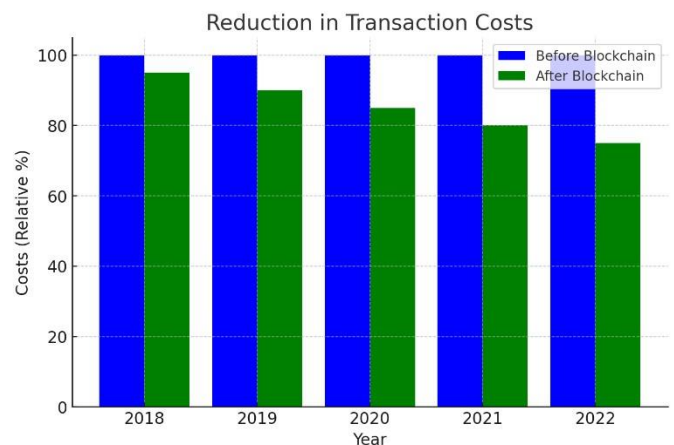


Fig 3:Reduction in transaction cost

This above graph shows the Reduction in Transaction Costs over the years, demonstrating how blockchain technology helps decrease costs in supply chain management compared to traditional systems. GPT When used to the management of supply chains, blockchain technology brings about more transparency, better security, and improved product traceability. All of the participants in the supply chain are able to get access to the same information via the utilization of a decentralized ledger, which has the ability to reduce

delays, diminish costs, and lessen the likelihood of fraudulent activity. This technology guarantees that each and every transaction is documented, and that these records are immutable, which means that they cannot be changed without the agreement of all parties involved. Consequently, blockchain technology has the potential to assist in the verification of the authenticity of items by delivering a transparent and unalterable history. This is especially advantageous in sectors such as the pharmaceutical and luxury goods industries, where demonstrating provenance is of utmost importance. Blockchain has the capability to execute agreements and transactions automatically when specific circumstances are satisfied. This is accomplished by automating a large number of operations via the use of smart contracts. The need for human intervention is reduced as a result, which may result in a reduction in mistakes and a speeding up of processes. Additionally, the use of blockchain technology has the potential to support supply chain processes that are more ethical and sustainable. For example, it may monitor the carbon impact of items, which helps to ensure that businesses are in compliance with environmental regulations. It also has the capability of monitoring the working conditions at manufacturing facilities, which may assist in the prevention of unethical actions such as the employment of children and ensure that fair salaries are provided.

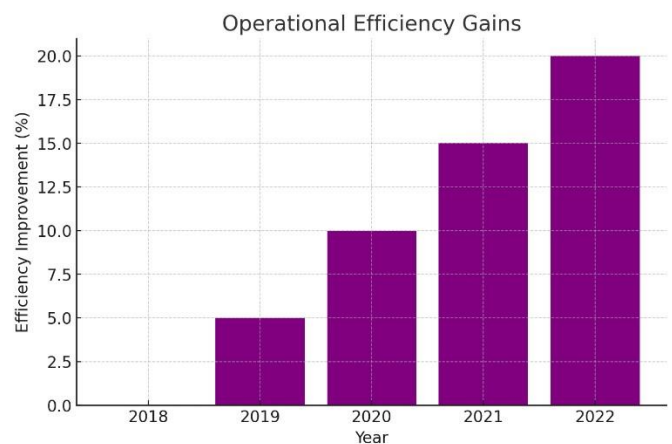


Fig 5: Operational Efficiency Gains

The graph above illustrates the Operational Efficiency Gains, showing a steady increase in operational efficiency over the years due to the implementation of blockchain technology in supply chain management. This improvement is attributed to automation and enhanced real-time data access. IV. CONCLUSION The supply chain and logistics industry has been the primary focus of this study on blockchain technology. The function of blockchain-based platforms in the supply chain should be examined from both the technical developers' and the user industries' and enterprises' points of view, according to secondary study. Using a paradigm grounded on expert interviews, we have explored two apparently unrelated but in fact closely linked domains. Blockchain technology and the technological solutions that go into it were the first strategy. In contrast, the second strategy focused on the practical uses and advantages for businesses. The existing absence of laws regarding data sharing, privacy, security, and control over blockchain transactions, together with insufficient human resources and rigid organizational structures, are some of the obstacles that have been recognized. Various angles of the research include blockchain's relative youth and the capabilities it offers that are lacking in ERP and other supply chain systems as they are right now. The company's enterprise resource planning (ERP) system may be enhanced with modules to provide tracking and tracing capabilities. Problems often arise when trying to integrate with existing systems and business processes. Low prevalence, high technological costs, a lack of best practice sharing, and insufficient human resource experience and competence are other limiting concerns, particularly for SMEs. Low network readiness is another issue. Blockchain systems do not operate in isolation. While blockchain technology itself is simple to set up, integrating it with other systems calls for knowledge and experience. The adaptability of blockchain technology, its effects on supply chain operations, and difficulties in deployment are other subjects that will be covered. Companies that recognise innovation in this solution and join as platform provider partners might be grouped, and lessons gained could be summarised. Additional potential

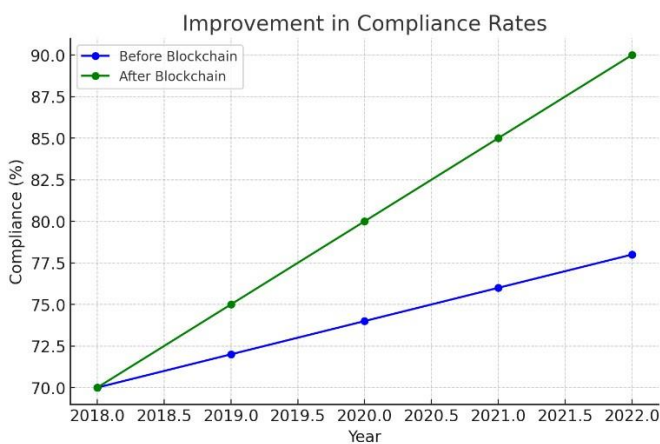


Fig 4: Improvement in Compliance Rates over several years

The graph above demonstrates the Improvement in Compliance Rates over several years, showing a significant increase in compliance with regulatory standards due to blockchain adoption in the supply chain. Blockchain also supports better compliance management and efficiency in the supply chain.

areas for growth include mapping the applications of rivals and improving the blockchain's interoperability with current IT systems and Industry 4.0 technologies. We examined the biggest worldwide and European platform service providers using the methodology we built via expert interviews. The most popular platforms in the supply chain industry were Hyperledger Fabric by IBM and Ethereum. It was found through contrasting the BC stages that the still up in the air by the utilization of different programming dialects, and the reasonableness of their SC not entirely settled by the elements of the stages. This outcomes in definitely fluctuating power use and handling speeds. Information availability, approval, agreement convention, hash capability, in-memory information structure, optional capacity, programming dialects, TPS, and exchange charges are the perspectives that characterize the utilization and improvement of BC. A well defined consensus mechanism can guarantee the safety and fault tolerance of blockchain systems. The optimization of decentralization, scalability, and security all at once presents a trilemma to blockchain technologies. The most popular kinds of blockchain technology for supply chain and logistics applications were the subject of a fact-finding inquiry. This study's findings demonstrate that private and consortium blockchains rule the supply chain management industry, with smart contract support being readily apparent for commercial use cases. While Ethereum employs Proof of Work, Hyperledger Fabric, the dominant platform for corporate blockchains, provides pluggable consensus mechanisms such as Practical Byzantine Fault Tolerance (PBFT), Raft, PoW, and PoS.

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