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Enhancing Transparency of Blockchain Technology in Supply Chain Management

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Abstract: Blockchain era has come up as a capability solution that can be used to enhance transparency in the supply chain. It affords an open, unchangeable database of transactions and actions of products by utilizing decentralized ledgers and cryptographic techniques. However, traditional techniques often lack transparency, resulting in inefficiencies, frauds, and product tracing problems. Manipulation is customary with centralized databases whilst paper-primarily based structures be afflicted by lack of real-time records go with the flow. This observe therefore proposes the usage of **Supply Chain Management using Blockchain Technology (SCM-BT)** as an alternative to this trouble. It uses Blockchain's distributed way to assemble a transparent and tamperproof device for following products inside the complete deliver chain under SCM-BT. These transactions are transparently traceable if SCM-BT is carried out, enabling stakeholders to ascertain whether the goods are genuine or were tampered with through their movement tactics. Moreover, within blockchain smart contracts automate transactions lowering guide activities subsequently extended performance. The findings showed that there have been good sized improvements in terms of transparency delivered approximately by SCM-BT which has brought about reduction of fraud and progressed usual performance in the supply chain. This fosters agree with and accountability among stakeholders consequently enhancing business environments conducive for both consumers and corporations.

Keywords: Blockchain technology, supply chain management, smart contract

1 Introduction

Blockchain technology could completely transform supply chains' operations since it allows for total efficiency, visibility, and traceability, which has never been seen before [1,2,3,4] . This way they will be able to diagnose problems even before they occur so that appropriate actions can be taken to address them accordingly. A blockchain would provide an unalterable safe account involving virtually any carry string orders promptly described at all times [5,6,7,8]. This might considerably decrease mistakes plus delays thus saving time as well as money. Businesses can increase their supply networks' effectiveness and openness with blockchain.

Blockchain technology provides businesses in the supply chain with an amazing new instrument: a verifiable decentralized record where every single modification in production carried out can be recorded publicly on it [9,10,11]. Thus it ensures accurate data access by all people involved in the supply chain at any

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time. For example, using blockchain's immutability as well as its built-in timestamps makes it easier for corporations to keep real-time tabs on both the location and current state of their products. It solves some of the most acute problems like counterfeit products, noncompliance, unnecessary delays and waste [12]. At many different types of enterprises, blockchain technology is becoming an integral part of supply chain management procedures. Blockchain technology is causing a major revolution in the supply chain management industry [13]. The main problem with transparent and traceable supply chains has always been that they are interlinked networks. However, there is a new technology referred to as Blockchain which could disrupt things significantly and thus change how companies manage and monitor product movement and information flow altogether. These technologies have now evolved into modern blockchain-based applications for facilitating transparency improved traceability [14]. This paper will look at the convergence between blockchain and supply chain by exploring how it contributes to increased traceability and transparency, discuss its advantages, disadvantages as well as practical uses. Bitcoin was the first application of blockchain, and it is a distributed ledger system that is both decentralized and secure. However, its benefits are not limited to the world of cryptocurrency [15]. Basically, a blockchain is a type of distributed ledger technology (DLT) where records are kept on various computers. Blocks are linked together to form chains with each block containing transaction records. As soon as data enters the chain it becomes immutable; there is no going back for subsequent entries made. In traditional supply chains, trust and transparency remain huge hurdles [16]. The supply chain has many players including manufacturers, distributors, logistics companies and buyers. The fragmented and unclear information flows among several parties may result in inefficiencies as well as risks. The proposed method in this paper suggests how blockchain technology can boost transparency throughout the supply chain by recording, verifying and audit-trailing every contract or transaction that happens therein [17] . This increased openness helps build business relationships while increasing consumer confidence hence reducing fraudulent activities through trust building with stakeholders [18]. The businesses within the supply chain can provide consumers with useful track and trace services. They make life easy for purchasers who want to verify genuine products at any point along their journey on ethical grounds through enabling responsible trade all over the value-chain. More so, honesty when conducting business with end users leads to trust gained between them therefore creating loyalty for sustainable customer relations.

1.1 Contribution

The contribution to the paper is given below,

–This paper introduces SCM-BT as a way to improve supply chain transparency. It achieves this by using cryptographic techniques in conjunction with Blockchain's distributed ledger systems, thus establishing a transparently immutable system for tracking items.
–It promotes confidence among stakeholders, keeps fraud at bay, and guarantees real-time visibility. By streamlining operations with smart contracts, SCM-BT creates a safe environment while increasing efficiency.
–The end result is a considerable improvement in supply chain efficiency, less fraud, and more openness.

In this paper, section 2 explains the related works, section 3 describes the proposed method of Supply Chain Management using Blockchain Technology. Section 4 shows the result and discussion and finally section 5 explains the conclusion.

2 Related works

Blockchain technology has recently gained attention as a possible way to improve supply chain management's transparency and sustainability. However, the difficulties inherent in their implementation necessitate the investigation of techniques and frameworks. This introduction aims to provide readers an idea of the current state of research into using blockchain technology to solve these problems successfully.

2.1 Hierarchical Enablers Framework Using Blockchain Technology

Blockchain technology may tackle agricultural supply chain issues including social responsibility and environmental performance by increasing supply chain transparency. However, using blockchain technology to improve supply chain transparency and sustainability is difficult [19]. The paper offers a hierarchical enablers framework for blockchain technology to improve Sustainable Supply Chain Transparency (SSCT) in the cocoa sector using the Technology-Organization-Environment (TOE) theoretical framework. Based on the case findings, Technical Characteristics is the key enabler, followed by blockchain smart contract, blockchain security, with tracking product components. The framework and approach of this analysis may assist administrators and supply managers with design plans to enhance SSCT using Blockchain.

2.2 Integrated Hesitant Fuzzy Set and regret theory

Blockchain technology may improve supply chain transparency. Supply chain managers must first assess and

choose the best blockchain technology. However, ambiguity and sustained transparency have complicated this judgement [20]. This paper uses hesitant fuzzy set and regret theory to present blockchain technology performance measures incorporating SSCT and technical attributes and a hybrid group decision method for blockchain technology evaluation and selection. This strategy highlights decision maker psychology and opinion variance. An example and sensitivity analysis enable supply chain managers and academics pick blockchain technology. Methodological and managerial effects of the decision tool and implementation are discussed. This paper establishes the basis for future supply chain blockchain technology assessment research.

2.3 Blockchain-based Traceability systems

Tracking and tracing information is traceability. Supply chains may be transparent with traceability. Traditional, centralised traceability systems are unsuitable for supply chains due to data tampering, single points of failure [21]. Blockchain a new distributed ledger technology, is gaining popularity for its many uses, especially in supply chain management. Blockchain-based traceability systems may improve centralised solutions. Companies have begun using Blockchain in their supply chains to monitor and trace events and increase transparency. Mainly, this paper shows how blockchain traceability technologies may make supply chains transparent. It discusses how blockchain traceability solutions influence supply chain distribution network visibility and how IoT and smart contracts enhance Blockchain's potential. A Microsoft Azure blockchain workbench Proof of Concept (PoC) for a cold chain scenario shows how blockchain traceability technologies increase supply chain transparency.

2.4 Big Data Analytics (BDA)

Climate change has made Sustainable Supply Chain Management(SSCM) a research priority. Sustainable development objectives promote sustainability globally. New information and communication technology, particularly BDA, may help identify unsustainable supply chain segments and members and take remedial action [22]. There is little research on BDA's effects on SSCM in industrial supply chains. Blockchain technology has recently gained attention as a possible way to improve supply chain management's transparency and sustainability. However, the difficulties inherent in their implementation necessitate the investigation of techniques and frameworks. This introduction aims to provide readers an idea of the current state of research into using blockchain technology to solve these problems successfully.

Various approaches to use of blockchain technology in supply chains have been discussed in recent literature. To achieve Sustainable Supply Chain Transparency, hierarchical enabler frameworks should be used. When faced with the uncertainty of blockchain technology, using hesitant fuzzy sets and regret theory may help with decision-making. Case studies in the real world illustrate how blockchain-based traceability solutions provide more transparency. Even more encouraging is the prospect of finding and fixing supply chain sustainability problems using Big Data Analytics. Collectively, these endeavours propel progress in supply chain management enabled by Blockchain.

3 Proposed method

The advent of blockchain technology has brought renewed optimism to the field of logistics management by guaranteeing more openness and responsibility. Traditional approaches suffer from lack of visibility and susceptibility to fraud which represents two major issues discussed herein. Calling for widespread adoption of SCM-BT or Supply Chain Management using Blockchain Technology, the SCM-BT project aims at revolutionizing supply chain management by exploiting blockchain's cryptographic functions and shared ledgers. Transactions carried out via SCM-BT are transparent and impenetrable, creating a more secure, efficient supply chain ecosystem that provides stakeholders with peerless transparency and certifies the genuineness of goods.

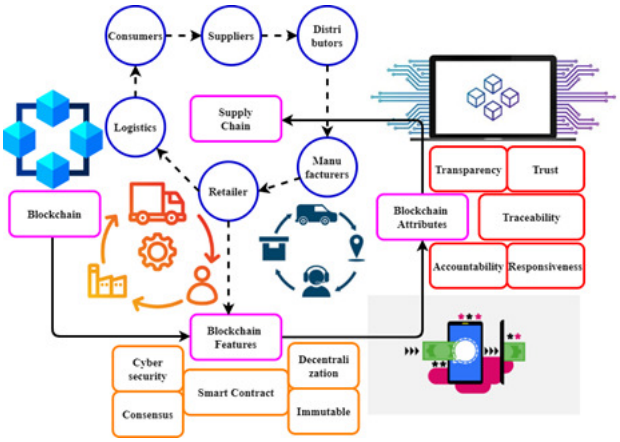

Fig. 1: Blockchain-Based Supply Chain to Achieve Triple Bottom Line Goals

Fig 1 shows the overall plan for changing supply chains to use blockchain technology to achieve a triple bottom line. The framework describes blockchain technology and its properties, which include distributed ledger decentralisation, cybersecurity, consistency, smart

contracts, and partner agreement. When taken as a whole, these traits help make the supply chain more responsive, transparent, trustworthy, and traceable.

Improving the preservation of the environment is made possible by blockchain's sophisticated monitoring and control systems, which allow for carbon emissions management. Furthering the promotion of environmental responsibility, smart contracts enable the introduction and frequent monitoring of carbon pricing regulations. In addition, customers have more faith in the brand and are more satisfied as a result of the improved product integrity and responsiveness of the entire supply chain. This model highlights the ways in which the blockchain system may be used to track and manage humanitarian supply chains as a whole, leading to more ethical business practices from all companies involved. The linked research likely delves further into the theoretical foundations, applications in practice, and empirical proof of blockchain's revolutionary role in attaining a triple bottom line in the management of supply chains in its three primary sections.

$$B \times T = \frac{1}{L} \sum_{l=1}^{L} B_L \times \max_{2 \le j \le p} \times b_{jk} \tag{1}$$

The expressions utilised in optimisation issues are represented by Equation 1. In this case, B stands for a weight vector, T for the iterations, and L for the overall count of observations. This equation takes j values between 2 and p and finds the average of the products with the highest value from a given range of b components.

$$U = C + C^2 + C^3 + C^4 + \ldots = C(1-C)^{-1} \tag{2}$$

The sum of a limitless number of elements is denoted by U in Equation 2, which represents an endless geometric series. The average proportion between successive terms is represented by C in this equation. To represent as C divided by the difference between 1 raised to the power of -1, we may use the following equation for the sum of an endless geometrical series.

For a global industry, supply chain management provides the backbone of any business by enabling precise coordination of flow of goods, services and data across networks that encompass stakeholders as well as geographical boundaries. Still, inefficiency, susceptibility to fraud and lack of transparency have haunted traditional centralised systems. In this regard, blockchain technology has emerged as an accord which changes everything affecting supply chain management by creating trust on distributed ledgers through the use of its decentralized nature and transparency. To overcome these challenges, Fig 2 presents a framework that explains how blockchain can be used to manage supply chains. By using blockchain technology, stakeholders can create a highly effective system for managing goods, services and

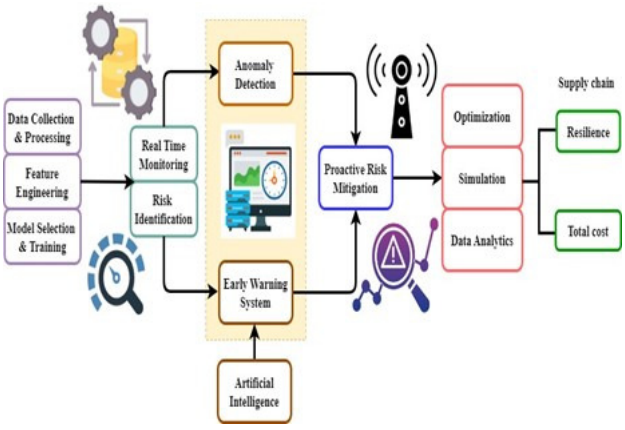

Fig. 2: Proposed method of SCM-BT

information. This becomes possible through the use of blockchain technology whereby every transaction is recorded securely on an immutable ledger making it possible for any one in the supply chain to trust others and take responsibility for their actions. Decentralization is crucial within this structure since it makes the supply chain robust eliminating all vulnerabilities. While maintaining control over their own data everyone can still contribute towards securing the network due to decentralised control systems in place with respect to data ownership. Due to cryptographic algorithms and consensus mechanisms facilitating distributed confidence transactions are made secure ensuring seamless cross-organizational cooperation.

Even when there is no overarching leader, the dispersed trust makes everyone feel like it can trust each other. In addition, intelligent agreements and immediate form product tracking and traceability are two ways in which blockchain science automates procedures and increases the effectiveness of supply chains. Saving money, cutting down on lead times, and making customers happier are all outcomes of these innovations.

$$S_j \times D_k = \sum_{k=1}^{p} u_{jk}; \quad j,k \ni (2,p) + (3,p) \tag{3}$$

In the setting of matrix multiplication, Equation 3 is utilised, where S_j and D_k indicate members of S and D matrices, respectively. The average of the j -th row is When k is a number that is between one and p, it represents the sum of the products of matching items.

$$U_{jk} = 1 - \left(\Delta^2_{jLf} - \Delta^2_{jlP}\right) - \left(\nabla^2_{jLf} - \nabla^2_{jlP}\right) \tag{4}$$

The variable efficiency U_{jk} in Equation 4 where Δ^2_{jLf} signifies the difference between the square of the $j-$th and $1-$th P values, and ∇^2_{jLf} stands for the difference in the

square of the Lf values at indices j and k. Furthermore, the inverse square is denoted by Δ^2_{jlP} and the square between the values is represented by ∇^2_{jlP}.

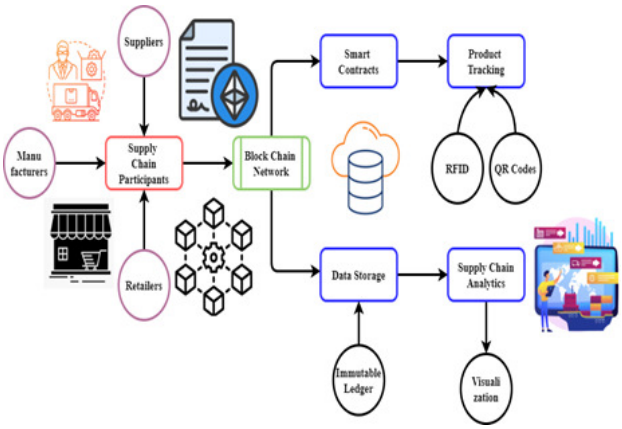

Fig. 3: Integration of Blockchain Technology into Supply Chains

The creative ecosystem shown in Fig 3 is made possible by blockchain technology, which turns conventional supply chains into trustworthy, linked webs of efficiency. Central to this ecosystem is the Blockchain Network, which is a distributed ledger that supports trustworthy and open transactions throughout the supply chain. Guaranteeing credibility throughout the network is a function of certain cryptographic methods that securely store each participant's identity and history of transactions. One such part on the Blockchain Network is Smart Contracts wherein protocols can be programmed to carry out certain activities automatically upon meeting some conditions; like ensuring that there are no intermediaries involved so that transactions can go smoothly from start to finish i.e., purchasing/ paying/ shipping etc.

The traceability feature enabled by blockchain technology allows products' life cycle tracking thus avoiding counterfeit ones using technologies such as QR codes or RFID IoT devices etc., which allow people or organizations involved parties track products from factories directly into customers' hands. This increased visibility on the other hand helps protect customers' safety and brand reputation by preventing fake goods and allowing quick responses to recalls or quality related issues.

At the same time, supply chain analytics are an add-on to product tracking because much of the information is stored in a blockchain. Thus, using data visualization and advanced analytics, stakeholders can gain better insights into supply chain efficiency, demand trends as well as market dynamics. Further more, these insights enable better inventory management processes, more informed decisions and operational excellence across the entire supply chain. This is an ecosystem that brings together manufacturers, suppliers, distributors and retailers through blockchain technology which makes it a more collaborative transparent and efficient approach for managing supply chains. As such, it is expected that digital transformations will make it so all future economies are reliant upon blockchains controlled by firms rather than centralized authorities like governments thereby making them a key component of tomorrow's business environment. These networks have potentials to offer unmatched benefits towards both businesses organizations and their consumers.

$$\beta = \text{Mean}\left(u_{jk}\right) + \text{TE}\left(u_{jk}\right); \quad j,k \ni [1,p] \tag{5}$$

In equation 5, the parameter β is defined as the total error and reduced fraud analysis are the mean of the components u_{jk}, where j and k are integers between 1 and p. The median value of these variables over the whole dataset is represented by the mean of TE and $\ni$.

$$Q_j \times F_j = S_j + D_{k/l=p} + 2\left(S_j + D_{k/l=p}\right) \tag{6}$$

The transparency constituents of the vectors Q and F are represented in Equation 6, where the product of the j-th elements of vectors when p is the value of l or k, the resultant product is subsequently added to the total of elements of matrices S and D that are situated at indices k/l. In addition, the preceding computation is increased by 2 and added to the sum of the components from matrices.

When it comes to efficiency and transparency, SCM-BT is the best for supply chain operations. This reduces mistake probabilities as well as potential elements of fraud by making transactions visible and traceable via blockchain's distributed database with smart contracts. The results indicate how SCM-BT may revolutionize a supply chain by increasing transparency, accountability, and productivity. This makes SCM-BT a revolutionary innovation in an industry that is increasingly embracing authenticity and transparency among businesses and customers; thus providing a secure environment with advantages for all stakeholders.

4 Result and discussion

Supply chain operations benefit greatly from increased transparency and less fraud when Blockchain Technology is used for Supply Chain Management. An in-depth evaluation of these results is presented in this section.

4.1 Dataset description

Cosmetics supply chain characteristics are captured by a fashion and beauty startup. Many of its properties,

including Product Type, SKU, Price, Availability, and Number of Products Sold, provide thorough sales success and product popularity analysis. Cash factors like cash earned and customer demographics reveal consumer preferences and purchasing behavior [23]. Stock levels, lead times, order quantities, and delivery statistics show inventory management, logistics efficiency, and operational performance. Supplier data, manufacturing procedures, inspection results, and defect rates enable production quality management and optimization. For beauty product supply chain analytics and data-driven decision-making, this dataset is important.

4.2 Analysis of Transparency

SCM-BT uses blockchain's decentralized ledger and cryptography to record supply chain transactions and product movements transparently and immutably is expressed in figure 4 and equation 6.

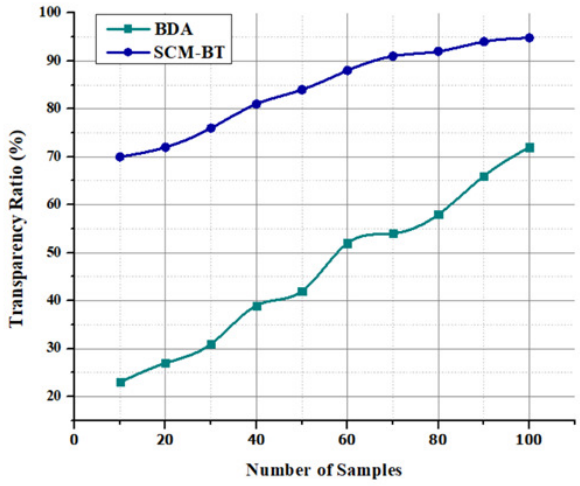

Fig. 4: Analysis of Transparency

This openness provides accurate and real-time goods flow information to all stakeholders. Blockchain technology allows direct supply chain communication and data exchange by removing middlemen and central agencies. This decentralized model gives stakeholders insight into each supply chain step, increasing transparency. Blockchain-integrated smart contracts automate contract execution and enforce regulations. Automation simplifies processes and provides transparency by ensuring transactions are handled clearly and according to agreed-upon conditions. SCM-BT transparency lets stakeholders track product origins, authenticity, and regulatory and industry compliance. Transparency decreases supply chain risks and uncertainties, increasing trust and responsibility.

4.3 Analysis of fraud detection

Distributed ledger technology (blockchain) records are almost impossible to alter, making supply chain fraud detection described in figure 5 and equation 5. It would be very difficult, if not impossible, for fraudulent parties to modify transaction data without the agreement of the majority of network members.

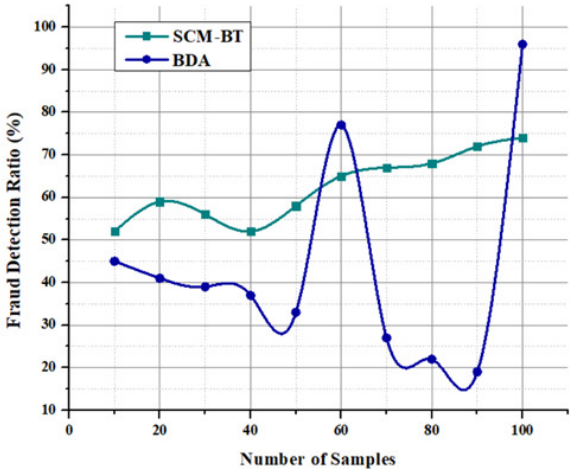

Fig. 5: Fraud detection ratio

By automating transaction procedures and removing the possibility of human mistake or malicious manipulation, smart contracts significantly contribute to the reduction of fraud. Smart contracts reduce the possibility of fraudulent actions like unauthorized changes or access by automatically performing transactions according to predetermined circumstances. The fact that all transactions are accessible to all users in SCM-BT is another factor that helps to discourage fraudulent conduct owing to the transparency of the system. The supply chain is safeguarded as a result of the increased visibility, which makes it less difficult to recognize fraudulent conduct and initiate corrective measures.

Fraud in the supply chain is dramatically decreased when SCM-BT is used, and transparency is significantly improved after its implementation. Through the use of the inherent characteristics of blockchain technology creates a reliable and open ecosystem that enhances the efficiency, transparency, and accountability of supply chain operations for both businesses and customers.

5 Conclusion

Utilizing SCM-BT has vast capability to revolutionize supply chain operations through improving transparency,

minimizing fraud, and enhancing performance. According to the findings, SCM-BT may offer supply chain individuals with unmatched visibility and monitoring talents, which might completely regulate the dynamics of the supply chain. The SCM-BT system is each visible and impenetrable since it makes use of blockchain technology, that is a allotted ledger, to supply an indelible record of all product moves and transactions. The fine manner to make sure that the products stakeholders purchase are free from fraud and counterfeits is to be obvious and honest with them. Smart contracts covered inside the blockchain additionally automate transaction procedures, which simplifies operations and cuts down on human intervention. Smart contracts incorporate pre-agreed terms and situations, which high in efficiency and decrease the possibility of fraud. Future research ought to purpose to make SCM-BT more realistic, effective, and scalable that the supply chain environment may be greater open, resilient, and efficient.

Acknowledgement

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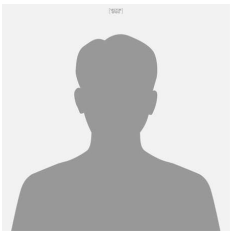

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