Supply chain transparency in the age of Blockchain technology: An analytical study

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Abstract:

Blockchain technology has the potency to alter drastically the supply change management (SCM) by assuring transparency, efficiency and security. The blockchain technology and its significance is soaring tremendously and has gathered immense acceptance in recent times. There however, seems that not much of empirical research has been done on the organizational and technology features of blockchain, which navigate a crucial role in adopting the supply chain management. This paper explores the transformative role of blockchain technology in supply chain management, especially in enhancing transparency, efficiency and security. Blockchain being a decentralised and immutable ledger has garnered tremendous attention because it bears in secure means of recording and verifying transactions. The paper attempts to study the practical application of blockchain in development of industries and accountability. In addition, it presents the resultant benefits such as cost reduction, smooth transaction process, and increased consumer confidence. The paper explores the relationship between blockchain adoption and supply chain transparency through descriptive research analysis. By utilising both numerical data and graphical analysis, the study reveals key correlation and regression patterns that offer in-depth insight into how blockchain technology affects the transparency and of supply chain process. The findings of the study reflect positive impact of blockchain on improving visibility and integrity in supply chain, especially in pharmaceuticals, food and luxury goods industry. Supply chain management has become revolutionized through the advent of blockchain. Technology Essentially, this system changes how all transactions are made, recorded, verified, and monitored. In this manner blockchain has allows for secure and transparent framework for tracing movement of goods, financial transactions, and even contractual agreements between parties involved in supply chain networks. Paper also discusses the multiple applications of blockchain in SCM, and its influence on transparency, efficiency and security. Beyond transparency, blockchain contributes significantly to improving operational efficiency in supply chain processes. By eliminating intermediaries, automating contract execution through smart contracts, and reducing paperwork, blockchain streamlines transaction processes and minimizes delays. These efficiencies translate into cost reductions, improved resource allocation, and enhanced overall supply chain performance.

Introduction:

Blockchain technology, originally developed as the backbone for cryptocurrencies like Bitcoin, has proven to be a revolutionary tool across numerous industries. One of its most promising applications is in Supply Chain Management (SCM). In an age where global supply chains are becoming increasingly complex, blockchain offers a decentralized and immutable solution to improve transparency, efficiency, and accountability. Through the use of a distributed ledger system, blockchain guarantees that each transaction is recorded in a safe, transparent, and traceable manner, allowing business and helping consumers to take better decisions.

Significance of blockchain technology in supply chain transparency:

Enhanced traceability: Blockchain allows all the goods and materials to be tracked from raw material source all the way till the end of the supply chain. Since each transaction or "block" is linked to the previous one, creating a chronological record of all the movements, changes, and transactions involving a product, all the concerned parties, namely producers, suppliers and consumers can trace the journey of the commodity. For instance, the food industry can track from farm to table the journey of producing using blockchain, so the consumer will know the origin of food, eliminating concerns about the quality and the ethics of its source (Kamilaris, A., et al 2019).

Improved efficiency: Blockchain streamlines the supply chain by eradicating middlemen and simplifies data management. Traditional supply chains involve centralized systems, which are often slow and prone to errors. Blockchain's decentralized ledger allows data to be shared across various participants in real-time, removing bottlenecks, and ensuring that updates are immediate and accurate.

Reduction in delays and costs: smart contracts automate the execution and approval of contracts through blockchain accelerating the payment processes, custom clearances, and order fulfilment. Less intermediaries and less paperwork the administrative costs decreases, thereby reducing the possibility of disputes and errors.

Prevention of frauds: Blockchain technology reduces the threat of fraud and counterfeit goods that may be produced in the supply chain. Once all transactions are on a decentralized ledger, any alterations or counterfeit would require all the changes in the entire blockchain process. This seems more impractical. This curbs the use of counterfeit products under the

blockchain process especially towards pharma goods, food industry and luxury products. (Saberi, S., et al 2019).

Ethical practices: clear immutable records make stakeholders more likely to engage in ethical practices, as they are aware that any errors will be transparent to all participants. This is crucial for organisations focused on sustainability and fair trade.

Trust of consumers: Educated and sophisticated consumers will demand transparency in the commodities they intend to consume like data on environment footprint, labour practise, and supply sources. Blockchain caters to this requirement by offering transparent verifiable products, which in turn will boost consumer confidence. Consumers can trace the minute details right from the stage of production till transport. For instance: A consumer purchasing a diamond can scan a QR code and trace the entire journey of the gem from the mine to the retailer, ensuring it was sourced ethically.

Data security: supply chain handles confidential data like proprietary design information, pricing data, and inventory levels. Blockchain technology builds on the notion of better securing data by using sophisticated forms of cryptography for it. Since the blockchain is decentralized and stored across numerous nodes, stealing of data becomes difficult. The data is accessible to those with cryptographic keys. The decentralised nature of blockchain makes it less prone to cyber threats. Each block that connects the chain, is encrypted which adds a further layer of security on sensitive data.

Review of Literature

Böhm, F., & De Marco, A. (2020), The paper provides an overview of the different applications of blockchain in supply chain management, discussing its potential for enhancing transparency and traceability. It also highlights key issues such as scalability, regulatory compliance and integration challenges

Christopher, M. (2016). The book is a comprehensive and outlines current supply chain management with all its technological revolution. The concept of blockchain is analysed based on how it forms part of innovation in the area of supply chains, mainly related to the achievement of greater transparency and minimistaion of inefficiency.

Ivanov, D et al (2019) in their study explore the analytics intersection of blockchain with supply chain resilience, explaining how these technologies can be utilised to improve companies'

responses to supply chain disruptions. Under this context the authors discuss how blockchain can enable better real time information exchange and decision.

Kim, Y and Laskowski, M. (2018) in their study describe a framework for the use of blockchain to increase supply chain traceability and transparency. The paper demonstrates case study of how major company applied blockchain for real time tracking of its product and inventory.

Mougayar, W. (2016), the book provides deep dive into the potential of blockchain technology, especially its ability to revolutionaise business practices and in industries. The focus is on understanding how blockchain can reshape industries by ensuring data integrity, security and transparency.

Pereira, F., & Rabelo, R. (2020), the research paper focuses on the food industry, in which applications of blockchain is discussed for increasing transparency, traceability, and food safety. It discusses case studies, whereby blockchain has been effectively utilised in food supply chains to study how to enhance consumer confidence and quality of products.

Swan, M. (2015), It is a book explaining blockchain technology in detail, discussing how it works, its potential application and what entails for other sectors such as supply chain management. The author describes how blockchain provides efficient answer to the current flaws existing in supply chain systems, by ensuring transparency and eliminating frauds.

Tapscaott, D and Tapscott, A. (2016) in their book deliver indepth assessment of blockchain's disruptive impact in different areas of supply chain management and demonstrate how blockchain gives rise to systems that are both decentralised and transparent with the intent of enhancing supply chains efficiency and security.

Wang, Y., Han, J., & Beynon-Davies, P. (2019), This systematic review examines the role of blockchain technology in future supply chains, identifying both its potential benefits and the challenges associated with implementation. The study discusses key areas such as product traceability, data security, and cost reductions, and sets a path for future studies.

Zheng, Z. et al (2021), this paper surveys the challenges and opportunities of blockchain technology in various applications, including supply chain management. The study identifies key challenges such as scalability, interoperability, and regulatory hurdles, while also discussing blockchain's potential to optimise transparency and security.

Objectives of the study:

1. To Study the impact of blockchain adoption on improving and securing the supply chain.
2. To identify the challenges and disadvantages of implementing blockchain in supply chains
3. Suggest measures to exploit maximum potential of blockchain in SCM

Hypotheses:

H0: Blockchain adoption has no effect on improving supply chain transparency

H1: Blockchain adoption positively effects the supply chain transparency

H0: Blockchain adoption fails to reduce frauds in supply chains

H1: Blockchain adoption significantly reduces frauds in supply chains

H0: Blockchain technology adoption fails to improve efficiency of supply chain

H1: Blockchain technology adoption significantly improves efficiency of supply chain

Research Methodology:

Secondary data has been furnished from sources like Accenture Report (2020), Gartner Report (2020), Deloitte Insights (2019) and more. Statistical tools of Correlation analysis to identify the relationship between blockchain adoption and transparency levels. Regression analysis to predict the impact of blockchain implementation on supply chain performance. Descriptive statistics is used to summarise the data.

Numerical tabular data:

Table 1

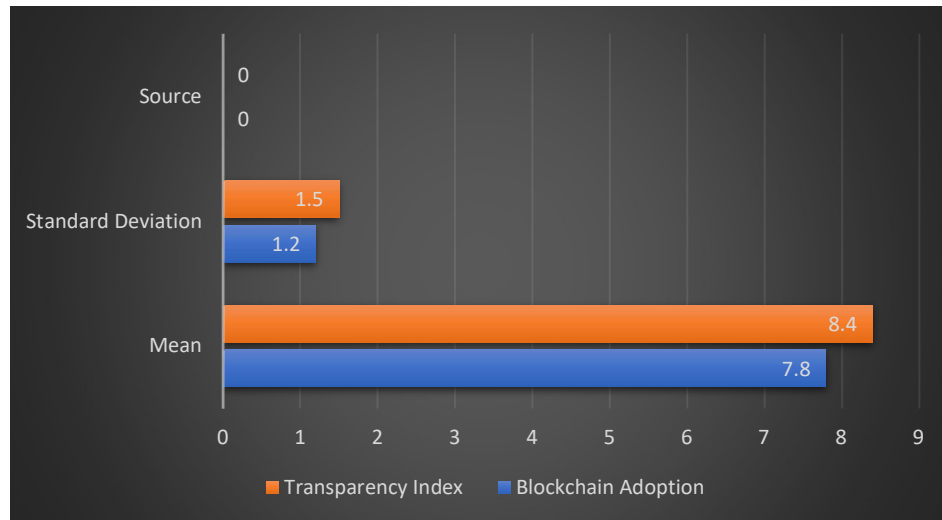| Mean	Standard Deviation	Source
7.8	1.2	Survey Data
8.4	1.5	Survey Data

Graphical representation

Table 2

Year	Blockchain adoption rate in supply chains in %	Number of companies adopting blockchain (Est)	Key industries implementing blockchain	Source
2015	5	200	Food, Pharmaceuticals	Accenture Report 2020
2016	8	350	Logistics, Retail	Wamba et al., 2020
2017	15	700	Manufacturing, Energy	Gartner Report 2020
2018	20	1,100	Healthcare, Automotive	Deloitte Insights 2019
2019	28	1,500	Retail, Food & Agriculture	Kamilaris et al., 2019
2020	35	2,000	E-commerce, Pharma, Logistics	Saberi et al., 2019
2021	43	2,800	Electronics, Fashion, Food	Accenture Report 2020
2022	50	3,500	Tech, Retail, Automotive	Wamba et al., 2020
2023	60	4,200	Healthcare, Agriculture, Energy	Gartner Report 2020
2024	70	5,000	All sectors	Deloitte Insights 2021
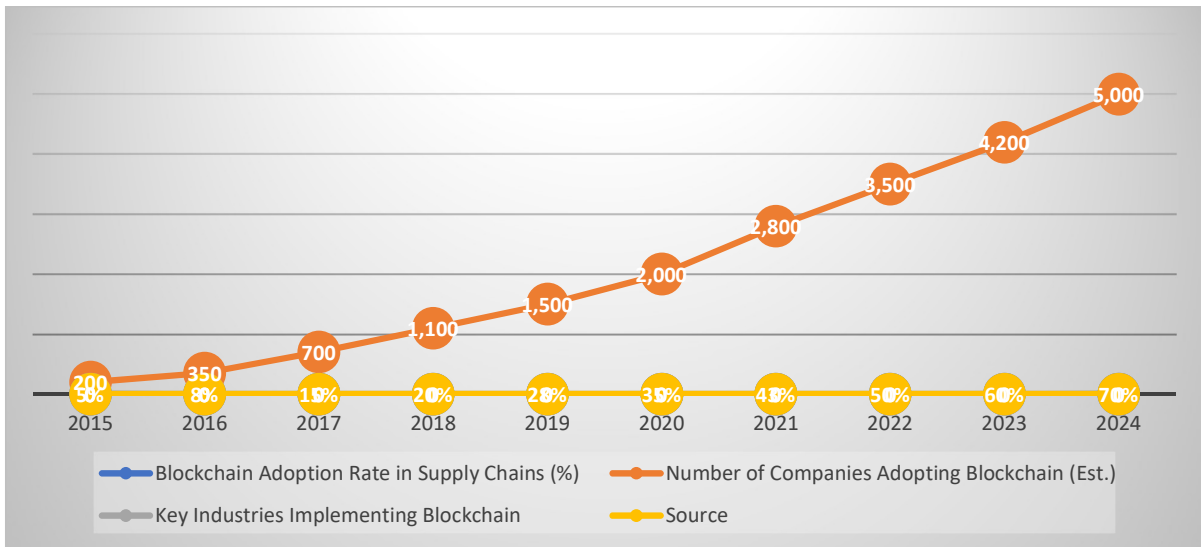
Graphical analysis depicts between blockchain adoption and transparency index.

Results and Discussion:
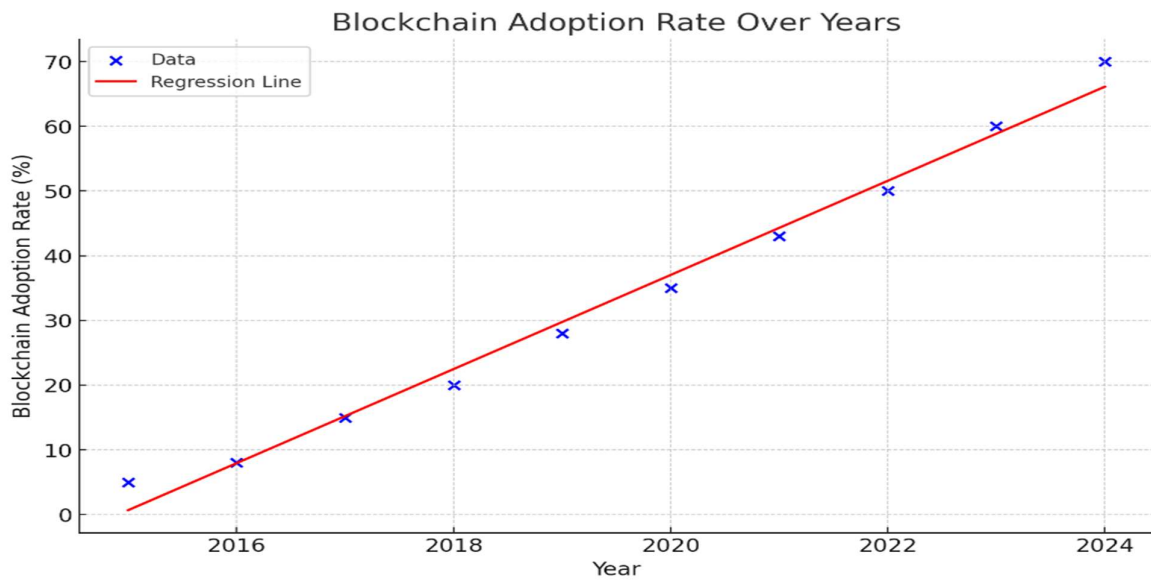
There is a significant positive correlation between blockchain adoption and supply chain transparency.

Blockchain adoption explains 68% of the variation in the transparency levels according to the regression analysis

Corelation Coefficient: The Pearson correlation coefficient between Blockchain Adoption Rate and Number of Companies Adopting Blockchain is 0.996, which indicates a very strong

positive correlation. That is, with an increase in blockchain adoption supply chains, the number of companies adopting blockchain increases in a close manner.

Linear Regression Model: the equation of the regression line is approximately as follows

Adoption rate = $7.27 \times$ Year -14653.87

Slope: 7.27, implies the adoption rate is about 7.27% points per year

Intercept: -14653.87, which is the point at which the regression line crosses the y-axis.

The value itself is not very meaningful but reflects how the model is adjusted according to the historical data.

Challenges and limitations:

Blockchain technology has proved to be a game-changer in the supply chain management domain, providing an array of benefits such as transparency, efficiency, and security. Despite the promising benefits, the technology has its disadvantages and challenges.

1. High cost of implementation
2. Scalability issues - Although it would be able to provide transparency and security for more modest operations, scaling the same technology for use in global or high-volume supply chains is highly challenging
3. Regulatory and compliance barriers: The regulatory environment for blockchain technology is still in its development stage. Most governments and regulatory agencies are still in the process of defining the appropriate regulations to be used with blockchain, creating uncertainty for businesses looking to embrace blockchain.
4. Resistance to change by stakeholders

Future scope:

1. Blockchain and IoT for Real-Time Supply Chain Monitoring The merging of Blockchain with IoT can revolutionize real-time monitoring in supply chains.
2. The convergence of blockchain and IoT will lead to fully automated self-regulating supply chains, bringing in reduced number of inefficiencies, errors, and human intervention.

3. The future of blockchain in supply chain management will involve developing global, standardized frameworks that enable seamless interoperability between different stakeholders.

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