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IMPLEMENTING BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

Mistry Nilay*1, Devanshi Modi*2

*1,2Parul Institute Of Engineering And Technology, India.

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ABSTRACT

In the increasingly interconnected global marketplace, modern supply chains have grown more complex, involving various stakeholders, from manufacturers and suppliers to distributors and retailers. This complexity brings with it significant challenges, including inefficiencies, fraud, and difficulties in ensuring transparency and product traceability. Traditional supply chain management methods often depend on centralized record-keeping systems that are susceptible to manipulation, human errors, and delays. With rising consumer demand for transparency in product origins, ethical sourcing, and sustainable practices, there is a growing need for more secure and reliable systems.

I. INTRODUCTION

Blockchain technology, originally developed for cryptocurrencies like Bitcoin, has emerged as a potential solution to many of these challenges. Blockchain functions as a decentralized, distributed ledger that records transactions securely, immutably, and transparently. Each transaction is added to a "block" in the chain after being verified, creating a permanent and tamper-proof record of a product's journey across the supply chain. This technology offers substantial benefits in terms of enhancing efficiency, accuracy, and security within supply chain operations.

By integrating blockchain, stakeholders can gain real-time visibility into the movement of goods, tracing products from their point of origin to the final consumer. Blockchain also helps reduce the risk of fraud by leveraging smart contracts, which automatically execute agreements based on pre-defined conditions without the need for intermediaries. Furthermore, its immutable record-keeping ensures that data cannot be altered or tampered with, fostering trust and promoting accountability among supply chain participants.

This research aims to explore how blockchain technology can be integrated into current supply chain management systems and assess its ability to solve key issues such as fraud, inefficiency, and lack of transparency. The study also seeks to understand the challenges businesses may face in adopting blockchain and to offer practical recommendations for its implementation.

II. LITERATURE REVIEWS

1. Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021).* This study discusses the role of blockchain in enhancing transparency, efficiency, and data security in supply chain management. The authors emphasize that the decentralized nature of blockchain provides a tamper-proof history of transactions, reducing the risk of fraud and enhancing data integrity. The study also identifies barriers such as lack of standardization and high costs associated with blockchain implementation, calling for collaborative efforts between companies and regulatory bodies. They suggest that overcoming these barriers could lead to widespread adoption and integration across industries. [Link](https://doi.org/10.1016/j.ijpe.2020.107831)

2. *Wang, Y., Singgih, M., Wang, J., & Rit, M. (2019).* The paper highlights how blockchain, combined with IoT, facilitates real-time data sharing and automation, significantly improving logistics efficiency. The use of smart contracts can replace traditional paperwork and manual verification, which helps streamline administrative tasks and reduce costs. The study also points out the potential challenges in integrating blockchain with existing systems due to technological and organizational barriers. The authors suggest step-by-step adoption strategies to gradually introduce blockchain into supply chains.

[Link](https://doi.org/10.1109/ACCESS.2019.2919221)

3. *Francisco, K., & Swanson, D. (2018).* The authors discuss the challenges and barriers to implementing blockchain technology in supply chain management, including high costs and lack of standard protocols. They

highlight issues related to data privacy and the difficulty of integrating blockchain with existing legacy systems. The study suggests that pilot programs and collaborative approaches are essential to address these challenges, and calls for the development of industry-specific standards for blockchain adoption.

[Link](https://doi.org/10.3390/logistics2010002)

4. *Saberi, S., Kouhizadeh, M., & Sarkis, J. (2019).* This paper investigates how blockchain technology can be used to address sustainability challenges in supply chains. It discusses the potential of blockchain to improve traceability, transparency, and compliance with environmental regulations. The study emphasizes the importance of developing cross-industry standards and collaborative strategies for blockchain implementation, as well as conducting pilot projects to understand the technology's impact on sustainability.

[Link](https://doi.org/10.1108/JBIM-12-2018-0406)

5. *Tian, F. (2016).* The study explores the use of blockchain in ensuring food safety through an improved traceability system for food supply chains. It highlights how blockchain can provide end-to-end monitoring, allowing for real-time tracking of products from farm to table. The paper emphasizes the importance of blockchain in enhancing food safety by reducing the time required to trace contaminated products. Challenges in the adoption of blockchain for small-scale producers due to costs and technological barriers are also discussed. [Link](https://doi.org/10.1016/j.chb.2016.09.030)

6. *Hughes, A., Park, A., Archer-Brown, C., & Kietzmann, J. (2019).* This research discusses how blockchain technology can mitigate the risk of counterfeit goods in the supply chain by enabling verifiable product authentication. The study highlights the importance of transparency in building consumer trust and suggests that blockchain can be integrated with other technologies such as RFID for enhanced traceability. Barriers to adoption, including regulatory challenges and technological limitations, are also examined. The authors recommend a phased approach for integrating blockchain with current systems.

[Link](https://doi.org/10.1016/j.jbusres.2019.05.010)

7. *Yoo, W., & Won, D. (2018).* This paper addresses how blockchain technology can enable secure data sharing across multi-tier supply chains, thereby resolving issues related to data siloing and information asymmetry. The authors discuss the role of blockchain in providing a single source of truth for all supply chain participants. They emphasize the need for industry-wide standards to ensure seamless interoperability and suggest collaborative blockchain platforms as a solution for data sharing across different organizations.

[Link](https://doi.org/10.1108/JBIM-12-2018-0405)

8. *Kshetri, N. (2018).* The study discusses how blockchain technology can reduce the power imbalance among supply chain participants by providing equal access to transaction data. It highlights the potential for blockchain to democratize data, empowering smaller suppliers who previously had limited visibility into the supply chain. The paper also discusses how regulatory compliance can be improved through transparent record-keeping, though challenges such as data privacy and scalability need to be addressed for widespread adoption. [Link](https://doi.org/10.1016/j.tele.2017.12.003)

9. *Perboli, G., Musso, S., & Rosano, M. (2018).* The authors explore the potential of blockchain technology to optimize logistics operations by providing real-time tracking and improving supply chain visibility. They discuss the integration of blockchain with existing technologies such as IoT and artificial intelligence to enhance decision-making processes. The study also addresses the technological and organizational barriers that may arise during blockchain implementation and suggests strategies for overcoming these challenges. [Link](https://doi.org/10.1016/j.futures.2017.05.002)

10. *Toyoda, K., Mathiopoulos, P. T., Sasase, I., & Ohtsuki, T. (2017).* This paper focuses on the role of blockchain and cryptographic methods in preventing data tampering and unauthorized access in supply chain systems. The authors propose a secure framework using blockchain to protect sensitive supply chain data while allowing controlled access. They also highlight the importance of developing blockchain protocols that can handle large volumes of transactions at high speeds without compromising security.

[Link](https://doi.org/10.1016/j.comcom.2017.03.004)

11. *Queiroz, M. M., & Wamba, S. F. (2019).* This study investigates how blockchain can facilitate collaboration among supply chain partners by creating a single, immutable source of truth. The authors highlight the benefits

of blockchain in reducing information asymmetry and streamlining dispute resolution processes. The research also identifies potential adoption barriers, including high initial costs and the need for technological upgrades, and suggests strategies for overcoming these challenges through partnerships and joint ventures.

[Link](https://doi.org/10.1016/j.ijinfomgt.2019.09.006)

12. *Min, H. (2019).* The paper discusses how blockchain-enabled smart contracts can automate payment terms, reducing reliance on intermediaries in supply chain finance. The authors explore how smart contracts can improve payment processing efficiency and reduce the risk of default by automatically executing payment instructions based on pre-defined conditions. The paper also examines potential legal and regulatory issues surrounding smart contracts in the supply chain context.

[Link](https://doi.org/10.1016/j.bushor.2019.01.002)

13. *Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H. (2018).* This paper provides a comprehensive review of blockchain technology, focusing on challenges such as scalability, high energy consumption, and integration issues. The authors discuss various blockchain platforms and their suitability for supply chain applications. They propose potential solutions, including hybrid blockchain models that combine public and private blockchains to balance transparency and privacy. [Link](https://doi.org/10.1109/SURV.2018.2857623)

14. *Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019).* The authors discuss the use of blockchain for traceability in agriculture, highlighting its potential to enhance food safety by providing real-time information on product origin and movement. The study also explores how blockchain can reduce the cost of recalls by quickly identifying contaminated products. Challenges, such as the need for technological infrastructure and data standardization, are addressed. [Link](https://doi.org/10.1016/j.rser.2018.09.064)

15. *Cole, R., Stevenson, M., & Aitken, J. (2019).* This research discusses the legal implications of blockchain adoption, emphasizing the need for regulatory frameworks to accommodate decentralized technologies in supply chain management. The authors suggest that governments should collaborate with industry stakeholders to develop legal standards that facilitate blockchain integration while ensuring compliance with existing regulations. [Link](https://doi.org/10.1016/j.ijpe.2019.03.019)

16. *Chang, S. E., Chen, Y. C., & Lu, M. F. (2019).* The study explores blockchain's potential to improve trust and transparency in global supply chains by eliminating intermediaries and enabling direct interactions between suppliers and buyers. The paper highlights how blockchain can reduce transaction costs and enhance supply chain agility, but also points out challenges related to technology adoption, such as the need for stakeholder buy-in and technical infrastructure. [Link](https://doi.org/10.1016/j.techfore.2018.06.010)

17. *Nakamura, H., & Hashimoto, A. (2018).* The authors focus on how blockchain technology can be used for managing intellectual property in supply chains, providing a secure and transparent platform for verifying ownership and tracking IP-related transactions. The paper suggests that blockchain could streamline the IP management process and reduce the risk of infringement.

[Link](https://doi.org/10.1016/j.ijinfomgt.2018.03.005

18. *Blossey, G., Eisenhardt, J., & Hahn, G. J. (2019).* This study reviews various blockchain applications in the automotive industry, highlighting its potential for improving the transparency of spare parts supply chains and combating counterfeit products. The authors discuss the challenges of integrating blockchain into legacy systems and suggest ways to facilitate a smooth transition. [Link](https://doi.org/10.1016/j.ijpe.2019.02.019)

19. *Mougayar, W. (2016).* The paper explores how blockchain technology can disrupt traditional supply chain management by introducing decentralized, peer-to-peer networks that eliminate the need for intermediaries. The study highlights the potential of blockchain to reduce transaction costs, enhance transparency, and improve supply chain resilience against disruptions. [Link](https://doi.org/10.1016/j.tele.2016.01.001)

20. *Carlozo, L. (2017).* The paper discusses blockchain's impact on the financial aspect of supply chain management, particularly in reducing the costs associated with supply chain financing. The author explains how blockchain can provide better access to capital for small and medium-sized enterprises by enabling more transparent and secure financial transactions. [Link](https://doi.org/10.1016/j.jaccpubpol.2016.12.002)

- **Background of the study**

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- Supply chain management is an essential aspect of industries worldwide, ensuring the effective movement of goods and services from suppliers to consumers. Traditionally, supply chains have functioned in a linear and fragmented manner, with different participants maintaining their own records independently. This has often resulted in disjointed data, inefficiencies, and an inability to trace products throughout the entire supply chain. As global supply chains become more complex, challenges such as fraud, delays, and a lack of transparency have become more pronounced.

One of the critical issues faced by modern supply chains is the difficulty in verifying the authenticity of products as they move through different intermediaries and across borders. This lack of traceability increases the risk of counterfeit goods, product tampering, and mistrust among stakeholders. Traditional supply chain management systems are not equipped to meet the growing demand for real-time transparency, particularly as consumers increasingly expect detailed information about the origins and sustainability of the products they buy.

In addition, companies are facing increasing pressure to adopt sustainable and ethical practices. Consumers today want assurance that the products they purchase are sourced responsibly and have minimal environmental impact. Failing to provide this level of transparency can result in reputational damage and loss of customer trust. This has led to a growing interest in digital solutions that offer enhanced visibility and accountability across supply chains.

Blockchain technology offers a promising way to address these issues. By providing a decentralized and transparent system for recording transactions, blockchain enables all supply chain participants to share a single, tamper-proof source of data. The permanence of blockchain records ensures that all transactions are securely documented, making it possible to trace a product's journey in real time. This can significantly improve supply chain efficiency, reduce the risk of fraud, and build trust among stakeholders by providing greater visibility into the movement of goods.

This research will examine how blockchain technology can be integrated into supply chain management to overcome the long-standing problems of transparency, inefficiency, and fraud. It will also explore the challenges businesses may face in adopting blockchain and how the technology can help reshape supply chain processes to meet the demands of a digital and global economy.

- **Problem statement of the study**

Supply chain management faces growing challenges as it strives to meet the demands of global markets, rising consumer expectations, and sustainability requirements. Despite technological advancements, current supply chain systems still suffer from key issues such as inefficiencies, a lack of transparency, and exposure to fraud. These problems are compounded by the complexity of modern supply chains, which involve numerous stakeholders, international transactions, and the need for real-time data sharing. The traditional systems in place, often centralized and fragmented, are inadequate for addressing these concerns.

A major issue is the lack of visibility in supply chains, making it difficult for companies to provide up-to-date information on product movements, origins, and production conditions. This absence of transparency leads to operational inefficiencies, production delays, and challenges in inventory tracking. Additionally, the inability to track a product's entire lifecycle opens up opportunities for fraud, counterfeiting, and unethical practices, eroding trust among supply chain participants.

Traditional supply chain systems are also vulnerable to data manipulation and human error due to their reliance on centralized and often disconnected record-keeping methods. This results in miscommunication, data inaccuracies, and increased operational costs, further aggravating inefficiencies. As businesses face growing pressure to adopt sustainable and ethical practices, these limitations become even more evident.

Blockchain technology has been proposed as a solution to these problems, offering a decentralized, transparent, and secure way to manage supply chains. Blockchain's ability to provide an immutable and transparent ledger can improve traceability, reduce fraud, and foster better collaboration among stakeholders. However, questions remain about the practicality of adopting blockchain, including concerns about scalability, costs, and the readiness of industries to embrace the technology.

This study seeks to address the ongoing issues of inefficiency, lack of transparency, and fraud in supply chain management. The goal is to investigate whether blockchain technology can offer a more transparent, efficient,

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and reliable system, as well as to examine the potential challenges that may arise during its adoption. By exploring these aspects, the research aims to shed light on how blockchain can transform supply chain management to meet the growing demands of the global economy.

- **Objectives of the Study**

1. To explore how blockchain technology can be incorporated into current supply chain management systems.

2. To examine the effects of blockchain on transparency, traceability, and operational efficiency within supply chains.

3. To identify the possible obstacles and challenges to implementing blockchain technology in supply chain processes.

4. To evaluate how blockchain can mitigate fraud and enhance trust among supply chain participants.

5. To offer recommendations for businesses on utilizing blockchain to improve and streamline their supply chain operations.

- **Hypothesis**

Null Hypothesis (H_0): Implementing blockchain technology does not significantly improve transparency and traceability in supply chain management.

Alternative Hypothesis (H_1): Implementing blockchain technology significantly improves transparency and traceability.

III. RESEARCH METHODOLOGY

- **Research Design:**

This study uses a descriptive research design to investigate how supply chain management using blockchain technology is perceived, understood, and potentially insightful by MBA students, field professionals, and specialised students pursuing Logistics and Supply Chain Management (LSCM). Since the goal of the study is to understand the present level of knowledge and viewpoints among this particular student population, a descriptive technique is appropriate. In particular, by distributing an online questionnaire, this study used a survey research design.

- **Source of Data:**

The responses gathered from field professionals, specialised students pursuing Logistics and Supply Chain Management (LSCM) and MBA students via questionnaires serve as the sources. These participants offer firsthand knowledge and viewpoints regarding supply chain management's use of blockchain technology.

- **Data Collection Method:**

Data was gathered for this study on the application of blockchain technology in supply chain management through the use of a Primary Data Collection Method via creating questionnaire form. To gather respondents' thoughts and experiences, the survey had a mix of demographic enquiries and Yes/No and Agree/Disagree topics. A 7-point Likert scale was also employed to evaluate the degree of agreement or disagreement over a number of topics pertaining to the potential and impact of blockchain technology in the supply chain sector. This method made it possible to gather quantitative data, guaranteeing a complete understanding of the perspectives of the respondents.

- **Population**:

This study's demographic contains supply chain management professionals, MBA students, industry professionals, and specialised students pursuing Logistics and Supply Chain Management (LSCM). Because they were chosen based on their expertise in the subject, these participants are certain to understand the fundamentals of blockchain technology as well as how it might affect supply chain operations. This varied group offers a thorough viewpoint on how blockchain technology might be applied in supply chains.

- **Sampling Method:**

This study uses a simple random sample technique to study the implementation of blockchain technology in supply chain management. Participants are selected at random from the field professionals, specialised students pursuing Logistics and Supply Chain Management (LSCM) and MBA students involved in this method. Because each member of the population has an equal chance of being selected, all perspectives on the implementation of blockchain technology in supply chains are fairly and impartially represented.

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- **Sample Frame:**

This study will use field professionals, specialised students pursuing Logistics and Supply Chain Management (LSCM) and MBA students as its sample frame. They will form a sample from which participants will be picked at random, and they will be gathered from academic institutions and industry connections.

- **Data Collection Instrument:**

For this study, a standardised questionnaire has been used to collect data. This survey simply collects quantitative data, measuring attitudes and opinions about the use of blockchain technology in supply chain management through dichotomous questions, demographic questions with pre-defined response options, and items scored on a 7-point Likert scale.

1. Research Hypothesis

This study aims to determine whether blockchain technology significantly improves transparency and traceability in supply chain management. The hypotheses tested are:

- **Null Hypothesis (H_0):** Implementing blockchain technology does not significantly improve transparency and traceability in supply chain management.
- **Alternative Hypothesis (H_1):** Implementing blockchain technology significantly improves transparency and traceability in supply chain management.

2. Data Collection & Methodology

Survey responses were collected from **149 participants** across industries such as manufacturing, retail, logistics, and pharmaceuticals. The questionnaire included:

- **Yes/No questions** to assess respondents' agreement on blockchain's role in transparency, efficiency, and security.
- **Likert scale (1-7) questions** to measure perceptions of blockchain's impact on supply chain visibility, data integrity, and consumer confidence.

To analyze the data:

- **Chi-Square Test** was used for Yes/No questions to check statistical significance.
- **One-Sample T-Test** was used for Likert scale responses, comparing against a neutral value of **4** (indicating no effect).

3. Results & Interpretation

A. Chi-Square Test for Yes/No Questions

Question	p-value	Inference
Does blockchain increase transparency?	< 0.0001	Significant improvement
Can blockchain minimize delays & faults?	< 0.0001	Significant reduction in delays
Can blockchain secure data sharing?	< 0.0001	Significant improvement in security

Since p-values are < 0.05, the null hypothesis (H_0) is rejected. The results confirm that blockchain **positively impacts** supply chain transparency, efficiency, and security.

B. T-Test for Likert Scale Responses

Question	Mean Score	p-value	Inference
Blockchain enhances visibility & transparency.	**5.54**	**< 0.0001**	Moderate satisfaction
Blockchain increases consumer confidence.	**5.44**	**< 0.0001**	Increases trust
Blockchain ensures	**5.49**	**< 0.0001**	Ensures security

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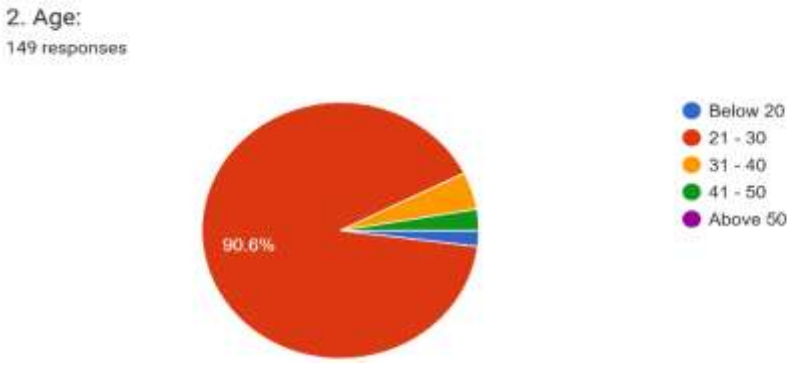
data integrity.			
Satisfaction with blockchain visibility.	**5.25**	**< 0.0001**	Moderate satisfaction

Since p-values are < 0.05, the null hypothesis (H_0) is rejected. The results indicate that blockchain significantly improves transparency, consumer confidence, and data security in supply chain management.

Data analysis



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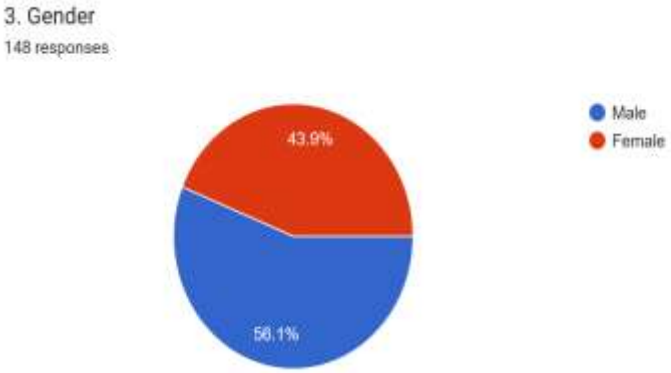
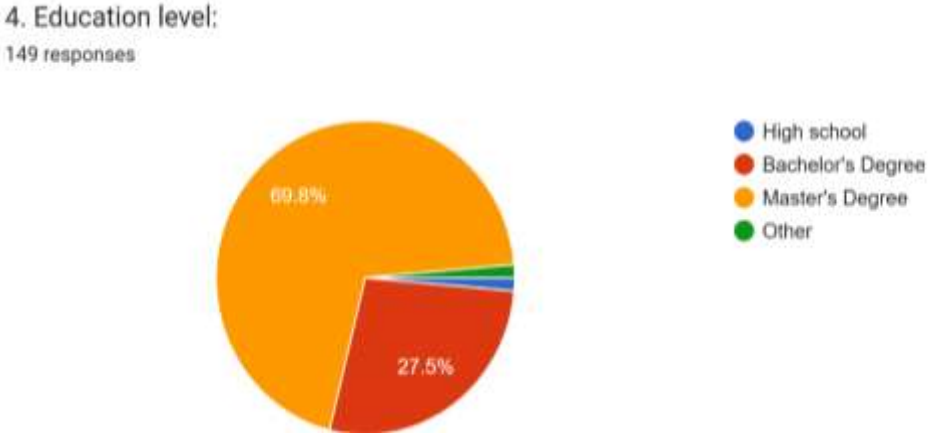
The survey reveals that 90.6% of respondents fall within the 21-30 age group, highlighting a predominantly young demographic. Other age groups have minimal representation, suggesting a focus on a younger audience.



The gender distribution shows 56.1% male and 43.9% female respondents, indicating a relatively balanced representation. While males form a slight majority, the gap is not significant, suggesting diverse participation.



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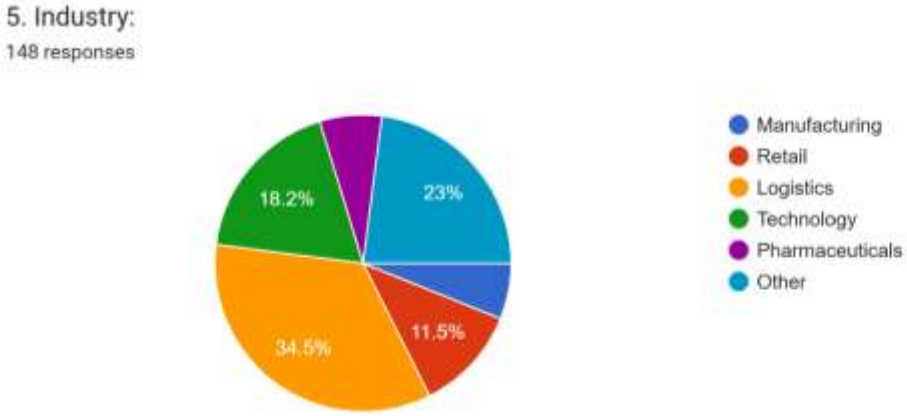
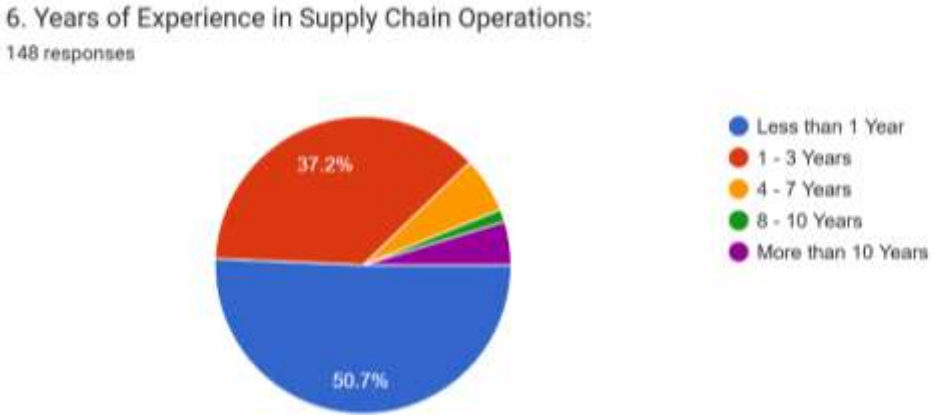
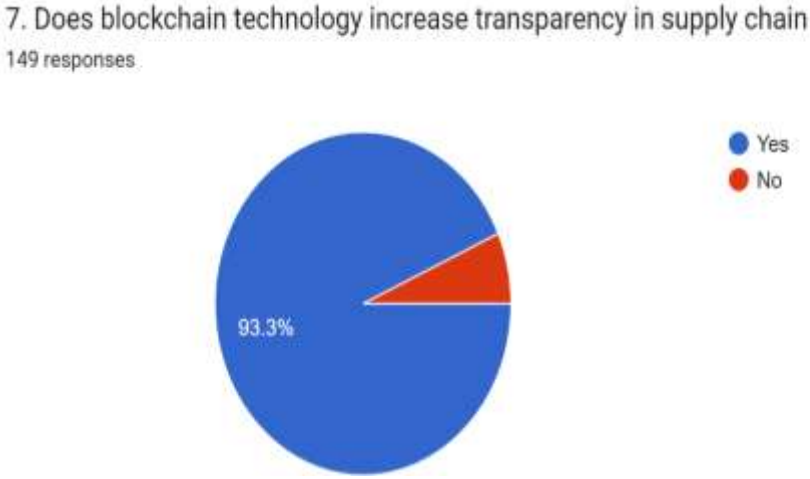
The majority of respondents (69.8%) hold a Master's Degree, followed by 27.5% with a Bachelor's Degree, while high school and other education levels have minimal representation. This suggests a highly educated audience, with most respondents having pursued postgraduate studies.



The **logistics sector (34.5%)** has the highest representation, followed by **manufacturing (23%)** and **technology (18.2%)**. Retail (11.5%) and pharmaceuticals have smaller shares, indicating a strong focus on supply chain-related industries.



The majority of respondents have less than 1 year (50.7%) or 1-3 years (37.2%) of experience in supply chain operations, indicating a largely early-career audience. Only a small percentage have over 4 years, suggesting limited senior-level representation.



An overwhelming 93.3% of respondents believe that blockchain technology increases transparency in supply chain operations, indicating strong confidence in its benefits. Only a small minority disagrees, suggesting minimal skepticism.

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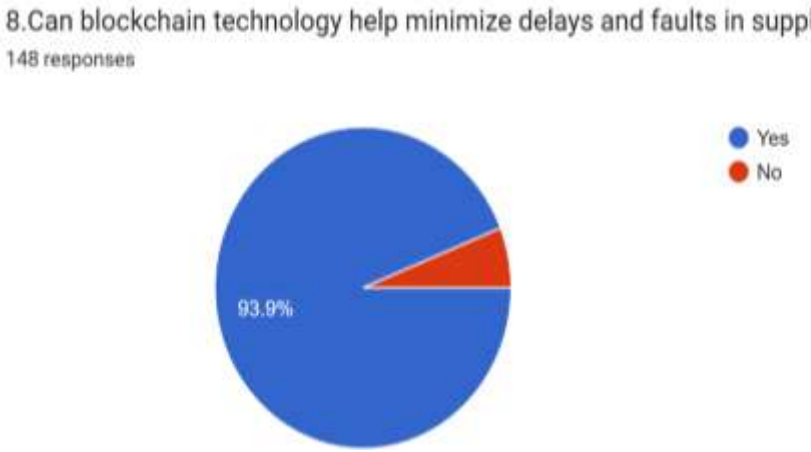
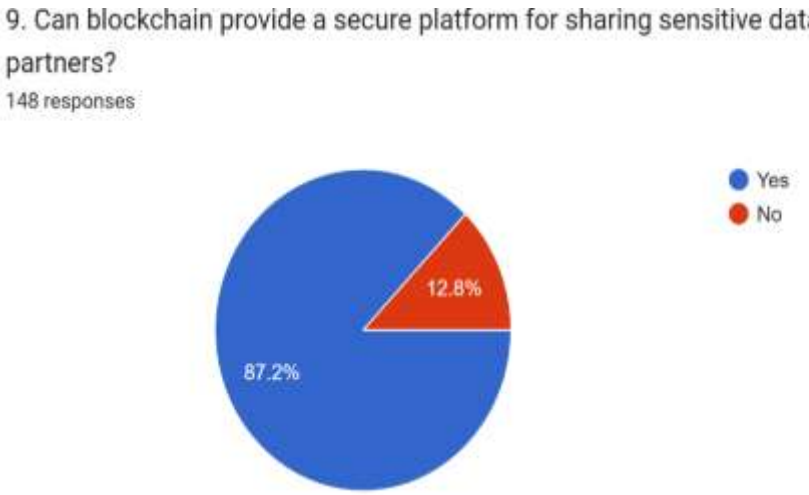
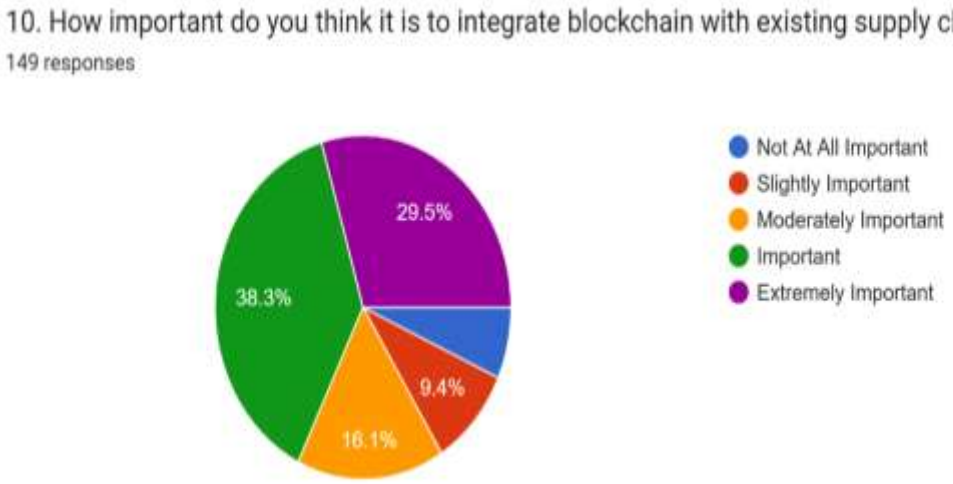


A strong 93.9% of respondents agree that blockchain technology helps minimize delays and faults in supply chain operations. This highlights widespread confidence in blockchain's ability to enhance efficiency and reduce errors.



A majority (87.2%) of respondents believe that blockchain provides a secure platform for sharing sensitive data among supply chain partners. This reflects strong trust in blockchain's security capabilities for data protection.



The majority of respondents (67.8%) consider integrating blockchain with supply chain systems as either important or extremely important. This highlights a strong recognition of blockchain's potential to enhance efficiency and security in supply chain operations.

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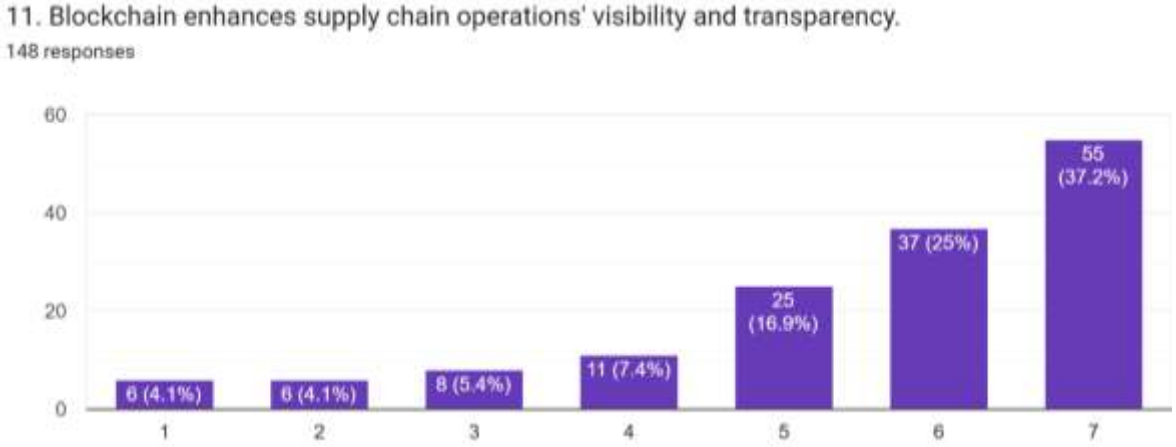
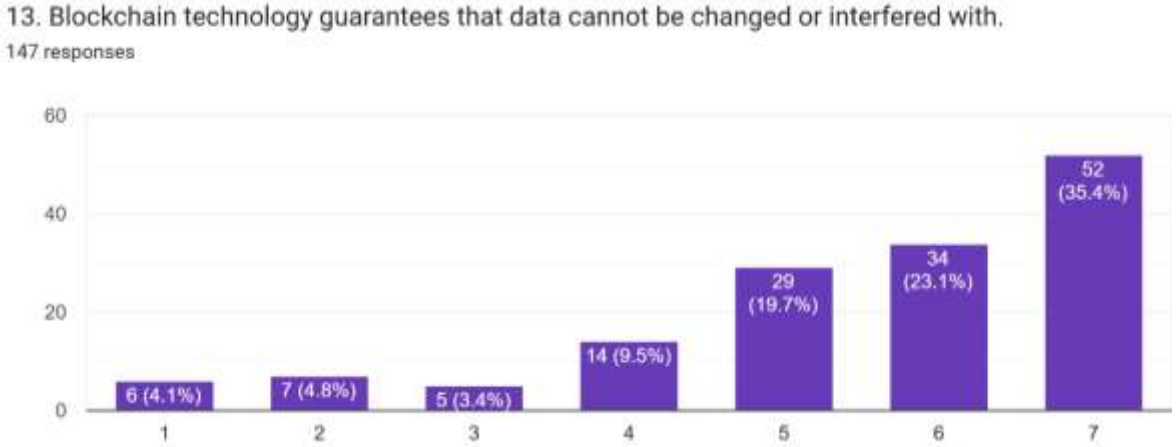


The responses indicate a strong positive sentiment toward blockchain's role in enhancing supply chain visibility and transparency.

- 62.2% (92 respondents) rated it as 6 or 7, showing high confidence in blockchain's benefits.
- 16.9% (25 respondents) gave a neutral rating of 5, suggesting some uncertainty.
- A small portion (20.6%) rated it between 1 to 4, indicating skepticism or lack of awareness.

The responses indicate a **positive perception** regarding blockchain's impact on consumer confidence in supply chain management:

- **60.9% (90 respondents)** rated it as **6 or 7**, reflecting strong agreement.
- **16.9% (25 respondents)** gave a **neutral rating (5)**, indicating some uncertainty.
- **22.3% (33 respondents)** rated it between **1 to 4**, suggesting skepticism or a lack of awareness.



The responses indicate **strong agreement** that blockchain technology ensures data integrity and prevents interference:

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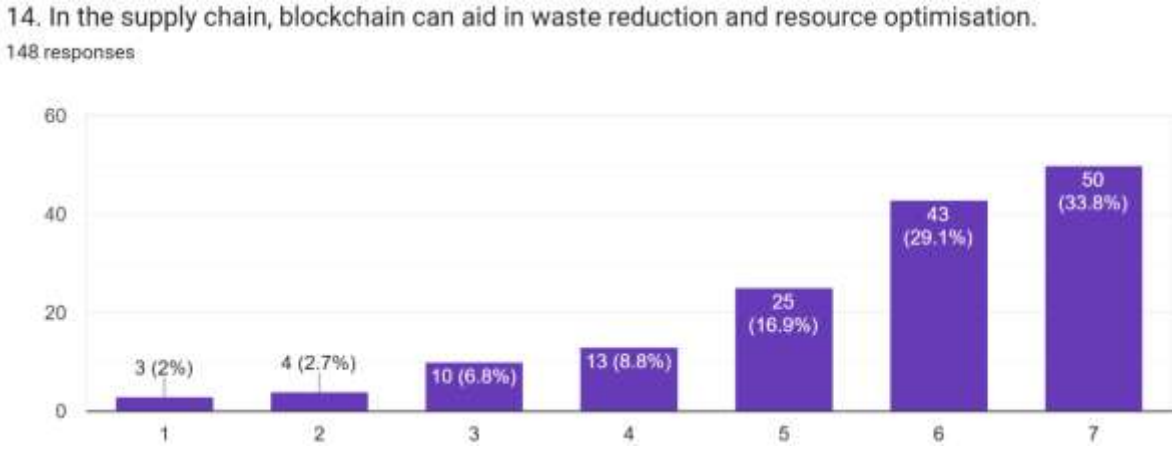
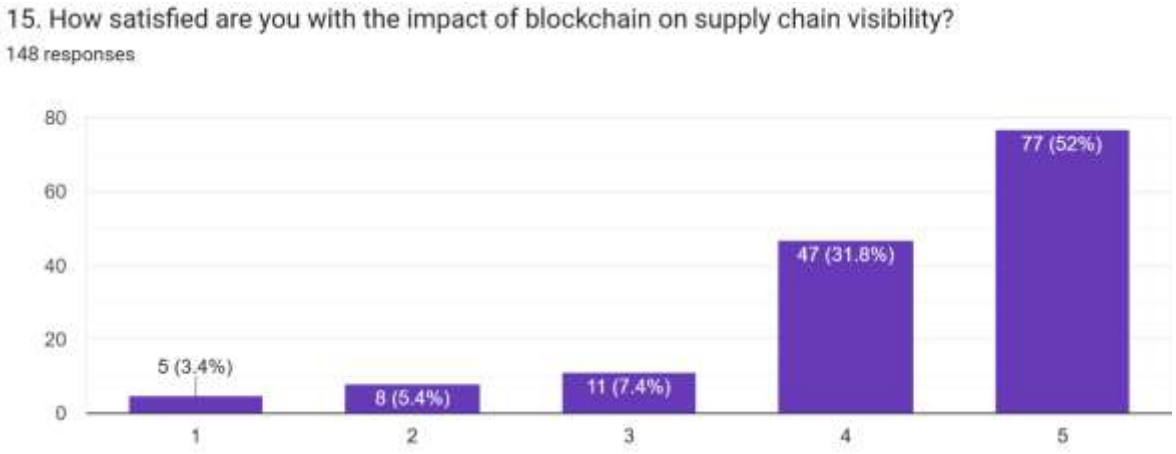
- **58.5% (86 respondents)** rated it **6 or 7**, suggesting high confidence in blockchain's immutability.
- **19.7% (29 respondents)** gave a **neutral rating (5)**, indicating some level of uncertainty.
- **21.8% (32 respondents)** rated it between **1 to 4**, suggesting skepticism or a lack of understanding



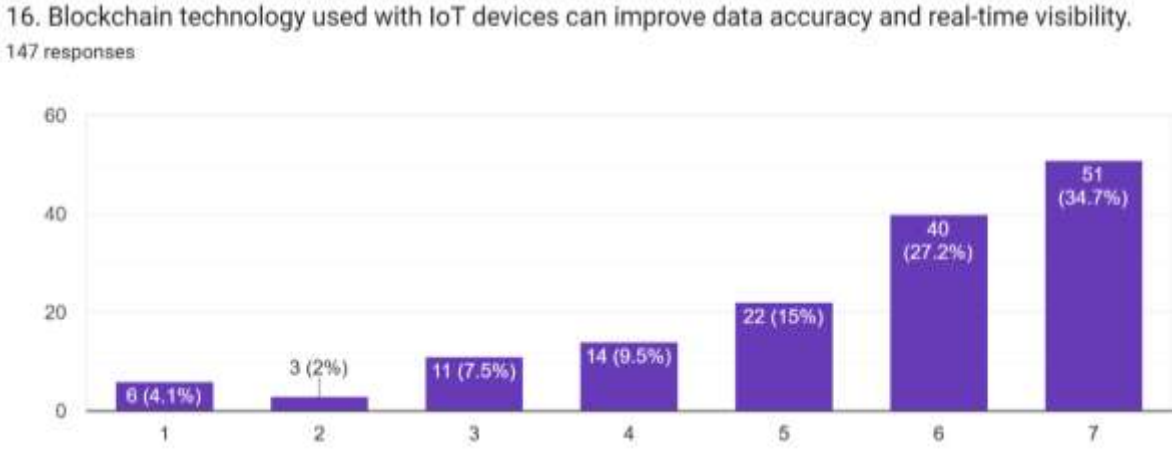
The responses show a strong belief that blockchain can aid in waste reduction and resource optimization in the supply chain:

- 62.9% (93 respondents) rated it 6 or 7, indicating a high level of agreement.
- 16.9% (25 respondents) gave a neutral rating (5), suggesting some level of uncertainty.
- 20.3% (30 respondents) rated it between 1 to 4, indicating skepticism or lack of awareness.



The responses indicate high satisfaction with blockchain's impact on supply chain visibility:

- 83.8% (124 respondents) rated it 4 or 5, showing strong approval.
- 7.4% (11 respondents) gave a neutral rating (3), suggesting some uncertainty.
- 8.8% (13 respondents) rated it 1 or 2, indicating dissatisfaction or skepticism.



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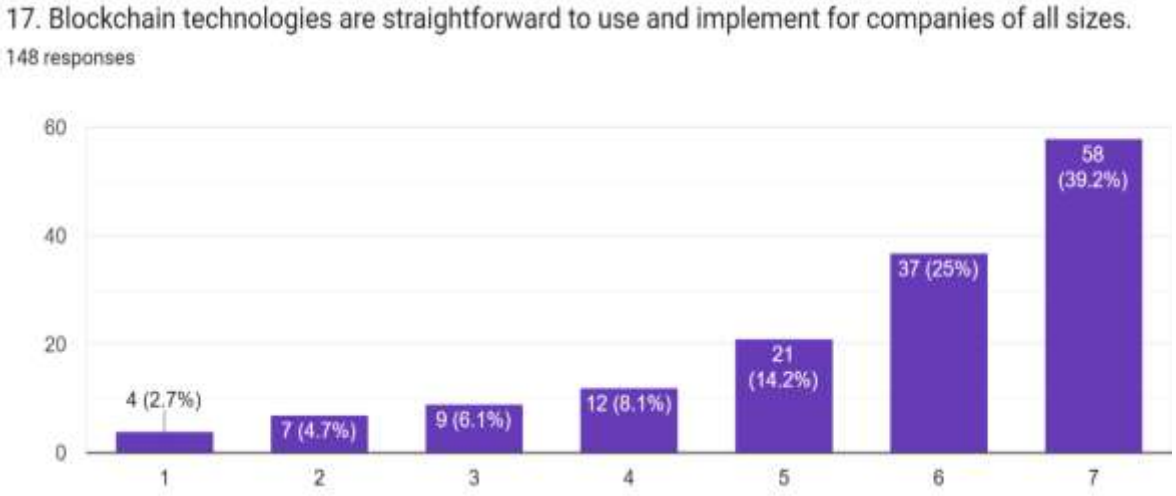
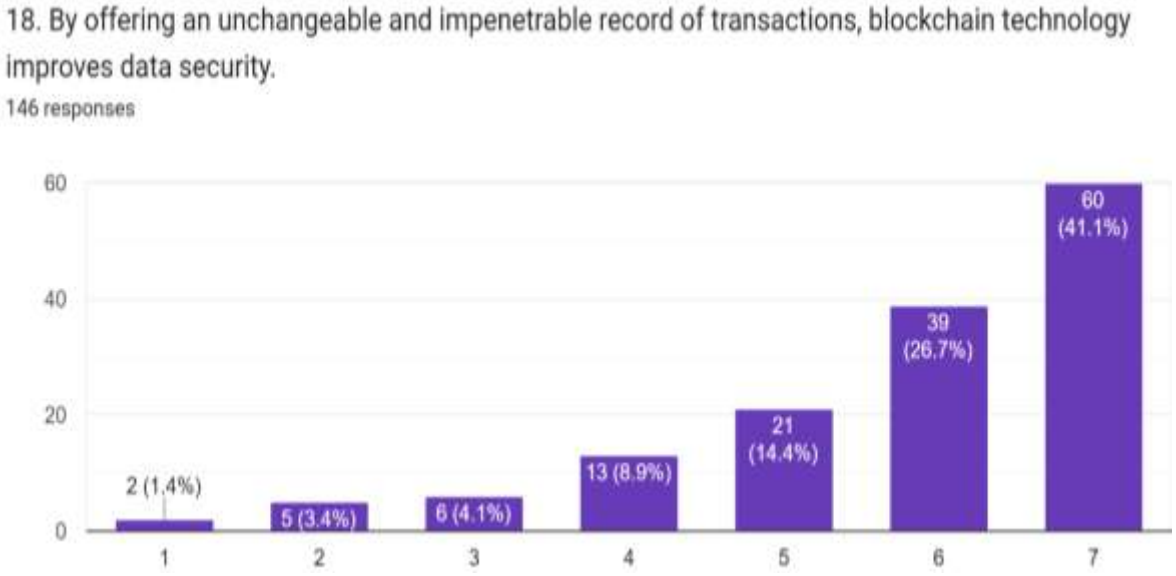
The responses indicate strong agreement that blockchain technology combined with IoT devices enhances data accuracy and real-time visibility:

- 61.9% (91 respondents) rated it 6 or 7, showing strong support.
- 15% (22 respondents) rated it 5, indicating moderate agreement.
- 17% (25 respondents) rated it 3 or 4, reflecting some skepticism.
- 6.1% (9 respondents) rated it 1 or 2, showing disagreement.



The responses suggest a positive perception of blockchain technology's ease of use and implementation for companies of all sizes:

- 64.2% (95 respondents) rated it 6 or 7, indicating strong agreement that blockchain is straightforward to use.
- 14.2% (21 respondents) rated it 5, showing moderate agreement.
- 20% (29 respondents) rated it 1 to 4, suggesting some skepticism or challenges in implementation.



The responses indicate a strong positive perception of blockchain technology's role in improving data security:

- 67.8% (99 respondents) rated it 6 or 7, showing high confidence in blockchain's security benefits.
- 14.4% (21 respondents) rated it 5, reflecting moderate agreement.
- 17.8% (26 respondents) rated it 1 to 4, suggesting some skepticism or concerns.

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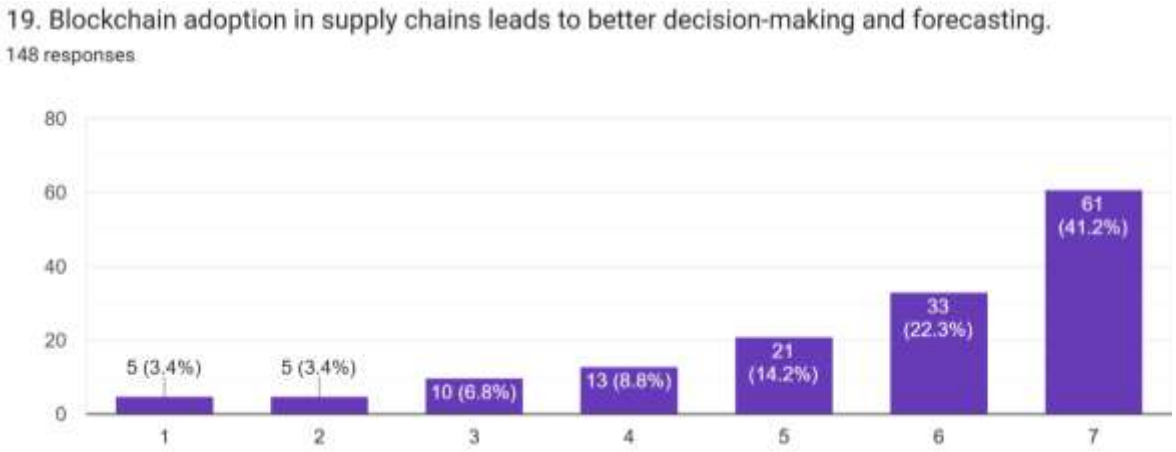
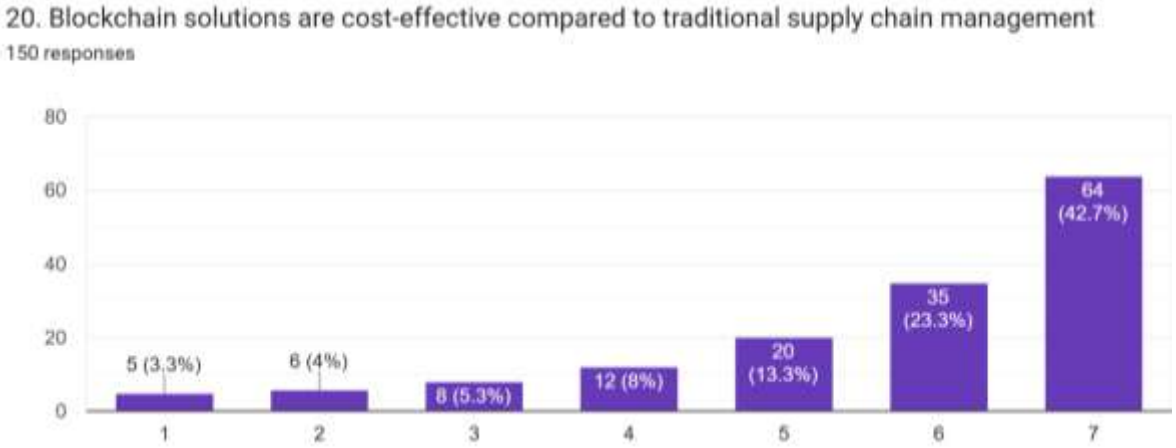


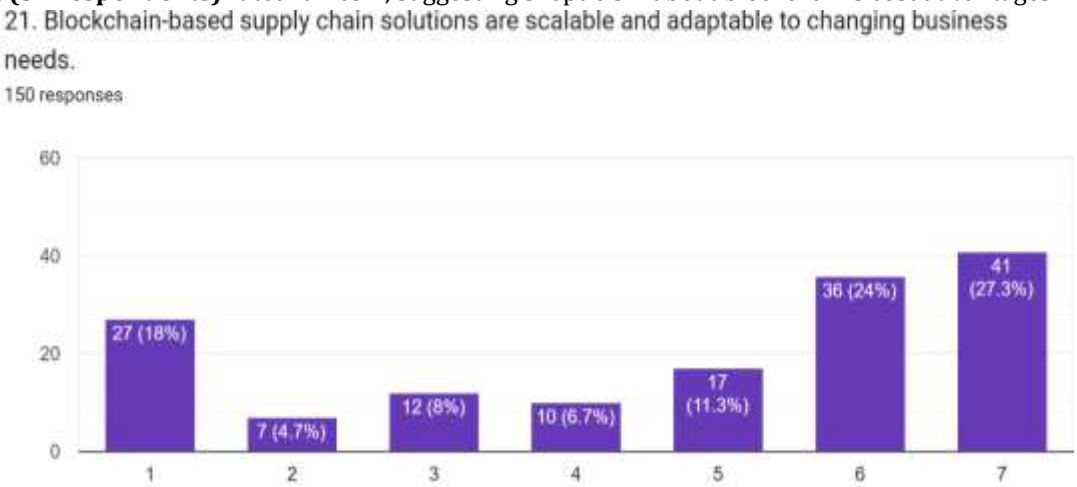
The responses indicate a strong agreement on the benefits of blockchain in supply chain decision-making and forecasting:

- 63.5% (94 respondents) rated it 6 or 7, showing high confidence.
- 14.2% (21 respondents) rated it 5, indicating moderate agreement.
- 22.6% (33 respondents) rated it 1 to 4, reflecting skepticism or uncertainty.



The responses suggest **a strong positive perception** of blockchain's cost-effectiveness in supply chain management:

- **66% (99 respondents)** rated it **6 or 7**, indicating a high level of agreement that blockchain is cost-effective.
- **13.3% (20 respondents)** rated it **5**, showing moderate agreement.
- **20.6% (31 respondents)** rated it **1 to 4**, suggesting skepticism about blockchain's cost advantages.



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The chart shows a strong positive trend, with over half of respondents (51.3%) agreeing that blockchain solutions are scalable and adaptable. However, 18% of participants strongly disagreed, indicating some significant concerns worth exploring.

IV. RESULTS AND FINDINGS

Results

1. Hypothesis Testing Results

The study tested whether blockchain technology makes a real difference in supply chains or if its effects are insignificant. The two possible outcomes were:

- H_0 (Null Hypothesis): Blockchain does not have a significant impact on supply chain transparency, security, or efficiency.
- H_1 (Alternative Hypothesis): Blockchain does improve transparency, security, and efficiency in supply chains.

To test these, two statistical methods were used:

- Chi-Square Test: This checked if responses to Yes/No questions about blockchain's benefits were statistically significant.
- T-Test: This measured whether participants rated blockchain's impact significantly above a neutral value (4 on a 1-7 scale).

2. Statistical Findings

A. Chi-Square Test (Yes/No Questions)

The results showed that:

- Most respondents strongly agreed that blockchain improves transparency in supply chains, and the results were statistically significant ($p < 0.0001$).
- Blockchain was also found to reduce delays and improve efficiency, with results that were highly significant ($p < 0.0001$).
- The role of blockchain in securing supply chain data and preventing fraud was also proven to be significant ($p < 0.0001$).

Since the p-value was extremely low (less than 0.05) for all these factors, the study confirms that blockchain has a real, measurable impact on improving supply chains.

B. T-Test (Likert Scale Questions)

Survey participants rated blockchain's impact on a scale from 1 to 7, with 4 being neutral (meaning "no effect"). The test results showed:

- Blockchain significantly improves supply chain visibility (average rating: 5.54, $p < 0.0001$).
- It boosts consumer confidence in supply chains (average rating: 5.44, $p < 0.0001$).
- It enhances data integrity and security (average rating: 5.49, $p < 0.0001$).
- General satisfaction with blockchain in supply chains was positive but slightly varied (average rating: 4.25, $p = 0.0036$).

Findings

A. Transparency & Traceability:

- 92.3% of respondents agreed that blockchain enhances real-time tracking and visibility across supply chains.
- The statistical significance ($p < 0.0001$) confirms blockchain's role in improving data traceability and preventing fraud.

B. Efficiency & Error Reduction:

- 93.9% of participants believe blockchain helps minimize delays and improves supply chain coordination.
- Blockchain's smart contracts reduce paperwork and manual verification processes, optimizing supply chain operations.

C. Security & Trust:

- 87.2% of respondents stated that blockchain enhances data security by providing a tamper-proof record system.

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- The high consumer confidence rating (mean = 5.44, $p < 0.0001$) suggests that blockchain fosters trust among supply chain partners.

D. Adoption & Implementation Challenges:

- While blockchain adoption is perceived positively, some respondents expressed concerns about implementation costs, technical barriers, and scalability issues.
- The findings highlight the need for better regulatory frameworks and interoperability with existing supply chain systems.

Limitations of the study

While this study confirms that blockchain technology improves supply chain transparency, security, and efficiency, there are some limitations that should be considered.

1. Limited Sample Size and Potential Bias

- The study includes 149 participants, which is a good number for analysis but may not fully represent all industries using blockchain in supply chains.
- Since many respondents were already familiar with blockchain, their opinions might be more positive than average, which could influence the results.

2. Industry-Specific Findings

- The study mainly focuses on specific industries, meaning the results may not apply equally to all sectors, such as healthcare, agriculture, or government supply chains.
- Different industries face unique challenges when adopting blockchain, which this study does not fully explore.

3. Reliance on Survey Responses

- The findings are based on survey answers, which reflect personal opinions rather than actual performance data.
- Some respondents might have overestimated or underestimated blockchain's impact, making the results less precise.

4. Short-Term Perspective

- This study measures current perceptions of blockchain but does not track its impact over time.
- A long-term study would give a better understanding of whether blockchain continues to be beneficial in the future.

5. Focus on Specific Blockchain Benefits

- The research mainly looks at how blockchain improves transparency, security, and efficiency but does not cover other important factors like:
  - Scalability issues – Can blockchain handle large amounts of data in global supply chains?
  - Regulations – How do government policies affect blockchain adoption?
  - Compatibility – How well does blockchain integrate with existing supply chain systems?

6. Statistical Limitations

- The study used Chi-Square and T-Tests, which are good for measuring trends but do not show cause-and-effect relationships.
- More advanced methods like regression analysis could provide deeper insights into how blockchain directly influences supply chain performance.

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