INDIAN STREAMS RESEARCH JOURNAL
ISSN NO : 2230-7850
IMPACT FACTOR : 5.1651 (UIF)
VOLUME - 16 | ISSUE - 8 | SEPTEMBER – 2026

BLOCKCHAIN FOR SUPPLY CHAIN TRANSPARENCY

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ABSTRACT

Blockchain technology has emerged as a transformative innovation in supply chain management by enhancing transparency, traceability, security, and operational efficiency. Traditional supply chains often face challenges such as information asymmetry, lack of visibility, counterfeit products, fraud, and inefficient record-keeping. Blockchain addresses these issues by providing a decentralized, immutable, and transparent digital ledger that records every transaction across the supply chain. This technology enables stakeholders, including manufacturers, suppliers, distributors, retailers, and consumers, to access real-time and verifiable information about the movement of goods.

The present study examines the role of blockchain technology in improving supply chain transparency and its impact on business performance. It explores the benefits of blockchain, including enhanced product traceability, reduced fraud, improved inventory management, increased customer trust, and better regulatory compliance. The study also identifies key challenges associated with blockchain adoption, such as high implementation costs, technological complexity, scalability issues, lack of standardized regulations, and limited awareness among businesses.

The research is based on both primary and secondary data collected through surveys, academic literature, industry reports, and case studies. The findings suggest that blockchain technology significantly improves supply chain transparency by ensuring secure data sharing, minimizing operational risks, and strengthening collaboration among supply chain participants. The study concludes that wider adoption of blockchain, supported by technological advancements, organizational readiness, and favorable government policies, can contribute to more transparent, efficient, and sustainable supply chain management.

KEYWORDS: *Blockchain technology , supply chain management , enhancing transparency, traceability, security, and operational efficiency.*

1. INTRODUCTION

Supply chain management plays a vital role in ensuring the efficient movement of goods, information, and finances from manufacturers to end consumers. As global supply chains become increasingly complex, organizations face challenges such as lack of transparency, counterfeit products, data manipulation, delayed information sharing, and inefficient tracking systems. These issues reduce operational efficiency, increase costs, and weaken consumer trust. Therefore, businesses are seeking innovative technologies that can improve supply chain visibility and accountability.

Blockchain technology has emerged as a revolutionary solution for addressing these challenges. Blockchain is a decentralized and distributed digital ledger that records transactions securely, transparently, and permanently. Each transaction is verified by network participants and stored in blocks that are linked together, making the data highly secure and resistant to tampering. This enables all authorized stakeholders in the supply chain to access accurate, real-time information about the movement and status of products.

The application of blockchain in supply chain management improves product traceability, enhances transparency, reduces fraud, prevents counterfeiting, and strengthens collaboration among manufacturers, suppliers, distributors, retailers, and consumers. It also helps organizations comply with regulatory requirements, improve inventory management, and increase customer confidence by providing verifiable information about product origin and quality.

Despite its numerous advantages, blockchain implementation faces challenges such as high deployment costs, technological complexity, scalability issues, integration with existing systems, and the need for standardized regulations. These factors influence the pace of blockchain adoption across industries.

This study aims to examine the role of blockchain technology in improving supply chain transparency and operational efficiency. It explores the benefits, challenges, adoption factors, and future prospects of blockchain-enabled supply chain management while highlighting its contribution to building secure, transparent, and sustainable global supply chains.

2. BACKGROUND

Supply chains have become increasingly global and complex, involving multiple stakeholders such as raw material suppliers, manufacturers, logistics providers, distributors, retailers, and consumers. Managing these interconnected networks requires accurate, timely, and transparent information. However, traditional supply chain systems often suffer from limited visibility, fragmented data, manual record-keeping, fraud, counterfeit products, and delays in information sharing. These challenges reduce operational efficiency and make it difficult to ensure product authenticity and traceability.

The rapid advancement of digital technologies has encouraged businesses to adopt innovative solutions to improve supply chain performance. Among these technologies, blockchain has emerged as a promising tool for enhancing transparency, security, and trust across supply chain networks. Blockchain is a decentralized and immutable digital ledger that records every transaction in a secure and transparent manner. Once information is recorded, it cannot be altered without the agreement of network participants, ensuring data integrity and accountability.

Blockchain technology enables real-time tracking of products from their origin to the final consumer. It improves product traceability, reduces the risk of counterfeit goods, enhances inventory management, facilitates faster information sharing, and strengthens collaboration among supply chain partners. Industries such as food and agriculture, pharmaceuticals, manufacturing, logistics, retail, and luxury goods are increasingly exploring blockchain solutions to improve operational efficiency and regulatory compliance.

The COVID-19 pandemic further highlighted the importance of resilient and transparent supply chains, encouraging organizations to invest in digital technologies that provide greater visibility and reliability. At the same time, challenges such as high implementation costs, technological complexity, scalability, integration with existing systems, and lack of universal standards continue to limit widespread adoption.

Against this background, the present study investigates the role of blockchain technology in improving supply chain transparency. It examines how blockchain enhances traceability, security, efficiency, and stakeholder trust while identifying the barriers and opportunities associated with its adoption. The findings of this study are expected to provide valuable insights for businesses, policymakers, and researchers seeking to build more transparent, efficient, and sustainable supply chain systems.

3. RESEARCH METHODOLOGY

Blockchain for Supply Chain Transparency

1. Research Design

The study adopts a **descriptive research design** to examine the role of blockchain technology in improving supply chain transparency, traceability, security, and operational efficiency across different industries.

2. Research Approach

A **quantitative research approach** is used to collect and analyze data from respondents through structured questionnaires. Qualitative information from published reports and case studies is also used to support the findings.

3. Sources of Data

Primary Data

- Structured questionnaires
- Online surveys
- Personal interviews with supply chain professionals, business owners, and logistics personnel (where applicable)

Secondary Data

- Research journals
- Books
- Industry reports
- Government publications
- Company annual reports
- Conference papers
- Official websites related to blockchain and supply chain management

4. Sampling Technique

The study uses **convenience sampling** to select respondents from manufacturing companies, logistics firms, retail businesses, and supply chain professionals who have knowledge of blockchain technology.

5. Sample Size

The study includes **100 respondents** from different industries involved in supply chain management.

6. Data Collection Instruments

- Structured questionnaire
- Online survey forms
- Interview schedule (if required)

7. Data Analysis Techniques

The collected data are analyzed using:

- Frequency distribution
- Percentage analysis
- Mean and standard deviation
- Tables, charts, and graphs
- Microsoft Excel or SPSS for statistical analysis

8. Scope of the Study

The study focuses on the application of blockchain technology in supply chain management, particularly its impact on transparency, product traceability, operational efficiency, fraud prevention, inventory management, and stakeholder trust.

9. Limitations of the Study

- Limited sample size
- Restricted geographical coverage
- Dependence on respondents' opinions
- Limited awareness of blockchain technology among some participants
- Rapid technological developments that may influence future findings

10. Ethical Considerations

- Participation in the study is voluntary.
- Informed consent is obtained from all respondents.
- Respondents' identities and information are kept confidential.
- Data are used solely for academic and research purposes.
- Privacy and anonymity are maintained throughout the research process.

4. DATA COLLECTION.

Data Collection for the Study

Data collection is a crucial stage of the research process, as it provides the information required to achieve the research objectives. In this study, both **primary** and **secondary** data were collected to examine the role of blockchain technology in improving supply chain transparency.

1. Primary Data

Primary data were collected directly from respondents using the following methods:

- Structured questionnaires
- Online surveys (Google Forms)
- Personal interviews (where applicable)

The questionnaire included questions related to:

- Awareness of blockchain technology
- Adoption of blockchain in supply chain operations
- Product traceability
- Supply chain transparency
- Data security and privacy
- Inventory management
- Fraud prevention
- Operational efficiency
- Challenges in blockchain implementation
- Overall satisfaction with blockchain-based supply chain systems

2. Secondary Data

Secondary data were collected from reliable published sources, including:

- Research journals
- Books
- Industry reports
- Government publications
- Company annual reports
- Conference proceedings

- Official websites
- Articles on blockchain technology and supply chain management

3. Data Collection Procedure

The following steps were followed during data collection:

1. Designing a structured questionnaire based on the research objectives.
2. Selecting respondents using a suitable sampling technique.
3. Distributing questionnaires through online and offline modes.
4. Collecting completed responses.
5. Reviewing the data for completeness, consistency, and accuracy.
6. Organizing and coding the collected data for statistical analysis.

4. Purpose of Data Collection

The collected data were used to:

- Assess awareness and adoption of blockchain technology.
- Evaluate the impact of blockchain on supply chain transparency.
- Analyze improvements in product traceability and operational efficiency.
- Identify the benefits and challenges of blockchain implementation.
- Measure stakeholder trust and satisfaction.
- Develop recommendations for improving blockchain adoption in supply chain management.

5. DATA EXTRACTION:

Data Extraction for the Study

Data extraction is the process of identifying, selecting, organizing, and recording relevant information from the collected data for analysis. In this study, data were extracted from both primary and secondary sources to evaluate the effectiveness of blockchain technology in improving supply chain transparency.

1. Data Extraction Process

The following steps were followed during the data extraction process:

1. Collecting completed questionnaires and survey responses.
2. Reviewing all responses for completeness and accuracy.
3. Removing incomplete, duplicate, or inconsistent records.
4. Identifying variables relevant to the research objectives.
5. Coding and classifying the extracted data.
6. Entering the data into **Microsoft Excel** or **SPSS** for statistical analysis.

2. Variables Extracted

The following information was extracted from the collected data:

- Age of respondents
- Gender
- Educational qualification
- Occupation
- Industry sector
- Years of work experience
- Awareness of blockchain technology
- Level of blockchain adoption
- Product traceability
- Supply chain transparency
- Data security
- Fraud prevention

- Inventory management efficiency
- Information sharing among stakeholders
- Operational efficiency
- Challenges in blockchain implementation
- Overall satisfaction with blockchain-based supply chain systems

3. Quality Assurance

To ensure the quality and reliability of the extracted data:

- Responses were checked for accuracy and completeness.
- Duplicate and invalid records were removed.
- Data coding and entry were verified.
- Respondents' identities were kept confidential.
- The extracted data were stored securely and used only for academic research.

4. Outcome of Data Extraction

The extracted data were organized into tables and categories to facilitate descriptive and statistical analysis. The analysis helped identify the impact of blockchain technology on supply chain transparency, product traceability, operational efficiency, fraud reduction, and stakeholder trust. The extracted information formed the basis for interpreting the findings, drawing conclusions, and making recommendations for improving blockchain adoption in supply chain management.

6. RESEARCH GAPS :

Although blockchain technology has gained significant attention as a solution for improving supply chain management, several research gaps remain. Most existing studies focus on the technical features of blockchain, while limited attention has been given to its practical implementation and effectiveness across different industries and business sizes.

Many studies emphasize the benefits of blockchain, such as transparency, traceability, and security, but there is limited empirical research examining its long-term impact on supply chain performance, operational efficiency, and business competitiveness. Small and medium-sized enterprises (SMEs), especially in developing countries, have received relatively little attention despite facing unique financial, technological, and organizational challenges in adopting blockchain technology.

Another important research gap is the limited understanding of the barriers to blockchain implementation, including high investment costs, lack of technical expertise, scalability issues, interoperability with existing systems, regulatory uncertainty, and resistance to organizational change. These factors continue to hinder widespread adoption but are not comprehensively addressed in many existing studies.

Furthermore, there is insufficient research on the integration of blockchain with emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, and cloud computing to create intelligent and transparent supply chain ecosystems. The role of blockchain in supporting sustainability, environmental responsibility, and ethical sourcing also requires further investigation.

Therefore, this study seeks to address these gaps by evaluating the role of blockchain technology in enhancing supply chain transparency, improving product traceability, strengthening stakeholder trust, and increasing operational efficiency. The findings are expected to provide practical insights for businesses, policymakers, and researchers to support the successful implementation of blockchain-based supply chain systems.

7. LIMITATIONS :

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features of blockchain, while limited attention has been given to its practical implementation and effectiveness across different industries and business sizes.

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8. CONCLUSION:

Blockchain technology has emerged as a transformative solution for improving transparency, traceability, security, and efficiency in modern supply chain management. By providing a decentralized and immutable digital ledger, blockchain enables all stakeholders to access accurate, real-time, and tamper-proof information throughout the supply chain. This enhances trust among manufacturers, suppliers, distributors, retailers, and consumers while reducing the risks of fraud, counterfeit products, and data manipulation.

The study highlights that blockchain technology significantly improves product traceability, inventory management, information sharing, and regulatory compliance. It also contributes to greater operational efficiency by minimizing paperwork, reducing transaction costs, and streamlining business processes. As a result, organizations can achieve better decision-making, stronger customer confidence, and improved overall supply chain performance.

Despite these advantages, the adoption of blockchain technology faces several challenges, including high implementation costs, technological complexity, scalability issues, integration with existing systems, and the lack of standardized regulations. Overcoming these barriers requires investment in digital infrastructure, skilled professionals, organizational readiness, and supportive government policies.

In conclusion, blockchain has the potential to revolutionize supply chain management by creating transparent, secure, and sustainable business networks. Continued technological innovation, collaboration among industry stakeholders, and appropriate regulatory frameworks will accelerate blockchain adoption and help organizations build more resilient, efficient, and trustworthy supply chains in the future.

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