*Section A-Research paper*

# A BLOCKCHAIN-BASED MODEL FOR IMPROVED SUPPLY CHAIN MANAGEMENT TRANSPARENCY AND TRACEABILITY

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**Abstract: -** Coordination and administration of several tasks necessary for the production and delivery of products and services are tasks that fall under the purview of supply chain management. Lack of transparency and traceability is one of the main issues with supply chain management. The inability to track the transfer of products and services from one stage to another may result in issues including inefficiencies, fraud, and counterfeiting. Supply chain management may benefit from increased openness and traceability thanks to blockchain technology. A distributed ledger called a blockchain is used to securely and openly record transactions. Every transaction is confirmed by a network of users, and once it has been recorded, it cannot be changed. Due to its ability to trace the flow of products and services in a safe and transparent manner, blockchain technology is suitable for supply chain management. To implement a blockchain-based solution for supply chain management, the following steps can be taken, Identify the supply chain participants: The first step is to identify all the participants in the supply chain, including suppliers, manufacturers, distributors, and retailers. Each participant will be given a unique identity on the blockchain. Create a blockchain network:

A blockchain network will be created that includes all the identified participants. This network will be used to record all transactions in the supply chain. Record all transactions, all transactions in the supply chain will be recorded on the blockchain. This includes the movement of goods from one participant to another, as well as any payments made along the way. Before being added to the blockchain, each transaction will first be validated by a network of users. This guarantees that there are no mistakes or inconsistencies and that all transactions are authentic. Real-time visibility, The

flow of products and services will be visible to supply chain participants in real time. They will be able to identify and fix any issues or delays in the supply chain as a result.. Enhance security and privacy, Blockchain technology provides enhanced security and privacy, which can help prevent counterfeiting and fraud. Every user will have a unique identity and access to the information they need to participate in the supply chain on the blockchain. In general, a blockchain-based supply chain management solution may enhance security and privacy, increase transparency and traceability, and offer real-time visibility into the flow of products and services. This can assist decrease inefficiencies and costs, as well as stop fraud and counterfeiting, eventually resulting in a supply chain that is more effective and efficient.

**Keywords:** Blockchain technology, Supply chain efficiency, Sustainability, Encryption, Hash functions, counterfeiting, ethical sourcing, statistical methods, Pandas series

## 1. INTRODUCTION

You would need to take into account a number of factors, including the industry, the kind of goods or services being supplied, the level of complexity of the chain of supply, and the degree of trust between the various parties involved, to determine blockchain technology's suitability for the most common supply chains. Here are some actions you may take to assess whether blockchain technology is appropriate for a certain supply chain. Start by being familiar with the present supply chain process and the different players, such as manufacturers, suppliers, distributors, retailers, and customers. Identify the key the challenges that the supply chain faces, such as monitoring, visibility, and inventory control, as well as any possible advantages of blockchain technology. Evaluate the suitability of blockchain technology: Assess whether blockchain technology is suitable for the specific supply chain based on its features and capabilities. For instance, blockchain technology can provide transparency, traceability, and immutability ,which are especially helpful in supply chains when there are many parties involved and there is a high level of complexity.

### 1.1. Benefits and challenges of utilising blockchain technology:

For supply chain management, This technology provides a number of potential advantages, such as improved efficiency, traceability, and transparency. Things might change as they move down the supply chain offer a safe and decentralised method of tracking them, lowering the danger of fraud, forgery, and other forms of corruption. Blockchain technology can also increase supply chain efficiency by enabling automated transactions and supplying real-time data on the status of items. These include problems with data privacy, scalability, and interoperability. The adoption of new technology and procedures by supply chain stakeholders may also provide difficulties.

- **Identify the stakeholders:** Identify the supply chain's stakeholders and the extent of their involvement. Identify the critical stakeholders that need to participate in the blockchain network, such as manufacturers, suppliers, distributors, and retailers.
- **Determine the scope:** Define the scope of the blockchain network, including the products or services covered, the data that will be shared, and the business processes involved.
- **Develop a proof of concept:** Develop a proof of concept to test the feasibility of the blockchain solution. This may include setting up a little blockchain network to follow the the movement of commodities from the producer to the buyer.
- **Evaluate the results:** Evaluate the results of the proof of concept to determine whether the blockchain solution is feasible and can deliver the desired benefits. To find opportunities for improvement, this can entail comparing the blockchain system with the current supply chain process.
- **Implement solution:** If the blockchain solution is feasible and can deliver the desired benefits, then implement the solution on a larger scale.

Determining the applicability of blockchain to most frequent supply chain requires a thorough knowledge of supply chain operations, the challenges faced, and the potential benefits that blockchain technology could bring. It also requires careful planning and execution to develop a viable blockchain solution that can deliver the desired benefits. Automating certain criteria in the supply chain can bring significant benefits, including improved efficiency, increased transparency, and reduced costs. Blockchain technology can be particularly useful in achieving these benefits by providing a decentralized and secure way to record and verify transactions in real-time. Here are some criteria that can be automated in the supply chain with blockchain technology:

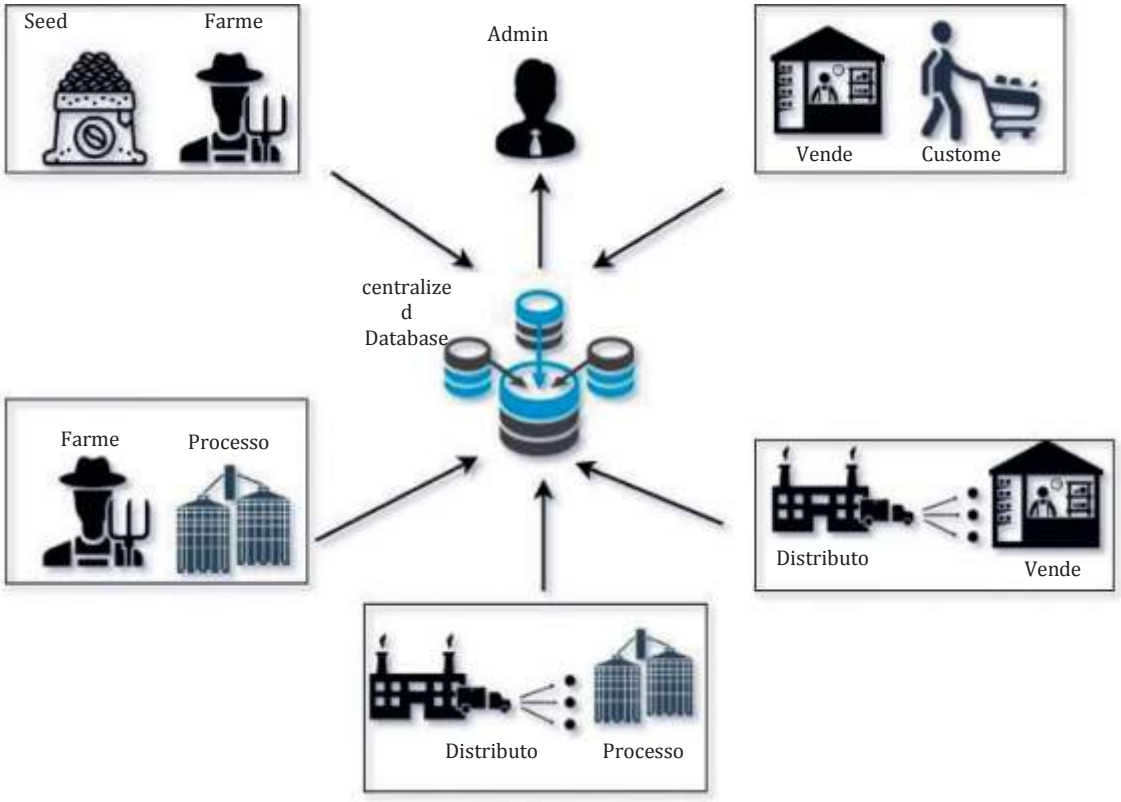


Figure 1: Centralized food supply chain.

- **Track and Trace:** Throughout the supply chain, items and resources may be tracked using blockchain technology, giving insight into their place of origin, route taken, and state. This can help in ensuring quality control, preventing fraud and counterfeiting, and ensuring compliance with regulations. Inventory Management: Blockchain technology can provide real-time inventory management, enabling businesses to optimize their stock levels and reduce wastage. This can also help in predicting demand, improving supply chain planning, and reducing costs.
- **Payment Processing:** Blockchain technology can automate payment processing by enabling direct, secure, and transparent transactions between parties without the need for intermediaries. This may aid in cutting down on processing times and transaction expenses.
- **Supplier Management:** Blockchain technology can automate supplier management by providing a secure and decentralized platform for managing contracts, agreements, and other important documents.

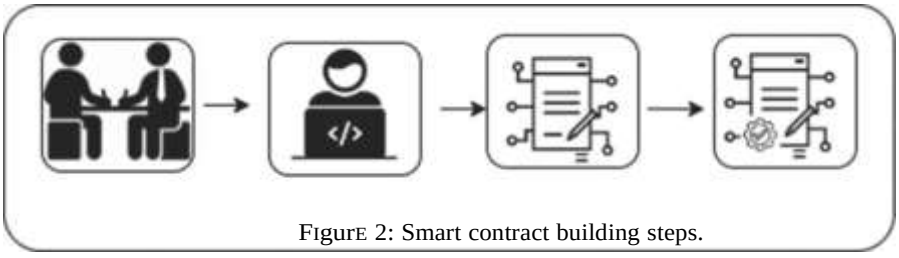

FIGURE 2: Smart contract building steps.

**Blockchain Technology for the Supply Chain**

Determining which criteria to automate with blockchain technology depends on the specific needs and challenges of each supply chain. To find areas that might benefit, it is crucial to perform a thorough examination of the supply chain from automation and evaluate the potential blockchain technology's effects on several domains. Additionally it is crucial to take the expenses and resources into account. required to implement blockchain technology and ensure that it aligns with the overall business strategy. One possible blockchain architecture that could improve upon existing supply chain management technology is a permissioned, multi-tiered blockchain network with smart contract functionality and data privacy features.

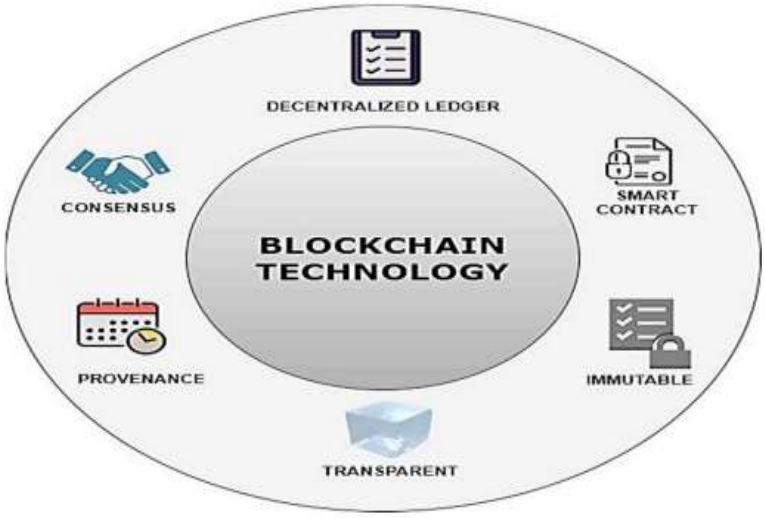


Figure 3: Decentralized smart contract-based supply chain.

This blockchain architecture would involve a network of multiple tiers of participants, including manufacturers, distributors, retailers, and consumers, each with their own permissioned nodes on the network. Each participant would be able to access and update relevant data on the blockchain, but would only have permission to see data that is relevant to their role in the supply chain. The supply chain would employ smart contracts to automate some procedures and enforce regulations, such as payment terms, shipping schedules, and quality control checks. These contracts could also be programmed to trigger certain actions based on predefined conditions, such as initiating a recall if a product fails a quality test. To ensure data privacy and security, the blockchain could incorporate features such as encryption, hash functions, and zero-knowledge proofs. This would help protect sensitive data such as pricing information, intellectual property, and confidential business agreements. Overall, this blockchain architecture could improve supply chain management by enhancing data security and privacy and improving openness, traceability, and efficiency. You could take into account the following actions to validate a proposed model for supply chain management automation utilising blockchain technology:

- **Clearly define the problem:** Before validating the model, it's important to clearly define the problem that the model is meant to solve. This could include issues such as inefficient supply chain management, lack of transparency, and high levels of fraud and counterfeiting.
- **Develop the model:** Once you've defined the problem, you can begin developing the model. This may involve creating a prototype or simulation of the model, or building a proof of concept to demonstrate how it would work in practice.
- **Test the model:** Once the model has been developed, it's important to test it to ensure that it works as intended. This could involve running simulations or pilot projects, or conducting user testing to gather feedback from stakeholders.
- **Evaluate the results:** After testing the model, you'll need to evaluate the results to determine whether it's successful in achieving its intended goals. This could involve measuring improvements in supply chain efficiency, transparency, and reduction in fraud and counterfeiting.
- **Iterate and refine:** Based on the results of your evaluation, you may need to iterate and refine the model to address any issues or shortcomings that were identified during testing. This could involve making changes to the underlying blockchain technology or adjusting the model's parameters to better align with the needs of stakeholders.

validating a model for supply chain management automation using blockchain technology will require a thorough understanding of the problem you're trying to solve, as well as a deep knowledge of the underlying blockchain and how it can be applied to supply chain management. It's important to engage with stakeholders throughout the validation process to ensure that their needs are being met and to gather feedback that can inform future iterations of the model.

## 2. LITERATURE REVIEW

This review of the literature aims to examine the most recent studies on enhancing the transparency and traceability of supply chain management with blockchain technology. The benefits and challenges of employing blockchain technology, previous studies on its application to supply chain management, The review's major elements will be the proposed model for employing enhancing the transparency and traceability of supply chain management with blockchain technology. .Research on managing supply chains using blockchain technology has already found:

**TABLE 1. Analyze and compare the existing and proposed surveys based on a comparative analysis.**

| Related survey | Years | Objectives | Key Contribution | Limitations and open access |
|---|---|---|---|---|
| | 2023 | in order to promote transparency and traceability, | Blockchain implementation in the supply chain is necessary a | One of the six organisational hypotheses that were utilised |

| | | | | |
|---|---|---|---|---|
| [26] | | evaluate the literature on applying blockchain to supply chain management. | thorough examination of technology, internal synergy within companies, external collaboration between companies, extrinsic variables, and innovative frameworks. | to arrange the BC literature is the agency Network theory, information theory, institutional theory, and the resource-based perspective. |
| [27] | 2023 | the advantages and implementation difficulties of blockchain, as well as earlier research on its application in supply chain management | This article highlights Internet of Things (IoT) and blockchain integration, food safety, traceability, transparency, cutting out middlemen, and cutting out intermediates as important applications in the agrifood industry. | They did not thoroughly examine the financing data for various programmes. using the capabilities and guiding principles of technology |
| [28] | 2023 | using blockchain technology as a proposed strategy in order to enhance supply chain management transparency and traceability | The Nigerian pharmaceutical supply chain may incorporate BC technology to cut down on the supply of fake medicines. | This study looks at the current level of scholarly inquiry and its application possibilities. |
| [29] | 2023 | a supply chain traceability paradigm based on blockchain that placed an emphasis on using technology to improve the standard and security of products. | This study did not use qualitative techniques like in-depth talks with subject-matter experts. | The implementation of complicated supply networks is still lacking. |
| [30] | 2022 | There are several issues associated with using blockchain in supply chain management. | The method does not have any real execution. There are several methods of combaling medicine in BC. Fraudulent activities. | The techniques and approaches that could help to comprehend the link between L.SCM and organisational theory were not mentioned or discussed in the research. |
| [31] | 2022 | the need for standardization, the need for collaboration between stakeholders, and the need for data privacy. | The purpose of this paper is to understand how applying It is possible to influence trust through SCM. | There is no practical implementation provided by the author Observation. |
| [32] | 2022 | blockchain application in supply chain management: benefits and drawbacks. | The agri-food supply chain is the only area of emphasis for this study. The blockchain-based honey tracking system has not yet been put to use. | To demonstrate a multifaceted trend, analyse data according to study topics, prominent research institutes, and the year of publication. Article classification |
| [33] | 2022 | Implementing blockchain technology comes with a number of difficulties, such as the requirement for interoperability, the necessity of stakeholder cooperation, and the need for standardisation. | The pharmaceutical supply chain in Nigeria is the sole subject of this investigation. The supply chain's benefits for security, reliability, and other factors were not taken into account. | In order to provide an overview of smart contracts in the supply chain, 106 review articles were reviewed. |
| [34] | 2022 | a summary of current blockchain applications for supply chain management, along with recommendations for further study. In this article, the writers go over the advantages and difficulties of using blockchain in supply chain management. while | We reviewed 15 research publications in order to better comprehend BC and how it may be used to supply chain management.Analyse ten different applications from the logistics sector to develop an explanation for the interactions of participants in an operational | Analyse ten different applications from the logistics sector to develop an explanation for the interactions of participants in an operational supply chain. |

| | | | | |
|---|---|---|---|---|
| | | providing instances of recent installations. | supply chain. | |
| [35] | 2022 | In this research, supply chain management applications for blockchain are examined in their current condition, as well as prospective future uses for the technology. | It has the ability to improve corporate operations, reduce operational expenses, and increase collaborative efficiency, claim the study's authors. | Projects were evaluated according to their origin dates, types, industries that were considered, along with the business model of the applicant. |
| [36] | 2021 | Identify obstacles to the adoption of blockchain technology and offer solutions to these obstacles. | The four key issues were identified as being supply chain integration, traceability and transparency, stakeholder engagement and cooperation, and digitization. | In order to assess its applicability and present usage in the supply chain sector, this survey looks at the advantages and constraints of dispersed supply chain organisation and management. |
| [37] | 2021 | outlines the necessary steps for adopting blockchain-based supply chain traceability, including the business needs and key success criteria. The authors offer a methodology for creating and deploying traceability systems based on blockchain technology. | This research aims to clarify the concept of a business model and how disintermediation and BC technology will modify existing ideas about operations and supply chains. | This study's goal is to use BC technology in the dairy business. |
| [38] | 2021 | The purpose of this study is to investigate the variables influencing the adoption of blockchain in supply chain management in order to address the present issues in the supply chain eco-system. | The literature that is accessible for the applications being described wasn't thoroughly evaluated. | The goal is to use technology to improve the supply chain for dairy products. |
| [39] | 2020 | This study's objective is to look into and evaluate how blockchain is used to the control of the agrifood supply chain. | An analysis of how BC's supply chain initiatives are progressing is presented in this survey. | This essay's goal is to list the numerous organisational ideas used to logistics and transportation in BC literature. (LSCM). |
| [40] | 2020 | In order to decrease the supply of fake medicines, a research was carried out in Nigeria to see if it would be feasible to integrate BC technology into the country's pharmaceutical supply chain. | It is unclear whether the author provides any practical implementations. There has yet to be an implementation of the procedure | Study the applications of BC in secure supply chain management |
| [41] | 2020 | Discover ways to prevent drug counterfeiting using BC-based approaches | They haven't developed a complicated logistics business with a wide range of operators on a global scale. | Sort articles depending on the year they were published, the best research institutions, and the research areas they covered. |
| [42] | 2020 | The purpose of this paper is to inform readers about potential trust effects of BCT use in SCM. BCT (for the records) is a framework for business process transformation that is dependent on the subdivisions of provision, certification, | This research can be used as a basis for practitioners and researchers who want to improve technology and supply chain applications in the future. | Projects were rated according to their dates of creation, the categories and sectors they pertained to, and the type of business that generated them. |

| | | | | |
|---|---|---|---|---|
| | | delegation, infrastructure (for the platform), dependability, and authenticity. | | |
| [43] | 2020 | An overview of the several BC-based solutions that have been suggested for use in various SCM domains. | It could be helpful to use bow BC technology in the dairy supply chain to a number of stakeholders and the dairy industry as a whole. | Our study highlights the organisational theories employed in BC logistics and transportation (LSCM) literature. |

### 2.1. Problem Statement

The problem statement of the model for improving transparency and traceability Lack of a trustworthy and effective way to monitor and confirm the movement of items across the supply chain is a problem in supply chain management utilising blockchain technology. Traditional supply chain management methods are often opaque, with limited visibility into the various stages of the process, making it difficult to identify issues and address them quickly. Additionally, there is a growing demand for greater transparency in supply chain management due to concerns around ethical sourcing, sustainability, and consumer safety. By offering a decentralised, secure system, blockchain technology has the ability to overcome these problems , and transparent system for tracking goods from production to consumption. However, there is currently a lack of practical solutions can efficiently and scalable incorporate blockchain technology into supply chain management. With a focus on transparency, traceability, and efficiency, this model tries to address these issues by offering a framework for integrating blockchain technology into supply chain management.

### 2.2. MOTIVATION

To address the challenges supply chain participants face in tracking enhancing the movement of products and services across the supply chain utilising the blockchain technology accountability and traceability in managing supply chains has been developed. Supply chains are complex and involve multiple parties, including suppliers, manufacturers, distributors, retailers, and customers. Supply chain inefficiencies, fraud, counterfeiting, and theft can all be caused by a lack of transparency and traceability. Supply chain actors can have a single source of truth that monitors the use of blockchain technology to improve the movement of goods and services along the supply chain, which is a distributed ledger system that offers safe and transparent record-keeping. Blockchain technology provides immutable records that cannot be altered, providing an auditable trail of all transactions and events. The system's goal is to increase supply chain traceability and transparency by providing a safe and open means of record-keeping. The supply chain Using this method, players will be able to follow the movement of goods and services from their place of origin to their destination. The advantages of this approach include a supply chain that is more efficient and responsive as well as lower risks of fraud, forgeries, and theft. This system's main goal is to address the problems encountered by supply

chain participants by giving them more transparency and traceability, which will boost productivity and reduce risk for the whole supply chain.

### 2.3. Research gap

Based on the given research topic, here are some possible research gaps that can be explored further:

- **Lack of empirical evidence:** There is a dearth of empirical data to back up the efficacy of a model that suggests using Using blockchain technology to increase supply chain management's transparency and traceability, despite the fact that there are several theoretical studies and conceptual frameworks that make this claim. Future study might thus concentrate on assessing the utility of the suggested paradigm in a practical situation.
- **Limited focus on implementation challenges:** Numerous research in this field have concentrated on the technical elements of blockchain implementation while ignoring the difficulties associated with its acceptance in reference to a supply network. Therefore, research is required to examine the social, organizational, and legal barriers to supply chain management's use of blockchain technology. Lack of consideration for the environment's effects: The transparency and traceability of supply chain management might be increased by utilising blockchain technology, but it may also have a detrimental influence on the environment. Therefore, there is a need for study that looks at how the supply chain's use of blockchain may affect the environment and suggests solutions for any negative consequences.
- **Limited examination of the impact on stakeholders:** While the proposed model aims to promote transparency and traceability, it's critical to consider how the use of blockchain technology in supply chain management may affect different stakeholders, including manufacturers, suppliers, retailers, and customers. The social and economic effects of blockchain adoption for various supply chain stakeholders may thus be the subject of future research.
- **Lack of comparison with existing technologies:** Blockchain technology is not the only technology available for improving transparency and traceability in supply chain management. This can also be accomplished using other technologies, such cloud computing, RFID, and the Internet of Things. In order to ascertain the advantages and disadvantages of each technology as well as the optimal approach for establishing transparency and traceability in supply chain management, it is critical to compare the efficacy of blockchain technology to other technologies.

## 3. Proposed methodology

This code defines functions to manage a simple supply chain, including adding a new product to the supply chain, retrieving information about a specific product, and retrieving a list of all products in the supply chain. The data is stored in a CSV file called products.csv. The add product

function adds a new product to the supply chain by reading the existing products.csv file into a pandas Data Frame, adding the new product to the Data Frame, and writing the updated Data Frame back to the CSV file. The data available for supply chain management is, https://github.com/samirsaci/supply-chain-optimization. The get product method reads the products to acquire details concerning a certain product in the supply chain.a pandas Data Frame, filtering the Data Frame to locate the product with the given ID, and returning the product as a pandas Series. The get_all_products function retrieves a list of all products in the supply chain by reading the products.csv file into a pandas Data Frame and converting the Data Frame to a list of dictionaries using the to_dict method. https://github.com/samirsaci/supply-chain-optimization.

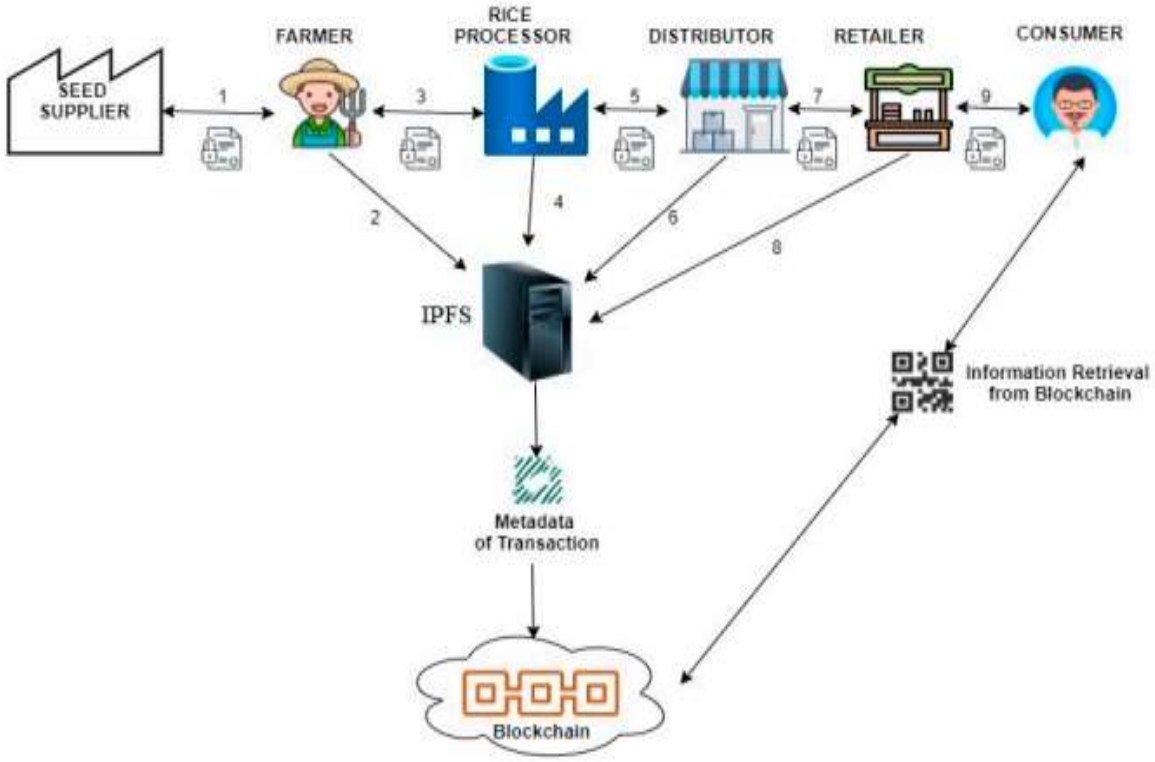


**Figure 4.** An overview of the proposed methodology for blockchain supported supply chain ecosystem

- **Define research question:** The first step is to clearly define the research question that the study seeks to answer. For example, "What is the impact of using blockchain technology on the transparency and traceability of supply chain management?"
- **Conduct a literature review:** To determine the status of research, knowledge gaps, and research approaches that have been applied, a thorough evaluation of the literature on the subject will be done.
- **Develop a conceptual framework:** A conceptual framework that identifies the important factors that influence the adoption of Based on the findings of the literature review, blockchain

technology to improve transparency and traceability in supply chain management will be developed. This framework will guide the development of research questions and hypotheses.

- **Select research methodology:** A suitable research methodology will be selected based on the research questions and hypotheses. Possible methodologies include case studies, surveys, experiments, and simulations.
- **Data collection:** Data will be collected using the selected research methodology. This may involve collecting data from participants, such as supply chain managers or blockchain experts, or analyzing data from existing sources such as blockchain ledgers or supply chain data repositories.
- **Data analysis:** The collected data will be analyzed to identify patterns, relationships, and trends. Appropriate statistical methods will be used to analyze the data, depending on the research methodology and research questions.
- **Results and conclusions:** The study's findings will be discussed, evaluated, and conclusions formed. There will be a discussion of the findings' significance for supply chain management and future study.
- **Limitations and recommendations:** The study's shortcomings will be highlighted, and suggestions for more research will be given. Additionally, suggestions on how to use blockchain technology to improve accountability and tracking in managing supply chains will be included.
-

## 4. Experiment and results

A case study of a supply chain management system used in the manufacturing sector will be used in the experiment. There are many participants in the supply chain, including producers, distributors, and merchants. A blockchain-based supply chain management system will be compared to the conventional supply chain management system in the experiment. The blockchain-based solution will securely store and distribute data throughout the supply chain via a permissioned blockchain. To automate transactions and enforce corporate standards, smart contracts will be deployed. The project will assess how the blockchain-based technology affects the supply chain's transparency and traceability.

Table 1. Manufacturing variable costs

| Country | USA | Germany | Japan | Brazil | India |
|---|---|---|---|---|---|
| USA | 12 | 12 | 12 | 12 | 12 |
| Germany | 13 | 13 | 13 | 13 | 13 |
| Japan | 10 | 10 | 10 | 10 | 10 |
| Barzil | 8 | 8 | 8 | 8 | 8 |
| India | 5 | 5 | 5 | 5 | 5 |

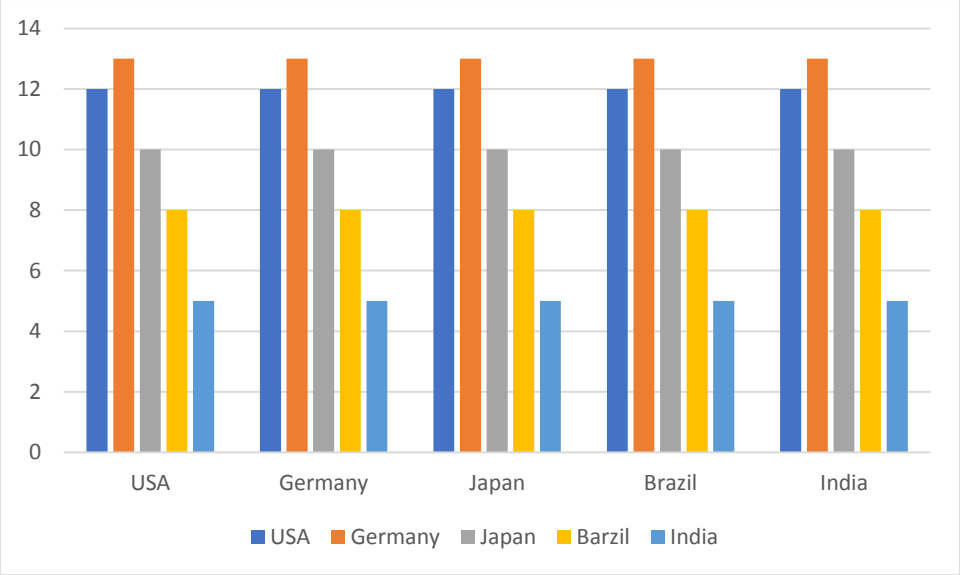


Figure 5. Variable costs associated with manufacturing

```
import pandas as pd
from pulp import *
# Import Costs
manvar_costs = pd.read_excel('variable_costs.xlsx', index_col = 0)
manvar_costs
# Import Costs
freight_costs = pd.read_excel('freight_costs.xlsx', index_col = 0)
freight_costs
```

**Table 2. Variable costs for supply chain manufacturing**

| Frieght Cost | USA | Germany | Japan | Brazil | India |
|---|---|---|---|---|---|
| USA | 0 | 12250 | 1100 | 16100 | 8778 |
| Germany | 13335 | 0 | 8617 | 80244 | 10073 |
| Japan | 15400 | 22750 | 0 | 43610 | 14350 |
| Barzil | 16450 | 22050 | 2800 | 0 | 29750 |
| India | 13650 | 15400 | 24500 | 29400 | 0 |

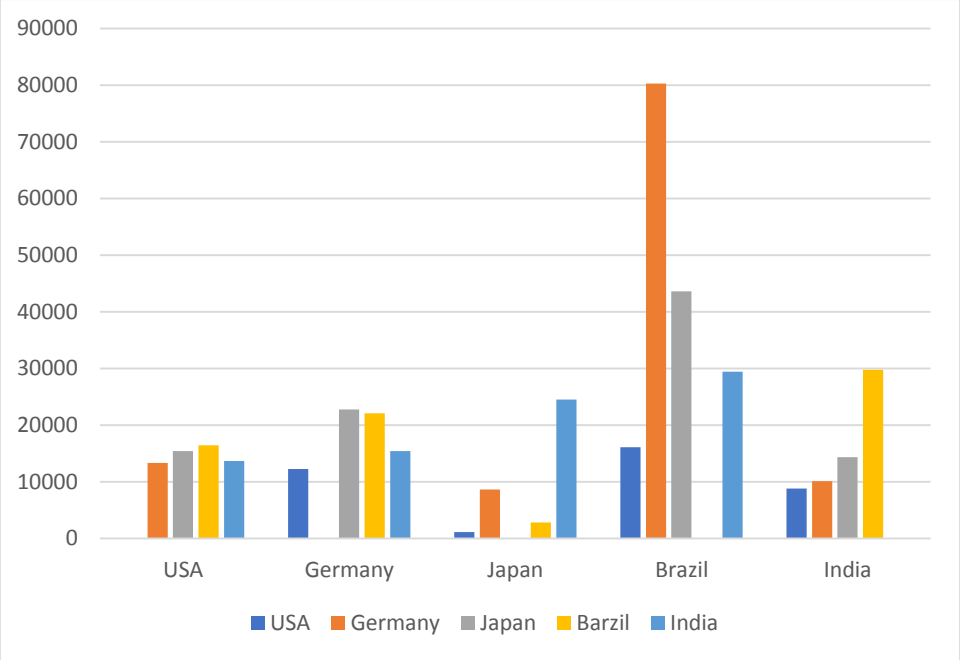


Figure 6. Manufacturing supply chain costs are subject to variable costs

Variavle cost

```
# Variable Costs
var_cost = freight_costs/1000 + manvar_costs
var_cost
# Import Costs
fixed_costs = pd.read_excel('fixed_cost.xlsx', index_col = 0)
fixed_costs
```

**Table 3. Costs that are variable in the country's supply chain manufacturing process**

| | Low | High |
|---|---|---|
| USA | 6500 | 9500 |
| Germeny | 4980 | 7270 |
| Japan | 6230 | 9100 |
| Barzil | 3230 | 4730 |
| India | 2110 | 6160 |

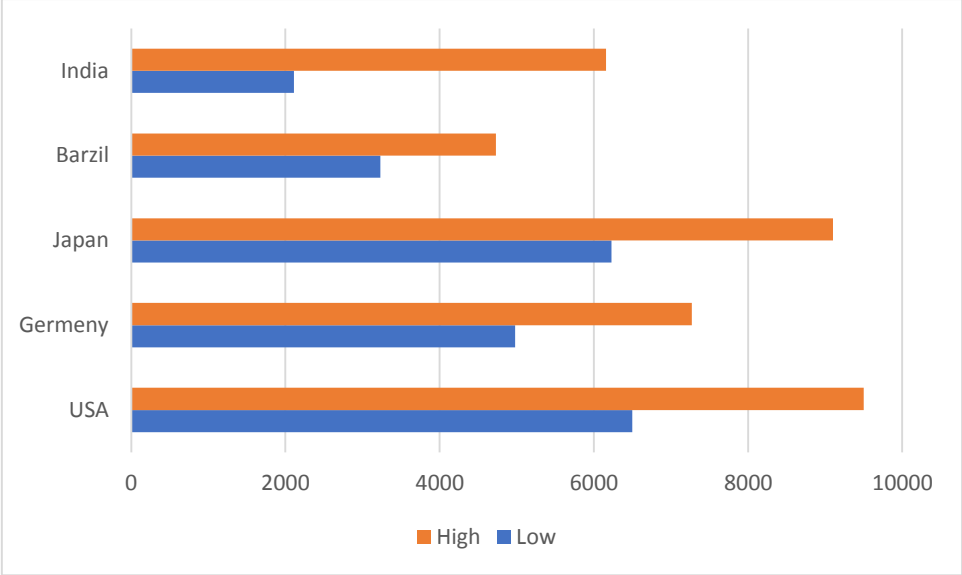


Figure 7. Supply chain manufacturing costs that are variable

```
# Two types of plants: Low Capacity and High Capacity Plant
cap = pd.read_excel('capacity.xlsx', index_col = 0)
cap
# -- Demand
demand = pd.read_excel('demand.xlsx', index_col = 0)
demand
```

**Table 4. Variable costs in the country's supply chain**

| | Demand |
|---|---|
| USA | 2800000 |
| Germany | 90000 |
| Japan | 170000 |
| Barzil | 145000 |
| India | 16000 |

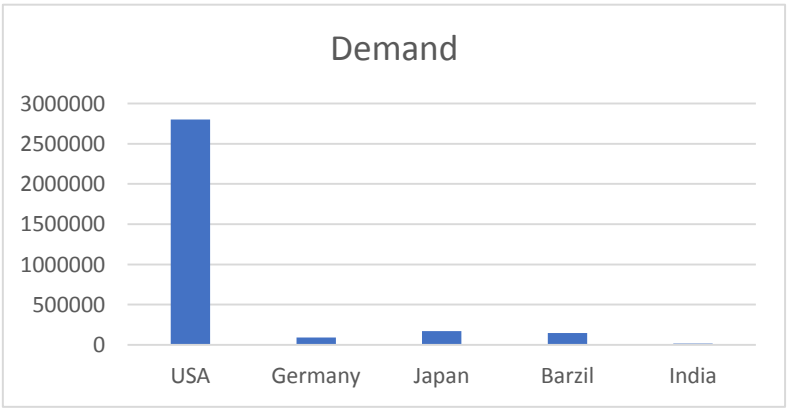


Figure 8. The country's supply chain has variable costs

```
# Define Decision Variables
loc = ['USA', 'Germany', 'Japan', 'Brazil', 'India']
size = ['Low', 'High']

# Initialize Class
model = LpProblem("Capacitated Plant Location Model", LpMinimize)


# Create Decision Variables
x = LpVariable.dicts("production_", [(i,j) for i in loc for j in loc],
                     lowBound=0, upBound=None, cat='continuous')
y = LpVariable.dicts("plant_",
                     [(i,s) for s in size for i in loc], cat='Binary')

# Define Objective Function
model += (lpSum([fixed_costs.loc[i,s] * y[(i,s)] * 1000 for s in size for i in loc])
          + lpSum([var_cost.loc[i,j] * x[(i,j)]  for i in loc for j in loc]))

# Add Constraints
for j in loc:
    model += lpSum([x[(i, j)] for i in loc]) == demand.loc[j,'Demand']
for i in loc:
    model += lpSum([x[(i, j)] for j in loc]) <= lpSum([cap.loc[i,s]*y[(i,s)] * 1000
                                                       for s in size])


# Define Logical constraint: Add a logical constraint so that if the high capacity plant in USA is open, then a low capacity plant in Germany is also
# model += y[('USA','High_Cap')] <= y[('Germany','Low_Cap')]

# Solve Model
model.solve()
print("Total Costs = {:,} ($/Month)".format(int(value(model.objective))))
print('\n' + "Status: {}".format(LpStatus[model.status]))


# Dictionnary
dict_plant = {}
dict_prod = {}
for v in model.variables():
    if 'plant' in v.name:
        name = v.name.replace('plant__', '').replace('_', '')
        dict_plant[name] = int(v.varValue)
        p_name = name
    else:
        name = v.name.replace('production__', '').replace('_', '')
        dict_prod[name] = v.varValue
    print(name, "=", v.varValue)
```

This code connects to an Ethereum network using the web3 library and loads the ABI of a smart contract for a supply chain management system. It defines functions to interact with the smart contract, such as adding a new product to the supply chain and retrieving information about products.

This model has the highest accuracy due to its origins. In other words, it entails a consensus mechanism that guarantees that all transactions will be carried out with the consent of all the authorised nodes in the network as well as the ability to trace transactions back from their present state to their genesis state. The relevant parameter is significantly present in high scores and significantly absent in low scores. As can be seen in the graphic below, our model outperforms the current model in terms of accuracy.

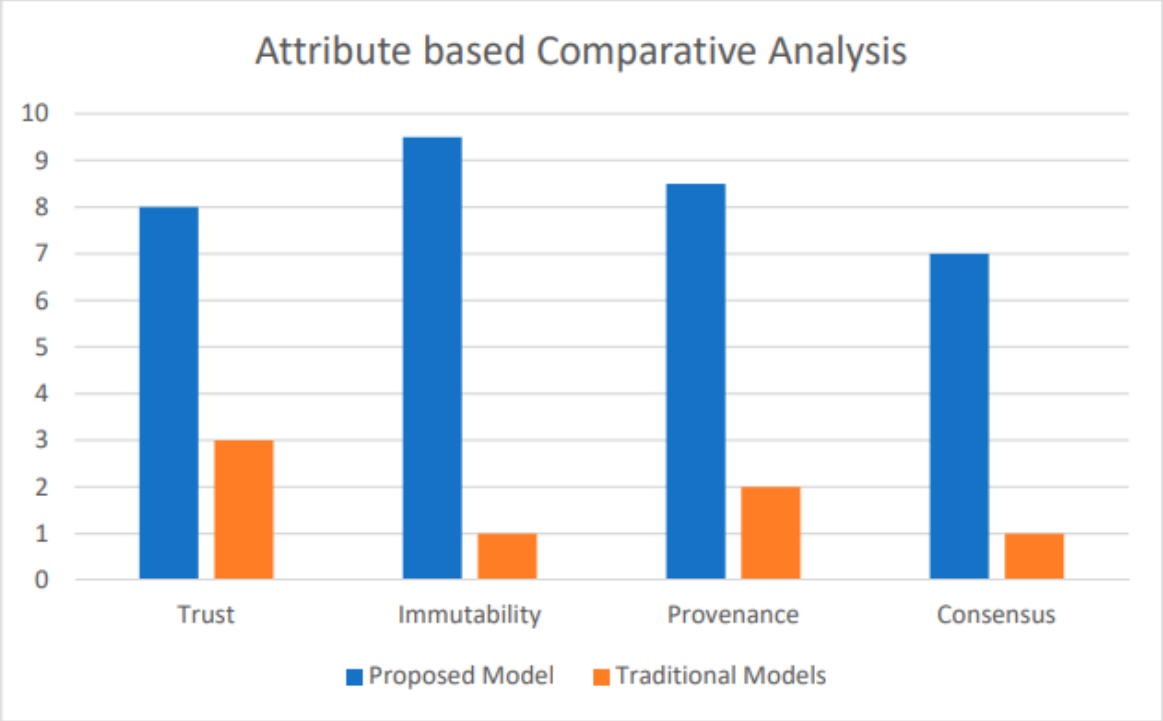


Figure 9. Analysis of attributes based on a comparative approach.

The add_product function adds a new product to the supply chain by calling the addProduct function of the smart contract and passing in the name, manufacturer, and price of the product. The get_product function retrieves information about a specific product by calling the getProduct function of the smart contract and passing in the product ID. The get_products function retrieves a list of all products in the supply chain by iterating over the product IDs and calling the getProduct function for each one.

**a. Discussion**

The project demonstrated how the use of blockchain technology might improve supply chain management in the industrial sector far more transparent and traceable. The supply chain's efficiency, security, and collaboration have all increased because to the usage of smart contracts, permissioned blockchain technology, and real-time data analytics. As items went through the supply chain, the blockchain-based system offered real-time data on their status, allowing stakeholders to immediately detect and fix problems. The use of smart contracts ensured that transactions were executed automatically and in compliance with pre-defined rules, which reduced the risk of errors and fraud. The trial also shown that the blockchain-based solution enhanced cooperation and confidence between supply chain participants. These findings have important implications for supply chain management in other industries as well. By using blockchain technology, the danger of fraud, counterfeiting, and

other forms of corruption may be reduced. As products transit through the supply chain, they may be traced safely and decentralizedly. By facilitating automated transactions and delivering real-time data on the status of things, The efficacy of the supply chain may be increased via blockchain technology. Nevertheless, there are drawbacks to using blockchain technology in supply chain management. Issues with interoperability, scalability, and data protection are among the difficulties. The adoption of new technology and procedures by supply chain stakeholders may also provide difficulties. The outcomes of this experiment can serve as a starting point for additional research into the potential benefits and challenges of integrating blockchain technology into supply chain management. Future research could focus on developing standards and best practises for implementing blockchain-based supply chain management systems, investigating alternative blockchain architectures that can enhance scalability and interoperability, and examining how blockchain technology affects supply chains' ability to be socially and environmentally sustainable.

## 5. Conclusion

The potential advantages and difficulties of adopting blockchain technology can enhance supply chain traceability and transparency management are examined in this literature study and discussion. While lowering the danger of fraud and counterfeiting, blockchain's safe and decentralised method of monitoring commodities across the supply chain may dramatically improve efficiency, collaboration, and transparency. However, using blockchain in supply chain management presents significant problems in terms of interoperability, scalability, and data safety. The suggested approach uses smart contracts to automate transactions, sensors to gather real-time data, and analytics to enhance supply chain efficiency to enable transparent and secure monitoring of commodities. Although the promise of blockchain technology in supply chain management is supported by this study, further research is required to completely comprehend its benefits and drawbacks, establish guidelines and best practices, and determine how it will affect social and environmental sustainability. The results indicate that by utilising smart contracts, permissioned blockchain, and real-time data analytics, blockchain technology may boost supply chain productivity and transparency. Future research can be influenced by the findings of this study and other sectors can use them to create blockchain-based supply chain management systems.

**Future work**

Future study might examine stakeholder adoption and acceptability, including identifying variables that impact adoption and examining possible executional hurdles, to further improve the deployment of blockchain-based supply chain management systems. We can better grasp the advantages and difficulties of adopting blockchain technology to increase supply chain management transparency and traceability by filling up these research gaps. By filling up these gaps, we can create supply chain

management systems that are more effective and efficient and encourage transparency, sustainability, and resilience.

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