



BLOCKCHAIN-ENABLED SUPPLY CHAIN TRANSPARENCY FOR SUSTAINABLE MANUFACTURING: A CASE STUDY OF LARSEN & TOUBRO LIMITED

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Abstract

The first chapter deals with the impact of blockchain technologies on the traceability and transparency of the company. The second chapter confers the effectiveness of blockchain along with challenges in the form of energy consumption and environmental issues. In the third chapter, the methodology section highlights the ways of data collection in the form of interviews with the stakeholders of L&T to get an insight into the operational process of the company.

In fourth chapter it examines the effectiveness of blockchain technology in enhancing transparency and sustainability within the supply chain of L&T. The interviews and literature review findings indicated improved operational efficiency and sustainability despite challenges like high implementation costs and energy consumption. In the fifth chapter, the research mainly explored the impact of blockchain technology on the supply chain of L&T. It is focused on transparency, resource utilisation and sustainable manufacturing. Despite challenges such as high implementation costs and small sample sizes, findings suggest blockchain improves operational efficiency. Future studies should expand the scope and address scalability and collaboration challenges.

Chapter 1: Introduction

1.1 Background

Larsen & Toubro Limited (L&T) is an Indian multinational conglomerate with interests in engineering construction, manufacturing and industrial technology. In order to maintain sustainable supply chain transparency, L&T company committed to achieving water neutrality by 2035 and carbon neutrality by 2040 (Larsen & Toubro, 2025). Furthermore, in 2023, L&T Limited planted more than 1.5 billion trees over 2 weeks (Larsen & Toubro, 2023). This shows the supply chain transparency and sustainable manufacturing of L&T.



Figure 1: L&T Company's tree plantation

(Source: Larsen & Toubro, 2023)

1.2 Research Rationale

Larsen & Toubro Limited (L&T) articulated a clear and sustainable vision of pursuing eco-friendly growth, and promoting a sustainable and innovative culture (Larsen & Toubro, 2025). However, supply chain transparency faced various issues in order to maintain sustainable manufacturing. The major issue faced by L&T is regarding challenges in *managing resource utilisation* and *environmental impact*. In the fiscal year 2023 to 2024, L&T generated 2.4 lakh tons of construction waste (Larsen & Toubro, 2024a). This shows that there is a significant need for improvement in the waste management practices of L&T Company.

Another significant problem faced by L&T Company regarding sustainability is volatility in raw material prices, particularly steel and cement. For example, the infrastructure segment reported an 11-12% rise in the price of project costs in the fiscal year 2022 to 2023 (Larsen & Toubro, 2024b). In order to mitigate the above issues, L&T has to adhere to ethical sourcing and specific traceability methods for raw materials. This research will provide blockchain-enabled supply chain transparency to maintain the sustainable practices of L&T.

1.3 Aim and Objectives

Research Aim

The aim of this research is to identify the integration of blockchain technology into the supply chain management practices of Larsen & Toubro Limited (L&T).

Research Objectives

- To analyse the impact of blockchain technologies implemented by Larsen & Toubro Limited (L&T) on supply chain management practices
- To examine the effectiveness of blockchain technologies in improving the transparency and traceability within the supply chain of L&T
- To assess the challenges regarding the adoption of blockchain technology in promoting sustainable manufacturing practices at L&T

1.4 Research Questions

1. What is the impact of blockchain technologies implemented by Larsen & Toubro Limited (L&T) on supply chain management practices?
2. What is the effectiveness of blockchain technologies in improving the transparency and traceability within the supply chain of L&T?
3. What are the challenges in the adoption of blockchain technology in promoting sustainable manufacturing practices at L&T?

1.5 Research Significance

The present research will be significant as it will highlight the transformative potential of challenges of supply chain management faced by L&T Limited in order to maintain sustainable practices like ethical sourcing. Furthermore, by analysing the blockchain adoption of L&T, this research will provide an in-depth understanding of improving the efficiency of its supply chain, product quality, and environment.



Chapter 2: Literature Review

2.1 Introduction

This chapter provides an understanding of “blockchain technology”, “supply chain management”, and “sustainable manufacturing”. Furthermore, this research critically analyses the impact and effectiveness of “blockchain technology” on “supply chain management” in promoting sustainable manufacturing.

2.2 Variables

2.2.1 Blockchain Technology

“Blockchain technology (BCT)” refers to a decentralised digital ledger that stores records across a network of computers in a secure way which is resistant, immutable and transparent to tempering (Habib *et al.* 2022). “Blockchain technology” is important within the “supply chain management” of an organisation because it helps in the verification of multistep transactions, which needs verification and traceability.

2.2.2 Supply Chain Management

“Supply chain management (SCM)” refers to the process of managing the entire flow of data, finance and goods from the raw materials to the consumer (Khedr, 2024). It involves building a network among suppliers, manufacturers, retailers, distributors and customers. SCM helps a business enhance profitability, resilience and competitiveness by reducing quality issues, ensuring product availability and delivering products or goods quickly.

2.2.3 Sustainable Manufacturing

The process of making products economically that minimises environmental impact, which promotes resource and energy conservation, is called sustainable manufacturing (Khanfar *et al.* 2021). Sustainable manufacturing has several benefits, like reducing the negative impact on the environment through the procurement of sustainable materials. However, in order to implement sustainable manufacturing practices, the initial investment can be high, which can create difficulties in balancing profitability.

2.3 Impact of blockchain technologies on supply chain management practices

As noted by Mubarik *et al.* (2021), “blockchain technology” brings traceability to the supply chain by ensuring assets are tracked along with providing visibility to the stakeholders. This process makes it possible to minimise unfair practices and boosts the overall efficiency of “supply chain management”. On a similar note, Park and Li (2021) opined that “blockchain technology” helps to entail smart contracts within the “supply chain management” that helps to enable the flow of automation of processes across enterprises.

However, Tokkozhina *et al.* (2023) commented that “blockchain technology” has several disadvantages in that it can provide traceability through digital records of transactions but cannot ensure the real-time condition of digital products. Furthermore, it is not always a suitable solution, particularly for lower-cost products, as it depends on the cost of the products. In contrast, Tokkozhina (2021) argued that “blockchain technology” has the potential to articulate resources efficiently along with reducing inventory level and supply chain risks during forecasting decisions and optimising planning.

2.4 Effectiveness of blockchain technologies in improving transparency and traceability

Decentralised transparency and traceability are two crucial aspects of “supply chain management”, which enables the stakeholders in order to track the authenticity of goods and products. In the view of Raparathi (2021), “blockchain technology” comes up with a decentralised ledger that keeps records of all transactions in a transparent and secure manner. It helps to form a chain of blocks by enabling each transaction to be recorded as a block, which is further linked to the previous block. Similarly, as attested by Lee and Zhang (2023), “blockchain technology” offers innovative solutions to improve transparency and traceability in the supply chain by combining with “machine learning” (ML). The fraud and inefficiency in the supply chain can easily indicated by the ML algorithm.

However, Adewusi *et al.* (2023) commented that in improving the transparency and traceability of the supply chain, “blockchain technology” faces various difficulties, especially scalability and interoperability. Along with the increasing number and size of transactions, it takes longer times and higher costs. On a similar note, Lee and Zhang (2023) stated that implementing “blockchain technology” within the existing system can be challenging due to interoperability issues.

2.5 Challenges of adopting blockchain technology in promoting sustainable manufacturing

“Blockchain technology” has the potential in order to improve sustainable manufacturing, though it has various challenges related to its adoption. According to Almutairi *et al.* (2023), “blockchain technology” can execute transactions that can build the idea of embracing the pillars of sustainability within industries. The implementation of sustainable manufacturing within the supply chain management requires considerable promise for the industrial and service sectors. Furthermore, Singh (2023) opined that in promoting sustainable manufacturing, the adoption of “blockchain technology” in “supply chain management” faces a significant lack of digital skills. The existing employees are not well trained digitally or have fewer skills.

In contrast, as mentioned by Kouhizadeh *et al.* (2021), the implementation of “blockchain technology” in “supply chain management” leads to challenges, including sustainability management. As the energy market requires security for its sustainability, the existing supply chain of the organisations might not adopt “blockchain technology”. On a similar note, Singh (2023) commented that in order to promote sustainable manufacturing, “blockchain technology” comes up with the issue of high-energy consumption. The amount of energy that “blockchain technology” requires a high amount of investment.

2.6 Theory

Resource-Based View (RBV)

The resource-based view (RBV) refers to a strategic framework that helps a business in the process of identifying and using resources in order to gain competitive advantages (Valaei *et al.* 2022). This theory will prominently align with this research because it will leverage “blockchain technology” as a strategic resource, which will improve L&T’s supply chain management traceability and transparency. Additionally, RBV will also explore how the investment of L&T in “blockchain technology” improves waste management, resource utilisation and sustainable manufacturing.

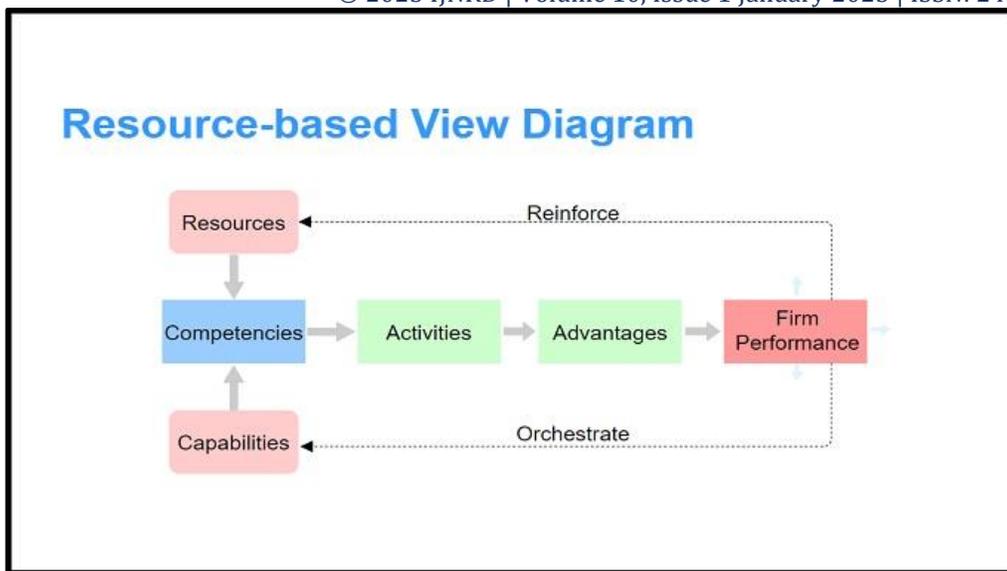


Figure 2: Resource-Based View (RBV)

(Source: Valaei *et al.* 2022)

2.7 Research Gap

This research will significantly highlight the potential of “blockchain technology” in improving the transparency of “supply chain management” and promoting sustainability. However, the present research fulfils the lack of practical implications of “blockchain technology” in large-scale companies such as L&T. Furthermore, this research also covers the significant lacks by addressing issues in the implementation of “blockchain technology”, such as sustainable manufacturing, cost volatility and resource utilisations.

2.8 Summary

This chapter critically analysed the impact and effectiveness of “blockchain technology” in improving the traceability and transparency of “supply chain management”. Furthermore, this research added a research theory using RBV theory and a literature gap.

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Chapter 3: Methodology

3.1 Research Philosophy

Inspired by Junjie and Yingxin (2022), this particular research has adopted an interpretivism philosophy, which puts an emphasis on understanding subjective experiences as well as perspectives of people that are involved in the “supply chain practices”. This approach has put proper facilitation on the complexities that are surrounded by “blockchain technology” and its integration in the supply chain process for increasing the aspect of sustainability. With this approach, the “supply chain management” at Larsen & Toubro Limited can be explored through the understanding of meetings and implications that are derived from the perspectives of the stakeholders. Yang *et al.* (2022), with this prospect, research aimed to uncover the complexities of different sustainable practices in “supply chain management” through “blockchain” integration.

3.2 Research Approach

Influenced by Tursunova (2023), this singular research utilised a deductive approach, as it used established theory and literature that exists on “blockchain technology” and “supply chain management”. This research mainly aimed to test these theories against the practical experiences of the people or stakeholders at L&T through interviews. With the formulation of theories that are based on the existing literature, this study sought to validate or refute these through empirical data collected from the interviews of the stakeholders. All these provide a structured path for the assessment of how “blockchain technology” impacts supply chain transparency as well as sustainability practices at L&T.

3.3 Research Design

Taking influence from the work of Toyon (2021), this research adopted an explanatory research design for the exploration of relationships between “blockchain technology” and “supply chain management” practices. This design facilitated an in-depth examination of how blockchain technology can enhance the aspect of transparency, along with traceability of the “supply chain” of L&T. As per Yang *et al.* (2022), with the focus on causal relationships, the research aimed to explain the mechanisms of the technology and how it can enhance the pre-existing manufacturing goals of the company.

3.4 Data Collection Method Databases

Influenced by Briel *et al.* (2021), this research primarily collected data through the utilisation of primary qualitative methods, specifically semi-structured interviews with the key stakeholders at L&T. These interviews were mainly designed for gathering rich quality data and a detailed analysis of the participant’s experiences with the “blockchain technology” in the current “supply chain” process. This aspect ensured that the data showed a holistic understanding of both the challenges and the benefits that are associated with the implementation of the technology.

3.5 Data Analysis Method

Taking an idea from Morgan (2022), this research used the method of thematic analysis with the usage of the data that is obtained from the interviews. This method involves the process of identifying, analysing and reporting patterns or themes that can be identified from the data that is gathered from the interviews. The aspect of thematic analysis allowed for a flexible approach to data interpretation, as it enabled the researcher to outline the important

themes of “blockchain technology”, and how it impacted the transparency of “supply chain” in L&T. As per Yang *et al.* (2022), this analytical framework mainly facilitates a nuanced understanding of the perspectives of the interviewees to understand the broader impact on the existing network.

3.6 Ethics

This study adhered to the principles of the Data Protection Act 2018, which ensured data authenticity and the confidentiality of the participants. Informed consent was obtained from the participants regarding the usage of their information, which prioritised privacy and integrity.

Chapter 4: Analysis and Discussion

4.1 Introduction

This chapter of the research examined the effectiveness of blockchain technology in improving transparency and sustainability within the supply chain of L&T. In this paper, the response to the interviews was analysed. In the discussion part, with the help of the comparison of the results of respondents and the literature review, the final findings were discussed, which show the necessity of blockchain in supply chain transparency.

4.2 Findings

“How has the implementation of blockchain technology impacted supply chain management practices at Larsen & Toubro Limited, particularly in terms of efficiency and sustainability?”

Stakeholder	Response
I1	"It has streamlined inventory tracking and reduced lead times significantly."
I2	"We've seen improved resource optimisation, contributing to lower carbon emissions."
I3	"Blockchain integration has reduced data redundancy, enhancing operational efficiency."

Table 1: Impact of blockchain on SC management practices

(Source: Author)

It was found that the adoption of “blockchain technology” streamlined inventory tracking, followed by the reduction of lead times, which the first interviewee mentioned. Moreover, the third interviewee mentioned that operational efficiency significantly improved with the adoption of “blockchain” due to the reduction of data redundancy.

“From your perspective, how has the use of blockchain technology influenced stakeholder collaboration and trust in L&T's supply chain operations?”

Stakeholder	Response
I1	"It has built stronger partnerships by ensuring data accuracy and visibility."
I2	"Stakeholders trust us more because we offer transparent sustainability metrics."
I3	"Smart contracts have reduced disputes by providing verifiable transaction records."

Table 2: Impact of Blockchain on Stakeholder Collaboration

(Source: Author)

On the other hand, the second interviewee claimed that transparent sustainability metrics are provided by “blockchain”, which is paramount to gaining stakeholders’ trust. Lastly, the third interview also quoted saying that “*Smart contracts have reduced disputes by providing verifiable transaction records*”, which signifies that operational disputes are minimised through “blockchain”.

Can you provide examples of how blockchain technology has improved transparency and traceability within the supply chain at L&T?

Stakeholder	Response
I1	"We now track raw materials from suppliers to final delivery in real-time."
I2	"Customers can verify the sourcing of sustainable materials instantly."
I3	"Tamper-proof records ensure authenticity and accountability at every supply chain stage."

Table 3: Improvement of transparency and traceability by blockchain technology

(Source: Author)

In the second question, the responses of stakeholders indicate that “blockchain technology” has significantly improved transparency and traceability within the supply chain of Larsen & Toubro. As a response to the first interviewee (I1), enhanced inventory tracking has led to reduced lead times. It ensures efficient resource utilisation. The second interviewee (I2) said that this technology improved resource optimisation and has contributed to sustainability by lowering carbon emissions. Moreover, “blockchain” integration has reduced data redundancy and also enhanced operational efficiency. This response demonstrates its role in streamlining processes and reducing inefficiencies.

In what ways has blockchain adoption supported sustainable manufacturing practices at L&T, such as reducing waste or ensuring compliance with environmental regulations?

Stakeholder	Response
I1	"Real-time data has minimised overproduction and excess inventory."
I2	"Blockchain helps verify compliance with green manufacturing standards across all suppliers."
I3	"Accurate tracking reduces errors and waste, promoting eco-friendly operations."

Table 4: Sustainable Manufacturing Practices

(Source: Author)

The responses of stakeholders highlight how "blockchain technology" adoption has supported sustainable manufacturing practices. According to the I1, real-time data access has reduced overproduction and excess investment, leading to more sustainable resource utilisation. Similarly, I2 respond that "blockchain technology" ensures compliance with green manufacturing standards across different suppliers. It supports accountability and environmental responsibility. On the other hand, I3 responds that accurate tracking reduces errors and waste and contributes to eco-friendly operations.

What challenges has L&T faced in adopting "blockchain technology" for supply chain management, and how have these challenges been addressed?

Stakeholder	Response
I1	"High implementation costs and high-energy consumption were a hurdle, but phased integration eased the financial burden."
I2	"Supplier onboarding was initially slow, but training programs accelerated adoption."
I3	"Ensuring compatibility with legacy systems was challenging such as environmental concerns; we used middleware solutions."

Table 5: Challenges of Blockchain Adoption

(Source: Author)

From the interview with the key stakeholders of L&T, it was found that high implementation costs were a burden for the company along with the supplier onboarding process. Besides, the third interviewee mentioned that there is a significant environmental concern while adopting "blockchain technology" in L&T.

4.3 Discussion

Theme 1: Operational efficiency enhancement and stakeholder collaboration by blockchain adoption in L&T

Data integrity and security have been paramount in this digital landscape, where "blockchain" reinforces data integration and security (Pehar, 2024). Moreover, the global market of "blockchain" is forecast to have over \$1200 trillion by 2032 with a CAGR of 82% (Best, 2025). These highlight the adoption rate of "blockchain" due to its immense benefits in inventory tracking and reduction of lead times. Furthermore, Livingston (2022) commented

that a universal carbon currency could be created through global carbon trading ledgers by “blockchain technology”, leading to the Race to Zero campaign of the UN. The literature review section also highlighted the transparency and operational efficiency of “blockchain technology”, where the effectiveness is heightened.

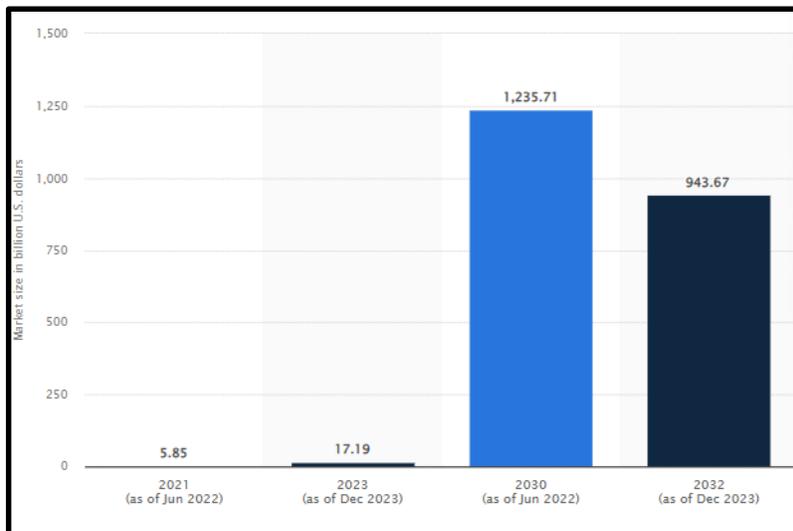


Figure 3: Blockchain technology market size

(Source: Best, 2025)

In this regard, the second interviewee was quoted saying,

“We’ve seen improved resource optimisation, contributing to lower carbon emissions”. (I2)

Apart from these, **smart contracts** are considered digital contracts that are automatically executed, leading to an enhancement in speed, transparency, accuracy, efficiency and trust while making international trade easier (IBM, 2025). Besides, distributed ledger technology is a pivotal aspect of “blockchain” characterised by improved efficiency, security and real-time tracking of goods (Mulligan *et al.* 2024). In this way, “blockchain” integration plays a major role in heightening collaborations among L&T stakeholders.

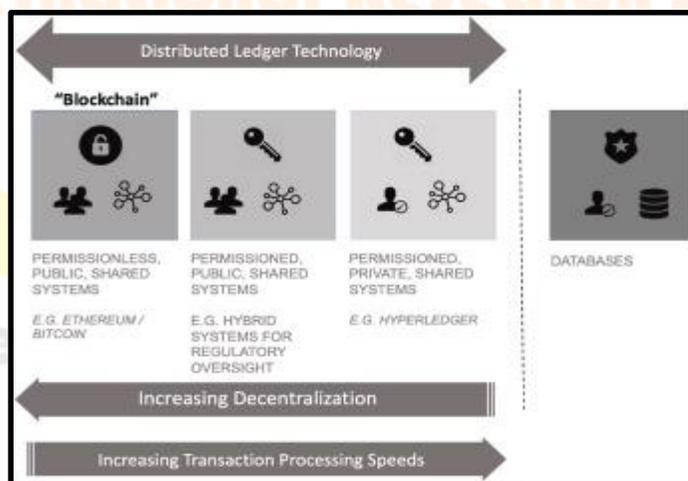


Figure 4: The distributed ledger technology

(Source: Mulligan *et al.* 2024)

Theme 2: Examination of the effectiveness of blockchain technologies in improving the transparency and traceability within the supply chain of L&T

The literature review and results of the interview both emphasise the effectiveness of “blockchain technology” in enhancing transparency and traceability with supply chains. According to Raparathi (2021), blockchain’s decentralised ledger records all transactions securely, aligning with stakeholder I1’s observation that real-time data access minimises overproduction. Moreover, Lee and Zhang (2023) highlight the combination of “blockchain technology” with ML to detect inefficiencies, which corresponds with the response of I3 regarding accurate tracking and reducing waste. On the other hand, challenges like scalability and interoperability, as noted by Adewusi et al. (2023), contrast with a positive outlook of stakeholders. The literature suggests that “blockchain” integration can encounter cost and compatibility challenges, while L&T stakeholders highlight operational efficiencies. As per the response of I2, it can be assumed that the role of “blockchain” in sustainability despite the potential implementation obstacles.

Theme 3: Challenges by the adoption of blockchain technology in the form of higher upfront costs and legacy systems

Other than these, the integration of “blockchain technology” is swamped with challenges in the form of energy consumption and environmental concerns. For instance, as imprinted by Schinckus (2021), “blockchain” networks, which use Proof-of-Work or *PoW* in particular, like Bitcoin, are known for their higher energy consumption. In a similar fashion, Interviewee 1 stated that

“High implementation costs and high-energy consumption were a hurdle, but phased integration eased the financial burden”. (I1)

Thus, it can be stated that “blockchain” negatively impacts the industry in the form of higher energy consumption. Besides, 30,700 tonnes of e-waste is produced every year by Bitcoin mining, giving rise to environmental concerns along with GHG emissions, necessitating the aspects of recycling initiatives (BBC, 2021). Huge energy consumption and massive carbon emissions are inextricably related to cryptocurrency, as Bitcoin mining leads to 65.4 megatonnes of CO₂ production per year (Salam, 2023). From the viewpoint of the third interviewee, it is clear that environmental compatibility was not adhered to by the integration of “blockchain technology” in L&T.

In addition to these, the price of Bitcoin reached \$69,000 as the regulators of the US approved various spot “Bitcoin Exchange-Traded Funds” or *ETFs* (BBC, 2024). Therefore, the creation of a public “blockchain technology” can be challenging for companies, leading to continuous expenses. The feasibility of technology adoption and the readiness of the organisation is reflected in the view of the first employee, where associated costs are associated with the training of employees (Salim *et al.* 2022). This is similar to the viewpoint of the first interviewee, who talked about the higher implementation costs associated with “blockchain technology”.

The literature also highlights the different challenges in adopting “blockchain technology” for sustainable manufacturing that align with the observation of the second interviewee (I2). As observed by Kouhizadeh *et al.* (2021), integrating “blockchain” into supply chains supports sustainability challenges, such as high energy consumption and compatibility with existing systems. Singh (2023) supports this by emphasising the substantial investment required for blockchain’s energy demands. Similarly, I2 acknowledged that

“Supplier onboarding was initially slow, but training programs accelerated adoption.” (I2)

It indicates that education and capacity-building initiatives helped overcome initial resistance and improved adoption rates. Despite these challenges, “blockchain” offers long-term sustainability benefits when effectively implemented.

4.4 Conclusion

The chapter discusses the responses of the stakeholders of L&T in terms of “blockchain technology” integration, where the majority commented that operational efficiency and inventory tracking are possible. However, there are challenges in the form of higher upfront costs along with the generation of e-waste.

Chapter 5: Conclusion and Recommendations

5.1 Conclusion

This research provided a valuable and in-depth understanding of the blockchain-enabled supply chain management of L&T Company. Furthermore, it also highlighted the supply chain management issues of this company, such as managing resource utilisations and volatility in raw materials prices. In this research, the researcher utilised a primary thematic data collection method with 3 interviewees and 5 questionnaires. Furthermore, the interviewee mentioned that “blockchain technology” improves inventory tracking and resource utilisation. Additionally, they have also mentioned that “blockchain technology” provides sustainable manufacturing within the “supply chain management”.

5.2 Linking with Objectives

Objective 1:

The first objective was linked with question 1 of the interview of this research, which suggested that the adoption of “blockchain technology” streamlined inventory tracking.

Objective 2:

The second objective of this research was addressed in the third question of the interview, which evaluated that blockchain technology is essential in improving supply chain management.

Objective 3:

The third objective was identified under the fourth question of the interview, which highlighted that implementation cost was the major issue in implementing “blockchain technology” in promoting sustainable manufacturing.

5.3 Research Limitations

This research provided valuable insights into the blockchain-enabled supply chain management practices of L&T company, though it had several limitations, including the small sample size. This research comprised only 3 interviewees and 5 questionnaires, which limited the generalisability of findings.

5.4 Future Scope

In future, this research will explore the implementation of “blockchain technology” in the large-scale supply chain across diverse industries. Furthermore, this research can expand the sample sizes, which will ensure the long-term impacts of “blockchain technology” on sustainable manufacturing within “supply chain management”.

5.5 Recommendations

Adopting Scalable Blockchain Solutions

In order to enable real-time tracking of products and raw materials, Larsen & Toubro Limited should invest in scalable blockchain solutions across its supply chain management. By adopting this approach, this company can improve transparency and resource utilisation within the supply chain, along with reducing cost volatility and waste management issues.

Providing Training and Collaboration Programs

In order to identify the challenges of adopting “blockchain technology”, L&T should provide training to supply chain partners. Adopting this approach will significantly improve the understanding of “blockchain technology”. Furthermore, developing collaboration with technology providers will help the company to reduce energy consumption in sustainable manufacturing.

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Appendices

Appendix 1: Interview questionnaires

- How has the implementation of blockchain technology impacted supply chain management practices at Larsen & Toubro Limited, particularly in terms of efficiency and sustainability?
- Can you provide examples of how blockchain technology has improved transparency and traceability within the supply chain at L&T?
- In what ways has blockchain adoption supported sustainable manufacturing practices at L&T, such as reducing waste or ensuring compliance with environmental regulations?
- What challenges has L&T faced in adopting blockchain technology for supply chain management, and how have these challenges been addressed?
- From your perspective, how has the use of blockchain technology influenced stakeholder collaboration and trust in L&T's supply chain operations?

