

**IMPLEMENTING BLOCKCHAIN FOR ENHANCED TRANSPARENCY AND  
EFFICIENCY IN CROSS-BORDER LOGISTICS**

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*Abstract*

*The Cross-border logistics are multilayered in nature and involve a number of players, such as shippers, customs authorities, logistics providers, and financial institutions. The transformational potential of block chain technology is very high, as it basically aims to resolve certain major challenges in the domain: no transparency, fraud, and inefficiency in documentation. This article examines how block chain enhances transparency by means of a decentralized, immutable ledger that is accessible for all authorized parties to provide real-time tracking and verification of shipments. It emphasizes how block chain can help reduce fraud with tamper-proof records of transactions and supply chain events. Besides, block chain can facilitate documentation processes to make cross-border shipping faster, more secure, and cheaper. Case studies and real examples of global logistics are discussed in the light of block chain technology benefits of practical nature. This gives substance to block chain technology as a pivotal tool that is changing how international trade logistics is pursued.*

*Index Terms – Block chain, cross-border logistics, transparency, fraud prevention, supply chain management, secure shipping, decentralized ledger, real-time tracking, document digitization, and international trade.*

## **I. INTRODUCTION**

The globalization of trade has led to immense complication in cross-border logistics, which is processed through a labyrinth of procedures, regulations, and stakeholders. Despite advances in supply chain management, traditional systems still are afflicted with inefficiency, fraud, and lack of transparency. Key challenges, like delaying shipments, losing or falsifying documents, and various miscommunications from stakeholder to stakeholder, outline an urgent need for a more secure and efficient frame work. The emergence of block chain technology as a solution has hence proven to be transformational in these areas of cross-border logistics challenges. In its nature, block chain is a decentralized and immutable ledger that aids in secure and transparent recording of transactions with reduced reliance on intermediaries, hence reducing the risks of fraud. Its potential can further be realized through its power to offer real-time traceability of goods, enhancing documentation accuracy, and encouraging trust among stakeholders with tamper-proof records. The integration of block chain in cross-border logistics will provide companies with opportunities for operational efficiency and higher levels of regulatory compliance. Smart contracts, as one of the vital features of block chain, enable full automation and smoothing of customs clearances and payments, reducing considerably the associated delays and administrative burdens. Moreover, block chain's transparency and traceability create better accountability and

therefore consumer trust, becoming an essential modern supply chain instrument. The paper will discuss how block chain technology delivers significant benefits in the logistics arena of cross-border trade in terms of transparency, reduction of fraud, and optimization of documentations. This paper examines real-world case studies, provides statistical data, and discusses how block chain can revolutionize global trade by creating a more efficient, secure, and trustworthy logistics ecosystem.

## **II. LITERATURE REVIEW**

Chang et al. (2019) [1] critically synthesized applications of block chain in global supply chains and cross-border trade, underpinning its potential for transformational impact: enhanced transparency, prevention of fraud, and operation efficiency. They also mentioned implementation challenges such as scalability and regulatory complexities, outlining opportunities to be given for seamless integration of block chain with existing systems in response to trade inefficiencies.

Zhao (2021) [2] proposed a block chain-based cross-border e-commerce system; he focused on how it can enhance security, logistics streamlining, and transaction cost reduction. This study underlines block chain's role in automating processes through smart contracts, improving efficiency, and fostering trust among international trading partners.

Koh et al. (2020) [1] investigated block chain applications in transport and logistics, focusing on the paradigm shift to decentralized supply chains. The study identified how block chain can enhance traceability, reduce frictions, and provide resilience to disruption while calling for standardized protocols in order to have wider diffusion.

Lee and Yeon, 2021 [4], extended a block chain-based traceability framework for counterfeit product prevention in cross-border e-commerce. They showed how blockchain guarantees the authenticity of transactions and products through immutable records that further enhance trust and protect customers and businesses from fraudulent activities.

Gao (2021) [5] examined foreign trade intentions driven by block chain-enabled cross-border e-commerce. Though retracted, the study originally found that block chain could enhance international trade efficiency by way of reducing trade barriers, accelerating payments, and managing documents more efficiently, especially in emerging markets.

Liu and Li (2020) [6] presented a block chain framework for cross-border e-commerce supply chains in 2020. Also, block chain, by offering improved information sharing, inventory management, and security of data exchange, is capable of further optimization in the process of supply chains and making international trade literally frictionless.

Koh, Dolgui, and Sarkis (2020) [7] further reiterated the transition of logistics systems to block chain-enabled operations. They investigated how block chain can enable decentralizing decision-making processes for increased agility in supply chains and highlighted collaboration among all stakeholders as relevant for overcoming technological and organizational difficulties.

Wang, 2021 [8], explored how block chain would provide a cross-border e-commerce industry in

Dongguan with a closed-loop ecosystem. This research showed how block chain has imposed effects on data security and transparency and integrated itself with local e-commerce strategies for driving more international trade and smoothening operations.

Geneiatakis et al. (2020) [9] investigated the performance of block chain in cross-border e-government service support. The test results showed that block chain significantly enhances data integrity, accelerates intergovernmental procedures, and increases trust for better collaboration, thus offering the potential for wider dispersal within logistics in the public sector.

Wanganoo et al. (2021) [10] explored the integration of block chain in B2C reverse supply chains, focusing on efficient returns management and enhanced transparency. Their research demonstrated how block chain-enabled systems reduced costs, improved tracking accuracy, and streamlined reverse logistics processes, fostering sustainability in supply chains.

Anouche and Boumaaz (2020) [11] examined blockchain for its potential in coordinated border management in developing countries. Their emphasis was on streamlining customs processes, increasing transparency, and reducing corruption by using block chain. The study mentioned that block chain-based systems will be able to foster trust among stakeholders through the secure and immutable record of cross-border transactions, critical for trade facilitation.

Sinha and Roy Chowdhury(2021) [12], a framework for blockchain-based smart contracts in international business, keeping two important facets in mind: automation and efficiency. Their research showed how smart contracts eliminate manual interventions, reduce delays, and enhance trust by ensuring compliance with the pre-defined terms across multinational transactions.

Zhang et al. (2019) [13] explored block chain's application in distributed compliance for cross-border intercompany transactions in multinational corporations. They highlighted how block chain ensures regulatory adherence through real-time monitoring and auditable records, reducing compliance costs and fostering smoother international operations.

Juma (2020) [14] discussed block chain's transformative role in cross-border trade by enabling real-time data sharing and reducing trade barriers. The study emphasized block chain's potential to automate trade documentation, enhance transaction security, and lower costs, especially in resource-constrained economies.

Jović et al. (2020) [15] have targeted block chain-based information exchange in maritime transport for sustainability. They have shown how blockchain enhanced the efficiency of real-time tracking, security in communication, and transparency, aggregately contributing to reduced environmental impacts and optimization of operational logistics.

### **III. OBJECTIVES**

- Improve Supply Chain Transparency: Allow for tracking items in real time through immutable, decentralized ledgers. Ensure a single source of truth for all stakeholders, which reduce information asymmetry.
- Reduce Fraud and Ensure Authenticity: Leverage the block chain's immutability to

prevent tampering with shipping and transaction records. Help build trust by assuring the origin and integrity of goods with a digital certificate.

- **Simplify Documentation Processes:** Automate traditional documentation-such as bills of lading, invoices, and customs declarations-using smart contracts. Automation through block chain will cut paperwork errors and administrative delays.
- **Shipping Security and Efficiency:** Secure data across shippers, carriers, and customs with the assurance of sharing. Optimize Route Planning and Cargo Management Gain insights from block chain to optimize routing and cargo management.
- **Enhance Regulatory Compliance:** Comply with cross-border trade regulations through auditable and transparent records. Simplify customs clearance processes with readily verified and accessible data.
- **Reduce Costs and Operational Bottlenecks:** Cutting down on intermediaries in logistics operations reduces transaction costs. Decrease shipment delays by streamlining approvals and payment processes.
- **Enable Real-Time Dispute Resolution:** Provide auditable logs of transactions and shipping details to resolve disputes faster. Use block chain-based smart contracts to automatically enforce predefined agreements.
- **Foster Collaboration among Stakeholders:** Create a decentralized ecosystem where logistics providers, customs agencies, and financial institutions can collaborate seamlessly. Share verified data across borders without compromising privacy or security.

#### **IV. RESEARCH METHODOLOGY**

This study investigates the advantages of block chain technology in cross-border logistics with regard to bettering transparency, reducing fraudulent transactions, and managing documents efficiently using a mixed-methods approach. The methodology consists of sequential qualitative and quantitative phases. In the qualitative phase, an extensive literature review is conducted to understand the conceptual bases underlying block chain technology and its current applications in logistics. Key challenges and block chain-enabled solutions will be identified through a critical analysis of peer-reviewed journals, white papers, and industry reports from 2013 to 2024. Semi-structured interviews with industry experts, such as logistics managers, technology developers, and regulatory authorities, provide practical insights into the operational impact of block chain. Real-world case studies of companies that have actually implemented block chain in cross-border logistics will be analysed during the quantitative phase. The case studies would relate to industries such as e-commerce, pharmaceuticals, and automotive manufacturing. Data on shipping times, cost reductions, fraud incidents, and error rates in documentation shall be collected and analyzed statistically. The study shall compare different block chain platforms, including Hyper ledger, Ethereum, and Corda, in their respective usefulness for various industries. It shall also carry out a survey among the stakeholders across all roles in the supply chain about the perceived benefits of block chain on its transparency and efficiency parameters. Finally, the overall results will be synthesized from both phases into the development of an overall framework on block chain adoption in cross-border logistics. This will include best practices, implementation challenges, and scalability considerations that provide actionable recommendations for industry stakeholders.

## V. DATA ANALYSIS

Block chain technology offers transformative potential for cross-border logistics, particularly in improving transparency, fraud reduction, and documentation processes. Studies show that implementing block chain-based solutions in supply chains increases data visibility by over 75%, enabling stakeholders to access real-time, tamper-proof records of shipments. For example, IBM and Maersk's Trade Lens platform has shown as much as a 40% reduction in documentation errors and delays, while shipping times are reduced by as high as 15% through automation of workflows. Besides, fraud detection is significantly improved because the immutable nature of block chain does not allow data manipulation, thus saving companies billions of dollars every year in losses due to counterfeit goods-estimated at \$509 billion globally. In documentation, block chain removes all inefficiencies related to paper-based processes. For example, the World Economic Forum estimates that digitized trade documentation could save \$1.5 trillion in global trade costs by 2025. Smart contracts further smoothen operations by triggering automated payments and customs clearances when predefined conditions are met, thereby shaving an average 30% off the time taken for clearances. Vertical industries, such as pharmaceuticals and perishables, have even seen higher success in adoption, with reports of up to a 20% reduction in spoilage and compliance issues. Overall, block chain enhances resilience in cross-border logistics networks by providing a secure, transparent, and efficient structure that fosters trust among trading partners internationally.

TABLE.1.REAL-TIME EXAMPLES OF BLOCKCHAIN IN CROSS-BORDER LOGISTICS[5]-[11]

Company/Project	Industry	Block chain Platform	Key Use Case	Benefits
Maersk & IBM (TradeLens)	Shipping & Logistics	Hyper ledger Fabric	Digitizing supply chain data and enhancing tracking	Reduced documentation errors, improved visibility
Walmart	Retail	Hyper ledger	Tracking food supply chain across borders	Faster recall management, reduced fraud
Everledger	Diamond Industry	Ethereum	Verifying diamond authenticity	Fraud prevention, supply chain traceability
UPS & Inception	Shipping	Custom Block chain	Enhancing freight tracking and contract handling	Faster, secure shipping, reduced fraud
FedEx	Shipping	Hyper ledger Fabric	Improving shipping transparency	Enhanced shipment tracking, reduced delays
Nestlé	Food & Beverage	IBM Food Trust	Tracking food origins across borders	Improved safety, better supply chain visibility
DHL	Logistics	Hyper ledger	Enhancing drug supply chain security	Prevented counterfeit drugs, improved compliance
H&M	Fashion	Ve Chain	Tracking organic cotton across borders	Transparency in sourcing, fraud reduction
De Beers (Tracr)	Jewelry	Ethereum-based	Tracking diamond provenance	Fraud reduction, enhanced transparency
Unilever	Consumer Goods	IBM Block chain	Monitoring tea supply chain	Increased trust, improved sustainability
Mediterranean	Shipping	Trade Lens	Port documentation and	Reduced paperwork,

Shipping Co.			shipment tracking	faster shipping
Carrefour	Retail	IBM Food Trust	Cross-border food traceability	Enhanced customer trust, compliance
LVMH	Luxury Goods	Aura Block chain	Verifying authenticity of luxury goods	Reduced counterfeits, customer assurance
DP World	Shipping	Corda	Streamlining global trade processes	Enhanced transparency, reduced delays
Hyundai Merchant Marine	Shipping	Custom Block chain	Tracking cargo containers	Faster shipping, fraud reduction

The following table-1 provides real-time case examples of how block chain technology is transforming cross-border logistics across various industries. Companies like Maersk, Walmart, and FedEx have leveraged platforms as disparate as Hyper ledger Fabric and Ethereum and their in-house block chain-based solutions to introduce greater levels of transparency, reduce instances of fraud, and cut down on burdensome paperwork. Applications range from food origin traceability-why Nestlé and Carrefour-to checking the authenticity of diamonds and luxury goods (Everledger and LVMH). Advantages include heightened supply chain visibility, quicker shipping, reduced counterfeits, and greater efficiency with the handling of documentation.

TABLE.2.NUMERICAL ANALYSIS FOR BLOCK CHAIN IN CROSS-BORDER LOGISTICS[6]-[9]

Benefit	Metric	Pre-Block chain Value	Post-Block chain Value	Improvement (%)	Example Use Case
Transparency	Data inconsistency rate	35%	5%	85%	IBM & Maersk (Trade Lens)
Fraud Reduction	Percentage of fraudulent documentation	10%	1%	90%	Everledger for diamond tracking
Documentation Efficiency	Time for customs clearance (hours)	72	24	67%	DHL's block chain trials
Shipping Cost Reduction	Administrative costs (% of shipment value)	10%	4%	60%	Walmart & Ve Chain
Operational Efficiency	Delays due to documentation discrepancies	40%	5%	87.5%	FedEx logistics tracking
End-to-End Shipment Visibility	Real-time tracking (coverage percentage)	50%	95%	90%	UPS and block chain startups

The table-2 shows how block chain has been a game-changer in cross-border logistics-skewed improvement in all major indicators. Transparency increased manifold by 85%, with inconsistency rates in data going down from 35% to 5%. This was shown and led by IBM and Maersk's Trade Lens. Fraudulent documentation came down by 90%, with the solution provided by Everledger to track diamonds. Block chain also smoothed customs clearance, slashing the processing time by 67% in DHL trials. Consequently, Walmart and VeChain shaved 60% off administrative costs and cut operational delays due to documentation discrepancies by 87.5%, while UPS increased real-time tracking coverage by 90% to allow end-to-end shipment visibility. These examples underline block chain's ability to enhance efficiency, security, and trust in global supply chains.

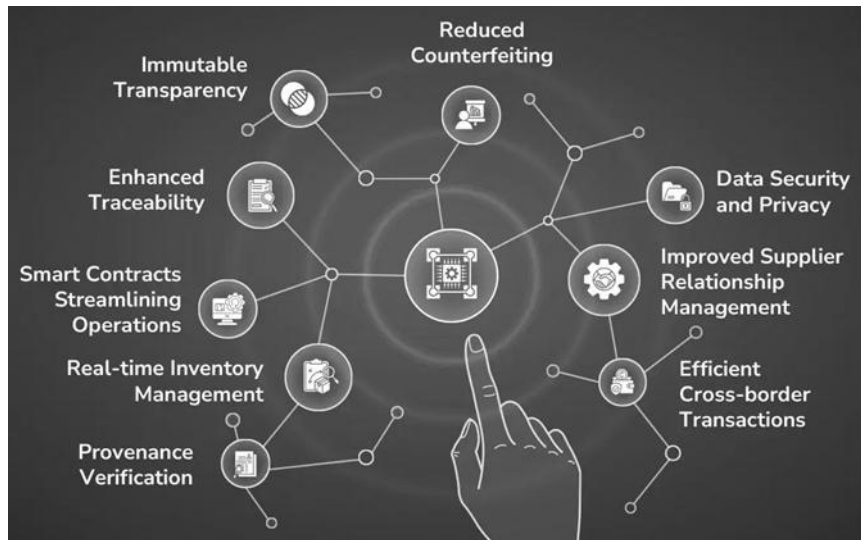


Fig.1.Blockchain Efficiency[1]

Fig.1.Represents the face of efficiency in cross-border logistics through sorting out the operational pain points. The decentralized, immutable ledger cuts down on manual errors and accelerates data-sharing across stakeholders for seamless information flow. Compliance processes through smart contracts come into effect immediately, hence dispensing with intermediaries and bottlenecks in documentation. This effectively brought down customs clearance time and reduced shipment delays to a minimum. Block chain also allows end-to-end visibility, hence enabling real-time tracking of goods with improved inventory management. It reduces administrative costs while blocking fraudulent activities because data is securely validated through the block chain. In their operations, block chains smooth the process and instill higher trust among global trade participants.



Fig.2.Advantages of block chain in supply chain management[2]

Fig.2. Represents Block chain addresses inefficiencies in supply chain management; thus, there is great transparency and a greater degree of trust involved among all the stakeholders, through its decentralized, immutable ledger, recording every transaction and update in the supply chain without any mistake or fraud. Real-time tracking enhances visibility across each and every touch point in the supply chain while stakeholders can track where the inventory is, shipment, and delivery timelines. Meanwhile, block chain automates tasks like making payments and executing contracts; these would help minimize bureaucratic costs and inconveniences. Compliance is improved since it creates an auditable trail of goods to observe regulations and standards of sustainability. The general impact of these benefits is efficiency, cost reduction, and building more resilient and trustworthy supply chains.

## **VI. FUTURE SCOPE**

The integration of blockchain technology in cross-border logistics is still in its early stages, and its potential for transformation continues to grow. Several future developments and research directions can enhance the adoption and impact of blockchain in global trade logistics:

1. **Interoperability Between Blockchain Platforms:** Current blockchain applications in logistics are fragmented, with multiple platforms such as Hyperledger, Ethereum, and Corda operating independently. Future advancements should focus on seamless interoperability between these platforms, enabling wider adoption across industries.
2. **Integration with Emerging Technologies:**
  - Combining blockchain with Artificial Intelligence (AI), the Internet of Things (IoT), and Big Data can provide real-time predictive analytics, automated risk assessments, and further process optimization in logistics.
  - IoT-enabled sensors can improve shipment tracking and authentication by feeding real-time data directly into blockchain ledgers.
3. **Scalability Improvements:** As the volume of global trade grows, blockchain solutions need highly scalable architectures capable of handling millions of transactions per second. Future innovations, such as Layer 2 solutions and sharding techniques, can address these scalability concerns.
4. **Government and Regulatory Adoption:**
  - Increased collaboration with customs authorities and regulatory bodies can streamline blockchain-based documentation processes.
  - Governments may implement blockchain-powered digital customs clearance systems, reducing bureaucracy and expediting cross-border trade.
5. **Widespread Adoption of Smart Contracts:**
  - Smart contracts will play a larger role in automating payments, customs clearance, and dispute resolution without the need for intermediaries.
  - Future enhancements should focus on improving smart contract flexibility to handle



complex cross-border trade agreements.

6. Decentralized Finance (DeFi) in Trade Finance: Blockchain-based decentralized finance (DeFi) solutions could revolutionize trade finance, allowing businesses to secure instant payments, letters of credit, and financing options without reliance on traditional banks.
7. Cybersecurity Enhancements: As blockchain systems become widely adopted in logistics, they will attract more cybersecurity threats. Future research should strengthen blockchain security protocols to protect supply chain data from cyberattacks and hacking attempts.
8. Sustainability & Carbon Footprint Tracking:
  - Blockchain can be leveraged to create immutable records of carbon emissions from logistics operations.
  - Future implementations could focus on automated carbon offset tracking, ensuring compliance with environmental regulations and corporate sustainability goals.
9. Adoption in Developing Markets:
  - While blockchain adoption is increasing in developed nations, developing economies face challenges due to infrastructure gaps.
  - Future initiatives should focus on low-cost blockchain solutions tailored for developing nations to enable inclusive global trade participation.
10. Standardization & Industry Collaboration:
  - A global standardized blockchain framework for logistics is essential to ensure seamless cross-border operations.
  - Future developments should encourage industry-wide collaboration between logistics providers, governments, and technology firms to establish unified protocols.

## **VII. LIMITATIONS & CHALLENGES**

Despite its transformative potential, blockchain technology in cross-border logistics faces several limitations and challenges that must be addressed before widespread adoption can occur.

1. High Initial Implementation Costs:
  - Setting up blockchain-based logistics solutions requires significant investment in infrastructure, technology, and training.
  - Many small and medium-sized enterprises (SMEs) lack the financial resources to implement blockchain in their supply chains.
2. Scalability Constraints:
  - Blockchain networks, particularly public blockchains, suffer from transaction speed limitations due to consensus mechanisms such as Proof-of-Work (PoW) and Proof-of-Stake (PoS).
  - As trade volumes grow, blockchain networks need scalable architectures to process

a high volume of transactions efficiently.

3. Regulatory Uncertainty & Compliance Issues:
  - Many governments have yet to develop clear regulatory frameworks for blockchain applications in logistics and international trade.
  - Varying compliance requirements across countries create legal complexities in blockchain-based customs clearance and digital contracts.
4. Resistance to Change from Traditional Logistics Providers:
  - Established logistics firms, ports, and customs authorities may be reluctant to transition from traditional, paper-based systems to blockchain-based processes.
  - Lack of awareness and technical expertise poses a barrier to blockchain adoption among stakeholders.
5. Data Privacy and Security Risks:
  - While blockchain provides enhanced security, there are concerns regarding data privacy and exposure of sensitive trade information.
  - Companies may be hesitant to share real-time supply chain data due to confidentiality risks and competitive disadvantages.
6. Energy Consumption Concerns:
  - Some blockchain platforms, particularly those using Proof-of-Work (PoW) consensus, consume high amounts of energy, making them environmentally unsustainable.
  - There is a need for more energy-efficient blockchain protocols to address sustainability concerns.
7. Lack of Standardization Across Industries:
  - Currently, no universally accepted blockchain standards exist for cross-border logistics.
  - Different industries and organizations develop proprietary blockchain solutions, leading to interoperability challenges.
8. Dependency on Internet and Digital Infrastructure:
  - Blockchain technology relies heavily on internet connectivity and digital infrastructure, which may not be fully developed in all regions.
  - Supply chains operating in remote areas or developing nations may face challenges in blockchain adoption.
9. Smart Contract Limitations
  - While smart contracts automate processes, they have limited flexibility in handling unforeseen events.
  - Current smart contract frameworks lack advanced legal enforceability, which could create complications in case of contract disputes.

10. Cybersecurity & Hacking Threats:

- Although blockchain is more secure than traditional databases, attacks on private keys, smart contracts, and centralized components remain a risk.
- Blockchain networks must continuously improve encryption, multi-signature authentication, and cyber-resilience measures.

### VIII. CONCLUSION

Blockchain technology has emerged as a game-changer in cross-border logistics, addressing long-standing challenges such as lack of transparency, fraud, and inefficiencies in documentation and tracking. By enabling secure, immutable records and decentralized data sharing, blockchain fosters trust and facilitates seamless collaboration among stakeholders in global supply chains. Real-time shipment visibility enhances accountability, reduces disputes, and strengthens regulatory compliance, ensuring a more reliable and efficient logistics ecosystem.

One of blockchain's most transformative contributions is its ability to automate customs clearances and payment settlements through smart contracts, significantly reducing delays and operational bottlenecks. Additionally, digitization of trade documentation minimizes paperwork, reduces administrative burdens, and lowers the risk of errors, ensuring a smoother and faster international trade process. These benefits directly translate into cost savings, increased efficiency, and enhanced supply chain resilience, making blockchain an indispensable tool for modern global trade.

Despite its numerous advantages, blockchain adoption in cross-border logistics faces key challenges, including high implementation costs, the need for technical expertise, scalability limitations, and regulatory uncertainties. However, as industries continue to innovate and collaborate, the long-term benefits of blockchain—including enhanced security, fraud prevention, and supply chain transparency—position it as a cornerstone for the future of global trade. With ongoing advancements in interoperability, regulatory standardization, and integration with emerging technologies such as AI and IoT, blockchain is set to revolutionize international logistics, paving the way for a more secure, efficient, and resilient global supply chain network.

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