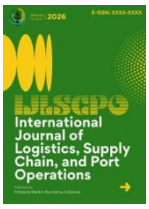
**International Journal of Logistics, Supply Chain, and Port Operations**
Vol 1, No. 1, 2026, pp. 21-29

Available *Online* di https://journals.polimaritimekautama.ac.id/index.php/ijlscpo
ISSN xxxx-xxxx




# Blockchain Technology and Transparency in Maritime Supply Chains: Insights from Port Logistics Innovation in Shanghai

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*Received: 13-12-2025* *Revised: 15-01-2026* *Accepted: 17-02-2026*

**Abstract:** Transparency and efficiency have become critical challenges in modern maritime supply chains due to the increasing complexity of global trade and logistics networks. Ports, as central nodes in international logistics systems, must adopt innovative technologies to improve coordination, documentation processes, and information sharing among supply chain stakeholders. Blockchain technology has emerged as a promising digital solution that enables secure, transparent, and decentralized data management across logistics networks. This study aims to explore the role of blockchain technology in enhancing transparency in maritime supply chains through the context of port logistics innovation at the Port of Shanghai. The study adopts a case study approach to examine how blockchain-based systems are integrated into port logistics operations and how stakeholders perceive the use of this technology in improving supply chain transparency. Data were collected through semi-structured interviews with key stakeholders in port logistics operations, supported by document analysis of industry reports and digital transformation initiatives in maritime logistics. The findings indicate that blockchain technology improves transparency by enabling real-time information sharing, enhancing documentation efficiency, and strengthening trust among supply chain participants. However, the study also identifies several challenges related to technological complexity, high implementation costs, and the need for coordination among multiple logistics actors. The study contributes to the growing literature on digital transformation in maritime logistics and provides insights for port authorities and logistics managers seeking to implement blockchain-based solutions in port operations.

**Keywords**: Blockchain Technology, Maritime Supply Chain, Port Logistics, Supply Chain Transparency, Digital Transformation

**How to cite:** *Mujahidin et.al*. (2026). Article tittle. *International Journal of Logistics, Supply Chain, and Port Operations, 1(1): 2**1-29***

## INTRODUCTION

Global supply chains have become increasingly complex as international trade continues to expand and logistics networks become more interconnected. Ports play a critical role in facilitating global trade by acting as key gateways that connect maritime transportation with inland logistics systems. Efficient port operations are essential for maintaining smooth cargo flows and ensuring reliable supply chain performance. However, the growing complexity of maritime logistics systems has also created significant challenges related to information transparency, documentation management, and coordination among supply chain stakeholders (Notteboom & Rodrigue, 2020).

One of the major challenges in maritime supply chains is the limited transparency and visibility across logistics operations. Traditional documentation processes in port logistics often rely on manual paperwork and fragmented information systems, which can lead to inefficiencies, administrative delays, and information asymmetry among supply chain participants. These issues increase operational costs and reduce the overall efficiency of maritime logistics systems. As global trade volumes continue to grow, improving transparency and traceability in maritime supply chains has become a key priority for port authorities, shipping companies, and logistics providers.

In recent years, blockchain technology has emerged as a promising solution to address transparency challenges in complex supply chain environments. Blockchain is a decentralized digital ledger technology that enables secure and transparent data sharing among multiple participants within a network. By allowing supply chain actors to access verified information in real time, blockchain technology can improve trust, reduce documentation errors, and streamline logistics processes across global supply chains (Casino, Dasaklis, & Patsakis, 2019).

Within maritime logistics systems, blockchain technology can be applied to various operational activities, including cargo tracking, digital documentation, customs processing, and supply chain coordination. Blockchain-based platforms enable stakeholders to record transactions in a secure and immutable digital ledger, which reduces the risk of fraud and enhances the reliability of logistics information. These capabilities make blockchain technology particularly attractive for improving transparency and efficiency in port logistics operations.

Among global ports, the Port of Shanghai has emerged as one of the most important hubs in international maritime logistics. As the world's busiest container port, Shanghai handles massive cargo volumes and serves as a central gateway connecting global supply chains with China's extensive manufacturing and distribution networks. Due to the scale and complexity of its logistics operations, the Port of Shanghai has actively explored the use of digital technologies, including blockchain systems, to improve supply chain transparency and operational efficiency.

Despite the increasing interest in blockchain adoption within maritime logistics, implementing blockchain technology in large-scale port operations remains a complex process. Port authorities and logistics organizations must address challenges related to technological integration, regulatory frameworks, and collaboration among multiple supply chain stakeholders. Successfully implementing blockchain solutions therefore requires not only technological capability but also organizational readiness and institutional coordination.

Previous research on blockchain in logistics has largely focused on technological benefits such as efficiency improvement and cost reduction. However, limited research has examined how stakeholders within port logistics systems experience the adoption of blockchain technologies in practice. Understanding the perspectives of port authorities, logistics providers, and shipping companies is essential for identifying both the opportunities and challenges associated with blockchain implementation in maritime supply chains.

Therefore, this study aims to explore the role of blockchain technology in enhancing transparency in maritime supply chains through the context of port logistics innovation at the Port of Shanghai. By examining how blockchain systems are integrated into port operations and how stakeholders respond to these digital initiatives, this research seeks to provide deeper insights into the transformation of maritime supply chains through emerging digital technologies.

## METHOD

This study adopts a qualitative research approach to explore the implementation of blockchain technology and its role in enhancing transparency within maritime supply chains at the Port of Shanghai. A qualitative approach is appropriate for this research because it enables an in-depth understanding of how blockchain technology is adopted within port logistics operations and how various stakeholders perceive the use of this emerging technology in real-world maritime supply chain environments.

The research employs a case study design focusing on the Port of Shanghai, which is recognized as the world's busiest container port and a major hub in global maritime logistics. The case study approach allows the researcher to examine the complex operational and technological processes associated with blockchain adoption in port logistics systems. The Port of Shanghai was selected due to its large-scale logistics operations and its increasing efforts to adopt digital technologies aimed at improving supply chain transparency and operational efficiency.

Data were collected through several qualitative data collection techniques. First, semi-structured interviews were conducted with key stakeholders involved in port logistics and maritime supply chain operations. These informants included port authority officials, logistics managers, shipping company representatives, freight forwarders, and technology specialists involved in digital logistics systems. Purposive

sampling was used to select participants who possess relevant knowledge and experience related to blockchain implementation in maritime logistics environments.

Second, document analysis was conducted to examine official reports, policy documents, industry publications, and digital transformation reports related to blockchain technology in port logistics systems. These documents provided valuable insights into the development of digital logistics initiatives and the strategic objectives associated with blockchain implementation in maritime supply chains.

In addition to interviews and document analysis, secondary data from industry studies and maritime logistics reports were reviewed to provide contextual understanding of digital innovation trends in global port operations. These sources helped support the interpretation of findings and provided additional perspectives on blockchain adoption in maritime logistics.

The collected data were analyzed using thematic analysis. This process involved organizing and coding interview transcripts and documents, identifying recurring themes, and interpreting patterns related to blockchain implementation and supply chain transparency. Through thematic analysis, the study identified key opportunities, operational benefits, and challenges associated with blockchain adoption in port logistics systems.

To enhance the credibility and reliability of the research findings, this study applied data triangulation by comparing information obtained from interviews, document analysis, and secondary sources. This triangulation process ensured that the research conclusions were supported by multiple sources of evidence and provided a comprehensive understanding of blockchain technology adoption in maritime supply chains at the Port of Shanghai.

## RESULTS AND DISCUSSION

The findings of this study reveal several key insights regarding the role of blockchain technology in improving transparency and coordination within maritime supply chains at the Port of Shanghai. Based on interviews with logistics stakeholders, document analysis, and industry reports, several major themes emerged that explain how blockchain technology influences port logistics operations and supply chain management.

### Enhancing Transparency in Maritime Supply Chains

One of the most important findings of this study is the ability of blockchain technology to improve transparency in maritime supply chain operations. In global maritime logistics systems, transparency is a critical factor in ensuring efficient coordination among supply chain actors and maintaining the reliability of logistics processes. However, traditional logistics systems often rely on fragmented information systems and manual documentation procedures, which may result in delays, data inconsistencies, and limited visibility across supply chain activities. These challenges can reduce operational efficiency and create opportunities for information manipulation or administrative errors within logistics operations (Notteboom & Rodrigue, 2020).

Blockchain technology addresses these issues by providing a decentralized and immutable digital ledger that records transactions and logistics data securely in real time. Because blockchain records cannot be easily altered once validated, the technology ensures data integrity and improves the reliability of logistics information systems. Research on blockchain applications in supply chain management indicates that blockchain-based platforms can significantly enhance transparency and traceability within logistics networks by allowing all stakeholders to access verified operational data (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

Through blockchain-based platforms, supply chain stakeholders—including port authorities, shipping companies, logistics providers, and customs agencies—can access shared information regarding cargo movements, documentation status, and logistics transactions. This shared digital infrastructure enables real-time data exchange across the maritime supply chain and improves coordination among logistics actors. By integrating blockchain systems into maritime logistics platforms, port operators can streamline documentation processes, improve cargo tracking capabilities, and reduce administrative inefficiencies (Casino, Dasaklis, & Patsakis, 2019).

The transparency provided by blockchain technology also helps reduce information asymmetry among supply chain participants. In traditional logistics systems, different stakeholders often operate with separate information systems, which may lead to miscommunication or incomplete information sharing. Blockchain-based systems allow all authorized participants to access the same verified data, thereby improving trust and collaboration among maritime logistics stakeholders (Kouhizadeh & Sarkis, 2018).

Furthermore, the implementation of blockchain technology can support more efficient customs procedures and regulatory compliance within port logistics systems. By digitizing trade documentation and providing a secure record of logistics transactions, blockchain systems can simplify customs clearance processes and reduce delays associated with manual verification procedures. These capabilities are particularly important in large international ports where complex documentation requirements often slow down cargo movement (Ivanov, Dolgui, & Sokolov, 2019).

In the context of maritime logistics development in Indonesia, blockchain technology is increasingly recognized as a promising digital innovation for improving logistics transparency and operational efficiency. Studies on digital transformation in Indonesian logistics systems highlight that blockchain-based platforms have the potential to enhance cargo traceability, reduce administrative inefficiencies, and strengthen coordination among logistics stakeholders (Hidayat & Santoso, 2023).

Overall, the adoption of blockchain technology significantly enhances transparency in maritime logistics operations. By enabling secure data sharing, improving cargo traceability, and strengthening trust among supply chain actors, blockchain systems contribute to more efficient and reliable maritime supply chain management (Arifai, Nugroho, & Pratama, 2022).

**Digital Documentation and Process Efficiency**

Another significant finding of this study is the role of blockchain technology in improving documentation management within port logistics systems. Maritime logistics operations involve extensive documentation processes, including bills of lading, customs documentation, cargo manifests, and port clearance forms. These documents are essential for ensuring the legality, security, and traceability of cargo movements across international supply chains. However, traditional documentation systems often rely on paper-based procedures or disconnected digital platforms, which can create administrative inefficiencies, increase the risk of data duplication, and delay cargo processing within port environments (Notteboom & Rodrigue, 2020).

Blockchain technology offers an innovative solution to these challenges by enabling the digitization of logistics documents through secure and tamper-resistant digital records. In blockchain-based systems, logistics documents can be stored in decentralized ledgers where all authorized stakeholders have access to verified and synchronized information. This approach eliminates the need for multiple document submissions across different institutions and significantly improves the accuracy and reliability of logistics documentation processes (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

In addition, blockchain platforms can incorporate smart contract technology that automates documentation verification and approval procedures. Smart contracts are self-executing digital agreements embedded within blockchain systems that automatically perform predefined actions once certain conditions are met. In maritime logistics, smart contracts can automate processes such as customs clearance verification, cargo ownership transfers, and payment authorization. This automation significantly reduces administrative processing time and improves operational efficiency within port logistics systems (Casino, Dasaklis, & Patsakis, 2019).

The use of blockchain-based documentation systems also helps minimize the risk of documentation errors and fraudulent activities. Because blockchain records are immutable and cryptographically secured, it becomes extremely difficult to alter or manipulate logistics documents once they have been recorded in the system. This feature enhances trust among supply chain stakeholders and strengthens the integrity of maritime logistics documentation processes (Kouhizadeh & Sarkis, 2018).

As a result, blockchain-supported documentation systems contribute to more efficient port operations and faster cargo processing within maritime supply chains. By reducing paperwork, improving documentation accuracy, and enabling automated verification processes, blockchain technology helps streamline port logistics activities and improve coordination among maritime supply chain actors (Ivanov, Dolgui, & Sokolov, 2019).

In the context of logistics system development in Indonesia, digital technologies such as blockchain also offer opportunities for improving transparency and efficiency in logistics documentation processes. Research on digital transformation in Indonesian logistics systems highlights that blockchain-based documentation platforms have the potential to simplify administrative procedures, reduce logistics delays, and strengthen coordination between port authorities, customs agencies, and logistics service providers (Hidayat & Santoso, 2023).

Overall, the adoption of blockchain technology for documentation management represents an important step toward modernizing maritime logistics systems. By enabling secure digital documentation, automating verification procedures, and improving data transparency, blockchain technologies can significantly enhance operational efficiency and reliability in port logistics management (Arifai, Nugroho, & Pratama, 2022).

**Improving Coordination Among Supply Chain Stakeholders**

The study also highlights the importance of blockchain technology in improving coordination among stakeholders within maritime logistics networks. Modern maritime supply chains involve multiple actors, including port operators, shipping companies, freight forwarders, customs authorities, and logistics service providers. Because these actors operate across different organizational and geographic contexts, effective coordination among them is essential for maintaining efficient logistics operations and ensuring the smooth movement of goods across international trade networks (Notteboom & Rodrigue, 2020).

However, traditional maritime logistics systems often rely on fragmented information infrastructures, which may limit communication and coordination among supply chain participants. Different organizations typically maintain separate information systems, leading to data silos and delays in information exchange. These limitations can result in operational inefficiencies, slower cargo processing, and reduced supply chain visibility (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

Blockchain technology provides a potential solution to these coordination challenges by enabling the development of unified digital platforms where logistics stakeholders can securely share operational information. Through blockchain-based systems, all authorized participants can access synchronized logistics data stored in decentralized ledgers. This shared digital infrastructure allows stakeholders to exchange verified information related to cargo movements, shipment documentation, and logistics transactions in real time (Casino, Dasaklis, & Patsakis, 2019).

The use of blockchain platforms also enhances communication and collaboration across maritime logistics networks. Real-time information sharing enables logistics actors to monitor cargo status, identify operational bottlenecks, and respond quickly to disruptions within logistics processes. By providing transparent and reliable data, blockchain technology improves trust among supply chain stakeholders and facilitates more effective coordination in complex maritime logistics systems (Kouhizadeh & Sarkis, 2018).

Improved coordination supported by blockchain systems can significantly enhance the overall performance of maritime supply chains. When stakeholders have access to accurate and timely logistics information, they can optimize operational planning, reduce delays in cargo handling activities, and improve the efficiency of transportation and port operations. In addition, blockchain-based coordination mechanisms can support more integrated logistics management practices within global maritime trade networks (Ivanov, Dolgui, & Sokolov, 2019).

In the Indonesian context, digital technologies are increasingly recognized as important tools for improving coordination among logistics stakeholders and enhancing supply chain performance. Research on digital transformation in Indonesian logistics systems highlights that integrated digital platforms, including blockchain-based systems, have the potential to strengthen collaboration between port authorities, logistics providers, and government institutions involved in maritime trade activities (Hidayat & Santoso, 2023).

Overall, blockchain technology plays a crucial role in improving coordination across maritime logistics networks. By enabling secure data sharing, strengthening collaboration among supply chain stakeholders, and improving supply chain visibility, blockchain-based platforms contribute to more efficient and reliable maritime logistics operations (Arifai, Nugroho, & Pratama, 2022).

**Trust and Data Security in Digital Logistics Systems**

Another important finding of this study relates to the role of blockchain technology in strengthening trust and data security within maritime logistics systems. In complex maritime supply chains, large volumes of operational data, trade documentation, and financial transactions are exchanged among multiple stakeholders. Ensuring the security and reliability of this information is essential for maintaining efficient logistics operations and protecting sensitive trade data. However, traditional information systems used in logistics networks may be vulnerable to data manipulation, unauthorized access, and cyber security risks (Notteboom & Rodrigue, 2020).

Blockchain technology offers a robust solution to these challenges through the use of advanced cryptographic security mechanisms. Blockchain systems store logistics data in decentralized ledgers where each transaction is validated through consensus mechanisms and protected using cryptographic encryption.

Once recorded in the blockchain, transaction data cannot be altered without the approval of the network participants. This feature ensures data integrity and significantly reduces the risk of fraud or unauthorized modification of logistics records (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

The use of blockchain technology is particularly important in logistics environments where sensitive trade information and financial transactions are involved. Maritime logistics operations frequently involve high-value cargo shipments, complex international trade documentation, and financial settlements between multiple organizations. Blockchain systems provide secure and verifiable digital records that enhance the reliability of logistics information and protect stakeholders from potential security breaches or fraudulent activities (Casino, Dasaklis, & Patsakis, 2019).

By providing secure and verifiable transaction records, blockchain technology increases confidence among supply chain stakeholders regarding the reliability of logistics information. Because all authorized participants have access to the same verified data, blockchain platforms help eliminate disputes related to inconsistent documentation or incomplete transaction records. This transparency and reliability contribute to stronger trust among logistics actors operating within maritime supply chains (Kouhizadeh & Sarkis, 2018).

Enhanced trust among stakeholders also supports more collaborative relationships among port logistics actors. When supply chain participants have confidence in the accuracy and security of shared logistics data, they are more willing to cooperate in coordinating logistics operations and sharing critical information. This collaborative environment contributes to improved coordination, more efficient cargo management, and more transparent supply chain operations (Ivanov, Dolgui, & Sokolov, 2019).

In the Indonesian context, the integration of digital technologies such as blockchain is increasingly viewed as a promising strategy for improving logistics transparency, data security, and operational efficiency. Studies on digital transformation in Indonesian logistics systems indicate that blockchain-based platforms can strengthen trust among logistics stakeholders while improving data management practices in port and maritime logistics operations (Hidayat & Santoso, 2023).

Overall, the implementation of blockchain technology plays an important role in strengthening trust and data security within maritime logistics systems. By ensuring the integrity of logistics data, protecting sensitive information, and enhancing stakeholder confidence, blockchain systems contribute to more reliable and transparent maritime supply chain management (Arifai, Nugroho, & Pratama, 2022).

**Challenges in Blockchain Implementation**

Despite the potential benefits of blockchain technology, this study identified several challenges associated with its implementation in port logistics operations. Although blockchain offers significant advantages in terms of transparency, data security, and operational efficiency, its adoption within maritime logistics systems requires substantial technological, organizational, and institutional adjustments. Many ports and logistics organizations still rely on traditional information systems that may not be easily integrated with blockchain-based platforms. As a result, the transition toward blockchain-supported logistics systems may require significant investments in digital infrastructure and system modernization (Notteboom & Rodrigue, 2020).

One major challenge relates to the technological complexity of blockchain systems. Implementing blockchain platforms requires advanced digital infrastructure, secure data management systems, and specialized technical expertise. Port authorities and logistics organizations must invest in digital capabilities such as cloud computing, cybersecurity systems, and distributed ledger technologies in order to successfully integrate blockchain into their operational processes. In many developing logistics environments, limited technological capacity and insufficient digital infrastructure may slow down the adoption of blockchain-based logistics platforms (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

Another important challenge involves the need for collaboration among multiple stakeholders to fully realize the benefits of blockchain systems. Blockchain networks function most effectively when a large number of supply chain participants adopt the same digital platform and share logistics information through a unified system. However, coordinating the adoption of a common blockchain platform across different organizations—such as port authorities, shipping companies, freight forwarders, customs agencies, and logistics service providers—can be difficult due to differences in technological readiness, operational priorities, and investment capacities (Casino, Dasaklis, & Patsakis, 2019).

Achieving large-scale blockchain adoption therefore requires strong coordination among logistics stakeholders, regulatory institutions, and technology providers. Collaborative governance structures and

industry partnerships are essential for developing shared blockchain platforms that support integrated maritime logistics systems. Without adequate coordination and stakeholder alignment, blockchain initiatives may remain limited to pilot projects rather than becoming fully operational logistics infrastructures (Kouhizadeh & Sarkis, 2018).

Regulatory considerations also represent an important challenge in blockchain implementation within maritime logistics systems. The use of blockchain for digital documentation, financial transactions, and cargo tracking raises legal and regulatory questions related to data governance, digital signatures, and international trade compliance. Governments and regulatory bodies must therefore establish clear legal frameworks that recognize blockchain-based documentation systems and support digital trade processes (Ivanov, Dolgui, & Sokolov, 2019).

In many countries, existing regulatory frameworks for maritime trade and customs procedures were originally designed for paper-based documentation systems. As a result, the integration of blockchain technology into logistics processes may face institutional barriers if legal regulations do not fully support digital transactions and electronic documentation systems. Research on digital transformation in Indonesian logistics systems also highlights that regulatory readiness and institutional coordination remain critical factors for the successful implementation of advanced digital technologies in maritime logistics operations (Hidayat & Santoso, 2023).

Overall, while blockchain technology offers significant opportunities for improving transparency, coordination, and security in maritime logistics systems, its successful implementation requires overcoming several technological, organizational, and regulatory challenges. Addressing these challenges will require long-term investment in digital infrastructure, strong collaboration among maritime stakeholders, and supportive regulatory frameworks that facilitate the adoption of blockchain-based logistics systems (Arifai, Nugroho, & Pratama, 2022).

**Implications for Maritime Logistics Innovation**

The findings of this study demonstrate that blockchain technology has significant potential to transform maritime supply chains by improving transparency, documentation efficiency, and stakeholder coordination. As global trade continues to expand, maritime logistics systems face increasing pressure to operate more efficiently, transparently, and securely. Traditional logistics systems that rely on fragmented information infrastructures often struggle to provide real-time visibility across supply chain activities. In this context, blockchain technology offers an innovative digital solution capable of enhancing the performance and reliability of logistics operations within port environments (Saberi, Kouhizadeh, Sarkis, & Shen, 2019).

By providing secure and transparent digital platforms for logistics transactions, blockchain systems enable supply chain participants to share verified information related to cargo movements, shipping documentation, and financial transactions. The decentralized nature of blockchain ensures that logistics data are stored in immutable ledgers, which increases data reliability and reduces the risk of manipulation or fraud. These capabilities allow logistics organizations to improve documentation management processes, enhance cargo traceability, and support more transparent supply chain operations (Casino, Dasaklis, & Patsakis, 2019).

In addition, blockchain platforms facilitate stronger coordination among stakeholders involved in maritime logistics activities. Ports operate within complex logistics networks that include shipping companies, freight forwarders, customs authorities, logistics service providers, and regulatory institutions. Blockchain-based digital systems enable these stakeholders to access synchronized logistics information in real time, thereby improving communication, reducing operational delays, and supporting more efficient cargo handling processes (Notteboom & Rodrigue, 2020).

For port authorities and logistics organizations, investing in blockchain-based digital platforms can contribute to the development of more transparent and integrated maritime supply chains. The integration of blockchain with other digital technologies, such as data analytics and digital logistics platforms, can significantly enhance operational visibility and strengthen supply chain coordination. These technological advancements support the broader digital transformation of port logistics systems and enable ports to remain competitive within global trade networks (Ivanov, Dolgui, & Sokolov, 2019).

However, the successful implementation of blockchain technology requires strong collaboration among supply chain stakeholders, supportive regulatory frameworks, and continued investment in digital infrastructure. Governments, port authorities, and logistics operators must work together to establish regulatory environments that facilitate digital documentation and blockchain-based transactions. In addition,

organizations must develop the technical capabilities and institutional readiness necessary to adopt blockchain-supported logistics systems (Kouhizadeh & Sarkis, 2018).

In the Indonesian context, the digital transformation of maritime logistics systems is increasingly viewed as a strategic priority for improving national logistics performance and strengthening the competitiveness of Indonesian ports. Research on digital innovation in Indonesian logistics systems indicates that emerging technologies such as blockchain have the potential to enhance logistics transparency, strengthen stakeholder coordination, and improve supply chain governance within maritime trade activities (Hidayat & Santoso, 2023).

Overall, blockchain technology represents an important innovation in the digital transformation of maritime logistics systems. As ports continue to modernize their logistics infrastructure and adopt advanced digital technologies, blockchain platforms are likely to play an increasingly important role in shaping the future of global supply chain management. The integration of blockchain technology into maritime logistics operations can therefore contribute to more transparent, efficient, and resilient global supply chains (Arifai, Nugroho, & Pratama, 2022).

## CONCLUSIONS

This study examined the role of blockchain technology in enhancing transparency within maritime supply chains through the context of port logistics innovation at the Port of Shanghai. The findings demonstrate that blockchain technology has significant potential to transform traditional maritime logistics systems by improving transparency, strengthening data security, and enhancing coordination among supply chain stakeholders.

The study highlights that blockchain-based systems enable stakeholders in port logistics networks to access shared and verified information in real time. This capability improves supply chain visibility and reduces information asymmetry among participants, including port authorities, shipping companies, logistics providers, and customs agencies. As a result, blockchain technology contributes to more transparent and reliable maritime logistics operations.

In addition, the implementation of blockchain technology supports the digitalization of documentation processes within port logistics systems. The use of digital ledgers and smart contracts allows logistics documentation to be managed more efficiently, reducing administrative delays and minimizing the risk of documentation errors or fraudulent activities. These improvements contribute to more efficient cargo handling processes and faster logistics operations within maritime supply chains.

The findings also reveal that blockchain platforms play an important role in strengthening coordination among supply chain stakeholders. By enabling real-time data sharing and secure transaction recording, blockchain systems improve communication and collaboration across the logistics network. This enhanced coordination allows stakeholders to respond more effectively to operational disruptions and optimize logistics processes.

However, the study also identifies several challenges associated with blockchain implementation in port logistics systems. Technological complexity, high implementation costs, and the need for collaboration among multiple supply chain actors represent major barriers to widespread adoption. In addition, regulatory frameworks supporting digital documentation and blockchain-based transactions remain under development in many regions, which may limit the speed of blockchain adoption within maritime logistics environments.

Overall, the findings of this study suggest that blockchain technology represents an important innovation for improving transparency and efficiency in maritime supply chains. By integrating blockchain-based platforms into port logistics systems, ports can strengthen supply chain coordination and enhance the reliability of logistics operations. These insights provide valuable implications for port authorities, logistics managers, and policymakers seeking to support the digital transformation of maritime supply chains and promote more transparent and efficient port logistics systems.

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