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Legal Validity of Blockchain-Based Contracts in Maritime Transport Systems

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Original Article

Abstract

This study aims to provide a juridical analysis of the application of blockchain technology in maritime transport contracts, with a focus on legal validity, recognition within existing regulatory frameworks, and dispute resolution mechanisms. Employing normative legal research, this study utilizes a statutory and literature review approach to examine the development and legal implications of blockchain technology. The findings indicate that while blockchain enhances transparency and data security, its legal recognition varies across national legal systems. Many countries lack clear regulations to govern blockchain-based contracts, leading to legal uncertainties. Additionally, dispute resolution for such contracts remains largely limited to arbitration mechanisms. This study highlights the need for international regulatory updates to accommodate blockchain technology in maritime transport contracts, ensuring a more standardized and effective legal framework that facilitates broader adoption and legal certainty in global trade.

Keywords: *Blockchain, Maritime Transport Contracts, Legal Recognition, Dispute Resolution, Technology*

Abstrak

Penelitian ini bertujuan untuk menganalisis secara yuridis penerapan teknologi blockchain dalam kontrak pengangkutan laut, dengan fokus pada validitas hukum kontrak, pengakuan hukum dalam sistem perundang-undangan yang berlaku, serta mekanisme penyelesaian sengketa. Metode yang digunakan dalam penelitian ini adalah penelitian normatif dengan pendekatan perundang-undangan dan studi literatur yang terkait dengan perkembangan teknologi blockchain. Hasil penelitian menunjukkan bahwa meskipun teknologi blockchain menawarkan banyak keuntungan, seperti transparansi dan keamanan data, tantangan utama terletak pada pengakuan hukum kontrak berbasis blockchain dalam sistem hukum negara-negara yang berbeda. Beberapa negara belum memiliki regulasi yang jelas untuk mengakomodasi teknologi ini, dan penyelesaian sengketa dalam kontrak berbasis blockchain masih terbatas pada mekanisme arbitrase. Penelitian ini menyarankan pentingnya pembaruan regulasi internasional untuk mengakomodasi penerapan blockchain dalam kontrak pengangkutan laut agar tercipta kerangka hukum yang lebih jelas dan efektif.

Kata kunci: *Blockchain, Kontrak Pengangkutan Laut, Pengakuan Hukum, Penyelesaian Sengketa, Teknologi*

1. INTRODUCTION

Blockchain technology is increasingly demonstrating significant potential across various sectors, including maritime transportation. With its decentralized and transparent nature, this technology offers innovative solutions to longstanding challenges in the maritime industry. The adoption of blockchain in this sector has the potential to enhance operational efficiency, reduce costs, and strengthen trust among stakeholders.

Maritime transportation is one of the key sectors in international trade, playing a vital role in the global economy. As the backbone of cross-border goods distribution, this sector must ensure a seamless supply chain and transactional certainty. Consequently, technological innovations that enhance security and efficiency are imperative for the industry's continued growth and global competitiveness.

Despite its critical role, the maritime transportation sector faces several challenges. High administrative complexity often delays shipping processes, while data manipulation vulnerabilities can undermine trust in transactions. Additionally, the lack of transparency in existing systems complicates oversight, increasing the risks of fraud and inefficiency. The integration of blockchain technology has the potential to address these challenges by providing secure, transparent, and immutable data recording.

One of the technological innovations being introduced to improve efficiency and reliability in maritime freight contracts is blockchain technology. With its decentralized and secure structure, blockchain offers solutions to mitigate various industry challenges. Blockchain technology enhances transparency in the global trade system by providing an open, secure, and immutable record-keeping mechanism.[1] This is particularly crucial in maritime freight contracts, which involve multiple parties, as it ensures that every transaction is clearly documented and verifiable.

By implementing blockchain, administrative processes in maritime freight operations can be conducted with greater transparency, security, and efficiency. This system allows all parties involved in a transaction to access immutable records, thereby minimizing the risks of fraud and administrative errors. The use of blockchain not only fosters trust among stakeholders but also accelerates business processes and reduces operational costs within the maritime freight industry.

However, the implementation of blockchain in maritime freight contracts also presents several legal challenges. While blockchain can reduce reliance on third parties, the primary challenge in its adoption concerns legal recognition and the status of contracts formed through blockchain systems.[2] This legal uncertainty arises because

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[1] Alexandros A. Papantoniou, "Smart Contracts in the New Era of Contract Law," *Digital Law Journal* 1, no. 4 (2020): 8–24, https://doi.org/10.38044/2686-9136-2020-1-4-8-24.

[2] Emmanuelle Ganne, "Blockchain's Practical and Legal Implications for Global Trade and Global Trade Law," in *Big Data and Global Trade Law*, ed. Mira Burri (Cambridge: Cambride University Press, 2021), 128–59.

many national legal frameworks have yet to fully accommodate the role of blockchain in international commercial contracts.[3]

For instance, while blockchain offers solutions for security and transparency, the recognition and enforcement of contracts executed on this platform remain significant challenges across different jurisdictions. Variations in national regulations may lead to inconsistencies in the implementation of blockchain-based contracts, particularly concerning legal evidence and dispute resolution mechanisms. Therefore, further research and the harmonization of regulations at the international level are necessary to facilitate the effective integration of blockchain technology into existing legal frameworks.

Moreover, the application of blockchain technology in the maritime transportation sector requires substantial adaptation to international treaty law and relevant regulations.[4] Blockchain-based contracts, which are digital and decentralized, may encounter legal challenges related to consumer protection, fraud prevention, and breach of contract provisions.[5] Traditional legal systems may not fully accommodate these aspects, necessitating regulatory adjustments to ensure that blockchain-based contracts are legally recognized and enforceable.

In this context, conducting a legal analysis of blockchain technology is essential to determine how contracts executed through this platform can be enforced within different legal systems. Additionally, the establishment of a clear dispute resolution mechanism is crucial to address potential differences in legal interpretation among the jurisdictions involved. The harmonization of international regulations and the development of more inclusive legal standards could provide a viable solution for strengthening the legal certainty of blockchain-based contracts in maritime transportation.

Although blockchain technology enhances the efficiency of contract and transaction management, significant obstacles remain concerning the recognition and enforcement of contracts executed through this system.[6] One of the primary challenges is the legal validity of documents stored on the blockchain. Without clear legal recognition, blockchain-based contracts may face evidentiary challenges in court,

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[3] Galang Firman Maulana and Agung Juliarto, "The Implementation of Blockchain in International Trade," *Diponegoro Journal of Accounting* 10, no. 4 (2021): 1–8, https://ejournal3.undip.ac.id/index.php/accounting/article/view/32969.

[4] Karen Czachorowski, Marina Solesvik, and Yuriy Kondratenko, "The Application of Blockchain Technology in the Maritime Industry," in *Studies in Systems, Decision and Control*, ed. Janusz Kacprzyk (Cham: Springer, 2018), 561–577, https://doi.org/10.1007/978-3-030-00253-4_24.

[5] Mohamed Ben Farah et al., "A Survey on Blockchain Technology in The Maritime Industry: Challenges and Future Perspectives," *Future Generation Computer Systems* 157 (2024): 618–37, https://doi.org/10.1016/j.future.2024.03.046.

[6] Shafaq Naheed Khan et al., "Blockchain Smart Contracts: Applications, Challenges, and Future Trends," *Peer-to-Peer Networking and Applications* 14 (2021): 2901–2925, https://doi.org/10.1007/s12083-021-01127-0.

particularly in jurisdictions that have not yet recognized digital documents stored in decentralized networks as admissible legal evidence.[7]

To maximize the potential of blockchain in the maritime transportation sector, The necessity of updating national laws and regulations to include the acceptance of blockchain-based contracts as part of international legal practice.[8] With clearer regulations and harmonized legal standards across jurisdictions, the validity and legal certainty of blockchain-based maritime transport contracts can be more effectively ensured. This would not only encourage the broader adoption of blockchain technology but also enhance the efficiency of global trade while mitigating legal risks associated with cross-border transactions.

Accordingly, this study aims to conduct a legal analysis of maritime transportation contracts utilizing blockchain technology. Specifically, it will examine the legal aspects associated with the implementation of blockchain in maritime transportation contracts, including the legal status of such contracts, their recognition and enforcement within existing legal systems, and potential legal challenges arising from this technological application. Through this analysis, the study seeks to provide a deeper understanding of the legal implications of blockchain adoption in maritime transportation.

2. RESEARCH METHODOLOGY

This study adopts a normative legal research approach to analyze and interpret legal norms governing maritime transportation contracts that incorporate blockchain technology. The primary focus is on evaluating relevant laws, regulations, and the application of established legal principles within this context. The research employs several methodological approaches, including the statute approach, which examines applicable legal provisions, and the case approach, which explores examples of blockchain applications in maritime transportation contracts. Additionally, a comparative approach is utilized to assess how different legal systems regulate blockchain-based contracts across various jurisdictions.

The study utilizes primary and secondary data sources. Primary data is collected through interviews with legal practitioners, industry experts, and professionals specializing in blockchain technology and maritime transportation. Secondary data includes books, peer-reviewed journals, legal documents, and official regulations relevant to blockchain, maritime transportation, and digital contracts. Data collection methods involve an extensive literature review for secondary data and interviews with key stakeholders for primary data. The research is conducted in university libraries, law offices, and maritime and blockchain technology companies, selected for their access

[7] Shi-Yi Lin et al., "A Survey of Application Research Based on Blockchain Smart Contract," *Wireless Networks* 28 (2022): 635–690, https://doi.org/10.1007/s11276-021-02874-x.

[8] Khan et al., "Blockchain Smart Contracts: Applications, Challenges, and Future Trends."

to legal literature and industry practices. Employing qualitative analysis, the study identifies legal patterns and compares blockchain-based maritime contracts with existing legal frameworks.

3. RESEARCH RESULT AND DISCUSSION

This study demonstrates that while blockchain technology offers numerous advantages, legal challenges persist, particularly regarding the legal recognition of contracts formed through blockchain within existing legal frameworks. Key findings of this research highlight a lack of regulatory clarity in various jurisdictions, the absence of international legal standards accommodating blockchain-based contracts, and challenges in dispute resolution processes involving decentralized technology. To address these issues, efforts to harmonize regulations and adapt legal frameworks are essential to facilitate the effective application of blockchain across various sectors, including maritime transportation.

3.1. Legal Status of Blockchain Contracts

The analysis reveals that many countries lack clear regulations on the recognition of blockchain-based contracts. While some jurisdictions acknowledge electronically signed agreements, the legal acceptance of blockchain technology as a valid contractual framework remains limited. This uncertainty poses a significant barrier to the widespread adoption of blockchain in maritime trade and transportation, as the absence of a well-defined legal foundation can undermine the enforceability and validity of blockchain-based contracts.

In countries such as the United States and Japan, blockchain-based contracts may be considered legally binding if they meet specific requirements, such as incorporating a legally recognized digital signature.[9] These nations have begun adapting their legal systems to accommodate technological advancements, demonstrating the crucial role of regulatory preparedness and digital authentication mechanisms in blockchain adoption.

However, many other countries—particularly in Africa and Southeast Asia—lack a robust legal framework for recognizing blockchain-based contracts.[10] The absence of clear regulations hinders innovation and creates legal uncertainty for businesses seeking to leverage blockchain for enhancing efficiency and transparency in transactions.[11] To promote broader adoption, developing a more inclusive legal framework is necessary to

[9] Ganne, "Blockchain's Practical and Legal Implications for Global Trade and Global Trade Law."

[10] Paulo Rupino da Cunha, Piotr Soja, and Marinos Themistocleous, "Blockchain for Development: A Guiding Framework," *Information Technology for Development* 27, no. 3 (2021): 417–38, https://doi.org/10.1080/02681102.2021.1935453%0D.

[11] Mohammad El Hajj and Imad Farran, "The Cryptocurrencies in Emerging Markets: Enhancing Financial Inclusion and Economic Empowerment," *Journal of Risk Financial Management* 17, no. 10 (2024): 1–27, https://doi.org/10.3390/jrfm17100467.

ensure that blockchain technology is legally recognized in contract formation and enforcement.

3.2. Legal Recognition and International Frameworks

At the international level, the recognition of blockchain-based contracts remains limited. Some jurisdictions, such as Estonia and Singapore, have proactively integrated blockchain technology into their regulatory systems, signaling their readiness to adopt innovations that enhance efficiency and transparency in legal transactions. However, blockchain adoption remains inconsistent across countries, particularly in regions that rely on traditional legal frameworks. Most nations still adhere to conventional contract laws, which can slow the implementation of blockchain technology in global trade.

The legal ambiguity surrounding blockchain-based digital contracts presents significant challenges for companies engaged in cross-border transactions. Regulatory inconsistencies between countries create legal uncertainty, potentially impeding the widespread adoption of blockchain in international trade and logistics.[12] Without a uniform legal framework, blockchain-based contracts may face recognition and enforcement issues across different jurisdictions, thereby diminishing their effectiveness in facilitating international commerce.

The diversity of legal systems worldwide results in varied interpretations and applications of digital contract laws, complicating dispute resolution and contract enforcement. Consequently, global regulatory efforts are essential to establish standardized legal frameworks that ensure blockchain-based contracts are legally recognized and enforceable across jurisdictions.

The lack of regulatory clarity and inconsistencies in legal recognition across different countries constitute major barriers to blockchain implementation in the international maritime transportation sector.[13] Divergent legal interpretations across jurisdictions complicate the development of global standards, creating uncertainty for stakeholders. Therefore, harmonizing regulations at the international level is crucial to facilitate the broader and more effective application of blockchain technology in global trade contracts.

3.3. Dispute Resolution

A significant challenge identified in this study concerns the resolution of disputes in blockchain-based contracts. In many instances, when conflicts arise between

[12] Maneerat Tangsakul and Panitas Sureeyatanapas, "Understanding Critical Barriers to The Adoption of Blockchain Technology in The Logistics Context: An Interpretive Structural Modelling Approach," *Journal of Open Innovation: Technology, Market, and Complexity* 10, no. 3 (2024): 1–14, https://doi.org/10.1016/j.joitmc.2024.100355.

[13] Czachorowski, Solesvik, and Kondratenko, "The Application of Blockchain Technology in the Maritime Industry."

contracting parties, traditional legal procedures struggle to address the unique, decentralized nature of blockchain technology. This difficulty stems from legal frameworks that remain oriented toward conventional contracts, which rely on physical documentation and clear territorial jurisdiction.

As a result, many parties involved in blockchain-based contracts opt for arbitration as their preferred dispute resolution method. Arbitration provides greater flexibility compared to court litigation, particularly in cases involving digital technology. Moreover, arbitration facilitates faster and more efficient dispute resolution, reducing reliance on national legal systems that may lack specific regulations for blockchain-based contracts.

Arbitration is a more practical approach, as it enables efficient and secure access to blockchain-recorded data. Given blockchain's transparent and immutable ledger system, it serves as strong evidentiary support in arbitration proceedings.[14] Consequently, the development of a legal framework supporting blockchain-based arbitration is crucial to ensuring the long-term sustainability and effectiveness of this technology in global business transactions.

3.4. Implications of Blockchain Adoption in Maritime Freight Contracts

The integration of blockchain technology into maritime freight contracts holds significant potential for enhancing efficiency and mitigating risks associated with fraud and administrative errors. This technology ensures that every transaction and contractual modification is permanently recorded, enabling real-time auditing by all stakeholders. With its transparent and tamper-proof characteristics, blockchain emerges as a promising solution for the maritime freight industry, which frequently encounters challenges such as forged documents and data manipulation.

However, the adoption of blockchain necessitates substantial changes to existing legal frameworks. Current maritime freight regulations remain rooted in traditional systems, which rely heavily on physical documentation and manual verification processes. These conventional methods often result in slow, inefficient procedures that are susceptible to fraud. By leveraging blockchain technology, the maritime freight system could become more transparent and secure; however, its successful implementation requires comprehensive regulatory reforms.

The transition to a blockchain-based system demands adjustments across multiple legal dimensions, including the recognition of digital contracts and the legal validity of electronic signatures in cross-border transactions. Many legal systems have yet to fully accommodate these digital mechanisms, which may create legal uncertainties in blockchain's practical application. Therefore, collaborative efforts among governments,

[14] Hangyun Tang et al., "DMOBAs: A Data Marketplace on Blockchain with Arbitration Using Side-Contracts Mechanism," *Computer Communications* 193 (2022): 10–22, https://doi.org/10.1016/j.comcom.2022.06.029.

legal institutions, and industry stakeholders are essential to establishing regulatory frameworks that ensure the legality and enforceability of blockchain-based contracts in international maritime trade.

One of the greatest challenges in blockchain adoption is the absence of international legal standards that recognize and safeguard contracts executed through this technology.[15] Without uniform global regulations, blockchain-based contracts in maritime transport may encounter obstacles concerning legal recognition and dispute resolution.[16] Thus, international cooperation in developing harmonized regulatory standards is imperative to facilitate the widespread and effective implementation of blockchain technology in global trade.

3.5. Legal Challenges in Recognizing Blockchain-Based Contracts

Research findings indicate that the recognition of blockchain-based contracts remains a significant challenge in many countries. Nations with more traditional legal systems often exhibit skepticism toward emerging technologies like blockchain, making its integration into existing legal frameworks particularly difficult. Legal regulations that still emphasize written contracts and physical documentation present various obstacles to the implementation of blockchain-based digital contracts, especially regarding their validity and enforcement mechanisms.

While blockchain holds immense potential to revolutionize transaction processes, many conventional legal systems are not yet equipped to fully regulate and adopt this technology.[17] A major challenge lies in the absence of global standards governing blockchain-based contracts, leading to inconsistent recognition across different jurisdictions. While some countries have initiated regulatory efforts to accommodate blockchain, others continue to rely on traditional legal frameworks that do not yet fully recognize the validity of digital contracts executed through blockchain technology.

This regulatory disparity creates significant legal uncertainty for businesses seeking to utilize blockchain in cross-border transactions, as no uniform legal framework exists for digital contract enforcement. Without standardized regulations, companies face legal risks when conducting blockchain-based transactions across multiple jurisdictions. Therefore, international cooperation is essential to developing regulations that harmonize the recognition and enforcement of blockchain-based contracts, enabling broader and more effective application of this technology in global commerce.

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[15] Alesia Zhuk, "Beyond the Blockchain Hype: Addressing Legal and Regulatory Challenges," *Springer Nature Social Sciences* 5, no. 11 (2025): 1–37, https://doi.org/10.1007/s43545-024-01044-y; Atul Kumar Singh et al., "Investigating the Barriers to The Adoption of Blockchain Technology in Sustainable Construction Projects," *Journal of Cleaner Production* 403 (2023): 1–18, https://doi.org/10.1016/j.jclepro.2023.136840.

[16] Papantoniou, "Smart Contracts in the New Era of Contract Law."

[17] Primavera De Filippi, Morshed Mannan, and Wessel Reijers, "The Alegality of Blockchain Technology," *Policy and Society* 41, no. 3 (2022): 358–372, https://doi.org/10.1093/polsoc/puac006.

To address these challenges, concrete regulatory measures must be established to ensure that legal frameworks remain adaptable to blockchain advancements. Governments and legal institutions must collaborate to formulate policies that accommodate blockchain-based contracts while upholding fundamental legal principles. With clear regulations and international legal harmonization, blockchain can be widely implemented across various industries, including maritime transportation and global trade.

3.6. Dispute Resolution in Blockchain-Based Contracts

Dispute resolution mechanisms for blockchain-based contracts require significant adaptation to function effectively within existing legal frameworks. The decentralized nature of blockchain poses challenges for traditional dispute resolution methods, such as litigation in conventional courts or standard arbitration, which often lack the flexibility needed to address blockchain-related disputes. In many cases, conflicts involving blockchain-based contracts span multiple jurisdictions, making it difficult to determine the applicable legal framework. Additionally, the legal validity of digital contracts stored on blockchains is often not explicitly addressed in current regulations, creating further challenges in the enforcement of legal decisions.

Traditional legal systems struggle to accommodate the transparency and security features inherent in blockchain technology, which can lead to difficulties in verifying the authenticity of digital evidence and identifying the appropriate legal authority to handle disputes. As a result, some legal scholars advocate for the implementation of technology-driven dispute resolution mechanisms, such as digital arbitration or smart contract arbitration, as more adaptable alternatives. These systems allow blockchain-stored data to be accessed transparently and securely, enhancing trust in dispute resolution outcomes while ensuring a more efficient legal process aligned with blockchain technology's characteristics.

Given blockchain's unique attributes, conventional dispute resolution methods must be adjusted to maintain data integrity and security.[18] In some instances, the use of immutable digital evidence on blockchain networks can expedite dispute resolution; however, without clear regulations, legal decisions may lack enforceability in certain jurisdictions. Therefore, a new dispute resolution framework is required, one that accommodates blockchain's technological aspects while ensuring compliance with diverse national legal systems.

As a potential solution, digital arbitration and blockchain-based dispute resolution platforms are proposed as more efficient alternatives. These mechanisms enhance

[18] Xiangbin Zuo et al., "Innovative Dispute Resolution: The Application of Blockchain in Cross-Border E-Commerce Governance," *Journal of Ecohumanism* 3, no. 8 (2024): 7157–70, https://doi.org/10.62754/joe.v3i8.5313.

transparency by storing all case-related decisions and evidence in an immutable system.[19] Furthermore, blockchain-based arbitration facilitates faster dispute resolution compared to traditional court proceedings. To ensure the widespread adoption and legal recognition of blockchain arbitration, regulatory support from governments and legal institutions is crucial. Establishing clear guidelines and international legal frameworks will allow blockchain-based dispute resolution to be effectively integrated into the global legal system.

CONCLUSION

This study concludes that blockchain technology holds substantial potential for improving efficiency, transparency, and security in maritime freight contracts. By reducing reliance on third parties, ensuring immutable transaction records, and minimizing data manipulation risks, blockchain technology offers a transformative solution for the shipping industry. However, despite these advantages, the primary challenge remains the legal recognition and enforceability of blockchain-based contracts, particularly in international transactions. Many countries lack clear regulatory frameworks addressing blockchain contracts, leading to legal uncertainties and difficulties in dispute resolution. Additionally, the absence of standardized regulations governing electronic contracts further hinders the full adoption of blockchain in maritime freight.

To facilitate blockchain integration into maritime contracts, several key legal and regulatory measures must be implemented. First, governments should update existing legal frameworks to accommodate blockchain-based contracts, ensuring their recognition and enforceability. Second, the establishment of globally recognized standards is essential to create a uniform regulatory environment, facilitating cross-border contract recognition and enhancing legal certainty. Third, legal practitioners and regulatory authorities must receive specialized training on blockchain technology to develop adaptive regulations suited to its unique characteristics. Finally, the development of blockchain-based arbitration platforms or digital dispute resolution mechanisms is necessary to ensure efficient and transparent dispute resolution.

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[19] Zuo et al.

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