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An Exploratory Study on the Application of Blockchain Technology to the Chinese Ship Auction Market

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ABSTRACT

The Chinese ship trading market has undergone remarkable development, transitioning into a global exemplar of ship transactions. Nevertheless, this market continues to confront a series of challenges, encompassing low transaction rates, delayed transaction values, and market instability. Blockchain, with its secure, transparent, and tamper-resistant technological features, presents a potential solution for the ship trading market. Through its decentralized architecture, blockchain technology can reduce platform operational costs, enhancing market competitiveness. Concurrently, the utilization of asymmetric encryption technology can enhance the security of platform data, effectively addressing privacy concerns. Furthermore, through a sharing mechanism, blockchain can aid in establishing a unified credit evaluation system, thereby increasing market trust to address the absence of a credit evaluation system. Moreover, blockchain technology can be employed to construct a risk identification mechanism, fortifying the platform's regulatory model to address regulatory deficiencies.

KEYWORDS

Blockchain, Online Auctions, Ship Auctions, Ship Transactions

The conceptualization of the 21st-century Maritime Silk Road necessitates the establishment of a globally integrated international shipping hub endowed with modern shipping service capabilities (Lu, 2014). Amid the rapid global development of the shipping industry, China is steadily emerging as an international shipping hub (Wang et al., 2023). This lays a robust foundation for the flourishing development of the Chinese ship trading market, particularly in ship auctions, where diverse and high-quality services facilitate its swift emergence. Behind this success lies the adoption of an open and transparent price formation mechanism, diverse auction models, efficient transaction processes, and accessible participation methods by ship auction platforms; these critical factors have propelled the rapid expansion of the market. Ship auction platforms have become central to China's ship property transactions.

The Chinese ship trading market plays an essential role in the maritime domain, fostering asset allocation and contributing to the robust development of the industry. The rapid advancement

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and ubiquitous use of the Internet provide tremendous convenience for commercial activities and unprecedented opportunities for innovation in business models (Li et al., 2023). Specifically, ship online auctions, with their distinctive features and advantages, have played an instrumental role in advancing the ship trading market. Ship commercial auction platforms play a pivotal role in the dynamics of the ship trading market. The ship trading market is the primary arena for exchanging ships, encompassing diverse types, including new and second-hand vessels. Its multitude of participants, scale, and vibrancy are directly linked to the flourishing state of the maritime market.

According to Figure 1, in contrast to traditional trading markets, ship commercial auction platforms address distinct ship transaction requirements, such as replacement and clearance, through online bidding. Participants comprise shipowners, shipyards, brokers, and investors. These two facets mutually reinforce each other, as commercial auction platforms afford additional opportunities for the trading market. They are not only a pivotal component of the ship trading market but also a fundamental driving force for the robust development of the maritime industry.

Amidst the swift evolution of Internet technology, the world has entered an era of profound interconnectedness, presenting opportunities for widespread resource integration and restructuring (Jiang, 2017). Consequently, online ship auction models have risen prominently. This unique commercial auction format exhibits transparency, a multitude of participants, substantial transaction values, notable premium rates, and extensive influence. This enables both transactional counterparts to engage concurrently on the auction platform, liberating them from traditional auctions' temporal and spatial constraints, thereby amplifying transactional convenience and efficiency (Yang et al., 2013).

More significantly, the information transmission speed of online auction platforms is exceptionally swift, facilitating the rapid dissemination of transactions on a national and global scale. This gives shippers significant advantages, enabling them to assess the market value and potential developmental opportunities of vessels more precisely, adjust routes and capacity flexibly, and cater to customers' diverse transportation needs. Additionally, online auctions' openness and transparency prevent potentially opaque operations, thereby elevating the integrity of transactions. Online auction platforms have become central to China's ship property transactions (Liu, 2013).

However, despite the substantial increase in the quantity of the Chinese ship auction market, the actual transaction process confronts many challenges. As shown in Figure 2, based on 2022 statistical data, despite the involvement of 1,080 instances of ships in public auctions, marking a year-over-year growth rate of as much as 20.4%, the transaction rate stands at only 37.8%. The cumulative starting auction price amounts to approximately 116.3 billion yuan, whereas the aggregate transaction price is only 51.1 billion yuan, experiencing year-over-year increases of 51.2% and only 3.9%, respectively

Figure 1. Transaction Process for Ship Auctions

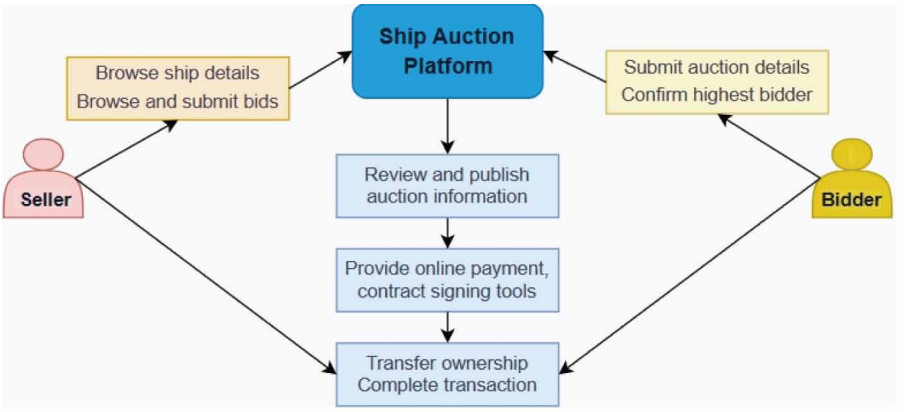
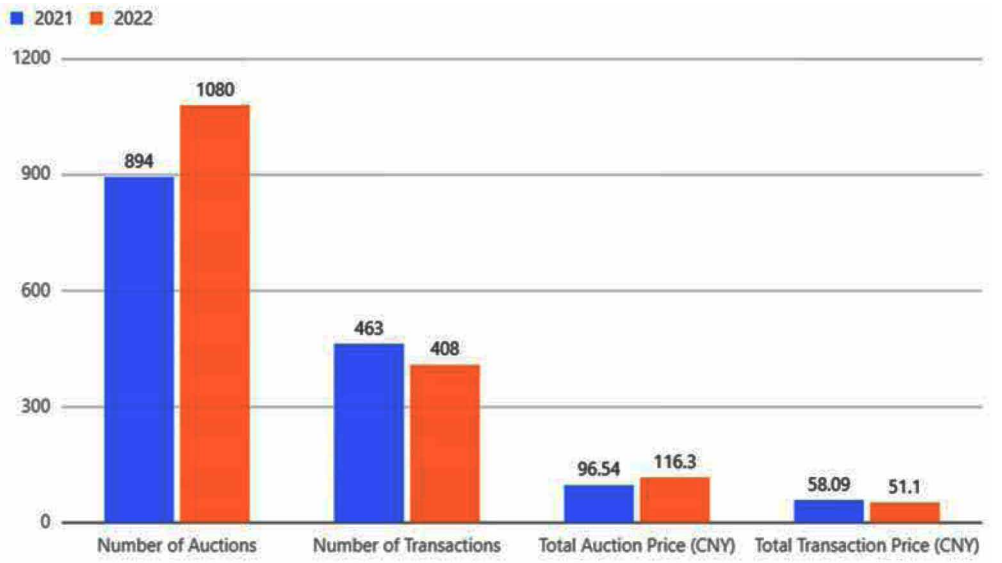


Figure 2. Changes in the Chinese Ship Auction Market From 2021 to 2022



(Wang, 2023). The data indicate that in 2022, the quantity of ships auctioned in the Chinese ship auction market experienced a substantial surge. However, the transaction scenario is less optimistic, with the overall auction turnover exhibiting restrained growth.

Firstly, transaction rates are low. Despite a substantial increase in the number of vessels involved in the ship auction market, the transaction rate is a mere 37.8%. This signifies that many vessels cannot complete successful transactions, leading to the inefficient use of market resources. Secondly, despite a significant increase in the total starting auction price over the past year, reaching 116.3 billion yuan, the growth in the total transaction price lags behind at only 51.1 billion yuan. This suggests that while the market size is expanding, the actual increment in transaction value is relatively modest. Lastly, the stability of the market is also worthy of consideration. Despite the increase in market size, the actual change in transaction conditions is limited, with a year-on-year growth of only 3.9%. This suggests an imbalance between market stability and growth. Overall, the Chinese ship auction market has experienced a notable increase in quantity, but the actual transaction conditions face multiple challenges. For instance, low transaction rates, delayed transaction values, and market stability necessitate collaborative efforts from all market participants to increase market efficiency and competitiveness.

The introduction of blockchain technology aims to ensure that the Chinese ship commercial auction market optimally harnesses its competitive advantages, including increasing market transparency, fortifying data security, and enhancing transaction efficiency. The implementation of blockchain ensures that each bid is permanently recorded within the auction activity, with network consensus mechanisms employed to maintain the integrity and immutability of data. Furthermore, introducing smart contracts automates the enforcement of auction rules, mitigating human intervention and enhancing operational precision. Upon determining the winning bid, the system automatically allocates maritime resources via smart contracts, thus ensuring the efficiency and accuracy of the transaction (Jiao et al., 2018).

However, the progression of blockchain technology is accompanied by the presence of risks. These risks arise from critical issues and technological trust models that remain unresolved in the technical domain (Xu & Gao, 2023). Therefore, introducing blockchain technology to the Chinese ship commercial auction market presents both advantages and risks. To ensure sustainable development,

market participants should devise prudent strategies, fully unleash the potential of blockchain, seamlessly implement the technology, and minimize risks. This will drive the ship commercial auction market toward innovation and progress, generating more opportunities for the Chinese ship trading market and elevating its pivotal role in the global shipping market.

EXPLORING THE SOURCE OF THE SHIP AUCTION MARKET DEVELOPMENT DILEMMA

While the maritime online auction model is progressively gaining traction, it confronts many challenges. Foremost among these challenges is the formidable issue of high operational costs, precipitating a sustained erosion of profit margins. In some instances, this predicament has triggered operational challenges and closures for multiple platforms, thereby impeding the advancement of the tangible economy (Huang, 2019). The elevated costs predominantly come from substantial capital investments in the marketing, post-service management, and auction system maintenance sectors. Consequently, the commercial revenue of ship auction platforms experiences a sustained decrease. Simultaneously, online operational costs are heightened, encompassing the procurement and enduring maintenance of server facilities alongside the human and material resources essential for ensuring business data security. Moreover, auction systems are susceptible to single-point failure issues, making the entire system dependent on specific central nodes and constituting a latent threat. In the event of a malfunction in such a node, services may be interrupted, significantly compromising the system's functionality (Fang & Lei, 2020).

Secondly, a deficiency exists in mechanisms safeguarding user privacy. With the widespread adoption of electronic auctions, online auction platforms have become the principal medium facilitating transactions between buyers and sellers, providing an efficient and convenient trading environment for ship transactions. However, the transformation of the ship transaction model leads to an urgent need for privacy protection. Against the backdrop of the swift development of Internet technology, the ascendancy of electronic auctions has led to widespread concerns among bidders concerning privacy security, notably the risk of potential leakage of sensitive bidder information (Li et al., 2021).

Thirdly, the absence of a unified user credit evaluation system leads to inconsistencies in credit data standards and non-uniform content. Credit data isolation hinders credit information sharing. Consequently, the credit evaluation system plays a pivotal role in credit risk management. It not only evaluates the transactional behavior of both supply and demand sides on the platform but also mirrors the effectiveness of the credit management mechanism (Ge & Wang, 2020). Nevertheless, distinct auction platforms typically lack collaboration, signifying that instances of user default behavior may recurrently appear across diverse platforms. This, in turn, exacerbates the operational risks of auction platforms and escalates the costs for users to obtain financial support.

The distinctive features of the online auction market include its rapid pattern iteration and the ongoing complexity of rule evolution, amplifying the market's stringent prerequisites for rational consumer decision-making, market transparency, and overall credit levels (Zhang et al., 2021). These requisites not only pertain to robust market development but also have profound implications for user trust. When users lack confidence in the credit evaluation mechanism of the market, they will decrease their engagement in online auctions. This not only decelerates the growth of the auction market but also harms the overall shipping economy. To address this issue, a comprehensive credit evaluation system must be established to ensure the authenticity and accuracy of data. It would aid in reducing credit risks, elevating market transparency, and rebuilding user confidence in online auction platforms, thereby creating more favorable conditions for the sustained growth of the market and safeguarding user rights.

Lastly, the deficiency in adequate supervision and constraints is a pivotal factor contributing to the challenges in the ship auction market. In circumstances of relative market transparency, consumers can more thoroughly access market information, facilitating more informed decision-making in the

dynamics of supply and demand (Gao, 2023). Nevertheless, specific platforms may exhibit irregular behaviors, including information leakage, manipulation of auction outcomes, and breaches of transaction agreements. These actions diminish market transparency and equitable competition, further eroding participants' trust in the market. The robust development of the new economy presents the challenge of lagging regulatory technology, where traditional regulatory methods prove inadequate to meet the demands of the new economy. With the widespread adoption of modern information technology, the regulatory costs in the new economy are gradually increasing. Concurrently, regulatory agencies encounter challenges related to information barriers and insufficient coordination in their efforts to digitize and enhance their operations, posing a threat to the effective regulation of the new economy (Li, 2020). Therefore, to guarantee the robust development of the online auction market and safeguard users' rights, there is a pressing need to strengthen relevant legal legislation and enforcement measures.

This paper examines the utilization of blockchain technology to enhance the ship auction market from multiple perspectives, addressing many challenges confronting the market, including high costs, privacy issues, the absence of a unified credit evaluation system, and regulatory inadequacies.

THE FIT BETWEEN BLOCKCHAIN TECHNOLOGY AND THE SHIP AUCTION MARKET

Technical Characteristics of Blockchain: Security, Transparency, and Immutability

The foundational concept of blockchain resides in integrating archived data, realizing distributed access, and facilitating seamless transmission and sharing among nodes. To realize this objective, blockchain employs a consensus mechanism and incentive constraints through multi-body collaborative governance coupled with innovative security measures, including encryption algorithms. These measures mitigate information asymmetry among participating entities and drive the advancement of blockchain. Moreover, these measures encompass a consensus mechanism, incentive constraints through multi-body collaborative governance, and innovative security safeguards such as encryption algorithms (Zhang & Mao, 2019).

Blockchain attains a heightened level of security and incorruptibility through the intricate operation of the consensus mechanism. The consensus mechanism, a mathematical algorithm inherent to blockchain, verifies and ensures the consistency of transaction information within a specified time window, thus guaranteeing transaction security. This process unfolds in a decentralized environment, illustrating the necessity of dependence on traditional central credit institutions. The data structure of blockchain consists of an array of blocks, each comprising a block header and a block body. Various transaction data sets generate unique blocks, which interconnect through hash values, culminating in the formation of a comprehensive blockchain (Chen, 2023). The block header incorporates transaction timestamps and documents the hash value of the preceding block, making the blockchain tamper-resistant. Should information within a block be tampered with, its hash value will change accordingly, impacting the coherence of the entire blockchain. Owing to the adoption of peer-to-peer technology in blockchain, every node can access the complete blockchain data to verify the authenticity of each transaction (UK, 2016). Any attempt to modify blockchain information must receive unanimous approval from all participants through the consensus mechanism, making tampering with blockchain information and safeguarding transaction security nearly impossible.

A conspicuous feature of blockchain technology is its impetus toward the transparency of the transaction process. This is achieved by constructing a distributed ledger, breaking away from the conventional centralized operational model, and employing an endorsement and real-time recording approach involving the participation of the entire populace. In this mode, various nodes of the blockchain share and collectively maintain transaction information, thereby preventing malicious third-party intervention and tampering. This decentralized foundational blockchain structure ensures the security of transactions and the immutability of information (Fairfield, 2014).

Within an open and transparent blockchain network, each transaction is disseminated to all user nodes, enhancing the transparency of the transaction process. This capability empowers users to perform comprehensive data analysis, improving the openness of the transaction process. Blockchain technology plays a pivotal role in ensuring the durability and reliability of interpersonal trust. It can decrease the costs associated with credit assessment in commercial transactions and the costs of reciprocal oversight among collaborating entities (Coase, 1988). Via its decentralized foundational structure, blockchain technology facilitates the secure flow of asset transactions, establishing a trust foundation for value interaction in both the digital and physical realms. This holds considerable significance for the profound transformation of the Internet from information dissemination to value exchange (Hu & Liu, 2023).

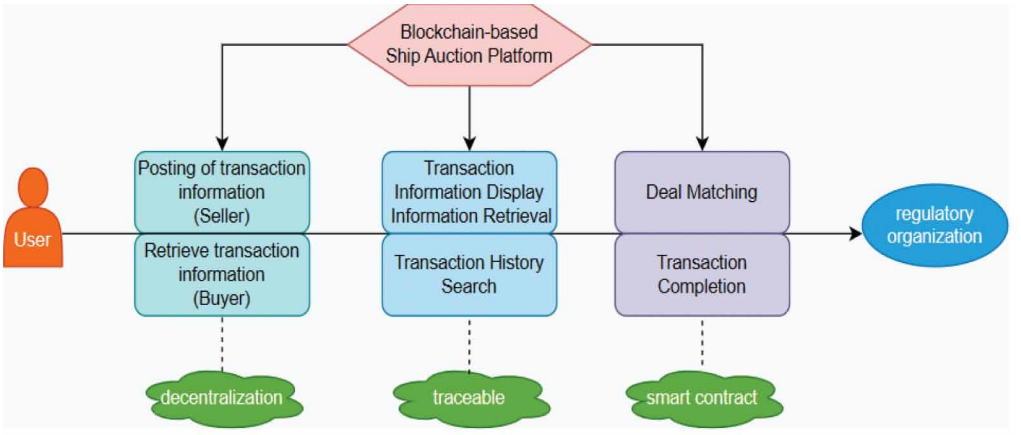
Empirical research has demonstrated that blockchain can streamline administrative procedures, secure and accelerate global transactions, and substantially diminish the time and costs involved in conventional freight forwarding and maritime logistics operations (Bavassano et al., 2020). Integrating blockchain technology in maritime transport can increase transparency, efficiency, and economic sustainability, providing a comprehensive framework for digital transactions and data interchange across global supply chains. The potential of blockchain extends to resolving issues related to cargo security and traceability with solutions that integrate physical cargo movements with digital information, thereby enhancing cargo tracking and ensuring security (Xu et al., 2018). Moreover, the exploration of blockchain applications in port operations and logistics management has illustrated how decentralized data storage and processing can enhance efficiency, transparency, and trust among supply chain stakeholders (Ahmad et al., 2021).

The Impact of Blockchain Technology on the Ship Auction Market

On October 24, 2019, the Chinese government issued a directive that emphasized seizing opportunities presented by integrating blockchain technology and harnessing its role in advancing industrial digitization. At the national and market levels, novel modes of integration between blockchain technology and the real economy are being actively explored.

Amid the swift evolution of blockchain technology, its integration within the ship auction market is gradually having far-reaching influences. As seen in Figure 3, blockchain technology will reshape the ship auction process. The integration of this technology with auction platforms has ushered in a series of revolutionary changes in the ship trading market. Blockchain technology, with features including decentralization, tamper resistance, verifiability, traceability, and automatic execution, effectively ensures the fairness and transparency of transactions, thereby enhancing transaction

Figure 3. Blockchain-Based Ship Auction Platform



security and credibility (Tang et al., 2023). Looking into the future, these pioneering factors will undoubtedly propel ship trading platforms to new heights in information disclosure, establishing a more robust foundation for developing shipping operations.

The core attribute of blockchain, its immutability, establishes a robust foundation for the auction market's equity and transaction credibility. Throughout the auction process, every piece of information is meticulously documented on the blockchain, and including timestamps guarantees the integrity and immutability of the data (Liu & Song, 2020). Furthermore, the irreversible nature of hash algorithms gives heightened security and credibility to the information stored on the blockchain (Xu & Yuan, 2020). The tamper-resistant transaction record feature of blockchain technology ensures that each transaction undergoes meticulous validation, rendering it less susceptible to fraudulent or opaque operations. This will draw in a larger pool of investors and participants, elevate market reputation, and potentially augment transaction rates. This transparency and traceability allow all stakeholders in the auction market to access vital information in real time, consequently mitigating the risks linked to information asymmetry and markedly amplifying societal benefits.

Secondly, blockchain technology's inherent anonymity and privacy protection functionalities facilitate the anonymous execution of bidding activities. Simultaneously, adopting zero-knowledge proof technology empowers users to validate their lawful identity without exposing the plaintext of their bids. The central function of zero-knowledge proof technology lies in furnishing a robust instrument, ensuring the non-identifiability, non-linkability, and non-traceability of digital transactions while upholding user privacy. This proves pivotal for transactional privacy and security (Shen et al., 2023). Applying this technology effectively guarantees the legitimacy and traceability of bids, mitigating redundant bidding behaviors.

Additionally, blockchain technology provides an effective solution for altering property registration information. Through the automatic execution of smart contracts, blockchain can ensure that the processing of pertinent documents following an auction or sale will not be subject to delays or processing difficulties (Yang & Sun, 2021). As an illustration, integrating blockchain with the Internet of Things (IoT) and communication technologies facilitates the direct transmission of electronic passkeys to the buyer's personal terminal, thereby reducing transaction costs and augmenting market efficiency concurrent with ownership transfer registration. This advancement is anticipated to heighten the credibility of auction platforms, fostering increased trust among participants and motivating active involvement in the auction market.

Crucially, the implementation of blockchain technology has facilitated a more effective execution of policy coordination and regulatory oversight. However, technological decentralization does not equate to regulatory decentralization, much less the decentralization of legal responsibilities (Sai, 2023). The decentralized and immutable nature of blockchain raises complex regulatory and legal issues. Determining jurisdiction in disputes, the legal status of smart contracts, and compliance with international regulations can be challenging in blockchain-based auction systems. The lack of clear regulatory frameworks can hinder the adoption and implementation of blockchain in auction markets (Shi et al., 2021). The Chinese ship auction market involves many participants, necessitating intricate policies and regulations to govern market conduct. Utilizing smart contracts and distributed ledgers, blockchain technology ensures that all participants adhere to the relevant policies during transactions, diminishing human intervention, automating the execution of contract conditions, and meticulously recording all transaction activities (Giancaspro, 2017). This not only aids in coordinating policies among various government departments but also furnishes regulatory authorities with an expanded toolkit for overseeing the market. As a cutting-edge technological application, online auctions are presently in a highly uncertain stage of development; thus, their regulation must consider safeguarding technological and business innovations, all while balancing the interests of the parties involved (Li, 2023).

The validation of the feasibility of blockchain applications, derived from insights provided by industry experts and stakeholders, necessitates a meticulous examination of crucial aspects. Industry experts underscore the potential of blockchain technology to bolster transparency and

trust within auction processes by citing its immutable ledger and smart contract functionalities as pivotal in mitigating fraudulent activities and bid rigging prevalent in conventional auction settings (Shelke et al., 2023). This perspective aligns with legal frameworks that aim to ensure fairness and integrity in commercial transactions. The case studies that examine blockchain's impact on auction efficiency and transparency in sectors such as energy further corroborate the feasibility of blockchain applications by showcasing tangible benefits such as enhanced bid traceability, reduced settlement times, and heightened participant satisfaction (Foti & Vavalis, 2019). This substantiates the argument for blockchain's viability in revolutionizing auction processes while adhering to legal principles of transparency, fairness, and regulatory compliance.

Integrating blockchain into auction markets profoundly impacts ancillary services and market competitors, enhancing efficiency and transparency and intensifying competitive pressures. Ancillary services, such as payment processing and logistics, transform as blockchain technology reduces transaction times and costs, facilitating more streamlined operations. Market competitors encounter a double-edged sword: blockchain not only offers opportunities for innovation but also elevates the threshold for entry and competition. Companies must evolve to adapt to a blockchain-centric environment or risk becoming obsolete. Consequently, blockchain's influence extends beyond auction participants, reshaping the entire market ecosystem, including ancillary service providers and competitors.

Modernization has led to the inevitable emergence of the risk society. With blockchain technology at their core, new digital technologies exhibit unprecedented characteristics in social security risks, showing exponential increases in propagation speed and coverage (Wei, 2021). Despite uncertain social security risks associated with the introduction of blockchain technology, its adoption remains pivotal in the ship auction market. Adopting this technology will enhance market fairness, credibility, and efficiency while simultaneously opening up new prospects for the market, albeit accompanied by opportunities and challenges. Especially in addressing current market challenges and the continually growing demand, blockchain technology is expected to improve information sharing, policy coordination, and market transparency. This initiative will effectively satisfy market demands, allowing it to play a pivotal role in the global shipping market and laying a robust foundation for the future development of the ship auction market.

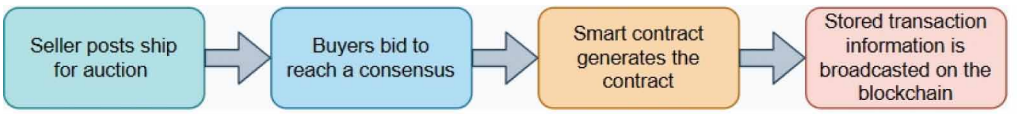
BLOCKCHAIN TECHNOLOGY RESHAPING THE SHIP AUCTION MARKET

The distinctive features of blockchain technology have propelled its prominence in the contemporary realm of information technology, resolving various issues inherent in conventional technical models and accentuating its considerable advantages. These advantages have theoretical significance and yield substantial benefits in practical applications.

Reduce Platform Operating Costs With "Decentralized" Architecture

The decentralized architecture of blockchain technology carries profound implications for mitigating platform operational costs. Within the digital society, issues embedded in traditional centralized organizational models include limitations in power structures, insufficient operational efficiency, and information distortion, all of which impede the sustainable development of businesses. In particular,

Figure 4. Ship Auction Process With Blockchain Technology



the Chinese ship auction market grapples with high operational costs, driven by intense competition demanding continuous market share expansion, requiring substantial investment in market promotion, later-stage operations, and product maintenance. These include expensive advertising campaigns, promotional activities, user growth initiatives, and online operational costs, such as the procurement and maintenance of servers. These investments not only heighten network response speed and enhance user experience but also directly fortify consumer trust in the platform (Huang & Huang, 2014). Despite the high nature of operational costs, their significance lies in upholding market order and cultivating user trust. Confronting this challenge, blockchain technology has erected a decentralized model through elements such as distributed ledgers, smart contracts, and consensus mechanisms, effectively addressing the deficiencies of centralized organizational models (Li & Gao, 2023). Its decentralized characteristics offer novel solutions to these issues, potentially reducing intermediary costs, enhancing transaction efficiency, and laying a more solid foundation for the sustainable development of the ship auction market.

The decentralized network architecture is a pivotal feature of blockchain technology, transcending the constraints of traditional centralized models (Yang, 2017). Via this architecture, data recording and verification tasks are dispersed to each node in the network, thus eliminating the risk of single-point failures. Each node holds an equal status and is capable of operating independently and collaboratively fulfilling data recording, authentication, and verification tasks. This characteristic of distributed management enhances market stability and effectively mitigates the risk of single-point failures in centralized institutions, thereby reducing associated operational costs.

Conversely, within the ship auction market, traditional centralized systems usually necessitate the completion of data recording and verification through intermediary steps (e.g., the involvement of auction institutions). Nevertheless, these intermediary steps augment the system's complexity and result in additional costs, encompassing service fees charged by intermediary institutions. According to Figure 4, the decentralized blockchain system empowers participants to interact directly with each other, eliminating the necessity for centralized intermediary institutions. This design significantly lowers associated costs, making ship auction transactions more efficient and economical. Eliminating intermediary steps decreases transaction costs and results in borderless, frictionless characteristics. This renders transactions more economically efficient. They no longer rely on the reputation of individuals, intermediaries, or governments, providing robust support for convenient and swift transactions (Kiviat, 2015). Implementing this design markedly decreases associated costs, creating conditions for efficient and economical transactions.

Beyond mitigating intermediary links and associated costs, blockchain technology systematically diminishes the reliance on third-party trust through its intrinsic decentralized characteristics. In traditional centralized systems, users conventionally must place trust in the security and integrity of central institutions. This trust is predicated upon legal regulations and regulatory frameworks. By contrast, via distributed management, blockchain technology renders data recording and verification processes more transparent and verifiable. Every network node can inspect and verify the complete data history, obviating the need for reliance on the unilateral promises of central institutions. Reducing the need for third-party trust makes the system more trustworthy and diminishes operational costs.

Through its decentralized architectural framework, blockchain technology gives the system notable advantages concerning data recording and validation through distributed management. These advantages include bolstering the system's robustness, diminishing intermediary steps and associated costs, and diminishing reliance on third-party trust. Collectively, these advantages decrease the operational costs of the platform. However, when considering the application of blockchain technology in the ship auction market, despite the theoretical prospect of reducing direct costs, in practice, it introduces new sunk costs, such as increased server capacity and high energy consumption (Peters & Panayi, 2016). Moreover, the resource-intensive nature of blockchain in this market prompts concerns about its environmental and ethical impact. Specifically, blockchain's energy demands, especially for proof-of-work consensus mechanisms, are considerable, and renewable energy strategies are needed to

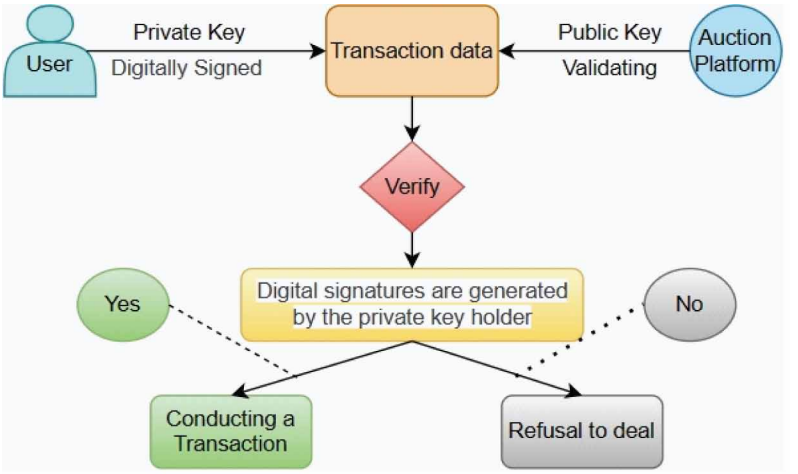
reduce their environmental effects. While blockchain's transparency and immutability can boost market integrity, they require stringent data protection measures to ensure privacy. Compared to centralized market structures, the advantages and disadvantages of blockchain require thorough evaluation. Nonetheless, the potential of this innovative technology to enable a more efficient, transparent, and secure digital economy is clear, establishing a foundation for future business ecosystems (Jović et al., 2020).

Enhancing Platform Data Security With "Asymmetric Encryption"

In the contemporary digital era, ship auction platforms have amassed a considerable volume of user-related sensitive information, underscoring potential risks associated with user privacy concerns. Users' personal information, transaction records, and financial data—all stored and maintained by ship auction platforms—exhibit clear confidentiality. If these are mishandled or stolen by malicious actors, this can pose a significant security threat to both users and the trading platform. On the one hand, at the infrastructure level, big data may be susceptible to hacker attacks or digital fraud, resulting in the exposure of private information. On the other hand, algorithms may be subject to manipulation by interest groups, thereby escalating the risk of privacy leaks (Hu & Chen, 2020). As a pivotal link in transaction and information transmission, ship auction platforms' data security is paramount. Blockchain technology, characterized by tamper-proof information, transparent processing, and high security, has emerged as a potent tool for safeguarding user privacy data. To effectively ensure the data security of ship auction platforms, consideration can be given to leveraging the asymmetric encryption mechanism within blockchain technology. Applying asymmetric encryption algorithms offers robust protection for user identity and transaction information.

Initially, asymmetric encryption algorithms utilize a pair of unique public and private keys. After encryption through the algorithm, only authorized users can acquire the private key to decrypt the data (Lou et al., 2021). As shown in Figure 5, during the transaction process, each user employs the private key to sign the data digitally; the ship auction platform then verifies the digital signature using the corresponding user's public key. If the digital signature matches the transaction data and successfully passes the public key verification, it can be affirmed that the digital signature was indeed generated by the private key holder, ensuring the authenticity of the transaction data. If the digital signature is tampered with or an incorrect private key is used, the verification will fail; the platform can promptly detect and reject such transactions, thereby preventing unauthorized tampering. This public

Figure 5. Operation Mechanism of Blockchain Asymmetric Encryption Algorithm



key verification process can expose any tampering activities, while the digital signature's uniqueness ensures the data's authenticity and integrity (Cai et al., 2020). On ship auction platforms, this security mechanism instills confidence in users, allowing them to conduct transactions in a relatively secure environment. Furthermore, due to the characteristics of asymmetric encryption algorithms, even if the public key is publicly disclosed, it does not compromise the security of the private key, thereby ensuring the stability and reliability of the entire system.

Additionally, within the blockchain, every transaction is meticulously recorded within a data structure known as a "block," with these blocks sequentially linked to create a chronological "chain." In the process of data transmission and storage, the information uploaded to the blockchain undergoes encryption, allowing various network nodes to record changing data in real time while making it challenging to decipher the information contained in the altered data. Once a transaction is recorded, it becomes permanently stored on the blockchain, impervious to the control of a single entity or central authority. This method maximally safeguards user privacy and mitigates potential risks. This equips ship auction platforms with robust data protection, as data is not concentrated in a vulnerable central database but distributed throughout the entire network, making it arduous for attackers to infiltrate and tamper with the data.

Furthermore, the transparent processing mechanism of blockchain technology provides strong support for the data security of ship auction platforms. Each network node autonomously processes, verifies, and retains the corresponding data on the blockchain. Each piece of information is transformed into an irreversible fixed-length output value and synchronously broadcasted to every blockchain node, causing any malicious attempt to tamper with the data to quickly change the computation outcome, thus rapidly detecting tampered data (Tong et al., 2018). Once transaction history is written into the blockchain and stored, it becomes immutable. Each node in the entire chain is transparent to the external world, with data backups distributed across different network nodes, ensuring absolute transparency in information processing. This further strengthens the integrity and authenticity of transaction data, offering robust protection for user privacy data.

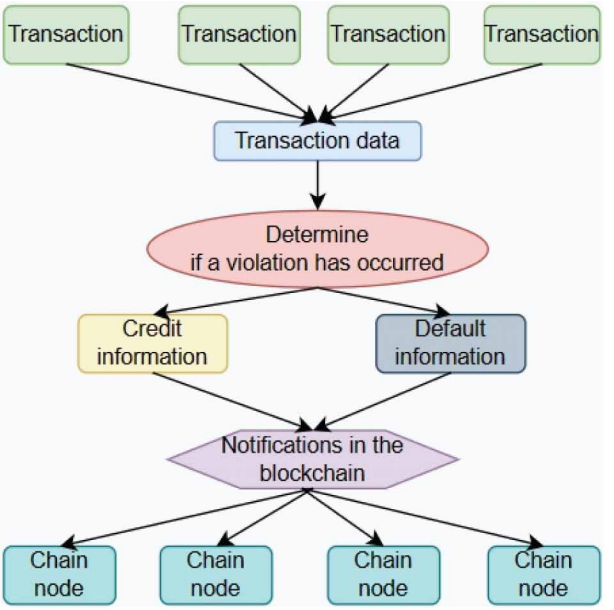
Renowned for its elevated data stability and reliability, blockchain technology establishes a robust foundation for data security (Zhao et al., 2017). This technological approach encompasses tamper-proof information, transparent processing, and heightened security. In addition, by applying asymmetric encryption, it establishes a strong foundation for user privacy data on ship auction platforms, ensuring more secure and reliable transactions and information transmission.

Establishment of a Credit Mechanism for the Platform Through a "Shared Mechanism"

In the ship trading market, considering language and cultural differences, the challenge of information asymmetry emerges as a pivotal obstacle impeding the establishment of a unified credit system. The credit system plays a crucial role in authenticating the identities, conducting qualification reviews, and assessing the creditworthiness of both buyers and sellers. This enhances transaction transparency and reliability, thereby fostering the establishment of mutual trust (Sun & Wang, 2015). Nevertheless, the traditional ship trading market grapples with fragmented credit data. Various service providers employ diverse approaches to gather user credit data, resulting in disparate data formats and a deficiency in information-sharing mechanisms (Fang, 2015). This situation impedes the potential for data to fully exploit economies of scale and may lead to dishonest users engaging in repetitive fraudulent activities across multiple platforms. The ease with which dishonest users can replicate their fraudulent behavior poses a severe risk of economic damage to auction platforms and maritime shipping in the ship trading market. Therefore, establishing an appropriate credit data-sharing mechanism has become an urgent priority.

To overcome the existing "data barriers" and "information silos" and intensify the collection efforts of credit information sharing platform data, thereby improving data availability and accuracy, adequate measures must be implemented in the establishment of credit mechanisms on ship auction

Figure 6. Blockchain Platform Trust Mechanism



platforms (Hu & Li, 2023). Consortium blockchain technology offers a distinctive solution for this challenge. By formulating standardized specifications for sharing user information across the industry, diverse platforms can share, view, and utilize a unified set of blockchain data, housing ship buyers' personal information, transaction records, and credit data within a cohesive system. By employing a consensus algorithm, processing nodes can ascertain the record nodes for data changes and broadcast notifications to other nodes for data updates (as illustrated in Figure 1). After receiving an update request for new data, other nodes autonomously cross-verify the stored information and subsequently effectuate its update within the node (Yuan & Wang, 2016).

In contrast to other models of blockchain platforms, the defining characteristic of a consortium blockchain lies in the emphasis on constraining the range of participants, thereby ensuring a heightened level of privacy and data security. Within the consortium blockchain, members can join different channels and choose, based on their requirements, the content of shared data and partners for data sharing (Chang & Han, 2016). As shown in Figure 6, each transaction is evaluated based on these rules, and the outcomes are recorded on the blockchain and disseminated to all participants, thereby establishing unified credit standards. This data-sharing mechanism not only contributes to the establishment of credit standards but also maximizes the economies of scale for information data. The credit mechanism of the ship auction platform, established through the sharing mechanism, possesses a high degree of transparency and real-time attributes. Blockchain technology ensures data immutability, enabling each transaction to be recorded and verified on the blockchain and broadcast to all participants, thereby providing a reliable foundation for the credit mechanism. Participants within the consortium blockchain can choose to share information based on their needs, simultaneously ensuring the privacy and security of data.

By sharing credit data, blockchain can establish a more robust foundation for the financing environment. Ship auction platforms can utilize transaction records on the blockchain for screening, review, and monitoring, thereby establishing a cohesive blockchain financing consortium (Liu & Yan, 2017). Blockchain records enterprises' transaction information, ensuring its immutability. This encourages users and auction platforms to uphold credit commitments, thereby sustaining the stability

of the financing trust mechanism. Financial institutions can leverage credit data on the blockchain to screen potential investment targets, lower rating costs, and improve accurate assessments of investors' performance capabilities. Enterprises with poor credit will be included in the blockchain's credit blocklist, reinforcing risk control. This cultivates a secure and reliable financing environment for industrial clusters and shipping enterprises, yielding multiple benefits.

Establishing a "Risk Identification Mechanism" to Build a Platform Regulatory Model

Amid the development of blockchain technology, the ship auction market is undergoing profound transformations. In this distinctive market context, government departments encounter unprecedented opportunities for innovation. They can leverage novel regulatory models such as "Internet + regulation" and "Blockchain + regulation" to enhance oversight precision, improving the operational environment of the market. However, the robust development of any industry necessitates a foundation built on corporate self-discipline and effective regulation (Yan, 2020). For burgeoning industries like the ship auction market, continuous progression in auction platforms' legal and regulatory compliance is imperative. Only by consistently advancing the legality and compliance of auction platforms in their operational processes can they be steered toward a more robust developmental trajectory. Presently, there is a conspicuous deficiency in regulatory bodies within this field, resulting in occasional compliance issues in operations.

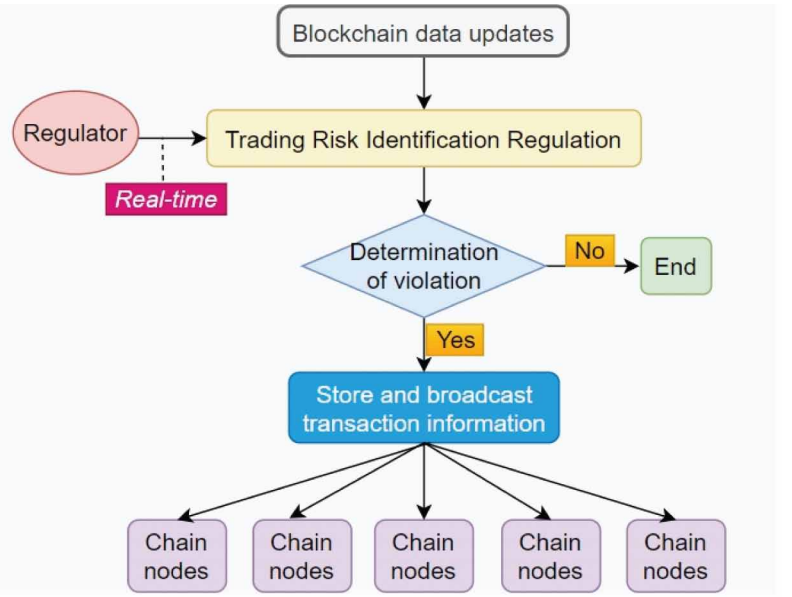
With its openness, transparency, and traceability, blockchain technology has emerged as a potential regulatory instrument. This technology ensures the authenticity and integrity of transactions, recording tamper-proof operational information that can be employed to trace and scrutinize the legitimacy of past transactions (Xian, 2016). Simultaneously, smart contracts, operating as internet technologies on distributed ledgers, leverage mathematical algorithms to eliminate the arbitral role of traditional trust mechanisms. They automatically execute transaction contracts and are impervious to interference from third-party institutions, thereby fulfilling the digital society's demands for a trustworthy and efficient framework (Li & Gao, 2023).

Introducing blockchain technology into the ship auction market and integrating it with artificial intelligence (AI) can establish the "chain governs chain" model, thereby effectively enhancing regulatory efficiency and accuracy. It can also introduce further innovation and security measures to the ship auction market. A collaborative regulatory ecosystem is formed by establishing a self-disciplined regulatory body comprised of representatives from government agencies, shipowner companies, and auction platforms. This self-disciplined regulatory body, built on a consortium blockchain, will be independently operated and managed by regulatory agencies. Desensitized data will be publicly disclosed to all shipping enterprises.

Figure 7 shows that the "risk identification mechanism" automatically triggers predefined regulatory processes upon each transaction data update to assess transaction information thoroughly and identify irregularities. This comprehensive process involves verifying participant identities, scrutinizing transaction contracts, and executing terms. Concurrently, the integration of AI technology enhances regulatory efficiency. The system utilizes machine learning algorithms to detect potential risk signals automatically, promptly analyzing and documenting abnormal transaction behavior. This includes identifying anomalies in transaction patterns and unusual amounts and conducting multidimensional risk assessments, such as comparisons with historical data.

Through the intelligent risk identification mechanism, regulatory bodies can automatically identify illicit transaction behavior, effectively preventing malicious transactions designed to evade oversight (Zhang, 2017). After inspection, if the data is deemed compliant, the automatic update mechanism ensures the synchronization of local data and the local data chain to the latest state. Upon confirming the data's authenticity, smart contracts will initiate the automatic updating process, ensuring the synchronization of local data for all participating nodes, thereby maintaining the overall consistency of the blockchain network.

Figure 7. Ship Auction Platform Based on a "Risk Identification Mechanism"



This automatic updating mechanism not only enhances regulatory efficiency, reducing the possibility of human intervention, but also ensures the data consistency of the blockchain network. It provides a more reliable and real-time foundation for regulatory and business decision-making. We propose a detailed roadmap to implement blockchain technology in the Chinese ship auction market. The pilot phase (0–2 years) will initiate small-scale projects to evaluate blockchain's applicability, targeting specific market segments to address technical, regulatory, and acceptance issues. In the integration and expansion phase (2–5 years), we will expand the use of blockchain, focusing on seamless integration with existing systems and ensuring scalability and security. The full-scale implementation phase (5–10 years) aims for comprehensive deployment in the ship auction market, improving operational efficiency, transparency, and transactional integrity. We will proactively tackle challenges like technical obstacles, regulatory compliance, and stakeholder acceptance to facilitate the smooth integration of blockchain into the market ecosystem.

This mechanism contributes to identifying issues and risks in the ship auction market, furnishing data support for the future formulation of industry policies. The government can fully harness blockchain technology to elevate its regulatory capabilities over the ship auction market, facilitating the orderly flow of data, standardizing governmental regulatory behavior, addressing challenges in market construction, and propelling a market that is efficiently regulated, fair, and fully open. This provides a robust safeguard for the orderly and legal flow of data in the construction of the ship auction market, ensuring data security, lowering transaction costs, optimizing the business environment, and constructing a ship auction market that aligns with high-quality development.

CONCLUSION

The ship auction market, characterized by online auctions, participant diversification, enhanced platform capabilities, and extended service offerings, is on the cusp of transformative growth. These elements collectively promise to augment ship auctions' convenience, transparency, and efficiency, revitalizing the shipping industry. However, market expansion intensifies the complexities of related issues. Blockchain technology, with its decentralization, tamper resistance, verifiability, traceability,

and automated execution, provides substantial support by ensuring fairness and transparency in the auction process and bolstering the security and credibility of transactions.

Looking forward, we plan to expand our research to investigate the integration of blockchain with other emerging technologies, such as AI, IoT, and big data analytics, in the ship auction market. This research will seek to uncover the synergistic impacts of these technologies on market efficiency, transparency, and security. Additionally, we aim to analyze the long-term economic effects of blockchain adoption on various market stakeholders, including shipowners, auction platforms, and regulatory agencies. This will involve thoroughly evaluating changes in market dynamics, transaction costs, and overall market competitiveness over time. Through these efforts, our research will provide a comprehensive roadmap that elucidates the intricate implications of blockchain technology within the ship auction market and its broader economic ecosystem, thus aiding in the strategic advancement of this crucial industry sector.

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DATA AVAILABILITY

The dataset can be accessed upon request.

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The authors of this publication declare there are no competing interests.

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