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## A systematic literature review of Blockchain application in maritime supply chain: the TOE framework

### **Extended Abstract (max. 1400 words)**

Maritime and shipping industry is under rising to improve operational efficiency and inter-organisational collaboration to increase their competitiveness. Supply chain integration (SCI) in maritime and shipping industry has become a predominant strategy to improve efficiency and cost reduction (Panayides and Song 2009). Blockchain technology (BCT), also known as distributed ledger technology, has been identified as a promising solution to enable maritime supply chain (MSC) integration and improve efficiencies. BCT is a shared, distributed electronic ledger with characteristics such as immutability by encryption, transparency, openness, security, and real-time update in data management (Scott et al. 2017). The technology is considered to have the potential to address a number of issues facing MSC, i.e., the issues of trust, product traceability, process optimisation, and coordination and communication in maritime communication (Jović et al. 2019).

This paper provides a systematic review of blockchain adoption in maritime and shipping industry and its relationship to MSC, especially container transport, by identifying adoptions factors.

### **Objective (max. 300 words)**

In recent years, major shipping liners have adopted BCT to integrate each player in maritime supply chain for end-to-end service. Shipping companies are developing BCT-based platform where encrypted data can be accessible to every party reducing inefficiency including time delay, human error, and miscommunication. One notable blockchain initiative is TradeLens, a blockchain -based platform initially developed by

Maersk with the tech company IBM to bring together all parties in a MSC – including traders, freight forwarders, inland transportation, ports and terminals, ocean carriers, customs and other government authorities – onto a single, secure data-sharing and collaboration platform (Zhong et al. 2021). Another example is a platform called the Global Shipping Blockchain Network (GSBN), set up by a few other shipping carriers and global terminal operators (Wagner and Wiśnicki 2019).

Notwithstanding the diffusion of BCT application, academic research of blockchain application in the maritime and shipping industry is still in fancy. While a wide range of literature has conducted conceptual and review analysis and provided valuable insights of BCT application, challenges, and opportunities in supply chain management context, there has been far less consideration in the maritime sphere. This study aims to fill the gap by consolidating not only the theoretical knowledge that can be obtained from the academic literature but also the practical evidence from industry.

The objectives of this paper are to (1) provide comprehensive review of the current BCT applications in maritime and shipping industry, especially container transport, (2) identifies blockchain adoption factors of maritime supply chain integration including benefits and challenges, (3) suggests a conceptual TOE framework where adoption factors are classified in the contexts of technology, organisation and environment.

#### **Data/Methodology (max. 300 words)**

A systematic literature review is used in this study to collect and explore literatures addressing the theme of BCT application in maritime supply chain. This study used Scopus database for searching academic source while Lloyd's list for exploring practical evidence. Using combination of key terms ("maritime" OR "shipping" OR "liner" OR "port"; "blockchain" OR "block-chain" OR "distributed ledger"), an initial search identified 171 articles from Scopus. After filtering according to inclusion and exclusion criteria, and abstracts reviewing in the context of titles and abstracts with the keywords, 60 articles were selected for the review. On the other hand, 170 articles were found in the search in Lloyd's based on the market (container) and section (technology and innovation; ports and logistics; ship operation; finance; regulation; environment) set. A total of 64 articles was identified, which reported the launch and development of blockchain programmes, initiatives, projects, consortiums in the business field by shipping liners, ports, forwarding, and software companies.

The findings from the analysis of the review were categorised into blockchain benefits and challenges factors based on blockchain domain: information management; transaction management; cargo, vessel and terminal operation. Next, the determinants of benefits and challenges were identified and grouped into the TOE framework.

#### **Results/Findings (max. 300 words)**

Firstly, the result of literature review presents main domains of blockchain application

in the MSC based on analysis of contents of articles and 19 cases of blockchain initiatives and projects. Blockchain applications are classified into three dimensions and specific roles and its benefits: document management (document digitalisation; real-time information exchange and accessibility; data management; document unification), transaction management (decentralisation of supply chain; consensus mechanism in transaction; automated transaction; data management; platform standardization), and cargo, vessel, and terminal operation (container and vessel traceability; terminal operation optimisation; connectivity with IoT; vessel data management). In addition, challenges of blockchain applications are identified: relationship among participants; antitrust issues; lack and difficulty of standardization; cost issues; regulatory issues; security issues; infrastructure and technological issues; industrial culture and skills; external issues.

Based on the findings of benefits and challenges determinants, the conceptual model was established in the TOE framework. Technological factors are identified as complexity, expected benefits, security and privacy, cost, complexity and compatibility. Organisational factors include organisations' readiness, and organisations' size and type. Environmental factors contain regulation, market circumstance and environment. Interorganizational relationship factors are trust, standardization, and Monopoly.

### **Implications for Research/Policy (max. 300 words)**

Our main contributions are twofold; First, the identification of current blockchain applications and factors of benefits and challenges of blockchain that are specific in maritime and shipping industry. Second, the development of a comprehensive TOE framework which integrates various blockchain adoption factors in the context of technology, organisation and environment.

Our findings offer valuable insights about how BCT leads to SCI in the maritime and shipping industry. BCT has been explored in other industries such as finance and supply chain focusing on only transaction process. In maritime and shipping industry, however, the technology might have a synergetic impact when it is applied to document management, transaction management, and cargo, vessel, and terminal operation. The TOE framework provides a structured theoretical lens to be validated further regarding how factors identified leads to BCT's further diffusion in maritime supply chain.

This study provides a direction for future empirical studies. With the increasing awareness of BCT, future research should focus on developing key indicators that can be used to examine the relationship between blockchain adoption factors and the performance of maritime SC stakeholders. This study clearly presents the key factors that an organisation should consider when deciding to introduce BCT from three perspectives within a systematic framework. Therefore, the study provides an opportunity for research to establish key indicators to measure the level of awareness or introduction, which supports organisations in formulating clear strategies for successful introduction of BCT in maritime and shipping sectors.

TOE framework	Factors
Technological factors	Expected benefits Cost Security and privacy Compatibility Complexity
Organisational factors	Organisations' readiness Organisation's size and type
Environmental factors	Regulation Market circumstances Environment
Interorganisational relationship	Trust Standardisation Antitrust

Table1. integrated TOE framework

Source: authors

Keywords: Blockchain, distributed ledger, shipping, maritime, supply chain, TOE framework.

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