A STUDY OF FULL AND LESS-THAN-FULL CONTAINER BOOKING FOR FEASIBILITY ANALYSIS OF DEVELOPING TEMPERATURE-CONTROLLED LESS-THAN-FULL CONTAINER BOOKING SOFTWARE FOR INTERNATIONAL SEA FREIGHT

Suttipa Chongterdtoonskul[1] and Natpatsaya Setthachotsombut[2*]

College of Logistics and Supply Chain, Suan Sunandha Rajabhat University, Bangkok, Thailand

E-mail: s67567808013@ssru.c.th, natpatsaya.se@ssru.ac.th

* Corresponding author

ABSTRACT

Abstract— This study investigates the booking processes of Full Container Load (FCL) and Less-than-Container Load (LCL) shipments and evaluates the feasibility of developing a temperature-controlled LCL container booking software for international maritime transport. A mixed-methods approach was employed, combining quantitative data from 393 respondents and qualitative insights from in-depth interviews with 18 key informants. The population consisted of 23,100 individuals from export companies and freight forwarding firms in Thailand. Descriptive statistics and content analysis were applied to analyze the data. The findings indicate that temperature-related factors, particularly the type of temperature-sensitive goods and required temperature levels, are the most critical determinants in container booking decisions. Overall, booking factors were rated at a high level, reflecting strong awareness of product quality and logistics efficiency. The feasibility assessment of the proposed temperature-controlled LCL booking software was also rated highly, especially in terms of technological readiness and market potential. Qualitative results further reveal that such a platform could significantly reduce logistics costs for small and medium-sized exporters, enhance flexibility in shipment planning, and improve transparency through real-time monitoring and system integration. Additionally, the development of domestic software is expected to reduce reliance on foreign platforms and strengthen national digital capabilities. In conclusion, the development of a temperature-controlled LCL container booking platform is both technically and commercially feasible, offering a practical solution to improve logistics efficiency, support SMEs, and enhance the competitiveness of Thailand's export sector in international maritime trade.

Keywords—Full Container Load (FCL), Less-than-Container Load (LCL), Temperature-Controlled Logistics, Maritime Transport, Booking Software, Feasibility Study

INTRODUCTION

International maritime transport plays a critical role in facilitating global trade and economic growth by enabling the movement of large volumes of goods at relatively low cost compared to other transport modes. It also strengthens connectivity among global port networks and supply chains, thereby enhancing trade efficiency at both global and national levels (UNCTAD, 2023). In Thailand, maritime logistics is particularly significant for export-oriented industries, especially those involving

temperature-sensitive products such as fresh food, frozen goods, pharmaceuticals, and chemicals. The advancement of containerization, particularly refrigerated containers (reefer containers), has significantly improved the ability to maintain product quality and safety during long-distance transportation (Notteboom & Rodrigue, 2020).

However, existing container booking systems are predominantly designed for Full Container Load (FCL) shipments, which are more suitable for exporters with sufficient cargo volume to fill an entire container. This creates structural limitations for small and medium-sized enterprises (SMEs), which typically operate with smaller shipment volumes. Consequently, SMEs often face higher logistics costs per unit or limited access to temperature-controlled transportation services (Marine Department, 2022). These constraints negatively affect the competitiveness of Thai exporters and contribute to inefficiencies in logistics resource utilization, including increased energy consumption, higher carbon emissions, and suboptimal container management within international supply chains (World Bank, 2022).

To address these challenges, the development of a Less-than-Container Load (LCL) booking system specifically designed for temperature-controlled containers has been proposed. This concept leverages digital technologies to enable multiple exporters to share container space efficiently through advanced scheduling, shared temperature management, and real-time monitoring systems (Lee et al., 2021). Such a system can significantly reduce transportation costs for SMEs, enhance flexibility in shipment planning, and improve overall logistics efficiency. Moreover, the adoption of digital logistics platforms is widely recognized as a key driver for improving supply chain competitiveness in the digital era (Kasemsap, 2020).

In addition, the development of a temperature-controlled LCL booking platform is aligned with Thailand's national digital economy and sustainable logistics policies. By optimizing container utilization, the system can contribute to reducing greenhouse gas emissions and promoting environmentally sustainable transport practices (Office of Energy Policy and Planning, 2023). Nevertheless, there remains a lack of comprehensive empirical studies focusing on the feasibility and development of such systems, particularly within the Thai context. This gap highlights the need for further research to evaluate both technological and commercial viability.

Therefore, this study aims to examine the current container booking processes and analyze the feasibility of developing a temperature-controlled LCL container booking software. The findings are expected to provide practical insights for developing a scalable digital logistics solution that enhances efficiency, supports SMEs, and strengthens Thailand's competitiveness in international maritime trade.

RESEARCH OBJECTIVES

1. To examine the booking processes of Full Container Load (FCL) and Less-than-Container Load (LCL) shipping in international maritime transport, with particular emphasis on operational procedures, decision-making factors, and service limitations.

2. To analyze the feasibility of developing temperature-controlled LCL container booking software for international maritime export operations, considering technological readiness, market potential, and operational efficiency.

LITERATURE REVIEW

3.1 Container Booking

Container booking is a fundamental process in maritime logistics, as it enables shippers to reserve container space and vessel capacity in advance to ensure timely shipment and avoid disruptions caused by container shortages. Effective booking practices are essential for maintaining operational continuity and improving supply chain efficiency, particularly during peak demand periods (Wang et al., 2024). Moreover, early booking allows exporters to optimize production planning, inventory management, and shipment scheduling, which are critical factors in reducing logistics costs and enhancing overall business performance (Xu et al., 2022). In addition, container booking plays a strategic role in balancing supply and demand across global shipping networks. Accurate booking data supports shipping lines in forecasting container demand, optimizing vessel capacity utilization, and managing container repositioning across different routes (Guo et al., 2021). This contributes directly to improving operational efficiency and reducing empty container movements within the global logistics system (J. Mar. Sci. Eng., 2025). With the advancement of digital technologies, electronic booking systems have been increasingly adopted to enhance transparency, traceability, and real-time information exchange among stakeholders, including exporters, freight forwarders, and shipping lines (Zeng, 2021). Furthermore, booking data has become a valuable input for revenue management, enabling shipping lines to adjust freight rates dynamically based on demand patterns and market conditions (Guo et al., 2021; Wang et al., 2024). Therefore, efficient container booking management is not only an operational necessity but also a strategic tool that influences competitiveness at both firm and industry levels.

3.2 Software Development

The development of temperature-controlled LCL container booking software represents a significant advancement in maritime logistics, particularly through the integration of digital technologies such as the Internet of Things (IoT), cloud computing, and real-time monitoring systems. These technologies enable continuous tracking of container conditions, including temperature, humidity, and location, thereby ensuring product quality and reducing the risk of spoilage for sensitive goods (Hapag-Lloyd, 2024; ORBCOMM, 2024). From a system development perspective, effective software design involves the integration of three key components: process, method, and tools. The process defines the workflow and operational sequence, while the method incorporates problem-solving techniques such as multi-zone temperature control and cargo consolidation across multiple users within a single container. The tools include IoT-enabled sensors, cloud-based platforms, and application programming interfaces (APIs) that facilitate real-time data exchange and user interaction (Nexxiot, 2024). Furthermore, recent studies have highlighted the application of advanced computational frameworks, such as Multi-Agent Systems (MAS), in managing container booking and vessel slot allocation. These systems enable autonomous communication among logistics stakeholders, improving booking accuracy, decision-making efficiency, and flexibility in resource allocation (Mandal et al., 2022). The integration of IoT and MAS technologies can significantly enhance system performance by enabling dynamic coordination and real-time responsiveness. Overall, the development of an LCL reefer booking platform can expand access to temperature-controlled

logistics services for small and medium-sized enterprises (SMEs), improve container utilization efficiency, and support the digital transformation of the maritime logistics sector.

3.3 International Logistics Management

International logistics management involves the systematic coordination of activities required to move goods across borders efficiently, with a focus on minimizing costs and delivery time while maintaining service quality. Key components include transportation planning, inventory control, route optimization, and the selection of logistics service providers (Song & Dong, 2024). In maritime logistics, these activities are closely integrated among multiple stakeholders, including exporters, freight forwarders, shipping lines, ports, and regulatory agencies (Song, 2023). The adoption of digital technologies has become a critical enabler in enhancing the efficiency and transparency of international logistics systems. Technologies such as IoT and real-time tracking systems facilitate better visibility of cargo movements, reduce operational uncertainties, and improve coordination across the supply chain (Zhong et al., 2023). These advancements contribute to reducing delays, minimizing errors, and enhancing supply chain agility in a highly dynamic global trade environment.

Risk management is another essential aspect of international logistics, as maritime transport is subject to various uncertainties, including fluctuating transportation costs, port congestion, weather disruptions, and geopolitical risks. Effective risk mitigation strategies involve the use of data analytics, insurance mechanisms, and collaborative planning among supply chain stakeholders (Huang & Xu, 2022). In addition, sustainability has become an increasingly important consideration in logistics management. Maritime transport contributes significantly to global greenhouse gas emissions; therefore, improving energy efficiency and optimizing resource utilization are key priorities (World Economic Forum, 2023). The integration of digital technologies supports sustainable logistics by enabling route optimization, reducing empty container movements, and improving overall system efficiency (MDPI Sustainability, 2023). Finally, collaboration and information sharing among stakeholders are essential for enhancing the resilience and performance of international logistics systems. Strong coordination mechanisms can reduce conflicts, improve service reliability, and strengthen the competitiveness of global supply chains (Martin-Navarro et al., 2023).

RESEARCH METHODOLOGY

This study adopted a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive analysis of container booking practices and system feasibility. The quantitative component aimed to capture general patterns and perceptions, while the qualitative component was used to gain in-depth insights from industry experts. The population comprised 23,100 individuals, including employees from frozen and chilled goods export companies affiliated with the Thai Frozen Foods Association (TFFA), as well as freight forwarding companies under the Thai International Freight Forwarders Association (TIFFA). The sample size for the quantitative phase was determined using Yamane's (1973) formula at a 95% confidence level and a 5% margin of error, resulting in a total of 393 respondents. For the qualitative phase, 18 key informants were purposively selected based on their professional experience in logistics and export operations. All participants had a minimum of three years of relevant work experience, ensuring the reliability and depth of the information obtained through in-depth interviews.

The research instruments consisted of a structured questionnaire for quantitative data collection and a structured interview guide for qualitative inquiry. The questionnaire was validated by experts using the Index of Item-Objective Congruence (IOC), which yielded a value of 1.0, indicating high content validity. Reliability testing was conducted using Cronbach's Alpha, with a coefficient of 0.86, demonstrating a high level of internal consistency. Data collection was carried out over a period of two months. Quantitative data were analyzed using descriptive statistics, including mean ($\bar{X}$), standard deviation (SD), and ranking analysis to assess the level of importance of each factor. Qualitative data were analyzed using content analysis to systematically interpret and synthesize key themes and insights derived from the interviews. This methodological approach ensures both the statistical robustness of the findings and the contextual richness necessary for evaluating the feasibility of developing a temperature-controlled LCL container booking system.

RESEARCH RESULTS

5.1 Quantitative Results

The quantitative findings were derived from 393 respondents and analyzed using descriptive statistics, including mean ($\bar{X}$), standard deviation (SD), and ranking analysis. The results indicate that overall factors influencing container booking decisions were rated at a high level ($\bar{X}$ = 4.29, SD = 0.62).

Among the evaluated factors, the type of temperature-controlled goods ($\bar{X}$ = 4.60) and the specified temperature requirements ($\bar{X}$ = 4.52) were identified as the most critical considerations, both at a very high level. These findings highlight the importance of maintaining product quality in maritime logistics, particularly for perishable and sensitive goods.

Other factors, including container size ($\bar{X}$ = 4.35), volume and weight of goods ($\bar{X}$ = 4.28), and transportation duration ($\bar{X}$ = 4.21), were also rated at a high level, indicating their significant role in operational decision-making. In contrast, booking period and urgency ($\bar{X}$ = 3.98) received the lowest mean score, reflecting a relatively moderate level of importance compared to other factors.

Regarding the feasibility of developing temperature-controlled LCL container booking software, the overall assessment was also at a high level ($\bar{X}$ = 4.31, SD = 0.59). The highest-rated dimensions were software development feasibility ($\bar{X}$ = 4.50) and market and customer feasibility ($\bar{X}$ = 4.47), indicating strong technological readiness and favorable market demand. Other aspects, such as the number of potential users ($\bar{X}$ = 4.40) and operational feasibility in container loading ($\bar{X}$ = 4.31), were also evaluated positively. These results suggest that the development of such a platform is both technically viable and commercially promising within the Thai logistics context.

5.2 Qualitative Results

The qualitative findings were obtained from in-depth interviews with 18 key informants, including professionals in logistics, export operations, and information technology. The results were analyzed using content analysis, leading to the identification of key thematic insights.

First, strong demand for temperature-controlled LCL services was observed, particularly among small and medium-sized exporters (SMEs). Participants emphasized the need for more flexible and cost-effective logistics solutions that allow partial shipments without compromising product quality.

Second, in terms of technological feasibility, experts highlighted that current digital infrastructure, including IoT, cloud computing, and real-time tracking systems, is sufficiently advanced to support the development of a temperature-controlled LCL booking platform. The integration of these technologies can enhance visibility, improve operational efficiency, and reduce the risk of cargo damage.

Third, from a business perspective, respondents indicated that there is a clear market opportunity for such a platform, as existing booking systems are largely dominated by international providers and may not adequately address the needs of local SMEs. The development of a domestic platform could reduce costs, increase accessibility, and strengthen the competitiveness of Thai logistics service providers.

Fourth, sustainability and resource efficiency were identified as additional benefits. The ability to consolidate shipments and optimize container utilization can reduce energy consumption and greenhouse gas emissions, aligning with global trends in green logistics.

Finally, user acceptance was found to be positive, with participants expressing confidence in adopting a digital booking system that offers transparency, real-time monitoring, and ease of use. These findings reinforce the quantitative results, confirming the overall feasibility and potential impact of developing a temperature-controlled LCL container booking platform.

CONCLUSION

This study aimed to examine the booking processes of Full Container Load (FCL) and Less-than-Container Load (LCL) shipments and to evaluate the feasibility of developing a temperature-controlled LCL container booking software for international maritime transport. The findings from both quantitative and qualitative analyses provide consistent evidence supporting the viability and potential impact of such a system.

The quantitative results indicate that temperature-related factors, particularly the type of temperature-sensitive goods and specified temperature requirements, are the most influential determinants in container booking decisions. This reflects the critical importance of maintaining product quality in maritime logistics, especially for perishable exports. In addition, the overall feasibility of developing a temperature-controlled LCL booking platform was rated at a high level, with strong support in terms of technological readiness and market demand.

The qualitative findings further reinforce these results by highlighting key industry perspectives. Experts emphasized the growing need for flexible and cost-effective logistics solutions, particularly for small and medium-sized enterprises (SMEs) that are constrained by limited shipment volumes. The integration of digital technologies, such as IoT and real-time tracking systems, was identified as a key enabler for improving transparency, operational efficiency, and service reliability. Moreover, the development of a domestic platform was viewed as an important step toward reducing dependence on foreign systems and enhancing national digital capabilities.

Overall, this study concludes that the development of a temperature-controlled LCL container booking platform is both technically feasible and commercially promising. Such a system has the potential to improve logistics efficiency, expand access to temperature-controlled shipping services, and strengthen the competitiveness of Thai exporters in the global market. Furthermore, it contributes

to sustainable logistics practices by optimizing container utilization and supporting the transition toward a more efficient and environmentally responsible maritime transport system.

DISCUSSION

The findings of this study provide strong empirical support for the role of digital transformation in enhancing maritime logistics systems. The results are consistent with prior studies emphasizing that the integration of digital technologies, such as Internet of Things (IoT) and real-time data systems, significantly improves operational transparency, coordination, and efficiency in global supply chains (Zhong et al., 2023; Song & Dong, 2024).

The quantitative findings reveal that temperature-related factors are the most influential determinants in container booking decisions. This aligns with the nature of temperature-sensitive supply chains, where maintaining product integrity is critical. Previous research has highlighted that effective temperature monitoring and control are essential for minimizing product loss and ensuring compliance with international logistics standards (Lee et al., 2021). Therefore, the high importance assigned to temperature-related factors in this study reflects real operational priorities in export logistics.

In terms of technological feasibility, the high level of readiness identified in this study supports existing literature on the application of IoT and cloud-based monitoring systems in maritime transport. Real-time tracking technologies have been shown to enhance cargo visibility, reduce operational risks, and improve decision-making processes (Hapag-Lloyd, 2024; ORBCOMM, 2024). Furthermore, the use of advanced computational approaches such as Multi-Agent Systems (MAS) has been found to improve container booking accuracy and optimize vessel slot allocation (Mandal et al., 2022), which is consistent with the proposed system in this research.

The qualitative findings further indicate a significant gap in existing logistics systems, particularly in addressing the needs of small and medium-sized enterprises (SMEs). Traditional Full Container Load (FCL) systems are often inefficient for smaller shipment volumes, leading to higher costs and reduced accessibility. The proposed temperature-controlled LCL platform addresses this limitation by enabling cargo consolidation and improving resource utilization, which aligns with the concept of collaborative logistics and shared transportation systems (Guo et al., 2021).

From a sustainability perspective, the study supports the notion that optimizing container utilization through LCL systems can contribute to reducing energy consumption and greenhouse gas emissions. This finding is consistent with global sustainability frameworks, which emphasize the importance of efficient resource use and digital technologies in promoting green logistics (World Economic Forum, 2023).

CONTRIBUTION

8.1 Novel Contribution

This study contributes to the literature in three main aspects. First, it proposes a context-specific framework for developing a temperature-controlled LCL booking platform tailored to the Thai export sector. Second, it integrates quantitative and qualitative evidence to provide a comprehensive assessment of both demand and feasibility. Third, it highlights the strategic importance of developing

domestic digital logistics platforms to enhance national competitiveness and reduce reliance on foreign systems.

8.2 Policy and Managerial Implications

The findings suggest that policymakers should support the development of digital logistics infrastructure and promote collaboration among stakeholders. Financial and technical support mechanisms for SMEs are also essential to facilitate system adoption. For logistics service providers, implementing such platforms can improve operational efficiency, expand service accessibility, and strengthen competitive advantage in the international market.

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