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The Role of Less-than-Container Load Services in Supporting E-Commerce Logistics Efficiency in Asia-Pacific

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Abstract

The growth of e-commerce in the Asia-Pacific region has increased demand for flexible maritime logistics services that can accommodate diverse shipment volumes and changing inventory requirements. Less-than-Container Load (LCL) shipping offers an alternative to Full-Container Load (FCL) by enabling multiple shippers to share container capacity. This study analyzes the role of LCL services in supporting e-commerce logistics efficiency, particularly in terms of cost considerations, shipment flexibility, inventory replenishment, and logistics network integration. This study used a qualitative descriptive approach and document analysis, with the Asia-Pacific Sea Freight Forwarding Market Report published by Mordor Intelligence as the primary industry source, supported by relevant academic literature. The findings indicate that LCL can accommodate smaller, fluctuating shipments, enable more frequent inventory replenishment, and improve access to international shipping networks. Digital freight platforms and expanded consolidation routes may further support shipment coordination and visibility. However, LCL does not automatically guarantee lower total logistics costs or faster delivery because its effectiveness depends on consolidation schedules, handling charges, infrastructure, and supply-chain coordination. The study concludes that LCL is a complementary logistics solution whose suitability depends on shipment characteristics and distribution requirements.

Keywords

Asia-Pacific, E-Commerce Logistics, Freight Consolidation, Less-than-Container Load, Logistics Efficiency.

1. Introduction

The rapid expansion of e-commerce has transformed logistics requirements by increasing demand for flexible, cost-effective, and responsive transportation services. As online retailers serve domestic and international markets, logistics systems must accommodate varying order volumes, frequent replenishment cycles, and changing consumer demand (Berling et al., 2023; Chowdhury et al., 2025). In the Asia-Pacific region, maritime freight forwarding remains essential to supporting manufacturing, international trade, and e-commerce distribution. Mordor Intelligence (2025) estimated the regional sea freight forwarding market at USD 144.55 billion in 2025, projecting growth to USD 198.42 billion by 2030 at a Compound Annual Growth Rate (CAGR) of approximately 6.67%. This expansion underscores the strategic importance of maritime logistics in regional trade networks.

Less-than-Container Load (LCL) shipping offers a potential solution to e-commerce businesses' changing logistics needs. Unlike Full-Container Load (FCL), which generally involves one shipper utilizing a container's capacity, LCL consolidates cargo from multiple shippers into a single container. This arrangement accommodates diverse products and smaller shipment volumes, allowing businesses to ship goods without waiting to fill an entire container. Mordor Intelligence (2025) identifies e-commerce growth as a driver of LCL demand in Asia-Pacific, particularly because it supports frequent inventory replenishment, shipment flexibility, and responsiveness to changing demand. China's online retail sales reached CNY 14 trillion (approximately USD 1.92 trillion) during the first eleven months of 2024, representing a 7.4% increase from the same period in 2023. These developments highlight the growing relevance of flexible maritime shipping services.

Nevertheless, LCL's contribution to e-commerce logistics efficiency requires further examination. Although cargo consolidation may improve container utilization and accommodate smaller shipments, it does not necessarily reduce total logistics costs or accelerate delivery. Coordination among multiple shippers may introduce additional handling, documentation, and deconsolidation processes (Adawiyah & Poernomo, 2022; Fauzi & Purnomo, 2023). Therefore, LCL's suitability depends on shipment characteristics, transportation schedules, service availability, and individual businesses' logistics requirements (Beškovnik & Stojaković, 2019; Lin et al., 2020). These considerations position LCL as a component of the broader e-commerce supply chain, and its benefits must be evaluated alongside its operational limitations.

Previous studies have examined e-commerce logistics from broader operational perspectives. Mangiaracina et al. (2019) reviewed innovative solutions for improving last-mile delivery efficiency in business-to-consumer e-commerce, highlighting delivery costs and opportunities for operational improvement. Similarly, Risberg (2023) synthesized 373 articles on e-commerce logistics and developed a decision framework encompassing supply, internal distribution, fulfillment, delivery, and reverse logistics. Although these studies show the interconnected nature of e-commerce logistics decisions, they primarily focus on last-mile delivery, broader logistics configurations, and omnichannel distribution. Accordingly, further analysis is warranted regarding how maritime LCL services support e-commerce logistics efficiency through cargo consolidation, shipment flexibility, and inventory replenishment in Asia-Pacific. This study addresses this narrower analytical gap without assuming that previous research has entirely overlooked LCL or maritime logistics.

This study analyzes the role of LCL services in supporting e-commerce logistics efficiency in Asia-Pacific. Specifically, it examines how cargo consolidation and shipment flexibility accommodate varying order volumes, how LCL supports inventory replenishment and supply chain responsiveness, and which operational

limitations affect its suitability for e-commerce businesses. This study uses a qualitative descriptive approach through document analysis, using Mordor Intelligence's Asia-Pacific Sea Freight Forwarding Market Report as the primary industry source and relevant academic publications to establish the conceptual context and research gap. The analysis interprets documented industry developments and LCL's operational characteristics rather than measuring causal effects or claiming empirically verified performance improvements.

The study contributes to maritime logistics research by connecting LCL service characteristics with the operational requirements of e-commerce supply chains. Its findings may inform e-commerce businesses and logistics providers as they consider shipment consolidation, transportation flexibility, and inventory replenishment strategies. By examining the intersection of LCL services and e-commerce logistics in Asia-Pacific, this study offers a focused perspective on maritime freight forwarding's potential to support evolving distribution needs while acknowledging the trade-offs of cargo consolidation.

2. Literature Review

2.1. Sea Freight Forwarding and Less-than-Container Load

Sea freight forwarding is an essential component of international logistics, facilitating the movement of goods through maritime transportation, cargo-space booking, freight-rate negotiation, route selection, documentation, and coordination between shippers and carriers. According to Mordor Intelligence (2025), the Asia-Pacific Sea freight forwarding market was valued at USD 144.55 billion in 2025 and is projected to reach USD 198.42 billion by 2030. The report identifies FCL and LCL as the market's two principal service segments. FCL generally involves a single shipper using an entire container, while LCL allows multiple shippers to share container capacity, making it particularly relevant for businesses with small or fluctuating shipment volumes.

LCL services operate through cargo consolidation, in which shipments from different customers are combined into a shared container for transport to their respective destinations. This approach aligns with the transportation economies of scale discussed by Hall (1987) and Campbell's (1990) freight-consolidation analysis, which explain how combining smaller shipments can improve transportation efficiency. In e-commerce, flexible logistics arrangements are increasingly important because online retailers must accommodate fluctuating order volumes, diverse product categories, and frequent inventory replenishment. Bask et al. (2012) emphasize the importance of logistics configurations in e-commerce, while Risberg (2023) highlights the complexity of logistics decisions across supply, fulfillment, delivery, and reverse logistics. Similarly, Mangiaracina et al. (2019) demonstrate that e-commerce logistics efficiency depends on coordinating transportation and distribution activities to balance costs and service requirements. Cano et al. (2022) further emphasize the importance of sustainable logistics practices in e-commerce operations. Accordingly, LCL represents a maritime logistics option that accommodates smaller shipments through shared container capacity. However, its actual efficiency depends on consolidation arrangements, handling requirements, transit schedules, and total logistics costs, rather than shipment size alone.

2.2. E-Commerce Logistics in Asia-Pacific

E-commerce logistics encompasses the activities involved in moving products from sellers to consumers, including transportation, warehousing, order fulfillment, inventory management, and distribution. In Asia-Pacific, expanding online retail and cross-border trade have increased demand for integrated logistics services that accommodate diverse shipment volumes and delivery requirements. Mordor Intelligence (2025) identifies e-commerce growth as a key driver of regional sea

freight forwarding demand, particularly for LCL services, given the importance of flexible shipments and frequent inventory replenishment. Beyond transportation speed, logistics efficiency depends on coordinating multiple supply chain activities. In a systematic literature review of 373 articles, Risberg (2023) developed an e-commerce and omnichannel logistics decision framework covering supply, internal distribution, fulfillment, delivery, and reverse logistics. Similarly, Mangiaracina et al. (2019) emphasize innovative logistics solutions to improve delivery efficiency and manage costs in business-to-consumer e-commerce.

Recent studies highlight the importance of technological integration, supply chain coordination, and risk management. Andrei et al. (2024) examine how artificial intelligence, supply chain consistency, last-mile logistics performance, and collaboration contribute to e-commerce logistics efficiency, while Bonilla et al. (2024) identify operational uncertainty and delivery-related challenges as important logistics risks. These findings underscore the need to coordinate transportation, information systems, and distribution processes. Within this context, maritime freight forwarding connects international suppliers with regional distribution networks, while LCL services may accommodate smaller shipments through shared container capacity and support flexible inventory replenishment (Malhotra & Kharub, 2025). However, their contribution to overall efficiency depends on consolidation processes, handling requirements, transit schedules, and coordination with downstream distribution. Examining LCL within the broader Asia-Pacific e-commerce logistics system therefore helps clarify its potential benefits and operational limitations.

2.3. Logistics Efficiency: Cost, Flexibility, and Inventory Responsiveness

Logistics efficiency in e-commerce can be understood through three interconnected dimensions: transportation cost, shipment flexibility, and inventory responsiveness. Mordor Intelligence (2025) identifies e-commerce expansion as a driver of LCL demand in Asia-Pacific, as LCL enables smaller shipment consolidation, more frequent inventory replenishment, and responses to fluctuating consumer demand. The report also highlights Maersk's (2024) expansion of its Shanghai LCL network in 2024, illustrating how broader shipping connectivity can support operational efficiency. Cost efficiency arises from sharing container capacity and distributing transportation expenses across multiple shipments. Campbell (1990) explains that freight consolidation generates transportation economies of scale by combining smaller consignments into larger flows. However, Zikopoulos (2019) demonstrates that freight rates and consolidation savings depend on demand conditions and shipment characteristics. Consequently, LCL does not necessarily minimize total logistics costs, particularly when additional handling and consolidation charges apply.

Shipment flexibility refers to the ability to adjust shipment quantities and schedules in response to changing demand. Richey et al. (2022) conceptualize responsiveness as an important perspective in logistics and supply chain management, while Qi et al. (2023) find that information sharing, joint planning, and logistics cooperation can strengthen e-commerce supply chain resilience. These findings suggest that LCL flexibility creates greater value when supported by effective coordination among logistics participants. Inventory responsiveness concerns the ability to replenish stock while maintaining product availability. Kim et al. (2023) examine network inventory deployment for responsive fulfillment, emphasizing the relationship between inventory positioning and fulfillment requirements. LCL may support smaller, more frequent replenishment cycles, although its benefits depend on transit schedules and consolidation lead times. Accordingly, logistics efficiency should be assessed by jointly considering transportation cost, shipment flexibility, and inventory responsiveness rather than relying on a single operational indicator.

3. Methods

This study employs a qualitative descriptive approach to examine the role of LCL services in supporting e-commerce logistics efficiency in the Asia-Pacific region. A qualitative approach is appropriate because the research interprets industry developments, service characteristics, and operational challenges through documentary evidence rather than statistical hypothesis testing. The use of secondary qualitative data is consistent with Cheong et al. (2023), who discuss the methodological value of online data in qualitative research. The study relies exclusively on secondary data obtained from industry reports, academic journal articles, relevant publications, and other credible documentary sources. The principal source is Mordor Intelligence's Asia Pacific Sea Freight Forwarding Market report, which provides information on market developments, LCL and FCL services, e-commerce-related demand, and industry initiatives. Supplementary sources include peer-reviewed journal articles addressing e-commerce logistics, freight consolidation, transportation costs, shipment flexibility, inventory management, and supply chain responsiveness. These additional sources provide conceptual foundations and supporting perspectives for interpreting the industry information. No primary data are collected through interviews, surveys, or direct observations.

Data collection is conducted through document review and documentation techniques. Relevant information is identified, extracted, and organized according to its relevance to the research objectives. The selection focuses on publications that explain the characteristics of LCL services, the logistics requirements of e-commerce, and the potential relationship between shipment consolidation and operational efficiency. Source credibility, publication relevance, and consistency with the research topic are considered during selection. The collected data are analyzed using thematic content analysis. Following the principles of qualitative document analysis discussed by Trautrims et al. (2012), the analysis involves reviewing the documents, identifying relevant information, coding recurring concepts, and organizing the findings into analytical themes. The themes comprise e-commerce growth and LCL demand, logistics cost efficiency, shipment flexibility and inventory responsiveness, and operational challenges. The report compares its findings with relevant academic literature to identify converging perspectives and differences. Conclusions are subsequently developed through interpretive synthesis, with claims limited to the available documentary evidence.

4. Results

4.1. E-Commerce Growth and Demand for LCL Services

The expansion of e-commerce has become an important driver of demand for sea freight forwarding services in the Asia-Pacific region. As online retail and cross-border trade continue to develop, businesses increasingly require logistics arrangements that accommodate varying shipment sizes, fluctuating order volumes, and inventory replenishment needs. Mordor Intelligence (2025) identifies e-commerce growth as a key driver of demand for LCL services, which allow multiple shippers to share container capacity rather than requiring each shipper to fill an entire container. This arrangement is particularly relevant for online retailers and Small and Medium-Sized Enterprises (SMEs) whose shipment volumes may not consistently justify FCL services. The importance of aligning commercial expansion with logistics capabilities is also highlighted by Qi et al. (2024), who examine the relationship between cross-border e-commerce and logistics development among Chinese SMEs.

The broader market outlook further illustrates the commercial significance of these developments. Mordor Intelligence (2025) estimates that the Asia-Pacific sea

freight forwarding market reached USD 144.55 billion in 2025 and projects that it will grow to USD 198.42 billion by 2030. Although these figures represent the overall sea freight forwarding market rather than the LCL segment alone, they provide context for understanding the expanding market in which LCL services operate. The report also identifies e-commerce-related demand and flexible cargo arrangements as relevant drivers of LCL development. These trends reflect the broader importance of logistics configurations in accommodating the interconnected distribution, fulfillment, and inventory requirements of e-commerce businesses (Risberg, 2023).

The relationship between e-commerce growth and LCL demand is further contextualized by academic research. In a systematic literature review of 373 articles, Risberg (2023) shows that e-commerce logistics involves interconnected decisions about distribution, fulfillment, delivery, and inventory management. This complexity helps explain why online retailers need logistics arrangements that can accommodate fluctuating order volumes and changing customer demand. Similarly, Qi et al. (2024) examine the relationship between cross-border e-commerce and logistics development among SMEs in China, emphasizing the importance of coordinating commercial activities with logistics capabilities. Together, these perspectives highlight the relevance of flexible shipping arrangements within increasingly complex e-commerce supply chains.

A concrete industry example is Maersk's (2024) designation of Shanghai as a global gateway for LCL shipments in February 2024. According to Mordor Intelligence (2025), the initiative introduced more than 50 new trade lanes connected to Shanghai and facilitated over 200 direct LCL routes. This expansion shows how logistics providers build consolidation networks to meet international shipping demand. By enabling multiple shippers to share container capacity, LCL also lets online retailers arrange smaller, more frequent shipments without waiting to fill an entire container. These developments align with broader efforts to improve coordination and information exchange in maritime shipping through evolving logistics arrangements and digital platforms (Rahardja et al., 2025).

These findings indicate that e-commerce growth generates demand not only for greater shipping capacity but also for adaptable transportation arrangements. LCL is particularly relevant because it accommodates smaller and fluctuating cargo volumes, especially for online retailers and SMEs engaged in cross-border trade. However, rising demand for LCL does not necessarily mean the service reduces total logistics costs or delivery times. Its practical contribution depends on consolidation efficiency, shipping schedules, handling requirements, and coordination between maritime transportation and downstream distribution. This conditional relationship reinforces the importance of evaluating LCL within the broader interaction between e-commerce activities and logistics capabilities (Fei et al., 2025).

4.2. The Role of LCL Services in Enhancing E-Commerce Logistics Efficiency

LCL services can improve logistics efficiency by allowing multiple shippers to share container space and accommodate varying shipment volumes. In Asia-Pacific, e-commerce growth has increased LCL's relevance as online retailers manage diverse products, fluctuating orders, and changing replenishment requirements (Mordor Intelligence, 2025). Unlike FCL, which allocates an entire container to one shipper, LCL accommodates smaller consignments without requiring businesses to wait until they have sufficient cargo to fill a container. This arrangement can facilitate more frequent inventory replenishment and improve responsiveness to consumer demand.

From a cost-efficiency perspective, LCL allows businesses with smaller shipment volumes to share transportation resources. However, it does not necessarily offer lower freight costs per unit than FCL because consolidation, handling, documentation, and deconsolidation may generate additional expenses. Lin et al.

(2020), examining container trade between China and Europe, found that origin consolidation could reduce overall logistics costs when LCL cargo was converted into more efficiently utilized FCL shipments. Thus, cost efficiency depends on shipment volume and supply chain configuration. LCL also offers flexibility in distribution and inventory management by enabling smaller, more frequent shipments aligned with sales patterns, potentially reducing excess inventory. Nevertheless, these benefits depend on consolidation schedules, customs clearance, and inland distribution coordination.

LCL and FCL are therefore suitable under different operating conditions. LCL generally accommodates smaller or irregular shipments and businesses requiring flexible shipment quantities, whereas FCL is often more appropriate for large, consistent cargo volumes that benefit from container-level economies of scale. De Moor et al. (2023) emphasize that proactive freight consolidation can improve transportation efficiency through coordinated shipment timing and combined cargo flows. Accordingly, selecting the right service requires considering shipment volume, handling charges, departure frequency, transit time, and inventory requirements. Digital freight platforms and consolidation networks identified by Mordor Intelligence (2025) may further improve LCL accessibility and coordination, positioning it as a complementary solution rather than a universally superior alternative to FCL.

Digitalization and logistics network expansion further support LCL development across Asia-Pacific. Mordor Intelligence (2025) reports that digital freight forwarding platforms enable customers to obtain quotations, compare rates, book shipments, and track cargo online. These capabilities improve shipment information availability and facilitate coordination, particularly for SMEs engaged in international trade. Maersk's (2024) designation of Shanghai as a global LCL gateway in February 2024 illustrates this development. The initiative introduced more than 50 trade lanes connected to Shanghai and established over 200 direct LCL routes, strengthening consolidation and international connectivity for regional import and export operations.

Academic research highlights technology's role in maritime logistics. Raza et al. (2023) identify artificial intelligence, the Internet of Things, and cloud computing as important enablers of digital transformation in liner shipping, while also emphasizing organizational barriers such as resistance to change and siloed functions. Zeng et al. (2025) explain how digital freight forwarding can address limitations in traditional maritime forwarding services. These findings are relevant to LCL because consolidation requires information coordination among shippers, freight forwarders, carriers, and destination-side logistics providers.

Integrating digital booking and tracking systems with broader consolidation networks can improve information continuity, shipment monitoring, and coordination of international cargo movements. However, these benefits depend on system interoperability, data accuracy, and cooperation among logistics partners. Expanded route networks do not automatically guarantee lower costs or shorter transit times, which also depend on sailing schedules, port congestion, customs procedures, and inland transportation. Digital integration and physical network expansion can strengthen LCL accessibility and responsiveness, but their effectiveness depends on how well freight forwarders coordinate technology, route planning, and operational partners. Digitalization should therefore be regarded as an enabling capability that enhances LCL coordination and service reach rather than a standalone solution.

4.3. Challenges and Implications of LCL for E-Commerce Logistics

Although LCL services offer flexibility for e-commerce logistics, their effectiveness depends on coordinating cargo consolidation, shipping schedules, and distribution activities. Mordor Intelligence (2025) identifies e-commerce growth as

an important driver of LCL demand in the Asia-Pacific region, particularly because online retailers handle diverse products and fluctuating order volumes. By allowing multiple shippers to share container space, LCL enables businesses to arrange smaller and more frequent shipments without waiting until they have sufficient cargo to fill an entire container. However, realizing these benefits requires effective coordination among shippers, freight forwarders, carriers, and cargo-handling facilities to ensure that shipments are consolidated, processed, and dispatched according to operational requirements.

One major challenge involves balancing transportation costs and delivery time. Although LCL lets businesses pay for the cargo space they use rather than reserve an entire container, total logistics costs may include consolidation, handling, documentation, storage, and deconsolidation charges. Moreover, departure schedules may be affected by the time required to consolidate sufficient cargo, potentially extending shipment lead times. Bertazzi et al. (2021) examine the integration of FCL, LCL, and air freight in vendor-managed inventory systems, highlighting the trade-offs among transportation costs, flexibility, and lead times. Their research underscores that LCL should not automatically be regarded as the most economical option in every situation. Its suitability depends on shipment volume and frequency, inventory requirements, delivery deadlines, and the availability of alternative transportation arrangements. Businesses must therefore evaluate total logistics costs and expected delivery performance rather than make decisions based solely on initial freight quotations.

Maintaining reliable delivery performance across the wider e-commerce supply chain presents another challenge. Because LCL involves multiple shipments and logistics actors, delays or coordination problems at one stage can disrupt subsequent distribution activities. Raj et al. (2024) identify risk-related challenges in e-commerce last-mile logistics, demonstrating that logistics performance is influenced by interconnected operational uncertainties beyond the primary transportation stage. Although their study focuses on last-mile logistics rather than LCL specifically, it reinforces the importance of evaluating maritime transportation as part of an integrated logistics process. Accordingly, LCL performance depends not only on cargo consolidation efficiency but also on customs clearance, port handling, inland transportation, and final delivery arrangements. Companies must also consider cargo characteristics when selecting a shipping method, as fragile, high-value, or handling-sensitive products may require additional packaging, protection, and handling procedures that affect both costs and operational complexity.

Infrastructure limitations and fluctuating fuel prices create additional challenges for LCL services in the Asia-Pacific region. Mordor Intelligence (2025) identifies these factors as constraints affecting the broader sea freight forwarding market. These implications are particularly relevant for LCL because consolidated shipments depend on reliable port facilities, efficient transportation connections, and predictable operating conditions. Infrastructure constraints may disrupt cargo movement and increase delay risk, while fuel-price fluctuations can affect freight rates and complicate logistics budgeting. Route availability, sailing frequency, port capacity, shipment visibility, and logistics providers' coordination capabilities are therefore important considerations when assessing service reliability. These conditions indicate that LCL expansion takes place within a broader operating environment shaped by infrastructure capacity, transportation costs, and regional connectivity.

From a managerial perspective, selecting LCL requires assessing shipment characteristics, delivery requirements, and total logistics expenditure. LCL generally suits small or irregular consignments that require flexibility, while FCL may be preferable when cargo volumes are large and consistent enough to justify using an entire container. Businesses handling urgent orders or products with strict

replenishment schedules should also assess whether LCL consolidation and handling procedures align with their lead-time targets. This assessment should account for the full range of logistics expenses, including freight charges, handling, documentation, storage, customs clearance, and inland distribution. Companies should also evaluate the reliability of available routes and sailing schedules, shipment visibility, and logistics providers' capacity to coordinate activities across the supply chain. Where operational conditions permit, combining LCL and FCL services may allow businesses to accommodate varying shipment volumes while balancing cost efficiency and responsiveness.

LCL can support e-commerce logistics by accommodating smaller consignments and providing flexibility in inventory replenishment. However, its contribution to logistics efficiency depends on the relationship among shipment volume, total logistics costs, delivery requirements, cargo characteristics, and supply-chain coordination. In the Asia-Pacific context, the market developments described by Mordor Intelligence (2025) indicate opportunities for LCL expansion, although infrastructure constraints and fluctuating fuel prices remain important considerations. Companies should therefore adopt a shipment-specific approach, selecting LCL when flexibility and smaller shipment sizes are priorities and FCL when cargo volume, cost structure, and delivery requirements make a dedicated container more appropriate. Using both services appropriately can provide a more balanced approach to managing transportation costs, delivery performance, and the changing demands of e-commerce distribution.

5. Discussion

The findings indicate that cargo consolidation is a central mechanism through which LCL services can support e-commerce logistics efficiency in the Asia-Pacific region. By combining shipments from multiple customers into a shared container, LCL accommodates businesses with small or fluctuating cargo volumes without requiring them to reserve an entire container. This arrangement can improve container utilization and provide greater flexibility in shipment frequency. These findings are consistent with Campbell (1990), who examined freight consolidation in relation to transportation economies of scale, and Zikopoulos (2019), who addressed freight rates and consolidation savings under stochastic demand. Lin et al. (2020) further examined the effects of upstream buyer consolidation on logistics costs in China–Europe container trade. Together, these studies support the importance of consolidation in organizing freight flows, although its actual benefits depend on shipment characteristics and network configuration. For e-commerce businesses, LCL therefore offers a practical option for managing variable order volumes while maintaining access to international maritime transportation.

Regarding cost efficiency and inventory replenishment, the findings show that LCL provides flexibility but does not automatically guarantee lower total logistics costs or shorter delivery times. Although businesses can share container capacity, consolidation, cargo handling, documentation, and deconsolidation may increase total expenditure. Moreover, waiting for sufficient cargo to form a consolidated shipment can affect delivery schedules. This finding aligns with Bertazzi et al. (2021), who examined the integration of FCL, LCL, and air freight within vendor-managed inventory systems and highlighted the importance of coordinating transportation alternatives with inventory requirements. Berling et al. (2023) also examined inventory control in omnichannel and multichannel distribution systems under variable customer order sizes, reinforcing the importance of accounting for demand variability when making logistics decisions. Accordingly, LCL may facilitate more frequent replenishment for businesses handling smaller consignments. However, its suitability depends on delivery deadlines, shipment frequency, inventory policies,

and the total cost of transportation and handling. FCL may remain preferable for consistently large shipments that can utilize a dedicated container efficiently.

The findings also highlight the importance of logistics network integration and digitalization in strengthening LCL accessibility and coordination. Maersk (2024) illustrates this development through its initiative to establish Shanghai as a global gateway for LCL shipments, expanding connections between the gateway and international trade lanes. Such network development can improve access to consolidation services and support international cargo movement. However, the benefits depend on coordination among shippers, freight forwarders, carriers, and destination-side logistics providers. Raza et al. (2023) examined digital transformation in maritime logistics, while Zeng et al. (2025) addressed the role of digital freight forwarders in maritime shipping services. Their research provides a basis for understanding how digital platforms can support booking, information exchange, and shipment visibility. These capabilities are particularly relevant to LCL, where multiple parties must coordinate cargo movements and documentation.

Nevertheless, LCL efficiency remains subject to operational risks and external constraints. The findings indicate that port infrastructure, customs procedures, inland transportation, fuel-price fluctuations, and delivery coordination can affect costs and service reliability. Raj et al. (2024) identified risk-related challenges in e-commerce last-mile logistics, emphasizing that delivery performance is influenced by interconnected operational uncertainties. Although their focus differs from maritime consolidation, their findings reinforce the need to assess LCL within the wider supply chain. LCL should be viewed as a complementary logistics solution rather than a universal substitute for FCL. Its contribution to e-commerce efficiency depends on aligning shipment volumes, inventory requirements, delivery schedules, digital coordination, and infrastructure conditions with the most appropriate transportation arrangement.

6. Conclusion

This study concludes that LCL services can support e-commerce logistics efficiency in the Asia-Pacific region through cargo consolidation, shipment flexibility, and adaptable inventory replenishment. The document analysis indicates that e-commerce growth increases the relevance of logistics services that can accommodate smaller and fluctuating shipment volumes. By letting multiple shippers share container capacity, LCL offers an alternative to FCL shipping. Digital freight platforms and expanded shipping networks can further facilitate booking, cargo tracking, and coordination. However, LCL does not automatically guarantee lower total logistics costs or faster delivery, as its effectiveness depends on consolidation schedules, handling requirements, infrastructure capacity, and transportation conditions. For logistics providers and e-commerce businesses, selecting between LCL and FCL should consider shipment volume and frequency, delivery deadlines, and total logistics costs. LCL generally suits smaller or irregular consignments, while FCL may be better for large, consistent shipment volumes. Businesses should also strengthen coordination with freight forwarders, monitor shipment movements, and integrate maritime transportation with customs clearance and inland distribution to align shipping arrangements with inventory requirements and customer delivery expectations.

This study relies exclusively on secondary sources, particularly the Mordor Intelligence industry report and relevant academic publications. Consequently, its findings represent an interpretive analysis of documented information rather than direct empirical evidence of LCL performance within individual companies. Future research could incorporate interviews, case studies, or quantitative comparisons of LCL and FCL to examine differences in total logistics costs, transit times, inventory levels, and delivery reliability. Comparative studies across Asia-Pacific countries

could also provide a more detailed understanding of how infrastructure capacity, shipping connectivity, and local logistics conditions influence LCL effectiveness in e-commerce supply chains.

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The data that support the findings of this study are available from the corresponding author upon reasonable request.



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