



Analysis of the Coordinated Development between Cross-Border E-Commerce and International Air Logistics

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Abstract. The transaction volume of China's cross-border e-commerce has experienced exponential growth, with the industry flourishing and a strong emphasis on efficiency. This rapid development not only poses new challenges to the aviation logistics sector but also presents fresh opportunities for its advancement. Based on research into the interaction mechanisms between cross-border e-commerce and aviation logistics, this study designs separate evaluation index systems for the development of China's cross-border e-commerce and international aviation logistics. The gray relational analysis method is employed to explore the correlation between the two, followed by an analytical evaluation. On this foundation, recommendations are proposed to further promote the synergistic development of China's cross-border e-commerce and international aviation logistics.

Keywords: cross-border e-commerce; international aviation logistics; synergistic development

1 Introduction

China, as a major exporting country, places great importance on the vigorous development of cross-border e-commerce (CBEC) for its economic growth. The Chinese government has introduced a series of favorable policies, leading to exponential growth in CBEC transaction volume and a thriving industry. In 2022, China's CBEC transaction volume reached 15.7 trillion yuan, marking a 10.56% year-on-year increase from 14.2 trillion yuan in 2021. To foster a robust CBEC business environment, logistics plays a pivotal role—not only because logistics costs account for a significant portion of product prices, but also because competition in the CBEC sector has shifted from cost-based to time-based rivalry, where speed is the key differentiator. Against the backdrop of consumption upgrading, China's import retail e-commerce is adapting to consumers' growing demand for high quality and efficiency. When prices are similar, consumers prefer CBEC platforms with faster delivery, making shipping efficiency a new core competitive advantage.

The relentless pursuit of efficiency in CBEC not only poses new challenges to the aviation logistics industry but also presents fresh growth opportunities. According

to the International Air Transport Association (IATA), 80% of CBEC goods are currently transported by air, and CBEC already contributes 20% of total air cargo revenue. However, China's aviation logistics sector still lags behind CBEC in development, failing to fully meet air freight demands in terms of both quality and capacity.

As a critical component of CBEC logistics, aviation logistics and CBEC development are interdependent, influencing each other's growth trajectory.

2 Literature Review

2.1 Aviation Logistics

Currently, aviation logistics has demonstrated significant potential, becoming a crucial component in building a strong civil aviation and logistics industry. However, it remains in the development stage, requiring further research on existing challenges and countermeasures to promote its growth.

Wang Ya analyzed China's aviation logistics supply chain from a systemic perspective, identifying issues such as the lack of core enterprises, difficulties in business process reengineering, inefficiencies in airline and airport cargo terminals, and short-term collaborations among supply chain nodes leading to high uncertainty and transaction costs. She proposed establishing core enterprises to integrate logistics information seamlessly across the supply chain ^[1].

Shi Jin highlighted four major challenges facing China's air cargo logistics: (1) competition from foreign airlines due to market liberalization, (2) high domestic aviation fuel prices increasing operational costs and triggering price wars, (3) insufficient cargo route networks, and (4) lagging informatization and standardization. He suggested optimizing fuel pricing, expanding cargo routes, and enhancing digitalization ^[2].

Kawa and Zdrenka introduced the concept of "integrators" in cross-border e-commerce (CBEC), proposing that integrators consolidate supply chains to achieve economies of scale and reduce international shipping costs ^[3].

Wei Ran and Zhang Li addressed issues like homogeneous business models, fragmented operations, and low informatization in China's aviation logistics. They recommended: (1) developing high-value air cargo products, (2) integrating service chains, (3) promoting strategic mergers, (4) advancing IT applications, and (5) formulating national development guidelines ^[4].

Lin Ruyu and Yin Xiaoli's analysis of Xi'an Xianyang International Airport revealed underutilized hub capacity, unsystematic operational management, and imbalanced passenger-cargo coordination ^[5].

2.2 Cross-Border E-Commerce Logistics

Scholars generally categorize CBEC logistics into five modes: postal parcels, international express, transnational services of domestic couriers, overseas/bonded warehouses, and dedicated logistics lines.

Ding Qi identified constraints including inadequate awareness, talent shortages, weak infrastructure/policy support, and underutilized logistics technologies ^[6]. Cai

Junfang and Huang Geng proposed solutions like hybrid overseas-border warehouses and fourth-party logistics, while envisioning future CBEC logistics models ^[7].

Zhong Zheng pointed out insufficient policy support, slower development compared to CBEC, low specialization of third-party logistics, and inadequate customs supervision. He provided corresponding development strategies ^[8].

Liu Xiquan argued that CBEC's future lies in global value chains, with logistics evolving toward worldwide warehouse networks centered on overseas hubs ^[9].

Yang Zi and Zhu Pengyi applied FAHP analysis to rank CBEC logistics influencers by importance: (1) IT systems, (2) logistics costs, (3) international transport quality, (4) carrier capabilities, and (5) external environment ^[10].

Qian Huimin and He Jiang developed a grounded theory model identifying seven synergistic factors, with the most controllable being collaborative environment, mechanisms, capabilities, and relationships ^[11].

2.3 Airport-Based CBEC Logistics

Li Chaojie assessed Sichuan's aviation logistics through metrics like cargo volume and infrastructure, analyzed problems from CBEC demand perspectives, and explored synergy strategies ^[12].

Cao Yunchun and Zhu Junhong examined airport CBEC logistics models, proposing solutions covering cargo facilities, customs efficiency, multimodal transport systems, IT applications, and flight slot allocation ^[13].

Wang Dan and Liu Junxia analyzed synergies between Xixian Airport Logistics and CBEC, addressing challenges like low integration, external disruptions, scarce aviation resources, and talent gaps ^[14].

Existing studies predominantly investigate aviation logistics and CBEC separately within theoretical frameworks, with limited quantitative analyses on their synergy—particularly airport-centric CBEC logistics. This paper bridges the gap by combining theoretical and empirical approaches to enrich the foundational research on CBEC-aviation logistics coordinated development.

3 Cross-Border E-Commerce - Aviation Logistics Interaction Mechanism

3.1 Mechanism of Cross-Border E-Commerce's Impact on Aviation Logistics

1. Demand-Side Effects

Cross-border e-commerce (CBEC) inherently generates demand for aviation logistics due to its distinctive transaction characteristics. Compared to traditional trade, CBEC typically involves smaller-order transactions that cannot leverage economies of scale to reduce costs. Consequently, CBEC goods tend to be higher in value and possess greater freight rate affordability, making air transport the preferred logistics solution. The rapid growth of CBEC directly stimulates aviation logistics demand.

2. Industrial Transformation Effects

CBEC drives industrial upgrading, thereby altering the logistics demand structure of domestic manufacturers. Specifically, it increases the proportion of aviation logistics demand within the total logistics demand. As producers adapt to global e-commerce markets, their supply chains shift toward air cargo to meet the requirements of faster, more reliable international deliveries.

3. Technology Spillover Effects

CBEC fosters technological advancements that upgrade aviation logistics supply capabilities. Since CBEC development is internet-driven, successful e-commerce firms invest heavily in information technology (IT) to optimize their logistics operations. These innovations—such as real-time tracking, automated warehousing, and data-driven route optimization—spill over into the aviation logistics sector, enhancing its efficiency, transparency, and service quality.

In summary, CBEC influences aviation logistics through demand stimulation, industrial restructuring, and technology diffusion, collectively driving the evolution of air cargo networks to better serve global e-commerce flows.

3.2 Mechanism of Aviation Logistics' Impact on Cross-Border E-Commerce

The influence of international aviation logistics on cross-border e-commerce (CBEC) demand can be analyzed through two distinct scenarios based on end-user types: individual consumers versus corporate clients.

For CBEC consumers, the delivery timeframe significantly impacts shopping experience - receiving goods within 3 days versus waiting a month creates fundamentally different satisfaction levels. Industry complaint analyses consistently identify slow logistics as a primary consumer grievance. This temporal sensitivity makes aviation logistics crucial for customer retention in CBEC platforms.

For corporate buyers, while air transport incurs substantially higher costs than alternative shipping methods, its velocity advantage provides critical financial benefits. Faster delivery accelerates capital turnover, enabling quicker fund recovery and ultimately enhancing corporate revenue streams. Particularly for businesses operating in fast-evolving markets where product lifecycle management is paramount, supply chain velocity becomes a decisive competitive factor.

4 Empirical Study on the Coordinated Development of Cross-Border E-Commerce and International Aviation Logistics

4.1 Indicator System Design

Drawing upon Sun Min's ^[15] classification criteria, the evaluation indicator system for China's cross-border e-commerce development can be divided into three components: transaction scale, development potential, and transaction structure. Specifically, trans-

action scale is subdivided into three indicators: total cross-border e-commerce transaction volume, total import and export transaction volume, and annual growth rate of cross-border e-commerce transaction scale. Transaction structure is subdivided into three indicators: proportion of cross-border e-commerce in total e-commerce transaction scale, share of cross-border import transaction scale, and share of cross-border export transaction scale, as shown in Table 1.

Table 1. TEvaluation Index System for China's Cross-Border E-Commerce Development

<i>Subsystem</i>	<i>Secondary Indicator</i>	<i>Order Parameter</i>
Cross-border E-commerce	Transaction Scale	Total CBEC transaction volume (trillion yuan)
		Total import/export volume (trillion yuan)
		Annual growth rate of CBEC transactions (%)
	Transaction Structure	CBEC share in total e-commerce transactions (%)
		Cross-border import transaction share (%)
		Cross-border export transaction share (%)

China's evaluation index system for international aviation logistics development is divided into three components: transportation capacity, infrastructure construction, and revenue. Specifically, transportation capacity is subdivided into three indicators: air express delivery volume, international and Hong Kong/Macao/Taiwan air express volume, and international route cargo and mail transportation volume. Infrastructure construction is subdivided into three indicators: international aviation route length, number of international routes, and investment in civil aviation infrastructure and technological upgrades. Revenue is subdivided into total aviation logistics industry revenue and air express delivery revenue. For details, please refer to Table 2.

Table 2. China's Evaluation Indicator System for International Air Logistics Development

<i>Subsystem</i>	<i>Secondary Indicator</i>	<i>Order Parameter</i>	<i>Variable</i>
International Air Logistic	Transport Capacity	Air express volume (100 million pieces)	Y ₁
		International & HK/MO/TW express volume (100 million pieces)	Y ₂
		Cargo/mail volume on international routes (10,000 tons)	Y ₃
	Infrastructure Development	International air route length (10,000 km)	Y ₄
		Number of international routes	Y ₅
		Investment in aviation infrastructure & tech upgrades (100 million yuan)	Y ₆
	Revenue	Total logistics industry revenue (trillion yuan)	Y ₇
		Express business revenue (100 million yuan)	Y ₈

4.2 Data Sources and Standardization Processing

The data were sourced from the E-Commerce Research Center, National Bureau of Statistics' Statistical Yearbook, iiMedia Data Center, China Logistics Yearbook, Statistical Bulletin on Civil Aviation Industry Development, China Federation of Logistics & Purchasing, among others. In cases where certain data points were unavailable, simple regression was employed to estimate the missing values. Due to inconsistencies in measurement units across directly obtained data, which made them unsuitable for direct computation, this study adopted the mean-value method to standardize data from 2012 to 2019.

4.3 Calculating Correlation Degree Using Grey Relational Analysis

This study employed grey relational analysis to compute the correlation coefficients and correlation degrees between six cross-border e-commerce indicators and eight international air logistics indicators in China from 2015 to 2019, followed by indicator screening for in-depth analysis.

$$R = \frac{1}{n} \sum_{k=1}^n \left(\frac{\min_{t} \min_k |x_{1k}(t) - x_{2k}(t)| + \alpha \max_{t} \max_k |x_{1k}(t) - x_{2k}(t)|}{|x_{1k}(t) - x_{2k}(t)| + \alpha \max_{t} \max_k |x_{1k}(t) - x_{2k}(t)|} \right) \tag{1}$$

The correlation degree calculation formula is as follows:

Here, $x_{1k}(t)$ and $x_{2k}(t)$ represent the standardized values of the cross-border e-commerce and cross-border logistics order parameter indicators at time t , respectively. α is the distinguishing coefficient, typically set at 0.5, and k denotes the year.

5 Empirical Analysis Results

The grey correlation degree between the 6 cross-border e-commerce indicators and the 8 international air logistics indicators was calculated using MATLAB software, with the results presented in Table 3.

Table 3. Results of Correlation Degree between Cross-border E-commerce and International Air Logistics Development Indicators

<i>Correlation Degree</i>	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
X_1	0.469	0.412	0.554	0.443	0.533	0.513	0.543	0.525
X_2	0.318	0.278	0.501	0.433	0.481	0.433	0.492	0.350
X_3	0.450	0.418	0.537	0.580	0.560	0.467	0.534	0.470
X_4	0.353	0.295	0.419	0.521	0.443	0.456	0.446	0.352
X_5	0.298	0.274	0.432	0.405	0.451	0.328	0.418	0.317
X_6	0.329	0.280	0.389	0.477	0.410	0.401	0.430	0.354

From Table 3, it can be observed that the correlation between China's cross-border e-commerce and cross-border logistics from 2015 to 2019 was not particularly high, with most values below 0.6.

In the column of total cross-border e-commerce transaction volume (X_1), on one hand, variable X_1 exhibits the highest correlation with Y_3 . This indicates that the total cross-border e-commerce transaction volume is most closely related to the cargo and mail transportation volume on international routes, which is why Y_{10} (number of international routes), closely associated with Y_3 , also shows a relatively high correlation with X_1 . On the other hand, X_1 has the lowest correlation with international and Hong Kong/Macao/Taiwan express delivery volume (Y_2). This is because the current transportation mode of cross-border e-commerce is primarily air freight, and the transaction structure is dominated by B2B. The consumer segment is not yet large enough, and with the establishment of overseas warehouses by cross-border e-commerce enterprises, the growth rate of international express delivery volume has gradually slowed. Therefore, the correlation between X_1 and Y_2 is not strong.

In the column of cross-border e-commerce's proportion in total e-commerce transactions (X_4), variable X_4 shows a relatively high correlation with Y_4 . This suggests that the proportion of cross-border e-commerce in the overall e-commerce scale is related to the level of infrastructure development, further indicating that air logistics and infrastructure play a decisive role in the development of cross-border e-commerce.

Table 3 also reveals several variable pairs with extremely low correlations. First, variables X_2 , X_6 , X_7 , and X_8 exhibit the lowest level of correlation with international and Hong Kong/Macao/Taiwan express delivery volume (Y_2), all below 0.3. Y_2 represents the number of international express parcels, which are primarily used in B2C transactions, as many enterprises in B2B models opt for self-operated logistics. Given that China's cross-border e-commerce structure is currently dominated by B2B, it is natural that the number of international express parcels shows minimal correlation with metrics such as total import/export volume and cross-border e-commerce transaction scale.

Looking at each column, the total logistics industry revenue (Y_7) demonstrates low correlation with all cross-border e-commerce indicators, with none exceeding 0.55. The highest correlation is observed between Y_7 and X_1 , indicating that while the total cross-border e-commerce transaction volume is somewhat related to total cross-border logistics revenue, the level of coordinated development remains limited.

6 Conclusions

6.1 Strengthening Aviation Logistics Infrastructure Construction

The characteristics of cross-border e-commerce (CBEC)—"small batch sizes, high frequency, lightweight packaging, and time-sensitive delivery"—impose higher requirements on the layout and efficiency of aviation logistics facilities. During the planning, construction, and operation of airports, it is essential to fully consider the features of CBEC. Strengthening cargo infrastructure at airports to meet CBEC de-

mands, optimizing airport layouts, and refining cargo handling processes are crucial steps. By integrating CBEC's information flow, capital flow, and logistics, a seamless "door-to-door" cross-border aviation logistics service can be established—connecting suppliers to end customers—thereby enhancing airport efficiency and convenience.

6.2 Improving the Aviation Logistics Network

Establishing a specialized global transportation system is not only the foundation for aviation logistics companies' future competitiveness but also a prerequisite for CBEC development. To avoid price wars caused by service homogenization, aviation logistics companies must actively expand into international and mass markets while reinforcing the high-efficiency and high-quality characteristics of air cargo services.

For CBEC, a more comprehensive route network means broader participation. The role of aviation networks in shortening geographical distances is self-evident—more local businesses can engage in international trade through CBEC platforms. A well-developed aviation logistics network can amplify the mutually reinforcing relationship between CBEC and air cargo.

However, due to the impact of U.S.-China trade tensions, the logistics demand for trans-Pacific routes has become unpredictable. Therefore, optimizing the route network could initially focus on emerging CBEC markets such as Russia and Brazil.

6.3 Building an Integrated CBEC-Aviation Logistics Service Platform

To further promote the coordinated development of CBEC and cross-border logistics, it is necessary to construct a comprehensive service platform that enables information exchange. While standalone platforms serving either CBEC or logistics currently exist, an integrated platform effectively bridging both sectors has yet to be established.

Such a platform would function as a hub, seamlessly connecting information between the CBEC and logistics industries. Enterprises, governments, and CBEC consumers could access all necessary data through this one-stop platform, significantly improving operational transparency and efficiency.

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