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Conceptual Modeling of Cross-border Air Logistics System Based on Hall's 3D Modeling

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Abstract

In the context of globalization and rapid development of e-commerce, cross-border air logistics still becomes an important factor restricting cross-border e-commerce. On the basis of analyzing the constituent elements and functions of cross-border air logistics system as well as the multiple structures of cross-border air logistics system, this paper constructs a four-dimensional conceptual model based on Hall's three-dimensional model, and discusses in detail the dimensions of the model as well as the role modes between the dimensions, which provides theoretical foundations and practical guidance for the construction and optimization of cross-border air logistics system in China.

Keywords: hall three-dimensional structure; cross-border logistics; logistics system

1. INTRODUCTION

In the economic context of globalization, the efficiency and reliability of cross-border air logistics system, as an important link connecting the global supply chain, is crucial for international trade and economic activities. With the rapid development of e-commerce and the growing consumer demand for fast delivery, the traditional logistics system is facing unprecedented challenges.XiaoL.(2019) points out that China's cross-border e-commerce logistics faces challenges such as slow logistics speed, high costs, and asymmetric logistics information. There exists the problem of insufficient synergy between cross-border e-commerce and cross-border logistics, and the lack of close cooperation between cross-border logistics and customs, commodity inspection, warehouses and other aspects. At the same time, there is a lack of effective connection between international logistics, domestic logistics and destination country logistics, and there is also a lack of synergy between cross-border logistics in terms of language, customs, policies and other logistics environments[1] . LeiN. (2019) pointed out that there is still a large gap between China's cross-border e-commerce relative to the overall logistics standards, and the construction of cross-border e-commerce logistics system has many deficiencies[2] . Pan H.L. (2020) elaborated on the logistics supply chain relationship between the components and puts forward the construction strategy of logistics supply

chain management model from the perspective of international e-commerce [3] . YuanQ(2019) analyzes the advantages and disadvantages of the three cross-border logistics modes of fourth-party logistics, overseas warehousing, and logistics alliance, and puts forward the principle of cross-border enterprises' logistics mode selection [4] . In summary, cross-border aviation logistics has a huge system, many model links and many market players involved, so building a cross-border aviation logistics system can stand in the overall perspective, make a complete portrayal and profound analysis of cross-border aviation logistics in China, carry out a logical exploration under the premise of a clear goal, and provide the theory and information needed to judge and decide the optimal system solution through the perspective of from part to the whole .

2. CONSTRUCTION OF CROSS-BORDER AIR LOGISTICS SYSTEM

2.1Components of a cross-border air logistics system

This paper discusses the constituent elements of cross-border aviation logistics system from the constituent elements of general logistics system. General logistics system elements include including general elements (people flow, logistics, capital flow, information flow), functional elements (transportation, storage, packaging, loading and unloading handling, distribution, circulation processing, information processing, etc.), supporting elements (systems and regulations, operation standards) and material base elements (facilities and equipment, means of delivery, information system, etc.). From the perspective of aviation cross-border logistics. Human flow refers to the movement of people involved in aviation cross-border logistics services, including relevant staff, management personnel and so on. Logistics refers to the processes and activities involved in the transportation and management of goods across national borders by air. This includes the collection, sorting, packaging, transportation, tracking, customs clearance and delivery of goods. Capital flow, on the other hand, is the flow of funds throughout the entire logistics process, involving such aspects as capital payment and settlement. In terms of function, the functional elements include transportation, storage, packaging, loading and unloading, distribution, circulation processing and information processing. In the China-ASEAN cross-border air logistics system, transportation is one of the core functions in which goods are transported quickly and efficiently from one location to another through air transportation. Storage involves the temporary storage and sorting of air cargoes at airports or air logistics centers. Packaging, loading, unloading and handling functions safeguard the safety and integrity of goods during transportation. Distribution, circulation processing is the key link to deliver the goods to the end user. Information processing is the basis for the operation of the whole system, including order processing, tracking and monitoring, data analysis and so on. Supporting elements refer to the system regulations and operational standards that support the normal operation of the China-ASEAN cross-border air logistics system. This includes regulations and standards related to cross-border trade, aviation safety, transportation agreements, etc., to ensure the compliance and safety of the logistics system. In terms of physical infrastructure elements, the China-ASEAN cross-border air logistics system needs to include applicable facilities and equipment, means of transportation and information systems. Facilities and equipment include air cargo airports, air cargo flights, and air cargo handling facilities. Means of delivery refer to air cargo planes, ground transportation means, etc. Information system is the key to support the operation of the whole logistics system, including flight information system, cargo tracking system, order management system and so on.

2.2 Multi-structure analysis of cross-border air logistics systems

Due to the integrality and complexity of the element structure of cross-border aviation logistics system, in

order to ensure the normal operation of the cross-border aviation logistics system, the element main body actively or passively forms an organic whole, and obeys a certain structure in both space and time. From the spatial point of view, the main body of each element carries out spatial layout according to their respective functions; from the temporal point of view, the constituent elements of the cross-border logistics system are articulated according to the logistics-related operational processes. Therefore, the structure of cross-border air logistics system under the perspective of supply chain management center can be analyzed from three aspects: cohesive structure, spatial structure and temporal structure.

2.2.1 Condensed state structure

There are many subjects in the cross-border aviation logistics system, and in order to accomplish the mission of the system together, all the relevant subjects continuously gather and evolve, optimize the system functions, improve their own advantages, and form a "cohesive structure" similar to the evolution of biological communities through continuous integration and interaction. From the perspective of upstream and downstream industry chain, the main bodies of cross-border air logistics system mainly include manufacturing enterprises, cross-border e-commerce enterprises, cross-border e-commerce platforms, express logistics enterprises, airports, airlines, freight forwarders, distributors, consumers, as well as the relevant government departments (Civil Aviation Administration, Customs, etc.) and various types of service providers (cross-border payment, logistics information system, etc.), and information sharing is guaranteed through the information platform. Promote synergy. Among them, the relevant subjects in the cross-border air logistics service chain include express logistics enterprises, airports, airlines, air freight forwarders, manufacturing enterprises and trading enterprises. Relevant government departments refer to the Civil Aviation Administration, Customs (Inspection and Quarantine).

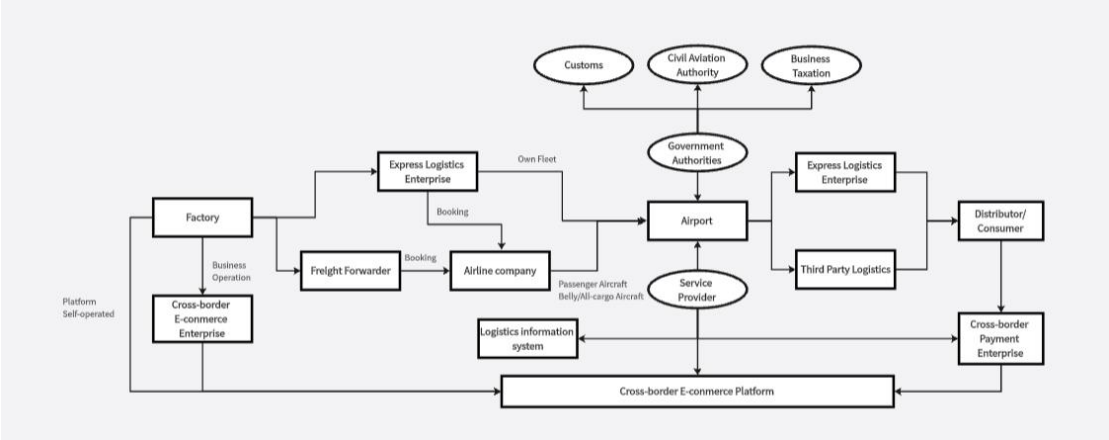

Figure 2-1 Cohesive structure of cross-border air logistics system

It can be seen that the various subjects serving the aviation cross-border logistics system complete the work of cross-border aviation logistics through coordinated operation. Among them, the relevant subjects in the aviation cross-border logistics service chain are interlocked and work together to complete the logistics supply chain services from manufacturing, trading, warehousing, cargo collection, ground transportation, booking, packaging, air transportation and distribution. Relevant government departments are the important foundation for ensuring the safety of cross-border aviation logistics and promoting the efficient operation of cross-border aviation logistics. In addition, service providers provide visualization services of logistics information, order information, and payment information to further enhance the efficiency and service level of cross-border air logistics.

2.2.2 Space structure

The spatial structure of cross-border air logistics system is a regular distribution of system elements gathered around the airport in order to realize the efficient operation of the system. Spatially, it can be categorized into internal space structure and external space structure.

The internal spatial structure mainly consists of logistics hub facilities and route networks. First, logistics hub facilities are the core component of the internal space structure, including air cargo terminals, express cargo centers and other logistics facilities. With the airport as the core, these facilities facilitate the loading, unloading, distribution and transshipment of cargo. The air cargo terminal serves as a distribution center for cargo and is responsible for operations such as cargo sorting, loading and unloading; while the express cargo center specializes in handling the sorting and packing of express parcels. The rational layout and efficient operation of these logistics facilities is an important guarantee for realizing the efficient operation of cross-border air logistics system. Secondly, the route network is another important component of the internal spatial structure, referring to the layout of the route network between domestic and foreign airports. The route network connects various airports, forming a complex and organic network system. These air routes not only connect different cities and countries, but also connect different logistics hub facilities, realizing the rapid transportation and circulation of goods. Through the route network, goods can be quickly transported from the place of production to the place of consumption, realizing the flow and exchange of goods on a global scale. Together, these components form the internal spatial structure of the cross-border air logistics system, providing a solid foundation for the efficient operation of the system.

The external space structure is another important component of cross-border air logistics system, which mainly includes cross-border logistics service facilities and supply chain extension service facilities. Cross-border logistics service facilities include customs supervisory warehouses, bonded logistics centers, logistics processing centers, express centers, distribution centers, living service areas and so on. These facilities play a key role in the cross-border logistics process. Customs supervised warehouses provide supervision and inspection functions for goods to ensure that they comply with international trade regulations and standards; bonded logistics centers provide convenient bonded services for imported and exported goods and reduce the cost of cross-border trade; logistics processing centers are responsible for value-added services such as processing and assembling of goods to increase the added value of the goods; courier centers and distribution centers are responsible for the last-mile distribution of the goods to ensure that the goods can be The express center and distribution center are responsible for the last-mile distribution of goods to ensure that the goods can be delivered to the destination on time; and the living service area provides life protection for logistics employees and meets their daily needs. Nodal facilities for supply chain extension services include exhibition and sales centers, business convention and exhibition centers, management office centers, etc. These facilities provide a platform for supply chain extension. These facilities provide important support for the extension of the supply chain. The exhibition center provides a platform for enterprises to display and promote their products, which promotes cross-border trade docking and cooperation; the business exhibition center organizes various international trade exhibitions and conferences, which promotes exchanges and cooperation in cross-border logistics business; and the management office center provides office and management services for enterprises, which improves the management efficiency of cross-border logistics business.

2.2.3 Time structure

The time structure of cross-border aviation logistics system refers to the state in which each service link is

connected according to the sequence, which is the product of a high degree of synergy of system elements. The time structure of cross-border aviation logistics system is relatively complex, involving a large number of subjects and diverse modes. With the current cross-border e-commerce and international trade demanding more and more timeliness in logistics, the articulation problem in time structure is the focus of cross-border air logistics system optimization. Therefore, in order to further improve the efficiency of the cross-border aviation logistics system and enhance its service capacity. From the perspective of the system, the overthrow and reconstruction of the cross-border air logistics system by merging the main bodies of related functions is an important breakthrough for the efficiency of the cross-border air logistics system to be improved by leaps and bounds.

2.3 Four-dimensional conceptual model design of cross-border air logistics system

According to the analysis of the components and structure of cross-border air logistics system, with reference to Hall's three-dimensional structure theory, the three dimensions of the cross-border air logistics system, namely, the executive layer, the management layer, and the decision-making layer, are summarized based on the cross-border air logistics operation, cross-border air logistics management, as well as the cross-border air logistics planning and planning decision-making. In addition, cross-border air logistics system is an open system, which is subordinate to the economic system, or even a branch of the overall logistics system, and it exchanges material, information, and energy with other systems. Therefore, on the basis of the three-dimensional structure, the fourth dimension of cross-border air logistics system is constructed according to the momentum space theory - the system dimension (both momentum dimension), as shown in Fig.

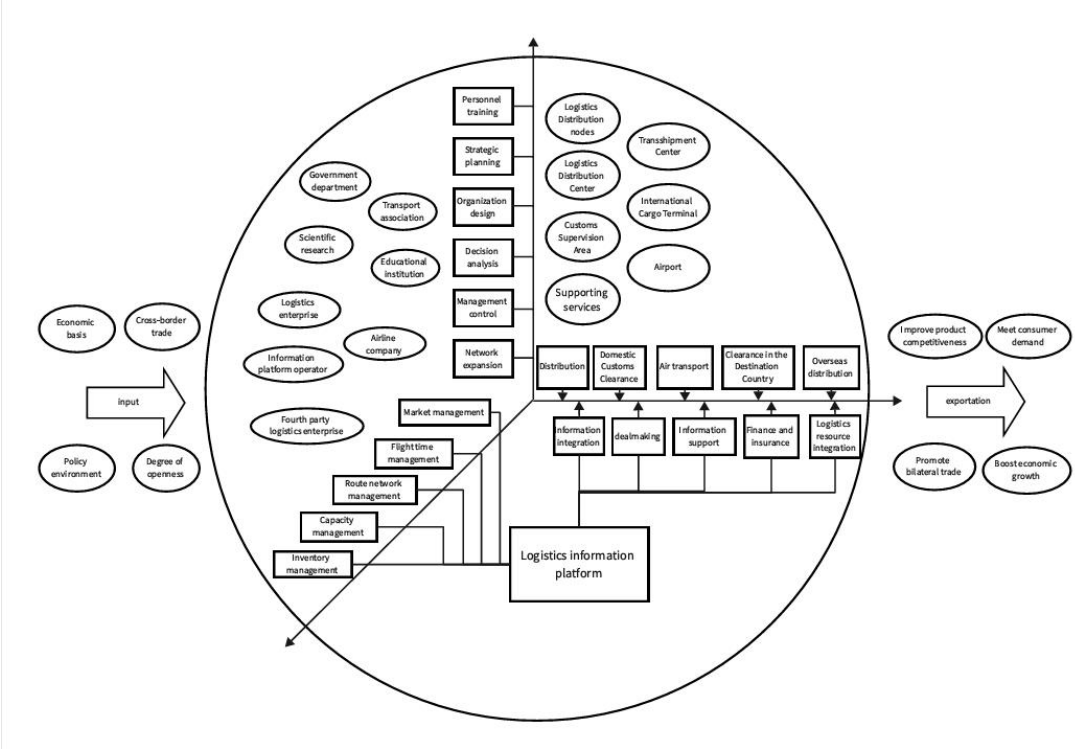

Figure 3-1 Four-dimensional conceptual model of cross-border air logistics system

In order to better understand the multidimensional role model of the cross-border air logistics system, this section will further elaborate the role played by each dimension in the system. Among them, the system dimension serves as the fourth dimension, and the other three dimensions can be regarded as the three

components of the system dimension. According to the momentum space theory, the input momentum of the system dimension will affect the energy of the other three sub-dimensions, while the other three dimensions together constitute the conversion carrier, which determines the output momentum of the system dimension; the decision-making dimension can be compared with the brain of the cross-border aviation logistics system, which, by keenly perceiving the changes of the market elements and the environment The decision-making dimension can be compared to the brain of the cross-border air logistics system, which, by keenly sensing the changes of market elements and environment, starts from the perspective of macro strategy and directly acts on the subjects involved in the management dimension through administrative, economic and legal means, thus further influencing the business process of the execution dimension. For example, government departments help the operating body of the logistics information platform to continuously improve the logistics information platform as well as promote the promotion and application of the logistics information platform in the cross-border logistics field through the issuance of financial policies and tax policies, which prompts the reconstruction of cross-border aviation logistics business processes; the management dimension can be compared to the nervous system of the human body, just as the nervous system is responsible for transmitting the instructions from the brain to all parts of the body, the management dimension ensures that the The strategies and plans developed by the Decision Dimension are effectively communicated to all departments and teams in the organization. It monitors the operation of the organization to ensure that all activities are carried out in accordance with the established plans and standards, and is also responsible for coordinating and adjusting resources to optimize the allocation of resources and improve efficiency to maximize benefits as far as possible under the premise of coping with market risks, ensuring market competitiveness, and adapting to changes in the market; the execution dimension plays a crucial role in the cross-border air logistics system, which can be compared to the human body's muscle system. Just as the muscle according to the mobilization of the nervous system to perform the same action, the executive dimension of the management dimension of the strategy and plan into specific actions and operations. It is the core of the activity process of the logistics system, covering every practical aspect from the reception, handling, transportation to the final delivery of goods, and is the final point of optimization of cross-border aviation logistics system. In terms of the overall role of the four-dimensional conceptual model, the overall optimization of the four dimensions of the model is the condition to ensure the reasonable operation of the cross-border aviation logistics system. It can be seen that by constructing the four-dimensional conceptual model of cross-border air logistics system, not only can we make full use of the system engineering theory as a cross-border air logistics system analysis tool to better explain the structure, function and operation mode of the cross-border air logistics system, but also through the creation of core node capacity in each dimension, we can carry out innovative design and optimization of the cross-border air logistics system construction scheme.

In the four-dimensional conceptual model of cross-border air logistics system, the execution dimension is the final landing point of the system, which maps the whole process of cargo from sender to consignee. Under the micro perspective, the process can be divided into logistics operations and value-added logistics services. It includes air logistics services such as consolidation, ground transportation, booking, packaging, air transportation, etc., and value-added logistics services such as information integration, transaction aggregation, logistics informationization support, finance and insurance, and logistics resource integration. The management dimension is the actual controller and operator of cross-border aviation logistics resources, and each subject in the management dimension seeks to maximize economic benefits by fully integrating existing logistics facilities and resources, participating in cross-border logistics operations as

much as possible in a fully competitive market environment, and providing corresponding facilities resources and service support for cross-border aviation logistics operations. Common management tools include logistics information platform management, capacity management, cargo terminal management and distribution management. Decision-making dimension is responsible for quickly responding to changes in the external environment, formulating global strategic planning and decision-making analysis, which is the key to ensure the efficient, flexible and sustainable development of cross-border aviation logistics system. As the fourth dimension, the system dimension interacts with the external environment through the mechanism of "input + conversion + output". Among them, "input" refers to the factors affecting cross-border air logistics, including economic base, cross-border trade, policy environment, degree of openness, etc. The transformation vector includes cross-border logistics-related factors. The conversion carriers include cross-border logistics-related infrastructure, many subjects in the cross-border air logistics chain and the logistics information platform linking each subject and each link. The "output" is the effect of the system on the external environment, including improving enterprise competitiveness, meeting consumer demand, boosting bilateral trade, and driving regional economic growth. These dimensions together constitute the operational framework of the cross-border air logistics system, which guarantees that goods can be circulated and exchanged smoothly and efficiently within the system.

The four-dimensional conceptual model of cross-border aviation logistics system systematically depicts the cross-border aviation logistics system from four different perspectives, in which the system dimension is the macroscopic perspective, the decision-making and management dimensions are the mesoscopic perspectives, and the execution dimension is the microscopic perspective. To build a complete cross-border air logistics system and make it operate efficiently, complete system elements and system structure are the foundation, scientific decision-making planning and advanced management methods are important means, and efficient operation process execution is the key.

4.4 Conclusion

This paper comprehensively analyzes the basic elements of cross-border air logistics system, including general elements such as human flow, logistics, capital flow and information flow, and functional elements such as transportation, storage and packaging. At the same time, supporting elements such as system regulations and material base elements such as facilities and equipment and information system are also considered. Further, this paper analyzes the structure of cross-border air logistics system from multiple dimensions, including temporal structure, spatial structure and cohesive structure, projecting the whole picture of cross-border air logistics system in a multi-faceted and three-dimensional way. Based on the above, this paper combines the theory of Hall's three-dimensional structural model to construct a four-dimensional conceptual model of cross-border air logistics system, which covers the four dimensions of execution, management, decision-making, and system dimension, and comprehensively depicts the intrinsic connection and operation logic of the cross-border air logistics system from the macro-, meso-, and microscopic perspectives, deepening the understanding of the overall picture of the cross-border air logistics system and its operation mechanism, and laying the foundation for the construction of the cross-border air logistics system. system.

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