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Research on the Influencing Factors of Air Logistics Supply Chain Toughness Based on DEMATEL-ISM Modeling

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Abstract

As a key link in the global supply chain, the aviation logistics supply chain is of great significance in protecting the security and development of China's supply chain, and in promoting the economy of air cargo and civil aviation. In recent years, the aviation logistics industry has been driven by both technological innovation and market demand, and has both opportunities and challenges. In order to make the aviation logistics supply chain more resilient when encountering risks and shocks, this paper constructs a set of factors influencing the resilience of aviation logistics supply chain, adopts the DEMATEL-ISM model, analyzes the causality and hierarchical structure between the resilience influencing factors, and puts forward the strategic suggestions to maintain the resilience of aviation logistics supply chain with respect to the important influencing factors, so as to enrich the related research in the field of resilience of aviation logistics supply chain.

Keywords: aviation logistics supply chain; aviation logistics supply chain resilience influencing factors; aviation logistics supply chain resilience

0 Introduction

With the deepening of globalization, competition among countries has become more intense, and countries are paying more attention to the resilience and security level of the industrial chain and supply chain. Modern logistics connects production and consumption, highly integrates and fuses transportation, warehousing, distribution, delivery, information and other service functions, and can provide support for industrial chain and supply chain security.[1] Airline Logistics As a kind of modern logistics industry,

aviation logistics has more advantages in guaranteeing the security of high value-added industrial chain and supply chain. The "14th Five-Year" Civil Aviation Development Plan proposes to build an efficient aviation logistics network, construct an aviation logistics supply chain system, strengthen the coordination of the logistics supply chain, and construct an aviation logistics service system with the synergistic development of the industrial chain, supply chain and value chain. In recent years, the academic research on aviation logistics supply chain has been increasing, which provides a theoretical basis for this paper to study aviation logistics supply chain, but the current research on aviation logistics supply chain mainly centers on the service nature of aviation logistics supply chain.[2] The research on aviation logistics supply chain is mainly centered on the service nature of aviation logistics supply chain, Problems of aviation logistics supply chain[3] and development strategy[4] and aviation logistics supply chain management[5] etc. There are fewer relevant studies on the resilience of aviation logistics supply chain. China's aviation logistics supply chain is still in the stage of continuous development, in the process of development may be due to changes in the internal and external links of the supply chain and impact, and the aviation logistics supply chain needs to have a certain degree of resilience and risk prevention ability if it wants to develop continuously, so it is necessary to carry out a study on the factors affecting the resilience of the aviation logistics supply chain.

Therefore, this paper will judge that a resilient aviation logistics supply chain should have the ability to respond, resist, recover, and learn, and sort out the influencing factors of the resilience of aviation logistics supply chain around the four capabilities and five dimensions of the external environment of the supply chain, and combine the DEMATEL method with the ISM model to construct the DEMATEL-ISM model, and analyze the causal relationship and hierarchical structure of the factors affecting the resilience of the aviation logistics supply chain. The DEMATEL-ISM model is constructed to analyze the causal relationship and hierarchical structure between the factors affecting the toughness of aviation logistics, and to provide reference for the enhancement of the toughness of China's aviation logistics supply chain and risk prevention.

1 Air Logistics Supply Chain Resilience Analysis

1.1 Air Logistics Supply Chain Concept

Aviation logistics industry as a composite service industry integrating transportation, warehousing,

freight forwarding, information and other industries, with service attributes, China's scholars Hu Wei believes that the aviation logistics supply chain should be a complete logistics service chain starting from the route planning to the cargo organization, entry and exit, air transportation, storage and ground transportation.[6] Hu Wei believes that aviation logistics supply chain should be a complete logistics service chain starting from route planning to cargo organization, immigration, air transportation, storage and ground transportation. Considering the transportation and service attributes of aviation logistics supply chain comprehensively, this paper considers that aviation logistics supply chain is a chain formed by all the parts involved in logistics activities in the economic activities undertaken by aviation logistics transportation within the timeframe from the beginning of product, service market and demand to the end of meeting the demand.

The aviation logistics supply chain mainly includes cargo suppliers, freight forwarders, ground transportation enterprises, airports, cargo terminals, airlines, cargo demanders and other main bodies. In the aviation logistics supply chain, the demand is mainly generated by the customer to demand-oriented drive chain for the circulation of goods, goods suppliers according to the demand for delivery, freight forwarding enterprises to undertake transportation services, and hand over the goods to the ground transportation enterprises through airports, cargo terminals, airlines, and other different subjects, through the ground transport - air transport - ground transport air-ground transport intermodal transport process, and finally transported to the hands of the demand for goods to achieve the process of delivery and matching the supply and demand of goods. Delivery and supply and demand matching process. Aviation logistics supply chain is not only a service chain of cargo transportation, but also a chain of information transmission through cargo suppliers, freight forwarders, ground transportation enterprises, airports, cargo terminals, airlines and cargo demanders. The operational structure of the aviation logistics supply chain is shown in Figure 1.

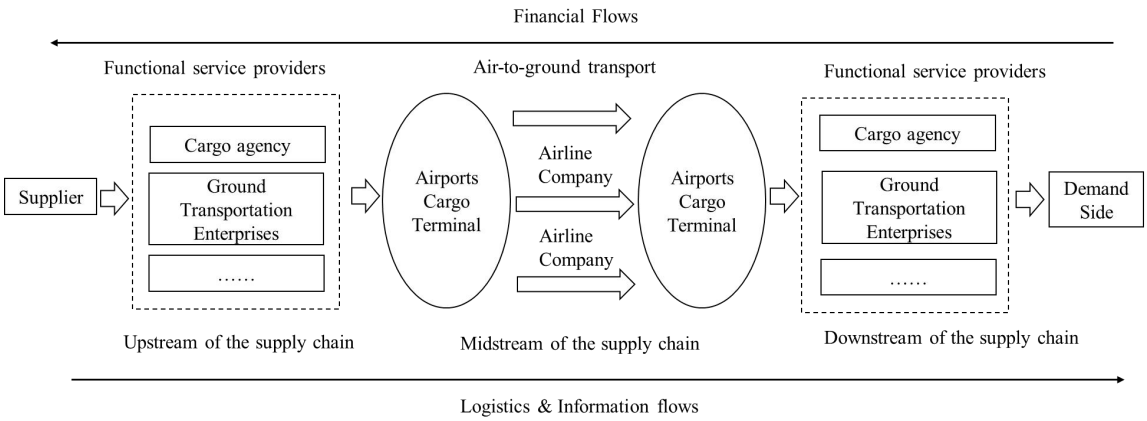

Figure 1 Air logistics supply chain operation structure

1.2 Air logistics supply chain resilience

Resilience began as an engineering concept and has been widely used in ecology, architecture, economics and other disciplines. The concept of "supply chain resilience" was first proposed in 2003, and then Christopher defined supply chain resilience as the ability of a supply chain to return to its original or more desirable state after a disruption.[7] The concept of "supply chain resilience" was first proposed in 2003. With the continuous development of supply chain resilience theory, scholars at home and abroad take supply chain disruption as a node and subdivide the definition of supply chain resilience into before supply chain disruption, during supply chain disruption and after supply chain disruption. Before supply chain disruption, resilience is mainly manifested as the ability that is crucial for the sustainable development of supply chain resilience, including the ability to react to what happens before it happens.[8] This includes the ability to react to what happens before it happens. During a supply chain disruption, resilience is primarily characterized by the ability to be alert, adaptive, and responsive to changes brought about by a supply chain disruption in an unstable environment.[9] Resilience in Supply Chain Disruptions After a supply chain disruption, resilience is mainly manifested in the supply chain's ability to resist, recover and survive after being impacted.[10] Resilience

Considering the dynamic nature of the aviation logistics supply chain industry, the resilience of the aviation logistics supply chain is defined as the ability of the aviation logistics supply chain to respond effectively in the face of a variety of risks, the ability to resist shocks, and the ability to recover and learn from the disruptions in the aviation logistics supply chain by adapting quickly and returning to the original state or to a better state.

1.3 Identification of Factors Influencing Resilience in the Air

Logistics Supply Chain

Considering that the resilience of the aviation logistics supply chain is not only related to the internal capacity of the supply chain, but also affected by the external environment of the supply chain, the measurement of the resilience of the aviation logistics supply chain in this paper mainly centers on the five dimensions of responsiveness, resilience, recovery, learning ability and the external environment of the supply chain.

Through the literature analysis method, with "aviation logistics supply chain", "logistics supply chain resilience", "Aviation logistics supply chain" and "Logistics supply chain resilience" as the theme, we searched in China Knowledge Network, web of Science and other databases, and analyzed 34 articles after screening. "Logistics supply chain resilience" as the theme in the China Knowledge Network, web of Science and other databases for searching, screening and analyzing 34 pieces of related literature, through the summarization of the 17 aviation logistics supply chain resilience of the main factors affecting Aviation logistics supply chain resilience factor set See Table 1.

Table 1 Air logistics supply chain resilience factor set

Level 1 indicators	Secondary indicators	hidden meaning
responsiveness (A)	Degree of information sharing in the aviation logistics supply chain (A1)	Information Sharing System Construction and Information Communication Efficiency of Various Links in the Aviation Logistics Supply Chain
	Nodal enterprise communication and collaboration mechanisms (A2)	Degree of collaboration and communication mechanisms among node enterprises in the supply chain in the flow of information and goods
	Market responsiveness of supply chain node enterprises (A3)	Ability of companies in the aviation logistics supply chain to provide timely feedback when exposed to risk
	Resource integration capacity of freight forwarding enterprises (A4)	The degree of integration and utilization of cargo resources, transportation resources, agency resources and human resources in the transportation process of freight forwarding enterprises
	Strength of control of logistics processes in shipping companies (A5)	Tracking of cargo information and security of transportation by shipping companies during transportation
resistance (B)	Air cargo volume (B1)	Civil air cargo and mail traffic
	Level of national economic	Combining the value of a country's GDP,

	development (B2)	foreign trade volume and disposable income per capita of the population
	Cargo infrastructure development at large hub airports (B3)	Cargo area at hub airports
	Construction of air-land intermodal transit facilities (B4)	Composition of facilities and equipment in the air-land transportation interface area and the degree of compliance with basic national requirements and requirements for the configuration of facilities and equipment
resilience (C)	Number of routes (C1)	Number of cargo routes
	Number of all-cargo aircraft (C2)	Number of all-cargo aircraft
	Investment in civil aviation fixed assets (C3)	Civil Aviation Authority's annual funding for capital and technological transformation investments
	Degree of standardization of air logistics transport (C4)	Degree of transportation standardization and warehousing standardization in the process of air logistics transportation
learning ability (D)	Degree of automation of equipment (D1)	Automation technology for operational use during transportation
	Extent of digital technology use (D2)	Use of new technologies in the transportation process by shipping companies, freight forwarders and ground transportation enterprises
external environment (E)	Doing business (E1)	Business Environment and Government Support for Air Logistics Supply Chain Development
	Number of air logistics supply chain policies (E2)	National or local governments introduce policies to support the development of the aviation logistics supply chain

2 DEMATEL-ISM model

2.1 Model fundamentals

The DEMATEL-ISM model is an integrated approach that combines the Decision Laboratory Approach (DEMATEL) with the Interpretive Structural Modeling (ISM) approach. Among them, the DEMATEL model was initially proposed by scholars A. Gabus and E. Fontela of the Battelle Institute in Geneva, Switzerland. The DEMATEL method, as a systematic analytical method, identifies the set of influencing factors of the research object, and then determines the influencing matrix, and after the

normalization of the influencing matrix and the calculation of influencing relationship factors, it ultimately results in the degree of influencing, being influenced, centered, and cause between the influencing factors ISM model is proposed by Prof. Warfiel, as a widely used system analysis method, based on treating the influencing factors of the research object as a big system, ISM model judges the correlation of each influencing factor, splits and combines the influencing factors, and gradually analyzes the hierarchical relationship between each influencing factor. DEMATEL method and ISM model, both through the analysis of the relationship between the influencing factors and matrix operations to arrive at the final results, have certain similarities, so the combination of the two methods to carry out the study of the resilience of the aviation logistics supply chain factors.

2.2 DEMATEL-ISM model construction

Construct DEMATEL-ISM model, mainly in the construction of the integrated impact matrix after the integration of the two methods, the use of DEMATEL method for the causal relationship analysis of the impact factors, and the integrated impact matrix unitization processing to calculate the overall impact matrix, combined with the ISM method of hierarchical structural analysis, DEMATEL-ISM model construction process is shown in Figure 2.

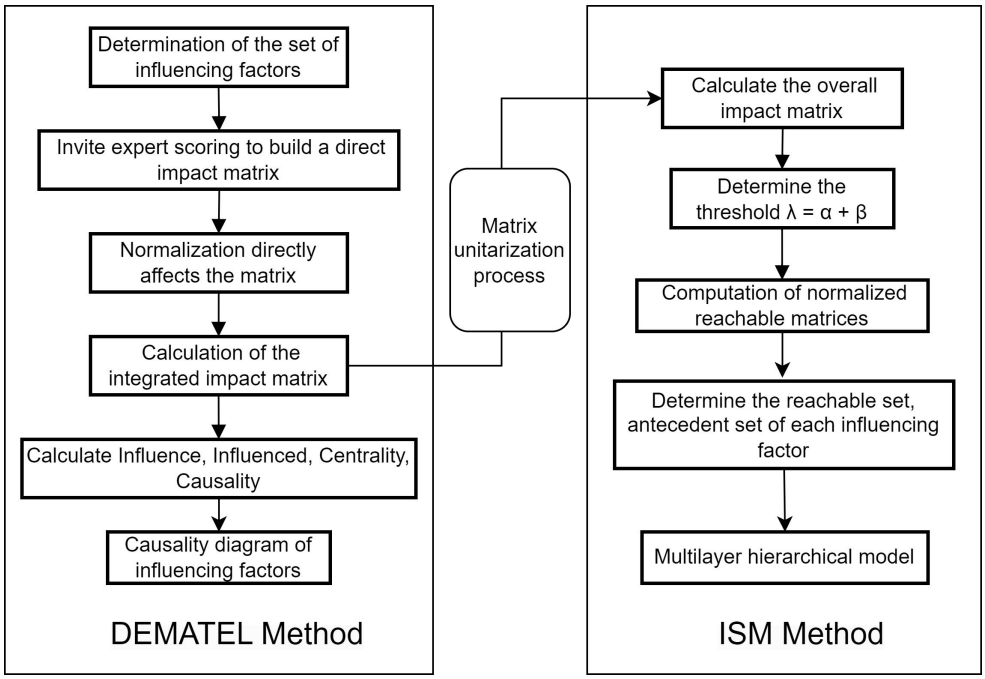

Fig. 2 Flowchart of the DEMATEL-ISM model

3 Measurement of the correlation of factors affecting the resilience of the aviation logistics supply chain

3.1 Calculation of the importance of factors influencing the resilience of the air logistics supply chain

After understanding the operating principle of the DEMATEL-ISM model, the factors affecting the resilience of the aviation logistics supply chain are numbered, and then a total of 10 experts and experienced practitioners in the field of aviation logistics supply chain are invited to score the role of the relationship between the factors using the Delphi method, and the scoring method adopts the 0-4 point system (in which the scores indicate respectively: 0 no impact, 1 low impact, 2 medium impact , 3 high impact, 4 very high impact), to get the direct matrix of factors affecting the resilience of the aviation logistics supply chain, as shown in Table 2.

Table 2 Direct impact matrix of factors influencing resilience in the aviation logistics supply chain

	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	E1	E2
A1	0	3	3	3	3	1	0	0	1	0	0	0	2	3	3	1	1
A2	3	0	3	3	3	1	0	0	0	0	0	0	3	1	1	0	0
A3	3	3	0	2	3	1	1	0	0	0	0	0	2	1	0	1	0
A4	3	3	2	0	2	4	1	1	1	2	2	0	3	1	1	1	0
A5	3	3	2	2	0	2	1	1	1	3	2	0	3	1	1	1	0
B1	1	1	1	3	3	0	2	2	2	3	4	1	2	2	2	1	2
B2	0	0	0	0	0	2	0	2	2	0	1	3	0	0	0	0	0
B3	0	0	0	1	1	2	0	0	2	0	1	0	0	1	1	0	0
B4	0	0	0	0	0	2	0	2	0	0	0	0	1	1	1	0	0
C1	0	0	0	0	2	3	1	0	0	0	1	0	0	0	0	0	1
C2	0	0	0	0	0	4	2	2	2	2	0	2	1	1	1	0	0
C3	0	0	0	0	0	2	0	3	3	0	1	0	0	0	0	1	0
C4	2	2	2	1	1	1	0	0	0	0	0	0	0	1	1	0	0
D1	1	0	1	2	2	2	0	1	1	0	0	0	2	0	2	0	0
D2	3	0	1	2	2	2	0	1	1	0	0	0	2	3	0	0	0
E1	2	2	1	0	0	2	0	0	0	0	0	1	2	0	0	0	3
E2	0	0	0	0	0	1	0	1	1	1	0	2	0	0	0	3	0

The direct impact matrix of factors affecting the toughness of the aviation logistics supply chain is normalized, and on the basis of the normalization, the comprehensive impact matrix of factors affecting the toughness of the aviation logistics supply chain is calculated, as shown in Table 3.

Table 3 Comprehensive impact matrix of factors influencing resilience in the aviation logistics supply chain

	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	E1	E2
A1	0.10	0.17	0.17	0.18	0.19	0.13	0.03	0.04	0.07	0.04	0.04	0.01	0.16	0.16	0.15	0.06	0.05
A2	0.17	0.08	0.16	0.17	0.17	0.11	0.03	0.03	0.04	0.04	0.04	0.01	0.18	0.09	0.08	0.03	0.02
A3	0.16	0.16	0.07	0.13	0.16	0.10	0.05	0.03	0.03	0.04	0.04	0.01	0.14	0.08	0.05	0.05	0.02
A4	0.18	0.17	0.14	0.09	0.16	0.23	0.07	0.08	0.09	0.11	0.12	0.02	0.19	0.10	0.10	0.06	0.03
A5	0.18	0.17	0.13	0.14	0.10	0.16	0.06	0.07	0.08	0.13	0.11	0.02	0.18	0.10	0.09	0.06	0.03
B1	0.12	0.10	0.10	0.17	0.18	0.13	0.10	0.12	0.13	0.15	0.18	0.06	0.16	0.13	0.12	0.06	0.08
B2	0.01	0.01	0.01	0.02	0.02	0.10	0.01	0.09	0.09	0.02	0.05	0.10	0.02	0.02	0.02	0.01	0.01
B3	0.03	0.02	0.02	0.06	0.06	0.10	0.01	0.02	0.08	0.02	0.05	0.01	0.03	0.06	0.05	0.01	0.01
B4	0.02	0.01	0.02	0.02	0.03	0.09	0.01	0.08	0.02	0.01	0.02	0.01	0.05	0.05	0.05	0.01	0.01
C1	0.02	0.02	0.02	0.03	0.09	0.13	0.05	0.02	0.02	0.03	0.06	0.02	0.03	0.02	0.02	0.01	0.04
C2	0.03	0.02	0.03	0.04	0.05	0.18	0.08	0.10	0.10	0.09	0.04	0.08	0.07	0.07	0.06	0.01	0.02
C3	0.02	0.01	0.01	0.02	0.02	0.10	0.01	0.11	0.12	0.02	0.05	0.01	0.02	0.02	0.02	0.04	0.01
C4	0.11	0.11	0.10	0.08	0.09	0.08	0.02	0.02	0.02	0.02	0.02	0.01	0.05	0.07	0.06	0.02	0.01
D1	0.09	0.05	0.07	0.11	0.12	0.12	0.02	0.06	0.06	0.03	0.03	0.01	0.12	0.04	0.10	0.02	0.01
D2	0.15	0.06	0.09	0.13	0.13	0.13	0.02	0.06	0.07	0.04	0.04	0.01	0.13	0.14	0.05	0.02	0.02
E1	0.10	0.10	0.07	0.04	0.05	0.10	0.01	0.02	0.03	0.02	0.02	0.04	0.10	0.03	0.03	0.02	0.11
E2	0.02	0.01	0.01	0.01	0.02	0.06	0.01	0.05	0.05	0.04	0.01	0.07	0.02	0.01	0.01	0.10	0.02

By calculating the degree of influence and the degree of being influenced by the factors influencing the resilience of the aviation logistics supply chain from the comprehensive influence matrix, the degree of centrality and the degree of cause of the influencing factors can be calculated, as shown in Table 4.

Table 4 Centrality and Causality of Factors Influencing Resilience of Air Logistics Supply Chain

Factor	Degree of influence	Fegree of influence	Centrality	Degree of causality
A1	1.76	1.52	3.28	0.24
A2	1.43	1.28	2.71	0.14
A3	1.32	1.21	2.53	0.11
A4	1.95	1.45	3.40	0.49
A5	1.81	1.62	3.44	0.19
B1	2.08	2.05	4.13	0.03
B2	0.61	0.60	1.20	0.01
B3	0.67	1.02	1.69	-0.35
B4	0.49	1.09	1.59	-0.60
C1	0.63	0.85	1.48	-0.22
C2	1.08	0.92	2.00	0.16
C3	0.61	0.51	1.12	0.11
C4	0.88	1.67	2.55	-0.78
D1	1.07	1.19	2.26	-0.12
D2	1.29	1.07	2.36	0.23
E1	0.90	0.59	1.49	0.31
E2	0.52	0.48	1.00	0.05

3.2 Hierarchical Calculation of Factors Influencing Resilience of Air

Logistics Supply Chain

On the basis of calculating the comprehensive impact matrix of factors affecting the toughness of aviation logistics supply chain and combining with ISM method, the overall impact matrix and reachability matrix of the toughness of aviation logistics supply chain are calculated. And according to the reachability matrix, we find the reachable set, prior set and intersection set between the factors affecting the toughness of aviation logistics supply chain in order, see Table 5.

Table 5 Hierarchy of factors influencing resilience in the aviation logistics supply chain

	Accessible set (math.)	Antecedent (logic)	Intersection (symbol ∩) (set theory)
A1	[1, 2, 3, 4, 5, 6, 13, 14, 15]	[1, 2, 3, 4, 5, 15]	[1, 2, 3, 4, 5, 15]
A2	[1, 2, 3, 4, 5, 13]	[1, 2, 3, 4, 5]	[1, 2, 3, 4, 5]
A3	[1, 2, 3, 4, 5, 13]	[1, 2, 3, 4, 5]	[1, 2, 3, 4, 5]
A4	[1, 2, 3, 4, 5, 6, 13]	[1, 2, 3, 4, 5, 6, 15]	[1, 2, 3, 4, 5, 6]
A5	[1, 2, 3, 4, 5, 6, 10, 13]	[1, 2, 3, 4, 5, 6, 14, 15]	[1, 2, 3, 4, 5, 6]
B1	[4, 5, 6, 8, 9, 10, 11, 13, 14, 15]	[1, 4, 5, 6, 10, 11, 14, 15]	[4, 5, 6, 10, 11, 14, 15]
B2	[7]	[7]	[7]
B3	[8]	[6, 8]	[8]
B4	[9]	[6, 9]	[9]
C1	[6, 10]	[5, 6, 10]	[6, 10]
C2	[6, 11]	[6, 11]	[6, 11]
C3	[12]	[12]	[12]
C4	[13]	[1, 2, 3, 4, 5, 6, 13, 14, 15]	[13]
D1	[5, 6, 13, 14]	[1, 6, 14, 15]	[6, 14]
D2	[1, 4, 5, 6, 13, 14, 15]	[1, 6, 15]	[1, 6, 15]
E1	[16]	[16]	[16]
E2	[17]	[17]	[17]

After obtaining the interrelationship between the factors influencing the resilience of the aviation logistics supply chain, the hierarchy of the influencing factors is divided, and the specific hierarchical structure is shown in Table 6 below.

Table 6 Hierarchy of factors influencing resilience in the aviation logistics supply chain

Level	Set of elements
first layer	b2, b3, b4, c1, c2, c3, c4, e1, e2
second layer	A2, A3, A4, A5, B1
third floor	D1
fourth floor	A1, D2

3.3 Comprehensive Analysis of Factors Influencing Resilience in the Air Logistics Supply Chain

3.3.1 Analysis of the significance of influencing factors

According to the calculation of center are and cause degree above, the cause and effect diagram between the influencing factors of aviation logistics supply chain resilience is derived, and the cause and effect factors between the influencing factors are observed more intuitively, see Figure 3.

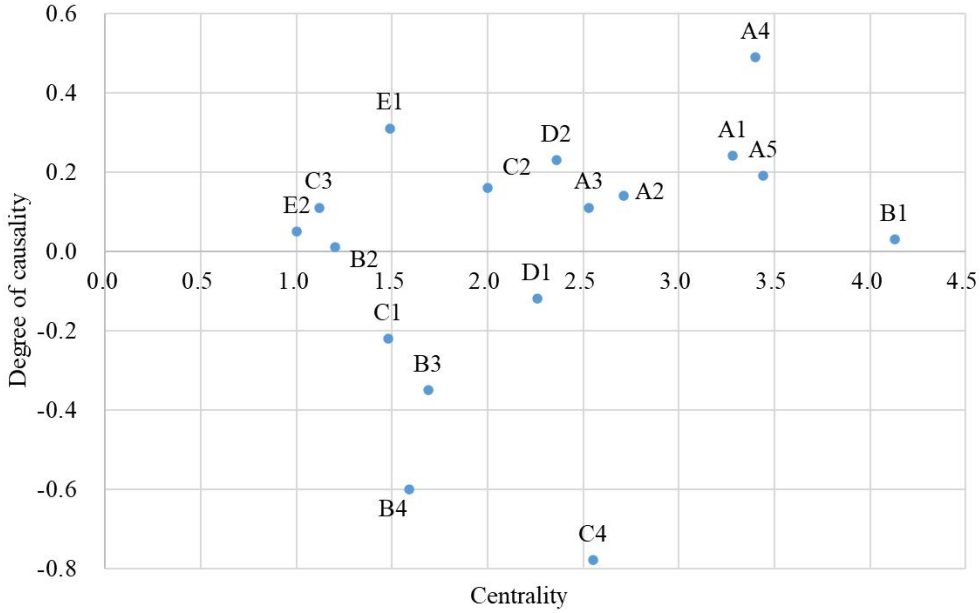

Fig. 3 Causal diagram of air logistics supply chain resilience influencing factor loading

According to the above air logistics supply chain toughness influencing factors center degree and cause degree measurement and causality diagram, the cause degree of each factor of air logistics supply chain toughness is analyzed to classify the cause factors and result factors of air logistics supply chain toughness. Taking 0 as the boundary, the cause degree greater than 0 is the cause factor, including resource integration ability of freight forwarding enterprises, business environment, the degree of information sharing in the aviation logistics supply chain, the degree of use of digital technology, the strength of control of the logistics process of the airline company, the number of all-cargo planes, the mechanism of communication and collaboration of the node enterprises, the market responsiveness of the node enterprises of the supply chain, the amount of investment in civil aviation fixed assets, the number of policies of the aviation logistics supply chain, the volume of air cargo , the level of national economic development etc. Cause factors are the key factors affecting the resilience of the aviation logistics supply chain and have an impact on the result factors. Factors with cause degree less than 0 are result factors, including the degree of equipment automation, the number of air routes, the construction of cargo infrastructure in large hub airports, the construction of air-land intermodal transfer facilities, and the degree of standardization of air logistics transportation. With the improvement of national economic

development level, China's demand for air logistics transportation will increase and the number of all-cargo planes in recent years has been a year-on-year growth trend, the demand for air cargo transportation capacity is getting higher and higher, including the requirements for the freight forwarder's cargo consolidation capacity and cargo information collection capacity in the process of ground transportation of goods to enhance the requirements for the air transportation process responsible for the transportation of goods by air company on the interline transfer of goods and air transportation control capacity and cargo tracking capacity, and the ability to control and track cargo, and the ability to control and track cargo. In the process of air transportation, the carrier in charge of cargo transportation has the ability to control and track the cargo, as well as the communication and cooperation mechanism and information sharing ability of each node enterprise in the supply chain. In addition, a favorable business environment, relevant policies and increased investment in civil aviation infrastructure can also provide impetus for the development of the aviation logistics supply chain. The use of digital technology in the aviation logistics supply chain and the improvement of science and technology level will also promote the automation degree of aviation logistics supply chain equipment.

After sorting the centrality of each factor of aviation logistics supply chain toughness, it can be concluded that the air cargo volume, the control strength of the logistics process of the airline division, the resource integration capability of freight forwarding enterprises, the degree of information sharing in the aviation logistics supply chain, communication and collaboration mechanism of node enterprises, and the degree of standardization of aviation logistics and transportation are the influencing factors of high importance, and in the operation of aviation logistics supply chain process, the adjustment and enhancement of the cause factors can better improve the supply chain resilience. In the process of aviation logistics supply chain operation, the adjustment and enhancement of the cause factors can better improve the toughness of the supply chain.

3.3.2 Correlation analysis of influencing factors

After dividing the 17 factors affecting the toughness of the aviation logistics supply chain into four levels, we further constructed a multilevel hierarchical structure model of the factors affecting the toughness of the aviation logistics supply chain. Due to the existence of different influencing factors with different degrees of influence and complex causal relationships, and even the existence of cross-level interactions, this paper only retains the interactions between levels, in order to present the role of the

influencing factors at each level more clearly. The recursive hierarchical model of aviation logistics supply chain resilience influencing factors is shown in Figure 4.

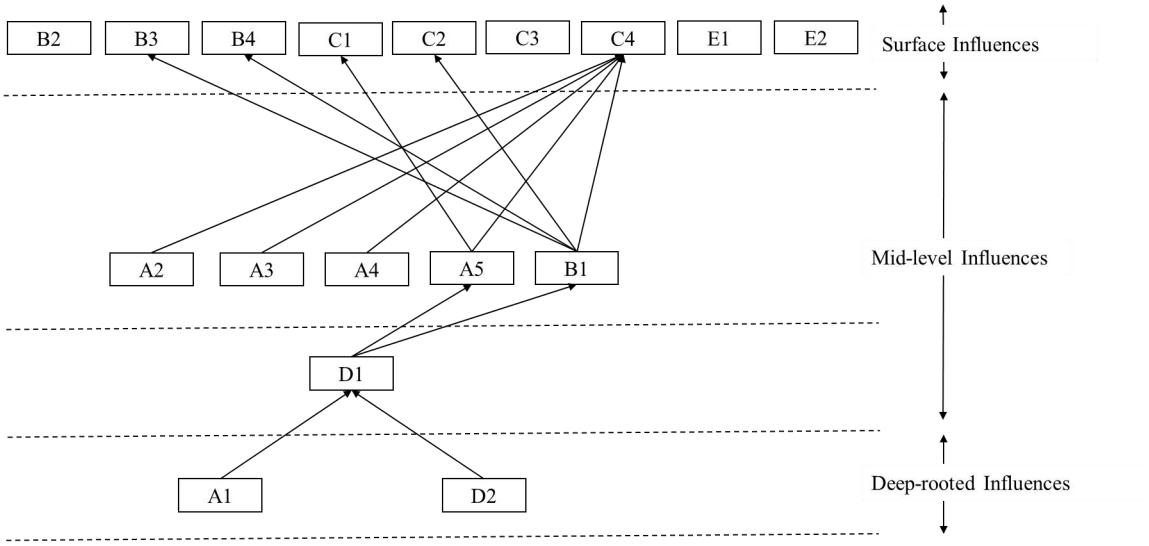

Fig. 4 Recursive hierarchical model of factors influencing the resilience of the aviation logistics supply chain

(1) Surface Influences

Dividing the first layer into superficial factors, the superficial influencing factors mainly include: the level of national economic development, the construction of cargo infrastructure in large hub airports, the construction of air-land intermodal transfer facilities, the number of air routes, the number of all-cargo planes, the amount of investment in civil aviation fixed assets, the degree of standardization of air logistics and transportation, the business environment, and the number of policies in the air logistics supply chain. These factors can be influenced by indirect factors in the middle layer and constrained by fundamental factors in the bottom layer.

(2) Deep-rooted Influences

The second and third layers are divided into mid-level factors, mainly including: node enterprise communication and collaboration mechanism, supply chain node enterprise market responsiveness, freight forwarding enterprise resource integration ability, the shipping company's logistics process control, air cargo volume, equipment automation degree, these factors will be the bottom of the fundamental factors constraints and at the same time on the surface layer of the impact of the direct factors.

(3) Underlying Influences

The fourth layer is divided into the fundamental factors of aviation logistics supply chain resilience, the fundamental influencing factors are mainly related to the degree of information sharing in the aviation

logistics supply chain, the degree of use of digital technology, which is the most fundamental reason affecting the resilience of the aviation logistics supply chain, and it is in a dominant position in the recursive hierarchical structure.

4 Conclusions and recommendations

After the hierarchical division of each influencing factor and the synthesis of center degree and cause degree measurement, it can be seen that the degree of information sharing in the aviation logistics supply chain, the resource integration ability of freight forwarding enterprises, the degree of logistics control of the airline division, the degree of use of digital technology, and other factors have higher scores in the cause degree and the center, which are the most important factors affecting the resilience of the aviation logistics supply chain. According to the analysis of the factors affecting the resilience of aviation logistics supply chain, the following three aspects are proposed to maintain good resilience in the future aviation logistics supply chain when facing risks and shocks.

(1) Accelerate the construction of informationization of aviation logistics supply chain to avoid the transportation inefficiency caused by the untimely communication of information in the process of cargo transportation. Aviation logistics supply chain involves a number of subjects and links, in the hands of the consignor of goods sent, logistics information to be in the ground transportation enterprises, freight forwarding enterprises, cargo terminals, air transport enterprises, and other subjects in circulation, the different transport links subject to protect the safety, the use of relatively independent information operation system, resulting in the transportation process may exist in a certain degree of information barriers. Therefore, in order to enhance the toughness of the aviation logistics supply chain, the main bodies of each link in the supply chain should increase the construction of the information sharing platform, or use new technologies such as blockchain technology to enhance the degree of information sharing.

(2) Promote the integrated development of the aviation logistics supply chain, and each subject in the supply chain should focus on the improvement of their respective capabilities on the basis of building a good communication mechanism. Compared with foreign countries, there is a lack of large integrated service-oriented logistics enterprises, freight forwarding enterprises are responsible for cargo collection, air transportation enterprises are responsible for air transportation. To maintain the resilience of the aviation

logistics supply chain, first of all, we need to improve the corresponding ability of each subject in the chain for the link they are responsible for, and secondly, the aviation logistics supply chain, as a complete logistics and transportation chain, needs the cooperation and coordination of enterprises in each link to realize the integration of logistics, information flow and capital flow, and to increase the degree of trust of different subjects in each transportation link by strengthening the integrated development of the supply chain.

(3) Increase the use of new technologies to enhance the digitization of the whole process and elements of aviation logistics. Enhancing the efficiency of logistics and information transfer involved in the process of aviation logistics supply chain operation requires increased investment in new technologies. The Civil Aviation Administration of China (CAAC) released the intelligent civil aviation construction route clearly puts forward to increase the investment in science and technology to provide more convenient, multi-level, personalized aviation logistics and transportation services. Therefore, the main bodies of the aviation logistics supply chain should increase the investment in new technologies during the operation process to promote the quality and efficiency of aviation logistics transportation.

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