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Research on Influencing Factors of Cross Border E-Commerce Supply Chain Resilience Based on Integrated Fuzzy DEMATEL-ISM

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ABSTRACT Supply chain resilience is the key for cross-border e-commerce enterprises to continuously obtain competitive advantages. This paper studies the influencing factors of cross-border e-commerce supply chain resilience (CBSCR), so as to further enhance the competitiveness of global supply chain and ensure the safe operation of cross-border e-commerce supply chain. Based on the ternary theory of supply chain resilience, this paper firstly constructs the CBSCR influencing factor system, and then analyzes the comprehensive influence degree, causal relationship and logical hierarchy among the influencing factors by using the fuzzy DEMATEL-ISM method. The results show that: recovery speed of supply chain disruption, response time of supply chain disruption, coordination ability among cross border e-commerce partners, experience sharing among cross-border e-commerce partners, joint planning among cross-border e-commerce partners, establish a good enterprise reputation for fairness, risk management team among partners, and develop a collaborative culture among partners are the key influencing factors of CBSCR. On this basis, it is proposed that the adaptability of supply chain is a top priority, which can be started from strengthening risk management culture, cooperation among partners and construction of supply chain agility.

INDEX TERMS Cross-border E-commerce, supply chain resilience, key factors, DEMATEL-ISM Method.

I. INTRODUCTION

With the development of economic globalization, cross-border e-commerce has become a new form of international trade development, providing a new impetus for China's foreign trade growth [1]. However, while China's cross-border e-commerce enterprises continue to integrate into the global supply chain, participate in the global market competition and gain advantages, the impact of external risks such as terrorism, natural disasters, political crisis, financial crisis, legal disputes and other external risks on the cross-border e-commerce supply chain is more prominent. These risks make the cross-border e-commerce supply chain more vulnerable and increase the risk of supply chain disruption. Therefore, supply chain resilience (SCR) is a powerful tool to maintain the safe operation of cross-border e-commerce supply chain, and it is also the key for cross-border e-commerce enterprises to continuously obtain competitive advantages and maintain global core competitiveness [2].

However, in the face of complicated cross-border e-commerce supply chain, what factors will affect and how do they affect SCR? What is the interaction relationship among these influencing factors? What aspects should cross-border e-commerce enterprises do to optimize the supply chain and improve the SCR? To explore the influencing factors of cross-border e-commerce supply chain resilience (CBSCR) will provide help to solve the above problems, which is also an urgent task in this field.

Scholars at home and abroad have attached great importance to the research on the influencing factors of SCR, and a series of valuable research results have been obtained from different perspectives, which mainly focus on supply chain engineering resilience research (M. Kamalahmadi *et al.*, 2016; A. Abubakar *et al.*, 2017)

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[3], [4], supply chain ecological resilience research (A. K.Alexandre *et al.*, 2018) [5] and supply chain evolutionary resilience research (G. K.Cigdem *et al.*, 2018) [6].

Although the research on the influencing factors of SCR has made some progress, there are still some gaps worth paying attention to.

First of all, extensive research mainly focuses on the study of a single factor or several factors. However, there are few literatures on systematic research. Especially, there are few research results on the influencing factors of CBSCR. Therefore, it is necessary to establish a relatively systematic influencing factor system of CBSCR in this field.

Second, the systematic research on the interaction between influencing factors is obviously insufficient. However, the interaction between these influencing factors is helpful to identify the uppermost influencing factors, deep influencing factors and surface influencing factors of CBSCR. Therefore, it is necessary to establish the logical hierarchy of influencing factors of CBSCR in this field.

Based on this, this study attempts to establish a complete system of influencing factors of CBSCR, prioritize the influencing factors, and establish a multi-level structure of influencing factors to fill these research gaps. Actually, the research on the influencing factors of CBSCR is a multi-criteria decision-making (MCDM) problem. MCDM refers to the choice of decision among conflicting schemes. It is one of the important contents of analytical decision theory. MCDM technique is usually used for mechanism analysis of influencing factors (C.B. Xu et al, 2020) [7].

Among the related MCDM techniques, the AHP (Analytic Hierarchy Method), ISM (Interpreted Structure Model), TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), DEMATEL (Decision Experiment Analysis Method) and VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje) have been widely used in the study of influencing factors [8]. Among them, DEMATEL is superior to other methods in identifying key influencing factors. ISM is superior to other approaches in revealing the logical hierarchy of influence [9].

Based on this, many scholars have successfully applied DEMATEL method to identify key influencing factors of supply chain, and applied ISM method to reveal the hierarchical structure of influencing factors of supply chain. However, there are few applications in the fields of cross-border e-commerce and SCR, which provides a large space for testing this study. For instance, H.Abid *et al.* (2019) and S. Sachin *et al.* (2020) used DEMATEL to identify the influencing factors of the agricultural supply chain [10], [11]. B.B. Gardas *et al.* (2019) and S.K.Mangla *et al.* (2018) used DEMATEL- ISM to analyze the logical structure of the influencing factors of the industrial supply chain [12], [13]. Vipul Jain *et al.* (2017) used DEMATEL- ISM to analyze the logical structure of the influencing factors of SCR [14].

In general, the required data are obtained through expert interviews and questionnaires in the DEMATEL method. But the data is highly subjective. Therefore, some scholars have improved the DEMATEL method to fuzzy DEMATEL method to reduce the subjectivity of the original data. For instance, M.F.Li *et al.* (2016) adopted fuzzy DEMATEL method to identify the key influencing factors of network channel selection of supply chain enterprises [15]. W.X.Dong *et al.* (2018) used fuzzy DEMATEL method to identify the key influencing factors of supply chain performance evaluation [16].

Based on this, the comprehensive influencing factor system is established on the basis of the ternary theory of SCR and literature review. This study combines expert scoring method and Fuzzy Set Theory, and uses DEMATEL to rank the influencing factors of CBSCR. In this study, ISM was used to construct a multi-level structure of influencing factors of CBSCR.

The rest of this study is organized as follows. The second section defines cross-border e-commerce supply chain and SCR and other related concepts, and introduces the ternary theory of SCR in detail, so as to deduce the concept of CBSCR. The third section reviews the influencing factors of CBSCR and constructs the comprehensive influencing factor system of CBSCR. The fourth section gives the related analysis steps and results through the integration of fuzzy DEMATEL-ISM method. The fifth part analyzes factor attribute, factor importance and factor hierarchy. The sixth section summarizes the main research results of the paper, and discusses the findings of management significance for cross-border e-commerce enterprises. Finally, the seventh part summarizes the main contributions and deficiencies of the paper, and puts forward suggestions for further research direction.

II. CONCEPT DEFINITION AND THEORETICAL BASIS

A. CONCEPT DEFINITION

Cross-border e-commerce supply chain refers to a special form of supply chain under the background of cross-border e-commerce. It is a modern supply chain form in the context of cross-border e-commerce, advocating the concepts of resource integration, collaborative operation, supply and demand matching, and benefit sharing [17]. According to the views of S.H. Ma (2003) [18], M.K.He (2018) [19], H.Song (2018) [20] and other scholars, and by referring to the Guiding Opinions of the General Office of the State Council of China on Actively Promoting Supply Chain Innovation and Application (2017), this study believes that the cross-border e-commerce supply chain is an organization form that is oriented by cross-border e-commerce customer needs, led by core enterprises, aimed at quality and efficiency and integrate resources as a means to achieve efficient collaboration in the entire process of product design, procurement, production, sales and service.

Therefore, compared with the general supply chain, the cross-border e-commerce supply chain has three characteristics: numerous nodes, cross-border nodes and complex structure.

1. Numerous nodes. "Core enterprises" of cross-border e-commerce can be divided into three forms: cross-border e-commerce operation platform, supply chain service enterprise and cross-border trade comprehensive service provider [21].The cross-border e-commerce operation platform is mainly based on the cross-border e-commerce platform; the supply chain service enterprises mainly include cross-border logistics service providers, cross-border payment service providers, import and export declaration service agencies, etc.; the cross-border trade comprehensive service providers are mainly the local cross-border e-commerce public service platforms [1].

2. Cross-border nodes. The two parties are located in different international market environments, confronted with different national policies and regulations, customs clearance rules, payment tools and other environments, therefore cross-border e-commerce supply chain coping strategies are different [22]. Even countries with different traffic conditions and natural environments have different coping strategies [17].

3. Complex structure. Core enterprise through the functions of platform building, demand matching, integration and innovation to connect "the resources" and "the customer" on both sides, and then to realize the cross-border electricity resource management, supply chain management, risk management, quality management and information management, and finally to provide customers with logistics, information flow, cash flow, value flow, service flow integrated solutions [1], [23].

B. THEORETICAL BASIS

The ternary theory of SCR includes three parts: Information Processing Theory (IPT), High Reliability Theory (HRT) and Social Exchange Theory (SET).

1. IPT focuses on the impact of supply chain dynamics on information sharing and supply chain practice, with special attention to the improvement of supply chain efficiency [24]. According to Pettit *et al.* (2010), SCR that improves the efficiency of supply chain to achieve supply chain recovery is called supply chain engineering resilience. Supply chain engineering resilience is mainly marked by anti-interference and the speed of system returning to equilibrium state [25].

2. HRT refers to the process of dealing with the complexity of interaction through the application of various strategies and remedies to create a reliable supply chain, with special attention to the improvement of supply chain adaptability [26]. Eltantawy (2016) believe that SCR that focuses on improving supply chain adaptability to achieve supply chain response and restructuring is called supply chain ecological resilience. Supply chain ecological resilience is mainly marked by the recovery to several possible equilibrium states [27].

3. SET refers to the activity reward in the process of interaction with other organizations, with special attention to the improvement of the evolution ability of the supply chain [18].Ambulkar *et al.* (2015) and Vipul Jain *et al.* (2017) believe that the SCR that improves the evolutionary capacity of the supply chain to achieve the renewal and improvement of the supply chain is called supply chain evolutionary resilience. Supply chain evolutionary resilience is accumulated through continuous adaptation process and learning from continuous disturbance [14], [29].

Based on this, Henry Adoor *et al.* (2018) revised the ternary theory of SCR. He believes that the ternary theory of SCR includes three parts: supply chain efficiency capability, supply chain adaptation capability and supply chain evolution capability [30]. The newly revised ternary theory of SCR has been widely accepted by scholars in this field [31], [32].

Based on the ternary theory of SCR and the background of cross-border e-commerce, this study holds that CBSCR refers to that the cross-border e-commerce supply chain restores its structure or function to the original state or a new ideal state by improving the efficiency, adaptability and evolutionary ability in the face of the influence of the disturbing events.

Among them,(1)"disturbing events" not only include uncontrollable external interference events such as natural disasters, political crisis, sudden epidemic situation, but also internal operation disturbing events such as cross-border logistics transportation and warehousing (such as overseas warehouse management) [33];(2) efficiency capability, adaptability and evolutionary capability all contribute to improving CBSCR, and none of them is indispensable [30].

In addition, few scholars in this field have comprehensively and systematically studied the influencing factors of CBSCR from the perspectives of supply chain efficiency capability, supply chain adaptation capability and supply chain evolution capability. Therefore, the ternary theory of SCR provides an integrated framework for influencing factors of CBSCR.

III. FACTORS IDENTIFICATION

A. LITERATURE REVIEW

SCR focuses on how long it takes the system to return to equilibrium or stable state after disturbance [34]. This study regards these capabilities as influencing factors that can achieve resilience in the supply chain [14].

According to the ternary theory of SCR, SCR is affected by many factors, including supply chain efficiency capacity, supply chain adaptation capacity and supply chain evolution capacity. Based on this, combined with the background of cross-border e-commerce, this study believes that the influencing factors of CBSCR can be divided into three categories, which are supply chain efficiency capacity, supply chain adaptation capacity and supply chain evolution capacity.

1) SUPPLY CHAIN EFFICIENCY CAPACITY

Supply chain efficiency capability focuses on the time and speed of supply chain recovery [35]. Referred to the research of relevant scholars, this study divides the supply chain efficiency capability into four parts: emergency plan, supply and demand capability, business continuity plan, and supply chain agility.

(1) Emergency plan is an effective tool to improve supply chain efficiency capacity, involving the development of response measures in advance to prevent supply chain disruptions [36]. When international trade friction, customs clearance and other risks impact supply chain of cross-border e-commerce, it can be expanded from the aspects of reconfiguration of supply chain contingency plan [37], supply chain disruption recovery contingency plan [38], resource reallocation contingency plan [25], etc. For example, Chang *et al.* (2018) proposed the selection and collaboration of foreign distributors as an emergency plan [39]. Chowdhury *et al.* (2017) proposed recovery of breakpoints and prevention of cascading events as an emergency plan [40]. Töyli *et al.* (2013) proposed commodity storage modes such as bonded warehouses or overseas warehouses as emergency plans [41].

(2) Supply and demand capacity is another effective tool to improve the efficiency of supply chain, which involves strategies such as delayed product differentiation and delayed use [39]. In other words, it is a way to reduce risks by delaying additional investment in products to the last possible moment to minimize costs. It can be expanded from the aspects of designing general products based on requirements, customizing general products based on requirements and using postponement skillfully to meet the needs of customers [42]. For example, Wang *et al.* (2020) proposed to design universal products based on consumer demand in foreign markets as supply and demand capacity [43]. Xiao *et al.* (2020) proposed to meet supply and demand through overseas distribution locations, domestic logistics packaging and other delayed forms [44].

(3) Business continuity plan is a tool to prevent supply risks [29]. Supply risks are often difficult to predict and have a very low probability of occurring, but if they do occur, they can have a catastrophic impact on the organization. It can be expanded from the aspects of evaluating the influence of core suppliers, evaluating the risk level of core suppliers and predicting warning signals of supply chain risks [29]. For example, Rui(2020) puts forward the geographical location of raw material suppliers and their national policies as one of the methods to evaluate the influence of core suppliers [45]. Pang (2019) proposes to determine the potential impact of losing suppliers by assessing risks, so as to understand the potential risks that may affect suppliers [1].

(4) Supply chain agility refers to the ability of supply chain to quickly respond to changes in supply and demand [46]. It can be expanded from the aspects of response time of supply chain disruption [35], recovery speed of supply chain disruption [29] and key link visibility of supply chain [47]. For example, Ponomarov *et al.* (2009) proposed the response time for demand changes in the cross-border e-commerce market [35]. Qrunflesh *et al.* (2013) put forward the identification of vulnerable suppliers, cross-border e-commerce supply chain environment and key assets as the main visible aspects of the key links of the supply chain [47].

2) SUPPLY CHAIN ADAPTATION CAPACITY

Supply chain adaptation capacity focuses on multiple steady state changes of supply chain recovery and supply chain reorganization [29]. Referred to the research of relevant scholars, this study divides it into four parts: functional redundancy, supply chain flexibility, risk management culture, and adaptive management.

(1)Functional redundancy is an effective tool to improve supply chain adaptability [48]. Gunderson *et al.* (2001) argue that functional redundancy refers to the diversity of species that contribute to the same function in the social ecosystem. It can be expanded from the aspects of multi-supplier procurement, redundancy of international transportation and storage capacity and reserve safe cross-border e-commerce inventory [49]. For example, Hendricks *et al.* (2009) proposed to prepare from transportation mode, port scheduling, customs clearance docking, distribution issues, domestic warehouse, border warehouse, overseas warehouse and other related facilities [50]. Choi *et al.* (2001) believe that an effective safety stock is set up according to the characteristics of the commodity market [51].

(2)Supply chain flexibility is the ability of the supply chain to respond flexibly to disturbing events [48]. It can be expanded from the aspects of cross-border e-commerce supply chain structure flexibility, cross-border e-commerce supply chain management awareness and flexible resources of cross-border e-commerce enterprise [39]. For example, Pettit *et al.*(2010) proposed to increase the flexibility of supply chain in terms of product development, international procurement, foreign warehousing, manufacturing, international logistics and information system [25].

(3)Risk management culture is the consciousness of the supply chain to deal with interference events, and the risk management culture is gradually established through various measures [3]. It can be expanded from the aspects of developing a collaborative culture among partners, collaborative contingency plan among partners, and risk management team among partners [52]. For example, Jafarnejad *et al.* (2019) proposed to create cultural criteria for collaboration among supply chain partners of cross-border e-commerce and continuous collaboration emergency plan as cultural measures for risk management. Kumar *et al.*(2020) proposed to create a cross-border e-commerce supply chain risk management team as a cultural measure of risk management [53].

(4)The goal of adaptive management is the ability to restructure the system in a desired state in response to changing conditions and disruptive events [54]. It can be expanded from the aspects of ability to cope with temporary disruption, ability to cope with continuous disruption and ability to cope with pre-disruption [40]. For example, to some extent, adaptive management involves the generation of awareness (Jia *et al.*, 2020) [2]. The above process allows managers to use the information they gain from the system to adapt to changing circumstances, while managers try to intervene and learn what works and what doesn't (Gu *et al.*, 2020) [55].

3) SUPPLY CHAIN EVOLUTION CAPACITY

Supply chain evolution capability focuses on the update and improvement after supply chain recovery and restructuring [29]. Referred to the research of relevant scholars, this study divides it into four parts: social memory, learning ability, trust between partners, and collaboration between partners.

(1) Social memory is an effective tool to improve the evolution ability of the supply chain, which involves relevant knowledge being stored and used to deal with future changes [5]. It can be expanded from the aspects of the amount of experience accumulated in response to risks [56], actively accumulating social relationship capital and the application ability of risks experience [6]. For example, Song *et al.*(2020) believe that valuable knowledge and asset management can be acquired from long-term partners, and it is important to spend time, energy and even money to maintain social relations in daily life [56].

(2)Learning ability is another effective tool for improving supply chain evolution ability. Effective learning will improve the organization's ability to correct, because learning is very important for dealing with ambiguous problems in dynamic systems [57]. It can be expanded from the aspects of personal learning ability to cope with risks [58], organizational learning ability to cope with risks and joint learning ability to cope with risks [59]. For example, Seyedmohsen *et al.*(2019) proposed that employees should have the awareness of independent learning, independent application, independent exploration of learning methods, and good at summarizing experience. Hosseini *et al.*(2019) proposed communication and learning approaches between supply chain partners of cross-border e-commerce, such as informal organizations and social network platforms [60].

(3) Trust between partners is another effective tool to improve the evolution capability of supply chain, especially the trust based on goodwill is very important (Henry Adoor *et al.*, 2018) [30]. When trust exists, it reduces risk, fosters cooperation, creates a sense of community, and makes social life predictable. It can be expanded from the aspects of establishing a good enterprise reputation for fairness, relationship management among cross-border e-commerce partners and integrity culture among cross-border e-commerce partners [61]. For example, Adger(2003) and Ghosh *et al.*(2008) proposed that cross-border e-commerce enterprises should have a good reputation in the same industry, that is, fair trade [62], [63].

(4) Collaboration among partners refers to the ability to cooperate effectively with other companies, which enables participants to handle the major inter-organizational problems that cannot be solved by any organization alone more effectively (Pettit *et al.*, 2013) [64]. It can be expanded from the aspects of experience sharing among cross-border e-commerce partners [41], joint planning among cross-border e-commerce partners and coordination among cross-border e-commerce partners [65]. For example, Imran *et al.* (2019) proposed that cross-border e-commerce supply chain partners should pay attention to the creation and sharing of knowledge [65]. Ismail *et al.* (2015) encourage mutual support among supply chain partners of cross-border e-commerce during interruption to enhance cohesion [36].

B. INFLUENCING FACTORS SYSTEM

Based on the literature review and combined with the characteristics of cross-border e-commerce supply chain, the influencing factor system, and hierarchical relationship and coding of cross-border e-commerce SCR are shown in Table 1. To sum up, this study constructs a CBSCR influencing factor system, which includes 3 primary influencing factors, 12 secondary influencing factors and 36 third level influencing factors.

IV. RESEAECH METHODS

Based on the above identified influencing factors of CBSCR, this study uses DEMATEL (Decision Experiment Analysis Method) to analyze the importance of influencing factors of CBSCR, and uses ISM (Interpretive Structural Model) to analyze the hierarchical logical relation of influencing factors of CBSCR [66], [67]. Among them, In order to avoid the subjectivity of experts' scoring, this study introduces triangular fuzzy number (TFN), which quantifies the evaluation results of experts using literal description variables (also known as linguistic variables) [68]. Then, the method of converting fuzzy data into crisp scores (CFCs) proposed by Opricovic and Tzeng is used to convert the triangular fuzzy numbers evaluated by experts into precise values [69]. The specific process is as follows:

A. TFN METHOD

In order to ensure the fairness of expert scoring, this study comprehensively considers the composition of stakeholders [70]. There are 15 experts who are compose of two parts: the 7 university experts from logistics management, international trade, e-commerce and other professional scholars, and 8 enterprise experts including cross-border logistics providers, supply chain service providers, third-party service providers, cross-border e-commerce platform and other enterprise leaders. All the experts recognized 36 influencing factors, and scored the degree of mutual influence among the influencing factors according to their knowledge and experience, thus we obtained 15 expert questionnaires. Among them, the questionnaire was designed according to the linguistic variable set by Wang M J J *et al.* (1995) and Chen CT (2000), as shown in Table 2 [71], [72]. Then, the decision results of each expert are transformed into corresponding triangular fuzzy numbers $(l_{ij}^k, m_{ij}^k, r_{ij}^k)$, i(j)= 1,2,3, ... 36, k = 1,2,3, ... 15, It means that the k-th expert evaluates the influence degree of factor i on factor j, and records them in 36 × 36 matrix respectively.

B. CFCS METHOD

According to CFCs method, the triangular fuzzy number of expert decision is transformed into accurate value. The whole

TABLE 1. Influencing factors system of CBSCR.

Primary	Secondary	Third level
Supply chain efficiency capability (A)	Emergency plan (A1)	Reconfiguration of supply chain contingency plan(A11)
		Supply chain disruption recovery contingency plan(A12)
		Resource reallocation contingency plan(A13)
	Supply and demand capability (A2)	Design general product based on requirement(A21)
		Customize general products based on requirements(A22)
		Use postponement skillfully to meet the needs of customers(A23)
	Business continuity plan (A3)	Evaluate the influence of core suppliers(A31)
		Evaluate the risk level of core suppliers(A32)
		Predict supply chain risk warning signals(A33)
	Supply chain agility (A4)	Response time of supply chain disruption(A41)
		Recovery speed of supply chain disruption(A42)
		Key link visibility of supply chain(A43)
Supply chain adaptation capability (B)	Functional redundancy (B1)	Multi suppliers procurement(B11)
		Redundancy of international transportation and storage capacity(B12)
		Reserve safe cross-border e-commerce inventory(B13)
	Supply chain flexibility (B2)	Cross-border e-commerce supply chain structure flexibility (B21)
		Awareness of cross-border e-commerce supply chain management(B22)
		Flexible resources of cross-border e-commerce enterprises(B23)
	Risk management culture (B3)	Develop a collaborative culture among partners(B31)
		Collaborative contingency plan among partners(B32)
		Risk management team among partners(B33)
	Adaptive management (B4)	Ability to cope with temporary disruption (B41)
		Ability to cope with continuous disruption (B42)
		Ability to deal with pre-disruption (B43)
Supply chain evolutionary capability (C)	Social memory (C1)	Amount of experience accumulated in response to risks(C11)
		Actively accumulate social relationship capital(C12)
		Application ability of coping with risk experience(C13)
	Learning ability (C2)	Personal learning ability to cope with risks(C21)
		Organizational learning ability to cope with risks(C22)
		Joint learning ability to cope with risks(C23)
	Trust between partners (C3)	Establish a good enterprise reputation for fairness (C31)
		Relationship management among cross-border e-commerce partners(C32)
		Integrity culture among cross-border e-commerce partners(C33)
	Collaboration among partners (C4)	Experience sharing among cross-border e-commerce partners(C41)
		Joint planning among cross-border e-commerce partners(C42)
		Coordination ability among cross-border e-commerce partners(C43)

TABLE 2. Linguistic variables and triangular fuzzy numbers.

Linguistic Variable	TFN
No impact	(0,0.1,0.3)
Impact is small	(0.1,0.3,0.5)
Not much	(0.3,0.5,0.7)
Impact is more	(0.5,0.7,0.9)
Impact is great	(0.7,0.9,1.0)

deblurring process is carried out according to the following three steps.

1) STANDARDIZATION

According to the formula (1) $\sim$ (3), the triangular fuzzy number of each expert's evaluation result is standardized, which can reduce the subjective difference among experts.

$$xl_{ij}^{k} = \frac{l_{ij}^{k} - \min\limits_{1\le k\le K} l_{ij}^{k}}{\Delta_{\min}^{\max}} \tag{1}$$

$$xm_{ij}^{k} = \frac{m_{ij}^{k} - \min\limits_{1\le k\le K} l_{ij}^{k}}{\Delta_{\min}^{\max}} \tag{2}$$

$$xr_{ij}^{k} = \frac{r_{ij}^{k} - \min\limits_{1\le k\le K} l_{ij}^{k}}{\Delta_{\min}^{\max}} \tag{3}$$

Among them, $\Delta_{\min}^{\max} = \max\limits_{1\le k\le K} r_{ij}^{k} - \min\limits_{1\le k\le K} l_{ij}^{k}$

2) CALCULATE THE STANDARD VALUE

Firstly, the normalized fuzzy number is transformed into left standard value and right standard value according to formula (4) and (5). Then the left and right standard values are converted into the total standard values according to formula (6).

$$xls_{ij}^{k} = \frac{xm_{ij}^{k}}{1 + xm_{ij}^{k} - xl_{ij}^{k}} \tag{4}$$

$$xrs_{ij}^{k} = \frac{xr_{ij}^{k}}{1 + xr_{ij}^{k} - xm_{ij}^{k}} \tag{5}$$

$$x_{ij}^{k} = \frac{xls_{ij}^{k}(1 - xls_{ij}^{k}) + xrs_{ij}^{k}xrs_{ij}^{k}}{1 - xls_{ij}^{k} + xrs_{ij}^{k}} \tag{6}$$

3) COMPLETE THE PROCESS OF FUZZINESS

Firstly, according to formula (7), the influence value of factor i reflected by the k-th expert to factor j is obtained; then, according to formula (8), the influence value of i factor to j factor is calculated, and the whole process of triangular fuzzy number quantification is completed.

$$a_{ij}^{k} = \min\limits_{1\le k\le k} l_{ij}^{k} + x_{ij}^{k}\Delta_{\min}^{\max} \tag{7}$$

$$a_{ij} = \frac{1}{k}\sum_{k=1}^{k} a_{ij}^{k} \tag{8}$$

Therefore, the final accurate value of the interaction degree between the evaluation factors of the expert group is obtained

TABLE 3. Direct influence matrix of CBSCR.

Factors	A11	A12	A13	······	C42	C43
A11	0.1217	0.7000	0.5357	······	0.3871	0.3871
A12	0.7000	0.1217	0.5357	······	0.3871	0.3871
A13	0.5357	0.5357	0.1217	······	0.3000	0.3000
A21	0.3000	0.4129	0.4643	······	0.1515	0.1217
······	······	······	······	······	······	······
C42	0.4386	0.4386	0.3000	······	0.1217	0.8248
C43	0.4386	0.4386	0.3000	······	0.8248	0.1217

and recorded in the matrix of 36 × 36, forming the direct influence matrix required by DEMATEL method, as shown in Table 3.

C. COMPREHENSIVE INFLUENCE DEGREE

In this study, Excel function and VBA program are used. Firstly, the direct influence matrix A is transformed into the standardized influence matrix D according to formula (9); secondly, the standardized influence matrix D is transformed into the total influence matrix T according to formula (10); finally, the sum of each row r_i and column c_j in the matrix T is calculated according to formula (11) and formula (12).

$$D = \frac{1}{\max\limits_{1\le i\le 15} \sum\limits_{j=1}^{15} a_{ij}} A \tag{9}$$

$$T = D(I-D)^{-1} \tag{10}$$

$$r_i = \sum_{j=1}^{15} t_{ij} \tag{11}$$

$$c_j = \sum_{i=1}^{15} t_{ij} \tag{12}$$

The calculated r_i value is the sum of the direct or indirect influence degree of i factor to other factors in the system, which is called the influence degree (D); and c_j represents the sum of the direct or indirect influence degree of j factor given by other factors in the system, which is called the affected degree (R). When factor i = j, r_i+c_j is the importance degree of i factor in the whole system, which is called centrality (D + R), and r_i-c_j is called cause degree (D-R). When r_i-c_j > 0, the attribute of factor i is the cause factor. when r_i-c_j < 0, the attribute of factor i is the result factor. The D, R, D + R and D-R solution values of the influencing factors of CBSCR are shown in Table 4.

D. GENERATING REACHABLE MATRIX

Since the mutual influence value of the factors themselves in DEMATEL method is 0, the original comprehensive influence matrix (T) plus the identity matrix (I) is generated into the system comprehensive influence matrix N, that is, N = I + T. The threshold (λ) is determined by the system comprehensive influence matrix, and the hierarchical structure of influencing factors of CBSCR is continuously optimized. If λ is small, the hierarchical structure of influencing factors is simple; if λ is large, the hierarchical structure of influencing factors is complex, and the feasibility analysis is different. Therefore, it is very important to select the appropriate λ for the hierarchical structure.

After continuous adjustment and attempt, this study set the threshold value λ as 0.022, 0.023, 0.024 and 0.025 respectively for multi-value comparison, and calculated the node degree of each influencing factor under different thresholds

TABLE 4. D, R, D + R and D-R solution values.

Factors			D	R	D+R	D-R
A	A1	A11	0.3546	0.3930	0.7476	-0.0384
		A12	0.3661	0.4034	0.7695	-0.0373
		A13	0.3447	0.3644	0.7091	-0.0197
	A2	A21	0.2261	0.2589	0.4850	-0.0327
		A22	0.2165	0.2290	0.4455	-0.0125
		A23	0.2855	0.2807	0.5662	0.0049
	A3	A31	0.2882	0.2561	0.5443	0.0321
		A32	0.2971	0.2721	0.5693	0.0250
		A33	0.2437	0.2776	0.5213	-0.0339
	A4	A41	0.5324	0.4939	1.0263	0.0385
		A42	0.5428	0.4899	1.0327	0.0528
		A43	0.4452	0.4587	0.9038	-0.0135
B	B1	B11	0.2838	0.3385	0.6223	-0.0546
		B12	0.2834	0.3184	0.6018	-0.0351
		B13	0.2816	0.3206	0.6022	-0.0390
	B2	B21	0.4112	0.3715	0.7827	0.0397
		B22	0.4254	0.3297	0.7552	0.0957
		B23	0.4037	0.3139	0.7175	0.0898
	B3	B31	0.4341	0.3942	0.8283	0.0399
		B32	0.5214	0.5354	1.0568	-0.0141
		B33	0.4527	0.4056	0.8582	0.0471
	B4	B41	0.5900	0.6524	1.2424	-0.0623
		B42	0.5659	0.6099	1.1758	-0.0440
		B43	0.5902	0.6521	1.2423	-0.0618
C	C1	C11	0.3620	0.3932	0.7553	-0.0312
		C12	0.4087	0.4672	0.8759	-0.0585
		C13	0.4209	0.4403	0.8612	-0.0194
	C2	C21	0.3715	0.3337	0.7053	0.0378
		C22	0.4157	0.3870	0.8027	0.0287
		C23	0.4176	0.3891	0.8068	0.0285
	C3	C31	0.4649	0.4467	0.9116	0.0183
		C32	0.4433	0.4585	0.9017	-0.0152
		C33	0.4148	0.4308	0.8456	-0.0160
	C4	C41	0.4959	0.4733	0.9693	0.0226
		C42	0.4922	0.4697	0.9619	0.0224
		C43	0.5043	0.4889	0.9932	0.0153

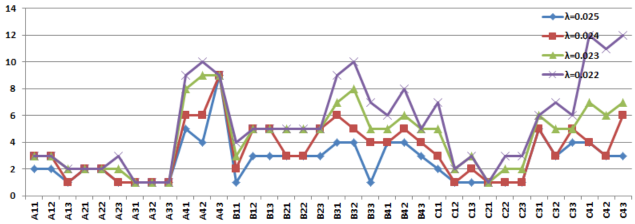

FIGURE 1. Different threshold adjustment diagrams.

TABLE 5. Accessibility matrix M of influencing factors of CBSCR.

Factors	A11	A12	A13	A21	A22	……	C42	C43
A11	1	1	0	0	0	……	0	0
A12	1	1	0	0	0	……	0	0
A13	0	0	1	0	0	……	0	0
A21	0	0	0	1	1	……	0	0
A22	0	0	0	1	1	……	0	0
……	……	……	……	……	……	……	……	……
C42	0	0	0	0	0	……	1	0
C43	0	0	0	0	0	……	0	1

respectively, in order to obtain the optimal system structure, as shown in Figure 1.

The analysis shows that when λ value is 0.022, 0.023, the nodal degree of influencing factors changes greatly. When λ is 0.025, the change range of node degree of influencing factors is small. After screening, the value of λ is 0.024. Zhang *et al.*(2020) believe that λ is the sum of the mean and standard deviation of all elements in the system comprehensive influence matrix N. According to the viewpoint of Zhang *et al.*(2020), the calculated value of λ is 0.024, which is consistent with the attempted discussion in this study. In conclusion, λ value in this study is 0.024. According to formula (13), the reachability matrix M of influencing factors of CBSCR can be obtained through calculation, as shown in Table 5.

$$a_{ij} = \begin{cases} 1, & a_{ij} \geq \lambda \\ 0, & a_{ij} < \lambda \end{cases} \qquad (i = 1, \cdots, 36; j = 1, \cdots, 36) \tag{13}$$

E. HIERARCHICAL MODEL CONSTRUCTION

According to the reachability matrix M and formula (14)-(16), the reachable set K, the antecedent set X and the common set G of the influencing factors of CBSCR can be obtained.

$$K(M_i) = \{M_i \left| a_{ij} = 1 \right.\} \tag{14}$$

$$X(M_i) = \{M_j \left| a_{ij} = 1 \right.\} \tag{15}$$

$$G(M_i) = K(M_i) \cap X(M_i) \tag{16}$$

It is assumed that L_i is the influencing factor of layer i. if there is a reachable set and a common set, the same factor is taken as the factor of layer i. After the factor is identified, delete the factor. All the factors of the next level are found again. Therefore, the hierarchy of influencing factors of CBSCR can be divided into: L1 = {A11, A12, A13, A21, A22, A23, A31, A32, A33, B21, B22, C11, C12, C13, C21, C22, C23, C31, C32, C33, C41, C42}; L2 = {A41, A42, B32, C43}; L3 = {A43, B31, B41, B42, B43}; L4 = {B11, B12, B13, B23, B33}.

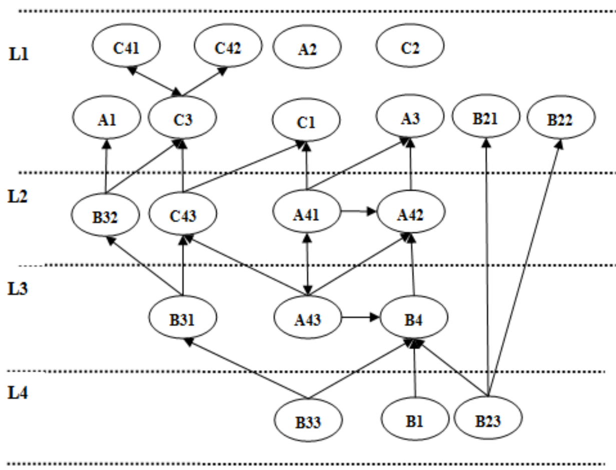

FIGURE 2. Hierarchical model of influencing factors of CBSCR.

Because A11, A12 and A13 in L1 belong to A1 and are the complete set of A1; A21, A22, A23 belong to A2 and are the complete set of A2; A31, A32, A33 belong to A3 and are the complete set of A3; C11, C12, C13 belong to C1 and are the complete set of C1; C21, C22, C23 belong to C2 and are the complete set of C2; C31, C32, C33 belong to C3 and are the complete set of C3. In order to avoid the complexity of the problem, the first level is simplified as: L1 = {A1, A2, A3, B21, B22, C1, C2, C3, C41, C42}.

Because B41, B42 and B43 in L3 belong to B4 and are the complete set of B4. In order to avoid the complexity of the problem, the third layer is simplified as: L3 = {A43, B31, B4}; because B11, B12 and B13 in L4 belong to B1 and are the complete set of B1. In order to avoid the complexity of the problem, the fourth layer is simplified as: L4 = {B1, B23, B33}. In addition, L2 = {A41, A42, B32, C43} remained unchanged. Through L1, L2, L3 and L4, the hierarchical model of influencing factors of CBSCR is established, as shown in Figure 2.

V. ANALYSIS AND DISCUSSION

A. FACTOR ATTRIBUTE ANALYSIS

Factor attribute analysis mainly analyzes from two aspects: cause factor and result factor. The cause factor is the factor that actively influences other factors; the result factor is the factor influenced by other factors [10].

1) CAUSE FACTOR ANALYSIS

It can be seen from table 4 that the three-level cause factors from strong to weak are: B22, B23, A42, B33, B31, B21,

A41, C21, A31, C22, C23, A32, C41, C42, C31, C43, A23, totaling 17.

(1) The main factors of strong initiative are: awareness of cross-border e-commerce supply chain management (B22), flexible resources of cross-border e-commerce enterprises (B23), recovery speed of supply chain disruption (A42), risk management team among partners (B33), develop a collaborative culture among partners (B31), cross-border e-commerce supply chain structure flexibility (B21).Among them, "Recovery speed of supply chain disruption" has strong influence and affected degree;

(2) The main factors of weak initiative are: evaluate the risk level of core suppliers (A32), experience sharing among cross-border e-commerce partners (C41), joint planning among cross-border e-commerce partners (C42), establish a good enterprise reputation for fairness (C31), coordination ability among cross-border e-commerce partners (C43), use postponement skillfully to meet the needs of customers (A23).Among them, "Coordination ability among cross-border e-commerce partners" has a strong influence and affected degree;

(3) Among the three level factors, the weak influence and affected degree factors are: evaluate the influence of core suppliers, evaluate the risk level of core suppliers, and use postponement skillfully to meet the needs of customers. It can be seen that the relationship between these three factors and other factors is relatively distant.

2) RESULT FACTOR ANALYSIS

It can be seen from table 4 that the order of the third level result factors from strong to weak is: B41, B43, C12, B11, B42, B13, A11, A12, B12, A33, A21, C11, A13, C13, C33, C32, B32, A43, A22, a total of 19.

(1) The strong passive factors mainly include: ability to cope with temporary disruption (B41), ability to deal with pre-disruption (B43), actively accumulate social relationship capital (C12), multi suppliers procurement (B11), ability to cope with continuous disruption (B42), reserve safe cross-border e-commerce inventory (B13). Among them, ability to cope with temporary disruption, ability to deal with pre-disruption and ability to cope with continuous disruption have strong influence and affected degree;

(2) The weak passive factors mainly include: application ability of coping with risk experience (C13), integrity culture among cross-border e-commerce partners (C33), relationship management among cross-border e-commerce partners (C32), and collaborative contingency plan among partners (B32), key link visibility of supply chain (A43), customize general products based on requirements (A22). Among them, "Collaborative contingency plan among partners" has a strong degree of influence and affected degree;

(3) Among the three level result factors, the main factors with low influence and affected degree are: predict supply chain risk warning signals, design general product based on requirement and customize general products based on requirements products based on demand. It can be seen that the relationship between these three factors and other factors is relatively distant.

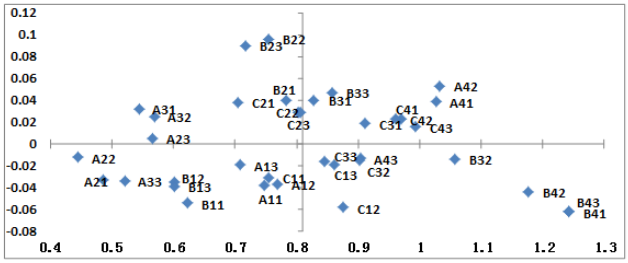

FIGURE 3. Cause and effect diagram of three level influencing factors.

B. FACTOR IMPORTANCE ANALYSIS

In this study, the average centrality of factors is introduced as the standard value of centrality, the centrality of factors is taken as the abscissa, and the cause degree is taken as the ordinate. The causality diagram is drawn and the importance of factors is analyzed by quadrant method [73]. Among them, if a certain factor shows strong passivity, it is not considered as a key factor. According to this analysis idea, the importance of the three level factors is analyzed. Taking the centrality of the third level factors as the abscissa, the cause degree as the ordinate, and the average centrality of the third level factors (0.81) as the standard value of the centrality, the causality diagram is drawn, as shown in Figure 3.

It can be seen from Figure 3 that the three level factors are divided into four quadrants. Among them, (1)the factors in the first quadrant refer to the factors whose centrality is greater than the average centrality of all the cause factors, which we call the key factors; (2)the factors in the second quadrant refer to the factors whose centrality is less than the average centrality of all the cause factors, which we call the driving factors; (3)the factors in the third quadrant refer to the factors whose centrality is less than the average centrality of all the result factors, which we call the conclusion factors;(4) the factors in the fourth quadrant refer to the factors whose centrality is greater than the average centrality of all the result factors, which we call the transitional factors.

In addition, the higher centrality of the factors is, the higher the importance of the corresponding factors is. Therefore, the importance of key factors and transitional factors is higher than that of driving factors and conclusion factors.

1) KEY FACTORS

It can be seen from Figure 3 that the key factors are ranked in descending order according to centrality, which are A42, A41, C43, C41, C42, C31, B33 and B31, totaling 8 factors. The key factors include recovery speed of supply chain disruption (A42), response time of supply chain disruption (A41), coordination ability among cross-border e-commerce partners (C43), experience sharing among cross-border e-commerce partners (C41), joint planning among cross-border e-commerce partners (C42), establish a good enterprise reputation for fairness (C31), risk management team among partners (B33), and develop a collaborative culture among partners (B31).

Key factors have strong centrality and initiative to influence other factors, which have important influence in the system and are closely related to other factors. Recovery speed of supply chain disruption, response time of supply chain disruption, coordination ability among cross-border e-commerce partners is particularly critical.

2) DRIVING FACTORS

It can be seen from Figure 3 that the driving factors are ranked in descending order according to centrality, which are C23, C22, B21, B22, B23, C21, A32, A23 and A31, totaling 9 factors. The driving factors include joint learning ability to cope with risks (C23), organizational learning ability to cope with risks (C22), cross-border e-commerce supply chain structure flexibility (B21), awareness of cross-border e-commerce supply chain management (B22), flexible resources of cross-border e-commerce enterprises (B23), personal learning ability to cope with risks (C21), evaluate the risk level of core suppliers (A32), use postponement skillfully to meet the needs of customers (A23), and evaluate the influence of core suppliers (A31).

Driving factors have weak centrality and initiative, and have less influence and less importance in the system. The three factors of evaluate the risk level of core suppliers, use postponement skillfully to meet the needs of customers and evaluate the influence of core suppliers have low degree of centrality and poor initiative.

3) CONCLUSION FACTORS

It can be seen from Figure 3 that the conclusion factors are ranked in descending order according to centrality, which are A12, C11, A11, A13, B11, B13, B12, A33, A21 and A22, totaling 10 factors. The conclusion factors include: supply chain disruption recovery contingency plan (A12), amount of experience accumulated in response to risks (C11), reconfiguration of supply chain contingency plan (A11), resource reallocation contingency plan (A13), multi suppliers procurement (B11), reserve safe cross-border e-commerce inventory (B13), redundancy of international transportation and storage capacity (B12), predict supply chain risk warning signals (A33), design general product based on requirement (A21), customize general products based on requirements (A22).

Conclusion factors have weak centrality and passivity, and have less influence and less importance in the system. The three factors of predict supply chain risk warning signals, design general product based on requirement and customize general products based on requirements have low centrality and poor passivity.

4) TRANSITIONAL FACTORS

It can be seen from Figure 3 that the transitional factors are ranked in descending order by centrality, which are B41, B43, B42, B32, A43, C32, C12, C13 and C33, totaling 9 factors. The transitional factors include ability to cope with temporary disruption (B41), ability to deal with pre-disruption (B43), ability to cope with continuous disruption (B42), collaborative contingency plan among partners (B32), key link visibility of supply chain (A43), relationship management among cross-border e-commerce partners (C32), actively accumulate social relationship capital (C12), application ability of coping with risk experience (C13), integrity culture among cross-border e-commerce partners (C33).

Transitional factors have strong centrality and passivity influenced by other factors, which have important influence in the system and are closely related to other factors. It is particularly important to deal with ability to cope with temporary disruption, ability to deal with pre-disruption and ability to cope with continuous disruption.

C. FACTOR HIERARCHICAL ANALYSIS

This part mainly analyzes the logical relationship between the factors from the surface factors, depth factors and transitional factors.

1) SURFACE FACTORS

It can be seen from Figure 2 that the 12 three-level factors, including emergency plan, business continuity plan, social memory and trust between partners, are the surface influencing factors of CBSCR, which have the most direct impact on CBSCR; Besides the above-mentioned 12 factors, the most direct factors affecting CBSCR still have: cross-border e-commerce supply chain structure flexibility (B21), awareness of cross-border e-commerce supply chain management (B22), experience sharing among cross-border e-commerce partners (C41) and joint planning among cross-border e-commerce partners (C42). Among them, trust between cross-border e-commerce partners can enhance the joint planning ability of both sides; there is a two-way relationship between trust and experience sharing between cross-border e-commerce partners, that is, trust between cross-border e-commerce partners promotes both sides to actively share experience, and cross-border e-commerce partners enhance the trust of cooperation between both sides.

In addition, Supply and demand capability (A2) and learning ability (C2) are special surface influencing factors. Because it contains six third level factors which are independent of other three-level factors and have no connection. However, attention should be paid to A2 and C2. Only by meeting the supply and demand ability of cross-border e-commerce market and enhancing the ability of individuals, organizations and mutual learning among cross-border e-commerce supply chains, can the CBSCR be improved.

2) DEPTH FACTOR

As can be seen from Figure 2, it can be seen that multi suppliers procurement (B11), redundancy of international transportation and storage capacity (B12), reserve safe cross-border e-commerce inventory (B13), flexible resources of cross-border e-commerce enterprises (B23) and risk management team among partners (B33) are depth influencing factors of CBSCR, which are not easy to detect. But the more invisible and imperceptible factors are, the more attention should be paid to them. Only with a sound and continuous risk management team, redundant international procurement, international transportation and warehousing capacity, cross-border e-commerce inventory, and flexible handling of human and financial resources of cross-border e-commerce enterprises, can the CBSCR be more guaranteed.

3) TRANSITIONAL FACTORS

As can be seen from Figure 2, Response time of supply chain disruption (A41), recovery speed of supply chain disruption (A42), collaborative contingency plan among partners (B32) and coordination ability among cross-border e-commerce partners (C43) are transitional influencing factors of CBSCR. Although the above four factors do not directly affect SCR, they are also factors that cannot be ignored to enhance CBSCR. The more immediate the response time is, the faster the recovery speeds is.

Key link visibility of supply chain (A43), develop a collaborative culture among partners (B31), ability to cope with temporary disruption (B41), ability to deal with pre-disruption (B43), ability to cope with continuous disruption (B42) are also transitional influencing factors of CBSCR. The stronger the visibility of key links in cross-border e-commerce supply chain, the stronger the ability to deal with temporary interruption, pre-disruption and continuous interruption of cross-border e-commerce supply chain. This means that information sharing is essential for adaptive management. Because information sharing is a key measure for visibility of key links in cross-border e-commerce supply chain.

VI. DISCUSSION AND ENLIGHTENMENT

First of all, based on the ternary theory of SCR, this study constructs the influencing factor system of CBSCR. The system divides 36 influencing factors into three categories: supply chain efficiency capability, supply chain adaptation capability and supply chain evolution capability. Then, the interaction of 36 influencing factors is analyzed by integrating fuzzy DEMATEL method, and the key influencing factors are identified. Finally, the hierarchical structure of influencing factors is constructed by the method of interpretative structure model, and the surface factors, depth factors and transition factors are identified. Through the above analysis, the research results of this study can provide some decision-making discussion and enlightenment for cross-border e-commerce enterprises.

1. Cross-border e-commerce enterprises can consider improving SCR from the perspective of key influencing factors. The key influencing factors have strong centrality and initiative to influence other factors, and have an important influence in the system. Recovery speed of supply chain disruption, response time of supply chain disruption, coordination ability among cross-border e-commerce partners, experience sharing among cross-border e-commerce partners, joint planning among cross-border e-commerce partners, establish a good enterprise reputation for fairness, risk management team among partners, and develop a collaborative culture among partners are the most critical factors affecting the CBSCR.

2. What is the interaction relationship between the influencing factors? How does it affect SCR? These questions can be answered from the interaction of influencing factors and transitional factors.

(1) The interaction relationship of influencing factors refers to the identification of the cause factors and the result factors. Factors that actively influence other factors in the system are called cause factors. The factors that are susceptible to other factors in the system are called result factors. The main cause factors include: awareness of cross-border e-commerce supply chain management, flexible resources of cross-border e-commerce enterprises, recovery speed of supply chain disruption, risk management team among partners, develop a collaborative culture among partners. The main result factors include: ability to cope with temporary disruption, ability to cope with continuous disruption, actively accumulate social relationship capital, multi suppliers procurement and ability to deal with pre-disruption.

(2)Transitional factors have strong centrality and passivity influenced by other factors, which have an important influence in the system. Ability to cope with temporary disruption, ability to deal with pre-disruption, ability to cope with continuous disruption, collaborative contingency plan among partners, key link visibility of supply chain, relationship management among cross-border e-commerce partners, actively accumulate social relationship capital, application ability of coping with risk experience, and integrity culture among cross-border e-commerce partners are the transitional factors.

3. Cross-border e-commerce enterprises can optimize supply chain from hierarchical factors to improve SCR.

(1) Adaptability of supply chain is the most critical factor and the deepest factor, which is very important to improve the CBSCR. We can further strengthen the construction of risk management culture, focusing on the risk management team among partners, the application ability of coping with risk experience, and the integrity culture among cross-border e-commerce partners.

(2) Evolutionary of supply chain is not only a secondary key factor, but also a surface factor, which has a direct impact on the improvement of CBSCR. It can be considered from three aspects: the coordination ability among cross-border e-commerce partners, the establishment of cooperation culture among partners, and the establishment of a fair reputation of enterprises.

(3) Efficiency of supply chain is one of the key factors, which is also a surface factor, which has a direct impact on the improvement of CBSCR. We can strengthen the construction of supply chain agility, focusing on the recovery speed of supply chain interruption, the response time of supply chain interruption, and joint planning among cross-border e-commerce partners.

(4) Strengthening the ability of improving the efficiency and evolutionary of supply chain, and deepening the adaptability of supply chain are the effective ways to improve the CBSCR. Among them, Emergency plan, business continuity plan, social memory and trust among partners have the most direct impact on the CBSCR; international procurement of multi suppliers, redundancy of international transportation and storage capacity, reserved safe cross-border e-commerce inventory, flexible resources of cross-border e-commerce enterprises and risk management team among partners have the most profound impact on the CBSCR.

VII. CONTRIBUTIONS AND DEFICIENCIES

A. CONTRIBUTIONS

The contribution of this paper has four aspects. Firstly, the ternary theory of SCR is creatively introduced into the analysis. Previous researches usually focus on one aspect of supply chain efficiency capability, supply chain adaptation capability and supply chain evolution capability, and seldom consider the three comprehensively. The research focus of this paper is to comprehensively consider the interaction between the three, which provides a new perspective for further research.

Second, based on the ternary theory of SCR, a comprehensive system containing 36 influencing factors of CBSCR at different levels is constructed. Previous studies rarely recognize the influencing factors of CBSCR on the whole. This study provides a holistic perspective for further research.

Thirdly, this study mainly discusses the relationship between the influencing factors, and uses the integrated fuzzy DEMATEL method to rank the 36 influencing factors. Previous studies usually focus on the relationship between influencing factors and SCR, and seldom consider the mechanism of action between influencing factors. This paper reveals the mechanism of action among influencing factors, which provides a theoretical basis for the further study of logical hierarchy.

Fourthly, the interpretative structure model method is used for the first time to construct a hierarchical structure of influencing factors of CBSCR, which helps to clarify the relationship between influencing factors.

B. DEFICIENCIES

At the same time, this study may have some limitations. The original data in the DEMATEL method were obtained through expert interviews. However, each expert's score is subjective to a certain extent, which has a potential impact on the subsequent research. Although the fuzzy set theory is introduced, the original data is fuzzy processed. However, the fuzzification process can only reduce the subjectivity of data to some extent, but it cannot eliminate it. Therefore, a large number of respondents can understand the relationship between the influencing factors of CBSCR through questionnaire survey.

In addition, the study is likely to attract more attention. The following issues can be further explored in future work.

(1) The more advanced MCDM technologies can be introduced to evaluate the influencing factors of CBSCR. For instance, methods such as ANP (Analytic Network Process) [70], VIKOR [70], [74], TOPSIS [75]–[77], ant colony algorithm and fuzzy integral [78] can be applied in future research.

(2) The logical hierarchy of influencing factors of CBSCR needs to be empirically studied. In other words, the influence path of CBSCR needs to be empirically studied. For example, the structural equation model (SEM) can be used to empirically test the influence path and effect of CBSCR.

(3) How to improve cross-border e-commerce enterprises' understanding of SCR, how to ensure the implementation of measures to improve CBSCR and how to optimize cross-border e-commerce supply chain also need to be further discussed in the future work.

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