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Research Article

Supply Chain Collaboration Risk Evaluation Based on Trapezoidal Fuzzy Numbers Similarity

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Abstract: Supply chains are confronted with more complicated risks on the current financial crisis, as makes risk control in supply chain management more exigent. Supply chain collaboration, as the important part of supply chain management, is the key method of improving supply chains profits. This study introduces risk management into the mechanism of supply chain collaboration. In supply chain risk management, supply chain collaboration risk is recognized as an important section which can help SCM more efficiently. This study is aimed to present a collaboration risk analysis methods based on trapezoidal fuzzy numbers similarity to solve this problem. By using two linguist terms probability of failure and severity of loss, supply chain collaboration risk can be calculated and expressed with linguistic term. At last, an example is used to identify the efficiency of this method.

Keywords: Fuzzy risk analysis, supply chain collaboration risk, trapezoidal fuzzy numbers similarity

INTRODUCTION

Supply Chain Management (SCM) is related to the coordination of materials, products and information flows among suppliers, manufacturers, distributors, retailers and customers. Supply chain collaboration is 1 of the critical activities for firms to gain collaboration competitive advantage and achieve the business objectives of the whole supply chain. A supply chain is a logistics network, which consists of all stages involved in producing and delivering a final product or service. The entire chain connects customers, retailers, distributors, manufacturers and suppliers, beginning with the creation of raw material or component parts by suppliers and ending with consumption of the product by customers. Modern enterprises have introduced risk management theory into supply chain collaboration management, providing feasible method for enterprises to improve their competitiveness.

Supply chain collaboration refers to two or more enterprises in order to achieve some sort of strategic purpose, formed a network of consortia through agreements or joint organization. Enterprises must alliance with the supply chain upstream and downstream enterprises, integrate the overall competitive capability and resources to achieve win-win situation. Due to the complexity and uncertainty in the supply chain collaboration process, supply chain operations may deviate from the expected goal, producing supply chain collaboration risk (Cachon *et al.*, 2005).

Gan (2004) presented that the collaborative risk is the key factor of coordination supply chain surplus profits allocation and affect the stability of coordination supply chain mechanism. In order to solve the surplus profits allocation problem, analyze the reasons and category of the collaborative risk and then measure the risk of supply chain members through the method of two-factor evaluation. On the basis establish the system of coordination supply chain surplus profits allocation considering the collaborative risk of the supply chain members (Gan, 2004).

Negate (2008) describes how the coordination supply chain risks produce. Under the coordination mechanism the supply chain is also a system, which evolves with the changing of the firm size, market conditions and economic environment, etc. The exchange of the information and materials among the enterprises forms the information flow and logistics, so the enterprises work on each other. The collaborative risks changes for this positive and negative feedback effects and that may lead the connection of the enterprises rupture, destroyed the coordination mechanism of the supply chain (Negate, 2008).

Sun (2009) discussed the mechanism designation of SCC from 2 aspects, which are risk bias of supply chain participants and asymmetric information. The perfect contracts should have sufficient flexibility, as is that by adjusting some parameters the supply chain profit can be divided arbitrarily among the participants and the final result of rent allocation with the flexible contracts relies on the bargaining of both parties

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involved. Under the circumstance of business risk, participant will have to consider the effect of risk volatility in the bargaining process to make the rational decision in the game (Sun, 2009).

In this study, we propose a supply risk analysis methods based on trapezoidal fuzzy numbers similarity.

FUZZY RISK ANALYSIS METHODS BASED ON TRAPEZOIDAL FUZZY NUMBERS SIMILARITY

A fuzzy set $\overline{A}$ in a universe of discourse X is characterized by a membership function $\mu_A(X)$, which associates with each element x in X a real number in the interval (0, 1). The function value $\mu_A(X)$, is termed the grade of membership of in $\overline{A}$. A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal (Chen and Chen, 2003).

A positive trapezoidal fuzzy number A can be defined as (a_1, a_2, a_3, a_4). The membership function $\mu_A(X)$, is defined as:

$$\mu_A(X) = \begin{cases} 0, x < a_1 \\ \frac{x-a_1}{a_2-a_1}, a_1 \le x \le a_2 \\ 1, a_2 \le x \le a_3 \\ \frac{x-a_1}{a_2-a_1}, a_3 \le x \le a_4 \\ 0, a_4 < x \end{cases} \quad (1)$$

A linguistic term is a variable whose values are expressed in linguistic terms (Chen, 2006). For example, "weight" is a linguistic term whose values are very low, low, medium, high, very high, etc. These linguistic terms can also be represented by fuzzy numbers.

Fuzzy risk analysis was proposed by Professor Schmucker (1984). Assume that there is component A consisting of n sub-components $A_1, A_2, \ldots, A_n$. Suppose that each sub-component is evaluated by 2 evaluating terms" Probability of failure" and "Severity of loss", where R_i and L_i are linguistic values trapezoidal fuzzy numbers, denoting the" Probability of failure" and the "Severity of loss" of sub-component A_i respectively.

A trapezoidal fuzzy numbers A = (a_1, a_2, a_3, a_4; w) is called a linguistic value trapezoidal fuzzy number if there are $0 \le a_1 \le a_2 \le a_3 \le a_4 \le 1$; w (0, 1). Suppose there are 2 linguistic value trapezoidal fuzzy numbers A and B, A = (a_1, a_2, a_3, a_4; w_1) and B = (b_1, b_2, b_3, b_4; w_2), xu proposed the new arithmetic operators of linguistic values trapezoidal fuzzy numbers (Zhangyan, 2010):

- Linguistic value trapezoidal fuzzy numbers addition $\oplus$:

$$A1 \oplus B1 = (a_1, a_2, a_3, a_4; w_A) \oplus (b_1, b_2, b_3, b_4; w_B) = (a_1 + b_1 - a_1b_1, a_2 + b_2 - a_2b_2, a_3 + b_3 - a_3b_3, a_4 + b_4 - a_4b_4; \min(w_A, w_B)) \quad (2)$$

- Linguistic value trapezoidal fuzzy numbers multiplication $\otimes$:

$$A1 \otimes B_1 = (a_1, a_2, a_3, a_4; w_A) \otimes (b_1, b_2, b_3, b_4; w_B) = (a_1b_1, a_2b_2, a_3b_3, a_4b_4; \min(w_A, w_B)) \quad (3)$$

- Linguistic value trapezoidal fuzzy numbers subtraction Ø:

$$A1 \text{ Ø } B_1 = (a_1, a_2, a_3, a_4; w_A) \text{ Ø } (b_1, b_2, b_3, b_4; w_B) = (a_1 \text{ Ø } b_1, a_2 \text{ Ø } b_2, a_3 \text{ Ø } b_3, a_4 \text{ Ø } b_4; \min(w_A, w_B) \quad (4)$$

where, a Ø b = {α/b α<b/1 else

- The degree of similarity of A and B denoted as S (A, B) is defined as follows:

$$S(A,B) = 1 - \frac{\sum_{i=1}^{4} |a_i - b_i|}{8} - \frac{d(A,B)}{2} \quad (5)$$

where,

$$d(A,B) = \frac{\sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}}{\sqrt{1.25}} \quad (6)$$

$$y_A = \begin{cases} \frac{w_A \times (\frac{a_3 - a_2}{a_4 - a_1} + 2)}{6}, & if a_4 \ne a_1; \\ \frac{w_A}{2}, & if a_4 = a_1; \end{cases} \quad (7)$$

$$y_B = \begin{cases} \frac{w_A \times (\frac{b_3 - b_2}{b_4 - b_1} + 2)}{6}, & if b_4 \ne b_1; \\ \frac{w_A}{2}, & if b_4 = b_1; \end{cases} \quad (8)$$

$$x_A = \begin{cases} \frac{y_A \times (a_3 + a_2) + (a_4 + a_1)(w_A - y_A)}{2w_A}, & if \quad w_A \ne 0 \\ \frac{a_4 + a_1}{2}, & if \quad w_A = 0 \end{cases} \quad (9)$$

$$x_B = \begin{cases} \frac{y_B \times (b_3 + b_2) + (b_4 + b_1)(w_B - y_B)}{2w_B}, & if \quad w_B \ne 0 \\ \frac{b_4 + b_1}{2}, & if \quad w_B = 0 \end{cases} \quad (10)$$

The algorithm of fuzzy risk analysis is presented as follows:

- **Step 1:** Calculate the total risk R of the component A by using the linguistic values R_i and L_i of each sub-component A_i. By using the Eq. (2) and (3) with linguistic values R_i and L_i of each sub-component, the total risk R of the component A is calculated as:

$$R = \frac{\sum_{i=1}^{n} L_i \otimes R_i}{\sum_{i=1}^{n} L_i} \quad (11)$$

- **Step 2:** Use the similarity of linguistic values trapezoidal fuzzy number to compute similarity between the linguistic values trapezoidal fuzzy number R and trapezoidal fuzzy number of each linguistic term. Then translate the linguistic values trapezoidal fuzzy number R into the linguistic term which has the largest degree of similarity with respect to R.

The collaboration risk factors analysis: Due to supply chain of many subjects, cross-boundary, much link characteristics, the supply chains are vulnerable from the external environment and internal unfavorable factors. Supply chain collaboration risk is a potential threat, because the supply chain systems have their own weaknesses and vulnerabilities. Therefore, in certain cases, this loss of potential threats will be translated into reality, cause damage to the supply chain system. From the perspective of the target control, supply chain risk is the possibility of supply chain collaboration deviating from the intended target.

From different angles, according to different standards, supply chain collaboration risk has different classification results. In general, the risk of supply chain collaboration can be divided into 2 types of internal risk and external risk. Internal risk comes from the interaction between the constituent elements of the supply chain system. External risk arises from the interaction between the supply chain and the external environment.

The risk of external collaboration mainly refers to the risk of the external environment, which supply chain system members cannot control and change, including the risk of the natural environment, policy and legal risk, economic risk, market risk. Internal collaboration risk is the risk due to system characteristics, including profit allocation risk, target conflicts risk, information risk, credit risk, capability risk, delivery risk, cost risk, inventory risk, cultural risk, moral risk.

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Table 1: Risk assessment index

S_i	Risk assessment index
S1	Natural environment risk
S2	Policy and legal risk
S3	Economic risk
S4	Market risk
S5	Profit allocation risk
S6	Target conflicts risk
S7	Information risk
S8	Credit risk
S9	Delivery risk
S10	Cost risk
S11	Cultural risk
S12	Inventory risk
S13	Capability risk
S14	Moral risk

- Supply chain related to wide areas and numerous resources and some even extended to the global supply chains therefore supply chain and the natural environment is closely linked. The interruption of production and transportation in supply chain caused by the change of natural environmental conditions, as well as the increase of supply chain operational cost, customers are not able to get the required products, such as the natural environment risk.
- Policy and legal risk refers to the risk influenced by international industry policy, finance and taxation policy and correlative law and regulation. The alteration of international industry policy, finance and taxation policy and correlative law and regulation can cause the difficulty of fund raising, the interruption of management strategy and so on, inhibit the development of supply chain and bring risks to node enterprise leading to the risk of the entire supply chain.
- The good economic environment create a favorable operatively environment for supply chain collaboration and a sluggish economy or slow development will seriously affect the efficiency of supply chain collaboration. Economic risks are associated with the change of the economic policy in the business environment of the supply chain. Economic risk mainly refers to the risk brought by the variation of economic system, economic policy, economic cycle and inflation.
- Market risk is due to the fluctuation of market mechanism, supply relationship and market price. The market environment is specific supply chain environment. The variation of market environment will seriously affect the supply chain operation. The uncertainty of market demand leads to the increasing difficulty of demand prediction. Frequently strenuous alterations of the demand make it easy to increase the whole supply chain risk. At the same time, the fierce market competition leads to the accession and exiting of

the supply chain members, bringing considerable instability to the supply chain.

- Profit allocation risk is associated with the uncertainty to achieve equitable distribution when the total output value of the supply chain partitioning between the strategies partners of the supply chain. Owing to cooperation between enterprises in the supply chain is driven and maintained by interest, it is formed on the basis of full consideration of their interests. Once the enterprises did not feel well deserved return, or other enterprises from the cooperation have far more interests than them, which make sense of injustice, would reduce the enthusiasm to participate in collaboration, could even take some immoral behavior, thereby endangering the entire supply chain risks. Therefore, the distribution of benefits is reasonable impact on the enthusiasm of node enterprises to participate in the collaboration of supply chain.
- Target conflicts risk arises from the objective conflicts between supply chain partner members and supply chain as well as between the members of the collaborative partnership. On the 1 hand, the various enterprises in the supply chain is an integral part of the supply chain system, but also economic entities with independent interests, whose behavioral objective is to maximize their own interests. Their decision-making becomes a double objective decision-making, to meet the requirement of the whole supply chain and maximization of their benefits. When the 2 are inconsistent, the collaboration risks produce along with it. In the other hand, in the process of supply chain optimization, objective conflicts sometimes occur between partner members, we need to optimize the different sections of the supply chain.
- Information as the carrier that link up every segment of the supply chain, play an important role in the cooperation between enterprises. The authenticity and integrity of information is not only the important guarantee for the combined efforts between node enterprises, but also risk factors that affect cooperation between the supply chain enterprises. The various members of the supply chain are independent entities. Individual members will inevitably take the speculation for their own sake in the process of the supply chain collaboration, to conceal part of their own information in the case of other members sharing their information to obtain more interests, accordingly bring risks to supply chain.
- In the process of supply chain collaboration, node enterprises are completely separate entities, which cooperate in the form of contract. The trust degree between both sides is the premise of supply chain collaboration, mutual trust within strategic alliance has a direct impact to the level of collaborative risks. Confidence is an invisible factor, damages of the supply chain caused by the lack of confidence is very difficult to quantify. Mutual trust can promote collaboration between node enterprises, improve the flexibility of production and services, enhance the bilateral sense of responsibility when unpredictable risk evens occur, suppress the immoral behavior to reduce respective risk. The mutual distrust of node enterprises in the supply chain will produce great harm to the supply chain; restrict the improvement of the supply chain synergistic benefits.
- Delivery is the cargo movement that between suppliers and manufacturers, manufactures and distributors, distributors and customers, as well as between them with logistics service provider. Delivery risk refers to the risk that caused by non-smooth information and unexpected events in the delivery process, including delivery quantity risk, delayed delivery risk, mistaken order risk, supply disruption risk and delivery flexible risk.
- Unknown increased cost of node enterprises in the supply chain will not only cause a rise cost in the enterprises, but also involve the increasing cost and reducing benefits of the whole supply chain. The incongruity of the cooperative relationship between node enterprises in supply chain will make correspondence, inventory cost and transportation cost increase. Cost risk is caused by the uncertainty of various links of procurement, production and marketing, mainly contains inventory cost risk, procurement cost risk, the risk of shortage cost and logistics cost risk.
- Culture risk is associated with the difference between node enterprises' culture and not timely communication in the supply chain. Different enterprises are different in term of value concept, business goal and moral standards. Communication disorder may occur between node enterprises in the language, behaviors and information understanding. The enterprise cultures of various links in the supply chain vary greatly in the geographical span. Different corporate cultures lead to different views on the same question to take a different approach and finally produce imparity results.
- Inventory risk is caused by the information risk to a great extent, inventory risks mainly include the risks associated with excessive inventory, the risks of slightly inventory and improper methods of inventory. Excessive inventory may cause the imbalance in the progress of supply chain production, because the excessive inventories make production process continue to work and then there are no production tasks. Similarly the slightly inventory cause the unbalance of the supply chain production, increase the production risk. The risks

of the node enterprises in the supply chain system increased with the decrease of the rest of enterprises. The mutual influence should be fully considered during the risks controlling process.

- Capability risk refers to the risks posed by the uncertainty of the strategic partner to complete the corresponding function in the supply chain. Whether the node enterprises in supply chain have the ability to accomplish the task assigned to them, have the ability to integrate the internal resource with high efficiency and could directly affect the supply chain collaboration. On the other hand, capability risk refers to the obsolescence of ability. The supply chain is developing dynamic, the development of scientific and technological progress and the pace of technology innovation continue to accelerate, putting forward higher requirement for the renewability of node enterprises. The core competence of the strategic partners cannot hold the superiority forever. The core competence is unique enterprise competitiveness. When the core competence maintains a competitive advantage, the supply chain can have a competitive strength.
- Members of the supply chain have a desire to pursue the maximization of self-interests and the asymmetric information between node enterprises, certain node enterprise has the information which other enterprises do not have, inevitably lead to moral hazard after the signing of the agreement. The moral risk has affected the establishment and permanence of partner relationship, may eventually lead to inefficiency of supply chain management. Supply chain is a group of enterprises, enterprises in the chain share the procurement, production, distribution and marketing functions through mutual cooperation to the coordinated development of the organism. The supply chain involve different benefit entity, strategic partners may do harm to the advantage of the entire supply chain for the benefit of their own interests.

The fuzzy collaboration risk analysis: In this study, we invited expert to estimate the collaboration risks and their impact to the supply chain. Then the supply chain collaboration risk is calculated by using fuzzy risk analysis methods based on trapezoidal fuzzy numbers similarity. To sum up, the supply chain collaboration risks between node enterprises include 14 aspects: S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14. We want to evaluate the linguistic terms probability of failure R of the supply chain collaboration. In this study, we use a 9-member linguistic terms set to represent the linguistic terms. Each linguistic term in the 9-member linguistic term set has a corresponding linguistic values trapezoidal fuzzy number. The Table 2 shows the 9-member linguistic term and its linguistic value trapezoidal fuzzy numbers. Table 3 shows the linguistic values R_i and L_i of the evaluating terms probability of failure and severity of loss of the risk S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14.

Table 2: 9-member linguistic term set

Linguistic terms	Linguistic values trapezoidal fuzzy numbers
Absolutely-low	{0, 0, 0, 0; 1.0}
Very-low	{0, 0, 0.03, 0.07; 1.0}
Low	{0.05, 0.1, 0.17, 0.24; 1.0}
Fairly-low	{0.18, 0.22, 0.35, 0.43; 1.0}
Medium	{0.33, 0.41, 0.58, 0.64; 1.0}
Fairly-high	{0.58, 0.64, 0.80, 0.87; 1.0}
High	{0.71, 0.77, 0.91, 0.96; 1.0}
Very-high	{0.92, 0.97, 1.0, 1.0; 1.0}
Absolutely-high	{1.0, 1.0, 1.0, 1.0; 1.0}

Table 3: Linguistic values R_i and L_i of risk factors

Risk factors S_i	Linguistic values L_i of severity of loss	Linguistic values R_i of probability of risk occur
S1	Very-low	Very-low
S2	Low	Low
S3	Fairly-low	Medium
S4	Medium	Fairly-low
S5	Fairly-low	Medium
S6	Fairly-low	High
S7	Medium	Fairly-low
S8	Medium	Medium
S9	Fairly-low	Low
S10	Fairly-high	High
S11	Medium	Fairly-high
S12	High	Medium
S13	Low	Low
S14	Low	Fairly-low

By using Eq. (11) the probability of failure R of the supply chain collaboration is calculated.

R = {very-low ⊗ very-low ⊕ low ⊗ low ⊕ fairly-low ⊗ medium ⊕ medium ⊗ fairly-low ⊕ fairly-low ⊗ medium ⊕ medium ⊗ High ⊕ high ⊗ very-high ⊕ medium ⊗ medium ⊕ fairly-low ⊗ low ⊕ fairly-high ⊗ high ⊕ medium ⊗ high ⊕ high ⊗ medium ⊕ low ⊗ low ⊕ low ⊗ fairly-low} ∅ {very-low ⊕ low ⊕ fairly-low ⊕ medium ⊕ fairly-low ⊕ fairly-low ⊕ medium ⊕ medium ⊕ fairly-low ⊕ fairly-high ⊕ medium ⊕ high ⊕ low ⊕ low}

= {(0, 0, 0.03, 0.07; 1.0)
⊗(0, 0, 0.03, 0.07; 1.0)
⊕ (0.05, 0.1, 0.17, 0.24; 1.0)
⊗(0.05, 0.1, 0.17, 0.24; 1.0)
⊕ (0.18, 0.22, 0.35, 0.43; 1.0)
⊗(0.33, 0.41, 0.58, 0.64; 1.0)
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⊗(0.33, 0.41, 0.58, 0.64; 1.0)
⊕ (0.33, 0.41, 0.58, 0.64; 1.0)
⊗(0.71, 0.77, 0.91, 0.96; 1.0)
⊕ (0.33, 0.41, 0.58, 0.64; 1.0)
⊗(0.18, 0.22, 0.35, 0.43; 1.0)
⊕ (0.33, 0.41, 0.58, 0.64; 1.0)
⊗(0.33, 0.41, 0.58, 0.64; 1.0)

$\oplus$ (0.18, 0.22, 0.35, 0.43; 1.0)
$\otimes$(0.05, 0.1, 0.17, 0.24; 1.0)
$\oplus$ (0.58, 0.64, 0.80, 0.87; 1.0)
$\otimes$(0.71, 0.77, 0.91, 0.96; 1.0)
$\oplus$ (0.33, 0.41, 0.58, 0.64; 1.0)
$\otimes$(0.58, 0.64, 0.80, 0.87; 1.0)
$\oplus$ (0.71, 0.77, 0.91, 0.96; 1.0)
$\otimes$(0.33, 0.41, 0.58, 0.64; 1.0)
$\oplus$ (0.05, 0.1, 0.17, 0.24; 1.0)
$\otimes$(0.05, 0.1, 0.17, 0.24; 1.0)
$\oplus$ (0.05, 0.1, 0.17, 0.24; 1.0)
$\otimes$(0.18, 0.22, 0.35, 0.43; 1.0)}
Ø {(0, 0, 0.03, 0.07; 1.0)
$\oplus$ (0.05, 0.1, 0.17, 0.24; 1.0)
$\oplus$ (0.18, 0.22, 0.35, 0.43; 1.0)
$\oplus$ (0.71, 0.77, 0.91, 0.96; 1.0)
$\oplus$ (0.92, 0.97, 1.0, 1.0; 1.0)
$\oplus$ (0.33, 0.41, 0.58, 0.64; 1.0)
$\oplus$ (0.71, 0.77, 0.91, 0.96; 1.0)
$\oplus$ (0.33, 0.41, 0.58, 0.64; 1.0)
$\oplus$ (0.18, 0.22, 0.35, 0.43; 1.0)
$\oplus$ (0.58, 0.64, 0.80, 0.87; 1.0)
$\oplus$ (0.33, 0.41, 0.58, 0.64; 1.0)
$\oplus$ (0.71, 0.77, 0.91, 0.96; 1.0)
$\oplus$ (0.05, 0.1, 0.17, 0.24; 1.0)
$\oplus$ (0.05, 0.1, 0.17, 0.24; 1.0)}

= (0.7777, 0.8837, 0.9810, 0.9976; 1.0)
Ø (0.9904, 0.9955, 0.9972, 0.9993; 1.0)
= (0.7851, 0.8861, 0.9788, 0.9971; 1.0)

$$y_R = \frac{w_r \times (\frac{0.9788 - 0.8611}{0.9971 - 0.7851} + 2)}{6} = 0.4133$$

$$x_R = \frac{0.4133 \times (0.9788 + 0.8611) + (0.9971 + 0.7851)(1 - 0.4133)}{2} = 0.9103$$

The degree of similarity between the linguistic value trapezoidal fuzzy numbers R and Absolutely-high can be calculated as follow:

S(R, Absolutely-high) =

$$1 - \frac{(|0.7851 - 1.0| + |0.8861 - 1.0| + |0.9788 - 1.0| + |0.9971 - 1.0|)}{8}$$

$$-\frac{\sqrt{(0.9103 - 1)^2 + (0.4133 - 0.5)^2}}{2\sqrt{1.25}} = 0.84132$$

In the same way, we can get the degree of similarity between the linguistic value trapezoidal fuzzy numbers R and the other linguistic terms, as shown in Table 4.

From the Table 4, we can see S (R, High) has largest value, which means the probability of failure R of the supply chain collaboration risks is high.

Table 4: The degree of similarity

Linguistic items X_i	The degree of similarity S (R, X_i)
Absolutely-low	0.13149
Very-low	0.17026
Low	0.25673
Fairly-low	0.42453
Medium	0.58766
Fairly-high	0.83120
High	0.93421
Very-high	0.90135
Absolutely-high	0.84132

CONCLUSION

In this study, we propose an efficient fuzzy risk analysis method for supply chain collaboration risk evaluation. The probability of failure and severity of loss of the risk factors are presented by trapezoidal fuzzy numbers. We can evaluate the collaboration risk by calculating the similarity degree of trapezoidal fuzzy numbers. At last an example is used to identify the correct of this method.

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