Risk Measurement and Emergency Management of Spare Parts Support Supply Chain System

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Abstract: Under the competitive environment of Internet of Things, the basic condition for spare parts to ensure the stable operation of supply chain system lies in the effective early warning and control of the risks in emergency situations. Based on the practice of spare parts supply chain system, this paper analyzes the risk factor set of spare parts supply chain, and gives a fuzzy evaluation method to measure the risk of spare parts supply chain system. It solves the disadvantage that the risk analysis of spare parts supply chain system is separated from the node risk analysis in the past, thus obtaining effective early warning and emergency management for the risk of spare parts supply chain system. The method has obvious application value and significance for selecting and evaluating spare parts to support supply chain contractors and strengthening emergency management of supply chain system efficiency risks.

Keywords: spare parts support; supply chain; Emergency management

1. Introduction

Spare parts support supply chain is a network system consisting of all internal and external entities involved in the process of military aircraft spare parts support, as well as their activities and relationships. The system risk of spare parts supply chain refers to the possibility that the spare parts supply chain will encounter uncertain events and cause uncertain results, that is, the possibility that the spare parts supply chain deviates from the predetermined target. Objectively, the supply chain is characterized by multi-participants, trans-regional and multi-links, which makes the supply chain vulnerable to the external environment and the internal unfavorable factors of each entity in the chain, thus forming the emergency risk of the supply chain. In other words, there are many influencing factors of spare parts support risk, including natural disasters and other force majeure factors, such as earthquake, fire, storm and snow, etc. There are also human factors, such as the default of key cooperation contractors, and some information in the influencing factors is known, and some information is unknown. In the practice of spare parts support risk management, it is impossible to accurately describe the risk degree of many factors in spare parts support supply chain system risk. In recent years, research on supply chain risk management shows that some progress has been made in identifying supply chain risks in emergency environment. But generally speaking, there is still a considerable gap between domestic research on supply chain risk management, especially in quantitative research and international frontier research. The purpose of this paper is to focus on the risk factors of spare parts supply chain system, and determine the warning forecast line of spare parts supply chain system by measuring and analyzing the risk of spare parts supply chain system, so as to effectively select cooperative contractors and carry out risk management of spare parts supply chain system [1].

2. Spare Parts Support Supply Chain System Risk Factors Analysis

There are many risk factors affecting spare parts support. To measure the risk of supply chain system, it is far from enough to simply analyze the risk factors of upstream and downstream contractors. The cooperation between contractors in supply chain will inevitably produce risks, and external environmental factors will also bring certain risks to the supply chain. Therefore, when analyzing the risk factors, we should make a concrete analysis from point to point. For the sake of simplicity, considering the above effects comprehensively, seven factors, namely information, logistics, quality, cost, service, reputation and flexibility, are taken as the evaluation factor set to evaluate the reliability level of spare parts supply chain system [2].

(1) Information. Whether the procurement, manufacturing, cargo flow, inventory and transaction information of the supply chain contractor of spare parts support are continuously carried out in the whole spare parts support, and whether all important customers effectively transmit connections.

(2) Logistics. Spare parts support the supplier's operational support ability of logistics distribution, including the delivery accuracy of logistics documents, the timely delivery rate of goods and the timely delivery rate, etc.

(3) Quality. Spare parts support the delivery quality of the contractor. Mainly including safety, reliability, advancement, machine performance and other quality

standards.

(4) Cost. In the spare parts support, the cost should be understood as all possible costs in the service life, that is, not only the purchase cost of spare parts should be considered, but also various late-stage costs needed to ensure the normal use of spare parts, such as supporting facilities, consumption of spare parts and energy, maintenance and repair costs, etc.

(5) Services. Generally including pre-sale services, in-sale services and after-sale services. Services can include service contract, service commitment, warranty period, response time, goods supply, maintenance force, technical support, etc.

(6) Reputation. The strength of suppliers can be measured by the reputation of spare parts suppliers, and the reputable spare parts suppliers can guarantee the stable performance of spare parts support. Mainly includes the supplier's popularity, scale, market share, supply history performance, etc.

(7) Flexibility. The agility of spare parts supply chain system to reflect market changes. It mainly includes time flexibility and quantity flexibility. Time flexibility refers to the speed of supply chain responding to customer demand; Quantity flexibility refers to the ability of supply chain to deal with the change of customer demand quantity [3].

3. The Fuzzy Measure of Spare Parts Supply Chain System Risk

For convenience, the risk of spare parts supply chain system is generally measured by calculating the reliability of spare parts supply chain system. The basic idea of using fuzzy comprehensive evaluation method to measure the risk of spare parts support is to comprehensively consider various risk factors of spare parts support supply chain system, determine the reliability of each risk factor, and then calculate the reliability of the whole spare parts support [7]. According to the analysis results in the previous section, among the seven evaluation factors listed, logistics, quality and cost risk factors can be further decomposed into quantitative evaluation indicators. On the one hand, the quantification of evaluation index is to obtain the characteristic value reflecting each evaluation index through calculation or evaluation; On the other hand, because of the different dimensions, it is impossible to unify the comparative evaluation indexes. First, these indexes can be fuzzified, and the membership function can be used to convert each index into a membership degree between 0 and 1:

$$g_s = \begin{cases} 1, f_s > m_s \\ \dfrac{f_s - m_s}{M_s - m_s}, m_s \le f_s < M_S \\ 0, f_s < m_s \end{cases}$$

Where, f_s is the value of index, M_s is the ideal maximum value and m_s is the required minimum value of index. Risk factors such as reputation, service and flexibility often exist in the form of qualitative indicators, and their values can be determined by expert scoring method in specific analysis. The processing method is as follows: the evaluation grade set V = {low risk, general risk, high risk}, and its corresponding score is: $X = \{x_1, x_2, x_3\}$. The expert scores the evaluation index according to the supply chain risk situation, and normalizes the result, $Y = \{y_1, y_2, y_3\}$ and the fuzzy processing result of the index is: $g = Y \bullet X^T, g \in [0,1]$.

The concrete steps of evaluating the reliability level of spare parts supply chain system are as follows:

(1) Let the evaluation factor set be $u = \{u_i\}$, where, $i = 1,2,\cdots,n$ .The evaluated factor is expressed u_i. According to the established risk evaluation index of spare parts supply chain system, the evaluation factor set u is: u = {information, logistics, quality, cost, service, reputation, flexibility}.

(2) Evaluation grade set V = {low risk, general risk, high risk}, and its corresponding standard score is $X = \{x_1, x_2, x_3\}$.

(3) Single factor evaluation is carried out, and the fuzzy relation matrix between factor discourse domain and comment discourse domain is established as follows:

$$R = (r_{ij})_{n\times m} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

Among them, r_{ij} represents the factors u_i have the subordinate relationship of comments v_j.

(4) Determine the weight. The importance of u_i in the risk assessment of the whole supply chain system is expressed by its weight. If the weight is a_i, the weight set is $A = \{a_i\}$, $0 \le a_i < 1$. In order to make the distribution of each weight scientific and feasible, AHP method can be used to determine the weight of evaluation index.

(5) By the evaluation index set: $u = \{u_i\}$, calculated: $B = A \cdot u = \{a_i\} \cdot \{u_i\}$. After normalization, three grades of scores B' are obtained, and the matrix is established: $V = \{C_1, C_2, C_3\}$, then the reliability level of spare parts supply chain system is $X = V \cdot B'$.

4. Spare Parts Support Supply Chain System Risk Early Warning Management

After obtaining the fuzzy measure (reliability) level of spare parts supply chain system risk, in order to carry out effective emergency management of spare parts supply

chain system, it is necessary to determine the warning forecast line of spare parts supply chain system risk, so as to judge the risk degree of spare parts supply chain system. The key to scientifically define the warning forecast line of spare parts supply chain system risk lies in reasonably selecting some thresholds of spare parts supply chain system risk. Generally, according to the actual needs, the rough boundaries of several thresholds can be drawn up first, which can be used as the actual effect division of police officers' intelligence level. After that, after continuous revision through practice, the warning forecast line with certain reliability can be finally determined. If the risk of a certain spare parts supply chain system is measured and forewarned, after comprehensively considering the above risk factors, the evaluation set of reliability R is defined as V = {low risk, general risk, high risk}, and its corresponding values are {1.0, 0.7, 0.4}. It is considered that the spare parts support supply chain system is safe when R>0.7, and dangerous when R<0.3, and the spare parts support supply chain system is in between After determining the evaluation factor set and the corresponding evaluation criteria, each risk factor and its weight are evaluated independently according to the fuzzy evaluation method, and the evaluation matrix and weight matrix of each risk factor are constructed, so as to calculate the fuzzy measurement value of risk factors in spare parts supply chain system. As shown in Table 1.

Table 1. Fuzzy measurement value of risk factors in spare parts supply chain system

Evaluation factor	Weight	Fuzzy measure value		
		A	B	C
Information	0.2	0.32	0.40	0.26
Logistics	0.1	0.30	0.18	0.28
Mass	0.2	0.25	0.25	0.32
Cost	0.1	0.13	0.14	0.11
Service	0.2	0.25	0.26	0.19
Reputation	0.1	0.08	0.16	0.30
Flexibility	0.1	0.21	0.06	0.15

Using fuzzy matrix distribution method, the normalized fuzzy evaluation set of the above evaluation indexes is $V=(0.384,0.327,0.289)$, and the score corresponding to the matrix after grade assignment is $B=\{0.853,0.7972,0.862\}$, according to the formula

$$B=V\cdot B^{'}=(0.348,0.327,0.289)\times\begin{bmatrix}0.853\\0.772\\0.862\end{bmatrix}=0.7984$$

That is, the reliability level of the spare parts support supply chain system is 79.84% (safety).

5. Conclusions

Spare parts supply chain is a complex and cross dynamic system covering contractors at all levels and end users. The cooperation between contractors of spare parts supply chain will lead to various risks due to information asymmetry, information distortion, market uncertainty and other political, economic and legal factors. Studying and managing the risks of spare parts supply chain system can improve the value of spare parts support from the aspects of reducing the transaction cost, reducing the expected cost of interruption of spare parts support and improving the satisfaction rate of military demand. The fuzzy risk measurement method of spare parts supply chain system established in this paper can evaluate the risk factors often faced in spare parts supply chain system as a whole, so as to control the risk of spare parts supply chain system more effectively.

References

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