Risk index evaluation algorithm of intelligent networked vehicle supply chain based on big data analysis

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ABSTRACT

Intelligent network connected vehicle is an important development direction of cutting-edge science and technology, which has a significant impact on intelligent transportation, modern logistics and other aspects. The environment awareness system is the foundation and guarantee of the safety and intelligence of the intelligent network connected vehicle. The application of intelligent and automatic driving technology to automobiles has become an inevitable trend in the future development of automobile industry. The complexity of the product structure and application technology of intelligent and connected vehicle(ICV) has brought great changes to the industrial ecological chain, which also determines the potential high risk of its supply chain(SC). Taking the automobile industry as the research object, this paper identifies the SC risks in the development of new products in the automobile industry. After screening, and combining with the characteristics of the automobile industry SC, the SC risks in the development of new products are classified into six categories: supply risk, manufacturing process risk, demand risk, cooperative relationship risk, logistics and distribution risk and external environmental risk. This paper aims to provide theoretical methods and strategic support for the risk management of automobile green SC, and promote the sustainable development of automobile green SC in China.

Key words: Big data analysis; Intelligent networked car; Risk of Supply chain; Risk index; Evaluation algorithm

1. INTRODUCTION

With the application of communication technology in the field of intelligent transportation, pedestrians and traffic infrastructure are connected to the communication network to improve driving safety and traffic efficiency, and intelligent and connected vehicle was born [1]. The development of the automobile industry is a microcosm of China's progress towards modern industrialization. Over the past 40 years, our country has gone from "lacking weight, less light, and no sedan" to "cars into thousands of households", completing the 100 year industrialization process of the old capitalist countries, which fully reflects the important achievements of China's industrial development. However, we should pay more attention to that although we are the world's first "auto power", there is still a big gap between us and the "auto power" [2]. At the same time, the production and marketing of automobile products are large, and there are high requirements for the scale benefits brought by large-scale procurement, production and sales. Therefore, The automotive industry must maintain the stability of the SC [3].

According to the relevant data as of June 2019, from 2009 to 2017, there were an average of 208,000 traffic accidents every year in China, resulting in more than 55,000 deaths. Among all traffic accidents, rear-end collisions accounted for 36.03%, resulting in 40.69% of economic losses and 55.08% of deaths. It can be seen that rear-end collisions rank first among all kinds of traffic accidents, and most of them are vicious accidents. Enterprises in the SC are closely connected. When a certain node enterprise has a risk event, other enterprises in the SC may be affected by it. Therefore, it is necessary not only to enrich the content of SC risk management in theory [4], but also to strengthen the investment in risk management in practice [5]. Improving the competitiveness of automobile enterprises is called the top priority. At this point, the competition between SCs becomes the embodiment of market competition [6].

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Intelligent Connected Vehicle is an important development project of cutting-edge science and technology [7]. It not only has a significant impact on social and economic development, national defense construction, scientific and technological development and other aspects, but also has great potential to ensure traffic safety and people's life and property safety [8].

Combining the theories of SC risk assessment and risk warning with the actual situation of China's automobile manufacturing industry, this paper can theoretically enrich the related content and application scope of SC risk management. Taking the improved SCOR model and comprehensive risk management theory as the risk identification principle of intelligent networked automobile SC, and taking academic research in related fields, national standard documents and authoritative reports of the industry as the support for risk identification, the risk evaluation index system of intelligent networked automobile SC is established. Based on the extension matter-element theory, the risk evaluation model of intelligent networked automobile SC is established, and the improved variable weight analytic hierarchy process is introduced as the index weight determination method. The risk sources are analyzed and management suggestions are given.

2. CONSTRUCTION OF RISK EVALUATION INDEX SYSTEM OF INTELLIGENT NETWORKED AUTOMOBILE SC

2.1 Research on supply chain risk management

On the basis of summarizing the previous definitions, different definitions are given: in the course of action aimed at specific interests, if there is a possible loss (potential loss) that is contrary to the original interests, the situation that the potential loss causes harm to the action subject can be called the risk faced by the action. In the SC financing mode, it leads to contagion of default, but usually it can be controlled within a single enterprise or a small group of enterprises [9]. The feature of contagion of default is more rapid and obvious in SC financing. When an enterprise defaults on credit, it may quickly spread to upstream and downstream enterprises, affect the stability of SC financing, and eventually lead to the full outbreak of default [10]. Therefore, in the process of risk management, it is necessary to find a balance between risk prevention cost and risk loss. On the one hand, efforts should be made to reduce risk prevention cost, on the other hand, risk loss should be controlled within a certain range. In general, we choose the lowest input cost and the lowest risk level, but the lowest overall loss. The cost can be divided into the cost to be paid to prevent risks and the loss caused by actual risks. Supply Chain Operations Reference Model (SCOR) is a set of SC process combing system built by the International Supply Chain Association. The model can be divided into three levels, in which the basic SC process types include planning, purchasing, production, distribution and return, as shown in Figure 1.

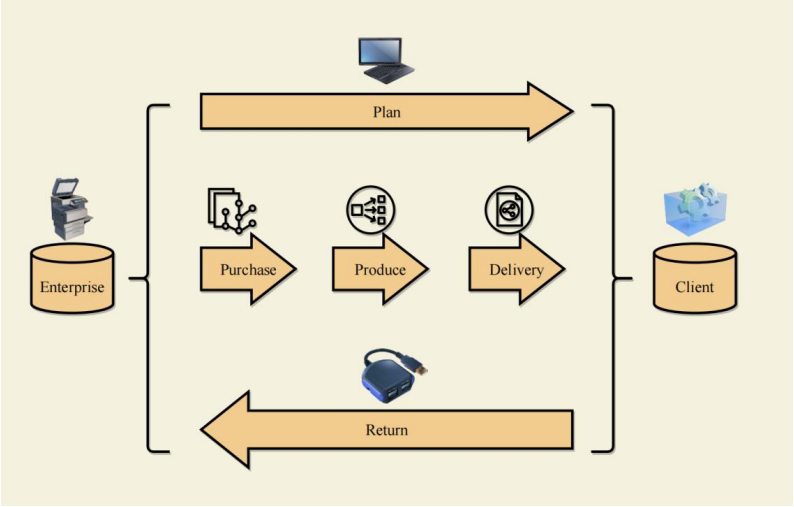

Figure 1. Basic process of SCOR model

Based on the definitions of various green SC risks, this paper defines the green SC risks as follows: Green SC risks refer to the risk events brought by various unpredictable uncertain factors in a certain environment, a certain period and a specific

whole, which affect the normal operation of green SC, and eventually lead to the deviation of green SC management from the original goal, or even the paralysis of the whole green SC system.

The traditional SC model can no longer meet the needs of current market competition. Therefore, enterprises will use external resources to maximize the satisfaction of market demand, so that a new SC management model emerges. At this time, the SC pays more attention to cooperation between enterprises and a network chain relationship around core enterprises. First, the SC is a network chain structure, which connects upstream and downstream enterprises as a whole. It is not only a functional chain, but also a logistics chain, capital chain and information chain. Second, the SC is a value-added chain, in which all enterprise nodes will benefit from their own business activities. Finally, the SC has developed into a network chain structure including all affiliated enterprises. In terms of scope, it includes more enterprise nodes; In terms of structure, all enterprises are connected as a network structure mode, and all enterprises in the whole chain are more closely connected. The SC network chain structure mode is shown in Figure 2.

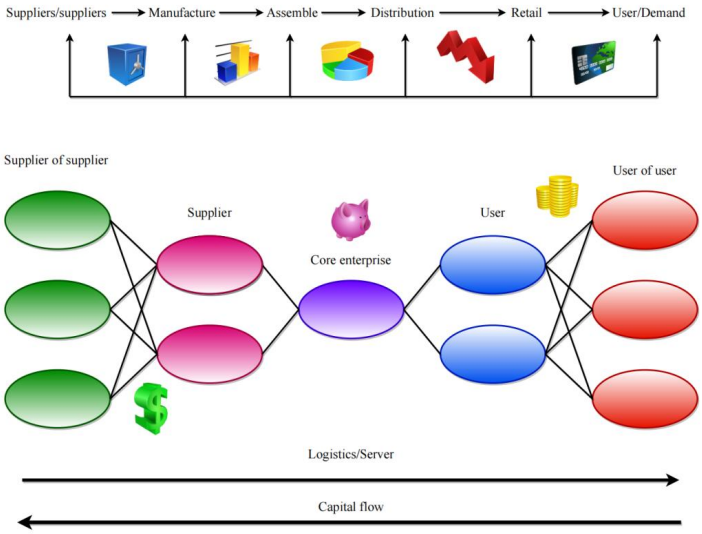

Figure 2. Supply chain network structure mode

As can be seen from Figure 2, the SC is a logistics chain or service chain that connects upstream enterprises and downstream enterprises. Through the transmission of the SC, the upstream enterprises can formulate production strategies and meet the needs of users through the business activities of vendors. This is a typical demand-driven process. In addition, due to the design and technological innovation of upstream enterprises, new products or services appear, and users will also have the demand for consumption. This is a production-driven logistics chain process.

2.2 Models and characteristics of automobile SC

In this way, financial institutions no longer consider the credit risk of a single enterprise, but develop a reasonable financing scheme according to the SC. Through SC financing, on the one hand, they can ease the financing difficulties of SMEs, On the other hand, improve the operation efficiency of the whole SC system. Supply chain risk identification is to discover the potential risk elements in the SC operation process, analyze the causes and laws of each risk event, summarize the characteristics of each risk event, and find out the relationship between each risk event. Accurate identification of objective or potential risk factors in the SC is the basis for effective SC risk management. If the risk identification is not comprehensive or accurate, the next risk management work will be futile.

Based on the premise of sustainable development, the green SC of automobile comprehensively considers resource allocation and environmental problems in the life cycle of automobile products from raw material procurement, manufacturing, processing, storage, transportation and use, and finally to automobile waste treatment and recycling, so as to realize the best state of the whole automobile green SC system environment. Obviously, the flow direction between the automobile green SC and the traditional SC is different. In the traditional automobile SC, the logistics, capital flow and information flow are unidirectional, while in the automobile green SC, the flow direction is bidirectional. In addition, from the perspective of long-term development, the traditional automobile SC has certain drawbacks, first of all, it is reflected in

the enterprise's own benefits, which can't obviously improve its benefits; Secondly, it has little effect on environmental and social benefits. Moreover, in the long run, some capabilities of the automobile manufacturing industry will be weakened, such as strategic management capability or competitiveness.

3. RISK EVALUATION MODEL OF INTELLIGENT NETWORKED AUTOMOBILE SC

3.1 Supply chain risk evaluation model

Due to the correlation between various risk assets, the measurement of portfolio risk cannot simply add the risk values of each risk asset, but adopt a certain method, Take this correlation into account. However, it is not enough for SC risk assessment to simply assess the possibility of risk occurrence and the possible impact or loss. It cannot fully reflect the relevance and transmissibility of SC risk and other essential characteristics. It should also assess the risks that key facilities, node enterprises, process channels, etc. may suffer, the response time to SC risk, and once the risk occurs, its development speed The duration should be evaluated.

Order $R(R_1,...,R_d)$, where d refers to the four processes in the operation process of automobile manufacturing enterprises (the number of risky assets in the portfolio), and R_i refers to the risk of the i process (the loss in the portfolio), with a marginal distribution of $F_i(R_i)$.

$$R = (F^{-1}_1(U), F^{-1}_2(U), \cdots, F^{-1}_d(U)) \tag{1}$$

Where u is a random variable with uniform distribution, the domain is [0,1], and $F^{-1}_i(U)$ is the inverse function of $F_i(R_i)$. It is the risk value of the process at the confidence level.

$$VaR^a(R_s) = \sum_{i=1}^{d} VaR^a_i \tag{2}$$

Calculate the sample correlation coefficient matrix:

$$r_{ij} = \frac{1}{n-1}\sum_{t=1}^{n} x_{li}x_{ij}, i, j = 1,2,...,n \tag{3}$$

The principal component analysis method is mainly used to determine the eigenvalues and eigenvectors in the matrix. The magnitude of the eigenvalues can reflect the amount of information contained in the indicators. In practical applications, sensitive factors with eigenvalues greater than 1 are usually selected, and the principal component factors are defined according to the economic meaning.

$$C(F_1(R_1), \cdots, F_d(R_d)) \geq \max\left[\sum_{i=1}^{d} F_i(R_1) - d + 1, 0\right] \tag{4}$$

An upper bound of risk value is pointed out.

3.2 Experimental analysis results

In this paper, an automobile manufacturing enterprise with whole vehicle manufacturing as its core is selected as the research sample. According to the above analysis of SC process, enterprise strategy and culture risk, parts purchasing risk, assembly manufacturing process risk and sales risk are selected as the first-level indicators of SC risk assessment. Similar to the estimation of overall risk value, the first-level indicators are estimated by opula function of the second-level indicators. To simplify the research, this is the opula function estimation process which mainly lists the overall risk. When there are multiple maximum membership degree evaluation results, it is impossible to choose. Median method and barycenter method can improve the deficiency of maximum membership method, but median method can't show the role of key factors, so it is not widely used.

After the driver's artificial assessment and the characteristic analysis of braking data, the Class I risk can be assessed as high predictability risk, the Class II risk as high predictability risk, the Class III risk as medium predictability risk, the Class IV risk as low predictability risk, and the Class V risk as low predictability risk. As shown in Table 1 of Figure 3 and Figure 4.

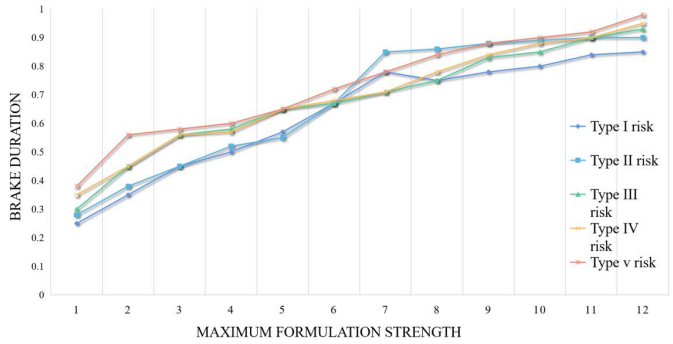

Figure 3. Braking clustering results

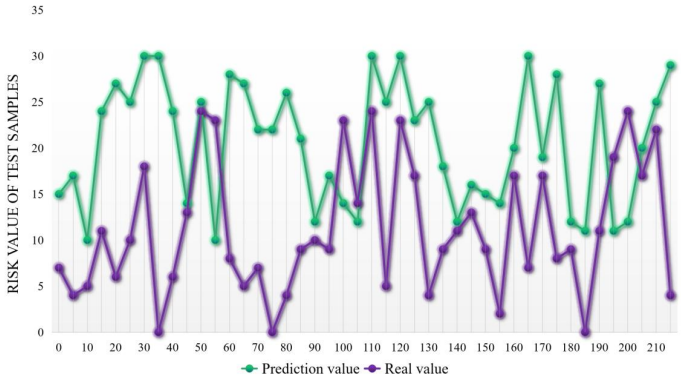

Figure 4. Determining the number of cluster centers based on CFSFDP algorithm

Table 1. Build training set and test set

Risk level	Category	Sample number
Type I risk	Train	14
	Test	6
Type II risk	Train	21
	Test	50
Type III risk	Train	27
	Test	23
Type IV risk	Train	15
	Test	16
Type v risk	Train	130
	Test	26

From a mathematical point of view, SC risk refers to a probability distribution. The SC operation entity can assign a probability value for any possible risk event according to a reasonable calculation or empirical value. From the perspective of management, SC risk early warning refers to a management method to prevent risks in advance. The SC operation subject, by observing the pre designed risk sensitive indicators, timely discovers the risk factors beyond the safety range, manages and controls them, and takes response measures to ensure the safe and orderly operation of the SC. In addition, the financing of spare parts enterprises under the SC financing mode by commercial banks is not completed at once, but will continue with the production and operation process of enterprises. During this period, spare parts enterprises may fail to complete the agreement on time due to business problems. The default of parts enterprises is not instantaneous, but caused by a series of internal and external factors in the business process. Increasing information control over enterprises under the SC financing mode is the key way to prevent such events. Commercial banks cannot always pay attention to the dynamics of financing entities in real time. Improving the information construction of each entity under the SC financing mode is the fundamental method to reduce loan losses.

Nowadays, the Internet has created a means of collaborative work, which has a far-reaching impact on the SC, making the SC management enter the deep-seated and whole-process management at the SC level from the real sense. According to the regression results of the model, the judgment accuracy rate of traditional parts enterprises in T+1 year for default enterprises is only 50%, while that of new energy and intelligent networked parts enterprises remains unchanged. By analyzing the reasons, it can be found that the production and sales of fuel vehicles declined significantly in 2018, and the production and sales of new energy vehicles continued to increase. This shows that the application of the model in the contraction period of industry development is not accurate enough. It also indirectly shows that the credit risk assessment of parts and components enterprises under the SC financing mode is a whole evaluation process, which needs to consider the operating conditions of core enterprises in the SC, the turnover of capital flow and information flow in the SC, and the operating conditions of parts and components enterprises themselves. But at a deeper level, China's commercial banks have not yet established a mature SC risk management mechanism and credit risk evaluation system. Many banks' credit risk evaluation of SC financing is still limited to traditional credit rating financing forms and mechanisms. Compared with traditional financing models, SC financing has more subjects, more complex process operations, and different principles from traditional financing models to reduce credit risk. Therefore, Risk control management is the most important part of the SC financing model. The above are the circular steps of SC risk alert status. If there is no alternative risk response scheme in the alternative scheme library, an expert group needs to be organized to formulate one or more new risk response schemes. If the proposed scheme can reduce or eliminate SC risks in a timely manner, the new scheme should be input into the scheme library of the system for future use in case of similar SC risks.

4. CONCLUSION

With the prevalence of global manufacturing and the rapid development of network information technology, the competition between enterprises has gradually become the competition between SCs. Supply chain management has become an important means for enterprises to enhance their competitiveness and obtain competitive advantages. The development of green SC has become an inevitable trend in today's society. Green SC management brings competitive advantages to automobile manufacturing enterprises, but it also inevitably brings some risks. Because of the development trend and the complexity of the implementation of green SC, researchers in various management fields pay close attention to the risk research of green SC. In this paper, the risk management of intelligent networked automobile SC is studied, and the risk evaluation index system of intelligent networked automobile SC is established from two dimensions of improved SCOR model and comprehensive risk management theory. The risk evaluation model is established by using the extended matter-element method and the improved variable weight analytic hierarchy process, and the risk evaluation is carried out by taking China's intelligent networked automobile industry SC as an example. From the evaluation value, it can be seen that the SC risk of Chery Automobile in product development is between the general and high risk level, and the risk values of six kinds of risks are supply risk, cooperation risk, manufacturing process risk, demand risk, logistics and distribution risk and external environment risk in turn, which has certain reference value and practical significance for Chery Automobile in new product development.

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