

# Application of AHP-FUZZY Comprehensive Evaluation Method on the Evaluation of Enterprises' Logistics Outsourcing Risks

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## Abstract

To evaluate the enterprises' logistics outsourcing risks including financial risk, information risk, market risk, management risk, etc. by building the AHP-FUZZY model; to explore the feasibility of AHP-FUZZY model in the enterprises' logistics outsourcing risks evaluation. To build the enterprises' logistics outsourcing risks evaluation index system based on the logistics outsourcing risks concept, identifying the weight of index system at all levels with the judgment matrix built by analytic hierarchy process. Then to conduct the comprehensive evaluation on the enterprises' logistics outsourcing risks with FUZZY comprehensive evaluation model built by weight sets and fuzzy evaluation matrix. According to instance analyses, the enterprises' logistics outsourcing risks evaluation index system possesses definite scientific and practical features, and the AHP-FUZZY comprehensive evaluation method is rational and feasible in the enterprises' logistics outsourcing risks evaluation.

Key Words: LOGISTICS OUTSOURCING, RISK ASSESSMENT, AHP-FUZZY COMPREHENSIVE EVALUATION

## 1. Foreword

Logistics outsourcing, a long-term, strategic, mutually permeating and beneficial manner for third-party business entrusting and contractual execution, has become a development trend in the market with refined commercial division, especially in the internet economy. The logistics outsourcing service is a double-edged sword. Only proper use of it could lead to good effect; otherwise the own benefit of the user would be affected.

Since 1990s, domestic and foreign scholars have conducted meticulous study on business logistics outsourcing risks from different perspectives. Bradi and Cooke et al, (1994) maintained that the biggest risk of logistics outsourcing is poor control on the third-party logistic service provider. The controllability risk may cause adverse impact on the quality control

and delivery period of enterprises. From the perspective of cost control, scholars such as Cross (2002), et al, studied the risk of logistics outsourcing, arguing that logistics outsourcing may bring with it quite high implicit cost and lead to the rise of management cost and transaction cost. Chinese scholars He Mingke, Zhang Xin (2008), summarized the risks of logistics outsourcing as environmental risk, market risk, self-control risk, potential risk from third-party logistic service provider and cooperation risk. On this basis, starting from the source of the logistics outsourcing risks, the author studies the risks of business logistics outsourcing and summarizes these risks as four major categories: financial risk, information risk, market risk and management risk.

Studies on business logistics outsourcing risks appraisal index system develops fast in recent years.

Chinese scholar Zhang Xin (2008) proposed an appraisal index system containing four first-grade indexes including market risk, internal control risk, coordination risk and potential contractor risk and twenty second-grade indexes; Zeng Xiaohong (2015) established a business logistics outsourcing risk control model for small and medium enterprises (SMEs) and proposed the SMEs logistics outsourcing risk matrix method. Based on traditional risk matrix principles, this SMEs logistics outsourcing risk matrix method integrated the essentials of the Delphi method, BOR-DA sequence value method and the analytic hierarchy process (AHP). According to the research results above, the author establishes this logistics outsourcing risk appraisal index system which is divided into two grades: the first grade includes four first-grade indexes: financial risk, information risk, market risk and risk management; each first-grade index includes four second-grade indexes, so there are 16 second-grade indexes in total.

If the business logistics outsourcing risk appraisal index system, uses AHP for appraisal, it would be subject to the influence of subjective factors of the experts; while the FUZZY method would fall short of the hierarchy of the indexes. Therefore, for the appraisal of a multi-hierarchy comprehensive business logistics outsourcing risk appraisal index system, AHP and FUZZY shall be combined to form a comprehensive AHP-FUZZY appraisal method which would make full use of the advantages of these two appraisal methods and overcome the respective shortages of them.

## **2. Source of logistics outsourcing risks and the establishment of the risk appraisal index system**

### **2.1. Source of logistics outsourcing risks**

The logistics outsourcing risks comes from multiple sources. In general, such sources are internal environment and external environment of the enterprises, the information distortion, poorly executed management in the business logistics outsourcing process as well as financial crisis. Only upon knowing these concrete risks from every aspect could enterprises know about what disadvantages there will be if the logistics outsourcing selections are improper. The defects must be identified first before the conclusions of reasons and the determination of reasonable and scientific solutions. As a portfolio of operation, business logistics outsourcing is based on the common interest of logistic service providers and enterprises. Though complicated, business logistics outsourcing has high openness. The so-called complexity is mainly reflected through the mutual interactions between the principals and the agents, plus poor communication

between enterprises and logistic service providers as well as problems emerging in the outsourcing management process, such as those related to decision-making, organization and management. All of such problems would have impact on the logistic sourcing of enterprises and bring potential risks.

(1) From the external environment, the logistics market for Chinese enterprises is not perfect enough, exposing the enterprises to quite high market risk of logistics outsourcing. Huge risk hidden in an imperfect market could hardly be identified. China's logistics industry has just started development and is now in the process of reform. Currently, China's logistics industry has not formed a perfect system. Compared to the scale of the foreign counterpart, China's infrastructure is relatively lagging behind. Besides, the shortage of China's laws and policies, uncertainty in the enforcement process and regional protectionism, among other factors, may all bring risks and hurdles to the set-up of business logistics outsourcing. Concretely speaking, such risks and hurdles are mainly reflected in following detailed aspects: first of all, business logistics outsourcing has not formed an effective logistics transportation network with mature and uniform arrangement and layout, so it is still very scattered and lacks of uniform coordination in general. Besides, a whole set of scientific and systematic business operation procedure is not in place, leading to especially severe phenomenon of repeated construction and investment by enterprises, not only affecting the own efficiency of business logistics outsourcing but also the realization of the enterprises' economic benefits and efficiency; secondly, the informatization is relatively in low level, which is mainly shown in low involvement of computer network and relatively lagging-behind transportation equipment. Such defects lower the efficiency of information transmission to a great extent and increase the difficulty of the logistics industry's fast development; in addition, laws and regulations governing the logistic industry are a mess-up. They are from multiple governing institutes and authorities and specific laws and regulations on logistics outsourcing are extremely rare, showing an imperfect system of corresponding laws and regulations. Therefore, logistics outsourcing operations could not be effectively protected by law, significantly increasing the risks for enterprises to unfold logistics outsourcing.

(2) From the internal perspective, enterprises have low management capacity and level, posing management risk for logistics outsourcing. As enterprises' own management level is low, there are problems for the control on and management means of external lo-

gistics outsourcing, and the management system is not perfect as well. Analyzing from the subjective point of view, the lagging-behind notion of logistic management is to blame. In particular, some state-owned enterprises focus on production but ignore management and lack of the initiatives for logistic reform and innovation; from the objective point of view, the overall layout of enterprises could hardly adapt to the pace of modern logistic development, as the current layout lacks of logistic planning and design.

(3) Limited rationality of decisions. Decisions are about making choices. According to Simon, a decision science expert, human beings have limited rationality. Therefore, their decisions are also featured with limited rationality. Enterprises must consider whether they would deal with logistics by themselves or outsource logistic services. This is a decision-making problem itself. Under normal conditions, limited by subjective and objective conditions, commercial and industrial enterprises only have limited access to information related to logistic service providers in the logistics outsourcing process. While making logistics outsourcing decisions, enterprises could only make decisions of limited rationality as they could not gather full information or materials of all logistic service providers. Under incomplete information, making limited-rationality decisions could only lead to a satisfactory solution, not the optimal solution. Once an enterprise chooses the wrong partner for logistics outsourcing, the enterprise would experience huge losses.

(4) Because of the asymmetry of information, business logistics outsourcing would also face information risk. No matter it is before or after signing the logistics outsourcing agreements, more or less, the two parties would face severe information asymmetry. In general, the cargo-owning enterprises are in the receiving end of the information asymmetry, while logistic service providers would get the upper hand of at this point. Undoubtedly, this would pose potential information risk for the enterprises as principals of logistics outsourcing.

**2.2. The establishment of the logistics outsourcing risk appraisal index system**

To sum up, logistics outsourcing decisions would bring various risks to enterprises. To effectively guard against such risks, enterprises must establish a perfect logistics outsourcing risk appraisal index system in the first place to help the enterprises reasonably avoid the risks so that the benefits of the enterprises would not be harmed by logistics outsourcing. Based on the traditional logistics outsourcing risk appraisal indexes, the author refers to relevant logistics outsourcing risk appraisal systems proposed by other scholars and targets the source of logistics outsourcing risks, proposing four first-grade indexes: financial risk ( $B_1$ ), information risk ( $B_2$ ), market risk ( $B_3$ ) and management risk ( $B_4$ ). Each first-grade index further includes 4 second-grade indexes, meaning there will be 16 second-grade indexes in total.

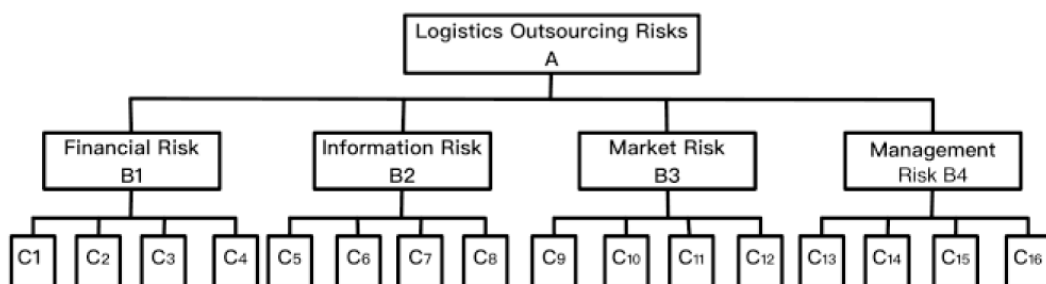
The financial risk ( $B_1$ ) includes four second-grade indexes below: equipment investment cost ( $C_1$ ), implicit cost ( $C_2$ ), risk of out-of-control cost ( $C_3$ ) and financial status of logistics contractors ( $C_4$ );

The information risk ( $B_2$ ) includes four second-grade indexes below: information communication channels of the two parties ( $C_5$ ), information asymmetry status ( $C_6$ ), risk feedback mechanism ( $C_7$ ) and information distortion or out-of-control ( $C_8$ );

The market risk ( $B_3$ ) includes four second-grade indexes below: uncertainty of the industrial environment ( $C_9$ ), maturity degree of the outsourcing market ( $C_{10}$ ), changes of the micro environment ( $C_{11}$ ) and uncertainty of customer demand ( $C_{12}$ );

The management risk ( $B_4$ ) includes four second-grade indexes below: cultural differences between the supplying and demanding parties ( $C_{13}$ ), risk of boycott from internal employees ( $C_{14}$ ), non-standard outsourcing agreements ( $C_{15}$ ) and service provider selection risk ( $C_{16}$ ).

Based on the thinking above, the business logistics outsourcing risk appraisal index system is established as shown in Fig. 1.



**Figure 1.** Logistics outsourcing risks appraisal index system

**3. Comprehensive AHP-Fuzzy appraisal method**

A. L. Saaty, an American professor at University of Pittsburgh, proposed in 1970s AHP (Analytic Hierarchy Process), a method for system analysis. AHP combines qualitative and quantitative analysis and could solve complicated multi-factor problems. L.A. Zadeh, an American automatic control expert, proposed the concept of Fuzzy Sets for the first time in 1965, aiming at describing the FUZZY concept with accurate mathematical methods. FUZZY (comprehensive fuzzy appraisal method) is about quantifying qualitative appraisal factors with the concepts of fuzzy mathematics, conducting comprehensive appraisal on indexes of each hierarchy from multiple dimensions. The comprehensive fuzzy appraisal method could make all-round appraisal of something subject to the influence of multiple factors.

**3.1. Determine the weights of indexes**

(1) Build judgment matrix of pairing comparison

For a multi-hierarchy index system, indexes of every hierarchy would impact those of the last hierarchy, with indexes of the same hierarchy having different extent of such influence. Such different extents of influences on the indexes of the last hierarchy are their weights. The relative importance of indexes of the current hierarchy is subject to pairing comparison, forming the comparison matrix. When doing so, A.L. Saaty's 1-9 hierarchy marking method is used for such pairing comparison.

(2) Single hierarchical sequence and consistency test

Set judgment matrix  $B=(b_{ij})_{m \times n}$ . Follow the steps below to calculate the relative weight of each index and conduct the consistency test:

① Normalize every array of the judgment matrix B (as shown in Eq.1);

$$b_{ij} = b_{ij} / \sum_{i=1}^n b_{ij} (i, j = 1, 2, \dots, n) \quad (1)$$

② Sum the rows of the array-normalized judgment matrix (as shown in Eq.2);

$$\bar{W}_i = \sum_{j=1}^n b_{ij} (i = 1, 2, \dots, n) \quad (2)$$

③ Normalize the vector  $\bar{W} = (\bar{W}_1, \bar{W}_2, \dots, \bar{W}_n)^T$  (as shown in Eq.3);

$$\bar{W}_i = \frac{\bar{W}_i}{\sum_{j=1}^n \bar{W}_j} (i = 1, 2, \dots, n) \quad (3)$$

④ Extract the maximum latent root  $\lambda_{\max}$  (as shown in Eq.4);

$$\lambda_{\max} = \sum_{i=1}^n \frac{(BW)_i}{nW_i} \quad (4)$$

⑤ CR test:

$$CI = \frac{\lambda_{\max} - n}{n - 1}, \text{ (CI is the Consistency Index).}$$

Obviously, when the judgment matrix has complete consistency,  $CI=0$ ; the bigger CI is, the less consistent the matrix would be.

Calculate the matrix's consistency ratio  $CR=CI/RI$  (RI values as shown in Table 1). When  $CR \leq 0.1$ , the judgment matrix would have satisfactory consistency and the test result is "pass"; otherwise the judgment matrix needs to be re-adjusted.

**Table 1.** RI values in different orders

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

**3.2. Conduct comprehensive appraisal**

(1) Determine the appraisal set of the appraisal target V.  $V=\{v_1, v_2, \dots, v_n\}$ , a set of appraisal grades consisting of various appraisal results. This paper uses five appraisal grades to appraise the risks,  $V=\{\text{Major, big, medium, small, minor}\}$  and the appraisal set after value assignment  $K=\{95,85,75,65,55\}$ .

(2) Determine the factor set of the appraisal target U.  $U=\{u_1, u_2, \dots, u_m\}$  is the m types of appraisal factors of the appraisal target. Wherein: m refers to the number of factors.

(3) Establish the fuzzy relation matrix R. Start from any factor for separate appraisal to determine the degree of membership of the appraisal target to V. After obtaining the grade fuzzy sub-set, quantifying treatment shall be conducted on the targets appraised one by one. In other words, each factor  $u_i$  would be quantified and further obtain the fuzzy relation matrix R (as shown in Eq.5).

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \quad (5)$$

(4) Conduct fuzzy comprehensive appraisal.

Use AHP to obtain the weight set W and fuzzy relation matrix R and establish the comprehensive risk appraisal model (as shown in Eq.6).

$$B=W \times R=(w_1, w_2, \dots, w_n) \times \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix}$$

$$=(b_1, b_2, \dots, b_n) \quad (6)$$

After normalization treatment, the obtained standard appraisal result is  $B'=(b'_1, b'_2, \dots, b'_n)$ .

Calculate the comprehensive appraisal value  $D=B' \times K^T$ .

**4. Case analysis**

This paper uses the example of Company A, a long-time manufacturer of automobile components. The company has strong power of funds and large scale. Taking multiple factors into consideration, Company A intends to conduct logistics outsourcing. Upon analysis, Company A's logistics outsourcing risks mainly come from four aspects below: financial risk, information risk, market risk and management risk, matching four first-grade indexes shown in Fig.1: the business logistics outsourcing risk appraisal index system. These four risks are indeed first-grade indexes  $B_1, B_2, B_3, B_4$ . The financial risk of business logistics outsourcing includes four second-grade indexes, denoted with  $C_1, C_2, C_3$  and  $C_4$ ; similarly, the information risk of business logistics outsourcing also includes four second-grade indexes, denoted with  $C_5, C_6, C_7$  and  $C_8$ ; the market risk of business logistics outsourcing includes four second-grade indexes, denoted with  $C_9, C_{10}, C_{11}$  and  $C_{12}$ ; the management risk of business logistics outsourcing includes four second-grade indexes, denoted with  $C_{13}, C_{14}, C_{15}$  and  $C_{16}$ . The mapping relations between concrete second-grade indexes and first-grade indexes are shown in Fig. 1.

**4.1. Build the pairing comparison matrix**

Through the analysis on Company A's logistics outsourcing risks appraisal index system, AHP is used to appraise the overall risks and each level of risk index. Five experts are invited to conduct pairing comparison of each level of indexes in Fig. 1 and build the comparison matrix, obtaining the following judgment matrix:

$$A = \begin{bmatrix} 1 & 3 & \frac{1}{6} & \frac{1}{3} \\ \frac{1}{3} & 1 & \frac{1}{4} & \frac{1}{3} \\ 6 & 4 & 1 & 2 \\ 3 & 3 & \frac{1}{2} & 1 \end{bmatrix}$$

$$B_1 = \begin{bmatrix} 1 & 3 & 5 & 4 \\ \frac{1}{3} & 1 & 3 & 2 \\ \frac{1}{5} & \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{4} & \frac{1}{2} & 2 & 1 \end{bmatrix} \quad B_2 = \begin{bmatrix} 1 & 3 & 4 & 5 \\ \frac{1}{3} & 1 & 3 & 2 \\ \frac{1}{4} & \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{5} & \frac{1}{2} & 2 & 1 \end{bmatrix}$$

$$B_3 = \begin{bmatrix} 1 & 3 & \frac{1}{5} & \frac{1}{4} \\ \frac{1}{3} & 1 & \frac{1}{4} & \frac{1}{3} \\ 5 & 4 & 1 & 2 \\ 4 & 3 & \frac{1}{2} & 1 \end{bmatrix} \quad B_4 = \begin{bmatrix} 1 & 2 & 4 & 5 \\ \frac{1}{2} & 1 & 3 & 2 \\ \frac{1}{4} & \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{5} & \frac{1}{2} & 2 & 1 \end{bmatrix}$$

**4.2. Determine the weights of index factors and conduct consistency test**

Use the sum-product method to calculate the weight of each index and conduct consistency test after normalization treatment. Calculate the obtained weight values:

$$W_A = (0.1303 \quad 0.0814 \quad 0.5127 \quad 0.2756);$$

$$W_{B1} = (0.5462 \quad 0.2323 \quad 0.0838 \quad 0.1377);$$

$$W_{B2} = (0.5492 \quad 0.2302 \quad 0.0900 \quad 0.1306);$$

$$W_{B3} = (0.1281 \quad 0.0815 \quad 0.4841 \quad 0.3063);$$

$$W_{B4} = (0.5109 \quad 0.2614 \quad 0.0920 \quad 0.1357).$$

Wherein,  $W_A$  means respective weight of the four first-grade indexes;  $W_{B1}$  refers to respective weight of four second-grade indexes included in the financial risk;  $W_{B2}$  refers to respective weight of four second-grade indexes included in the information risk;  $W_{B3}$  refers to respective weight of four second-grade indexes included in the market risk;  $W_{B4}$  refers to respective weight of four second-grade indexes included in the management risk.

Respectively extract their maximum latent roots  $\lambda_{max}$ , consistency index CI and consistency ratio CR and conduct consistency test. See Table 2 for the calculation results:

**Table 2.** Consistency test result of each matrix

Index	A	B1	B2	B3	B4
$\lambda$	4.2354	4.0511	4.1023	4.2618	4.0720
CI	0.0785	0.0170	0.0341	0.0873	0.0240
CR	0.0872	0.0189	0.0379	0.0970	0.0267

From the calculation results above we can see that each index's consistency ratio CR meets the condi-

tion that  $CR < 0.1$ , showing satisfactory consistency of the indexes.

**4.3. Determine the appraisal set**

6 experts are invited to rate the business logistics outsourcing risks indexes, leading to following comprehensive fuzzy appraisal matrix:

$$R_{B1} = \begin{bmatrix} 0.53 & 0.29 & 0.06 & 0.12 & 0.00 \\ 0.55 & 0.28 & 0.10 & 0.07 & 0.00 \\ 0.45 & 0.32 & 0.08 & 0.07 & 0.08 \\ 0.46 & 0.24 & 0.15 & 0.10 & 0.05 \end{bmatrix}$$

$$R_{B2} = \begin{bmatrix} 0.49 & 0.24 & 0.17 & 0.10 & 0.00 \\ 0.47 & 0.39 & 0.06 & 0.06 & 0.02 \\ 0.57 & 0.22 & 0.13 & 0.04 & 0.04 \\ 0.60 & 0.26 & 0.11 & 0.03 & 0.00 \end{bmatrix}$$

$$R_{B3} = \begin{bmatrix} 0.48 & 0.30 & 0.11 & 0.06 & 0.05 \\ 0.43 & 0.35 & 0.10 & 0.10 & 0.02 \\ 0.52 & 0.25 & 0.12 & 0.11 & 0.00 \\ 0.54 & 0.20 & 0.15 & 0.11 & 0.00 \end{bmatrix}$$

$$R_{B4} = \begin{bmatrix} 0.39 & 0.35 & 0.16 & 0.06 & 0.04 \\ 0.41 & 0.31 & 0.20 & 0.08 & 0.00 \\ 0.42 & 0.29 & 0.24 & 0.03 & 0.02 \\ 0.43 & 0.32 & 0.13 & 0.11 & 0.01 \end{bmatrix}$$

Wherein,  $R_{B1}$  is the fuzzy relation matrix obtained in the process of six experts appraising financial risk  $B_1$ 's 4 second-grade indexes: equipment investment cost  $C_1$ , implicit cost  $C_2$ , risk of out-of-control cost  $C_3$ , financial status of logistics contractors  $C_4$ ;  $R_{B2}$  is the fuzzy relation matrix obtained in the process of six experts appraising information risk  $B_2$ 's 4 second-grade indexes: information communication channels of the two parties  $C_5$ , information asymmetry status  $C_6$ , risk feedback mechanism  $C_7$ , information distortion or out-of-control  $C_8$ ;  $R_{B3}$  is the fuzzy relation matrix obtained in the process of six experts appraising market risk  $B_3$ 's 4 second-grade indexes: uncertainty of the industrial environment  $C_9$ , maturity degree of the outsourcing market  $C_{10}$ , changes of the micro environment  $C_{11}$ , uncertainty of customer demand  $C_{12}$ ;  $R_{B4}$  is the fuzzy relation matrix obtained in the process of six experts appraising management risk  $B_4$ 's 4 second-grade indexes: cultural differences between the supplying and demanding parties  $C_{13}$ , risk of boycott from internal employees  $C_{14}$ , risk of out-of-control cost  $C_3$ , service provider selection risk  $C_{16}$ .

(1) Single element appraisal

According to the fuzzy appraisal model equation  $B=W \times R$ , concrete values of  $B_1, B_2, B_3$  and  $B_4$ , respectively representing the fuzzy appraisal matrix of the 4 first-grade indexes.

$$B_1 = W_{B1} \times R_{B1} = (0.51830 \ 0.28331 \ 0.08336 \ 0.10144 \ 0.01359)$$

$$B_2 = W_{B2} \times R_{B2} = (0.50696 \ 0.27534 \ 0.13324 \ 0.07625 \ 0.00820)$$

$$B_3 = W_{B3} \times R_{B3} = (0.51367 \ 0.24924 \ 0.12628 \ 0.10278 \ 0.00804)$$

$$B_4 = W_{B4} \times R_{B4} = (0.40342 \ 0.33075 \ 0.17375 \ 0.06925 \ 0.02363)$$

The calculation results above are used to form the new matrix as the fuzzy weights of the first-grade index system and build the fuzzy appraisal matrix  $R$  of U-V.

$$R = \begin{bmatrix} 0.51830 & 0.28331 & 0.08336 & 0.10144 & 0.01359 \\ 0.50696 & 0.27534 & 0.13324 & 0.07625 & 0.00820 \\ 0.51367 & 0.24924 & 0.12628 & 0.10278 & 0.00804 \\ 0.40342 & 0.33075 & 0.17375 & 0.06925 & 0.02363 \end{bmatrix}$$

(2) Comprehensive appraisal

$B = W_A \times R = (0.483 \ 0.278 \ 0.134 \ 0.091 \ 0.013)$ ,  $B$  represents the fuzzy appraisal matrix for Company A's overall logistic risk appraisal index system.

$D = B \times K^T = 86.3$ ,  $D$  represents the comprehensive appraisal value of the logistic risk appraisal index system.

Similarly, calculate the scores of each first-grade index: financial risk  $D_{B1} = 86.91$ , information risk  $D_{B2} = 86.97$ , market risk  $D_{B3} = 86.58$ , management risk  $D_{B4} = 85.27$ .

According to the calculation result, the comprehensive appraisal value of Company A's logistics outsourcing risk appraisal is 86.3, meaning that Company A faces a big logistics outsourcing risk and they shall not start logistics outsourcing. The appraisal values of all four first-grade indexes (financial risk, information risk, market risk and management risk) are higher than 85, indicating big risk for Company A in these four aspects if they decide to go with logistics outsourcing.

**5. The control strategy of logistics outsourcing risks**

Through AHP-FUZZY and other methods, the source of risks for logistics outsourcing could be effectively identified. Enterprises could apply effective control on logistics outsourcing risks according to the risk identification results to reduce the possibility of logistics outsourcing risks and restrict the loss caused to the enterprises. The control risk targeting logistics outsourcing risks may include following aspects:

(1) Reinforce the supervision on logistic service providers

Logistic service providers may be, out of various reasons, unable to execute the agreements and would subsequently violate the agreements, which is the result of the failure of supervision after logistics outsourcing. For example: resources could not be

available and delivered to enterprises within specified time; failure of frequent urge and promotion; shift of focal point; decreased level of attention, etc. To a great extent, these would affect the quality of the business logistics outsourcing. Only by constant urge and supervision could outsourcing service providers maintain always diligent service, gradually improve their service quality and avoid out-of-control of logistic operations. Therefore, enterprises shall maintain timely supervising measures at the same time of conducting logistic outsourcing.

### (2) Reinforce customer relation management

Reinforcing the customer relation management is not only an important link in marketing management, but also one of the measures effectively lowering logistics outsourcing risk. Customer relation management could not only increase sales of products, but, more importantly, could also increase the satisfaction degree of customers and the service level of enterprises. After conducting logistics outsourcing, if enterprises do not maintain direct contact with customers, it would be very difficult to collect customer-related information and know the customers' experience with the enterprises. Through customer relation management, the distance between enterprises and consumers could be drawn further closer. When logistic service providers are providing quality service to consumers, the concern and care of enterprises toward consumers shall also be felt by the latter. Thus the logistic cost could be further reduced and the profits of the enterprises could be increased.

### (3) Reinforce control on logistics outsourcing activities and establish information-sharing mechanism

In the cooperation process with joint effort from both parties, information shall be as transparent as possible. It is better that the information could be shared. Enterprises should not only supervise the benefit and efficiency of the logistic service providers, but also should offer necessary support service to logistic service providers, reinforce information sharing and the optimization of the coordination process. The key to the success of logistics outsourcing is that the principal and the agent shall share relevant procedural information, demand information and consumer feedback information in an effective and timely manner. Such information sharing mechanism would be helpful for enterprises to effectively control and manage the logistics outsourcing activities. If problems that could not be settled emerge, relevant employees shall not make decisions arbitrarily but should report to superiors timely and wait for the disposal result. Meanwhile, it shall be made clear that disclosing commercial secrets in any form would mean bearing

legal responsibilities, and communications regarding the confidentiality mechanism and information sharing shall be properly conducted.

### (4) Constantly solidify the cooperation relation and establish the "win-win" notion

The principal and agent of logistics outsourcing shall maintain decent cooperation. The extent of intimacy between the two parties would directly affect the cooperation effect and decide the success or failure of the logistics outsourcing. First of all, the two parties shall maintain generally similar notions and update their own notions to reach a notion of cooperation. The culture between enterprises would be removed of the dross and the false and retained of the essentials and the true to prepare for sort-out and integration. The two parties shall orient on their common benefits and care about the overall interest, working all-out together to solve various problems in the cooperation process. The two parties of logistics outsourcing have the principal-agent relation and their final purpose is to serve the consumers. Possible risks in logistics outsourcing shall be faced by the two parties together. The two parties have certain extent of connections and as long as they maintain stable cooperation, both parties would benefit from their cooperation. Therefore, establishing a good outsourcing cooperation relationship would help with common development of the two parties. The key factors for establishing a good cooperation relationship depends on the level of mutual trust of the two parties. When they both fulfill their commitments and maintain communication, they will maintain solid cooperation.

## 6. Conclusions

Based on the comprehensive AHP-FUZZY appraisal method, this paper conducts quantitative analysis on Company A's logistics outsourcing risks, discussing whether Company A shall choose logistics outsourcing. Through a series of modeling and calculation, the comprehensive appraisal value of the overall logistics outsourcing risks appraisal index system is extracted, reflecting the risk level of Company A's business logistics outsourcing in a more intuitive manner and serving a ground for making the decision of logistics outsourcing. Examples show that the comprehensive AHP-FUZZY appraisal method has high application value for the appraisal of logistics outsourcing risks.

However, as the logistics outsourcing system is not perfect, various kinds of risks would rise in the business logistics outsourcing process. Therefore, how to find the control strategy to avoid logistics outsourcing risks is very important for the future of the enterprises. Logistics outsourcing risks have very complicated

reasons, and combining qualitative and quantitative analysis to appraise the business outsourcing risk and increase the benefits of the enterprises is a future development trend. Although this paper uses the comprehensive AHP-FUZZY appraisal method to establish the model and conduct quantitative analysis on logistics outsourcing risks, it also has shortages. For example, the experts are more or less subjective in determining the weights. Therefore, in future study, appraisal index shall be further quantified to increase the objectiveness of this method.

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