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基于模糊综合法构建物流企业客户信用评价指标体系

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摘要:针对物流企业客户信用评价进行了研究,基于模糊综合法构建了以企业信誉及违约记录、速动比率及资产负债率、人力资源水平及盈利能力、产权清晰程度及担保状况、区域信用状况及区域法制环境等10个因素为指标的物流企业客户信用评价指标体系;通过层次分析法(AHP)确定了指标权重,并采用专家咨询法(Delphi method)确定了指标评价标准;通过实证案例进行了验算,验算结果与事实相符,该指标体系能有效评价客户信用状况.

关键词:物流企业;模糊综合法;层次分析法(AHP);客户信用评价

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In current market situation, cash transaction mode is gradually decreasing in rate on sums. Most of transactions are that supplying service is the first step and then collecting cash. These are the credit transactions. Credit management is a solution of market expansion. It is also a very common way for expanding the logistics market.

Much accounts receivable is occurred in the transactions of logistics enterprises. One reason is the production enterprises and consumer goods wholesale enterprises occupy large amounts of money of the logistics enterprises, even seriously arrear of logistics service payment to develop market and expand blindly. The logistics enterprises will lead to financial deterioration, operation difficulties, and even bankruptcy. The other reason is that the production enterprises and consumer goods wholesale business also will meet the logistics providers of poor reputation, and even encounter the phenomenon of cheat goods. So the judgment of risk is necessary for operation of the logistics enterprises. The credit management of logistics enterprises is requirement. To new contact clients, logistics enterprises should grasp its business scale according to its condition of faith. So client credit evaluation of logistics enterprises is the first step for credit management. In many previous studies, the logistics enterprise were outsourcing customers of the core enterprise supply chain, therefore, the studies focused on credit evaluation of logistics enterprises. While, standing on the perspective of logistics enterprises, this paper focused on credit evaluation of logistics enterprise Clients.

1 Construction of index system

1.1 Client credit evaluation index system Construction based on fuzzy comprehensive method

1.1.1 Evaluation index selection

According to the characteristics of logistics enterprise, the design requirements of credit evaluation index system of logistics enterprises management mainly include: ① The content of index system should be comprehensive.

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Not only the basic of default risk capacity evaluation of financial, management and service level should be included, historical records of credit and regional area credit conditions should also be included; ② Index structure should be distinctive nuance, avoiding repetition and disordered; ③Index should be convenient for computer data processing.

Character, Capital, Capacity of Management, Collateral and Condition of Business are included in client credit evaluation of logistics enterprises. Based on the above three requirements, a three layer progressive structure index system is constructed. The first layer is target layer, and the target is client credit evaluation index of logistics enterprise; the second layer is criterion layer, and character, capital structure, capacity of management, collateral and condition of business are considered as five elements of criterion; the third layer is index layer, according to the 5C element analysis and the expert investigation method, the following ten index factors are determined: corporate reputation, breach of contract; the quick ratio, the ratio of liabilities to assets; human resource level, profit ability; clarity of property rights, guarantee condition; regional credit status, regional legal environment.

1.1.2 Evaluation standard

Evaluation standard determination is the difficulty step in constructing evaluation index system. The method of expert consultation is introduced in Evaluation standard determination. Through several times of consultation to the logistics enterprise managers and university management expert in Hunan Province, specific indicators are selected according to the difference among different evaluation object characteristics. Then, the client credit evaluation standard is established as shown in Table 1.

Tab. 1 Client credit evaluation index of logistics enterprises

表1 物流企业客户信用评价指标

Target layer A	Standard layer B	Index layer C	Standard value	Unit	Source of information
Client credit evaluation elements of logistics enterprise	B_1 character	C_1 corporate reputation*	≥6		peer evaluation
		C_2 default records	≤2	times/year	company records
	B_2 capital	C_3 quick ratio	≥200	%	financial statements
		C_4 ratio of liabilities to assets	≤60	%	financial statements
	B_3 capacity of management	C_5 human resource level	≥60		peer evaluation
		C_6 profit ability	≥6		financial statements
	B_4 collateral	C_7 clarity of property rights*	≥6		accepted data
		C_8 guarantee condition	≥10	%	company to negotiate
	B_5 condition of business	C_9 regional credit status*	≥6		accepted data
		C_{10} regional legal environment *	≥6		

The above indexes with '*' indicators such as corporate reputation are qualitative indicators which using 10-point score scale.

1.1.3 Fuzzy comprehensive evaluation method[1]

The above evaluation index is represented by Vector B. The fuzzy relation matrix $R_i(i=1,2,3,4,5)$ is constructed through the comment terms set $V=\{v_1,v_2,v_3,v_4,v_5\}$, where r_{ij} is the degree of membership about evaluation indicator i belongs to reviews of grade j. Combined with the Analytic Hierarchy Process (AHP)[2] to determine the weight vector W, and index vector B is calculated by $B=W\cdot R$. Fuzzy synthetic value A is calculated by $A=B\cdot V(V=10,7.5,5,2.5,0)$, where A is a comprehensive fuzzy evaluation results less than 10, and it is used to

evaluate client credit status of logistics enterprises.

1.2 Index weight determination by AHP

1.2.1 Analytic Hierarchy Process

The AHP method is put forward by Professor T. L. Saaty[2]. AHP is a simple, flexible and practical multiple criteria decision making method for the quantitative analysis of qualitative problems. The characteristic of the method is that the complex question of various factors is well-organized by dividing into interconnected orderly level. The opinions of expert and the objective judgments of analysts are combined directly and effectively, according to certain objective reality subjective judgment. The importance of two elements in a same layer comparing is described quantitatively. Then, the sequence of weights importance of each level element relative is calculated by mathematical method. All elements of the relative weights is computed and sorted through the total sequencing of all layers.

2.2.2 Index selection

1) Constructing the hierarchical structure model

There are both quantitative and qualitative indicators in the client credit evaluation index system of logistics enterprise. Therefore, a comparable index is provided in order to give out the final scientific conclusion. The index weight is decided democratically by expert group, and the index weight coefficient is determined by AHP. The hierarchical structure model of client credit evaluation index system[3] for logistics enterprise is constructed based on the AHP, as shown in Table1.

The process of application of AHP to calculate the weight of index:

Step 1:Hierarchical structure model construction

A recursive and orderly hierarchy model[3-4] is constructed according to the analysis about each client credit influence factor of logistics enterprise, and the influence and subordination relationship among each factors. The model is shown in Fig. 1.

Step 2: Judgment matrix construction

The importance of each element is quantified by judgment matrix. In this process, a judgment matrix R is formed using DELPH method. The questionnaires are filled by the logistics management experts from logistics enterprises and institutions. Each expert gives a quantitative judgment for each layer of constituent elements by comparing the importance between two elements.

$$R=\left\{r_{ij}\right\}_{nn},i,j=1,2,\cdots,n \quad \text{(Eq. 1)}$$

Experts give the judgment value of relative importance r_{ij} for various elements, where r_{ij} values generally range of 1, 3, 5, 7 and 9 which represents the degree of importance between r_i and r_j. Larger of the number represents that higher degree of importance.

step 3: Hierarchical ranking

The relative importance of influence is obtained through the judgment matrix from high to low layer of various elements, and then the importance of each element is sorted from high to low layer for each layer. That determines the weight of all the elements in the right layer. It can be called hierarchical ranking. The geometry average method is applied for hierarchical ranking. The equation is shown as follows:

$$W_i=\bar{W}_i\times\frac{1}{\sum_{i=1}^{n}\bar{W}_i},\ i=1,2,\cdots,n \quad \text{(Eq. 2)}$$

$$\bar{W}_i = \sqrt[j]{\prod_{j=1}^{n} r_{ij}},\ i,j = 1,2,\cdots,n \quad \text{(Eq. 3)}$$

step 4: Total sorting of layers

The integrated weight of the upper element, namely total sorting of layers, is computed based on the weight hierarchical ranking of each level. The equation is shown as follows:

$$W_i = \sum W_C \cdot W_B,\ i = 1,2,\cdots,n \quad \text{(Eq. 4)}$$

step 5: Consistency test

Consistency test to the evaluation results of judgment matrix is necessary for the validation of total sequencing results. Consistency is defined as an evaluation index of scoring rationality. If the score is obviously unreasonable, then sort result is defined as invalid. Complete consistency is not possible to achieve because the result of judgment matrix is composed of experts experience fuzzy quantification. So if the consistency variation is in the allowable range, the consistency is effective. T.L.Saaty proposed a random consistency ratio, referred as $C \cdot R$. When $C \cdot R$ <0.1, it shows that the judgment matrix is consistency. Otherwise, the judgment matrix should be adjusted and recalculated until $C \cdot R < 0.1$. $C \cdot R$ can be calculated by the following equation:

$$C \cdot R = \frac{C \cdot I}{R \cdot I} \quad \text{(Eq. 5)}$$

Where $R \cdot I$ in Eq. 5 is a given ratio, it´s relative to order number of the judgment matrix, it commonly values as shown in Table 2.

Tab. 2 $R \cdot I$ Value table

表2 R·I取值表

N	1	2	3	4	5	6	7	8	9	10
$R \cdot I$	—	—	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Where $R \cdot I$ is the consistency index, it can be calculated by the following equation:

$$C \cdot I = \frac{\lambda_{\max} - n}{n - 1} \quad \text{(Eq. 6)}$$

Where $\lambda_{\max}$ is the maximum characteristic root of judgment matrix. The approximation calculation equation of the maximum characteristic root is shown as follows:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(B \cdot W_B)_i}{(W_B)_i} \quad \text{(Eq. 7)}$$

Where B is given judgment matrix

n is judgment matrix order

W_{Bi} is column vector of relative weight

2) Judgment matrix of evaluation index weight construction by AHP

An expert team is consisted of fifteen logistics management experts from colleges and universities, logistics industry association and logistics enterprises. Expert opinions are repeatedly consulted and summarized, which tends to consistency. Expert opinions are collected, and then the calculation results are as follows.

① The judgment matrix $A-B$ shows the relative importance comparison among factors of criterion layer relative to the total target of client credit evaluation of logistics enterprises.

$$\boldsymbol{R}_{AB}=\begin{array}{c} \\ B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{array}\begin{array}{c} \begin{array}{ccccc} B_1 & B_2 & B_3 & B_4 & B_5 \end{array} \\ \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 1/3 & 1/5 & 3 & 2 \\ 3 & 1 & 1/2 & 5 & 4 \\ 5 & 2 & 1 & 7 & 6 \\ 1/3 & 1/5 & 1/7 & 1 & 1/2 \\ 1/2 & 1/4 & 1/6 & 2 & 1 \end{bmatrix}$$

② The judgment matrix B_1-C, B_2-C, B_3-C, B_4-C and B_5-C show that the relative importance comparison among interior influencing factors according to character, composition of capital, capacity of management, collateral and condition of business, respectively.

$$\boldsymbol{R}_{B_1C}=\begin{array}{c} \\ C_1 \\ C_2 \end{array}\begin{array}{c} \begin{array}{cc} C_1 & C_2 \end{array} \\ \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix} \qquad \boldsymbol{R}_{B_2C}=\begin{array}{c} \\ C_3 \\ C_4 \end{array}\begin{array}{c} \begin{array}{cc} C_3 & C_4 \end{array} \\ \begin{bmatrix} r_{33} & r_{34} \\ r_{43} & r_{44} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 2 \\ 1/2 & 1 \end{bmatrix} \qquad \boldsymbol{R}_{B_3C}=\begin{array}{c} \\ C_5 \\ C_6 \end{array}\begin{array}{c} \begin{array}{cc} C_5 & C_6 \end{array} \\ \begin{bmatrix} r_{55} & r_{56} \\ r_{65} & r_{66} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 3 \\ 1/3 & 1 \end{bmatrix}$$

$$\boldsymbol{R}_{B_4C}=\begin{array}{c} \\ C_7 \\ C_8 \end{array}\begin{array}{c} \begin{array}{cc} C_7 & C_8 \end{array} \\ \begin{bmatrix} r_{77} & r_{78} \\ r_{87} & r_{88} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 1/5 \\ 5 & 1 \end{bmatrix} \qquad \boldsymbol{R}_{B_5C}=\begin{array}{c} \\ C_9 \\ C_{10} \end{array}\begin{array}{c} \begin{array}{cc} C_9 & C_{10} \end{array} \\ \begin{bmatrix} r_{99} & r_{9,10} \\ r_{10,10} & r_{10,10} \end{bmatrix} \end{array}=\begin{bmatrix} 1 & 2 \\ 1/2 & 1 \end{bmatrix}$$

3) Evaluation index system sorting

Geometric average method is applied to calculate the importance coefficients W_{Bi} of $B_i(i=1,2,3,4,5)$ relative to A according to judgment matrix $A-B$. The equations to calculate the relative weight coefficients are Eq. 2 and Eq. 3, and the process of calculation is shown as Table 3.

Tab. 3　The detailed process of calculation W_{Bi}

表3　W_{Bi}的计算过程

A	B_1	B_2	B_3	B_4	B_5	M_{Bi}	$\overline{W}_{Bi}$	W_{Bi}
B_1	1	1/3	1/5	3	2	2/5	0.832 6	0.118 5
B_2	3	1	1/2	5	4	30	1.974 4	0.281 0
B_3	5	2	1	7	6	420	3.347 0	0.476 3
B_4	1/3	1/5	1/7	1	1/2	1/210	0.343 2	0.048 8
B_5	1/2	1/4	1/6	2	1	1/24	0.529 6	0.075 4
$\sum$							7.026 7	1.000 0

The calculation results in Table 3 shows that capacity of management (B_3) is the first Influence factor to client credit evaluation (A) of logistics enterprise, the second is the composition of capital (B_2), and the last is the character (B_1). It is the important basis for evaluating for client credit layer of logistics enterprises. The calculation of the judgment matrix $B-C_1$, $B-C_2$,$B-C_3$,$B-C_4$, $B-C_5$ and The results of client credit evaluation index weight of logistics enterprise are shown in Table 4.

The weights in the above table show that the importance sequence of the credit layers are as following: human resource level C_5, profit ability C_6, quick ratio C_3, ratio of liabilities to assets C_4, default records C_2, corporate reputation C_1, regional credit status C_9, regional legal environment C_{10}, guarantee condition C_8 and clarity of property rights C_7.

4) Consistency test

Consistency test for weight evaluation results of judgment matrix is necessary after the index weight is calculated. Eq. 5, Eq. 6 and Eq. 7 are used for the consistency test. Consistency is tested by calculating $C\cdot R$, $C\cdot I$ and $\lambda_{\max}$, respectively. According to the definition of consistency index, maximum characteristic root of judgment matrix is calculated. Then the consistency of each judgment matrix is tested separately.

Tab.4 Client credit evaluation index weight of logistics enterprise

表4 物流企业客户信用评价指标权重

	B_1	B_2	B_3	B_4	B_5	Index weight
	W_{B1} =0.118 5	W_{B2} =0.281 0	W_{B3} =0.476 3	W_{B4} =0.048 8	W_{B5} =0.075 4	
C_1	0.431 1					0.051 1
C_2	0.568 9					0.067 4
C_3		0.568 9				0.159 9
C_4		0.431 1				0.121 1
C_5			0.608 1			0.289 6
C_6			0.391 9			0.186 7
C_7				0.344 4		0.016 8
C_8				0.655 6		0.032 0
C_9					0.568 9	0.042 9
C_{10}					0.431 1	0.032 5
$\sum$	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0	1.000 0

Firstly, the consistency of judgment matrix A is tested. The calculation process of maximum characteristic root is shown as follows:

$$\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{n}\frac{(B\cdot W_B)_i}{(W_B)_i}=\frac{1}{5}\sum_{i=1}^{5}\frac{\left(\begin{bmatrix}1 & 1/3 & 1/5 & 3 & 2\\ 3 & 1 & 1/2 & 5 & 4\\ 5 & 2 & 1 & 7 & 6\\ 1/3 & 1/5 & 1/7 & 1 & 1/2\\ 1/2 & 1/4 & 1/6 & 2 & 1\end{bmatrix}\cdot\begin{bmatrix}0.118\,5\\ 0.281\,0\\ 0.476\,3\\ 0.048\,8\\ 0.075\,4\end{bmatrix}\right)_i}{\left(\begin{bmatrix}0.118\,5\\ 0.281\,0\\ 0.476\,3\\ 0.048\,8\\ 0.075\,4\end{bmatrix}\right)_i}=\frac{1}{5}\times 25.440\,2=5.088\,0$$

The consistency test is shown as follows:

$$C\cdot I=\frac{5.088\,0-5}{5-1}=0.022\,,\ n=5\,,\text{so } RI=1.12\,,\ C\cdot R=\frac{C\cdot I}{R\cdot I}=\frac{0.022}{1.12}=0.019\,6<0.1$$

The consistency of judgment matrix A is well, so the calculation is reasonable.

Because the order of judgment matrix $B_i(i=1,2,3,4,5)$ is 2, the consistency test is unnecessary.

1.2.3 Evaluation set description of evaluation index

The evaluation model is applied to evaluate the client credit layers of logistics enterprise. The evaluation set of evaluation index system for each criterion can be referred as $V=\{v_1,v_2,v_3,v_4,v_5\}$,in which $v_1=\{10,represents"best"\}$, $v_2=\{7.5,represents"better"\}$, $v_3=\{5,represents"good"\}$, $v_4=\{2.5,represents"bad"\}$, $v_5=\{0,represents"worse"\}$. The following comment set is summed up through referring to relevant information and investigating several logistics enterprises managers and university logistics experts in Changsha city, which shown in Table 5. The fuzzy relation matrix[[5,6]] $R_i(i=1,2,3,4,5)$ is constructed according to the above comment set and combining with the evaluation index system. The elements r_{ij} of R represents the degree of evaluation index i attached to comment j. The index vector B is calculated by $B=W\cdot R$. Fuzzy synthetic value A is calculated by $A=B\cdot V(V=10,7.5,5,2.5,0)$, where A (comprehensive fuzzy evaluation results) is less than 10.

$$A = B \cdot V = W \cdot R \cdot V = \begin{pmatrix} w_1 & w_2 & \cdots & w_{10} \end{pmatrix} \cdot \begin{bmatrix} r_{1,1} & \cdots & r_{1,5} \\ \vdots & \ddots & \vdots \\ r_{10,5} & \cdots & r_{10,5} \end{bmatrix} \cdot \begin{pmatrix} 10 & 7.5 & 5 & 2.5 & 0 \end{pmatrix} \quad \text{(Eq. 8)}$$

The highest score of the model is 10 marks, while the lowest score is 0 marks. It is Class-A clients when scored 8 ~ 10 points, Class-B clients are scored 5 ~ 7, and Class-C clients are scored 1 ~ 4. The line of credit is determined by the clients´ credit rating[7,8,9]. The logistics enterprises can adjust credit factors according to the actual situation, and determine the weight of Specific Indicators. For example, it is difficult for non-listed companies to obtain financial information, so other factors should be replaced or reduced characteristic factors.

2　Application examples and evaluation

A total of ten employees in a company department are investigated in order to test the performance of the evaluation index system. They are asked to evaluate credit condition of monthly billing client F, and detailed results are shown in Table 5.

Tab.5　The evaluation set and credit evaluation rating score of client F

表5　指标评语集和F客户信用评价评分　　%

Specific Indicators		Standards of grading					Weight
		10	7.5	5	2.5	0	
C_1	corporate reputation	best	better	good	bad	worse	0.051 1
		70	20	10	0	0	
C_2	default records	default record number within the last 12 months					0.067 4
		0	1	2	3	4	
		0	100	0	0	0	
C_3	quick ratio	quick ratio of client− quick ratio of industry average					0.159 9
		20%	10%	0	−10%	−20%	
		0	100	0	0	0	
C_4	ratio of liabilities to assets	ratio of liabilities to assets of client− ratio of liabilities to assets of industry average					0.121 1
		20%	10%	0	−10%	−20%	
		0	100	0	0	0	
C_5	human resource level	best	better	good	bad	worse	0.289 6
		80	10	10	0	0	
C_6	profit ability	best	better	good	bad	worse	0.186 7
		10	70	20	0	0	
C_7	clarity of property rights	most clear	more clear	clear	basic clear	not clear	0.016 8
		70	20	10	0	0	
C_8	guarantee condition	guarantee ratio					0.032 0
		20%	15%	10%	5%	0	
		0	100	0	0	0	
C_9	regional credit status	best	better	good	bad	worse	0.042 9
		50	40	10	0	0	
C_{10}	regional legal environment	best	better	good	bad	worse	0.032 5
		60	20	10	10	0	
	$B = W \cdot R$	33.883	57.729	8.063	0.325	0	1
	$A = B \cdot V$	812.925					8.129 3

The credit rating score of client F in the above table is 8.129 3. The result of evaluation method coincides with the facts by comparing the actual situation. So client F is one of the company's good-quality customers.

3 Conclusions

Standing on the perspective of logistics enterprises, this paper focuses on credit evaluation of logistics enterprise Clients. The research angle of view has certain innovation. The client credit evaluation index system of logistics enterprise is constructed based on the fuzzy comprehensive analysis method, which overcoming the subjectivity of evaluation indicators and evaluation criteria by using the expert evaluation method only, making more accord with the reality. The index weight factor is determined by using the AHP method. The main difference of the index system between this paper and the other relevant articles is that better operability of the evaluation indicators and standards, such as the number of default records quantifications the index of company character. An application example is detailed illustrated, and the checking results are compatible with the facts. Therefore, the index system can be used in practice. But the AHP method to determine weight is kind of subjectivity, further study and discuss should be followed so that each index weight coefficient is more objective and scientific.

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Numerical Simulation on Solid-Liquid Two-phase Flow of Structure Parameters in Sedimentation Zone of Vortex Clarifier

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Abstract: Based on Fluent, combining with the standard k-ε two equations turbulence model and the simplified double fluid Mixture model, this study carries out three-dimensional numerical simulation of the vortex clarifier sedimentation zone. Validation shows that the model can simulate the pool flow field and the distribution of sludge well. Under the condition of constant inlet flow and suspended solids, simulation research is conducted at different baffle length, inclined plate spacing and dip angle to choose the optimal structure parameters for enhancing precipitation effect and improving the removal rate. According to the simulation results and actual conditions, it maintains that optimal structural parameters include the length of the baffles being 300 mm, the optimal plate spacing being 55 mm and the angle being 50°.

Key words: vortex clarification tank; sedimentation zone; structure parameters; numerical simulation

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Client Credit Evaluation Index System of Logistics Enterprises Constructing Based on Fuzzy Comprehensive Method

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Abstract: Client credit evaluation index system of logistics enterprises construction is studied in this paper. The evaluation index system of client credit for logistics enterprises is constructed by using the method of fuzzy comprehensive method, and the index weight is determined by analytic hierarchy process (AHP). An application example is studied, and the results are compatible with the facts. The client credit for logistics enterprises can be evaluated effectively by the index system.

Key words: logistics Enterprises; fuzzy comprehensive; analytic hierarchy process; client credit evaluation

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