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A WEB-BASED ALLY SELECTION METHOD FOR AGILE VIRTUAL ENTERPRISE

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ABSTRACT

In the agile virtual enterprise forming process, with the increase of optional scheme, to use the traditional analytic hierarchy process (AHP) to choose ally will produce judgment matrix inconsistency problem. Therefore, combining the AHP and the fuzzy theory, a new ally selection method which is based on web is proposed. The proposed method uses the AHP to calculate the weight of the evaluating indexes, uses the fuzzy matrix to calculate the value of each scheme, and then by merging to get the evaluation result. This paper uses B/S pattern to develop an AVE ally selection system that is based on the method, and combines with the distributor selection of an enterprise to introduce the practical application of the system. The results show that the method can not only eliminate the judgment matrix inconsistency problem, but also integrate group opinion effectively, and access to a fair and reasonable evaluation result. At the same time, to each evaluating indexes, the proposed method can obtain opinions that are relatively consistent.

Keywords: *Agile Virtual Enterprise; Ally Selection; Analytic Hierarchy Process; Fuzzy Matrix*

1. INTRODUCTION

Since the end of last century, due to the development of information technology and economic globalization, the competition between enterprises does not simply focus on product quality and performance, it gradually turns to the competition between agile virtual enterprises that the enterprises belong to [1]. In the AVE, allies cooperate with each other to accomplish the total process from raw material supply to the final sales. In this process, if a certain link appears problem, it will slow down the response time to the market and customer needs, so as to reduce the whole AVE competitiveness. Therefore, in the early stages of the AVE formation, it is necessary for the main alliance enterprise to choose appropriate allies to keep and improve the competitiveness in the market. Combining the AHP with the fuzzy theory, this paper puts forward the specific steps of ally selection and evaluation, in order to improve the ability of solving practical problems.

In section 2, we introduce the related work about ally selection and evaluation. Section 3 introduces the process of ally selection. Section 4 presents the specific steps of the proposed method. In section 5, we use an example to introduce the practical application of the method. Section 6 gives a conclusion to the whole paper.

2. RESEARCH BACKGROUND

Since there are many factors that can influence the cooperation between enterprises in the AVE, ally selection and evaluation become very complex. Using the analytical hierarchy process and the fuzzy analytic hierarchy process to settle this problem, domestic and foreign scholars have found out a large number of research results [3-6], but these results have an obvious defect. Using the AHP to evaluate schemes, if there are to many optional schemes to choose(such as more than 7), you should analyze them in batches, otherwise, the evaluation will be difficult and the results will have deviations (this is because when the judgment matrix dimension is no less than 7, and the consistency index is less than 0.1, the not passing rate of matrix consistency is more than 30% [7]), but analyzing in batches will make some excellent schemes be eliminated too early. So the AHP is not applicable for evaluation that has many optional schemes. In addition, these results may have some defects, such as, neglecting group evaluation, model structure against programming and application and so on.

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3. THE PROCESS OF ALLY SELECTION FOR AVE

In the past, manufacturing enterprises usually select their cooperation partners by bidding, but since the narrow scope of bidding, the small quantity of bidding enterprises, lack of knowledge of bidding enterprises, the high costs of bidding process, the long time that the bidding will take, and the inflexible way to settle problems, the enterprise you finally choose is not the ideal partner [5].

The rapid development of Internet and the improvement of the environment of electronic business not only make more enterprises become selected schemes, but also provide advanced and efficient method for the main alliance enterprise to choose allies. The main alliance enterprise puts its demands in the public Web server, and uses Email to inform the relevant enterprises as many as possible. Evaluating indexes of the selected enterprises are included in the demands. Generally speaking, the demands include product or service, the requirements to partner, time of delivery, and the promised deadline and so on. After releasing the demands, the main alliance enterprise waits to receive other enterprise's responds. Web provides forms for enterprises to fill in their information, and you can use CGI to switch the Web received information, then store in partner evaluation and selection database. Before the deadline, evaluators (whether in the enterprise or in the distance) have the right to log on the database, using mathematical models and methods to evaluate the enterprises that have filled their information in the forms. On the deadline, the system will automatically figure out the ideal allies or the best combination of enterprises, and provide details of the evaluation for the decision-makers to refer.

4. THE EVALUATION AND SELECTION METHOD BASED ON THE AHP AND THE FUZZY THEORY

The AHP mainly includes two aspects [2-3], one is to determine the index weight at each level; the other is to make comprehensive evaluation based on the weight and the attribute value of the indexes in the lowest level. If the number of the index is more than 7, we can classify these indexes into groups. Since the effectiveness and accuracy of the AHP, the weight of indexes in each level (including the lowest level) that have been calculated is reasonable and effective. So we can use this method to get the weight of the indexes. But when there are many selected schemes to choose (such as more than 7), the AHP is not suitable for calculating the weight of each scheme. So we need to introduce some basic concepts of the fuzzy theory to determine the attribute value of each scheme.

To the comprehensive evaluation, we combine the AHP and the fuzzy theory to put forward the steps as follows.

(1) Determine the index domain $U=\{u_1,u_2,\cdots,u_n\}$ and the comment level domain $V=\{v_1,v_2,\cdots,v_m\}$.

u_i is the index in the lowest level（i=1,2,…,n）.If n is more than 7, we should use the hierarchical structure, that is to say, there are small indexes under the large indexes to ensure each level will not have more than 6 indexes. m is the number of comment level set, and each level can has a fuzzy subset. Usually, m can be 3, 5, 7, this is not only in conformity with the quality requirements of the fuzzy comprehensive evaluation, and can make the selected schemes have a level of middle class. The specific level can be described with some appropriate words according to the content of the evaluation.

(2) Determine the weight vector of the index $w=(w_1,w_2,\cdots,w_n)^T$

In the steps of the AHP to calculate the single weight in the same level, we can use logarithmic least square method, that is to say we can use Eq.(1) to calculate minimum value of Z, and we can get a vector $\omega=(\omega_1,\omega_2,\ldots,\omega_n)^T$, then by normalization, we can get a new vector $w=(w_1,w_2,\ldots,w_n)^T$. This method is not only accuracy and reasonable, and usually we can omit the inspection of the consistency of judgment matrix.

$$Z=\sum_{i=1}^{n}\sum_{j=1}^{n}[\ln a_{ij}-\ln(\frac{\omega_i}{\omega_j})]^2 \qquad (1)$$

In the process of evaluation, according to the fairness and justice principles, more than one evaluator or the inspection team will participate in the evaluation, so the element a_{ij} in the judgment matrix have more than one value (represent for the opinions of different persons or groups), and Eq.(1) should be

$$Z=\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{b}(\ln a_{ijk}-\ln\omega_i+\ln\omega_j)^2 \qquad (2)$$

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The letter b in this new equation represents the number of evaluation groups and evaluators.

In order to calculate the minimum value of Z, we should calculate the partial derivative to ω_p on the both sides of Eq.(2), and then let the equation equals 0. Since $\ln a_{ipk} = \ln(1/a_{pjk})$, we can simplify Eq.(2) and then get the results as follows.

$$n \ln \omega_p - \sum_{j=1}^{n} \ln \omega_j = \frac{1}{b} \sum_{j=1}^{n} \sum_{k=1}^{b} \ln a_{pjk} \quad (3)$$

By simplifying Eq.(3), we get Eq.(4)

$$\omega_p = (\prod_{k=1}^{b} \prod_{j=1}^{n} \omega_j)^{\frac{1}{bn}} \cdot (\prod_{k=1}^{b} \prod_{j=1}^{n} a_{pjk})^{\frac{1}{bn}} = t \cdot (\prod_{k=1}^{b} \prod_{j=1}^{n} a_{pjk})^{\frac{1}{bn}} \quad (4)$$

where $t = (\prod_{k=1}^{b} \prod_{j=1}^{n} \omega_j)^{\frac{1}{bn}}$. Finally, we standardize ω_p to $w=(w_1,w_2,\ldots,w_n)^T$, $\sum_{p=1}^{n} w_p = 1$, and then we get Eq.(5)

$$w_p = \frac{(\prod_{k=1}^{b} \prod_{j=1}^{n} a_{pjk})^{\frac{1}{bn}}}{\sum_{i=1}^{n} (\prod_{k=1}^{b} \prod_{j=1}^{n} a_{ijk})^{\frac{1}{bn}}} \quad (5)$$

(3) Evaluate each selected schemes and establish the fuzzy relation matrix R

Quantify the indexes u_i（i=1,2,…,n） that are from the lowest level of the selected schemes to determine the degree of membership （$R|u_i$） of the fuzzy subsets of the selected schemes. Then we get the fuzzy relation matrix R as Eq.(6) shows [8].

$$R = \begin{bmatrix} R|u_1 \\ R|u_2 \\ \cdots \\ R|u_n \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}_{n \times m} \quad (6)$$

r_{ij} represents from index u_i to see the degree of membership of the fuzzy subset in level v_j. For example, in the personnel selection, there are 10 judges for 3 candidates (A, B, C) for evaluation. There are 3 indexes in the index domain: u_1 - ability, u_2- moral character, u_3 - health. There are 3 indexes in the comment level domain, which are 3 fuzzy subsets: v_1 - good, v_2 - general, v_3 – poor. To evaluate the ability of A, there are 4 people think it is good, 5 people think it is general and 1 people think it is poor.

$$R_A | u_1 = (0.4, 0.5, 0.1) \quad (7)$$

(4) Calculate the evaluation result vector S and make a comprehensive comparison

$$S = w \circ R = (w_1, w_2, \cdots, w_n) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} = (s_1, s_2, \cdots, s_m) \quad (8)$$

In Eq.(8), S is the vector of the evaluation result, and it reflects the degree of membership of the fuzzy subsets in the comment level domain. Herein $\circ$ represents the fuzzy composite operators $M(\cdot,\oplus)$, to j=1,2,…,m, it can be expressed specifically as follows.

$$s_j = (w_1 \cdot r_{1j}) \oplus (w_2 \cdot r_{2j}) \oplus \cdots \oplus (w_n \cdot r_{nj}) = \min(1, \sum_{i=1}^{n} w_i r_{ij}) \quad (9)$$

Finally, we deal the results of the evaluation with the weighted average method.

$$T = \sum_{j=1}^{m} (s_j^k \cdot j) \Big/ \sum_{j=1}^{m} s_j^k \quad (10)$$

T is the final result after the quantification, and it represents the selected scheme's location in the comment level domain. K is the undetermined coefficient (it usually can be 2) to control the affection that the biggish s_j （j=1,2,…,m） makes. It's easy to see that the smaller the T is, the previous the selected scheme will located, which is to say that the scheme is more superior.

5. CASE STUDY

According to the evaluation process and the mathematical model that have been mentioned, we use B/S pattern to develop an AVE main menu of the system includes the selected enterprises, evaluation groups, the condition of evaluation, the opinions of evaluators and the results of the evaluation. The types of allies of the AVE are suppliers, design leaguer, manufacturing leaguer, distributors and so on. This section uses the example of distributor selection and evaluation of a private enterprise to show the process of selection and evaluation and display the main results that are calculated by the system.

(1) Construct the index system

We should determine the general objective and the criteria of the evaluation model. To evaluate the total performance of the distributor, we take 6 criteria into consideration, financial ability, profitability, market influence, service performance, information-sharing capability and development potential.Fig.1 shows the evaluation

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model for the decision maker to choose distributor from the 7 enterprises.

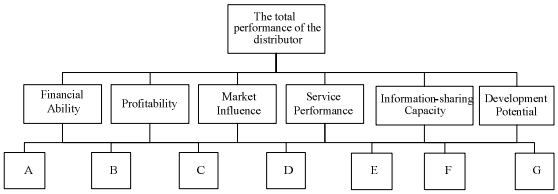

Fig.1 A Tertiary Hierarchical Evaluation Model For Distributor

(2) Determine the evaluation groups and the judgment matrix

The leadership of the enterprise (3 people), the chiefs of the sales department (3 people) and the experts (4 people) constitute three evaluation groups. The judgment matrix is as follows.

	Financial Ability	Profitability	Market Influence	Service Performance	Information-sharing Capacity	Development Potential
Financial Ability	(1,1,1)	(1,1,3/2)	(2,3/2,2)	(3/2,1,2)	(3/2,2,3/2)	(2,2,3/2)
Profitability	(1,1,2/3)	(1,1,1)	(3/2,3/2,2)	(3/2,3/2,1)	(3/2,2,2)	(3/2,3/2,3/2)
Market Influence	(1/2,2/3,1/2)	(2/3,2/3,1)	(1,1,1)	(3/2,1,4/3)	(3/2,3/2,1)	(2,2,3/2)
Service Performance	(2/3,1,1/2)	(2/3,2/3,1)	(2/3,1,3/4)	(1,1,1)	(3/2,2,3/2)	(2,2,3/2)
Information-sharing Capacity	(2/3,1/2,2/3)	(2/3,1/2,1/2)	(2/3,2/3,1)	(2/3,1/2,2/3)	(1,1,1)	(1,1,3/2)
Development Potential	(1/2,1/2,2/3)	(2/3,2/3,2/3)	(1/2,1/2,2/3)	(1/2,1/2,2/3)	(1,1,2/3)	(1,1,1)

(3) Calculate the weight of the indexes

Using Eq.(5), we can get the weight of each index as Table 1 shows.

Table 1. The Weight Of The Indexes

Index	weight
Financial Ability w_1	0.2322
Profitability w_2	0.2036
Market Influence w_3	0.1673
Service Performance w_4	0.1673
Information-sharing Capacity w_5	0.1205
Development Potential w_6	0.1091

(4) Determine the comment level domain $V=\{v_1,v_2,\cdots,v_5\}$, establish the fuzzy relation matrix R.

The specific situation of the comments that $v_i\,(i=1,2,\cdots,5)$ represents is as follows.

Table 2. Corresponding situation of the comment level and the comments

By managing the data, we can get the distributors' fuzzy relation matrixes as follows.

(5) Calculate the comprehensive evaluation results for each distributor and make the comparison.

Using Eq.(8), we can get the S_X, just like Table 3 shows. From Table 3, we can get the comment level of each distributor. Using the Eq.(10), we can get the relative position (T_X) of each distributor in the comment level domain. Just like Table 4 shows, we can know the distributor F is the best choice.

The level of the comment v_i	Corresponding situation
v_1	Quite pleased
v_2	Satisfactory
v_3	General
v_4	Discontented
v_5	Very unsatisfied

$$R_A=\begin{bmatrix}0.3&0.3&0.4&0&0\\0.2&0.4&0.3&0.1&0\\0&0.4&0.2&0.2&0.2\\0&0.1&0.3&0.6&0\\0.1&0.7&0.2.&0&0\\0.3&0.2&0.2&0.3&0\end{bmatrix}\quad R_B=\begin{bmatrix}0.3&0.3&0.3&0.1&0\\0.2&0.3&0.3&0.2&0\\0&0.4&0.2&0.2&0.2\\0&0.1&0.3&0.5&0.1\\0.1&0.7&0.2.&0&0\\0.3&0.3&0.2&0.2&0\end{bmatrix}$$

$$R_C=\begin{bmatrix}0.2&0.3&0.4&0.1&0\\0.3&0.3&0.3&0.1&0\\0.3&0.3&0.2&0.2&0\\0&0.1&0.3&0.6&0\\0.1&0.6&0.3.&0&0\\0.3&0.2&0.2&0.2&0.1\end{bmatrix}\quad R_D=\begin{bmatrix}0.4&0.3&0.2&0.1&0\\0.2&0.5&0.3&0&0\\0&0.3&0.3&0.2&0.2\\0&0.1&0.3&0.5&0.1\\0.2&0.5&0.3.&0&0\\0.3&0.2&0.2&0.2&0.1\end{bmatrix}$$

$$R_E=\begin{bmatrix}0.1&0.4&0.4&0.1&0\\0.2&0.4&0.3&0.1&0\\0.3&0.3&0.2&0.1&0.1\\0&0.1&0.3&0.6&0\\0.1&0.5&0.4.&0&0\\0&0&0.7&0.2&0.1\end{bmatrix}\quad R_F=\begin{bmatrix}0.7&0.3&0&0&0\\0.4&0.3&0.2&0.1&0\\0&0.5&0.2&0.2&0.1\\0.1&0.3&0.6&0&0\\0&0.6&0.3.&0.1&0\\0&0.2&0.3&0.4.&0.1\end{bmatrix}$$

$$R_G=\begin{bmatrix}0.6&0.3&0.1&0&0\\0.4&0.4&0.1&0.1&0\\0.1&0.2&0.5&0.2&0\\0&0.1&0.2&0.7&0\\0&0.5&0.3&0.2&0\\0&0&0.4&0.4&0.2\end{bmatrix}$$

Table 3. The Comprehensive Evaluation Results Of Each Distributor

Distributor	S_x
A	(0.15516,0.34092, 0.28353, 0.18693, 0.03346)
B	(0.15516,0.33147, 0.26031, 0.20287, 0.05019)
C	(0.20249,0.29178, 0.29558, 0.19924, 0.01091)
D	(0.19043,0.32045, 0.26587, 0.16215, 0.0611)
E	(0.12618,0.30149, 0.36218, 0.18251, 0.02764)
F	(0.26071, 0.3587, 0.24344, 0.10951,

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G	0.02764) (0.23749,0.26154, 0.24048, 0.23867, 0.02182)

Table 4. The Relative Position Of Each Distributor In The Comment Level Domain

Distributor	T_x
A	2.5046
B	2.5443
C	2.4978
D	2.4098
E	2.6769
F	2.0654
G	2.4864

6. CONCLUSION

In this paper, we combine the AHP and the fuzzy theory to put forward a new method for AVE to choose and evaluate their allies. This method uses the AHP to calculate the weight of each index, and uses the fuzzy theory to get the attribute value, and finally merges these results to get the evaluation result. In the process of calculating the weight of the indexes, to use the logarithmic least square method generally can omit the consistency check for the judgment matrix, and the equations we get are easier and more realizable on the computer. This method not only can well solve the problems that the traditional ally selection method has, such as the regional restrictions, the long time and the inflexible ways to settle problems, and can better make up the problems of the limited number of the scheme and the inconsistency of the judgment matrix that the traditional AHP or the fuzzy AHP has. The evaluation result we get from this new method is fair and reasonable, and it can be realizable in the practical application. At the same time, as for the index evaluation on any levels of the evaluation model, we can get the useful data for decision reference. The further research involves how to cooperate with partners to make the virtual ally get the maximum benefit.

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