Evaluation of Information System Disaster Recovery Ability based on Experts' Weight and Improved TOPSIS*

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Abstract - Given that current evaluation technique takes no consideration in assignment of experts' weight, we propose a determinate expert weight approach to get different experts' evaluation weight, based on which reasonable significance value is assigned to evaluation index. Then we improve accuracy of expert grading matrix by referring to experts' weight and produce decision matrix. We also establish a disaster recovery ability evaluation model using improved TOPSIS which is upgraded with index weight and positive and negative ideal solution, based on recovery index characters. At last, we demonstrate the feasibility and practicality of the proposed model with experiment statistics.

Index Terms - Information System Disaster Recovery Ability; Experts' Weight; Improved TOPSIS; Evaluation Model.

1. Introduction

With the rapid development of the information technology, the loss caused by the disaster of the Information systems become larger[1]. At present, the evaluation of domestic information systems' disaster recovery ability is still in infancy, with little systematic and mature theoretical method and system. However, there are little relevant literatures on disaster recovery evaluation. Respectively, relevant reference [2~4] integrate analytic hierarchy process (AHP), fuzzy comprehensive evaluation etc. But the authors writing above models take no considerations on the knowledge structure, personal experience, the understanding of the project and personal predilection of these experts. Expert judgment information is the basis of the comprehensive evaluation method, and gathering experts' evaluation information based on their weight can make the results of the system evaluation more accurate. To solve this problem, this paper based on the thought of average values and variation coefficients proposes an experts' weight determined method to empower the experts. Then it establishes a evaluation model of information systems' disaster recovery ability using improved TOPSIS, which is based upon evaluation index characteristics.

2. Basic Principle Modeling

A. Experts' Weight determination

The expert's weight determination of group decision making in this paper is based on the degree of consistency between an expert's judgment and the panel's ones. When an expert's judgment has high information consistency with most experts', he should have larger evaluation weights. Otherwise, when his judgment has bad information consistency with most experts', then he has lower weights. The method borrows the idea of the variation coefficient method, which is the weight of decision problems can be determined by the degree of the differences among decision-making data. But pure thoughts of variation coefficients would cause the loss of evaluation information. Therefore, this method improves itself combined with the thought of average values, and makes the greatest use of the judgment information. The model is as follows:

Now set up a multi-attribute and multi-expert evaluation problems that includes an experts set $X=\{x_1,x_2,x_3,...x_n\}$ and an attributes set $A=\{a_1,a_2,a_3,...a_m\}$. Through appropriate method, the weight vectors are set as follows:

$$W_1=(w_{11},w_{12},...w_{1m})$$
$$W_2=(w_{21},w_{22},...w_{2m})$$
$$\cdots$$
$$W_n=(w_{n1},w_{n2},...w_{nm})$$

In which, $\sum_{j=1}^{m} w_{ij}=1 \quad i\in\{1,2,3...n\}$

Step1: Set

$$\overline{w_i}=\sqrt[n]{w_{1i}\times w_{2i}\times w_{3i}\times ...w_{ni}}$$
$$\overline{W}=(\overline{w_1},\overline{w_2},\overline{w_3},...\overline{w_m})$$

Step2: Set

$$\left|\overline{W_i}-\overline{W_j}\right|=\sqrt{(w_{i1}-w_{j1})^2+(w_{i2}-w_{j2})^2+...(w_{im}-w_{jm})^2}$$
$$i,j\in\{1,2,3...n\}$$

Step3: Set

$$D_i=t\times\sum_{k=1}^{n}\left|W_i-W_k\right|+(1-t)\times\left|W_i-\overline{W}\right|$$
$$i\in\{1,2,3...n\} \quad 0\le t\le 1$$

Step4: Suppose

$$W^{'}=(\frac{1}{D_1},\frac{1}{D_2},\frac{1}{D_3},...\frac{1}{D_n})$$

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Normalize W' *and* get expert weights' empowerment vector

$$W^* = (w_1^*, w_2^*, w_3^*, \ldots w_n^*)$$

Step5: Achieve the comprehensive weighting vector W of attribute set A by weighting method:

$$W = W^* \times \begin{pmatrix} w_{11} & \cdots & w_{1n} \\ \vdots & \ddots & \vdots \\ w_{n1} & \cdots & w_{nm} \end{pmatrix}$$

As can be seen from the model, $\frac{1}{D_i}$ expresses the consistency of experts and better reflects the consistency of experts' evaluation, and it's reasonable to choose it to measure experts' weight. In addition, the algorithm will not abandon the extreme information, and make full use of all experts' evaluation information. Experts can use subjective and objective evaluation method to empower different attributes. The method is simple and convenient in determining the weights of experts, and it has great practicability.

B. Improved TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a multi-index and multi-scenario analysis method on systematic review, first put forward by C.L.Hwang and K.Yoon[5] . According to the proximity between the existed schemes and the constructed "positive ideal solution", "negative ideal solution", TOPSIS sorts different decision schemes to make evaluation of the relative merits of limited programs. The procedure is as follows:

Suppose the multi-target and multi-program program set is $M = \{m_1, m_2, m_3, \ldots m_n\}$ and index set is $A = \{a_1, a_2, a_3, \ldots a_m\}$. Let the scheme m_i's value on index a_j is x_{ij}.

Step1: Structure the normalized decision-making matrix $R(r_{ij})$

$$r_{ij} = x_{ij} / \sqrt{\sum_{j=1}^{m} x_{ij}^2}$$

Step2: Determine the positive ideal solution $F^+(f_{ij}^+)$ and negative ideal solution $F^-(f_{ij}^-)$

$$F^+ = [(\max_i r_{ij} \mid j \in J) or (\min_i r_{ij} \mid j \in J^{'})]$$

$$F^- = [(\min_i r_{ij} \mid j \in J) or (\max_i r_{ij} \mid j \in J^{'})]$$

In which $J = (J = 1, 2, \ldots n \mid J - benefit\ type)$

$J^{'} = (J^{'} = 1, 2, \ldots n \mid J^{'} - loss\ type)$

Step3: Calculate the distance between schemes and positive ideal programs:

$$S^+ = \sqrt{\sum_{j=1}^{m} (r_{ij} - f_{ij}^+)^2}$$

The distance between schemes and negative ideal program is as follows:

$$S^- = \sqrt{\sum_{j=1}^{m} (r_{ij} - f_{ij}^-)^2}$$

Step4: Calculate the relative similarity between schemes and positive ideal program:

$$u_i = S^- / (S^+ + S^-) \quad i = 1, 2, 3, \ldots n$$

Step5: Sort. The bigger u_i is, the closer scheme m_i is to positive ideal solutions, and the better the scheme is.

In this paper, we improve the traditional TOPSIS according to actual situation in the process of the information systems disaster recovery ability evaluating. The improvement is as follows:

*1)*Before constructing normalized decision-making matrixes, weight different experts' evaluation matrixes by obtained experts' weights using the proposed method of experts' determination, and structure compositive evaluation matrixes. We fully consider the experts' own decision-making component in the new evaluation matrixes, which is more practical and reasonable than the original ideal that experts are at the same position.

*2)*There is no available dimensions of information systems disaster recovery ability evaluation indexes, and when experts judge the evaluation indicators, they unified adopt the centesimal system. So we can directly use raw data of different indicators in the evaluation matrix achieved, and then leave out the standardization of the decision-making matrixes.

Besides, evaluation indexes of information systems disaster recovery ability belong to the objective attribute in benefit type. According to the principle of centesimal marking system, we can suppose the positive ideal programme $F^+ = 100 \times (w_1, w_2, w_3, \ldots w_m)$, and the negative ideal programme $F^- = 0 \times (w_1, w_2, w_3, \ldots w_m)$.

*3)*When calculating the distance to the positive and negative ideal schemes, index weight coefficients are introduced. There are no considerations of the effect on each index's weight to the total target in the traditional TOPSIS, so the evaluation consequence achieved after the introduction of weight coefficients can be more actual.

3. Structure the Assessment Model

A. Evaluation Index System of Information Systems Disaster Recovery Ability

To make an accurate evaluation of information systems disaster recovery ability, how to establish a reasonable evaluation index system is the foundation[6]. Evaluation index systems consist of several interrelated and interacted evaluation indexes which compose an organic whole according to certain gradation and framework. An evaluation index system is the tie linking evaluation experts and evaluation objects, as well as a bridge between evaluation methods and evaluation objects. The evaluation index system is shown in Fig.1.

B. Procedure of Evaluation

Suppose there are *n* information system disaster recovery solutions, *m* information system disaster recovery evaluation indexes, *z* experts judging each indicator and program. *Z* experts empower *m* indicators on a certain method, getting evaluation index weighting matrix $W(w_{ij})$, in which w_{ij} is the empowerment of expert *i* to attribute *j*. Respectively *z* experts rate n information system disaster recovery programs, getting *z*

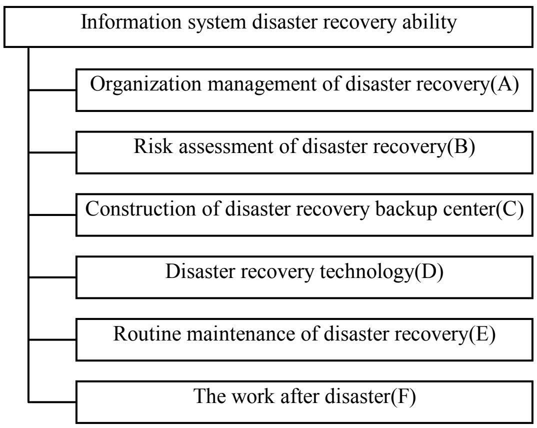

Fig.1 Evaluation Index System of Information Systems Disaster Recovery Ability

decision matrixes $R_1, R_2, \ldots R_z$ and each decision matrix $R(x_{ij})$, in which x_{ij} is the score of program *i* beneath index *j*.

Step1: Empower $W(w_{ij})$ based on the evaluation index. And calculate z-experts' weight vector $W^* = (w_1^*, w_2^*, w_3^*, \ldots w_z^*)$ according to experts weight determination proposed in 2.A and *m* weight vector $W = (w_1, w_2, w_3, \ldots w_m)$ of evaluation indexes.

Step2: Obtain $R'(x_{ij})$ based upon experts weight W^* achieved and decision-making matrix $R_i (i = 1,2,..z)$:

$$R' = \sum_{i=1}^{z} (w_i^* \times R_i)$$

Step3: Calculate the index weights weighting standardized matrix $V(v_{ij})$:

$$v_{ij} = w_j \times x_{ij}$$

in which w_j is index weight.

Step4: Determine the positive ideal solution F^+ and negative ideal solution F^-

$$F^+ = 100 \times (w_1, w_2, w_3, \ldots w_m)$$

$$F^- = (0, 0, 0, \ldots 0)$$

Step5: Get the distance between each program and positive ideal solutions by reference to the evaluation index weight coefficients:

$$S^+ = \sqrt{\sum_{j=1}^{m} w_j \times (v_{ij} - f_{ij}^+)^2}$$

The distance between each program and negative ideal solutions is as follows:

$$S^- = \sqrt{\sum_{j=1}^{m} w_j \times (v_{ij} - f_{ij}^-)^2}$$

Step6: Compute the relative closeness of each program and positive ideal solutions

$$u_i = S^- / (S^+ + S^-) \; i = 1, 2, 3, \ldots n$$

Step7: Sort by u_i which is obtained by calculating. The larger the program u_i is, the stronger the program's information systems disaster recovery capabilities are. On the contrary, the program's information systems disaster recovery capabilities are weaker.

4. Applications of Examples Summary

An enterprise's in Beijing 4 kinds of information systems disaster recovery plans are marked by four experts in the field of disaster recovery. Data is as follows:

TABLE I Empowerment for evaluation index

	A	B	C	D	E	F
1	0.12	0.16	0.25	0.13	0.08	0.26
2	0.08	0.19	0.27	0.11	0.05	0.3
3	0.05	0.14	0.29	0.18	0.11	0.23
4	0.11	0.18	0.15	0.21	0.17	0.18

TABLE Ⅱ Scoring table of expert 1

	A	B	C	D	E	F
1	78	45	68	41	89	56
2	48	55	85	75	56	65
3	68	65	78	64	63	52
4	72	71	85	73	69	74

TABLE Ⅲ Scoring table of expert 2

	A	B	C	D	E	F
1	68	55	69	52	70	57
2	53	60	92	84	43	62
3	62	63	82	70	58	57
4	69	65	81	83	76	72

TABLE Ⅳ Scoring table of expert 3

	A	B	C	D	E	F
1	76	62	67	64	63	67
2	62	64	88	85	54	61
3	58	59	73	75	68	62
4	65	81	85	80	74	76

TABLE Ⅴ Scoring table of expert 4

	A	B	C	D	E	F
1	62	58	75	76	78	50
2	59	67	81	74	62	54
3	71	64	75	70	62	64
4	72	75	83	79	71	75

Step1: Calculate according to the Evaluation step 1 (In which t values 0.5) and table 1:

$$W^* = (0.31664, 0.24227, 0.26299, 0.17810)$$
$$W = (0.09012, 0.16557, 0.24746, 0.15255, 0.09665, 0.24765)$$

Step2: Calculate experts weights' weighting decision-making matrix R' according to the Evaluation step 2 and table 2~5:

$$R' = \begin{pmatrix} 72.2019 & 54.2088 & 69.2259 & 55.9470 & 75.5999 & 58.0667 \\ 54.8523 & 60.7154 & 86.7726 & 79.6324 & 53.3929 & 61.2622 \\ 64.4506 & 62.7594 & 77.1199 & 69.4152 & 62.9255 & 57.9784 \\ 69.4322 & 72.8887 & 83.6747 & 78.3323 & 72.3671 & 74.2195 \end{pmatrix}$$

Step3: Compute index weights' weighting decision-making matrix V based on the Evaluation step 4 and index weight W:

$$V = \begin{pmatrix} 6.5067 & 8.9754 & 17.1373 & 8.5348 & 7.3067 & 14.3747 \\ 4.9432 & 10.0526 & 21.4812 & 12.1480 & 5.1604 & 15.1656 \\ 5.8082 & 10.3911 & 19.0916 & 10.5894 & 6.0817 & 14.3528 \\ 6.2571 & 12.0682 & 20.7143 & 11.9474 & 6.9942 & 18.3734 \end{pmatrix}$$

Step4: Based upon the Evaluation step 5 ~ 7 and matrix V, we can obtain the relative similarity between schemes and the positive ideal scheme, which are: u_1=0.620523, u_2=0.694662, u_3=0.662672 and u_4=0.769252 respectively.

Step5: Sort them according to the relative similarity:

$$u_4 > u_2 > u_3 > u_1 .$$

Step6:Based on calculation results, the sequencing of disaster recovery ability in each program is as follows:

$$Scheme4 > Scheme2 > Scheme3 > Scheme1 .$$

Though compared with the traditional TOPSIS evaluation results, there are different relative similarities among different schemes; the sequencing of schemes is identical. It shows that the improved TOPSIS reflects the effect after the index weighting, and this method is feasible and simple to calculate.

5. Summary

In the process of the comprehensive assessment on the information system disaster ability, it's crucial that how to gather the experts' evaluation information. The experts weight determination proposed in this paper solves the experts' empowering problem effectively, and provides a thought and important basis for integrating expert's information. What's more, we have fully considered the consequence of the evaluation weigh indexes to the general goal in the improved TOPSIS, and its evaluation is consistent with the traditionary TOPSIS'. Thus, the established model of information systems disaster recovery ability's evaluation is feasible and practical.

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