Combining Entropy Weight and TOPSIS Method for Information System Selection

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***Abstract*—This study proposes a combined entropy weight and TOPSIS method for information system selection. In the present paper, information entropy is employed to derive the objective weights of the evaluation criteria, and a modified TOPSIS method is employed to rank a finite number of feasible alternatives in order of preference and then select a suitable information system that conforms to the decision maker's ideal. An empirical study demonstrated the feasibility and practicability of the proposed method for real-world applications. The result shows that the approach is computationally simple and its underlying concept is rational and comprehensible, thus facilitating its implementation in a computer-based system.**

***Keywords*—entropy weight, TOPSIS, information system selection**

I. INTRODUCTION

Increasingly, information plays an extremely important role in most organizations, more and more modern organizations have become dependent on their information systems (IS) for their daily business operations. The selection of information systems is a recurring decision faced by every modem organization. It is recognized that selecting the right system is a challenging task that may give some competitive advantages [1-3]. However, owing to the complexity of the business environment, the limitations in available resources and the given considerable financial investment, and obviously, the selection is conducted in highly dynamic situations, including complex tradeoffs and high levels of uncertainty, selection of the appropriate information system is a complex problem and requires an extensive evaluation process that considers the organizational mission and requirements.

Several methods have been proposed to help organizations make good IS selection decisions including scoring, ranking, mathematical optimization, and multi-criteria decision analysis, etc. There are some obvious limitations by using scoring, ranking or mathematical optimization to the real-world IS selection decision, such as scoring or ranking method is too simple to truly reflect opinions of the decision makers, mathematical optimization is often weakened by sophisticated mathematic models and not too easy for managers to understand, and so on, which have been discussed in some literatures [4-6]. Wei et al [4] provide an excellent review of these methods.

Since the decision process of selecting an appropriate information system usually depends on multiple factors [5,6], IS selection can be viewed as a multi-criteria decision making (MCDM) problem. So, more and more researchers address the area of developing MCDM methods for IS selection in order to overcome the shortcomings as mentioned above. Recently, researchers focus on the methods based on AHP/ANP [4,7,8,9]. As we all well known, AHP/ANP-based methods is based on expert's judgments and pairwise comparisons, however, expert intuitions and opinions frequently conflict in uncertainty, pairwise comparisons might be inconsistent with each other. When the pairwise comparisons matrix dose not satisfy the consistency measure, modification of inconsistent judgments must be iterated in order to improve the consistency. IS selection based on AHP is tedious and time consuming. In addition, the subjectivity and the non-determinacy in expert's judgments can not be avoided by using AHP-based methods to IS selection.

The technique for order preference by similarity to ideal solution (TOPSIS) [10] is quite effective in identifying the best alternative quickly. This study proposes a combined entropy weight and TOPSIS method for information system selection. In the present paper, information entropy is employed to derive the objective weights of the evaluation criteria, and a modified TOPSIS method is employed to rank a finite number of feasible alternatives in order of preference and then select a suitable information system that conforms to the decision maker's ideal.

The remainder of the paper is structured as follows. Section 2 describes the proposed method and algorithm steps. An empirical study of IS selection is used to demonstrate the feasibility and practicability of the proposed method in Section 3. Finally, Section 4 concludes this paper.

II. THE PROPOSED METHOD

IS selection is the procedure to find the best alternative among a set of feasible alternatives. In this section, an approach for IS selection is proposed. Firstly, section *A* describes the conceptual mode of IS selection. The problem of determination of evaluation criteria weights will be solved in section *B*. Thirdly, based on these, section *C* describe the steps of the proposed algorithm for IS selection.

A. Conceptual Mode of IS Selection

As mentioned above, IS selection can be viewed as a multi-criteria decision making (MCDM) problem. An MCDM problem with m alternatives and n criteria can be expressed in matrix format as follows:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

$$W = (w_1, w_2, \cdots, w_n)$$

where $A_1, A_2, \ldots, A_m$ are feasible alternatives, $C_1, C_2, \ldots, C_n$ are evaluation criteria, x_{ij} is the performance rating of alternative A_i under criterion C_j, and w_j is the weight of criterion C_j, satisfying $\sum_{j=1}^{n} w_j = 1$.

In general, evaluation criteria can be classified into two types: benefit and cost. Benefit criterion means that a larger value is more valuable whilst cost criteria are just the reverse.

The data in matrix D have different dimensions, thus it needs to be normalized in order to transform various criterion dimensions into the non-dimensional criterion, which allows comparison across the criteria. In this paper, matrix D is normalized for each criterion C_j as

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, j \in [1..n] \quad (2)$$

As a consequence, a normalized decision matrix representing the relative performance of the alternatives is obtained as

$$P = \left(p_{ij}\right)_{m \times n}, i \in [1..m], j \in [1..n] \quad (3)$$

B. Determination of Evaluation Criteria Weights

According to requirements of purchaser, an organization often selects information system from several competing alternatives under various criteria, and each evaluation criterion is not of equal importance. It is generally necessary to know the relative importance of each criterion. There are many techniques to elicit weights, such as the weighted evaluation technique, the eigenvector method, the weighted least square method, the entropy method, the AHP method and so forth. Here, the entropy method is employed to derive the weights of the evaluation criteria in the proposed method.

Entropy, in information theory, is a criterion for the amount of uncertainty [11,12], represented by a discreet probability distribution, in which there is agreement that a broad distribution represents more uncertainty than does a sharply packed one.

The amount of decision information contained in EQ. (3) and emitted from each criterion C_j can thus be measured by the entropy value e_j as

$$e_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln(p_{ij}), \quad i \in [1,m], j \in [1,n] \quad (4)$$

The degree of diversity of the information contained by each criterion can be calculated as

$$d_j = 1 - e_j, j \in [1,n] \quad (5)$$

Thus, the objective weight for each criterion is given by

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, j \in [1,n] \quad (6)$$

C. Selection of the Suitable Alternative

In this section, entropy weight and TOPSIS method is combined for ranking and then selecting from competing alternatives.

The technique for order preference by similarity to ideal solution (TOPSIS) proposed by Hwang and Yoon [10] is one of the well-known methods for classical MCDM. This technique is based on the concept of the positive ideal solution (*PIS*) and negative ideal solution (*NIS*). The *PIS* is a solution that maximizes the benefit criteria and minimizes the cost criteria whereas the *NIS* maximizes the cost criteria and minimizes the benefit criteria. The basic principle of TOPSIS is that the chosen alternative should have the shortest distance from the *PIS* and the farthest distance from the *NIS*.

TOPSIS is rational and comprehensible, and the computation involved is simple, however, in the classical TOPSIS, the effects of weighting are doubled [13], and the resultant Euclidean distances are not weighted at all [14]. The present paper uses the weighted Euclidean distances instead of the weighted decision matrix required by TOPSIS in the aggregation process.

Thus, based on the concepts behind TOPSIS, the proposed method consists of the following steps:

Step 1: Determine the problem of IS selection;

Step 2:Identify the characteristics of the competing vendors and filter out the candidates called $A_1, A_2, \ldots, A_m$;

Step 3: Construct the criteria for evaluating the candidates called $C_1, C_2, \ldots, C_n$;

Step 4: Collect the data of decision matrix, as D in EQ. (1), and calculate the normalized decision matrix, as P in EQ. (3) by EQ. (2);

Step 5:Elicit the weights of criteria using EQ. (4) to EQ. (6);

Step 6: Determine PIS (A^+) and NIS (A^-), respectively, by

$$A^+ = (p_1^+, p_2^+, \cdots, p_m^+) \quad (7)$$

$$A^- = (p_1^-, p_2^-, \cdots, p_m^-) \quad (8)$$

where

$$p_j^+ = \left\{ \max_i p_{ij}, j \in J_1; \min_i p_{ij}, j \in J_2 \right\} \quad (9)$$

$$p_j^- = \left\{ \min_i p_{ij}, j \in J_1; \max_i p_{ij}, j \in J_2 \right\} \quad (10)$$

and where J_1 and J_2 are the sets of benefit criteria and cost criteria, respectively;

Step 7: Calculate the weighted Euclidean distances [14], between A_i and A^+, and between A_i and A^-, respectively, as

$$d_i^+ = \sqrt{\sum_{j=1}^{n} w_j (d_{ij}^+)^2} \quad (11)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} w_j (d_{ij}^-)^2} \quad (12)$$

where

$$d_{ij}^+ = p_j^+ - p_{ij}, i \in [1, m] \quad (13)$$

$$d_{ij}^- = p_j^- - p_{ij}, i \in [1, m] \quad (14)$$

Step 8: Calculate the relative closeness of each alternative to the ideal solution. The relative closeness of the alternative A_i with respect to A^+ is defined as

$$\xi_i = \frac{d_i^-}{d_i^+ + d_i^-}, i \in [1, m] \quad (15)$$

Step 9: Rank the alternatives according to the relative closeness to the *PIS*. The larger the index value, the better the performance of the alternative A_i. The best alternative is the one with the greatest relative closeness to the *PIS*.

III. EMPIRICAL STUDY

In this section, the proposed method is used to an empirical study of IS selection. In this case, an university wants to purchase a MIS system, and there are 7 candidates as A_1, A_2, . . . , A_7. According to the requirements of this organization, the criteria for evaluating the candidates is describes as follows:

(1) Total costs (C_1);

(2) Implementation time (C_2);

(3) Performance of system such as functionality, flexibility, reliability, security and so forth (C_3);

(4) R&D capability and the capability of supplying ongoing service (C_4);

(5) Organizational reputation (C_5).

Obviously, C_1 and C_2 are benefit criteria whilst C_3, C_4 and C_5 are cost criteria. In order to quantize all criteria, performance of system is tested and scored by an experts group, and organizational reputation is expressed by market share of each vendor. The decision matrix is described as TABLE I.

By using the proposed method, the normalized decision matrix, *PIS*, *NIS* and the results of relative closeness of each alternative to the ideal solution are described as TABLE II and TABLE III as follows. Based on ξ_i values, the ranking of the alternatives in descending order are A_6, A_2, A_7, A_3, A_4, A_1 and A_5. According to the last step, the principle of TOPSIS mentioned above, the best alternative for IS selection is A_6.

TABLE I
DECISION MATRIX

	C_1	C_2	C_3	C_4	C_5
A_1	120	40	82.5	182	25
A_2	130	30	85.6	239	25
A_3	95	35	80.9	147	21
A_4	110	35	81.7	153	22
A_5	120	45	82.3	177	28
A_6	100	25	80.4	193	23
A_7	98	30	81.2	162	20

TABLE II
NORMALIZED DECISION MATRIX,, PIS AND NIS

	C_1	C_2	C_3	C_4	C_5
A_1	0.155	0.167	0.144	0.145	0.152
A_2	0.168	0.125	0.149	0.191	0.152
A_3	0.123	0.146	0.141	0.117	0.128
A_4	0.142	0.146	0.142	0.122	0.134
A_5	0.155	0.188	0.143	0.141	0.171
A_6	0.129	0.104	0.140	0.154	0.140
A_7	0.127	0.125	0.141	0.129	0.122
A^+	0.123	0.104	0.149	0.191	0.171
A^-	0.168	0.188	0.140	0.117	0.122

TABLE III
RELATIVE CLOSENESS

	d_i^+	d_i^-	ξ_i
A_1	0.049	0.024	0.328
A_2	0.023	0.058	0.714
A_3	0.051	0.032	0.385
A_4	0.049	0.029	0.371
A_5	0.061	0.023	0.277
A_6	0.023	0.059	0.716
A_7	0.041	0.043	0.515

IV. CONCLUSIONS

In this paper, entropy weight and TOPSIS have been combined to rank and then select IS system from a finite number of competing vendors. The result presented the proposed method is practical and useful. Significantly, the proposed method provides more flexible and objective information in determine the weights vector of the criteria. Furthermore, the approach is computationally simple and its underlying concept is rational and comprehensible, thus facilitating its implementation in a computer-based system. An empirical study demonstrated the feasibility and practicability of the proposed method for real-world applications.

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