Accounting and Corporate Management (2021) 3: 83-90 **DOI: 10.23977/accm.2021.030113**
Clausius Scientific Press, Canada **ISSN 2523-5788**

Selection of ERP Software Combining EWM and VIKOR Methods

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Keywords: ERP, EWM, VIKOR

Abstract: Enterprise Resource Planning (ERP) provides the optimal solution for information integration for enterprises, but the evaluation and selection of ERP software is closely related to the success of a project. Many previous studies have adopted Analytic Hierarchy Process (AHP) and Ideal Point Method (TOPSIS) for the evaluation and selection of ERP software suppliers, but the former has the disadvantage of being subjective and one-sided, while the latter can not reflect the lack of actual proximity between the solution and the positive and negative ideal solution. Accordingly, this study combines Entropy Weight Method (EWM) and VIKOR method as the evaluation choice of ERP software, because EWM is able to determine the weight of each index objectively, while the VIKOR method can effectively deal with the fuzziness and uncertainty of people's evaluation and decision-making process, so that a more ideal decision can be obtained.

1. Introduction

Enterprise Resource Planning (ERP) not only serves as a software product, but also contains advanced management ideas, which provides the optimal solution for information integration for enterprises. With the deepening of enterprise information construction in our country, the implementation of ERP has become an important means for enterprises to improve their management level and market competitiveness. Unfortunately, the implementation of ERP is a complex system engineering, in which the evaluation and selection of ERP software more directly determine the success of the project.

In the past, there have been many studies on the evaluation and selection methods of ERP software suppliers [1-4]. However, Shou & Zhang (2013) [5] point out that compared with AHP, the use of Entropy Method to calculate the index weight can greatly reduce the subjectivity and one-sidedness of the AHP method. As a result, many related studies have been published [6-7]. In addition, Opricovic and Tzeng (2007) [8] hold that VIKOR is a ranking method based on compromise optimization, which overcomes the shortcomings that TOPSIS cannot reflect the actual closeness of the solution to the positive and negative ideal solutions, while taking into account the maximization of group utility and the minimization of individual regrets as well as the integration of the subjective preferences of decision makers, which helps to ensure the rationality of the decision results. In recent years, related application papers have also emerged correspondingly [9-10].

Therefore, EWM and VIKOR methods are used as the evaluation choice of ERP software, and it is expected that EWM can objectively determine the weight of each index. VIKOR method can effectively deal with the fuzziness and uncertainty of people's evaluation and decision-making process, and provide a more ideal decision.

2. Research Methods

2.1 Ewm

The concept of entropy originated from classical thermodynamics theory. In 1948, the concept of entropy was introduced into information theory. The uncertainty of information source signals was called information entropy, and the degree of uncertainty eliminated was called information. Information entropy describes the relative rate of sample data change. The closer the coefficient is to 1, the closer to the target; the closer the coefficient is to 0, the further away from the target. EWM is a method to determine the weight according to the order degree of the information contained in each indicator. The smaller the information entropy, the larger the index weight. The method of using EWM to determine the weight can eliminate the interference of human factors, so that the evaluation results can be more scientific and reasonable. The calculation steps of EWM are as follows:

Step 1: Construct the initial matrix X:

$$X = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix}$$, wherein, represents the *n*-th index data of the *m*-th individual.

Step 2: Data standardization processing:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \quad (1)$$

Step 3: Calculate the index information entropy value E and the information utility value d, the information entropy value of the j-th index is:

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^{m} P_{ij} \ln(P_{ij}) \quad (2)$$

Step 4: Calculate the information utility value:

$$d_j = 1 - E_j \quad (3)$$

Step 5: Calculate the weight of the evaluation index:

The greater the value of information utility, the more important the index is, the more important it is to the evaluation. Finally, the weights of j indicators are obtained as follows:

$$W_j = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (4$$

2.2 Vikor

VIKOR method is a compromise ranking method, which compromises and ranks limited decision-making solutions by maximizing group utility and minimizing individual regret. The basic point of view of VIKOR is to first determine positive ideal solution and negative ideal solution, where the former refers to the optimal value of each alternative in each evaluation criterion, while the latter refers to the worst value of each option in each evaluation criterion. Then, the priority of the solution is ranked according to the closeness of the ideal solution of each evaluation of each option. The steps of using VIKOR method to evaluate are as follows:

Step 1: the VIKOR method requires that the weight of the index be integrated before the evaluation.

Step 2: Standardize the evaluation value. The normalized decision matrix is obtained by the method of vector normalization.

$$Z_{ij} = \frac{X_j}{MaxX_j} \quad (5)$$

Step 3: Calculate the positive ideal solution and negative ideal solution of each index for the normalized decision matrix Z:.

$$f_i^+ = \left[max_j f_{ij} \middle| i \in I_1, min_j f_{ij} \middle| i \in I_2\right] \forall i \quad (6)$$

$$f_i^- = \left[min_j f_{ij} \middle| i \in I_1, max_j f_{ij} \middle| i \in I_2\right] \forall i \quad (7)$$

Where in, represents the set of benefit evaluation criteria, and represents the set of cost evaluation criteria.

Step 4: Calculate the values of the optimal solution for the comprehensive evaluation of the program and the worst solution of the comprehensive evaluation for the program:

$$S_j = \frac{\sum_{i=1}^{n} w_i \left(f_i^+ - f_{ij}\right)}{f_i^+ - f_i^-}, \ \forall j \quad (8)$$

$$R_j = Max_i \left[\frac{w_i \left(f_i^+ - f_{ij}\right)}{\left(f_i^+ - f_i^-\right)}\right], \forall j \quad (9)$$

Wherein, refers to the weight of each indicator, indicating the relative importance between them.

Step 5: Calculate the value of the benefit ratio generated by the solution; j=1,2,3,…..n.

$$Q_j = \frac{v\left(S_j - S^*\right)}{S^- - S^*} + \left(1 - v\right)\left(R_j - R^*\right) / \left(R^- - R^*\right) \quad (10)$$

Wherein, $S^* = min_j S_j; S^- = max_j S_j$; $R^* = min_j R_j; R^- = max_j R_j$ v refers to “Majority Criterion”.

Step 6: determine the sort order. The solution is sorted from small to large according to the value of , and , and the higher the solution is, the better it is. The ranking sequence of three solutions is obtained, and the first in each sequence is better than the last in each sequence.

Step 7: Determine a compromise

Condition 1: Threshold conditions for acceptable benefits:

$$Q'' - Q' \geq 1 / \left(J - 1\right) \quad (11)$$

Wherein, Q' represents the Q value of the solution that is ranked first after sorting by the Q value, and Q'' represents the Q value of the solution that is ranked second after being sorted by the Q value.

Condition 2: Acceptable decision-making reliability: Q' is a solution ranked first according to the S value or the R value. If one condition is not met, then:

(1)If condition 2 is not satisfied, then the solutions and are compromise solutions.

(2)If condition 1 is not satisfied, then the solution, , … is its compromise solution, where satisfies the condition .

3. Case Analysis

3.1 Construction of Evaluation Indexes for Erp Software Suppliers

Through the analysis of the data of various ERP software suppliers at home and abroad, combined with the experience of users in the process of using, and referring to the relevant research in the past, the index system of ERP software evaluation is established, as shown in Table 1.

Table 1 Erp Software Evaluation Index System

First-level index	Second-level index
X1 Technology Maturity	X11 Software Flexibility and Operability
	X12 Software Fault Tolerance
	X13 Software Function Completeness
	X14 Software Technology Advancement
	X15 System Safety and Reliability
X2 Software Fee	X21 Software Price
	X22 Training and Consulting Costs
	X23 Secondary Development and Maintenance Costs
X3 User Service Level	X31 Pre-Sales Service
	X32 Implementation Process Service
	X33 After-Sales Service
X4 Software Vendor Attributes	X41 Software Supplier Reputation
	X42 Software Supplier Development Capabilities

3.2 Design of the Questionnaire

The questionnaire describes in detail the 13 indicators extracted and takes them as the evaluation factors for the selection of ERP software suppliers. The importance of the thirteen indicators is divided into ten levels, of which 1 means very unimportant, and 10 means very important. Secondly, the satisfaction of the five ERP software suppliers selected by SX, OrX, UX, KX and OdX is scored, which is divided into ten grades, of which 1 meass very dissatisfied, and 10 meass very satisfied.

3.3 Statistics and Collation

Seven professional teachers who are familiar with the operation of ERP software are invited to score, and a total of 7 questionnaires are sent out. After collecting the importance score of ERP software indicators, the entropy method is used to calculate the index weight, and then the VIKOR formula is used to calculate the index weight.

3.4 Calculation Process

3.4.1 Using Ewm to Calculate Weights, the Detailed Steps Are as Follows:

(1)Construct the initial matrix X.
(2)Indicator evaluation data statistics, as shown in Table 2:

Table 2 Indicator Evaluation Data Statistics

	X11	X12	X13	X14	X15	X21	X22	X23	X31	X32	X33	X41	X42
Expert #1	8	8	7	6	9	7	6	7	6	9	8	6	7
#2	8	9	7	8	10	6	5	8	8	8	9	8	9
#3	10	8	9	8	10	9	9	9	8	10	9	9	8
#4	7	4	6	7	8	8	9	7	8	6	9	6	6
#5	5	6	7	8	9	7	8	7	6	8	9	7	8
#6	6	7	8	9	8	7	6	6	5	7	8	8	8
#7	7	8	9	8	6	8	7	6	6	8	7	8	6

(3)Standardized processing: According to Eq. (1), the standardized processing data is shown in Table 3:

Table 3 Standardized Processing Data

	X11	X12	X13	X14	X15	X21	X22	X23	X31	X32	X33	X41	X42
Expert #1	0.16	0.16	0.13	0.11	0.15	0.13	0.12	0.14	0.13	0.16	0.14	0.12	0.13
#2	0.16	0.18	0.13	0.15	0.17	0.12	0.1	0.16	0.17	0.14	0.15	0.15	0.17
#3	0.2	0.16	0.17	0.15	0.17	0.17	0.18	0.18	0.17	0.18	0.15	0.17	0.15
#4	0.14	0.08	0.11	0.13	0.13	0.15	0.18	0.14	0.17	0.11	0.15	0.12	0.12
#5	0.14	0.08	0.11	0.13	0.13	0.15	0.18	0.14	0.17	0.11	0.15	0.12	0.12
#6	0.1	0.12	0.13	0.15	0.15	0.13	0.16	0.14	0.13	0.14	0.15	0.13	0.15
#7	0.12	0.14	0.15	0.17	0.13	0.13	0.12	0.12	0.11	0.13	0.14	0.15	0.15

(4)According to Eq. (2), the index information entropy contribution degree E value is calculated:
E=(1.13, 1.09, 1.12, 1.13, 1.13, 1.14, 1.15, 1.14, 1.15, 1.12, 1.15, 1.12, 1.12)
(5)According to Eq. (3), the information utility value d is obtained:
d=(-0.13, -0.09, -0.12, -0.13, -0.13, -0.14, -0.15, -0.14, -0.15, -0.12, -0.15, -0.12, -0.12)
(6)According to Eq. (4), the weight of the evaluation index is calculated:
w=(0.08, 0.05, 0.07, 0.08, 0.08, 0.09, 0.09, 0.08, 0.09, 0.07, 0.09, 0.07, 0.07)

3.4.2 Vikor Method

(1)The results of user satisfaction data collection are shown in Table 4.

Table 4 User Satisfaction Data

	X11	X12	X13	X14	X15	X21	X22	X23	X31	X32	X33	X41	X42
SX	6.71	7.43	8.29	8.14	8	7	7.43	7.57	7.71	7.43	7	9.14	8
OrX	6.71	7.43	8	8.14	8.29	7.71	7.29	7.57	7.29	8	7.43	9	8
UX	7.71	7.57	7.43	7	7.86	7.57	7.29	7.57	8	7.86	7.57	7.43	8.14
KX	8	7.43	8.14	7.43	7.86	6.71	7.29	7.43	7.86	7.71	8	7.86	7.43
OdX	7.57	6.71	6.86	6.29	6.29	6.14	6.71	6	6.14	6.71	6.14	6.57	7

(2)According to Eq. (5), the standardized value is calculated. The normalized decision matrix Z is formed using the vector normalization method, as shown in Table 5.

Table 5 Normalized Data

	X11	X12	X13	X14	X15	X21	X22	X23	X31	X32	X33	X41	X42
SX	0.84	0.98	1	1	0.97	0.91	1	1	0.96	0.93	0.88	1	0.98
OrX	0.84	0.98	0.97	1	1	1	0.98	1	0.91	1	0.93	0.98	0.98
UX	0.96	1	0.9	0.86	0.95	0.98	0.98	1	1	0.98	0.95	0.81	1
KX	1	0.98	0.98	0.91	0.95	0.87	0.98	0.98	0.98	0.96	1	0.86	0.91
OdX	0.95	0.89	0.83	0.77	0.76	0.8	0.9	0.79	0.77	0.84	0.77	0.72	0.86

(3)According to Eqs. (6) and (7), the values of positive ideal solution f_i^+ and negative ideal solution f_i^- of each index are calculated respectively:

Positive ideal solution f_i^+ = (1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 , 1.00)

Negative ideal solution f_i^- = (0.84, 0.89, 0.83, 0.77, 0.76, 0.80, 0.90, 0.79, 0.77, 0.84, 0.77, 0.72, 0.86)

(4)According to Eqs. (8) and (9), the values of the optimal solution and the worst solution of the comprehensive evaluation of the program are calculated:

The optimal solution of the comprehensive evaluation of the solution S_j=(0.24, 0.19, 0.23, 0.25, 0.95)

The worst solution of the comprehensive evaluation of the solution R_j=(0.08, 0.08, 0.05, 0.05, 0.09)

(5)According to formula (10), the value of the benefit ratio Q_j generated by the solution is calculated at v approximately 0.5:

$Q_j=(0.39,\ 0.36,\ 0.02,\ 0.11,\ 1.00)$

(6)Determine the sort order. Sort S_i, R_i, Q_i from small to large, as shown in Table 6.

Table 6 s, R, q Value Sorting Table

	SX	OrX	UX	KX	OdX
Seqencing of S score	3	1	2	4	5
Seqencing of R score	4	3	1	2	5
Seqencing of Q score	4	3	1	2	5

4. Discussion

4.1 Compromise Solution

Condition 1: Threshold conditions for acceptable benefits: v
Sequencing of Q Score: UX>KX>OrX>SX>OdX;
Sequencing of R Score: UX>KX>OrX>SX>OdX;
Sequencing of S Score: OrX>UX>SX>KX>OdX.

According to formula (11), it is judged whether condition 1 is satisfied, and we get: 1/(J-1)=0.25, so:

Q(KX)-Q(UX)=0.09<0.25;Q(OrX)-Q(UX)=0.34>0.25;Q(SX)-Q(UX)=0.37>0.25;Q(OdX)-Q(UX)= 0.98>0.25; Q(OrX)-Q(KX)=0.25=0.25; Q(SX)-Q(OrX)=0.03<0.25; Q(OdX)-Q(SX)= 0.61>0.25.

Q(SX)-Q(OrX)=0.03<0.25; Q(OdX)-Q(SX)= 0.61>0.25.

Among them, those that do not meet Condition 1 are Q(KX)-Q(UX)=0.09<0.25 and Q(SX)-Q(OrX)=0.03<0.25. After comprehensive judgment and determination of the compromise solution, the compromise solution cannot be clearly defined when v=0.5.

4.2 Comparison of Coefficients of Different Decision-Making Mechanisms

V in VIKOR equation is the coefficient of decision-making mechanism. When v is greater than 0.5, decisions are made according to the way most decisions are made, when v is approximately 0.5, decisions are made according to approval, and when v is less than 0.5, decisions are made according to rejection. When v=0.5, the compromise cannot be determined. Next, we will discuss the cases of v<0.5 and v>0.5 respectively.

When v<0.5, take v as 0.3. According to Eq. (10), when v=0.3, the value of the benefit ratio generated by the calculation solution is obtained: =(0.52, 0.50, 0.01, 0.13, 1.00).

(1)Determine the sort order. Sort , , from small to large, as shown in Table 6.

(2)According to formula (11), it is judged whether condition 1 is satisfied, and we get: 1/(J-1)=0.25, so:

Q(KX)-Q(UX)=0.11<0.25;Q(OrX)-Q(UX)=0.49>0.25;Q(SX)-Q(UX)=0.51>0.25;Q(OdX)-Q(UX) =0.99>0.25;

Q(OrX)-Q(KX)=0.38>0.25;Q(SX)-Q(OrX)=0.02<0.25;Q(OdX)-Q(SX)=0.48>0.25.

Among them, those that do not meet Condition 1 are: Q(KX)-Q(UX)=0.11<0.25 and Q(SX)-Q(OrX)=0.02<0.25.

(3)After comprehensive judgment and determination of the compromise solution, it is concluded that when v=0.3, the compromise solution cannot be clearly defined.

When v>0.5, set v as 0.7. According to Eq. (10), when v=0.7, the value of the benefit ratio Q_j generated by the calculation solution is obtained: v=(0.26,0.22,0.03,0.10,1.00)

(1)Determine the sort order. Sort S_i, R_i, Q_i from small to large, as shown in Table 6.

(2)According to formula (11), it is judged whether condition 1 is satisfied, and we get:

1/(J-1)=0.25, so:

Q(KX)-Q(UX)=0.06<0.25; Q(OrX)-Q(UX) =0.18<0.25; Q(SX)-Q(UX)=0.22<0.25; Q(OdX)-Q(UX)=0.97>0.25; Q(OrX)-Q(KX)=0.12 <0.25; Q(SX)-Q(OrX)= 0.04 <0.25; Q(OdX)-Q(SX) =0.74 >0.25.

Among them, those that do not meet Condition 1 are:

Q(KX)-Q(UX)=0.06<0.25; Q(OrX)-Q(UX)=0.18 <0.25; Q(SX)-Q(UX)=0.22 <0.25; Q(OrX)-Q(KX)=0.12<0.25; Q(SX)-Q(OrX)=0.04<0.25.

(3)After comprehensive judgment and determination of the compromise solution, it is concluded that when v=0.7, the compromise solution is still not clear.

Based on the above analysis, it is found that UX, KX and OrX have obvious advantages, while Q (UX) has no obvious advantages over Q (KX) and Q (OrX). However, considering that enterprises need to comprehensively consider the software benefit ratio and performance-to-price ratio, the preferred ranking of the alternative software according to the Q value is as follows: UX>KX>OrX>SX>OdX.

5. Conclusion

In this paper, EWM is introduced through the evaluation of ERP supplier selection, and the evaluation criteria are objectively weighted according to the calculation of index information entropy. Then, combined with the VIKOR method, the evaluation model is constructed, which overcomes the uncertainty in the decision-making process, and ensures the minimization of individual regrets while pursuing the maximization of group utility. Finally, an example is used to prove the effectiveness of the decision-making method, and an ERP software evaluation model based on the entropy method and the VIKOR integration method is established. Compared with other evaluation methods, it obtains more accurate evaluation results. However, this study inevitably has some shortcomings, such as insufficient evaluation indicators and insufficient selection of evaluation experts. In addition, it should be noted that the reintegration of fuzzy theory is also the direction of future expansion.

References

[1] C. Uenal, M. G. Guener (2009). Selection of ERP suppliers using AHP tools in the clothing industry. International Journal of Clothing Science and Technology, vol.21, no.4, p.239-251.
[2] N. Karaarslan, E. Gundogar (2009). An application for modular capability-based ERP software selection using AHP method. The International Journal of Advanced Manufacturing Technology, vol.42, no.10, p.1025-1033.
[3] J. H. Pang, L. Ma, X. J. Liu (2010). The performance evaluation of ERP systems based on fuzzy AHP. 2010 International Conference on Management and Service Science, p.1-4.
[4] S. Parthasarathy, M. Daneva (2014). Customer requirements based ERP customization using AHP technique. Business Process Management Journal, vol.20, no.5, p.730-751.
[5] H. Shou, Y. A. Zhang (2013). Study on early warning of risk index of commercial banking system based on AHP-Entropy method. East China Economic Management, vol.27, no.10, p.44-49.
[6] E. Qi, J. Shen, R. L. Dou (2016). Entropy-Based ERP System Selection Model Study. Proceedings of the 22nd International Conference on Industrial Engineering and Engineering Management, p.33-39.
[7] V. Arya, S. Kumar (2020). Multi-criteria decision making problem for evaluating ERP system using entropy weighting approach and q-rung orthopair fuzzy TODIM. Granular Computing, vol.6, no.1, p.1-13.
[8] S. Opricovic, G. H. Tzeng (2007). Extended VIKOR method in comparison with outranking methods. European Journal of Operation Research, vol.178, no.2, p.514-529.
[9] A. Sanayei, S. F. Mousavi, Y. Yazdankhah (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. Expert Systems with Applications, vol.37, no,1, p.24-30
[10] T. Kaya, C. Kahraman (2011). Fuzzy multiple criteria forestry decision making based on an integrated VIKOR and AHP approach. Expert Systems with Application, no.6, p.7326-7333.