Research on Financial Software Selection Decisions Based on a Fuzzy Evaluation Model

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Abstract. Appropriate financial software is the foundation of strengthening the enterprise information construction. For enterprises, choosing appropriate financial software is not only conducive to improving the efficiency and profitability of business processing, but also to ensuring the authenticity of financial information and the accuracy of decision-making. In this paper, we first established an evaluation index system of financial software evaluation, and then combined two-dimensional uncertain linguistic variables (2DULV) and grey relational analysis (GRA) to evaluate and select the financial software. Finally, the effectiveness of the proposed 2DULV-GRA model is verified by an example of an enterprise. The fuzzy evaluation model proposed in this paper allows decision-makers to express uncertainty, which provides a reference for the enterprise decision-making.

Keywords: Financial software; fuzzy evaluation; 2DULV; gray relations analysis.

1. Introduction

The 21st century is an information age, Internet technology has become a new force to promote the development of companies[1]. On July 27, 2016, the State Council of China issued the outline of the national informatization development strategy, which proposed that informatization should be carried out throughout the modernization process of China. On October 8, 2016, the outline of the 13th five-year plan for accounting reform and development issued by the Ministry of Finance of China stated that the construction of accounting informatization should be strengthened. Financial software is an important application of computer technology in the field of accounting[2]. On the one hand, accounting information system is the core component of enterprise management information system, and financial software is the core component of accounting information system. So, the quality of financial software directly affect the informatization construction level of the whole enterprise, and ultimately affect the management efficiency and economic benefits of the enterprise. On the other hand, the quality of financial software directly determine the efficiency of accounting work and the quality of accounting information. Due to the high requirements of self-developed financial software on the level of enterprise information construction, buying financial software from the market has become the choice of most enterprises. However, there are various types of financial software in the market, so how to evaluate and select financial software is a problem faced by many enterprises. Studying the influencing factors and evaluation methods of financial software selection will help enterprises to find suitable financial software and improve business processing efficiency, and ultimately improve decision-making accuracy and profitability. At present, the focus of theoretical research is more on accounting information, while the research on financial software evaluation and selection is less[3]. Therefore, this paper constructs an
evaluation index system and an evaluation model of financial software selection, which can guide enterprises to make reasonable choice in financial software selection.

2. Theoretical Basis

In this part, we will introduce the basic theoretical knowledge of our evaluation model, including two-dimensional uncertain linguistic variables (2DULVs) and grey relational analysis (GRA).

2DULVs. It is often difficult to evaluate the schemes with accurate numbers in decision making, so language variables are widely used[4]. Two-dimensional uncertain language variables can express the judgment of the evaluation results and reliability in the form of interval, which makes the evaluation results more accurate[5].

Definition 1: Suppose \( s_i = ([s_{1i}, s_{2i}]; [s'_{1i}, s'_{2i}]) \), where \([s_{1i}, s_{2i}]\) represents an evaluation result of the decision maker on the assessed object, and \( s_{1i} \in S_1, s_{2i} \leq s_{2i}, S_1 = \{s_{ij} | S_1, s_{1j}, \cdots, s_{nj}\} \). \([s'_{1i}, s'_{2i}]\) represents the decision maker’s reliable judgment on the evaluation result, and \( s'_{1i}, s'_{2i} \in S_1, s'_{1i} \leq s'_{2i}, S_2 = \{s'_{ij} | S_1, s'_{1j}, \cdots, s'_{nj}\} \). Then \( s_i \) is a 2DULV.

Definition 2: Suppose \( \tilde{s}_i = ([s_{1i}, s_{2i}]; [s'_{1i}, s'_{2i}]) \) and \( \tilde{s}_j = ([s_{1j}, s_{2j}]; [s'_{1j}, s'_{2j}]) \) are two 2DULVs, then the Hamming distance \( d(s_i, s_j) \) can be expressed as formula (1) [6].

\[
d(s_i, s_j) = \frac{1}{4(l-1)} \left\{ d_1(a_1, a_2; a_1', a_2') + d_2(b_1, b_2; b_1', b_2') \right\}
\]

Where \( l \) is the number of language terms in language evaluation set \( S_1 \), \( t \) is the number of language terms in language evaluation set \( S_2 \).

GRA. GRA is a method to measure the correlation of factors according to the similarity or difference of factors over time or different objects [7].

Definition 3: Positive reference sequence \( R^+ \) and negative reference sequence \( R^- \) in GRA method are sequences of data that reflect the characteristics of the system. We obtain them by formula (2).

\[
R^+ = (r_{1}^+, r_{2}^+, \cdots, r_{n}^+), R^- = (r_{1}^-, r_{2}^-, \cdots, r_{n}^-)
\]

where \( r_{ij}^+ = \max_{j=1}^{n} r_{ij} \), \( r_{ij}^- = \min_{j=1}^{n} r_{ij} \).

Definition 4: Gray relational coefficient is the degree of correlation between the sample sequence and the reference sequence in different situations. \( \tau_{ij}^+ \) and \( \tau_{ij}^- \) respectively represent the relational coefficient between each point and positive and negative reference number. They can be calculated by formula (3) [8].

\[
\tau_{ij}^+ = \frac{\min_{j=1}^{n} d(r_{ij}^+, r_{ij}^-) + \rho \max_{j=1}^{n} d(r_{ij}^+, r_{ij}^-)}{d(r_{ij}^+, r_{ij}^-) + \rho \max_{j=1}^{n} d(r_{ij}^+, r_{ij}^-)}
\]

\[
\tau_{ij}^- = \frac{\min_{j=1}^{n} d(r_{ij}^+, r_{ij}^-) + \rho \max_{j=1}^{n} d(r_{ij}^+, r_{ij}^-)}{d(r_{ij}^+, r_{ij}^-) + \rho \max_{j=1}^{n} d(r_{ij}^+, r_{ij}^-)}
\]

Where \( d(r_{ij}^+, r_{ij}^-) \) and \( d(r_{ij}^+, r_{ij}) \) are the Hamming distance between the evaluation value of the \( j_{th} \) index of the \( i_{th} \) scheme and reference number of the \( j_{th} \) index respectively. \( \rho \in [0,1] \) is the distinguish coefficient and we set it at 0.5 in this paper.

Definition 5: gray relational grade is the average value of grey relational coefficient of each object. \( T_{ij}^+ \) and \( T_{ij}^- \) respectively represent the grey relational grade between each object and positive and negative reference sequence. They can be calculated by (4):
Where \( t^+_ij \) and \( t^-_ij \) are the gray relational coefficient between each point and positive and negative reference sequences number respectively.

3. ASI Quality Evaluation Index System Construction and Weight Determination

In this part, we will introduce the index system of financial software evaluation and calculate the weight of each index. There are many factors that enterprises need to consider when choosing financial software. Due to the diverse needs of enterprises, there is no unified index system to evaluate financial software. We set up an index system to evaluate financial software by means of consulting literature and experts. It covers 11 indexes (see figure 1) and reflects the most concerned issues when choosing financial software. The evaluation index system established in this paper involves four aspects, including cost, profitability, performance and suitability[9]. The cost dimension takes into account the purchase price and later maintenance cost. The profitability dimension takes into account profit growth forecast and asset turnover growth forecast. The performance dimension including the evaluation of reliability, business process efficiency, functions, maintainability and portability. The suitability dimension includes suitability for business content and personnel and procedures.

After establishing the evaluation index system of financial software selection, we further determined the weight of the index. We distributed questionnaires to information staff and managers of a company, and invited them to rate the importance of each index. A total of 20 questionnaires were distributed and 16 valid questionnaires were collected. Finally, weighted average method was used to determine the weight of each index. The average weight of each index is as \([0.11, 0.10, 0.09, 0.08, 0.1, 0.12, 0.09, 0.08, 0.07, 0.09, 0.07]\).

4. Financial Software Evaluation Modeling

This section mainly introduces the modeling process of the evaluation model we used. For convenience, we call it 2DULV-GRA model. Suppose the set of evaluated schemes is \( P = \{ P_i \mid i = 1, 2, \cdots m \} \), and the set of evaluation indexes is \( Q = \{ Q_j \mid j = 1, 2, \cdots n \} \). First, an original decision matrix with \( m \) rows multiplied
by n columns can be obtained if the decision maker evaluates n indexes of m evaluation schemes. The original decision matrix can be expressed as:

\[
R = [r_{ij}]_{m \times n} = \begin{bmatrix}
(x_{11}', x_{11}) & (x_{12}', x_{12}) & \cdots & (x_{1n}', x_{1n}) \\
(x_{21}', x_{21}) & (x_{22}', x_{22}) & \cdots & (x_{2n}', x_{2n}) \\
\vdots & \vdots & \ddots & \vdots \\
(x_{m1}', x_{m1}) & (x_{m2}', x_{m2}) & \cdots & (x_{mn}', x_{mn})
\end{bmatrix}
\]

Second, we multiply the original decision matrix by the weight corresponding to each index to get the weighted decision matrix. Third, the reference sequences are obtained according to formula (2). Fourth, according to formula (3) and (4), the gray relational coefficient and grey relational grade of each scheme can be obtained. Finally, we calculate the closeness of each scheme through formula (5) and so rank them.

\[
C_i = \frac{T_i^+}{T_i^+ + T_i^-}
\]  

(5)

Where \(T_i^+\) and \(T_i^-\) respectively represent the grey relational grade between each scheme and positive and negative reference sequence.

5. Application of the 2DULLV-GRA Model

In the modern society, financial software has become a favorable weapon to improve enterprise management level and enhance enterprise competitiveness. However, the differences among the financial software in the market cause many enterprises to face difficulties and disputes when choosing the financial software of their own company.

A manufacturing enterprise in Anhui province wanted to purchase a relatively mature financial software from the market to improve its information construction level due to the continuous expansion of the company scale. They have identified four financial software suppliers and need to decide which one to buy. Now the 2DULLV-GRA model is applied to this case of financial software evaluation and decision-making. We take the four alternative financial software as evaluated scheme set P, then \(P = \{p_1, p_2, p_3, p_4\}\). And the set of evaluative terms for financial software by decision makers is as \(S_1 = \{\text{extremely bad, bad, slightly bad, general, good, very good, excellent}\}\) while the set of evaluative terms for the reliability of the judgment given by decision makers is as \(S_2 = \{\text{very uncertain, uncertain, general, certain, very certain}\}\). Then through the expert meeting method and expert scoring method, the original evaluation matrix of the four alternatives can be obtained. As is shown in table 1.

### Table 1. The initial 2DULLV results of the alternatives.

| Indexes | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 |
|---------|----|----|----|----|----|----|----|----|----|-----|-----|
| P1      | [X4, X4] | [X2, X1] | [X2, X1] | [X2, X1] | [X3, X4] | [X1, X4] | [X1, X4] | [X4, X4] | [X2, X1] | [X4, X4] | [X4, X1] |
|         | [Y2, Y1] | [Y1, Y2] | [Y2, Y1] | [Y2, Y1] | [Y3, Y1] | [Y1, Y2] | [Y1, Y2] | [Y2, Y1] | [Y3, Y1] | [Y2, Y1] | [Y3, Y1] |
| P2      | [X5, X4] | [X3, X4] | [X2, X3] | [X5, X3] | [X5, X4] | [X3, X4] | [X3, X4] | [X5, X4] | [X3, X4] | [X5, X4] | [X3, X4] |
|         | [Y2, Y1] | [Y1, Y2] | [Y2, Y1] | [Y2, Y1] | [Y3, Y1] | [Y1, Y2] | [Y1, Y2] | [Y2, Y1] | [Y3, Y1] | [Y2, Y1] | [Y3, Y1] |
| P3      | [X5, X4] | [X3, X4] | [X5, X3] | [X4, X4] | [X4, X4] | [X3, X4] | [X3, X4] | [X4, X4] | [X3, X4] | [X4, X4] | [X3, X4] |
|         | [Y2, Y1] | [Y1, Y2] | [Y2, Y1] | [Y2, Y1] | [Y3, Y1] | [Y1, Y2] | [Y1, Y2] | [Y2, Y1] | [Y3, Y1] | [Y2, Y1] | [Y3, Y1] |
| P4      | [X4, X4] | [X3, X3] | [X4, X3] | [X4, X3] | [X4, X3] | [X3, X3] | [X3, X3] | [X4, X3] | [X3, X3] | [X4, X3] | [X3, X3] |
|         | [Y2, Y1] | [Y1, Y2] | [Y2, Y1] | [Y2, Y1] | [Y3, Y1] | [Y1, Y2] | [Y1, Y2] | [Y2, Y1] | [Y3, Y1] | [Y2, Y1] | [Y3, Y1] |

By multiplying the original evaluation index by the corresponding weight of each index, we can get the weighted evaluation matrix. According to the formula (2), we got the positive and negative reference sequences. According to (3) and (4), the grey correlation coefficient and grey correlation degree of each alternative software and positive reference sequence were obtained. The specific results are shown in
Table 2. Similarly, the calculation results of grey correlation coefficient and grey correlation degree of alternative software and negative reference sequence are shown in Table 3.

Table 2. Positive gray relational coefficient and grey relational grade.

|    | \( T^+ \) | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | T^- |
|----|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| P1 | 0.9565   | 0.6333 | 0.6667 | 0.3333 | 1.0000 | 0.3333 | 0.3846 | 0.6667 | 0.3333 | 0.5699 | 0.6000 | 0.5889 |
| P2 | 1.0000   | 0.9500 | 1.0000 | 0.6000 | 0.8596 | 0.4286 | 0.3333 | 0.7143 | 1.0000 | 0.5699 | 1.0000 | 0.7687 |
| P3 | 0.6667   | 0.6333 | 1.0000 | 0.6000 | 0.7778 | 1.0000 | 0.4118 | 1.0000 | 0.6000 | 0.9636 | 0.3333 | 0.7260 |
| P4 | 0.7857   | 1.0000 | 1.0000 | 1.0000 | 0.9608 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.3621 | 1.0000 | 0.4375 | 0.8678 |

Table 3. Negative gray relational coefficient and grey relational grade.

|    | \( T^- \) | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | T^+ |
|----|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| P1 | 0.6296   | 1.0000 | 1.0000 | 1.0000 | 0.6667 | 1.0000 | 0.8557 | 1.0000 | 1.0000 | 1.0000 | 0.5625 | 0.8831 |
| P2 | 0.4722   | 0.5652 | 0.3333 | 0.4286 | 0.8235 | 0.6000 | 1.0000 | 0.9091 | 0.3333 | 1.0000 | 0.4615 | 0.6297 |
| P3 | 1.0000   | 1.0000 | 0.3333 | 0.4286 | 1.0000 | 0.3333 | 0.8058 | 0.6667 | 0.4286 | 0.5529 | 1.0000 | 0.6863 |
| P4 | 0.7727   | 0.5417 | 0.3333 | 0.3333 | 0.7000 | 0.3333 | 0.5425 | 0.6667 | 0.8077 | 0.5402 | 0.7059 | 0.5707 |

Finally, according to the formula (5), the closeness of the each alternatives is as \([0.4001, 0.5497, 0.5141, 0.6033]\). So the order of the four alternative financial software is 4,2,3,1. According to the results, the enterprise A should choose the financial software provided by the fourth supplier.

6. Conclusion

We constructed the index system of financial software selection and evaluation from four aspects of cost, profitability, performance and suitability, including 11 indexes in this paper. And we proposed a 2DULVs- GRA model to make financial software selection decisions based on 2DULVs and GRA. The use of 2DULVs allows decision makers to express the uncertainty of their own opinions, and the ranking of complex multi criteria problems can be obtained through the GRA method. The main contribution of this paper is to establish an evaluation index system by comprehensively considering the structure and characteristics of financial software, and to put forward a scientific evaluation model. This study provides a new idea for enterprises to make decisions. Based on fuzzy methods, this study provides a new idea for enterprises to make decisions.

References

[1] Y. Wei, Computer Application Technology in Enterprise Informatization, 2019.
[2] S. K. Garg, B. Sharma, R. N. Calheiros, R. K. Thulasiram, P. Thulasiraman, and R. Buyya, Financial Application as a Software Service on Cloud. 2012.
[3] S. C. Guengoer, B. Hayri, S. Selcuk. "An integrated decision support system dealing with qualitative and quantitative objectives for enterprise software selection," Expert Systems with Applications. 36(2009) 5272-5283.
[4] T. N. Chuang, J. Y. Kung, Y. F. Lin, and H. C. Ku, "Expert decision making method based on uncertain linguistic variables," in FUZZ-IEEE 2011, IEEE International Conference on Fuzzy Systems, Taipei, Taiwan, 27-30 June, 2011, Proceedings, 2011.
[5] H.-C. Liu, Y.-P. Hu, J.-J. Wang, and M. Sun, "Failure Mode and Effects Analysis Using Two-Dimensional Uncertain Linguistic Variables and Alternative Queuing Method," IEEE Transactions on Reliability, 2018, pp. 1-12.
[6] Q. Liu, "An extended TOPSIS method for multiple attribute decision making problems with unknown weight based on 2-dimension uncertain linguistic variables" 27(2014) 2221-2230.
[7] H.-C. Huang, T.-F. Tsai, and Y.-M. Subeq, "Using grey relational analysis and grey integrated multi-objective strategy to evaluate the risk factors of falling of aboriginal elders in Taiwan," Soft Computing, 2019.

[8] Y. Kuo, T. Yang, and G.-W. Huang, "The use of grey relational analysis in solving multiple attribute decision-making problems," Computers & Industrial Engineering. 55(2008) 80-93.

[9] Q. Yi, W. Yong, S. D. Center, and C. A. Bank, "A Software Evaluation Model Based on Hierarchy Attribute," Computer Measurement & Control. 2017.