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A Fuzzy Decision Support for the Selection of Information System Outsourcing Company

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Abstract: - The outsourcing of information systems can not only reduce installation cost, but also allow a company to focus more on its core competence. Being sure of selecting the best contractor can increase the likelihood that information system outsourcing will be a success. This study uses the fuzzy concept to develop a decision support system which can help decision-maker to get a better judgement and with the explanations for the result. Via implementing this system, we not only can select the best one contractor among the outsourcing information service companies, but also the information service companies can assess themselves to adjust or improve the caused factors if the aggregative capability does not meet the needs.

Keywords: - Fuzzy numbers; Decision support system; Outsourcing; Information systems; Aggregative capability

1 Introduction

Computer technology is evolving rapidly and being used in an increasingly wide range of applications. Information systems play an increasingly important role within corporate organizations, and make a major contribution to competitive capability and competitive strategies. Nevertheless, the great majority of firms are not primarily in the computer business, and their departments can't be expected to keep up with computer technology. The hardware, software, and technical manpower entailed by computer systems are a heavy burden in terms of organization, management, maintenance, and installation cost. The outsourcing of information systems can therefore reduce installation cost and allow the company to focus on its area of core competence.

Information system outsourcing is currently one of the fastest growing parts of the computer services industry. Contemporary thinking on outsourcing is summed up in several Harvard Business Review and Sloan Management Review articles [5]. Quinn et al. [9] argue that technological change in services offers strategic opportunities. Service companies have evolved that employ the most advanced technologies and industry standard practices. These suppliers offer their services at lower cost and with quality that is often superior to the same services generated inside the firm. Also, Quinn et al. [10] argue that the indirect benefits of outsourcing may be the most important. By outsourcing non-strategic activities, organizations can devote more time and attention to the core activities that give them competitive advantage. Outsourcing can reduce the size of the organization and make it less hierarchical, allowing focus on obtaining, development, and motivating the people who create value. It can also allow a shift in management attention toward strategy, coordination, and the skills that promote competitive success. Clark et al. [2] identify factors in information systems technological change, technology management, and business change that favor outsourcing. Sobol and Apte [11] found cost savings, cost predictability, reduction in the need for information technological staff, focus on core competencies, and wide choice of outsourcing vendors to be the major reasons for outsourcing.

In order to trim manpower at administrative agencies and stimulate the development of the information industry, the R.O.C. government announced that it would gradually implement the total outsourcing of computer services at government agencies and public enterprises.

At present few domestic software firms are able to pass the ISO-9001 quality system's design, development, production, installation, and service quality assurance requirements. In order to conform to the domestic situation, based on Lee [6], we refer to ISO-9000~3[1-3, 7-8] and "the software development capability assessments" [12], to build up a structure model as a measure for evaluating the software development capability of domestic software firms.

An effective decision support system can assist corporate computer departments to perform fair and open assessments of the capabilities of suppliers offering computer system services. Use of such a system can reduce outsourcing risk and increase the likelihood of success. In evaluating the rate of factors affecting outsourcing, most decision-makers, project-managers or evaluators, in fact, viewed those factors as linguistic values (terms), e.g., very high, high, middle, low, very low, etc. After fuzzy sets theory was introduced by Zadeh [14] to deal with problem in which vagueness was presented, linguistic value could be used for approximate reasoning within the framework of fuzzy sets theory [15] to effectively handle the ambiguity involved in the data evaluation and the vague property of linguistic expression, and normal triangular fuzzy numbers were used to characterize fuzzy values of quantitative data and the linguistic terms used in approximate reasoning.

In this study, we applied the Borland Delphi 3.0 and Microsoft Access 97 as tools for developing this system. We used the Borland Delphi 3.0 as an inference engine, the work tables consisted of questionnaire as database.

The decision-maker can extract the best one of the software companies by this system. Also, the manager/leader of the software company may apply this system to evaluate and improve it while the evaluating rate is low.

2 Framework of the Proposed System

Based on the schematic view of a decision support system [13], the framework of a fuzzy decision support system of this article is shown in Fig. 1.

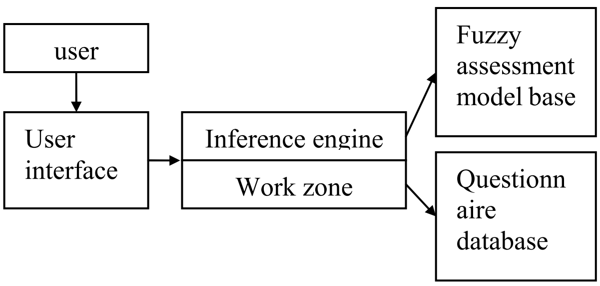

Fig.1 Framework of the proposed system

The system designed in this article chiefly employs comprehensive fuzzy assessments as a reference tool for decision-makers. The reasons for this are as follows:

(1) Easy to put into practice: When comprehensive fuzzy assessments are employed, the user may take advantage of spreadsheet programs such as Excel, plus some simple Visual Basic applications, or Borland Delphi to quickly establish a decision-making support system.

(2) Able to express fuzzy concepts: When comprehensive fuzzy assessments are used, the information employed to assess contractors can itself be fuzzy, and the results of the assessment consists of a fuzzy vector. The user can make a final judgement based on an interpretation of the resulting fuzzy vector.

(3) Can be used with weight: The decision-maker can add a weight to each item depending on his individual requirements.

3 Questionnaire Design for the Assessment of Software Firms

Although the outsourcing of information systems has already become a major trend and offers many benefits to corporate organizations, because outsourcing involves many complicated legal, economic (benefits), management, and technical factors, the benefits must be carefully assessed before an outsourcing decision is reached. The likelihood of success could be greatly improved if a project can be entrusted to a competent and suitable contractor.

Because the outsourcing of information systems in Taiwan places the heaviest emphasis on the development of software systems, this study will chiefly focus on contractors' software development capability. This study's discussion of the assessment of the capabilities of software firms is primarily based on the "software development capability assessments" [12], the "Design, Development, Production, Installation, and Service Quality Assurance Models for Quality Systems" [3], Klepper and Jones [5], and ISO 9000~3[1-3, 7-8]. Assessment is performed by means of the hierarchical analysis to organize important information concerning information system contractors, as shown in the Fig. 2.

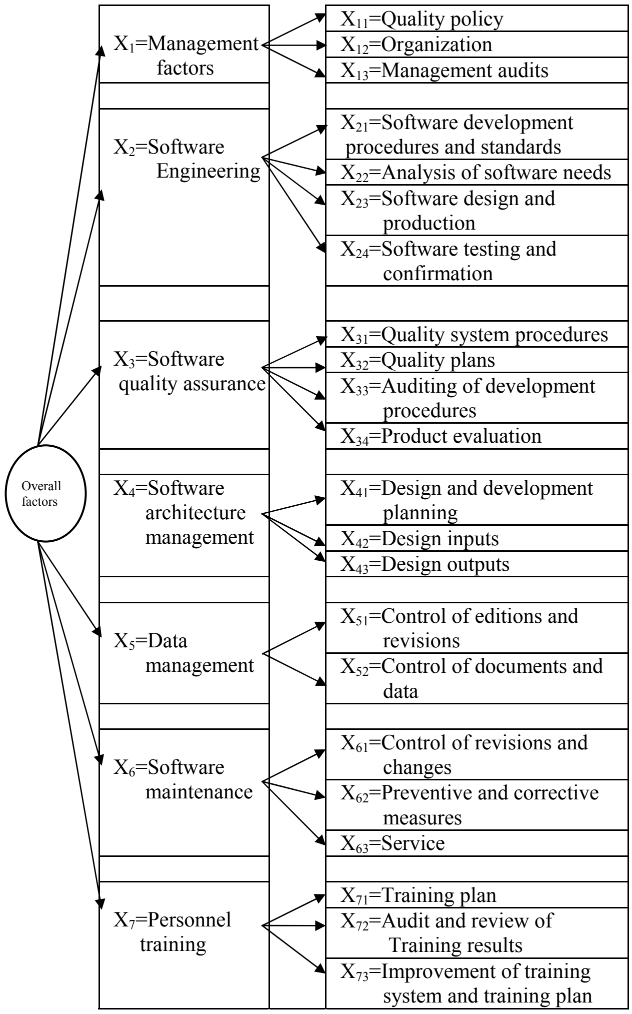

Fig. 2 Hierarchical structure model of overall factors affecting information system outsourcing

For convenience, we denote the attribute Management factors to be X_1, Software engineering to be X_2, …, Personnel training to be X_7, and the items such as quality policy denoted by X_{11}, organization denoted by X_{12}, etc., as shown in Fig. 2.

4 A Fuzzy Assessment Model

There are currently a number of theoretical models that can be used for the processing of indeterminate knowledge. This study has adopted the fuzzy logic model [15] of processing indeterminate knowledge. As long as a small number of criteria are available, the fuzzy logic model provides us with a complete description of the entire situation. Because decision-making frequently involves indeterminate situations, clear-cut numerical values cannot be used in some analyses, such as the assessment of risk.

(1) Establishment of a factor set:

A factor set is an ordinary set composed of all the factors that may affect a judgement. Taking computer service outsourcing as an example, a factor set can be drawn up as shown in Fig. 2.

(2) Establishment of a weight set:

A weighting set reflects the user's subjective beliefs about each assessment set.

(3) Establishment of an assessment set:

An assessment set is a set consisting of factors generated by the overall evaluation of each possible outcome. No matter how many categories into which the factors have been divided, there is one assessment set. This study identifies five grades of assessment set, say, V={V1= very low, V2=low, V3=medium, V4=high, V5=very high}. These linguistic values are treated as fuzzy numbers with normal triangular membership functions as follows:

$$V_1 = (0,\ 0,\ \frac{1}{4}), \qquad \mu_{V_1} = \begin{cases} 1-4x, & 0 \le x \le \frac{1}{4} \\ 0, & \frac{1}{4} \le x \le 1 \end{cases}$$

$$V_n = (\frac{n-2}{4},\ \frac{n-1}{4},\ \frac{n}{4}), \qquad \mu_{V_n} = \begin{cases} 0, & 0 \le x \le \frac{n-2}{4} \\ 4x(n-2), & \frac{n-2}{4} \le x \le \frac{n-1}{4} \\ n-4x, & \frac{n-1}{4} \le x \le \frac{n}{4} \\ 0, & \frac{n}{4} \le x \le 1 \end{cases} \qquad \text{for } n = 2, 3, 4$$

$$V_5 = (\frac{3}{4}, 1, 1) \qquad \mu_{V_5} = \begin{cases} 0, & 0 \le x \le \frac{3}{4} \\ 4x-3, & \frac{3}{4} \le x \le 1 \end{cases}$$

(4) The first-stage assessment.

We ranged the grade of capability for each factors into eleven ranks. We made the linguistic values 1, 2, …, 11 into corresponding reasonable fuzzy numbers with triangular membership functions as listed in Table 1 [6].

Table 1 Fuzzy numbers of grade of capability [6]

Grades of capability	Linguistic values	Normal triangular fuzzy numbers
1	Definitely low	$\tilde{N}_1$=(0.0,0.0,0.1)
2	Extra low	$\tilde{N}_2$=(0.0,0.1,0.2)
3	Very low	$\tilde{N}_3$=(0.1,0.2,0.3)
4	Low	$\tilde{N}_4$=(0.2,0.3,0.4)
5	Slightly low	N_5=(0.3,0.4,0.5)
6	Middle	$\tilde{N}_6$=(0.4,0.5,0.6)
7	Slightly high	$\tilde{N}_7$=(0.5,0.6,0.7)
8	High	$\tilde{N}_8$=(0.6,0.7,0.8)
9	Very high	$\tilde{N}_9$=(0.7,0.8,0.9)
10	Extra high	$\tilde{N}_{10}$=(0.8,0.9,1.0)
11	Definitely high	$\tilde{N}_{11}$=(0.9,1.0,1.0)

By fuzzy relation on Xi xV, we can form a fuzzy assessment matrix M(Xi) for XixV [16]. For instance, let Xi=X2, then the fuzzy assessment matrix M(X2) as follows

$$M(X_2)=\begin{bmatrix} V(a_{21},1) & V(a_{21},2) & \dots & V(a_{21},5) \\ V(a_{22},1) & V(a_{22},2) & \dots & V(a_{22},5) \\ V(a_{23},1) & V(a_{23},2) & \dots & V(a_{23},5) \\ V(a_{24},1) & V(a_{24},2) & \dots & V(a_{24},5) \end{bmatrix}$$

By the same way, we can form fuzzy assessment matrices M(X_1), M(X_3), M(X_4), M(X_5), M(X_6) and M(X_7) , respectively.

Evaluate the first-stage assessment capability for X2 as follows:

Let

(R(2, 1), R(2, 2), R(2, 3), R(2, 4), R(2, 5))

=(W1(2, 1), W(2,2), W1(2,3), W1(2, 4)) * M(X2)

where $R(2,k)=\sum_{j=1}^{4} W1(2,j)\times V(a_{2j},k)$ for k=1, 2, …5,

W1(2, j) is the weight of the item X2j, for j=1, 2, 3, 4

We denote R1(2)=(R(2, 1), R(2, 2), R(2, 3), R(2, 4), R(2, 5)) the vector of the first-stage assessment for X2. Similarly, we have R1(1), R1(3), R1(4), R1(5), R1(6) and R1(7) vectors of the first stage assessment for attribute X_1, X_3, X_4, X_5, X_6, and X_7 respectively.

(5) By the second-stage assessment.

Let

$$(R2(1), R2(2), R2(3), R2(4), R2(5))$$

$$=(w2(1), w2(2), w2(3), w2(4), w2(5), w2(6), w2(7)) * \begin{bmatrix} R1(1) \\ R1(2) \\ R1(3) \\ R1(4) \\ R1(5) \\ R1(6) \\ R1(7) \end{bmatrix}$$

where $R2(i)=\sum_{k=1}^{7} w2(k)\times R(k,i) \quad for\ i=1,2,\dots 5$

(6) Defuzzification by the centroid

The final aggregative capability (denoted by *Agg_C*) is defuzzified by the centroid method

$$Agg\_C=\frac{\sum_{i=1}^{5} VG(i)\cdot R2(i)}{\sum_{k=1}^{5} R2(k)} = \sum_{i=1}^{5} VG(i)\cdot R2(i)$$

where VG(1)=0.083, VG(2)=0.25, VG(3)=0.5, VG(4)=0.75, VG(5)=0.917 are the centroid of the V_1, V_2, V_3, V_4, and V_5 , respectively. The value of *Agg_C* is the aggregative development capability of the software company.

5 Examples of Applications

Suppose we assess the fuzzy data of the form Table 2 of four companies, say, Firm A, Firm B, …, and Firm D, the data are as in Table 3. By this system, we obtain the results of implementation as shown in Table 4. The final results of comprehensive fuzzy assessment are provided to estimation personnel.

Table 2 The contents of factors affecting outsourcing

Attribute	Weight-1	Item	Weight-2	Assessed value
X_1: management factors	W2(1)	X_{11}	w1(1,1)	a_{11}
		X_{12}	w1(1,2)	a_{12}
		X_{13}	w1(1,3)	a_{13}
X_2: Software engineering	W2(2)	X_{21}	w1(2,1)	a_{21}
		X_{22}	w1(2,2)	a_{22}
		X_{23}	w1(2,3)	a_{23}
		X_{24}	w1(2,4)	a_{24}
X_3: Software quality assurance	W2(3)	X_{31}	w1(3,1)	a_{31}
		X_{32}	w1(3,2)	a_{32}
		X_{33}	w1(3,3)	a_{33}
		X_{34}	w1(3,4)	a_{34}
X_4: Software architecture management	W2(4)	X_{41}	w1(4,1)	a_{41}
		X_{42}	w1(4,2)	a_{42}
		X_{43}	w1(4,3)	a_{43}
X_5: Data management	W2(5)	X_{51}	w1(5,1)	a_{51}
		X_{52}	w1(5,2)	a_{52}
X_6: Software maintenance	W2(6)	X_{61}	w1(6,1)	a_{61}
		X_{62}	w1(6,2)	a_{62}
		X_{63}	w1(6,3)	a_{63}
X_7: Personnel training	W2(7)	X_{71}	w1(7,1)	a_{71}
		X_{72}	w1(7,2)	a_{72}
		X_{73}	w1(7,3)	a_{73}

This example shows that awarding the computer system contract to firm D is the more suitable choice.

6 Conclusions

This fuzzy decision support system to evaluate the development capability of software company is very useful in selecting the better company for decision-maker to select the more suitable as an information services contractor. Moreover, we made some comments about this system.

(1) The manager/leader of the software company may apply this system to evaluate the development capability of his/her company. If the development

capability is low, he/she might either adjust or improve the item factor until he/she can accept it.

(2) By the structure model and algorithm described in Section 3 and 4, we can set up this system by a computer and we can run it any time if it is necessary.

Table 3 The assessed value of four software companies

Attribute	Weight-1	Item	Weight-2	Firm A	Firm B	Firm C	Firm D
X_1	0.2	X_{11}	0.3	6	7	7	8
		X_{12}	0.3	5	6	8	7
		X_{13}	0.4	2	3	4	9
X_2	0.2	X_{21}	0.25	6	7	7	8
		X_{22}	0.25	6	6	6	6
		X_{23}	0.25	4	4	5	8
		X_{24}	0.25	5	5	7	9
X_3	0.2	X_{31}	0.25	4	3	6	8
		X_{32}	0.25	3	5	6	8
		X_{33}	0.25	4	5	8	7
		$X_{340.}$	0.25	6	6	6	5
X_4	0.1	X_{41}	0.3	3	5	8	8
		X_{42}	0.3	5	6	7	7
		X_{43}	0.4	9	9	8	8
X_5	0.1	X_{51}	0.5	4	4	5	9
		X_{52}	0.5	5	6	7	8
X_6	0.1	X_{61}	0.3	2	4	5	9
		X_{62}	0.3	5	5	5	7
		X_{63}	0.4	3	2	3	6
X_7	0.1	X_{71}	0.3	4	5	8	9
		X_{72}	0.3	4	4	8	7
		X_{73}	0.4	2	5	5	9

Table 4 The computed results

Firm A	0.449
Firm B	0.511
Firm C	0.614
Firm D	0.79

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