

Capability Assessment Model for Software Outsourcing Service Providers Based on Interval Evidential Reasoning

Sheng-Qun Chen

Fujianjiangxia University, Fuzhou 350108, PR China

csq@fjxxu.edu.cn

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Abstract. An enterprise may benefit from software business outsourcing depending on the suitability of the outsourcing service provider. This research addresses the assessment of the contracting capability of software outsourcing vendors and proposes a decision-making model based on Interval Evidential Reasoning (IER). Firstly, a capability assessment index system for software outsourcing vendors is developed. The idea of transforming different types of assessment information into evidence probability is presented and an assessment model based on IER is established. Finally, the feasibility and validity of this approach is demonstrated by an example calculation.

Introduction

Software business outsourcing refers to the software requirement activity whereby software enterprises subcontract a software project, either entirely or in part, to software outsourcing service providers. Software business outsourcing may yield a number of benefits, namely, it may allow the contract-issuing party to focus on enterprise core competency business to a greater extent, and it may lower the cost of software projects. However, the failure rate of software outsourcing projects continues to remain very high. One of the key reasons for failure is the blind selection of software outsourcing service providers. Therefore, the outsourcing industry urgently demands a set of scientific rules and a mature capability assessment model to enable them to assess software outsourcing service providers. Currently, researchers mainly employ a quantitative approach to address the issue of capability assessment of outsourcing service providers. For example, a decision-making model for shipbuilding enterprises to select IT outsourcing service providers was proposed by Hu et al. [1]; a study on capability assessment methods for IT outsourcing providers based on eSCM-SP was conducted by Luan et al. [2]; a fuzzy attribute measurement approach was employed by Zhang et al. [3] to address the assessment issues for core competences of IT outsourcing service providers. These scientific assessment models provide a theoretical basis and methodological support for selecting suitable software outsourcing service providers. However, due to the fact that it is difficult to identify objective information and the subjective judgment is constrained, the assessment information obtained is normally characterized by interval values or even unknown values, which leads to the inapplicability of these methods. Thus, a novel approach is required to address these issues.

Evidence theory [4, 5] was originally developed by Dempster and later extended and refined by Shafer. Evidential reasoning (ER) based on both decision theory and DS theory was proposed by Yang and Singh [6]. The ER approach has been widely applied to multiple attribute decision making (MADM) problems with uncertainty in business performance assessment [7, 8], environmental impact assessment [9], organizational self-assessment [10], safety analysis [11, 12], and group decision analysis [13]. That is to say, ER is a powerful and flexible mathematical tool for processing uncertain information. The availability of information of this nature in multiple formats, such as exact values and interval values, when assessing software outsourcing service providers prompted us to develop the Interval Evidential Reasoning (IER) to address assessment related issues.

Assessment Index System

A rational assessment index system is of great significance for increasing the success rate of software outsourcing projects. Based on a reported selection model [14], the following capability assessment index system for software outsourcing service providers is proposed:

- Fundamental qualities: including enterprise scale, financial standing, and human resources;
- Technical level: consisting of technical maturity, project experience, and technical innovation;
- Track records: comprising brand familiarity and historical reputation;
- Management capabilities: including people management, quality management, progress management, contract management, and cultural compatibility.

The assessment index system for software business outsourcing service providers is presented schematically in Fig.1.

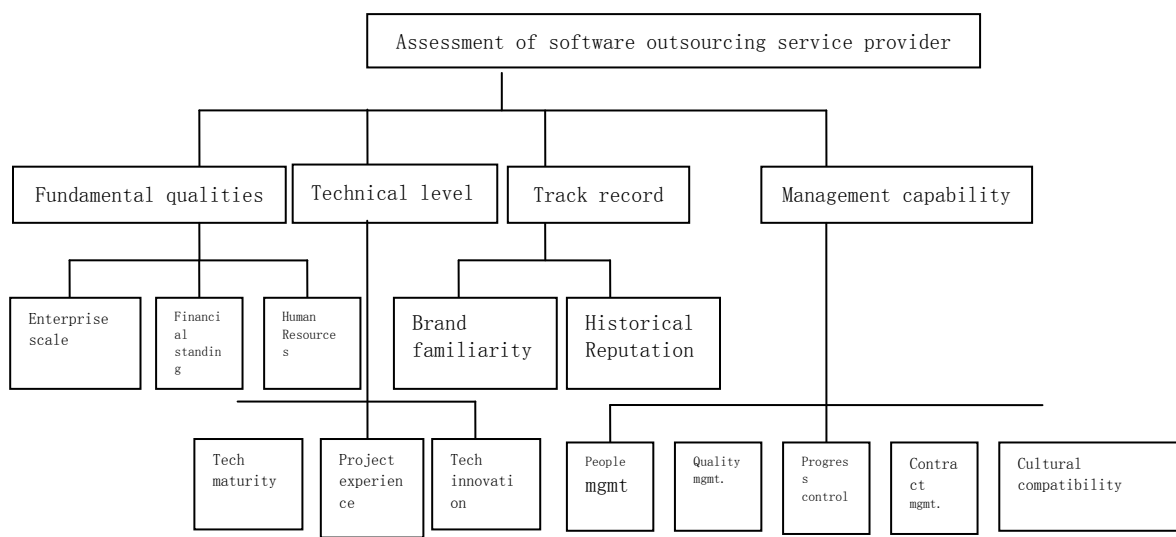


Fig.1 Index hierarchy for software business outsourcing service provider

Assessment Model

This paper proposes the IER approach as the basic tool to address the issue of capability assessment of software outsourcing service providers. The main objective of this approach is to transform the assessment information of various indexes into probabilistic representations required of ER. Besides, an interval evidential fusion model is established for capability assessment, and this enables the final decision-making scheme to be obtained. Before the assessment model is presented, the following related definition is given:

Definition 1 Let Y_1, \dots, Y_N denote the standard values corresponding to assessment ranks H_1, \dots, H_N , and let (H_i, α_i) represent the degree of belief for the assessment value at rank H_i to be α_i ; thus, α_i is referred to as the rank belief degree at rank H_i , besides, $\{(H_1, \alpha_1), \dots, (H_N, \alpha_N)\} (\sum_{i=1}^N \alpha_i \leq 1)$ is referred to as the structure of rank belief degrees.

In terms of the information on linguistic values, when y is the standard linguistic value for the assessment rank H_n , then the probability of the assessment value y at assessment rank H_n equals 1, thus y is transformed into the corresponding rank belief degree $\{(H_n, 1)\}$;

According to previous research [15], information on the exact values and interval values will be transformed into the corresponding rank belief degrees.

As to the unknown values, it is obvious that the transformed respective rank belief degrees also remain unknown, namely, they fall over any location of rank H_1, H_2, \dots, H_N with 100% degree of belief, thus, making their corresponding rank degree of belief to be $\{((H_1, H_2, \dots, H_N), 1)\}$.

Evidential reasoning (ER) is a reasoning approach capable of processing uncertainty, and allows the decomposition of evidence into sub-evidence. Moreover, following the corresponding processing of sub-evidence, the solution of the entire problem may be obtained by means of the ER combination rule; hence, ER is also a decision-making approach. Our previous report about IER [15] concerned a study of the application of interval-value multi-attribute decision-making to the IER approach. Let the assessment rank H_1, \dots, H_N represent the evidence identification framework, then the optimal evidence fusion model is established as follows:

$$\text{Max / min } f(H_1, \dots, H_N) = \sum_{n=1}^N [\beta_{n,12\dots L} \cdot U(H_n)] + (1 - \sum_{n=1}^N \beta_{n,12\dots L}) \cdot \sum_{n=1}^N U(H_n) / N \quad (1)$$

$$\text{s.t. } \beta_{n,12\dots L} = \frac{m_{n,12\dots L}}{1 - m_{H,12\dots L}}, \quad n = 1, \dots, N, \quad (2)$$

$$m_{12\dots L} = m_1 \oplus m_2 \cdots \oplus m_L \quad (3)$$

$$m_i : m_{n,i} = w_i \beta_{n,i}, \bar{m}_{H,i} = 1 - w_i, m_{H,i} = w_i \beta_{H,i}, \quad n = 1, \dots, N; \quad i = 1, \dots, L, \quad (4)$$

$$\beta_{n,i}^- \leq \beta_{n,i} \leq \beta_{n,i}^+, \widetilde{\beta_{H,i}} \leq \beta_{H,i} \leq \widetilde{\beta_{H,i}^+}, \quad n = 1, \dots, N; \quad i = 1, \dots, L, \quad (5)$$

$$\sum_{n=1}^N \beta_{n,i} + \widetilde{\beta_{H,i}} = 1, \quad i = 1, \dots, L. \quad (6)$$

where, $\beta_{n,12\dots L}$ denotes the degree of belief for rank n following the fusion of evidence $1, 2, \dots, L$, $(1 - \sum_{n=1}^N \beta_{n,12\dots L})$ represents the degree of belief for unknown information after the fusion, $U(H_n)$ denotes the utility value of rank H_n , and $f(H_1, \dots, H_N)$ stands for the mean utility value of rank belief degrees.

The meanings of various formulae for the above model are given below: Eq. 1 is an objective function, which solves the maximum value f^+ and minimum f^- , thereby providing the utility value of the alternative scheme $f \in [f^-, f^+]$; Eq. 2 represents that the Basic Probability Assignment (BPA) values of fused evidence are transformed into rank degrees of belief; Eq. 3 denotes that the evidence with regard to various attributes is fused by means of the ER combination rule, thereby providing the BPA values of fused evidence; Eq. 4 represents that prior to the fusion, rank degrees of belief are transformed into the BPA of evidence; Eq. 5 denotes the interval values of assessment degrees of belief; Eq. 6 represents that the sum of assessment degrees of belief for different ranks is equal to 1.

Analysis by an Example Calculation

In this section, an example is provided to demonstrate the proposed IER approach. A high-tech enterprise in China publishes a software outsourcing project. SC1 and SC2 are service providers willing to undertake this project. Thus, in compliance with the above indexes, the contract-issuing party conducts an assessment of service providers SC1 and SC2, of which the assessment index values and corresponding weights are presented in Table 1.

Table 1. Assessment index values and corresponding weights of the two service providers

Basic criteria	Sub-index	SC1	SC2
Fundamental qualities (0.25)	Enterprise scale (sq.m.) (0.35)	180	320
	Financial standing (ten thousand CNY) (0.30)	[550,680]	[480,630]
	Human resources (No. of people) (0.35)	96	145
Technical level (0.25)	Technical maturity (%) (0.50)	[70,76]	-
	Project experience (0.30)	Normal	Poor
	Technical innovation (%) (0.20)	[35,39]	[42,52]
Track record (0.25)	Brand familiarity (%) (0.40)	[52,68]	[55,66]
	Historical reputation (No. of awards for the previous three years) (0.60)	85	93
Management capability (0.25)	People management (staff turnover/yr) (0.30)	60	45
	Quality management (0.15)	Good	Normal
	Progress management (%) (0.20)	[70,79]	[55,68]
	Contract management (signed contracts/yr) (0.15)	86	72
	Cultural compatibility ratio (%) (0.15)	-	[32,44]

In order to identify a comparatively satisfactory service provider, the following detailed solving steps are given based on the approach proposed in this paper:

Step 1: Based on the preferences of decision makers, a set of assessment ranking criteria and utilities values is compiled. These criteria are provided in Table 2.

Table 2. Assessment ranking criteria and utility values

Basic criteria	Sub-index	H_1	H_2	H_3	H_4	H_5
Fundamental qualities	Enterprise scale	50	150	200	250	350
	Financial standing	300	500	600	700	800
	Human resources	30	90	120	150	180
Technical level	Technical maturity	20	40	50	60	100
	Project experience	Very poor	Poor	Normal	Good	Very good
	Technical innovation	0	20	40	60	100
Track record	Brand familiarity	10	30	50	70	100
	Historical reputation	60	70	80	90	100
Management capability	People management	10	30	50	70	90
	Quality management	Very poor	Poor	Normal	Good	Very good
	Progress management	0	40	60	80	100
	Contract management	0	30	50	70	100
	Cultural compatibility ratio	10	30	50	70	100

Step 2: Based on the probabilistic method of transforming information assessment values into evidence, the degrees of belief for the assessment ranking are thereby established.

Table 3. Assessment rankings determined for each service provider

Basic criteria	Sub-index	SC1	SC2
Fundamental qualities	Enterprise scale	$\{(H_2, 0.4), (H_3, 0.6)\}$	$\{(H_4, 0.3), (H_5, 0.7)\}$
	Financial standing	$\{(H_2, [0, 0.192]), (H_3, [0.315, 1]), (H_4, [0, 0.492])\}$	$\{(H_1, [0, 0.013]), (H_2, [0.12, 0.8]), (H_3, [0.14, 0.86]), (H_4, [0, 0.06])\}$
	Human resources	$\{(H_2, 0.8), (H_3, 0.2)\}$	$\{(H_3, 0.166), (H_4, 0.833)\}$
Technical level	Technical maturity	$\{(H_4, [0.6, 0.75]), (H_5, [0.25, 0.4])\}$	$\{(H_1, H_2, H_3, H_4, H_5), 1\}$
	Project experience	$\{(H_3, 1.0)\}$	$\{(H_2, 1.0)\}$
	Technical innovation	$\{(H_2, [0.05, 0.25]), (H_3, [0.75, 0.95])\}$	$\{(H_3, [0.4, 0.9]), (H_4, [0.1, 0.6])\}$
Track record	Brand familiarity	$\{(H_3, [0.1, 0.9]), (H_4, [0.1, 0.9])\}$	$\{(H_3, [0.2, 0.75]), (H_4, [0.25, 0.8])\}$
	Historical reputation	$\{(H_3, 0.5), (H_4, 0.5)\}$	$\{(H_4, 0.3), (H_5, 0.7)\}$
Management capability	Staff management	$\{(H_3, 0.5), (H_4, 0.5)\}$	$\{(H_2, 0.25), (H_3, 0.75)\}$

Quality management	$\{(H_4, 1.0)\}$	$\{(H_3, 1.0)\}$
Progress management	$\{(H_3, [0.05, 0.5]) (H_4, [0.5, 0.95])\}$	$\{(H_2, [0, 0.096], (H_3, [0.657, 1]), (H_4, [0, 0.355])\}$
Contract management	$\{(H_4, 0.466), (H_5, 0.533)\}$	$\{(H_4, 0.933), (H_5, 0.067)\}$
Cultural compatibility ratio	$\{(H_1, H_2, H_3, H_4, H_5), 1\}$	$\{(H_2, [0.3, 0.9]) (H_3, [0.1, 0.7])\}$

Step3: based on solving Eqs. 1-6 of the model, the final utility values of SC1 and SC2 are presented as follows: $SC1 \in [0.532335, 0.5730509]$; $SC2 \in [0.5664709, 0.608773]$. Generally, the mean utility value is employed to identify the respective utility value of a service provider. Thus, SC2 is superior to SC1; therefore, service provider SC2 is preferred.

Conclusion

This paper proposes an approach whereby uncertain information with respect to capability assessment of software outsourcing service providers is transformed into probabilistic representations of evidence. Moreover, an IER-based optimization combination model is established to facilitate decision making regarding the selection of software outsourcing service providers. It presents a simple and rational approach, the validity and feasibility of which are verified by an example calculation. Admittedly, some issues subject to further research continue to exist: in particular, the probability of transforming information into evidence needs to be further simplified.

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