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Strategic decisions using the fuzzy PROMETHEE for IS outsourcing

Ying-Hsiu Chen [a,1], Tien-Chin Wang [b,*], Chao-Yen Wu [c,2]

[a] Department of Information Engineering, I-Shou University, No. 1, Section 1, Hsueh-Cheng Rd., Ta-Hsu Hsiang, Kaohsiung 840, Taiwan
[b] Department of International Business, National Kaohsiung University of Applied Sciences, No. 415, Jiangong Rd., Kaohsiung 807, Taiwan
[c] Department of Information Management, I-Shou University, No. 1, Section 1, Hsueh-Cheng Rd., Ta-Hsu Hsiang, Kaohsiung 840, Taiwan

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ABSTRACT

Outsourcing has become a common strategy in the information system/information technology (IS/IT) field in recent years. Many organizations attempt to enhance their competitiveness, reduce costs, increase their focus on internal resources and core activities, and sustain competitive advantage by IS/IT outsourcing. Selection of appropriate outsourcing partners is an extremely important goal for organizations. This study presents the fuzzy Preference Ranking Organization METHod for Enrichment Evaluation (fuzzy PROMETHEE) to evaluate four potential suppliers using seven criteria and four decision-makers using a realistic case study. Rankings results provide a reference that assists decision-makers or organizations seeking to improve the efficiency of the IS/IT outsourcing decision processes.

1. Introduction

Outsourcing has become a common practice since the 1980s. Outsourcing typically transfers production functions of goods or services to external providers (Araz, Ozfirat, & Ozkarahan, 2007). Outsourcing is defined as ongoing purchasing of services and parts from an outside company that is already provided by the outsourcing company (Linder, 2004). Companies outsource for various reasons. For example, in many instances a third party can provide efficient procurement services. Outsourcing can also provide access to specialized technology and operational platforms. Additionally, outsourcing can reduce the staffing levels. Current advancement in technology has made procurement a very specialized service (Camperi, 2005).

One of the most outsourcing practices is information system/information technology (IS/IT) outsourcing. Notably, IS outsourcing first developed as a unique area in *IS management* in literature (Barki, Rivard, & Talbot, 1993). Dhar and Balakrishnan (2006) indicated that IS/IT outsourcing can transfer some or all of IS/IT-related decision-making rights, business processes, internal activities, and services to external providers, which can more effectively manage time and costs, and improve productivity, quality, and customer satisfaction. Many studies have analyzed the reasons most often leading to IS outsourcing. Smith, Mitra, and Narasimhan (1998) classified the drivers of IS outsourcing into the following five categories: cost reduction; focus on core competencies; liquidity needs; IS capability factors; and, environmental factors. Ngwenyama and Bryson (1999) underscored that fact that the primary objective of managers making IS outsourcing decisions is to minimize total cost (service and transaction costs) and maximize total value for the firm. Claver, Gonzalez, Gasco, and Llopis (2002) identified the following reasons for IS outsourcing: reducing costs; increasing the flexibility of the IS department; focusing on IS strategic issues; eliminating troublesome, everyday problems; reducing technology costs; improving IS quality; increasing access to new technologies; and, decreasing risk. In sum, most organizations seek to improve their competitiveness, reduce costs, focus internal resources on core activities, and sustain their competitive advantage by IS/IT outsourcing (Parry, James-Moore, & Graves, 2006).

Wrong IS outsourcing decisions are one reason accounting for IT outsourcing failure. Therefore, a scientific IS outsourcing decision process is needed to increase the success rate of outsourcing. How to make scientific IS outsourcing decisions is an important problem. Once a decision to outsource is made, the next most critical activity is supplier selection. The selection process engenders complex decision problems (Araz et al., 2007). To deal with complex decision-making problems, fuzzy logic or a fuzzy set is a systematic way of defining a particular knowledge domain by handling uncertainty, vague situations, and imprecise information by emulating skilled humans when conventional mathematics is ineffective (Zadeh, 1965). Some researchers have applied fuzzy multicriteria decision-making (FMCDM) methods in the field of IS outsourcing. Kahraman, Engin, Kabak, and Kaya (2009) presented a fuzzy group decision-making methodology based on Technique for Order Preference by Similarity to Ideal Solution

* Corresponding author. Tel.: +886 7 3814526x6126; fax: +886 7 5716013.
E-mail addresses: ivychen31@gmail.com (Y.-H. Chen), tcwang@cc.kuas.edu.tw (T.-C. Wang), cywu@isu.edu.tw (C.-Y. Wu).
[1] Tel.: +886 7 8100888x5242; fax: +886 7 5716013.
[2] Tel.: +886 7 6577711x6570.

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(TOPSIS) for IS outsourcing provider selection for the largest office furniture manufacturer in Konya, Turkey. Chen and Wang (2009) proposed a fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje (fuzzy VIKOR) for IS outsourcing provider selection for a Taiwan-based computer manufacturer.

Therefore, by integrated fuzzy logic and the Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE) method, this study provides an efficient delivery approach, the fuzzy PROMETHEE, for selecting the best supplier. The fuzzy PROMETHEE, as proposed, was also described by Wang, Chen, and Chen (2008). The remainder of this study is organized as follows. A literature review of methods and criteria that support supplier selection and evaluation are given in Section2. Section 3 describes the fuzzy PROMETHEE methodology in detail. Section 4 presents a realistic case study. Finally, concluding remarks are given in Section 5.

2. Literature review

This section has for subsections fuzzy sets and fuzzy numbers, the PROMETHEE, supplier selection methods, and supplier selection criteria.

2.1. Fuzzy sets and fuzzy numbers

Fuzzy set theory was developed to extract primary possible outcomes from information expressed in vague and imprecise terms (Zadeh, 1965). A fuzzy set is defined by a membership function used to map an item onto an interval [0, 1] that can be associated with linguistic terms (Lee, Hong, & Wang, 2008). A triangular fuzzy number (TFN), a special case of a trapezoidal fuzzy number, is a very popular tool in fuzzy applications. According to the definition by Laarhoven and Pedrycz (1983), a TFN should possess the following features.

Definition 1. A fuzzy number $\widetilde{A}$ on X is a TFN if its membership function $\mu_{\widetilde{A}}(x): X \to [0,1]$ equals

$$\mu_{\widetilde{A}}(x) = \begin{cases} (x-l)/(m-l), & l \leqslant x \leqslant m, \\ (u-x)/(u-m), & m \leqslant x \leqslant u, \\ 0, & \textit{otherwise}. \end{cases} \tag{2-1}$$

where l and u are for the lower and upper bounds of fuzzy number $\widetilde{A}$, respectively, and m is median value.

A TFN is denoted as $\widetilde{A} = (l, m, u)$ and the following are the operational laws of two TFNs, $\widetilde{A}_1 = (l_1, m_1, u_1)$ and $\widetilde{A}_2 = (l_2, m_2, u_2)$, derived as (Kaufmann & Gupta, 1988, 1991):

Fuzzy number addition (+):

$$\begin{aligned}\widetilde{A}_1(+)\widetilde{A}_2 &= (l_1, m_1, u_1)(+)(l_2, m_2, u_2) \\ &= (l_1 + l_2, m_1 + m_2, u_1 + u_2).\end{aligned} \tag{2-2}$$

Fuzzy number subtraction (−):

$$\begin{aligned}\widetilde{A}_1(-)\widetilde{A}_2 &= (l_1, m_1, u_1)(-)(l_2, m_2, u_2) \\ &= (l_1 - u_2, m_1 - m_2, u_1 - l_2).\end{aligned} \tag{2-3}$$

Fuzzy number multiplication (×):

$$\widetilde{A}_1(\times)\widetilde{A}_2 = (l_1, m_1, u_1)(\times)(l_2, m_2, u_2) \cong (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad \text{for } l_i > 0,\ m_i > 0,\ u_i > 0. \tag{2-4}$$

Fuzzy number division (/):

$$\widetilde{A}_1(/)\widetilde{A}_2 = (l_1, m_1, u_1)(/)(l_2, m_2, u_2) \cong (l_1/u_2, m_1/m_2, u_1/l_2) \quad \text{for } l_i > 0,\ m_i > 0,\ u_i > 0. \tag{2-5}$$

Notably, the computational results of Eqs. (2-4) and (2-5) are not TFNs; however, these computational results can be approximated by TFNs. This study adopts a triangular fuzzy number, which is the most common membership function shape.

2.2. The PROMETHEE

The PROMETHEE is a multicriteria decision-making method developed by Brans, Vincke, and Mareschal (1986). It compares each pair of alternatives for each criterion and grades the alternatives in the 0–1 interval. Implementing the PROMETHEE requires two additional types of information (Albadvi, Chaharsooghi, & Esfahanipour, 2007).

(1) Information of relative importance (i.e., weights) of criteria considered.
(2) Information of the preference function of a decision-maker, the decision-maker is used when comparing the contribution of alternatives in terms of each criterion.

In the PROMETHEE, a chosen preference structure leads to preference indicators $P_j(a, b)$ for the jth criterion, which depends on the difference in assessment of alternative a and alternative b for this criterion.

$$P_j(a, b) = x_{aj} - x_{bj}. \tag{2-6}$$

If a is better than b, then $P_j(a, b) > 0$; otherwise, $P_j(a, b) = 0$.

Preference indexes are then aggregated using the relative weights for each criterion (w_j) into the global preference index of a over b.

$$\pi(a, b) = \sum_{j=1}^{k} w_j P_j(a, b). \tag{2-7}$$

The PROMETHEE I provides a partial ranking of alternatives. Alternatives can be ranked according to following indices (Leeneer & Pastijn, 2002; Albadvi et al., 2007).

(1) The sum of indices, $\pi(a, y)$, indicating the preference of alternative a over all others. This is called the "outgoing/leaving flow" $\phi^+(a)$ and shows how 'good' alternative a is. The alternative with the highest leaving flow is superior.
(2) The sum of indices, $\pi(y, a)$, indicates the preference of all other alternatives compared to a. This is called the "incoming/entering flow" $\phi^-(a)$, and shows how 'inferior' alternative a is. The alternative with the lowest entering flow is superior.

In PROMETHEE II, the net flow $\phi(a)$ (difference in leaving flows minus entering flows) is used, which permits a complete ranking of all alternatives. The alternative with the highest net flow is superior.

The PROMETHEE has been applied in different areas such as selecting automated inspection systems, designing IT (Information Technology) strategies, planning and producing renewable energies and selecting superior stocks (Albadvi, 2004; Albadvi et al., 2007; Pandey & Kengpol, 1995; Potvin, Soriano, & Vallée, 2004).

2.3. Methods of supplier selection

Selecting the best supplier is a difficult task. Different mathematical, statistical and theoretical game models have been proposed to solve this selection problem (Wadhwa & Ravindran, 2007). Lacity, Willcocks, and Feeny (1996) presented a 2 × 2 decision matrix that guides selection of outsourcing candidates based on business, economic, and technical factors. Hsu, Chiu, and Hsu