Expert Systems with Applications 41 (2014) 3047–3059

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Fuzzy heterogeneous multiattribute decision making method for outsourcing provider selection

Deng-Feng Li [a,*], Shu-Ping Wan [b]

[a] School of Management, Fuzhou University, Fuzhou, Fujian 350108, China
[b] College of Information Technology, Jiangxi University of Finance and Economics, Nanchang 330013, China

ARTICLE INFO

Keywords:
Outsourcing provider
Multiattribute decision making
Fuzzy set
Fuzzy linear programming
Supply chain management

ABSTRACT

One of the critical activities for outsourcing success is outsourcing provider selection, which may be regarded as a type of fuzzy heterogeneous multiattribute decision making (MADM) problems with fuzzy truth degrees and incomplete weight information. The aim of this paper is to develop a new fuzzy linear programming method for solving such MADM problems. In this method, the decision maker's preferences are given through pair-wise alternatives' comparisons with fuzzy truth degrees, which are expressed with trapezoidal fuzzy numbers (TrFNs). Real numbers, intervals, and TrFNs are used to express heterogeneous decision information. Giving the fuzzy positive and negative ideal solutions, we define TrFN-type fuzzy consistency and inconsistency indices based on the concept of the relative closeness degrees. The attribute weights are estimated through constructing a new fuzzy linear programming model, which is solved by using the developed fuzzy linear programming method with TrFNs. The relative closeness degrees of alternatives can be calculated to generate their ranking order. An example of the IT outsourcing provider selection problem is analyzed to demonstrate the implementation process and applicability of the method proposed in this paper.

1. Introduction

In the ever-increasingly business competitiveness, outsourcing has become a main stream practice in global business operations (Cai, Chen, Xiao, Xu, & Yu, 2013; Kaya, 2011; Liu & Nagurney, 2011; Shi, Tsuji, & Zhang, 2011; Sharp, Atkins, & Kothari, 2011; Yue, Xia, & Tran, 2010). Traditionally, outsourcing is an abbreviation for "outside resource using". Many organizations attempt to enhance competitiveness, reduce costs, and pay attention to internal resources and core activities and hereby further sustain competitive advantages by information technology (IT) outsourcing (Elitzur, Gavious, & Wensley, 2012).

IT outsourcing is a very complex process, which is a transformation of IT developers and practitioners to IT application managers and discriminators. Generally, the IT outsourcing process may be divided into seven phases, including: (1) IT demand, application status, and department performance evaluation; (2) IT development and programming; (3) outsourcing strategy; (4) contract object design and outsourcing provider selection; (5) contract negotiation; (6) implementation and supervision; (7) project approval, depicted as in Fig. 1.

Once the outsourcing decision is made, the next critical activity is to select outsourcing providers. The main factors affecting the outsourcing process are providers' reliability, technical competence, financial stability, and manufacturing capability. To be successful in outsourcing, a company (or an organization) should have strong relationships with its outsourcing providers. Selecting outsourcing providers should take into consideration this factor. However, selecting suitable outsourcing providers is a difficult task due to the fact that outsourcing providers cannot meet all selection criteria (or attributes, factors, indexes) simultaneously. In other words, outsourcing providers may meet some selection criteria whereas may fail in other selection criteria. Therefore, selecting outsourcing providers may be regarded as a type of multiattribute decision making (MADM) problems (Buyukozkan & Cifci, 2012; Chang, Yen, Ng, & Chang, 2012; Chen & Wang, 2009; Chen, Wang, & Wu, 2011; Fan, Suo, & Bo, 2012; Ho, He, Lee, & Emrouznejad, 2012; Hsu, Liou, & Chuang, 2013; Lin, Lin, Yu, & Tzeng, 2010; Liou, Wang, Hsu, & Yin, 2011; Tsai, Leu, Liu, Lin, & Shaw, 2010; Tjader, Shang, & Vargas, 2010; Yang & Huang, 2000; Wang & Yang, 2007; Yang, Kim, Nam, & Min, 2007).

1.1. Review of MADM methods for outsourcing provider selection

Currently, few of MADM methods have been developed for solving outsourcing provider selection problems. Roughly, these

* Corresponding author. Address: School of Management, Fuzhou University, No. 2, Xueyuan Road, Daxue New District, Fuzhou District, Fuzhou, Fujian 350108, China. Tel./fax: +86 0591 83768427.
E-mail address: lidengfeng@fzu.edu.cn (D.-F. Li).

0957-4174/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.eswa.2013.10.036

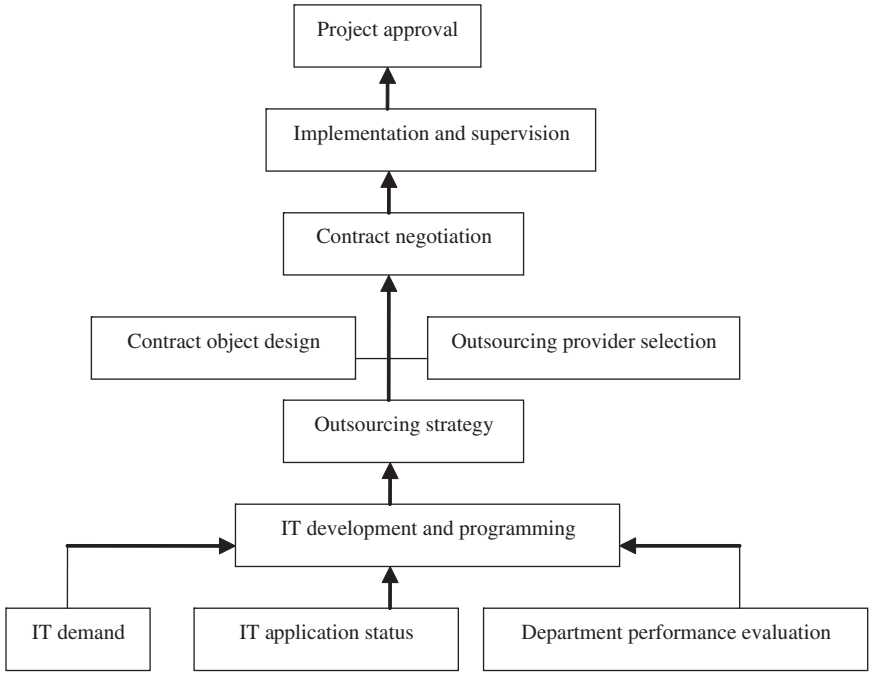

Fig. 1. The IT outsourcing process.

methods may be divided into two types, which are briefly reviewed in the following, respectively.

The first type is the MADM methods with independent attributes. Yang et al. (2007) identified factors affecting the business process outsourcing (BPO) decision and constructed a decision model using the analytic hierarchy process (AHP) method. Tjader et al. (2010) used the analytic network process (ANP) to create the evaluation framework, which was used to evaluate four policy options on economic, political, and technological factors from a policy-maker's perspective. Chang et al. (2012) combined Delphi technique and AHP method to select IT outsourcing providers for small-sized and medium-sized enterprises in Taiwan. Wang and Yang (2007) argued that six factors (economics, resource, strategy, risk, management, and quality) should be considered for outsourcing providers and proposed the AHP and preference ranking organization method for enrichment evaluations (PROMETHEE) as aids in IT outsourcing provider selection. Lin et al. (2010) proposed a hybrid MADM method for outsourcing provider selection through combining interpretive structural modeling (ISM) and the ANP method. To find the best governing policy for offshore outsourcing of business activities, Chou, Chou, and Tzeng (2006) developed a fuzzy MADM method for evaluating IT investments. Chen and Wang (2009) developed the fuzzy Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method for optimizing partners' choice in IT outsourcing projects. Chen et al. (2011) presented the fuzzy PROMETHEE for evaluating four potential suppliers through using seven criteria and four decision makers (DMs) by a realistic case study. Ho et al. (2012) integrated the quality function deployment (QFD), fuzzy set, and AHP method for evaluating and selecting optimal third-party logistics service providers. Based on fuzzy decision making Trial and evaluation laboratory (DEMATEL), fuzzy ANP and fuzzy technique for order preference by similarity to ideal solution (TOPSIS), Buyukozkan and Cifci (2012) proposed a hybrid MADM method for evaluating green suppliers.

The second type is the MADM methods with dependent attributes. Yang and Huang (2000) argued that five factors (management, strategy, economics, technology, and quality) should be considered for outsourcing provider selection and hereby proposed a decision model through combining the AHP method, DEMATEL, ANP, and zero-one goal programming. Tsai et al. (2010) developed a MADM approach for outsourcing strategy mix decision in IT projects. Combining DEMATEL and ANP method, Hsu et al. (2013) proposed a hybrid model, which addressed the dependent relationships among various criteria. Liou et al. (2011) proposed a hybrid MADM model to discuss the above similar issue. They further used the fuzzy preference programming and ANP to construct a model for outsourcing provider selection. Fan et al. (2012) utilized an extended DEMATEL to identify risk factors of IT outsourcing through using interdependent information.

The aforementioned two types of methods seem to be effective and applicable for selecting outsourcing providers. However, they have two main disadvantages. The first is that the most of the methods in the first type assume the attribute weights are completely given *a priori*. This assumption always cannot avoid subjective randomness of the DM's preference. With ever-increasingly complexity in many real decision situations, there are some challenges for the DM to provide precise and complete preference information due to time pressure, lack of knowledge and/or data, and limited expertise about the problem domain. In other words, usually weights are completely unknown or partially known *a priori*. Namely, weight preference information in MADM problems is usually incomplete (Cabrerizo, Pérez, & Herrera-Viedma, 2010; Li, 2011; Zhang & Guo, 2012). The second is that the aforementioned MADM methods seldom considered the heterogeneous evaluation information. For instance, the methods (Yang et al., 2007; Tjader et al., 2010; Chang et al., 2012; Wang & Yang, 2007; Lin et al., 2010) only considered attribute ratings expressed with real numbers. The methods (Chen & Wang, 2009; Chen et al., 2011; Chou et al., 2006) only considered attribute ratings expressed with the linguistic variables. The method (Ho et al., 2012) only considered attribute ratings expressed with the triangular fuzzy numbers (TFNs). The real-life MADM problems often involve in multiple types of attribute ratings. In assessment process, different attributes need to be evaluated. Due to the DM's knowledge field and the nature of evaluated attributes, the DM may provide the assessments with different formats such as real numbers, intervals,