An integrated fuzzy model for supplier management: A case study of ISP selection and evaluation

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ABSTRACT

Supplier selection is a multi-criteria decision-making problem which consists of both qualitative and quantitative metrics. A lot of investigations have been published in the supplier selection area and it has been notified that in the majority of these publications supplier selection and evaluation and development have the same meaning. However, one needs integrated models to cover all of these stages. In addition, most of the proposed models focused on manufacturing environments and a few papers have been allocated for service industries. To our knowledge, no Internet service provider (ISP) selection and evaluation has been published up to now.

In this paper, we propose a new framework on the basis of company's strategy for supplier management including supplier selection, evaluation, and development. In the first phase, quality function deployment (QFD) is utilized to rank the best ISPs based on qualitative criteria. Then, a quantitative model is adopted to consider quantitative metrics. Finally, we compose two models and select the best ISPs. In the next phase, we propose a novel algorithm to evaluate selected ISPs from three perspectives: customer, performance, and competition. Meanwhile, the fuzzy logic and triangular fuzzy numbers are utilized to deal with vagueness of human thought. Furthermore, a case study is conducted to illustrate the stages of ISP selection and evaluation. The implementation of the proposed model is easy and do not need optimization background.

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1. Introduction

Supply chain management (SCM) has generated a substantial amount of interest both among managers and researchers. SCM is now distinguished as a governing element in strategy and as an effective way of creating value for customers. A structure of supply chain is composed of potential suppliers, producers, distributors, retailers and customers, etc. (Fiala, 2005). Therefore, suppliers play an important role in achieving the objective of supply management. They enhance customer satisfaction in a value chain. Hence, strategic partnership with better performing suppliers should be integrated within the supply chain for improving the performance in many directions including reducing costs by eliminating wastages, continuously improving quality to achieve zero defects, improving flexibility to meet the needs of the end-customers, reducing lead time at different stages of the supply chain, etc. (Kumar, Vrat, & Shankar, 2004). Manufacturing cannot forecast demand precisely, and they prefer to manage suppliers via different methods such as supplier development, supplier evaluation, supplier selection, supplier coordination, etc. (Chou & Chang, 2008).

The objective of supplier selection is to identify suppliers with the highest potential for meeting a firm's needs consistently and at an acceptable cost (Kahraman, Cebeci, & Ulukan, 2003). In the supplier selection process a pool of suppliers is chosen for procurement according to a predefined set of criteria (Aissaoui, Haouari, & Hassini, 2007). While several methods have been proposed and utilized for evaluation and selection of suppliers, they have limitations including: evaluation solely based on operational metrics, simple weighted scoring methods based on subjective assessments, and lack of relative evaluation across various suppliers (Talluri & Narasimhan, 2004). In addition, the majority of previous investigations have focused on supplier selection or supplier evaluation or supplier development separately. We aim to develop an integrated model for supplier management and fill the gap in the literature. Besides, the new model combines both qualitative and quantitative criteria simultaneously. Moreover, unlike the case of parts purchasing, there is only a limited number of studies that model the service supplier selection problem (Aissaoui et al., 2007; De Boer, Labro, & Morlacchi, 2001; Degraeve, Labro, & Roodhooft, 2004). In this article, we propose a novel model for Internet service provider (ISP) selection and evaluation which can be applied for most of the service sectors. In addition, most published models in this area focus only on the customer perspective or

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supplier's performance perspective, or competition situation, and hence these models pay no attention to all of these factors simultaneously. In order to solve the above shortages we propose a novel method that considers competition position, current performance and customers' viewpoint concurrently.

This paper proposes a decision model that consists of two phases. In the first phase, QFD model will be integrated with a quantitative model to select the best ISPs. In the second phase, the selected ISPs will be evaluated based on a novel algorithm. Furthermore, special attention is paid to the various subjective assessments in the selection and evaluation process by using triangular fuzzy numbers. Meanwhile, a case study is conducted to illustrate the proposed model. The model can be easily implemented with spreadsheet packages.

The organization of this paper is as follows. Section 2 discusses the literature review. Quality function deployment is introduced in Section 3. Section 4 describes fuzzy set theory. Next, case review (case of suppliers' selection in ISP service sector) is presented in Section 5. Section 6 introduces ISP selection approach. Subsequently, Section 7 presents ISP evaluation process. Furthermore, sensitivity analysis is presented in Section 8. Finally, conclusions are presented in Section 9.

2. Literature review

Supplier selection is one of the most widely researched areas in purchasing with methodologies ranging from conceptual to empirical and modeling streams (Talluri & Narasimhan, 2004). The existent literature surveys focuses on papers starting from the mid 1960s. The earliest review is by Moore and Fearon (1973) where they focused on industry applications of computer-assisted supplier selection models. Kingsman (1986) highlighted the inadequacy of classical inventory management models for tracking purchasing decisions and described some of the major models that were used for the different purchasing decision-making stages. Holt (1998) reviewed and compared several decisional methods applied in contractor evaluation and selection. De Boer et al. (2001) did not restrict the review to the final choice models. They recognized the prior steps to the ultimate stage and presented the main published works that deal with all the supplier selection process. These stages are problem formulation, formulation of criteria, qualification and final selection. Recently, Aissaoui et al. (2007) have presented a literature review that covers the entire purchasing process. They proposed different classifications of the published models based on single and multiple periods and Items.

2.1. Criteria selection

Determining the criteria is the first step in supplier selection process. Dickson (1966) identified 23 different criteria based on a questionnaire sent to 273 purchasing agent and managers from United States and Canada. The most prominent ones were quality, delivery, performance history, warrant and claim policy, production facilities and capacity, net price, and technical capabilities. Ellram (1990) applied hierarchy framework including financial, performance, technology, organizational culture and strategy, and other factors. Weber, Current, and Benton (1991) selected price, delivery, quality, facilities and capacity, geographic location, and technology capability as the most important factors in supplier selection. Mandal and Deshmukh (1994) proposed interpretive structural modeling (ISM) as a technique based on group judgment to identify and summarize relationships between supplier choice criteria through a graphical model. They suggested it aids the purchaser by separating dependent criteria from independent criteria. Vokurka, Choobineh, and Vadi (1996) developed an expert system

that covers multiple phases in the supplier selection process, among which the formulation of supplier selection criteria. Other (non-experts) users may consult the system to obtain suggestions as to which criteria to use in a particular situation. Ghodsypour and O'Brien (1998) stated that cost, quality, and service have considerable effects on supplier selection parameters. Kahraman et al. (2003) mentioned that selection criteria typically fall into one of four categories: supplier criteria, product performance criteria, service performance criteria, and cost criteria. Humphreysa, Wong, and Chan (2003) integrated environmental criteria into the supplier selection process. Bottani and Rizzi (2006) presented a multi-attribute approach for selection and ranking of the most suitable 3PL service provider. They applied service criteria such as breath of service, business experience, characterization of service, compatibility, financial stability, flexibility of service, performance, price, physical equipment and information, quality, strategic attitude, trust and fairness. Recently, Huang and Keskar (2007) presented basic structure with seven categories for selecting the criteria based on the firms' strategy. In addition, they organized these categories into three tracks such as product related, supplier related, and society related. Furthermore, they determined sub criteria for each one. Demirtas and Ustun (2008) defined 14 different criteria under Benefits, Opportunities, Costs, and Risks (BOCR) merits.

2.2. Technique selection

Table 1 depicts the supplier selection techniques including analytic hierarchy process (AHP), multi-objective programming (MOP), expert systems, data envelopment analysis (DEA), mixed integer programming (MIP), goal programming (GP), mathematical programming (MP), linear weighting (LW), total cost of ownership (TCO), genetic algorithm (GA), analytic hierarchy process (ANP), case-based reasoning (CBR), data mining (DM), cluster analysis (CA), activity based costing (ABC), TOPSIS, rough sets theory (RST), grey approach, neural network (NN), and quality function deployment (QFD). It can be inferred from Table 1 that in recent publications, the majority of authors have combined at least two techniques together. In addition, fuzzy logic has been used because supplier selection involves subjective, vague and imprecise assessments, which are by nature fuzzy. Fuzzy assessment expressed in linguistic terms is often intuitive and effective for DMs during the assessment process (Chou & Chang, 2008). However, in the most of these papers, the supplier selection and supplier evaluation have similar meaning, and therefore studies become unrealistic for practical decision-makers. In other words, practitioners may need integrated models that can take into account three stages: supplier selection, supplier evaluation, and supplier development.

Application of quality function deployment (QFD) as a tool for supplier selection has been limited. To date there have been few works that have applied this tool for supplier evaluation purposes. Ansari and Modarress (1994) discussed the roles of suppliers in the various phases of QFD. Holmen and Kristensen (1998) illustrated how the house of quality (HOQ) can be used in the pre-interactive stage of a single product development project, and how the identified correlations and non-correlations between the characteristics of the planned product can be used by a customer as a practical approach for discrimination between the three types of suppliers. Temponi, Yen, and Tiao (1999) developed a fuzzy logic-based extension to HOQ for capturing imprecise requirements to both facilitate communication of team members and have a formal representation of requirements. Recently, Bevilacqua, Ciarapica, and Giacchetta (2006) suggested a new method that transfers the house of quality approach typical of QFD problems to the supplier selection process by using triangular fuzzy numbers. However, their work only considered qualitative criteria and did not address