Expert Systems with Applications 38 (2011) 334–342

Contents lists available at ScienceDirect

Expert Systems with Applications

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

Supplier selection and order allocation based on fuzzy SWOT analysis and fuzzy linear programming

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ARTICLE INFO

Keywords:
Supplier selection
SWOT (Strengths, Weaknesses, Opportunities and Threats)
Fuzzy logic
Linear programming

ABSTRACT

Supplier selection is a multi criteria decision-making problem that comprises tangible and intangible factors. The majority of previous supplier selection techniques do not consider strategic perspective. Besides, uncertainty is one of the most important obstacles in supplier selection.

In this paper, quantified SWOT is applied in the context of supplier selection for the first time. SWOT (Strengths, Weaknesses, Opportunities and Threats) is one of the most well-known techniques for conducting a strategic study. In addition, the fuzzy logic and triangular fuzzy numbers are integrated with SWOT analysis – as a novel innovation – to deal with vagueness of human thought. SWOT analysis can consider both qualitative and quantitative criteria. The managers can understand the position of suppliers in a competitive environment with a glance at SWOT matrix. Moreover, a fuzzy linear programming model is proposed to determine how much should be purchased from each supplier. It is supposed that the demand is a fuzzy number. Besides, the capacity of warehouse is considered as a constraint. A case study is utilized concurrently to show the efficiency of the proposed model.

1. Introduction

Companies try to reduce costs and manage risks. It is important to know that one of the major portions of the firms' expenses is related to logistics activities which mostly are more than 50% of all companies' costs (Aissaoui, Haouari, & Hassini, 2007). Therefore, companies try to manage purchasing tasks. Experts believe that supplier selection is one of the most prominent activities of purchasing departments (Xia & Wu, 2007). But, supplier selection is a difficult problem for managers because the performances of suppliers are varied based on each criterion (Liu & Hai, 2005).

In the previous investigations, several methods have been suggested to solve the supplier selection problem. However, the most of them have not paid attention to the strategic perspective. SWOT (Strengths, Weaknesses, Opportunities and Threats) is a useful technique which is commonly known in strategic management area. SWOT analyzes the external opportunities and threats as well as the internal strengths and weaknesses. Besides, it is one of the most famous tools for strategy formulation. The goal of the analysis of external opportunities and threats is to evaluate whether a company can capture opportunities and avoid threats when facing an uncontrollable external environment such as change in the rule of law (Chang & Huang, 2006). SWOT can also be used when strategy alternative emerges and the relevant decision context needs to be analyzed (Christensen, Berg, & Salter, 1976). On the other hand, the majority of papers assume that the demand is deterministic, but in reality this assumption is not true (Snyder, 2006).

In this paper, we use quantified SWOT analysis as a decision tool to formulate strategic plans for supplier selection. To our knowledge, no one has applied SWOT analysis in supplier selection. Furthermore, fuzzy logic has been integrated with SWOT analysis to deal with vagueness and imprecision of human thought. The proposed decision model is more comprehensive and competitive rather than other published MCDM models for supplier selection due to its dynamic nature and strategic oriented. This model has been implemented in a company that manufactures automobile. The company intends to buy products from multiple supplies. Furthermore, we utilize a proposed fuzzy linear programming model to determine the order quantity from each supplier. In this model, demand is a fuzzy number. The output of SWOT analysis is applied as an input in the mathematical model. The majority of previous models suppose that there is a single product, but our model has been designed for multiple products. In addition, the capacity of warehouse is taken into account as a constraint.

The organization of this paper is as follows: Section 2 discusses the literature review. Fuzzy logic is presented in Section 3. In Section 4, a case study is illustrated. In the first phase, suppliers are assessed based on fuzzy SWOT analysis. Then, the order

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doi:10.1016/j.eswa.2010.06.071

quantity is determined by a fuzzy linear programming model. Subsequently, discussion is presented in Section 5. Finally, conclusions are presented in Section 6.

2. Literature review

Supplier selection is a multi criteria decision-making problem. Criteria and decision-making techniques are two important elements in a supplier selection problem. Dickson (1966) was one of the first ones in this field of study. He identified 23 different criteria for supplier selection based on a questionnaire sent to managers of companies of North America. These criteria include quality, delivery, performance, warrant and claim policy, production facilities and capacity, net price, and technical capabilities. Moore and Fearon (1973) presented a review where focused on industry applications of computer-assisted supplier selection models. Weber, Current, and Benton (1991) categorized the literature on supplier selection by reviewing 74 articles. They identified price, delivery, quality, facilities and capacity, geographic location, and technology capability. De Boer, Labro, and Morlacchi (2001) identified four stages in supplier selection problem which consist of problem formulation, formulation of criteria, qualification and final selection. They stated that the majority of authors have focused on final selection stage. Degraeve, Labro, and Roodhoofi (2004) presented some published supplier selection models and compared their relative efficiency using the total cost of ownership. Aissaoui et al. (2007) have presented another literature review according to the purchasing process. Their proposed classification is based on single and multiple items and periods.

2.1. Supplier selection based on fuzzy logic

Uncertainty is one of the most challenging but important problems in SCM (Melo, Nickel, & Saldanha-da-Gama, 2009; Snyder, 2006). In order to solve the problem of ambiguity of the attributes' outcomes in the realistic environment some researchers have used assorted methods based on fuzzy sets theory (FST) and fuzzy logic. Li, Fun, and Hung (1997) used fuzzy sets theory in supplier selection problem to consider imprecise data. Kwong, Ip, and Chan (2002) presented fuzzy expert system for supplier assessment; however, application of their proposed method is difficult in practice. Kahraman, Cebeci, and Ulukan (2003) utilized fuzzy analytical hierarchy process to select the best suppliers. Jain, Tiwari, and Chan (2004) evaluated the supplier performance using an evolutionary fuzzy-based approach and linguistic variables. Kumar, Vrat, and Shankar (2004, 2006) focused on fuzzy goal programming to solve a vendor selection problem. They minimized cost, rejections and late deliveries simultaneously. Bevilacqua, Ciarapica, and Giacchetta (2006) suggested a method that utilizes the house of quality concept for the supplier selection, but they ignored quantitative metrics. They used triangular fuzzy numbers. Bottani and Rizzi (2006) presented a fuzzy approach for the selection of the most suitable 3PL service provider. They applied fuzzy TOPSIS. Chou and Chang (2008) presented a fuzzy multi attribute rating technique approach for solving the vendor selection problem from the perspective of strategic management. They utilized triangular fuzzy numbers; however, the model does not regard external criteria such as opportunities and threats. Amin and Razmi (2009) proposed an integrated model which covers supplier selection, evaluation and development stages. Besides, they applied a fuzzy-based algorithm for selecting the best Internet service provider (ISP). In other words, they examined the supplier selection in service environments. The most of above literature has discussed the strengths and weaknesses of the suppliers without considering the external attributes and strategic perspective. In the proposed method it will be illustrated that how the SWOT method can be applied to respond this shortage.

2.2. Supplier selection and order lot sizing

Some authors not only solve the supplier selection problem, but also they determine how much should be purchased from each selected supplier. The majority of these papers have written in manufacturing environments. Ghodsypour and O'Brien (1998) combined analytical hierarchy process (AHP) and linear programming to consider both tangible and intangible factors in supplier selection problem. However, their model is deterministic and does not consider uncertainty in human though. In this paper, we extend their model. Weber, Current, and Desai (2000) utilized DEA for evaluating the suppliers and multi-objective programming for determining the vendor order quantity. Kim, Leung, Taepark, Zhang, and Lee (2002) considered a supply network consisting of a manufacturer and its suppliers. They formulated a nonlinear programming model and determined how much of each raw material and component part to order from which supplier according to the capacity of suppliers and manufacturer. It is assumed that demand is stochastic. However, they only determined the order quantity and they did not select the suppliers. Liao and Rittscher (2007) proposed a multi-objective supplier selection model under stochastic demand conditions. Stochastic supplier selection has been determined with simultaneous consideration of the cost, quality, delivery and flexibility according to the limitations of capacity. Xia and Wu (2007) presented a new method based on analytical hierarchy process improved by rough sets theory and multi-objective to determine the number of suppliers and the order quantity allocated to these suppliers. In addition, they considered discount. Wadhwa and Ravindran (2007) optimized Price, lead-time and rejects (quality) to select the best vendor in the field of outsourcing. They applied quantity discount in the model. Faez, Ghodsypour, and O'Brien (2009) proposed vendor selection and order allocation using an integrated fuzzy case-based reasoning and mix integer programming model. However, they did not examine strategic issues in the process of supplier selection. Demirtas and Ustun (2008) presented integrated approach of analytic network process (ANP) and multi-objective linear programming for selecting the best suppliers. The main purpose of integrated models is to consider both qualitative and quantitative criteria. According to these papers, most of authors have used multi-objective programming for lot sizing.

2.3. SWOT

SWOT is a management tool to formulate strategic action plans. Christensen et al. (1976) developed the SWOT analysis on the basis of Grand Strategy Matrix (GSM). SWOT is an acronym for strengths, weaknesses, opportunities and threats. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable for achieving that objective. SWOT maximizes strengths and opportunities, and minimizes threats and weaknesses. In other words, it transforms weaknesses into strengths, and threats into opportunities (Arslan & Deha Er, 2008; Christensen et al., 1976). Kurttila, Pesonen, Kangas, and Kajanus (2000) presented a new hybrid method for improving the usability of SWOT analysis. They combined SWOT and analytic hierarchy process (AHP) to provide information for strategic planning processes. Chang and Huang (2006) also suggested the quantified SWOT analytical method which was adapted to the concept of Multiple-Attribute Decision Making. They used AHP and a multi-layer scheme to simplify complicated problems. They performed SWOT analysis on several enterprises concurrently. It is well known that through AHP, the