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A weighted additive fuzzy multiobjective model for the supplier selection problem under price breaks in a supply Chain

Amin Amid[a], S.H. Ghodsypour[b], Christopher O'Brien[c,*]

[a]Department of Management and Accounting, Shahid Beheshti University, Tehran, Iran
[b]Department of Industrial Engineering, Amirkabir University of Technology (AUT), No. 424, Hafez Avenue, Tehran, Iran
[c]Nottingham University Business School, Jubilee Campus, Wollaton Road, Nottingham NG8 1BB, UK

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Abstract

Supplier selection is one of the most critical activities of purchasing management in a supply chain, because of the key role of supplier's performance on cost, quality, delivery and service in achieving the objectives of a supply chain. Supplier selection is a multiple-criteria decision-making (MCDM) problem that is affected by several conflicting factors. Depending on the purchasing situations, criteria have varying importance and there is a need to weight criteria. In practice, for supplier selection problems, most of the input information is not known precisely. In these cases, the theory of fuzzy sets is one of the best tools for handling uncertainty. The fuzzy multiobjective model is formulated in such a way as to simultaneously consider the imprecision of information and determine the order quantities to each supplier based on price breaks. The problem includes the three objective functions: minimizing the net cost, minimizing the net rejected items and minimizing the net late deliveries, while satisfying capacity and demand requirement constraints. In order to solve the problem, a fuzzy weighted additive and mixed integer linear programming is developed. The model aggregates weighted membership functions of objectives to construct the relevant decision functions, in which objectives have different relative importance. A numerical example is given to illustrate how the model is applied. Finally, the conclusions and recommendations are presented.

Keywords: Supplier selection; Fuzzy MCDM; Quantity discount; Weighted additive; Supply chain

1. Introduction

Organizations must pursue strategies to achieve higher quality, reduced costs and shorter lead times to maintain a competitive position in the global market. Within new strategies for purchasing and manufacturing, suppliers play a key role in achieving corporate competition. Hence, selecting the right suppliers is a vital component of these strategies. Supplier selection is a multiple-criteria decision-making (MCDM) problem that is affected by several conflicting factors. Consequently, a purchasing manager must analyze the trade-off among the several criteria. MCDM techniques support the decision makers (DMs) in evaluating a set of alternatives. In real situation, for supplier selection problems, the weights of criteria are different and depend on purchasing strategies in a

*Corresponding author.
E-mail address: Chris.Obrien@nottingham.ac.uk (C. O'Brien).

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supply chain (Wang et al., 2004). It is a common practice for suppliers to offer quantity discounts to encourage the buyer towards larger order. In this case, the buyer must decide what order quantities to assign to each supplier. This is a complicated multiobjective decision-making problem affected by several conflicting factors. In a real situation, for a supplier selection problem, most of the input information is not known precisely. At the time of making decisions, the value of many criteria and constraints are expressed in vague terms such as "very high in quality" or "low in price". Deterministic models cannot easily take this vagueness into account. In these cases, the theory of fuzzy sets is one of the best tools to handle uncertainty. Fuzzy set theories are employed due to the presence of vagueness and imprecision of information in the supplier selection problem.

In this paper, a fuzzy multiobjective model has been developed for the supplier selection problem under price breaks that depend on the sizes of order quantities. Through this model, purchase managers can assign different weights for numbers of criteria in order to manage flow of supply materials, components and finished products to improve quality, service and reduced cost, in order to make improvement in supply chain performance. This model can be used as a decision support system by the purchasing manager to decide what order quantities to place with each supplier in the case of multiple sourcing. The paper has the following structure. Section 2 presents a brief literature review of the quantitative approaches related to a supplier selection problem. Section 3 provides the necessary background of mixed binary integer programming and multiobjective supplier selection problem under price breaks that depend on the sizes of order quantities. Section 4 presents the weighted additive method to generate optimal solutions in a fuzzy environment. Section 5 gives a numerical example and reports the results of computational experiments. Finally, section 6 is devoted to conclusions and recommendations.

2. Literature review

Weber and Current (1993) used a multiobjective approach to systematically analyze the trade-offs between conflicting criteria in supplier selection problems. Ghodsypour and O'Brien (1998) developed an integrated analytic hierarchy process (AHP) and linear programming model to consider both qualitative and quantitative factors in purchasing activity. Karpak et al. (1999) used a goal programming model to minimize costs and maximize delivery reliability and quality in supplier selection when assigning the order quantities to each supplier. Degraeve and Roodhooft (2000) developed a total cost approach with mathematical programming to treat supplier selection using activity-based cost information. Ghodsypour and O' Brien (1997) developed a mixed-integer nonlinear programming approach to minimize the total cost of logistics, including net price, storage, ordering costs and transportation, in supplier selection. Cebi and Bayraktar (2003) proposed an integrated lexicographic goal programming and AHP model, including both quantitative and qualitative conflicting factors. In these papers, it was assumed that the unit price remains constant over ranges of order quantity. Although extensive research on economic order quantities with quantity discounts exists, only a few methods address the problem from the perspective of supplier selection and order quantity allocation.

This type of model was discussed in Gaballa (1974), Bender et al. (1985), Turner (1988), Sharma et al. (1995), Benton (1991), Chauhdry et al. (1993), Rosenthal et al. (1995) and Ghodsypour (1996). Chaudry et al. (1993) developed a linear mixed integer programming for supplier selection. In their model price, delivery, quality and quantity discount are included. The objective of the model is to minimize aggregate price by considering both cumulative and incremental discount. Delivery and quality were considered as constraints. They suggested that goal programming is an appropriate technique for this multiobjective problem. Rosenthal et al. (1995) developed a mixed integer programming model for supplier selection with bundling, in which a buyer needs to buy various items from several vendors whose capacity, quality and deliveries are limited and who offer bundled products at discounted prices. They used single objective programming in their model. Ghodsypour and O' Brien (1997) proposed an integrated AHP and linear programming model to help managers consider both qualitative and quantitative factors in their purchasing activity in a systematic approach. In their model, buyer's limitations on budget, quality, and service and price discount were considered.

In real cases, due to the vagueness of the information related to parameters, these deterministic models are unsuitable to obtain an effective