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A two-phase possibilistic linear programming methodology for multi-objective supplier evaluation and order allocation problems

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Abstract

In this study, an integration of the analytic hierarchy process (AHP) and a multi-objective possibilistic linear programming (MOPLP) technique is developed to account for all tangible, intangible, quantitative, and qualitative factors which are used to evaluate and select suppliers and to define the optimum order quantities assigned to each. A multi-objective linear programming technique is first employed to solve the problem. To model the uncertainties encountered in the integrated supplier evaluation and order allocation methodology, fuzzy theory is adopted. Hence, possibilistic linear programming (PLP) is proposed for solving the problem, as it is believed to be the best approach for absorbing the imprecise nature of the real world. In the supplier evaluation phase, environmental criteria are also considered.

Keywords: Supplier evaluation; Order allocation; AHP; Multi-objective possibilistic linear programming

1. Introduction

Supply chain management (SCM) is often defined as optimization of the network, which comprises a number of systems that are responsible for the procurement, manufacturing, warehousing, and transportation activities. Management of each of these systems involves a series of complex trade-offs between various business function costs. SCM is generally considered as an effective means to help companies reduce costs, improve responsiveness, and increase competitiveness. In order to remain competitive in the global market, the entire supply chain network should be designed as an integrated system, where the focus is on planning and management of the flow of materials from suppliers to end users. Suppliers are highly responsive and flexible in responding to end user orders. Hence, many issues in the supply network are influenced by the proper selection

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of suppliers. Supplier evaluation and selection affect almost every subsequent decision to be made in the management of supply network. Selecting the right suppliers and quota allocations significantly reduces purchasing costs, improves competitiveness, and enhances end user satisfaction by eliminating waste, improving quality and flexibility to meet the requirements of the end users, and reducing lead-time at different stages of the network [28]. Supplier evaluation and selection is a complex and multiple-criteria decision-making (MCDM) problem that is affected by different tangible and intangible variables including, but not limited to, price, quality, performance, technical capability, delivery.

Basically, there are two kinds of supplier selection and sourcing problems: single-sourcing and multiple-sourcing. In the former, one supplier can satisfy all requirements of the buyer, whereas in the latter, more than one supplier is required to satisfy all needs of the buyer. In the first case, management needs to make only one decision – ''which supplier is the best'' – whereas in the second case, management allocates order quantities among suppliers to create a competitive environment [15]. Order allocation or sourcing decisions incorporate operational metrics such as cost, quality and delivery, and strategic capabilities of suppliers such as quality management practices, management practices, and design development, process and cost reduction capabilities. The problem of how to allocate orders among suppliers properly in multiple supplier environments is more complicated than the supplier evaluation and selection problem in the single-sourcing case, because the activities of order allocation, or sourcing problems, are co-dependent. However, both supplier evaluation and order allocation problems are selection problems [42,25].

Supplier evaluation and selection has received considerable attention in the SCM literature. Also, many methods have been developed for solving single- and multiple-sourcing problems since the 1960s. The most commonly used methods for these kinds of problems are mathematical programming models, multiple attribute decision aid methods, cost-based methods, statistical and probabilistic methods and combined methodologies. Mathematical programming approaches have been widely used for modeling selection and allocation problems. They include linear programming [36,2,46], mixed integer programming [5,37,12,34,7,11,39], goal programming [6,26,8], and multi-objective programming [49–53]. Multiple attribute decision aid methods such as linear weighting methods [13,16,44,45] and the analytic hierarchy process (AHP) [34,3,35,43] have also been applied to problems. Several studies have been presented, which use cost-based methods and statistical/probabilistic methods. Additionally, there are some combined methods such as a combination of the AHP and linear programming [15], the AHP and mixed integer programming [27], the analytic network process (ANP) and multiple objective programming [14], ANP, TOPSIS and the nominal group technique [41].

Several papers on order allocation or sourcing have been published recently. Some of them have been combined with supplier evaluation and selection problems. The supplier evaluation and selection method can be adopted to model the order allocation problem by considering the dependence between the activities, especially in the form of precedence constraints. Hammami et al. [18] proposed a mathematical model to solve the supplier selection and order allocation problem. They then applied a long-term optimization based on the AHP and weighted point methods. Hazra et al. [19] analyzed capacity allocation among multiple suppliers and presented a basis for allocating a buyer's requirements among multiple suppliers in order to minimize the cost. Talluri and Narasimhan [42] proposed a methodology for effective supplier sourcing by using data envelopment analysis (DEA) models and non-parametric statistical techniques. Choi and Chang [10] developed a two-phased semantic optimization modeling approach for strategic supplier selection and allocation problems. Demirtas and Ustun [14] proposed an integrated ANP and multi-objective mixed integer programming methodology for choosing the most suitable suppliers and defining optimum quantities among the selected suppliers.

The supplier evaluation and selection problem is a complex, multi-criterion decision-making problem which includes both tangible and intangible criteria, some of which may conflict. To handle tangible and intangible criteria, certain methods were suggested by some authors. The most important point is that all methods make some kind of trade-off between tangible and intangible factors to find the best supplier. When considering complex supplier evaluation and order allocation problems together, a multi-stage multi-object programming approach that includes both quantitative and qualitative aspects should be used to find a solution. However, much of the information discovered in this kind of process is not known with certainty. Due to the imprecision and fuzziness of the information related to parameters, deterministic models are not suitable to obtain an effective solution for supplier evaluation and order allocation problems. To overcome