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An integrated multi-objective decision-making process for multi-period lot-sizing with supplier selection☆

Ozden Ustun, Ezgi Aktar Demirtas*

Department of Industrial Engineering, Eskisehir Osmangazi University, 26030 Eskisehir, Turkey

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Abstract

Supplier selection is a multi-criteria problem which includes both tangible and intangible factors. In these problems if suppliers have capacity or other different constraints two problems will exist: which suppliers are the best and how much should be purchased from each selected supplier? In this paper an integrated approach of analytic network process (ANP) and multi-objective mixed integer linear programming (MOMILP) is proposed. This integrated approach considers both tangible and intangible factors in choosing the best suppliers and defines the optimum quantities among selected suppliers to maximize the total value of purchasing (TVP), and to minimize the total cost and total defect rate and to balance the total cost among periods. The priorities are calculated for each supplier by using ANP. Four different plastic molding firms working with a refrigerator plant are evaluated according to 14 criteria that are involved in the four clusters: benefits, opportunities, costs and risks (BOCR). The priorities of suppliers will also be used as the parameters of the first objective function. This multi-objective and multi-period real-life problem is solved by using previous techniques and a reservation level driven Tchebycheff procedure (RLTP). Finally the most preferred nondominated solutions are determined by considering the decision maker's (DM's) preferences and the results obtained by these techniques are compared.

Keywords: Analytic network process; Multi-objective mixed integer linear programming; Reservation level driven Tchebycheff procedure; Multi-criteria decision making; Supplier selection; Multi-period lot-sizing

1. Introduction

Companies need to work with different suppliers to continue their activities. In manufacturing industries the raw materials and component parts can equal up to 70% of the product cost. In such circumstances the purchasing department can play a key role in cost reduction, and supplier selection is one of the most important functions of purchasing management [9].

Several factors may affect a supplier's performance. Dickson [8] identified 23 different criteria for vendor selection including quality, delivery, performance history, warranties, price, technical capability and financial position. Hence, supplier selection is a multi-criteria problem which includes both tangible and intangible criteria, some of which may conflict.

Basically there are two kinds of supplier selection problem. In the first kind of supplier selection, one supplier can satisfy all the buyer's needs (single

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* Corresponding author. Tel.: +90 222 230 39 72x279.
E-mail addresses: oustun@ogu.edu.tr (O. Ustun), eaktar@ogu.edu.tr (E.A. Demirtas).

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sourcing). The management needs to make only one decision: which supplier is the best. In the second type (multiple sourcing), no supplier can satisfy all the buyer's requirements. In such circumstances management wants to split order quantities among suppliers for a variety of reasons, including creating a constant environment of competitiveness. Several methods have been proposed for single and multiple sourcing problems in the literature [9].

First publications on vendor selection can be traced back to the early 1960s. Although the problem of supplier selection is not new, quite a few researchers treat the supplier selection issue as an optimization problem, which requires the formulation of an objective function [22]. Since not every supplier selection criterion is quantitative, usually only a few quantitative criteria are included in the optimization formulation. To overcome this drawback, Ghodsypour and O'Brien [9] combined analytic hierarchy process (AHP) and linear programming to take into account tangible as well as intangible criteria and to solve order allocation problem among suppliers. Their single period model contains two different objectives: maximization of total value of purchasing (TVP) and minimization of defect rate. They used ε-constraint method to solve the problem. By following this study; Wang et al. [22] developed an integrated AHP and preemptive goal programming (PGP) approach based on multi-criteria decision-making methodology to maximize TVP and to minimize the total cost of purchasing. In Xia and Wu's paper, an integrated approach of analytical hierarchy process improved by rough sets theory and multi-objective mixed integer programming is proposed to simultaneously determine the number of suppliers to employ and the order quantity allocated to these suppliers in the case of multiple sourcing, multiple products, with multiple criteria and with supplier's capacity constraints [24].

Although timehorizon was not considered in the previous studies [7,9,22,24], time cannot be neglected in real-life problems such they are working on. To eliminate this drawback, Demirtas and Ustun [6] have also used analytic network process (ANP) and goal programming approach for multi-period lot-sizing.

In this paper an integration of ANP and multi-period multi-objective mixed integer linear programming (MOMILP) is proposed to consider both tangible and intangible factors for choosing the best suppliers and define the optimum quantities among the selected suppliers.

In the evaluation stage, the suppliers are evaluated according to 14 criteria that are involved in four control hierarchies: benefits, opportunities, costs and risks (BOCR). It will be useful to determine priorities by ANP, a new theory that extends the AHP. With the ANP it is recognized that there is feedback between the elements in different levels of the hierarchy and also between elements in the same level, so the decision elements are organized into networks of clusters and nodes. ANP deals systematically with all kinds of feedback and interactions (inner and outer dependence). When elements are linked only to elements in another cluster, the model shows only outer dependence. When elements are linked to the elements in their own cluster, there is inner dependence. Feedback can better capture the complex effects of interplay in human society [17].

In the shipment stage, MOMILP model is solved to obtain nondominated solutions by considering decision maker's (DM's) preferences. Over the last decade, various interactive methods and decision support systems have been developed to deal with multi-objective programming (MOP) problems [2]. In the same period, a variety of scalarization methods for finding efficient solutions of multiple objective programs MOPs have been developed. Although some of the methods work well only on problems with concave objective functions and a convex feasible region, most of the real-life problems have discrete variables, so the set of nondominated solutions for these problems is not convex. Weighted sums of the objective functions do not provide a way of reaching every nondominated solution. Besides supported nondominated solutions, there exist unsupported ones—solutions that are dominated by convex combinations of other nondominated solutions. Tchebycheff metric-based scalarizing programs have the advantage over weighted-sums programs of being able to reach, not only supported, but also unsupported nondominated solutions. A general characterization for the nondominated solution set based on the Tchebycheff metric was first proposed by Bowman [3]. A Tchebycheff scalarizing program computes the (weakly) nondominated solution closest to a reference point (e.g. the ideal criterion point) according to a (weighted) Tchebycheff (L_∞) metric.

The use of reference points appeared in the early development of multiple objective programming as part of the work by Charnes and Cooper [5] on goal programming. Wierzbicki [23] produced seminal research on reference point methods, including an investigation of the characteristics of various achievement functions for allowing the search for attractive nondominated solutions to be controlled by reference points. In general, reference point approaches for multi-objective problems (considering discrete variables or not) rely on the