Available online at www.sciencedirect.com

ScienceDirect

Computers & Industrial Engineering 56 (2009) 677–690

computers & industrial engineering

www.elsevier.com/locate/caie

Analytic network process and multi-period goal programming integration in purchasing decisions

Ezgi Aktar Demirtas *, Ozden Ustun

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

Available online 21 December 2006

Abstract

This paper presents a multi-period inventory lot sizing scenario, where there is single product and multiple suppliers. By considering multi-period planning horizon, an integrated approach of Archimedean Goal Programming (AGP) and Analytic Network Process (ANP) is suggested. This integrated approach proposes a two-stage mathematical model to evaluate the suppliers and to determine their periodic shipment allocations given a number of tangible and intangible criteria. In the evaluation stage, the suppliers are evaluated according to 14 criteria that are involved in four control hierarchies; benefit, opportunity, cost and risk (BOCR). In the shipment stage, a multi objective mixed integer linear programming (MOMILP) model is described to solve the order allocation problem. This MOMILP model is suggested to achieve target values of periodic goals: budget, aggregate quality, total value of purchasing (TVP) and demand over the planning horizon, without exceeding vendor production capacities. This multi-period model is solved by using AGP. Finally some computational experiments are conducted to test the performance of the proposed method.

Keywords: Supplier selection; Analytic Network Process; Goal Programming; Multi-criteria decision making; 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% 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 (Ghodsypour & O'Brien, 1998).

Several factors may affect a suppliers' performance. Dickson (1966) 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 sourcing). The management needs to make only one decision;

* Corresponding author. Tel.: +90 222 2303972; fax: +90 222 2213918.
E-mail address: eaktar@ogu.edu.tr (E. Aktar Demirtas).

0360-8352/$ - see front matter
doi:10.1016/j.cie.2006.12.006

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 (Aissaoui, Haouari, & Hassini, 2006).

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 (Wang, Huang, & Dismukes, 2004). 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 (1998), Wang et al. (2004) proposed integrated approaches. They are achieved in two phases. At first, a supplier evaluation is elaborated using a multi-criteria tool. In these studies, the Analytic Hierarchy Process (AHP) method was applied to make the trade-off between tangible and intangible factors and calculate a rating of suppliers. The second stage of these global approaches consists of effectively selecting the suppliers and allocating orders using mathematical programming to take into account the system constraints. Thereby in the study of Ghodsypour and O'Brien (1998), calculated ratings are applied as coefficients of an objective function in a linear program such that the total value of purchasing becomes a maximum. This single period single item model was constrained by the demand, capacity and quality requirements. They used ε-constraint method to solve the problem. In addition to a goal that maximizes the total value of purchase (AHP ratings input), Wang et al. (2004) considered a second goal that minimizes the total cost of purchase. The resulted preemptive goal programming (PGP) determines the optimal order quantity from the chosen suppliers considering as constraints vendor capacities and demand requirements. Demirtas and Ustun (2005a) combined ANP and MOMILP model to solve order allocation problem by using a Reservation Level Driven Tchebycheff Procedure. They minimized total defect rate and total cost of purchasing, and maximized TVP. On the other hand, none of these integrated approaches considered a multi-period planning horizon.

Several researchers combine supplier selection and procurement lot-sizing by considering a multi-period planning horizon and defining variables to determine the quantity purchased in each elementary period (Bender, Brown, Isaac, & Shapiro, 1985; Buffa & Jackson, 1983; Tempelmeier, 2002; Basnet & Leung, 2005). Buffa and Jackson (1983) presented a schedule purchase for a single product over a defined planning horizon via a GP model considering price, quality and delivery criteria. It included buyer's specification such as material requirement and safety stock. Bender et al. (1985) studied a purchasing problem faced by IBM involving multiple products, multiple time periods, and quantity discounts (the type of quantity discount was not mentioned). The authors described, but not developed, a mixed integer optimization model, to minimize the sum of purchasing, transportation and inventory costs over the planning horizon, without exceeding vendor production capacities and various policy constraints. Contrary to single period models dealing with any form of price discount, by considering inventory management in a multi-period horizon planning, Tempelmeier (2002) incorporates a trade-off between ordering larger quantities to get a reduction on purchasing costs and maintaining low inventories to minimize holding costs. Basnet and Leung (2005) balance ordering and holding costs in a multi-item model by considering a multi-period scheduling horizon. They proposed an uncapacitated mixed linear integer programming that minimizes the aggregate purchasing, ordering and holding costs subject to demand satisfaction. The authors proposed an enumerative search algorithm and a heuristic to solve the problem. Although they considered multi-period planning horizon, neglected intangible criteria.

Both of multi-period planning horizon and intangible criteria can not be neglected in real life problems such they are working on. To eliminate this drawback, Demirtas and Ustun (2005b) have also used ANP and GP approach for multi-period lot-sizing.

In this paper, an integration of ANP and multi-period MOMILP is proposed to consider both tangible and intangible factors for choosing the best suppliers and define the optimum quantities among the selected suppliers. This two-stage mathematical model is proposed to evaluate the suppliers and to determine their shipment allocations given a number of tangible and intangible criteria.

In the evaluation stage, the suppliers are evaluated according to 14 criteria that are involved in four control hierarchies; BOCR. It will be useful to determine priorities by ANP, a new theory that extends the AHP. With