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ScienceDirect
Computers & Industrial Engineering 54 (2008) 918–931
computers & industrial engineering
www.elsevier.com/locate/caie

Multi-period lot-sizing with supplier selection using achievement scalarizing functions

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Received 30 January 2007; received in revised form 26 October 2007; accepted 31 October 2007
Available online 7 November 2007

Abstract

In this paper, an integration of Analytic Network Process (ANP) and achievement scalarizing functions is proposed to choose the best suppliers and define the optimum quantities among the selected suppliers by considering tangible–intangible criteria and time horizon. To reflect the decision maker's (DM's) preferences more accurate, an additive achievement function is defined consist of several components. In this additive function while unwanted deviations from periodic budget and aggregate quality goals are balanced by Minmax Goal Programming (MGP), and unwanted deviations from total cost, total value of purchasing (TVP) and aggregate quality are minimized by Achimedean Goal Programming (AGP) to provide more acceptable solutions. This multi-period model enables us to reflect DM's preferences more flexible than the other traditional models that use only one type of achievement function. The sensitivity analysis was also performed for different levels of periodic demands. It is also possible to enlarge the sensitivity analyses for other parameters such as different levels of capacity, and different weights of components.

Keywords: Achievement scalarizing functions; Analytic network process; Goal programming; Multi-criteria decision making; Lot-sizing with supplier selection

1. Introduction

Basically there are two kinds of supplier selection problem; single and multiple sourcing. Several methods have been proposed for single and multiple sourcing problems in the literature (Aissaoui, Haouari, & Hassini, 2007).

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.

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0360-8352/$ - see front matter
doi:10.1016/j.cie.2007.10.021

(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 (TVP), 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 (2008) combined ANP and multi-objective mixed integer linear programming (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 (Basnet & Leung, 2005; Bender, Brown, Isaac, & Shapiro, 1985; Buffa & Jackson, 1983; Tempelmeier, 2002 etc.). 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. Time horizon was not considered in the previous integrated approaches (Demirtas & Ustun, 2008; Wang et al., 2004). To eliminate this drawback, Demirtas and Ustun (2007) have also used ANP and AGP approach for multi-period lot-sizing but there are many other potential forms of achievement function, although usually ignored by Goal Programming (GP) users and researchers. This point is important since results derived from GP models are generally very sensitive to the type of achievement function chosen. Consequently, a wrong achievement function, as does not reflect the real DMs preferences, can provide unacceptable solutions (Romero, 2004). In this study, being different from the previous ones, an additive achievement function is defined consist of MGP and AGP regarding to DM's preferences. In this function unwanted deviations from periodic budget and aggregate quality goals are balanced by using MGP, and unwanted deviations from total cost, TVP and total aggregate quality are minimized by using AGP to reflect the preferences more accurate and provide more acceptable solutions.

In this paper, an integration of ANP and an additive achievement scalarizing function is proposed to choose the best suppliers and define the optimum quantities among the selected suppliers by considering tangible–intangible criteria and time horizon.

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.

In the shipment stage, a GP model is described for a multi-period inventory lot-sizing scenario, where there are multiple suppliers and single product. It is suggested to balance unwanted deviations from periodic budget and aggregate quality and minimize unwanted deviations from total cost, TVP and aggregate quality without exceeding supplier production capacities. Some computational experiments are conducted to test the performance of the proposed method.

2. ANP and multi-period MOMILP integration in supplier selection and order allocation

As mentioned in Part 1, this integrated approach proposes a two stage mathematical model which includes supplier evaluation and shipment allocation. Fig. 1 shows the flowchart of this integrated approach. Evaluation and shipment stages are briefly summarized as follows.