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The total cost of logistics in supplier selection, under conditions of multiple sourcing, multiple criteria and capacity constraint

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Abstract

Little attention is given in the literature to decisions on the appropriate selection of suppliers, and on assigning order quantities to these suppliers, in the case of multiple sourcing, with multiple criteria and with suppliers' capacity constraints. Only a few mathematical programming models to analyse such decisions have been published to date, and these have tended to consider only net price as the cost of purchasing, although the costs of transportation, ordering and storage may be significantly important to the decision. In this paper a mixed integer non-linear programming model is presented to solve the multiple sourcing problem, which takes into account the total cost of logistics, including net price, storage, transportation and ordering costs. Buyer limitations on budget, quality, service, etc. can also be considered in the model. An algorithm is proposed to solve the model, and the model is illustrated using a numerical example. © 2001 Published by Elsevier Science B.V.

Keywords: Logistics; Sourcing; Criteria; Constraints

1. Introduction

In most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70% [1]. In high technology firms, purchased materials and services represent up to 80% of total product cost [2]. Thus the purchasing department can play a key role in an organization's efficiency and effectiveness because it has a direct effect on cost reduction, profitability and flexibility of a company.

Selecting the right suppliers significantly reduces the purchasing cost and improves corporate competitiveness, which is why many experts believe that the supplier selection is the most important activity of a purchasing department [3,4].

In spite of the importance of supplier selection problems only a few articles have addressed the decision making. Weber and Current [5] stated that only 10 articles analysed the problem up to the time of their review. A comprehensive review of the articles which have addressed the problem can be found in Ghodsypour [6] and Ghodsypour and O'Brien [7]. The most important articles are described below.

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Moore and Fearon [8] stated that price, quality and delivery are important criteria for supplier selection and they explained that linear programming can be applied to this decision making. They also discussed other applications of computer technology in the purchasing area.

Gaballa [9] is the first author who applied mathematical programming to vendor selection in a real case. He used a mixed integer programming model to formulate this decision making problem for the Australian Post Office. The objective of this programming is to minimize the total discounted price of allocated items to the vendors, under constraints of vendors' capacity and demand satisfaction.

Anthony and Buffa [10] developed a single objective linear programming model to support strategic purchasing scheduling (SPS). The linear model minimizes total cost by considering limitations of purchasing budget, vendor capacities and buyer's demand. Price and storage cost are included in the objective function. The costs of ordering, transportation and inspection are not included in the model.

Buffa and Jackson [11] presented a multi-criteria linear goal programming model for supplier selection. In this model two sets of factors are considered: (1) supplier attributes, which include quality, price, service experience, early, late and on-time deliveries and (2) the buying firm's specification, including material requirement and safety stock.

Bender et al. [12] applied single objective programming to develop a commercial computerized model for vendor selection at IBM. They used mixed integer programming, to minimize the sum of purchasing, transportation and inventory costs by considering multiple items, multiple time periods, vendors' quality, delivery and capacity. In this model quantity discount also is included. No mathematical formulations were presented and they did not indicate the kind of discount.

Narasimhan and Stoynoff [13] applied a single objective, mixed integer programming model to a large manufacturing firm in the Midwest, to optimize the allocation procurement for a group of vendors. The objective of this model is to minimize the sum of the shipping and the penalty costs. The model constraints are related to vendors' production capabilities and demand.

Kingsman [14] stated that one of the most important problems which has received little attention from OR practitioners is the purchasing of materials whose prices are continually fluctuating in a stochastic manner over time. He discussed conceptually linear programming and dynamic programming as tools for purchasing raw materials with fluctuating prices.

Turner [15] presented a single objective linear programming model for British Coal. This model minimized the total discounted price by considering the vendor capacity, maximum and minimum order quantities, demand, and regional allocated bounds as constraints.

Pan [16] proposed multiple sourcing for improving the reliability of supply for critical materials, in which more than one supplier is used and the demand is split between them. Most purchasing managers agree that buying from more than one vendor will protect the buying firm in the case of shortages. Pan [16] used a single objective linear programming model to choose the best suppliers, in which three criteria are consiered – price, quality and service. The total cost is taken into account as an objective function and quality and service are considered as constraints.

Sharma et al. [17] proposed a non-linear, mixed integer, goal programming model for supplier selection. They considered price, quality, delivery and service in their model, in which all criteria are considered as goals. The cost goal is decreased in relation to the increase in purchased quantity and is raised in relation to the increase in quality level.

Seshadri et al. [18] developed a probabilistic model to represent the connection between multiple sourcing and its consequences, such as number of bids, the seller's profit and the buyer's price. Only one criterion, cost, is considered in this model and the authors stated that the user should transfer the other criteria such as quality, delivery, etc., into an equivalent price.

Benton [19] developed a nonlinear program and a heuristic procedure using Lagrangian relaxation for supplier selection under conditions of multiple items, multiple suppliers, resource limitations and quantity discount. The model objective is to minimize the sum of purchasing costs, inventory