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A deterministic, multi-item inventory model with supplier selection and imperfect quality

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Abstract

This paper considers the scenario of supply chain with multiple products and multiple suppliers, all of which have limited capacity. We assume that received items from suppliers are not of perfect quality. Items of imperfect quality, not necessarily defective, could be used in another inventory situation. Imperfect items are sold as a single batch, prior to receiving the next shipment, at a discounted price. The demand over a finite planning horizon is known, and an optimal procurement strategy for this multi-period horizon is to be determined. Each of products can be sourced from a set of approved suppliers, a supplier-dependent transaction cost applies for each period in which an order is placed on a supplier. A product-dependent holding cost per period applies for each product in the inventory that is carried across a period in the planning horizon. Also a maximum storage space for the buyer in each period is considered. The decision maker, the buyer, needs to decide what products to order, in what quantities, with which suppliers, and in which periods. Finally, a genetic algorithm (GA) is used to solve the model.

Keywords: Inventory control; Integer programming; Mathematical programming; Optimization; Supplier selection; Genetic algorithms

1. Introduction

In the past several decades, supplier selection problem has gained great attention in the business management literature and practice (cf. Burton [1], Degraeve and Roodhooft [2], Degraeve et al. [3], Dickson [4], Jayaraman et al. [5], Patton III [6], Weber et al. [7–9]). Under the business environment of global sourcing, core-competence outsourcing strategy, supply base reduction, strategic buyer–supplier relationship, cross-functional purchasing program, Internet and e-commerce and so forth, the supplier selection decision is becoming ever important and complicated decision.

Recently, the issue of supplier selection integrated with inventory management. Buffa and Jackson [10] presented a schedule purchase from mix of vendors over a defined planning horizon via goal programming model.

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Bender et al. [11], described, but not developed, a mixed integer optimization model, to minimize the sum of purchasing, transportation and inventory costs over multiple time periods, constraints of vendor capacity and policy. Degraeve and Roodhooft [2] put forward a mixed integer non-linear programming model to consider vendor selection and inventory management decision together, under conditions of multiple sourcing, multiple criteria and capacity constraints.

Basnet and Leung [12] presented a model for optimal procurement lot-sizing with supplier selection. Their model is an extension of Wagner and Whitin's seminal work [13], which is a lot sizing model for a single product, to the multi-product case. In addition, it is a multi-period model, considering the possibility of exploiting economies of scale in the procurement process in exchange for accruing inventory costs from one period to the next. Multi-period models also offer the opportunity to change suppliers for a product from one period to the next. Many supplier selection models (cf. Ganeshan [14], Jayaraman et al. [5], Kasilingam and Lee [15], Rosenthal et al. [16]) are single period models. Capacities on resources, in general, were considered in the important work of Manne [17], in which he introduced a mixed-integer linear programming model in the presence of labor limitations. Benson [18] by introducing capacities for the suppliers, considered a supply chain with multiple suppliers, all of which have limited capacity and determined an optimal procurement strategy for this multi-period horizon.

In a real production environment, it can often be observed that there are defective items being produced. These defective items must be rejected, repaired, reworked, or, if they have reached the customer, refunded. In all cases, substantial costs are incurred. Therefore, it is more appropriate to take the quality-related cost into account in determining the optimal ordering policy. In the literature, Porteus [19] and Rosenblatt and Lee [20] are among the first to explicitly elaborate on the significant relationship between quality imperfection and lot size. Porteus [19] describes a system that begins each production run in control. As each unit is produced, there is a probability p that the system goes out of control, at which time all subsequent units are defective. He used this model to study the optimal setup investment in relation to reducing the probability p of the process going out of control. His work has encouraged many researchers to deal with modeling the quality improvement problems that we refer to some of them.

Rosenblatt and Lee [20] assumed that the time between the beginnings of the production run until the process goes out of control is exponential and that defective items can be reworked instantaneously at a cost. They concluded that the presence of defective products motivates smaller lot sizes. In a subsequent paper [21], they considered a joint lot sizing and inspection policy is studied under an economic order quantity model where a random proportion of units are defective. Salameh and Jaber [22] hypothesized a production/inventory situation where items, received or produced, are not of perfect quality. Items of imperfect quality, not necessarily defective, could be used in another production/inventory situation, that is, less restrictive process and acceptance control. They extended the traditional EPQ/EOQ model by accounting for imperfect quality items when using the EPQ/EOQ formulae. Chan et al. [23] provided a framework to integrate lower pricing, rework and reject situations into a single EPQ model. A 100% inspection is performed in order to identify the amount of good quality items, imperfect quality items and defective items in each lot. Papachristos and Konstantaras [24] looked at the issue of non-shortages in models with proportional imperfect quality, when the proportion of the imperfects is a random variable and revised the papers of Salameh and Jaber [22] and Chan et al. [23]. Hayek and Salameh [25] presented an inventory model of shortage and backlog that considers rework of defective products. Zhang and Gerchak [26] considered a joint lot sizing and inspection policy studied under an EOQ model where a random proportion of units are defective. Wee et al. [27] developed an optimal inventory model for items with imperfect quality and shortage backordering. They assumed that all customers are willing to wait for new supply when there is a shortage. Ouyang et al. [28] investigated the lot size, reorder point inventory model involving variable lead time with partial backorders, where the production process is imperfect. Francis Leung [29] proposed an EPQ model with a flexible and imperfect production process. He formulated this inventory decision problem using geometric programming. Freimer et al. [30] investigated the effect of imperfect yield on economic production quantity decisions. Ouyang and Chang [31] investigated the impact of quality improvement on the modified lot size reorder point models involving variable lead time and partial backorders. Chiu [32] considered the effects of the reworking of defective items on the economic production quantity (EPQ) model with allowed backlogging. Urban [33] proposed a finite replenishment inventory model in which the demand of an item is a deterministic function of price and advertising expenditures. The formu-