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Concurrent pricing and lot sizing for make-to-order contract production

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Abstract

This paper develops a model for the simultaneous (i.e. concurrent) determination of the inventory and pricing policies of a supplier, which produces and supplies a product to a buyer, on the basis of a contractual agreement, calling for the delivery of a specific quantity periodically. Assuming that the customer is rational, i.e. it follows its own optimal purchasing policy, the objective of the supplier is to determine the product's selling price, in conjunction with an appropriate production/inventory policy, so that a predetermined gross profit level is achieved. It is further assumed that the supplier's production batch size is an integer multiple of the buyer's order quantity. In formulating a mathematical model of this situation, the interactions between the product's price, the buyer's economic order quantity and the supplier's selling price, costs and profit are taken into account. For solving this model, a simple iterative algorithm is proposed, which is illustrated through a numerical example. Sensitivity analysis performed on the model demonstrates that it is relatively robust and quite insensitive to errors in estimating the buyer's ordering to carrying cost ratio on the part of the producer.

Keywords: Pricing; Inventory lot sizing; Contracted production

1. Introduction

An important problem often encountered by industrial producers and suppliers involves the determination of a product's selling price in order to achieve a given profit objective. If a product has several customers, ordering it regularly and frequently, it may be reasonable and economical for the supplier to have it available for delivery practically at all times. In other words, the item may be produced to stock; in which case, setting an appropriate price and formulating a production policy for it becomes relatively easy. On the other hand, if there is only one customer for a product, which is produced on a contractual basis and delivered periodically in specified discrete lot sizes, its price and production policy must be determined judiciously in order to satisfy the supplier's profit

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goal. We assume that for such a product, the customer's ordering behavior will be based on its economic purchasing policy.

In a pioneering paper, Goyal (1977) developed a model for formulating the supplier's economic production policy in response to the buyer's purchase orders, implicitly assuming an infinite production rate on the part of the former. Rosenblatt and Lee (1985) have generalized Goyal's results by incorporating a finite supplier production rate in the model in conjunction with a price discount. In addition, Banerjee (1986a) and Monahan (1984) have independently suggested a price discount approach for enticing the customer to deviate from its economic policy in order to increase the supplier's profits. Along similar lines, Lal and Staelin (1984), among others, have also developed a price discount model for maximizing supplier profits. All of these approaches, however, assume that the base price of the product in question is given and do not directly address the issue of pricing for achieving a specified profit objective on the part of the supplier. In contrast, Whitin (1955) has addressed the pricing issue, but from the perspective of the customer. Subsequently, Banerjee (1986b) has addressed the supplier's pricing and lot sizing issues simultaneously, albeit his work suffers from the drawback of the restrictive assumption of a lot-for-lot production scenario. In recent years, researchers have focused largely on the simultaneous determination of pricing, capacity and/or quality decisions, particularly in service systems (see for example, Stidham, 1992; Boronico and Panayides, 2001), as well as buyer–supplier coordination (for instance, see Vishwanathan and Piplani, 2001; Banerjee and Kim, 1995); and the question of concurrent pricing and lot sizing has received scant attention. This paper relaxes the lot-for-lot assumption towards extending and generalizing the results obtained in an earlier work by Banerjee (1986b).

It is to be noted that the customer's economic policy is dependent upon the product's purchase price, among other factors. More specifically, in the well-known and widely used economic order quantity (EOQ) formula, the item's holding cost based on its price plays an important role (see for instance, Silver et al. 1998). At the same time, the customer's purchasing policy directly affects the supplier's relevant cost factors and its eventual profits, if it produces to order, rather than to stock. However, without knowing the product's price the buyer cannot formulate its own economic policy, without which, in turn, the supplier cannot accurately estimate its own cost. Overpricing the product may encourage the customer to seek other sources of supply, while under-pricing may leave the supplier short of its profit objective or may even result in economic loss. Thus, an important step for the supplier is to establish a "correct" price for the product, in conjunction with an appropriate production/inventory policy, for achieving a desired level of profit. As indicated above, initially, the supplier does not know the buyer's lot size and it is likely that the former does not have explicit information about the latter's relevant cost parameters.

In this paper we develop a concurrent inventory and pricing model from the perspective of a supplier, which produces a product for a single customer on a make-to-order basis. The objective is to simultaneously determine the product's manufacturing batch sizing policy and selling price in order to achieve a stated level of gross profit. In contrast to previous work in this area, we relax the lot-for-lot assumption and examine a more generalized scenario, where the supplier may satisfy a series of K consecutive orders from the customer through the production of a single batch (K being a positive integer). In other words, the supplier's production lot size is an integer multiple of the buyer's economic order quantity. Rosenblatt and Lee (1985) provide a proof for the integrality of K as a necessary condition for achieving optimality from the supplier's perspective.

It is important to note that this model does not attempt to achieve buyer–supplier coordination from a joint optimization perspective, which requires the assumption that the supplier has explicit knowledge of the buyer's relevant cost parameter values (see for example, Stidham, 1992). Instead, as explained later, it is sufficient for the supplier to have a reasonably good estimate of the value of the buyer's ordering to holding cost ratio (which can be arrived at implicitly) towards