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Multi-period dynamic supply contracts with cancellation

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Abstract

This paper considers a class of multi-period dynamic supply contracts in which a buyer orders a product from a supplier in each period and the supplier allows the buyer to cancel a portion of an outstanding order with penalty during a planning horizon. We assume that both the buyer and the supplier have common knowledge. We first characterize the buyer's ordering and canceling policy that minimizes his expected cost during the planning horizon. We also characterize the supplier's optimal production policy under a very mild assumption on the costs of production and storage. Based on this structure, we then use simulation to show how the supplier chooses cancellation costs that minimize her expected cost during the planning horizon. Our simulation shows that both the buyer and the supplier would benefit from the contract.

Keywords: Inventory; Cancellation; Coordination; Additive function; Dynamic programming; Simulation

1. Introduction

In the last decade, one focus of supply-chain research has been on flexible supply policies that help firms to adapt more rapidly to changing market conditions. Tsay et al. [1] give an excellent review on contributions in this area. The sequel reviews a few of these and other contributions that are most relevant to our research.

The shorter the lead time for delivery of a product, the lower will be the minimum expected cost—provided the ordering cost is independent of the lead time. One way that a buyer may achieve greater flexibility is by using alternate lead times. The buyer could choose different lead times depending on the inventory and demand information. Fukuda [2] studies a problem in which there are two possible

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delivery lead times that differ only by one period. He shows that the optimal ordering policy in a period is described by two constants. Zhang and Hausman [3] discuss heuristics for the case in which there are two lead times that differ by an arbitrary positive integer.

If there is only a single nominal lead time available initially, the buyer may achieve flexibility by asking the supplier to accelerate or delay delivery of existing outstanding orders in a period according as the inventory on hand is low or high. Lawson and Porteus [4] consider a model in which there is only one lead time available initially and a buyer can accelerate a portion of an outstanding order in each period arbitrarily or delay by one period. Their paper shows that the optimal ordering, acceleration and delay policy in a period is described by constants.

A commitment is an agreement between a supplier and a buyer that specifies the size and the time of each delivery before the beginning of the planning horizon. Commitments have potential advantages for both the supplier and the buyer. An advantage to the supplier is to assure demand for her product. An advantage to the buyer is the potential ability to secure a lower price and a quantity for the product from the supplier because of a prior commitment. An advantage to both parties is that a commitment provides the supplier guidance on the amount needed by the buyer and so helps the supplier assure timely delivery. Commitments may also be flexible, i.e., allow revision within specified limits as new information becomes available. Anupindi and Akella [5] discuss models in which there are initial commitments in each period during the planning horizon, commitments can only be altered in current period by at most a given percentage and there is no lead time. Tsay [6] considers a two-stage single period model in which a buyer commits order quantities initially and the commitment can be revised within specified limits without penalties. The author also discusses channel coordination. Milner and Rosenblatt [7] examine a two-period model in which a buyer makes a firm commitment for the first period and combination of firm and flexible commitments in the second period. Bassok and Anupindi [8] discuss models in which there is an initial fixed minimal total commitment during horizon and no lead time. Bassok and Anupindi [9] and Tsay and Lovejoy [10] also study models that allow commitments to be revised in each period by at most a given percentage of the commitments in the preceding period without penalties and provide heuristics.

Various cancellation contracts have been practiced in the industry and studied in the literature. Eppen and Iyer [11] study a backup contract in which a buyer commits order quantities for the first and second periods. After observing the demand in the first period, the buyer is allowed to place an actual order within the limit of the commitment in the second period and pays a penalty for any committed units that are not purchased. As Eppen and Iyer [11] observe, such contracts are practiced in the apparel catalog industry. Barnes-Shuster et al. [12] consider an option contract in which a buyer commits order quantities for the first and second periods and purchases options for the second period. After observing the demand in the first period, the buyer uses the options to purchase additional units up to given quantities in the second period. For example, Taiwanese Semiconductor Manufacturing Company, a semiconductor fabrication foundry, offers option contracts for capacity reservation (Chang [13]). Option contracts are also popular in the aerospace industry. For example, Boeing offers options to airline companies for purchase of aircraft (Cole [14]). Note that both the backup contract and the option contract allow cancellation in the second period. Our research extends the two-period contracts to a class of multi-period dynamic supply contracts in which a supplier allows a buyer to cancel a portion of an outstanding order with penalty in each period during a planning horizon.

One paper on dynamic contracts that is relevant to our work is Moinzadeh and Nahmias [15]. However, our research differs from their research mainly in the following ways: first, we study both the buyer's and