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Supply chain strategies based on recourse model for very short life cycle products

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ABSTRACT

Firms that sell very short life cycle products often receive quantity discounts from their suppliers and transporters for placing larger orders. Practitioners and researchers have begun to recognize the need to decide the end of the season markdowns by studying the sales pattern. The use of these options can affect supply chain mismatch risks and costs. In this paper, we study the impact of quantity discounts and transportation cost structures on procurement, shipment and clearance pricing decisions through a stochastic programming with recourse formulation. We propose a solution procedure that efficiently solves this stochastic non-linear problem. Our computational experiments suggest that it is not always necessary to select the most complex action plan. Under some business environments, the conventional strategy of placing and transporting a single large order is a better option. We then identify situations where options such as markdowns and the use of quick response suppliers could be useful.

1. Introduction

Very short life cycle products such as fashion and seasonal products have life cycles ranging between 3 and 6 months (Sen, 2008; US Office of Technology Assessment, 1987), and these products exhibit high demand uncertainty before their launch. In the past, firms that procured and sold such products to end customers or retailers usually ordered the entire order quantity well before the selling season due to the demand uncertainty, the short lifespan and quick obsolescence of the products, the difficulties in repeated negotiations and procurement, and the long procurement lead-time. Depending upon how the products performed vis-à-vis the original forecast, the firms used to incur mismatch costs due to either short supply or surplus supply. Since the last decade, these firms have been using quick response strategies to reduce the mismatch costs for such products (Fisher et al., 2001). The initial business volume could be between 60% and 100% of the total anticipated order (Subrahmanyan, 2000). For example, suit buyers procure 80% before season, keeping the remaining 20% of the budget back until after the season starts (Daily News Record, 1993). The various trade-offs involved in the ordering of such products are shown in Fig. 1.

Research that uses analytical methods to design quick response strategies is referred to as the two period or two stage problem in the extant literature (Cattani et al., 2008; Cheaitou et al., 2009; Fisher et al., 2001; Fisher and Raman, 1996; Li et al., 2009). In this paper, we further investigate this research stream, taking into consideration the following practical issues.

Vendors often offer discounts to get economies of scale in purchasing, manufacturing, and transportation (Munson and Rosenblatt, 1998). In the fashion industry in particular, intense competition has prompted vendors to increasingly use monetary support such as quantity discounts to attract retailers (Kincade et al., 2002). In the shipping industry, custom fees and container charges are fixed costs that are incurred for each shipment, which can be considered as quantity discounts because the average shipping cost per unit decreases with the increase in the shipped quantity (Popken, 1994). In the road and rail transportation industry, transporters often provide discounts on full truck loads and full wagon loads (Munson and Rosenblatt, 1998). Hence, it would be interesting to study the role of both the procurement and the transportation quantity discount structures in the two stage model.

Given that the demand for these products is stochastic in nature, instead of offering a predefined markdown price, the markdown offered at the end of the season needs to be rationally determined by the unsold quantity at the end of the season (Cachon and Kok, 2007). The markdown price should depend upon the number of unsold units at the end of the product life cycle, among other factors. We attempt to study the behaviour of

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Order Variable	Ordering Continuum	
Initial business volume (before product launch)	100% of total volume	less than total volume
Second business volume (during product life cycle)	No	Yes
Shipments	Single ←----------→	Multiple
Price markdown (during product life cycle)	No	Yes
Impact on metrics →	Lower ← material cost, shipping cost, responsiveness →	Higher
	Higher ← inventory cost, stock outs, clearance sales (at end of product lifecycle) →	Lower

Fig. 1. The ordering continuum.

the clearance price as a function of the leftover inventory and the discount cost structures.

Though the traditional practice was to receive all merchandise before the start of the season, retailers nowadays are using different delivery windows during the season. For example, suit retailers use two delivery windows in a season (Sen, 2008). Taking into consideration that the cost of retail shelf space is progressively increasing, we explore the possibility of computing the optimal delivery schedule for these products. This will allow us to explicitly study the trade-offs between the cost and responsiveness dimensions of the quick response supply chain. We propose a non-linear (sometimes discontinuous) stochastic programming with recourse formulation to model this problem with the objective of maximizing the retailer's expected product life cycle profit by keeping the initial business promised, and by using subsequent replenishment orders, transport batch sizes, and markdowns as recourse decision variables. We subsequently propose an efficient numerical procedure to solve this complex problem.

In the next section, we present a review of the relevant literature, and lay out the motivation for the problem under study. In Section 3, the stochastic programming with recourse model and the proposed algorithm are presented. Section 4 discusses the results of the numerical study, and the managerial implications. The final section reports the conclusions of our study.

2. Literature review and motivation

The problem of sourcing new products that face stochastic demand has been investigated from different viewpoints. Earlier research assumed that the procurement decision had to be made before the realization of the demand, as in the case of the classic newsboy problem where the entire demand for a style product occurs in a single period. Khouja (1999) provides a detailed review of the newsboy problem.

Though the demand for the product is highly uncertain and unpredictable at its launch, it becomes more predictable after an analysis of the early demand pattern (Fisher and Raman, 1996). The quick response supply chains research stream used this more refined demand information and suggested some sourcing strategies by representing the resulting problem as a two stage stochastic program (Fisher and Raman, 1996; Bradford and Sugrue, 1990).

Several variations and enhancements to this problem have been proposed. Fisher et al. (2001) suggest an efficient heuristic to compute the first and the second period order quantities for a catalogue retailer's products when the replenishment lead-time was positive. Choi and Li (2003) suggest an optimal two stage ordering policy based on the Bayesian information updating using dynamic programming. They further discuss the impact of the optimal policy on service level and profit uncertainty. Cheaitou et al. (2009) investigate the two period problems under a capacity constraint situation, and slower and faster production mode options. Cattani et al. (2008) consider a two product, two stage problem, and identify those situations where speculative, reactive, and mixed strategies could be optimal. Li et al. (2009) generalize the Fisher et al. (2001) model by taking into consideration time dependent inventory holding and backorder costs.

Earlier research on the quick response supply chains has assumed that the unit product cost and the unit transportation cost would not change with the quantity that was ordered or transported. However, a customer could receive a price discount when placing large orders as was discussed earlier (Silver et al., 1998). In the single period newsboy context, Lin and Kroll (1997) investigate the impact of all unit and incremental quantity discount policies on the optimal ordering quantities and profits using a numerical procedure taking into account positive shortage costs. Pantumsinchai and Knowles (1991) compute the optimal number of newsboy containers required in the newsvendor problem under container size discounts.

Prior research shows that in situations where quantity discounts exist, the unit sourcing and transportation costs should decrease with an increase in the ordered quantity; the monetary risk is lower here compared with situations where there are no quantity discounts. This gives rise to an interesting question: How will the reduced monetary risk influence the reactive and the speculative ordering quantities? In this paper, we investigate the impact of quantity discounts on both the initial and the replenishment order quantities in the general two stage problem.

Scenario dependent markdowns can reduce the risk of unsold inventory at the end of the season. A popular product with less clearance inventory will need a smaller discount while an unpopular product having higher clearance inventory will require a higher markdown (Cachon and Kok, 2007). We propose that this practice would influence both the initial and the replenishment order quantities. The second objective of this research is to test this hypothesis and study its interaction with the quantity