Available online at www.sciencedirect.com
ScienceDirect
European Journal of Operational Research 180 (2007) 601–616
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

Production, Manufacturing and Logistics

A quantity discount approach to supply chain coordination

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Received 5 March 2004; accepted 2 April 2006
Available online 23 June 2006

Abstract

Quantity discounts provide a practical foundation for inventory coordination in supply chains. However, typical supply chain participants may encounter difficulties in implementing the coordination policy simply because (1) specified lot size adjustments may deviate from the economic lot sizes and (2) the buying firm may face amplified overstocking risks related to increased order quantities. The main objective of this study is to develop a quantity discount model that resolves the practical challenges associated with implementing quantity discount policies for supply chain coordination between a supplier and a buyer. The proposed Buyer's Risk Adjustment (B-RA) model allows the supplier to offer discounts that capitalize on the original economic lot sizes and share the buyer's risk of temporary overstocking under uncertain demand. The analytical results suggest that the proposed B-RA discount approach is a feasible alternative for supply chain coordination under uncertain demand conditions.

Keywords: Quantity discounts; Inventory coordination; Supply management

1. Introduction

The popularity of quantity discounts in practice stems from the fact that suppliers' discount offers can influence buying firms' purchasing behavior by providing economic incentives to the buying firms. The terms, "buying firm" and "buyer" will be used interchangeably. Since Monahan (1984), the literature has shown that the application of all-units discounts contributes to reducing the buyer's inventory cost and improving the supplier's profit simultaneously (Rubin and Benton, 2003; Yano and Gilbert, 2004). The literature includes Rosenblatt and Lee (1985), Lee and Rosenblatt (1986), Kim and Hwang (1989), Weng and Wong (1993), Weng (1995), Klastorin et al. (2002), Rubin and Benton (2003) and Shin and Benton (2004). This research herein is an extension of Lee and Rosenblatt (1986) and Weng and Wong (1993) which model the use of all-units discounts to coordinate inventory decisions between a single buyer and a single supplier. For a more

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0377-2217/$ - see front matter
doi:10.1016/j.ejor.2006.04.033

comprehensive review of the literature, readers may refer to the review articles in this subject area, including Rubin and Benton (2003) and Yano and Gilbert (2004).

The motivation for this research is driven by the shortcomings of the traditional quantity discount literature. Specifically, there are many hidden costs associated with the operational characteristics of the traditional discount approach when supply chain relationships are considered. First, a common assumption made in the literature is that the supplier and the buyer are willing to deviate from their current order quantities as a quantity discount policy is adopted. In practice, however, the current order quantities may represent the firms' economic lot sizes which minimize the combination of inventory carrying cost, ordering cost, and transportation cost. Chen (2000) addressed that in practice materials flows from one stage to another usually occur in the form of fixed lot sizes, such as full truckloads and full containers, to achieve transportation economies of scale. Under these circumstances, any lot size adjustment may force the buyer to carry less-than-truck loads, resulting in hidden freight costs that were not considered in the conventional quantity discount models. Economies of freight lots are one of the primary concerns of logistics managers (Rabinovich et al., 1999), and it is possible that the freight rate condition may mitigate any discount savings.

Second, most quantity discount models consider deterministic demand, assuming that the buyer faces no risk when accepting quantity discounts from the supplier. Conventionally, deterministic quantity discount models are designed to maximize the supplier's profit. In other words, these deterministic models schedule a minimum level of discounts which barely compensates the buying firm for its increased cycle-inventory holding cost, only to leave marginal or zero cost savings to the buying firm (Rubin and Benton, 2003, p. 182). When demand is uncertain, however, this minimum discount approach may not be acceptable to the buyer because an increase in order quantity in exchange for quantity discounts escalates the buyer's temporary overstocking risk and cost. If the realized demand becomes lower than the expected demand for a period, the buyer eventually must carry *a larger volume of cycle inventory for a longer period* under the quantity discount policy than under the no-discount policy. Thus, it is likely that the buyer will reject the supplier's discount offer, and the supplier's attempt for supply chain inventory coordination will fail.

Given the limitations in the literature, the primary objective of this paper is to suggest a more equitable quantity discount model under stationary stochastic demand (uncertain demand hereafter). In our Buyer' Risk Adjustment (B-RA) modeling approach, we intend to improve both supplier's and buyer's profitability without changing the basis of both parties' economic lot sizes. In other words, the economic lot sizes for both the buying and selling firms are kept intact under the proposed B-RA modeling approach.

In addition, the B-RA discount approach allows for a supplier's discount schedule that considers the buyer's amplified overstocking risk under uncertain demand. The objective is to ensure that the supplier offers a discount schedule that is acceptable to the buyer cost and risk structure. The B-RA model is useful for supply chains where the supplier and the buyer are independent entities and have little motivation to sacrifice their own profitability, yet they share enough information to achieve a degree of coordination for better supply chain performance. The results from the numerical experiments verify that the proposed B-RA approach can be a more practical supply chain coordination mechanism under uncertain demand conditions.

2. The model

In most instances, all-units discount models for supply chain inventory coordination have evolved from the supplier's perspective (Benton and Park, 1996; Rubin and Benton, 2003). The supplier is usually the active party who offers the discount schedule to the buyer in order to entice the buyer to place a larger order quantity. The modeling tradition has been to determine an appropriate single price break in order to maximize the profitability of the supplying firm. As an example, if the discount is set too high, the supplier experiences on the average decreased profits. If the discount is set too low, the buyer will ignore the supplier's discount policy. To reconcile the conflicting interests between the buyer and the supplier, it has been suggested that the supplier find a minimum level of discount, which would compensate for at least the buyer's increased inventory holding costs under the discount policy. With the objective stated above, typical all-units discount models evaluate the optimal values that include (1) supplier's economic lot size, (2) discount per unit, and (3) buyer's corresponding order quantity given the discount. The structure of the proposed B-RA model is consistent with the conventional all-units discount models. However there are two points of departure. They are: