Available online at www.sciencedirect.com
ScienceDirect
European Journal of Operational Research 180 (2007) 194–214
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

Production, Manufacturing and Logistics

The value of early order commitment in a two-level supply chain

Xiande Zhao [a,1], Jinxing Xie [b,2], Jerry C. Wei [c,*]

[a] Department of Decision Sciences and Managerial Economics, The Chinese University of Hong Kong, Shatin, NT, Hong Kong
[b] Department of Mathematical Sciences, Tsinghua University, Beijing 100084, China
[c] Mendoza College of Business, The University of Notre Dame, Notre Dame, IN 46556, USA

Received 22 October 2003; accepted 31 January 2006
Available online 13 June 2006

Abstract

One approach to supply chain coordination is early order commitment, whereby a retailer commits to purchase a fixed-order quantity at a fixed delivery time before demand uncertainty is resolved. In this paper, we develop an analytical model to quantify the cost savings of an early order commitment in a two-level supply chain where demand is serially correlated. A decision rule is derived to determine whether early order commitment will benefit the supply chain, and accordingly to determine the optimal timing for early commitment. Our results indicate that the supply chain would experience greater savings from early order commitment when – (a) the inventory item receives less value-added activities at the retailer site; (b) the manufacturing lead time is short; (c) demand correlation over time is positive but weak; or (d) the delivery lead time is long (if a condition exists). We also propose a rebate scheme for the supply chain partners to share the gains of practicing early order commitment.

Keywords: Supply chain management; Production; Purchasing; Advanced order

1. Introduction

Effective supply chain management requires coordination between members of the supply chain. By coordinating activities across company boundaries, it is believed that significant benefits can be achieved for the partners in a supply chain. Previous research has recognized different approaches to supply chain coordination. One such approach is to share real-time demand data collected at the points of sale with upstream suppliers (Lee et al., 2000; Cachon and Fisher, 2000; Raghunathan, 2001). Another approach uses a collaborative, centralized forecasting mechanism (Chen et al., 2000a,b; Xu et al., 2001; Aviv, 2001). And yet another approach is to adopt a vendor managed inventory (VMI) in which the vendor is authorized to manage the replenishment process (Fry et al., 2001; Aviv, 2002). These streams of research reveal that supply chain

* Corresponding author. Tel.: +1 574 631 5460; fax: +1 574 631 5255.
E-mail addresses: xiande@baf.msmail.cuhk.edu.hk (X. Zhao), jxie@math.tsinghua.edu.cn (J. Xie), jwei@nd.edu (J.C. Wei).
[1] Tel.: +852 2609 7650; fax: +852 2603 6840.
[2] Tel.: +86 10 6278 7812; fax: +86 10 6278 5847.

0377-2217/$ - see front matter
doi:10.1016/j.ejor.2006.01.048

coordination can significantly enhance the performance of the supply chain by reducing the ''bullwhip effect'' (Lee et al., 1997), a phenomenon of demand variability amplification along a supply chain from downstream members to their suppliers.

Nonetheless, these approaches to supply chain coordination do not prevent a buyer from canceling an order or from changing the order quantity and delivery time. Such order cancellation or revision would still cause the bullwhip effect along a supply chain. Therefore, it is to the seller's advantage to encourage buyers to commit to their purchase orders before actual production begins. Fisher and Raman (1996) help a fashion skiwear firm use early orders to revise and improve sales forecasts. Iyer and Bergen (1997) report that explicit total quantity volume, or dollar volume commitments, from retailers helped a supplier procure materials, schedule production, and better utilize capacity (Iyer and Bergen, 1997). In this paper, early order commitment (EOC) means that a retailer commits to purchase from a manufacturer a fixed order quantity, for a specific delivery time, before the real need occurs. This order, once placed, cannot be cancelled. Generally speaking, the effect of EOC on supply chain performance is intuitively clear. On the one hand, EOC increases a retailer's risk of mis-estimating the demand and thus increasing the inventory holding and shortage costs. On the other hand, EOC helps the manufacturer reduce inventory holding and shortage costs because of reduced exposure to demand risk. Zhao et al. (2002) conduct extensive simulation studies on the effect of EOC on supply chain performance under various operational conditions, including demand pattern, forecast errors, cost structure, number of retailers, and capacity cushion. These studies find that the EOC benefits are only valid within a feasible range of order commitment periods, which are affected by these operational conditions. Furthermore, they show that EOC produces substantial cost savings for the manufacturer, but increases costs for the retailer.

To entice buyers to commit orders earlier, two types of incentive are common. In some industries, suppliers provide price discounts or better payment terms to buyers in exchange for the commitment of their purchase orders. For example, Gilbert and Ballou (1999) conduct an analysis of a steel distribution supply chain, and quantify the maximum discount that can be offered to consumers who commit to orders in advance. Cvsa and Gilbert (2002) examine the tradeoff between early order commitment and order postponement in the context of competition. Using a game theory model involving a monopolistic supplier without capacity constraint and two duopolistic buyers, they find that a supplier can influence the form of competition in the downstream market. Such a finding provides another justification for the use of EOC even in the absence of capacity or lead time considerations. In the second type of incentive, a buyer can permit a supplier to offer value-added services, such as faster replenishment time, or vendor managed inventory, in lieu of price recessions (Iyer and Bergen, 1997; Lee et al., 2000). In this paper, we develop a rebate scheme that varies with the duration of EOC and allows the supply chain partners to split the net savings resulting from EOC.

To maximize the cost savings from EOC, the members at different levels of the supply chain should make the tradeoff based on a careful evaluation of both the costs and the benefits. However, to date no general analytical model has been available to quantify the effect of EOC, or to guide the decision of the retailer on how early to commit orders. This paper proposes such an analytical model to quantify the effects of EOC on the performance of a simple two-level supply chain consisting of a manufacturer and a retailer. The end demand is a non-stationary auto-regressive AR(1) process which is prevalent in the high-technology and grocery industries (Lee et al., 2000). Studying an AR(1) demand process increases the complexity of the model but makes the model more realistic than using the typical assumption of independent identical demand found in the literature. Our analyses show that the EOC is more beneficial when the cost structure ratio between the retailer and the manufacturer is lower, the manufacturing lead time is shorter, the delivery lead time is longer, and the demand correlation is positive but weak. A decision rule is developed to determine whether EOC can benefit the supply chain and accordingly choose the optimal period for early commitment. A rebate scheme is developed to induce the retailer's participation in EOC and help determine how the two parties should split the net savings from practicing EOC.

2. The supply chain model

2.1. Basic assumptions

The basic assumptions of the model in this paper are similar to those proposed by LST (Lee et al., 2000). The supply chain is assumed to be composed of a manufacturer and a retailer. The retailer faces an external