

# Supply chain coordination with manufacturer's limited reserve capacity: An extended newsboy problem

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## Abstract

This paper develops an extended newsboy model and presents a coordination decision policy in a supply chain consisting of one manufacturer and one retailer. In order to meet a random demand, the retailer can place a second order at the end of the period if a stock-out occurs. The manufacturer's reserve capacity for the retailer's second order is limited to  $M$  units. To maximize each individual's expected profit, the retailer decides his optimal order quantity and the manufacturer decides his optimal reserve capacity. A coordination mechanism is designed which can make the supply chain increase profit. A price discount policy is developed to allocate the expected increased profits between two sides of the supply chain. © 2007 Elsevier B.V. All rights reserved.

*Keywords:* Newsboy problem; Supply chain coordination; Price discount

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## 1. Introduction

As product lifecycles become shorter and market demands become more intense than before, the risk faced by the parties of a supply chain is higher than before, especially for the retailers' (the downstream party of a supply chain) order management and the manufacturers' (the upstream party of a supply chain) production management. Traditionally, the retailers and the manufacturers decide their order and production quantity, respectively, thus both of them are facing two types of risks. One is the risk of too much supply and the other is the risk of too much demand. This situation impels both manufacturers and retailers to coordinate their decisions

together rather than to determine them separately (Webster and Weng, 2000). In this paper, we consider a supply chain consisting of one manufacturer and one retailer, and analyze how they make decisions so as to deal with the above two types of risks better under a random demand within one single period. Different from the classical newsboy model, our model emphasizes that the retailer can place a second order at the end of a sales period when the first order quantity  $Q$  does not meet the demand. However, the quantity of the second order cannot exceed the manufacturer's reserve capacity  $M$ . Since the decision variable  $M$  may affect both sides' profits, it needs to be considered by the manufacturer when deciding both the individual and coordinating policies.

Some business practices in the automobile and PC industries in China help to motivate this research. With the rapid development of the Chinese economy,

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the demands for these products in cities are growing so dramatically that it is difficult for retailers to forecast demands. Thus, retailers are facing two types of risks at the end of a sales period: one is the risk of excessive inventory, if their order quantity in the beginning of the period is more than the real demand during the period, and the other is the risk of insufficient supply if their order quantity in the beginning of the period is less than the real demand. In the latter scenario, retailers often promise the customers to provide more products again within a reasonable period at a discounted on price so long as customers would like to wait. Since the total supply is often insufficient in today's China, some of the customers would like to do so. Thus, retailers will order again based on the information of booked customers. In order to meet a retailer's second order, the manufacturers have to prepare more capacity at the beginning of the period because of the long production lead time. Since the manufacturers may get more profit by setting higher wholesale price for the urgent order, they would like to do so. Our research tries to describe this situation by developing an extended newsboy model and analyzes the decision-making behaviors of both retailers and manufacturers.

In this model, there are some special problems for the two sides of the supply chain in their decision making. On the one hand, since the manufacturer needs to pay for the reserve capacity and higher costs for the rush production, he will expect the retailer's first order quantity to be as large as possible. On the other hand, in order to avoid the risk of excessive inventory, the retailer will keep his first order quantity at a moderate level and expect the manufacturer's reserve capacity to be as large as possible so that he can get sufficient quantity for his second order. Thus, there exists a conflict on the first order quantity and reserve capacity between the two sides, which leads to the supply chain having a low performance. We analyze how to establish a coordination mechanism between the two sides to improve supply chain performance. In many supply chain coordination policies, the optimal quantity subject to the maximum of the system profit is a main decision variable, while in our model, we use both the retailers' optimal first order quantity and the manufacturer's optimal reserve capacity to coordinate the supply chain.

The rest of the paper is organized as follows. Section 2 reviews the related literature. In Section 3, we establish the basic model and give the optimal

decisions for both sides in the decentralized system. In Section 4, we design the coordination mechanism and the profit-allocating method. In Section 5, we give numerical examples to illustrate the validity of the model and discuss management insights of coordination. Finally, in Section 6, we conclude and discuss future extensions.

## 2. Literature review

The research related to this work can be divided into two broad sets. The first set includes papers that use the newsboy model to study the multistage inventory management issues. The second set studies supply chain coordination issues (Lee, 2007; Qin et al., 2007; Li and Liu, 2006; Weng, 1995). Supply chain coordination issues under the newsboy setting also have been studied extensively (see Tasy et al., 1999; Cachon, 2003, for recent surveys). Some of them closely related to our work are as follows.

Thomas and Griffin (1996) point out that companies have an opportunity to reduce operating costs by coordinating the planning of the three fundamental stages of the supply chain: procurement, production and distribution. They review the literature addressing coordinated planning between two or more stages of the supply chain and emphasize that firms can reduce operating cost by coordinating plans of production and ordering. Chung and Flynn (2001) develop an extended newsboy model by introducing reactive production, which considers how to decide the optimal order quantity to minimize a buyer's cost. Konstantin and Sheldon (2003) analyze a dynamic, continuous-time generalization of the single-period newsboy problem. The objective is to minimize shortage and surplus costs occurring at the end of a period. Lin and Kroll (1997) study the single-item newsboy problem with quantity discount, whose objective is to maximize the expected profit subject to a constraint that the probability of achieving a target profit level is no less than a predetermined risk level; two types of quantity discount policies as coordinating methods are considered. Studies on the classical newsboy problem seldom consider the newsboy's supplier's decision policies, while Weng (2004) extends it, analyzes a generalized newsboy problem and gives a coordination mechanism by means of quantity discount. Mostard et al. (2005) study the case of a catalogue/internet mail order retailer selling style goods and receiving large

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