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Improved inventory models with service level and lead time

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Abstract

This paper explores the mixed inventory backorder and lost sales problem in which both the lead time and order quantity are treated as decision variables. In a recent paper on *Computers and Operations Research*, Ouyang and Wu considered this problem. However, their algorithms might not find the optimal solution due to flaws in their solution procedure. We develop some lemmas to reveal the parameter effects and then present two complete procedures for finding the optimal solution for the models. The savings are illustrated by solving the same examples from Ouyang and Wu's paper to demonstrate the superiority of our revised algorithms.

Keywords: Inventory; Lead time; Backorder; Lost sales; Distribution-free approach

1. Introduction

Today, the just-in-time (JIT) production system is in vogue. It emphasizes high quality, low stock and short lead time. Many business scholars have focused on "high quality, low stock and short lead time as competitive business goals. The ultimate goal of JIT is a smooth, rapid flow of materials through the system. The idea is to make the process time as short as possible using resources in the best-possible way. Sometimes, the lead time is too long prolonging the process. In this situation lead time reduction is important and a serial improvement objective. Continual improvement can reduce internal production time and satisfy the exterior market. The business service level and competitiveness can then be raised. The issue of lead time reduction in inventory management has thus become a matter of great interest.

Recent studies by scholars on how to control lead time are reviewed in this paper. In the traditional inventory model, as described by Silver and Peterson [1], lead time is considered as a predetermined

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constant or a stochastic parameter. Liao and Shyu [2] stated that lead time is negotiable and can be decomposed into several components, each having a different piecewise linear crash cost function for lead time reduction. Ben-Daya and Raouf [3] extended Liao and Shyu's [2] work to consider both lead time and order quantity as decision variables. Moon and Gallego [4] assumed unfavorable lead time demand distribution and solved both the continuous review and periodic review models with a mixture of backorders and lost sales using the minmax distribution-free approach. Ouyang et al. [5] generalized Ben-Daya and Raouf's [3] assumption that shortages were allowed and constructed variable lead time from a mixed inventory model with backorders and lost sales. Moon and Choi [6] and Lan et al. [7] pointed out the problem in Ouyang et al's. [5] method. They found individual optimal order quantities and optimal lead time for a mixed inventory model, and developed a simplified solution procedure. Ouyang and Wu [8] extended the Ouyang et al. [5] article. They relaxed the assumption about the cumulative lead time distribution demand and applied the minimax distribution-free procedure to determine the optimal order quantity and optimal lead time. Wu and Tsai [9] considered that the lead time demands from different customers are not identical. They developed a mixed inventory model with backorders and lost sales for variable lead time demand with a mixed normal distribution. Pan and Hsiao [10] presented inventory models with backorder discount and variable lead time to ensure that customers would be willing to wait for backorders.

This article will study the same inventory model as Ouyang and Wu [11] who considered both lead time and order quantity as decision variables for a mixed inventory model. Ouyang and Wu [11] thought that it is often difficult to determine the stock-out cost value in inventory systems. Therefore, they replaced the stock-out cost with a service level condition. In their paper, first they assumed that the lead time demand follows a normal distribution. They then relaxed the assumption about the lead time distribution demand function and applied the minmax distribution-free procedure to solve the problem. However, there are critical flaws in their solution algorithms under different assumptions. The model studied in this article is the same used by Ouyang and Wu [11]. We will point out the questionable algorithms in their model. Their algorithms are complicated and cannot obtain the optimal solution, as demonstrated by their examples. We will construct correct and efficient algorithms to find the optimum order quantity and reorder point simultaneously when the lead time probability distribution is normal or free. We developed lemmas to reveal the parameter effects and illustrate our improvement by solving the same examples.

2. Notation and assumptions

We use the same notations and assumptions as Ouyang and Wu [11].

Notations:

A	fixed ordering cost per order
D	average demand per year
h	inventory holding cost per item per year
L	length of lead time
Q	order quantity
X	the lead time demand which has a distribution function F with finite mean μL and standard derivation $\sigma\sqrt{L}$ (>0)