# 行政院國家科學委員會專題研究計畫　成果報告

# 欠撥折扣對籌購成本與前置時間有關之週期檢查存貨模型的影響

計畫類別：個別型計畫
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計畫主持人：歐陽良裕

計畫參與人員：莊博仁、林裕仁

報告類型：精簡報告

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# 行政院國家科學委員會補助專題研究計畫 ■ 成 果 報 告 □期中進度報告

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**Impact of Backorder Discounts on Periodic Review Inventory Model with Ordering Cost Dependent on Lead Time**

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**摘要**

本研究探討縮短前置時間對含有欠撥折扣之週期檢查存貨模型的影響，其中籌購成本的縮減與前置時間有關。主要目的是同時找出最適的檢查週期、前置時間和欠撥折扣，使能極小化總相關成本。研究中假設保護期間內需求量的機率分配服從常態分配，並且考慮兩種情況：(1) 籌購成本的縮減與前置時間呈線性關係 (2) 籌購成本的縮減與前置時間呈指數關係。我們發展出一個演算法去求得最適解，並舉兩個數值範例說明求解的過程與結果。

關鍵字（詞）：存貨；週期檢查；保護期間；欠撥折扣

**Abstract**

This study investigates the impact of lead time reduction on the periodic review inventory model with backorder discounts, where ordering cost reductions vary according to different lead times. The objective is to minimize the total related cost

by simultaneously optimizing the review period, lead time and backorder discounts. The protection interval demand is assumed to be normally distributed, and then we consider two cases: (i) the lead time and ordering cost reductions with linear function, (ii) the lead time and ordering cost reductions with logarithmic functional relationship. A procedure of finding the optimal solution is developed, and two numerical examples are given to illustrate the results.

Keywords: inventory; periodic review; protection interval; backorder discount

**Source and purpose**

In traditional economic order quantity (EOQ) literature dealing with inventory problems, either using deterministic or probabilistic models, lead time is viewed as a prescribed constant or a stochastic variable. Therefore, lead time is not subject to control (see, e.g., Naddor (1966), Montgomery et al. (1973), Johnson and Montgomery (1974) and Silver and Peterson (1985)). However, this may not be realistic. As pointed out by Tersine (1982), lead time usually consists of the following components: order preparation, order transit, manufacture & assembly, transit, and uncrating, inspection and transport. In some practical cases, lead time can be shortened at an added crashing cost; in other words, it is controllable. By shortening lead time, we can lower the safety stock, reduce the stockout loss and improve the service level to the customer so as to increase the competitive edge in business. Also, through the Japanese experience of using Just-In-Time (JIT) production, the advantages and benefits associated with efforts to control the lead time can be clearly perceived.

Recently, there has been some inventory model literature considering lead time

as a decision variable. Initially, Liao and Shyu (1991) presented an inventory model in which lead time is a unique decision variable and the order quantity is predetermined. Ben-Daya and Raouf (1994) extended Liao and Shyu's (1991) model by allowing both the lead time and the order quantity as decision variables. Ouyang et al. (1996) generalized Ben-Daya and Raouf's (1994) model by allowing shortages with partial backorders, while Pan and Hsiao (2001) revised Ouyang et al.'s (1996) model to consider the backorder discount as one of the decision variables.

It is noticed that the above papers (Liao and Shyu (1991), Ben-Daya and Raouf (1994), Ouyang et al. (1996) and Pan and Hsiao (2001)) are all focusing on the continuous review inventory model to derive the benefits from lead time reduction, and the ordering cost is treated as a fixed constant. However, for the periodic review inventory model, lead time as a decision variable has rarely been discussed. The applications of the periodic review inventory model can often be found in managing inventory cases such as smaller retail stores, drugstores and grocery stores (see, for example Taylor III (1999, p.779)). In a recent article, Ouyang and Chuang (2001) proposed a periodic review inventory model to study the effects of lead time and ordering cost reductions. We note that reducing lead time and ordering cost in Ouyang and Chuang (2001) are assumed to act independently; however, this is only one of the possible situations. In practice, the lead time and ordering cost reductions may be related closely; the reduction of lead time may accompany the reduction of ordering cost, and vice versa. For example, the implementation of electronic data interchange (EDI) can reduce both the lead time and ordering cost simultaneously (see, Silver and Peterson (1985, p.150)). Therefore, it is more reasonable to assume that ordering cost reductions vary according to different lead times.

In the real market, as unsatisfied demands occur, we can often observe that some customers may prefer their demands to be backordered, and some may refuse the

backorder case. When a shortage occurs, many factors may affect the customers' willingness of accepting backorders. For example, for well-famed products or fashionable goods such as certain brand gum shoes, hi-fi equipment, cosmetics, and clothes, customers may prefer to wait for backorders. Besides, there is a potential factor that may motivate the customers' desire for backorders. The factor is an offering of a price discount from the supplier (see, Pan and Hsiao (2001)). In general, provided that a supplier could offer a price discount on the stockout item by negotiation to secure more backorders, it may make the customers more willing to wait for the desired items. In other words, the bigger the discount, the bigger the advantage to the customers, and hence, a larger number of backorder ratio may result. This phenomenon reveals that, as unsatisfied demands occur during the stockout period, how to find an optimal backorder ratio through controlling a price discount from a supplier to minimize the relevant inventory total cost is a decision-making problem worth discussing.

The purpose of this study is to study the effect of lead time reduction on the periodic review inventory system with partial backorders. Specifically, we modify Ouyang and Chuang's (2001) model to include the controllable backorder discount and the cases of the linear and logarithmic relationships between lead time and ordering cost reductions. The objective is to minimize the total related cost by simultaneously optimizing the review period, backorder discount and lead time.

**Result and discussion**

This study modifies the previous work Ouyang and Chuang (2001) of periodic review inventory model with variable lead time and backorder discount to include the cases of the linear and logarithmic relationships between lead time and ordering cost

reductions. We minimize the total expected annual cost by optimizing the review period $T$, backorder discount $\beta$, (or price discount $\pi_x$), and lead time $L$. Under the assumption that the protection interval demand is normally distributed, an algorithm procedure of finding the optimal solutions is established. Numerical results show that when the reduction of lead time accompanies a decrease of ordering cost, the smaller target level and larger savings of total expected annual cost can be realized.

In future research on this problem, it would be interesting to deal with a mixed stochastic inventory model with the distribution free case where only the mean and standard deviation of protection interval demand are known and finite.

**Self-evaluation**

This research corresponds to the original plan and has attained its aim. Hence, the study is of great academic value and suitable for publication in academic journals. It is now being submitted to International Journal of Production Economics

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