

# 行政院國家科學委員會專題研究計畫 成果報告

## 非即時退化物品在允許延遲付款下的最適訂購策略

計畫類別：個別型計畫

計畫編號：NSC94-2213-E-032-011-

執行期間：94年08月01日至95年07月31日

執行單位：淡江大學管理科學研究所

計畫主持人：歐陽良裕

計畫參與人員：吳坤山、楊志德

報告類型：精簡報告

處理方式：本計畫可公開查詢

中 華 民 國 95 年 8 月 10 日

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

非即時退化物品在允許延遲付款下的最適訂購策略

An optimal ordering policy for non-instantaneous deteriorating items  
under permissible delay in payments

計畫類別： 個別型計畫  整合型計畫

計畫編號：NSC 94-2213-E-032-011-

執行期間：94年8月1日至95年7月31日

計畫主持人：歐陽良裕

計畫參與人員：吳坤山、楊志德

成果報告類型(依經費核定清單規定繳交)： 精簡報告  完整  
報告

執行單位：淡江大學管理科學研究所

中 華 民 國 95 年 8 月 2 日

# 行政院國家科學委員會補助專題研究計畫

## 非即時退化物品在允許延遲付款下的最適訂購策略

### An optimal ordering policy for non-instantaneous deteriorating items under permissible delay in payments

計畫編號：NSC 94-2213-E-032-011-

執行期間：94年8月1日至95年7月31日

計畫主持人：歐陽良裕

計畫參與人員：吳坤山、楊志德

#### 摘要

本研究將針對非即時退化的物品，在供應商提供允許延遲付款優惠下，建立一個適當的存貨模式，並找出使存貨相關總成本為最小的最適補貨策略。我們將發展一些理論結果，且提出一個簡單容易使用的方法，以方便得到在不同情況下的最適補貨週期。我們也將舉一些數值範例說明求解過程，並做敏感度分析。

關鍵詞：存貨、非即時退化、允許延遲付款、財務

## **Abstract**

In this research, we will establish an appropriate inventory model for non-instantaneous deteriorating items when the supplier provides a permissible delay in payments. The purpose of this research is to find an optimal replenishment policy in order to minimize the inventory relevant cost. We will develop some useful theorems to characterize the optimal solutions and provide an easy-to-use method to find the optimal replenishment time under various circumstances. Finally, several numerical examples will give to illustrate the theoretical results, and the sensitivity analysis of major parameters is also included.

Keywords: Inventory, Non-instantaneous deterioration, Permissible delay in payments, Finance.

## **Source and purpose**

In recent years, inventory problems for deteriorating items have been widely studied. The first attempt to describe the optimal ordering policies for such items was made by Ghare and Schrader (1963). They presented an EOQ model for an exponentially decaying inventory. Later, Covert and Philip (1973) formulated the model by considering variable deteriorating rate with two-parameter Weibull distribution. Philip (1974) then proposed the inventory model with a three-parameter Weibull distribution deterioration rate and no shortages. Shah (1977) extended Philip's (1974) model and considered that allows shortage was permitted. Recently, Goyal and Giri (2001) provided an excellent and detailed review of deteriorating inventory literatures.

In the aforementioned deteriorating items inventory literatures mentioned, all

researchers assume that the deterioration of the items in inventory starts from the instant of their arrival in stock. In fact, most goods would have a span of maintaining quality or original condition, namely, during that period, there is no deterioration occurring. Wu *et al.* (2006) defined the phenomenon as “non-instantaneous deterioration”. In the real world, this type of phenomenon exists commonly such as firsthand vegetables and fruits have a short span of maintaining fresh quality, in which there is almost no spoilage. Afterward, some of the items will start to decay. For this kind of items, the assumption that the deterioration starts from the instant of arrival in stock may cause retailers to make inappropriate replenishment policies due to overvalue the total annual relevant inventory cost. Therefore, in the field of inventory management, it is necessary to consider the inventory problems for non-instantaneous deteriorating items.

Furthermore, in deriving the traditional EOQ inventory model, it was tacitly assumed that the payment must be made to the supplier for the items immediately after receiving the consignment. However, in practice, for encouraging the retailer to buy more, the supplier allows a certain fixed period for settling the account and doesn't charge any interest from the retailer on the amount owed during this period. Goyal (1985) first derived an EOQ model under the conditions of permissible delay in payments. It was assumed that the unit purchase cost is the same as the selling price per unit. Aggarwal and Jaggi (1995) then extended Goyal's (1985) model to consider the deteriorating items. Next, Jamal *et al.* (1997) generalized the model to allow for shortages. Recently, Teng (2002) amended Goyal's (1985) model by considering the difference between unit price and unit cost, and found that it makes economic sense for a well-established buyer to order less quantity and take the benefits of permissible delay more frequently. There were several interesting and relevant papers related to the trade credits such as Davis and Gaither (1985), Shah (1993), Arcelus and

Srinivasan (1995), Khouja and Mehrez (1996), Hwang and Shinn (1997), Liao *et al.* (2000), Chang and Dye (2001), Ouyang *et al.* (2002), Chang *et al.* (2003), Huang and Chung (2003), Shinn and Hwang (2003), Chang (2004), Shah (2004), Ouyang *et al.* (2006) and so forth.

In this study, an attempt is made to develop an appropriate inventory model for non-instantaneous deteriorating items when the supplier provides a permissible delay in payments. Specifically, we establish a mathematical model, which is a general framework that comprises numerous previous models such as in Ghare and Schrader (1963), Goyal (1985), Teng (2002) as special cases. There are some useful theorems developed in this study to characterize the optimal solutions. We also provide the reader an easy-to-use method to find the optimal replenishment cycle time and order quantity under various circumstances. Finally, according to the results of numerical examples, we obtain some managerial insights and provide several ways for the retailer to effectively reduce total annual relevant inventory cost.

## **Result and discussion**

In this study, we develop an appropriate model for non-instantaneous deteriorating items when the supplier provides permissible delay in payments. The purpose of this research is to help the retailer to determine the optimal replenishment policy under various situations. Our model is a general framework that includes numerous previous models such as in Ghare and Schrader (1963), Goyal (1985), Teng (2002) as special cases. We also develop some useful theorems to characterize the optimal solutions and provide an easy-to-use method to find the optimal replenishment cycle time under various circumstances. From the theoretical results, it can be found that the ordering cost is an influential factor when determining an optimal replenishment policy in this study. Furthermore, the higher the ordering cost

is, the longer the replenishment cycle time and the greater the order quantity will be. Finally, we provide several numerical examples to illustrate the theoretical results, and obtain some managerial phenomena. The outcome shows that the retailer can reduce total annual relevant inventory cost by ordering lower quantity when the supplier provides a permissible delay in payments, raising the length of time in which the product has no deterioration, or improving storage conditions for non-instantaneous deteriorating items.

### References

- [1] Aggarwal S.P., Jaggi C.K. (1995), Ordering policies of deteriorating items under permissible delay in payments, *Journal of the Operational Research Society* 46:658-662.
- [2] Arcelus F.J., Srinivasan G. (1995), Discount strategies for one-time-only sales, *AIIE Transactions* 27: 618-624.
- [3] Chang C.T. (2004), An EOQ model for deteriorating items under inflation when supplier credits linked to order quantity, *International Journal of Production Economics* 88: 307-316.
- [4] Chang C.T., Ouyang L.Y., Teng J.T. (2003), An EOQ model for deteriorating items under supplier credits linked to ordering quantity, *Applied Mathematical Modelling* 27: 983-996.
- [5] Chang H.J., Dye C.Y. (2001), An inventory model for deteriorating items with partial backlogging and permissible delay in payments, *International Journal of Systems Science* 32: 345-352.
- [6] Covert R.P., Philip G.C. (1973), An EOQ model for items with Weibull distribution deterioration, *AIIE Transaction* 5: 323-326.

- [7] Davis R.A., Gaither N. (1985), Optimal ordering policies under conditions of extended payment privileges, *Management Science* 31: 499-509.
- [8] Ghare P.M., Schrader G.H. (1963), A model for exponentially decaying inventory system, *International Journal of Production Research* 21: 449-460.
- [9] Goyal S.K. (1985), Economic order quantity under conditions of permissible delay in payments, *Journal of the Operational Research Society* 36: 335-338.
- [10] Goyal S.K., Giri B.C (2001), Recent trends in modeling of deteriorating inventory, *European Journal of Operational Research* 134: 1-16.
- [11] Huang Y.F, Chung K.J. (2003), Optimal replenishment and payment policies in the EOQ model under cash discount and trade credit, *Asia-Pacific Journal of Operational Research* 20: 177-190.
- [12] Hwang H., Shinn S.W. (1997), Retailer's pricing and lot sizing policy for exponentially deteriorating products under the condition of permissible delay in payments, *Computers and Operations Research* 24: 539-547.
- [13] Jamal A.M., Sarker B.R., Wang S. (1997), An ordering policy for deteriorating items with allowable shortage and permissible delay in payment, *Journal of the Operational Research Society*, 48: 826-833.
- [14] Khouja M., Mehrez A. (1996), Optimal inventory policy under credit policies, *Journal of Manufacturing Systems* 15: 334-339.
- [15] Liao H.C., Tsai C.H., Su C.T. (2000), An inventory model with deteriorating items under inflation when a delay in payment is permissible, *International Journal of Production Economics* 63: 207-214.
- [16] Ouyang L.Y., Chen M.S., Chuang K.W. (2002), Economic order quantity model under cash discount and payment delay, *International Journal of Information Management Sciences* 13: 1-10.



- [17] Ouyang L.Y., Teng J.T., Chen L.H. (2006), Optimal ordering policy for deteriorating items with partial backlogging under permissible delay in payments, *Journal of Global Optimization* 34: 245-271.
- [18] Philip G.C. (1974), A generalized EOQ model for items with Weibull distribution, *AIIE Transaction* 6: 159-162.
- [19] Shah N.H. (1993), Probabilistic time scheduling model for an exponentially decaying inventory when delay in payments are permissible, *International Journal of Production Economics* 32: 77-82.
- [20] Shah N.H. (2004), Probabilistic order level system when items in inventory deteriorate and delay in payments is permissible, *Asia-Pacific Journal of Operational Research* 21: 319-331.
- [21] Shah Y.K. (1977), An order-level lot size inventory model for deteriorating items, *AIIE Transaction* 9: 108-112.
- [22] Shinn S.W., Hwang H. (2003), Optimal pricing and ordering policies for retailers under order-size dependent delay in payments, *Computers and Operations Research*, 30: 35-50.
- [23] Teng J.T. (2002), On the economic order quantity under conditions of permissible delay in payments, *Journal of the Operational Research Society* 53: 915-918.
- [24] Wu K.S., Ouyang L.Y., and Yang C.T. (2006), An optimal replenishment policy for non-instantaneous deteriorating items with stock-dependent demand and partial backlogging, *International Journal of Production Economics* 101:369-384.

**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 Computers & Industrial Engineering.