行政院國家科學委員會專題研究計畫 成果報告

訂購量與信用交易有關條件下允許儲存退化性產品的兩倉庫存貨決策模式
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 99-2221-E-263-001-
執 行 期 間 ：99 年 08 月 01 日至 100 年 07 月 31 日
執 行 單 位 ：致理技術學院企業管理系(科)

計 畫 主 持 人：廖瑞容

計畫參與人員：碩士班研究生-兼任助理人員：翁郁權
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處 理 方 式 ：本計畫涉及專利或其他智慧財產權，2 年後可公開查詢

中 華 民 國 100 年 08 月 24 日

行政院國家科學委員會補助專題研究計畫成果摘要

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行政院國家科學委員會專題研究計畫成果報告

題目:（中文）訂購量與信用交易有關條件下允許儲存退化性產品的兩倉庫存貨決策模式

（英文）Two-warehouse inventory model with deteriorating items under an order-size-dependent trade credit

計畫編號：NSC 99-2221-E-263-001-

執行期限：99 年 08 月 01 日至 100 年 07 月 31 日

主 持 人：廖瑞容

研究人員：翁郁權、陳穩在

一、中文摘要

在現實生活中，很多實務的原因使得存貨管理者儲存物品超過自有倉庫(記為OW)的庫存容量(當銷售量增加而造成倉庫容量不敷使用時)，此時，零售商會考慮租用另一倉庫(記為RW)。因此，兩倉庫模式的研究者認為當企業自有倉庫空間不足以支應儲存需求時, 可選擇在鄰近租倉儲放, 透過決策, 其所決定的生產或採購批量將優於(至少不劣於)一倉庫政策。為了提升存貨模式的實用性，本研究針對現有兩倉庫存貨問題做一延伸，探討當供應商提供零售商大量訂購才允許信用交易的策略下，零售商該如何訂定退化性商品在兩倉庫存貨模式的最佳訂購策略，以使其存貨總成本為最低?同時，並探討總成本函數是否具有凸性？若不具有凸性，是否具有某種函數特性？在上述討論下，試著發展一些簡單、正確並易執行之演算法，供實務界使用。最後，以數值範例來闡明理論的結果及探討系統中參數變動對最佳解的敏感度分析。

Abstract

In real-life, there exist many practical cases that force inventory managers to hold more items than can be stored in own a warehouse (denoted by OW). Here, one additional warehouse is required. This additional warehouse may be a rented warehouse (denoted by RW) and the renting cost of a rented warehouse is seemed as an additional cost of business. From the practical point of view, the supplier proposes a certain credit period when the order quantity is more than a quantity at which the delay in payments is permitted. Here, when the retailer orders quantity more than the own warehouse, these excess quantities may stored in a rented warehouse. Therefore, this study will investigate that payment delays depend on the quantity ordered and according to such phenomenon, if the order quantity exceeds the owned warehouse capacity, it will be necessary to rent a warehouse which results in a rental cost of business is arrived. Otherwise, renting a warehouse is unnecessary. Finally, we provide the optimal ordering policy for the decision-maker to decision whether or not to rent RW for sale environment which is the

supplier offers an order-size-dependent trade credit to minimize the cost. Moreover, is the total cost function convex ? Try to develop a simple, accurate and rapid algorithm for the practitioners under above condition. Numerical examples are presented to illustrate the proposed model and the sensitivity analysis of the optimal solution with respect to parameters of the system is also included.

1. Scope and Purposes

In recent decades, many studies have examined the problem of managing deteriorating items including medicines, volatile liquids, blood banks, foodstuffs and electronic components. Raafat (1991) presented a complete survey of the inventory literature on deteriorating inventory models. Moreover, Ghare and Schrader (1963) the first proponents proposed for developing a revised form of the EOQ model that assumed exponential decay. Covert and Philip (1973) then extended this model to consider the Weibull distribution deterioration. The conventionally adopted EOQ model assumes that the retailer must pay the sce to purchase the item immediately upon receiving it from a supplier. However, such an assumption does not necessarily reflect nario in the real world. In fact, suppliers generally allow retailers access to forward financing to increase demand or decrease inventory. This means that the supplier permits a trade credit period for the settlement of payment. The effect of the trade credit on the optimal inventory model has been examined in various studies. Goyal (1985) established an inventory model under permissible delay in payments. Shah (1993a, b) designed EOQ models for perishable items where payment delay is permissible. Other noteable works on this area were by Chand and Ward (1987), Aggarwal and Jaggi (1995), Chung and Liao (2006), Jamal et al. (2000), Chung (1998), Daellenbach (1986), Shinn (1997), Shinn and Hwang (2003), Liao (2007a, b) and others. In fact, a key finding of these studies was that EOQ is independent of trade credit. Chung and Liao (2004) and Chang et al. (2003) considered the deteriorating items given the conditions of an order-size-dependent trade credit.

In more practical terms, any warehouse has a limited capacity. On the other hand, due to some reasons such as an attracted price discount for bulk purchase, the order costs higher than one using rented warehouse, and so on, inventory managers usually are attracted to hold more items than can be stored in an owned warehouse. From this perspective, the two warehouse inventory models recently have been considered by various authors. This kind of system was first proposed by Hartely (1976). Sarma (1983) designed a deterministic inventory model with infinite replenishment rate and two storage levels. Furthermore, Murdeshwar and Sathe (1983) extended the case to incorporate finite replenishment rate. Other researchers that have studied in this area include Goswami and Chaudhuri (1992), Bhunia and Maiti (1998), Sarma (1987), Pakkala and Achary (1992a, 1992b), Benkherout (1997), Zhou (1998), Yang (2004) and Zhou and Yang (2005).

Due to the factors mentioned above,

Chung and Huang (2006) considered a two-warehouse inventory problem for deteriorating item with limited shortage space under permissible delay in payments. However, in certain practical situations, trade credits can be applied as an alternative to price discounts to order more quantities. Consequently, an important problem associated with inventory maintenance is deciding whether to rent an additional warehouse to hold more items to obtain a trade credit period.

Based on the above arguments, this study incorporates both Chung and Huang (2006) and Chung and Liao (2004) under above conditions. This study considers payment delay to depend on order quantity where the order quantity is less than that at which delayed payment is permitted, meaning payment must be made immediately. Otherwise, the fixed trade credit period is permitted. Additionally, if the order quantity exceeds owned warehouse capacity it becomes necessary to rent a warehouse which results in an additional rental cost is arrived. Given this marketing situation, this study develops a deterministic inventory model for deteriorating items with two warehouses (one is OW and the other is RW) and where trade credit is linked to order quantity. This study then demonstrates easy-to-use theorems to identify the optimal replenishment cycle time and the optimal order lot-size to minimize. Numerical examples are used to illustrate all of the study theorems and revealed the decision whether to rental an additional warehouse. Finally, sensitivity analysis of the optimal solution with respect to the parameters of the system is carried out and some important managerial insights are obtained.

2. Notations and Assumptions

The notations adopted in this study are as below.

C = unit purchase cost

S = ordering cost

A = rental cost for renting an additional warehouse

M = credit period set by the supplier

h = unit stock holding cost for item in OW (excluding capital opportunity cost)

k = unit stock holding cost for item in RW (excluding capital opportunity cost)

R = capital opportunity cost (as a percentage)

I = earned interest rate (as a percentage)

Q = order size

T = replenishment cycle time

D = annual demand rate

λ = a constant deterioration rate

$\overline{W}$ = quantity at which the delay in payments is permitted

W = the storage capacity of OW

t_W = the time that inventory level reduce to W

$$T_{\overline{W}} = \frac{1}{\lambda}\ln(\frac{\lambda}{D}\overline{W} + 1)$$

$$T_a = \frac{1}{\lambda}\ln(\frac{\lambda}{D}W + 1)$$

(1) Replenishments are instantaneous with a known and constant lead time.

(2) No shortages are allowed.

(3) The demand rate is known with certainty and uniform.

(4) The supplier proposes a certain credit period in paying for purchasing cost and

I . At the end of the period, the credit is settled and the retailer starts paying the capital opportunity cost for the items in stock with rate R $(R \geq I)$.

(5) The daily expenses of the system can be overcome from the difference between retail price and unit cost.

(6) The time to deterioration of each item follows an exponential distribution with parameter λ , and the deteriorated units are not replaced.

(7) If $Q < \overline{W}$, the delay in payments is not permitted. Otherwise, certain fixed trade credit period M is permitted.

(8) The owned warehouse (OW) has a fixed capacity of W units and the rented warehouse (RW) has unlimited capacity.

(9) The items of OW are consumed only after consuming the items kept in RW.

(10) The time of transporting items from RW to OW is ignored.

Finally, the total cost of the inventory system is obtained as following：

$$TVC(T) = \begin{cases} TVC_1(T) & if \quad 0 < T < T_a \\ TVC_2(T) & if \quad T_a \leq T < T_{\overline{W}} \\ TVC_3(T) & if \quad T_{\overline{W}} \leq T < M \\ TVC_4(T) & if \quad M \leq T \end{cases}$$

3. Conclusions

This study optimizes ordering policy for a deteriorating commodity under capacity constraint when trade credit is linked to ordering quantity. By using theorems, the decision-maker can easily determine whether it will be financial advantageous rent a warehouse to hold much more items to obtain a trade credit period. Finally, numerical examples are used to illustrate all of the study results. From the sensitivity analysis, we can see that the ordering cost, deterioration rate and demand rate cost affect the total cost of the retailer.

4. 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.

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國科會補助計畫衍生研發成果推廣資料表

日期:2011/08/18

國科會補助計畫	計畫名稱: 訂購量與信用交易有關條件下允許儲存退化性產品的兩倉庫存貨決策模式
	計畫主持人: 廖瑞容
	計畫編號: 99-2221-E-263-001- 學門領域: 作業研究

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：廖瑞容	計畫編號：99-2221-E-263-001-
計畫名稱：訂購量與信用交易有關條件下允許儲存退化性產品的兩倉庫存貨決策模式	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	2	2	90%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	1	2	85%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：(以 100 字為限)

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限）

透過本研究的討論與分析,對於零售商在存貨的管理上有很大的幫助.