行政院國家科學委員會專題研究計畫 成果報告

供應鏈中在允許部分信用交易及倉儲空間有限下，零售商對於退化性產品的最佳價格及最佳訂購策略之簡化求解程序

研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 100-2221-E-263-001-
執 行 期 間 ：100 年 08 月 01 日至 101 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：陳信因

公 開 資 訊 ：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 101 年 09 月 18 日

中 文 摘 要 ： 傳統論文多假設零售商擁有單一倉庫且其倉儲容量是沒有限制的，但在現實生活中，有些零售商是擁有自己的倉庫且其容量是有限的(簡稱OW)；因此，當訂購量超過零售商自有倉庫庫存容量，零售商也會考慮租用倉庫(簡稱RW，此時的倉儲空間可視為無限的)。此外，一般物品在市場上的需求並非是固定維持不變的，需求率可能與產品的價格存在著密切的關係；因此，在信用交易條件下，再考慮物品的價格對市場需求率的影響將能使存貨模型更加接近實務情況。綜合上述討論，為了使現今的存貨模型與實際情況更為接近，本研究將以信用交易為主要架構，另考慮一實務觀點，結合(1)倉庫容量無限制的情形修改為其倉庫容量是有限的，(2)貨到付款的情形放寬為二階信用交易(two-level trade credit)，其中一階為部分信用交易(partial trade credit)，(3)產品的需求率與售價有關條件下，建構零售商對於退化性產品在上述條件下的二變數之經濟訂購量存貨模式，其存貨模型以使單位時間銷售總利潤最大為目標。

中文關鍵詞： 部份信用交易,存貨,現金折扣, 延後付款,供應鏈

英 文 摘 要 ：

英文關鍵詞： partial trade credit； inventory； cash discount； delay payments； supply chain.

行政院國家科學委員會補助專題研究計畫成果摘要

供應鏈中在允許部分信用交易及倉儲空間有限下，零售商對於退化性產品的最佳價格及最佳訂購策略之簡化求解程序

計畫類別： 個別型計畫

計畫編號： NSC 100-2221-E-263 -001 -

執行期間： 100 年 08 月 01 日至 101 年 07 月 31 日

執行單位: 致理技術學院企業管理系

計畫主持人:廖瑞容

計畫參與人員：陳信音

報告類型:精簡報告

處理方式:本計畫可公開查詢

中 華 民 國 101 年 8 月 26 日

行政院國家科學委員會專題研究計畫成果報告

題目:（中文）供應鏈中在允許部分信用交易及倉儲空間有限下，零售商對於退化性產品的最佳價格及最佳訂購策略之簡化求解程序

（英文）The simplified solution for joint pricing and lot-sizing policy for deteriorating items with limited storage capacity under partial trade credit financing

計畫編號：NSC 100-2221-E-263 -001 -

執行期限：100 年 08 月 01 日至 101 年 07 月 31 日

主 持 人：廖瑞容

研究人員：陳信音

一、中文摘要

在現實的情況中，多數的存貨在持有過程中，會因為存貨的儲存時間過長導致存貨發生腐敗、揮發、血液、退化、變質等現象，導致存貨的價值和數量也因此減少。因此這類存貨通稱為「退化性存貨」(deteriorating or perishable inventory)，故退化性存貨會產生額外的成本，若不加入退化性的因素探討，會造成存貨模式結構不正確而作出錯誤的決策。此外，一般物品在市場上的需求並非是固定維持不變的，需求率可能與產品的價格存在著密切的關係；因此，在信用交易條件下，再考慮物品的價格對市場需求率的影響將能使存貨模型更加接近實務情況。

再者，傳統論文多假設零售商擁有單一倉庫且其倉儲容量是沒有限制的，但在現實生活中，有些零售商是擁有自己的倉庫且其容量是有限的(簡稱 OW)；因此，當訂購量超過零售商自有倉庫庫存容量，零售商也會考慮租用倉庫(簡稱 RW，此時的倉儲空間可視為無限的)，且租用倉庫的存貨持有成本往往會比自己的倉庫高。

綜合上述討論，為了使現今的存貨模型與實際情況更為接近，本研究將以信用交易為主要架構，另考慮一實務觀點，結合(1)倉庫容量無限制的情形修改為其倉庫容量是有限的，(2)貨到付款的情形放寬為二階信用交易(two-level trade credit)，其中一階為部分信用交易(partial trade credit)，(3)產品的需求率與售價有關條件下，建構零售商對於退化性產品在上述條件下的二變數之經濟訂購量存貨模式，其存貨模型以使單位時間銷售總利潤最大為目標。

Abstract

Thangam & Uthayakumar (2010) investigated perishable items with limited storage capacity under partial trade credit policy. They assumed the demand rate is a function of retailer price. Thereafter, the authors want to simplify the process of finding the solution procedures, so their results are based on the assumption that

the number θT should be sufficiently small, and their solution procedure ignored the explor- ations of the functional behaviors to find the optimal solutions which will result in the proofs of their solution procedures are not perfect from the viewpoint of logic. Consequently, the main purposes of this article proves not only accurate and reliable solution procedures to improve Thangam & Uthayakumars' solution but also gives an algorithm to derive the optimal solutions under various circumstances. Several numerical examples are given to demonstrate the theoretical approach. Sensitivity analysis with respect to various parameters of system is carried out and the results are discussed in detail.

1. Scope and Purposes

Basically, trade credit is an important source of finance for buyers in business, in practices, the supplier provides trade credit policies, the retailer tends to extend this benefit to customers by offering a delayed payment period. This is called two-level trade credit policy. Since then, there are many researchers have studied inventory model under two-level trade credit policy such as Huang (2003) proposed an inventory model to discuss the retailer's optimal ordering policy under a two-level trade credit policy. Later, Huang (2007) extended Huang (2003) to an EPQ model with two-level trade credit. Huang & Hsu (2008) extended Huang (2003) further by proposing an EOQ model with a two-level trade credit policy in which the retailer obtained the full trade credit from the supplier, but only offered a partial trade credit to end customers. Huang (2006) incurporates Huang (2003) and Teng (2002) to incorporate a retailer's storage space limitation into the model. Chung & Huang (2007) extended Huang (2006) to explore the optimal retailer's ordering policies for deteriorating items under the two-level trade credit policy. Liao (2007) considered an EOQ model with non-instantaneous receipt and exponentially deteriorating items under two-level trade credit. More related articles can be found in the work by Teng & Goyal (2007), Chung (2008, 2009, 2010), Teng & Chang (2009), Ouyang et al. (2009), Teng et al. (2009), Liao and Huang (2010) and Liang and Zhou (2011).

Moreover, market demand falls as retail price rises which means that there is a negative correlation between market demand and retail price. Based on the above arguments, Thangam & Uthayakumar (2010) combined the two-level trade credit policy and demand is a downward sloping function of retail price to investigate a two-warehouse inventory system for perishable items. In fact, their inventory model is correct and interesting. However, in order to simplify the process of the solution procedures, their results are based on the assumption that the number θT should be sufficiently small, this assumption will result in the process of the derivation to search for the optimal solution is not correct when the deteriorating items are considered. In addition, their solution procedures were ignored the explorations of the functional behaviors (such as increasing, decreasing, convex, concave…, etc.) of the annual total relevant function, Chung (2009)

implied that if the functional behaviors of the annual total relevant function are ignored to locate the optimal solutions such that the proofs of their solution procedures are not perfect from the viewpoint of logic. Furthermore, this paper derives not only the accurate optimal joint pricing and lot-sizing policy but also develops an exact algorithm to improve those in Thangam & Uthayakumar (2010). Finally, numerical examples illustrate that the algorithm to locate the optimal solution is rather accurate and rapid.

2. Notations and Assumptions

The following notation and assumptions will be used throughout the paper.

A Ordering cost per cycle.

h_1 Retailer's holding cost per unit time in W_1 excluding interest charges. $h_2 (> h_1)$ Retailer's holding cost per unit time in W_2 excluding interest charges.

c Retailer's procurement cost per unit item.

s Retailer's selling price per unit item (decision variable).

$\lambda(s)$ Annual demand as a function of s.

θ Deterioration rate of an item.

Z Storage capacity of W_1.

t_1 The time period during which the demand is fulfilled from W_1.

α A customer's fraction of the total amount owed payable at the time of placing an order offered by the retailer, $0 \le \alpha \le 1$.

M Delay period in payment for the retailer offered by the supplier.

N Delay period in payment for the customer offered by the retailer.

I_e Interest earned per \$ per year.

I_k Interest charged per \$ per year by the supplier.

T Cycle time in years (decision variable).

Q Order quantity per cycle.

$TP(s,T)$ Annual total profit, which is a function of s and T.

(1) Demand, $\lambda(s)$, is a downward sloping function of s.

(2) The sales revenue, $(s-c)\lambda(s)$, is a concave function of s. It stems from the standard economic effect: the marginal revenue decreases as output decreases.

(3) The time to deterioration of a product follows an exponential distribution with parameter θ, i.e., the deterioration rate is a constant fraction of the on-hand inventory. It is assumed that the deterioration rate in W_1 is the same as in W_2.

(4) Before the settlement of an account, the retailer can use sales revenue to earn the interest. At the end of period M, the credit is settled and the retailer starts paying the capital opportunity cost for the items in stock with an annual rate I_k.

(5) The retailer offers partial payment scheme at the rate of α to his customer. Then his customer must pay off the remaining balance at the end of period N. Hence the retailer can earn interest with rate I_e for the period of length M.

(6) Time horizon is infinite.

(7) Inventory holding cost is charged only on the amount of undecayed stock.

(8) Shortages are not allowed.

Finally, the total cost of the inventory system is

obtained as following：

Case (A)：Suppose that $M < N$.

(A1) Suppose that $t_1 \le M$,

$$TP(s,T) = \begin{cases} TP_1(s,T) & if \quad 0 < T \le t_1 \\ TP_2(s,T) & if \quad t_1 < T \le M \\ TP_3(s,T) & if \quad M < T \end{cases}$$

(A2) Suppose that $t_1 > M$,

$$TP(s,T) = \begin{cases} TP_1(s,T) & if \quad 0 < T \le M \\ TP_4(s,T) & if \quad M < T \le t_1 \\ TP_3(s,T) & if \quad t_1 \le T \end{cases}$$

Case (B)：Suppose that $M \ge N$.

(B1) Suppose that $t_1 < N$,

$$TP(s,T) = \begin{cases} TP_5(s,T) & if \quad 0 < T \le t_1 \\ TP_6(s,T) & if \quad t_1 < T \le N \\ TP_7(s,T) & if \quad N < T \le M \\ TP_8(s,T) & if \quad M < T \end{cases}$$

(B2) Suppose that $N \le t_1 \le M$,

$$TP(s,T) = \begin{cases} TP_5(s,T) & if \quad 0 < T < N \\ TP_9(s,T) & if \quad N < T \le t_1 \\ TP_7(s,T) & if \quad t_1 < T \le M \\ TP_8(s,T) & if \quad M < T \end{cases}$$

(B3) Suppose that $M < t_1$,

$$TP(s,T) = \begin{cases} TP_5(s,T) & if \quad 0 < T \le N \\ TP_9(s,T) & if \quad N < T \le M \\ TP_{10}(s,T) & if \quad M < T \le t_1 \\ TP_8(s,T) & if \quad t_1 < T \end{cases}$$

3. Conclusions

By analyzing the joint profit function, this article in accordance with the effect of the functional behaviors of the total profit per unit time to locate the optimal solution. Then, a valid algorithm is developed to solve the inventory model in Thangam & Uthayakumar (2010). Finally, numerical examples reveal that why the approximate optimum solutions obtained by Thangam & Uthayakumar (2010) may be inappropriate sometimes. Further, numerical examples show that the algorithm in this paper is easier to understand, implement and better than those of Thangam & Uthayakumar (2010).

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:2012/09/18

國科會補助計畫	計畫名稱: 供應鏈中在允許部分信用交易及倉儲空間有限下，零售商對於退化性產品的最佳價格及最佳訂購策略之簡化求解程序
	計畫主持人: 廖瑞容
	計畫編號: 100-2221-E-263-001- 學門領域: 作業研究

無研發成果推廣資料

100 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：100-2221-E-263-001-
計畫名稱：供應鏈中在允許部分信用交易及倉儲空間有限下，零售商對於退化性產品的最佳價格及最佳訂購策略之簡化求解程序	

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	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%		
國外	論文著作	期刊論文	1	1	100%	篇	IMA Journal of Management Mathematics
		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	1	1	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)
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