科技部補助專題研究計畫成果報告
期末報告

供應鏈中在供應商提供不同的兩階延遲付款以及零售商的營運資金有限,倉儲空間有限下的最佳訂購策略

計 畫 類 別 ：個別型計畫
計 畫 編 號 ：MOST 103-2221-E-263-001-
執 行 期 間 ：103 年 08 月 01 日至 104 年 07 月 31 日
執 行 單 位 ：致理學校財團法人致理科技大學企業管理系

計 畫 主 持 人：廖瑞容

計畫參與人員：大專生-兼任助理人員：劉宇軒
大專生-兼任助理人員：賴宇亭
大專生-兼任助理人員：洪鈺婷

處 理 方 式 ：
1.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
2.「本研究」是否已有嚴重損及公共利益之發現：否
3.「本報告」是否建議提供政府單位施政參考：否

中 華 民 國 104 年 09 月 08 日

中 文 摘 要 ： 在本計畫中,我們探討另一類型的二階段信用交易以反映實際生活情況。當零售商因供應商提供延遲付款期限(permissible delay in payments)而訂購大批量貨品時，超過自有倉庫最大容量的部分，便需向外租用倉庫儲存。另考慮一實務觀點，為了鼓勵零售商訂購更多的數量，供應商會提供兩個不同的延遲付款期限，(1)如果零售商在第一個延遲付款期限到期時即可付清貨款，則零售商不需貸款融資付款，此外，在此期限後，零售商還可以繼續賺取銷貨收入以及利息收入直到整個週期結束。(2)如果零售商在第一個延遲付款期限到期時，無法付清貨款，則零售商需對不足額部分進行貸款融資付款；另一方面，因為零售商的營運資金是有限的，故零售商將面對兩種情況:第一種情況為第二個延遲付款期限到期前，零售商一有銷貨收入時便需立即支付欠款，此時貸款利率較低( )，直到付清貸款且不持有任何利潤。第二種情況為零售商對不足額部分先以較低的利率進行貸款融資，同時，零售商繼續利用銷售所得賺取利息收入直到第二個延遲付款期限，並在第二個延遲付款期限到期後，一有銷貨收入時便立即支付欠款，此時貸款利率較高( )，且不持有利潤，直到付清貸款。

所以本計劃結合上述觀點，發展一更符合供應鏈實務的模式，以此模式加以探討不同二階信用交易條件下零售商之訂購策略，期盼此研究成果可供學術界及實務界之參考。本計劃所得之存貨模式，將在零售商之最高的每年總相關利潤條件下，求取零售商最佳之訂購策略，並將導出一簡單有效的最佳訂購策略的決定程序。

中文關鍵詞： 存貨、延遲付款策略、財務、兩階信用交易、供應鏈管理

英 文 摘 要 ： In this article, we explore another kind of two-level trade credit to reflect the real-life situations. The supplier offers two-level trade credit for the retailer to settle the account, if the retailer pays off all accounts at the end of the first credit period, then he/she can utilize the sales revenue to earn interest until the inventory cycle time. On the other hand, if the retailer cannot pay off the unpaid balance at the end of the first credit period, then he/she can decide to pay off unpaid balance either after the end of the first credit or after the second credit period. Herein, the retailer reduces the financed loan from constant sales and revenue

creviced gradually and he/she still can utilize the sales revenue to earn interest when he/she pays off all accounts. The maximizing profit is used as the objective to develop the inventory model. Based on the obtained properties of the optimal solution, two theorems are developed to determine the optimal replenishment policy.

英文關鍵詞： Inventory、Permissible delay in payments, Finance, Two-level trade credit, Supply chain management

科技部補助專題研究計畫成果報告
（□期中進度報告/☒期末報告）

(計畫名稱)

供應鏈中在供應商提供不同的兩階延遲付款以及零售商的營運資金有限,

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執行單位：致理技術學院企業管理系

中　華　民　國　**104** 年　**9**　月　**7**　日

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（中文計畫名稱）

供應鏈中在供應商提供不同的兩階延遲付款以及零售商的營運資金有限, 倉儲空間有限下的最佳訂購策

(英文計畫名稱)

Retailer's optimal ordering policies with restricted working capital and limited storage capacity when the supplier provides different two-level delay payments in a supply chain system

中文摘要

在本計畫中,我們探討另一類型的二階段信用交易以反映實際生活情況。當零售商因供應商提供延遲付款期限(permissible delay in payments)而訂購大批量貨品時，超過自有倉庫最大容量的部分，便需向外租用倉庫儲存。另考慮一實務觀點，為了鼓勵零售商訂購更多的數量，供應商會提供兩個不同的延遲付款期限，(1)如果零售商在第一個延遲付款期限到期時即可付清貨款，則零售商不需貸款融資付款，此外，在此期限後，零售商還可以繼續賺取銷貨收入以及利息收入直到整個週期結束。(2)如果零售商在第一個延遲付款期限到期時，無法付清貨款，則零售商需對不足額部分進行貸款融資付款；另一方面，因為零售商的營運資金是有限的，故零售商將面對兩種情況:第一種情況為第二個延遲付款期限到期前，零售商一有銷貨收入時便需立即支付欠款，此時貸款利率較低(I_1)，直到付清貸款且不持有任何利潤。第二種情況為零售商對不足額部分先以較低的利率進行貸款融資，同時，零售商繼續利用銷售所得賺取利息收入直到第二個延遲付款期限，並在第二個延遲付款期限到期後，一有銷貨收入時便立即支付欠款，此時貸款利率較高(I_2)，且不持有利潤，直到付清貸款。

所以本計劃結合上述觀點，發展一更符合供應鏈實務的模式，以此模式加以探討不同二階信用交易條件下零售商之訂購策略，期盼此研究成果可供學術界及實務界之參考。本計劃所得之存貨模式,將在零售商之最高的每年總相關利潤條件下，求取零售商最佳之訂購策略，並將導出一簡單有效的最佳訂購策略的決定程序。

關鍵詞：存貨、延遲付款策略、財務、兩階信用交易、供應鏈管理

Abstract

In this article, we explore another kind of two-level trade credit to reflect the real-life situations. The supplier offers two-level trade credit for the retailer to settle the account, if the retailer pays off all accounts at the end of the first credit period, then he/she can utilize the sales revenue to earn interest until the inventory cycle time. On the other hand, if the retailer cannot pay off the unpaid balance at the end of the first credit period, then he/she can decide to pay off unpaid balance either after the end of the first credit or after the second credit period. Herein, the retailer reduces the financed loan from constant sales and revenue creviced gradually and he/she still can utilize the sales revenue to earn interest when he/she pays off all accounts. The maximizing profit is used as the objective to develop the inventory model. Based on the obtained properties of the optimal solution, two theorems are developed to determine the optimal replenishment policy.

Keywords: Inventory、Permissible delay in payments, Finance, Two-level trade credit, Supply chain management

一、報告內容

（報告內容請依國科會結案報告格式撰寫，例如：前言、研究目的、文獻探討、研究方法、結果與討論。各節編號請自訂。）

1. Introduction

Actually, trade credit is widespread and represents an important proportion of company finance. Especially small businesses, with limited financing opportunities, may be financed by their suppliers rather than by financial institutions (Petersen and Rajan, 1997). In addition, the supplier is usually willing to offer the retailer a certain credit period without interest to promote the market competition. Goyal (1985) first developed an economic order quantity (EOQ) model when a supplier offers its retailer a permissible delay in payments. Chang et al. (2010) extended the EOQ models for deteriorating items when the supplier offers a permissible delay in payments to the purchaser if the order quantity is greater than a predetermined quantity. Chung and Liao (2009) considered an inventory system for deteriorating items under the permissible in payment and DCF approach. More recently, Musa and Sani (2012) explored inventory ordering policies of delayed deteriorating items under permissible delay in payments. Liao et al. (2012) extended Goyal's model to allow for deteriorating items with two warehouses under an order-size-dependent trade credit. There were several interesting and relevant papers related to the trade credits such as Liao (2008a), Teng and Lou (2012), Liao and Huang (2010), Liao et al. (2013a, 2013b), Yang et al. (2013) and their references.

Additionally, Huang (2003), Liao (2008b) and Teng (2009) explored inventory models under two levels of trade credit policy in which the supplier offers the retailer a permissible delay period M, and the retailer in turn provides his/her customers a permissible delay period N in order to stimulate the demand. Ouyang et al. (2013a) developed an EOQ model for deteriorating items under supplier's up stream trade credit linked to ordering quantity. Liao et al. (2014) explore an

EOQ model for deteriorating items with capacity constraints under two-levels of trade credit policy. Many additional related articles can be found in Teng and Chang (2009), Ouyang et al. (2013b), Yen et al. (2012) and their references.

All the inventory models mentioned above did not consider the progressive payment scheme. Goyal et al. (2007) explored the notion of progressive credit period is as follows: If the retailer settles the outstanding amount by the first period, M_1, the supplier does not charge any interest. If the retailer pays after M_1 but before the second period, M_2, offered by the supplier, then the supplier charges the retailer on the un-paid balance at the rate I_{c1}. If the retailer settles the account after M_2, then he will have to pay at interest rate I_{c2} on the un-paid balance ($I_{c2} > I_{c1}$). Soni and Shah (2008) explored the optimal ordering policy for the retailer under a stock-dependent demand and two progressive credits periods. Teng et al. (2011) extended Soni and Shah (2008) to obtain the retailer's optimal ordering policy for stock-dependent demand when the supplier offers a progressive permissible delay in payments.

In this study, we attempt to extend the existing literature related to inventory model with delay in payments to a more general case. We will establish an inventory system in which the supplier offers another kind of two-level of trade credit to settle the retailer's accounts. Herein, if the retailer pays off all accounts at the end of the first credit period, then he/she can utilize the sales revenue to earn interest throughout the inventory cycle. On the other hand, if the retailer cannot pay off the unpaid balance at the end of the first credit period, then he/she can decide to pay off unpaid balance either after the end of the first credit or after the second credit period. With this in mind, the retailer reduces the financed loan from constant sales and revenue creviced gradually and he/she still can utilize the sales revenue to earn interest when he/she pays off all accounts. The maximization of the average profit per unit of time is taken as the objective function to study the retailer's optimal ordering policy in this paper. Based on the obtained properties of the optimal solution, two theorems are developed to determine the optimal replenishment policy. Finally, numerical examples are given to illustrate the theoretical results.

2. Notations and Assumptions

Notation:

- D the demand rate per year
- h the inventory holding cost rate excluding interest charges rate.
- p the selling price per unit
- C the purchasing cost per unit $C < p$
- M the first offered credit period in settling the account without extra charges
- N the second permissible credit period in settling the account with interest charge of I_2 on un-paid balance and $N > M$
- I_1 the interest charged per \$ in stocks per year by the supplier when the retailer pays during $[M, N]$

I_2 the interest charged per \$ in stocks per year by the supplier when the retailer pays during $[N, T]$ $(I_2 > I_1)$

I_e the interest earned per \$ per year $(I_1 > I_e)$

S the ordering cost per order

T the inventory cycle time (the decision variable)

$\pi(T)$ the total relevant profit per year

W^* $\frac{p}{C}M + \frac{pI_e}{2C}N^2$

$\overline{W}$ $\frac{p}{C}N + \frac{pI_e}{2C}[M^2 + (N-M)^2]$

Assumptions:

(1) The demand for the item is constant with time.

(2) Shortages are not allowed.

(3) Replenishment rate is infinite.

(4) When $M > T$, the supplier does not charge the retailer any interest and the retailer earns interest on sales revenue up to the permissible period M.

(5) When $M \le T$, there are three cases to occur as follows; one case is that if the retailer pays by M, the supplier does not charge to the retailer and the retailer can continuous utilize the sales revenue to earn interest throughout the inventory cycle time T, another case is that if the retailer cannot pay off the balance at time M but before N, then the supplier charges the retailer an interest rate of I_1 on un-paid balance. At the same time, the retailer must utilize the sales revenue to pay off the remaining amount owed to the supplier. Once the retailer pays off all accounts, he/she still can utilize the sales revenue to earn interest throughout the inventory cycle time T and the other case is that if the retailer pays after N, then the supplier charges the retailer an interest rate of I_2 $(I_2 > I_1)$ on un-paid balance.

(6) Time horizon is infinite.

3. Mathematical formulation and the optimal solutions

The elements comprising the annual total relevant profit of the retailer are listed below:

(1) Annual ordering cost $= \frac{S}{T}$

(2) Annual stock-holding cost (excluding interest charged) $= \frac{hD}{2}T$

(3) According to assumptions (4) and (5), there are four cases to occur in interest payable and / or interest earned per year: (i) $T \le M$; (ii) $M < T \le W^*$; (III) $W^* < T \le \overline{W}$; and (IV) $\overline{W} < T$.

Case 1: $T \le M$

In this case, the total interest earned per year is

$$\frac{pI_eDT}{2}+[(pI_eD+\frac{pI_e^2DT}{2})(M-T)]$$
$$=pI_eD[\frac{T}{2}+(1+\frac{I_eT}{2})(M-T)]$$

Case 2: $M<T\le W^*$

In this case, the total interest earned is

$$\frac{pI_eDM^2}{2T}+\frac{pI_eD(T-M)^2}{2T}$$
$$+\frac{I_e}{T}(pDM+\frac{pI_eD}{2}M^2-CDT)(T-M)$$

Case 3: $W^*<T\le\overline{W}$

In this case, the interest payable per year is given by

$$\frac{I_1}{2pDT}\left[CDT-pDM(1+\frac{I_eM}{2})\right]^2$$

The total interest earned is

$$\frac{pI_eDM^2}{2T}+\frac{pI_eD}{2T}(T-M-\frac{CDT-pDM-\frac{pI_eDM^2}{2}}{pD})^2$$

Case 4: $\overline{W}<T$

In this case, the interest charged per year in this case is

$$\frac{I_1(M_2-M_1)D}{T}\left[CT-pM(1+\frac{I_eM}{2})\right]$$
$$+\frac{I_2D}{2pT}\left\{CT-pN-\frac{pI_e}{2}\left[M^2+(N-M)^2\right]\right\}^2$$

Similarly, the total interest earned is

$$\frac{pI_eD}{2T}M^2.$$

As mentioned earlier, the total annual profit for the retailer can be expressed as follows:

$$\Pi(T)=\begin{cases}\pi_1(T) & if \quad 0<T\le M & (1a)\\ \pi_2(T) & if \quad M<T\le W^* & (1b)\\ \pi_3(T) & if \quad W^*<T\le\overline{W} & (1c)\\ \pi_4(T) & if \quad \overline{W}<T\end{cases}$$

where

$$\pi_1(T)=(p-C)D-\frac{S}{T}-\frac{hDT}{2}+pI_eD[\frac{T}{2}+(1+\frac{I_eT}{2})(M-T)] \quad (2)$$

$$\pi_2(T)=-\frac{S}{T}-\frac{hDT}{2}+\frac{1}{T}\{(pDM+\frac{pI_eDM^2}{2}-CDT)[1+I_e(T-M)]\}$$
$$+\frac{pD}{T}(T-M)+\frac{pI_eD}{2T}(T-M)^2 \quad (3)$$

$$\pi_3(T) = (p-C)D - \frac{S}{T} - \frac{hDT}{2} + \frac{pI_eDM^2}{2T} - \frac{I_1}{2pDT}\left[CDT - pDM(1+\frac{I_eM}{2})\right]^2 + \frac{pI_eD}{2T}(T - M - \frac{CDT - pDM - \frac{pI_eDM^2}{2}}{pD})^2 \quad (4)$$

and

$$\pi_4(T) = (p-C)D - \frac{S}{T} - \frac{hDT}{2} + \frac{pI_eDM^2}{2T} - \frac{I_1(N-M)}{T}\left[CDT - pDM(1+\frac{I_eM}{2})\right] - \frac{I_2}{2pDT}\left\{CDT - pDN - \frac{pI_eD}{2}\left[M^2 + (N-M)^2\right]\right\}^2 \quad (5)$$

We find that $\pi_1(M) = \pi_2(M)$, $\pi_2(W^*) = \pi_3(W^*)$ and $\pi_3(\overline{W}) > \pi_4(\overline{W})$. Hence, $\pi(T)$ is continuous on $(0,\infty)$ expect at $T = \overline{W}$.

From eqs. (2)-(5) , we have that

$$\pi_1'(T) = \frac{1}{2T^2}\left\{2S - D(h + pI_e - pI_e^2M)T^2 - 2pI_e^2DT^3\right\} \quad (6)$$

$$\pi_2'(T) = \frac{1}{2T^2}\left\{2S + pI_e^2DM^3 - D(h - pI_e + 2CI_e)T^2\right\} \quad (7)$$

$$\pi_3'(T) = \frac{1}{2T^2}\{2S + \frac{pI_e^2DM^4}{4}(I_1 - I_e) + pDM^2(I_1 - I_e) + pDI_1I_eM^3 + D[\frac{C^2(I_e - I_1)}{p} - (h - pI_e + 2CI_e)]T^2\} \quad (8)$$

$$\pi_4'(T) = \frac{1}{2T^2}\{2S - hDT^2 - pI_eDM^2 - 2I_1(N-M)pDM(1+\frac{I_eM}{2}) - \frac{I_2}{pD}\{C^2D^2T^2 - [pDN + \frac{pI_eD}{2}(M^2 + (N-M)^2)]^2\}\} \quad (9)$$

$$\pi_1''(T) = -\frac{2S}{T^3} - pI_e^2D < 0 \quad (10)$$

$$\pi_2''(T) = -\frac{2S}{T^3} - \frac{pI_e^2DM^3}{T^3} < 0 \quad (11)$$

$$\pi_3''(T) = -\frac{2S}{T^3} - \frac{pDI_e^2M^4(I_1 - I_e)}{4T^3} - \frac{pDM^2(I_1 - I_e)}{T^3} - \frac{pDI_1I_eM^3}{T^3} < 0 \quad (12)$$

and

$$\pi_4''(T) = \frac{-2S}{T^3} + \frac{pI_eDM^2}{T^3} + \frac{2I_1(N-M)}{T^3}pDM(1+\frac{I_eM}{2}) - \frac{I_2pD\left[N^2 + \frac{I_e}{2}(M^2 + (N-M)^2\right]^2}{T^3} \quad (13)$$

Moreover, eqs. (6), (7), (8) and (9) yield

$$\pi_1'(M) = \frac{\delta_1}{2M^2} < \pi_2'(M) = \frac{\delta_2}{2M^2}, \quad (15)$$

$$\pi_2'(W^*) = \pi_3'(W^*) = \frac{\delta_3}{2W^{*2}}, \quad (16)$$

$$\pi_3'(\overline{W}) = \frac{\delta_4}{2\overline{W}^2}, \tag{17}$$

and

$$\pi_4'(\overline{W}) = \frac{\delta_5}{2\overline{W}^2} \tag{18}$$

where

$$\delta_1 = 2S - D(h + pI_e + pI_e^2 M)M^2 \tag{19}$$

$$\delta_2 = 2S + pI_e^2 DM^3 - D(h - pI_e + 2CI_e)M^2 \tag{20}$$

$$\delta_3 = 2S + pI_e^2 DM^3 - D(h - pI_e + 2CI_e)W^{*2} \tag{21}$$

$$\begin{aligned}\delta_4 = {} & 2S + \frac{pI_e^2 DM^4}{4}(I_1 - I_e) + pDM^2(I_1 - I_e) + pDI_1 I_e M^3 \\ & + D[\frac{C^2(I_e - I_1)}{p} - (h + 2CI_e - pI_e)]\overline{W}^2\end{aligned} \tag{22}$$

and

$$\delta_5 = 2S - pI_e DM^2 - 2I_1(N - M)pDM(1 + \frac{I_e M}{2}) - Dh\overline{W}^2 \tag{23}$$

Furthermore, we obtain that $\delta_1 < \delta_2$, $\delta_2 > \delta_3 > \delta_4$ and $\delta_2 > \delta_5$. In addition, let T_i^* denote the optimal solution of $\pi_i(T)$ on $T > 0$ if T_i^* exists for $i = 1, 2, 3$ and 4. The objective is to find the optimal replenishment time T^* to maximize the average profit per unit time $\pi(T)$ of the retailer. Eqs. 1(a, b, c, d) imply

$$\pi(T^*) = \max imize\{\pi_1(T_1^*), \pi_2(T_2^*), \pi_3(T_3^*), \pi_4(T_4^*)\}$$

where

$$\pi_1(T_1^*) = \max imize\{\pi_1(T) : 0 < T \le M\}$$

$$\pi_2(T_2^*) = \max imize\{\pi_2(T) : M \le T \le W^*\}$$

$$\pi_3(T_3^*) = \max imize\{\pi_3(T) : W^* \le T \le \overline{W}\}$$

$$\pi_4(T_4^*) = \max imize\{\pi_4(T) : \overline{W} \le T\}$$

From the above arguments, we have the following results:

Theorem 1 : Suppose that $\delta_4 \le \delta_5$, the maximizes the annual total profit $\pi(T)$ is given as follows:

(1) If $\delta_5 \ge 0$, $\delta_4 \ge 0$, $\delta_3 \ge 0$, $\delta_2 \ge 0$, and $\delta_1 \ge 0$, then T^* is $\overline{W}$ or T_4^* associated with the most profit.

(2) If $\delta_5 \ge 0$, $\delta_4 \ge 0$, $\delta_3 \ge 0$, $\delta_2 \ge 0$, and $\delta_1 < 0$, then T^* is T_1^*, $\overline{W}$ or T_4^* associated with the most profit.

(3) If $\delta_5 \ge 0$, $\delta_4 < 0$, $\delta_3 \ge 0$, $\delta_2 \ge 0$, and $\delta_1 \ge 0$, then T^* is T_3^* or T_4^* associated with the most profit.

(4) If $\delta_5 \ge 0$, $\delta_4 < 0$, $\delta_3 \ge 0$, $\delta_2 \ge 0$, and $\delta_1 < 0$, then T^* is T_1^*, T_3^* or T_4^* associated with the most profit.

(5) If $\delta_5 \ge 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \ge 0$, and $\delta_1 \ge 0$, then T^* is T_2^* or T_4^* associated with the most profit.

(6) If $\delta_5 \ge 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \ge 0$, and $\delta_1 < 0$, then T^* is T_1^*, T_2^* or T_4^* associated with the

most profit.

(7) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is T_3^*.

(8) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^* or T_3^* associated with the most profit.

(9) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is T_2^*.

(10) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^* or T_2^* associated with the most profit.

(11) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 < 0$, and $\delta_1 < 0$, then T^* is T_1^*.

Theorem 2 : Suppose that $\delta_4 > \delta_5$, the maximizes the annual total profit $\pi(T)$ is given as follows:

(1) If $\delta_5 \geq 0$, $\delta_4 \geq 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is $\overline{W}$ or T_4^* associated with the most profit.

(2) If $\delta_5 \geq 0$, $\delta_4 \geq 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^*, $\overline{W}$ or T_4^* associated with the most profit.

(3) If $\delta_5 < 0$, $\delta_4 \geq 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is $\overline{W}$.

(4) If $\delta_5 < 0$, $\delta_4 \geq 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^* or $\overline{W}$ associated with the most profit.

(5) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is T_3^*.

(6) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 \geq 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^* or T_3^* associated with the most profit.

(7) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \geq 0$, and $\delta_1 \geq 0$, then T^* is T_2^*.

(8) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 \geq 0$, and $\delta_1 < 0$, then T^* is T_1^* or T_2^* associated with the most profit.

(9) If $\delta_5 < 0$, $\delta_4 < 0$, $\delta_3 < 0$, $\delta_2 < 0$, and $\delta_1 \geq 0$, then T^* is T_1^*.

4. Conclusions

In this paper, we have considered another kind of two-level trade credit to reflect the real-life situations in which the supplier offers two levels of trade credit and the retailer can decide to pay off the unpaid balance either after M but before N or after N when the retailer cannot pay off the unpaid balance at the end of M. Theorems 1 and 2 are proposed to characterize the optimal solution under different conditions. Finally, numerical examples are given to illustrate the theoretical results.

5. 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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科技部補助計畫衍生研發成果推廣資料表

日期:2015/09/07

科技部補助計畫	計畫名稱: 供應鏈中在供應商提供不同的兩階延遲付款以及零售商的營運資金有限,倉儲空間有限下的最佳訂購策略
	計畫主持人: 廖瑞容
	計畫編號: 103-2221-E-263-001- 學門領域: 作業研究

無研發成果推廣資料

103 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：103-2221-E-263-001-

計畫名稱：供應鏈中在供應商提供不同的兩階延遲付款以及零售商的營運資金有限,倉儲空間有限下的最佳訂購策略

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	0	1	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%	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	

科技部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

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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

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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）

本研究探討當零售商因供應商提供延遲付款期限(permissible delay in payments)而訂購大批量貨品時，超過自有倉庫最大容量的部分，便需向外租用倉庫儲存。另考慮一實務觀點，為了鼓勵零售商訂購更多的數量，供應商會提供兩個不同的延遲付款期限，但零售商的營運資金是有限的，故在考慮短期融資時，零售商該如何使用免費的信用部份以及付費的信用部份。因此，本計劃結合上述觀點，發展一更符合供應鏈實務的模式，以此模式加以探討不同二階信用交易條件下零售商之訂購策略，期盼此研究成果可供學術界及實務界之參考。本計劃所得之存貨模式，將在零售商之最高的每年總相關利潤條件下，求取零售商最佳之訂購策略，並將導出一簡單有效的最佳訂購策略的決定程序。