科技部補助專題研究計畫成果報告
期末報告

以折現現金流分析各種支付方案下退化性商品的訂價和生產策略

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本研究具有政策應用參考價值：■否 □是，建議提供機關
（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
本研究具影響公共利益之重大發現：□否 □是

中 華 民 國 109 年 04 月 17 日

中 文 摘 要 ： 實際的交易市場中，存在不同的付款方式:為刺激買氣，鼓勵消費，供應商往往會提供允許延遲付款的優惠給購買者；為避免被拖欠貨款，降低或控制違約風險，供應商亦常會要求購買者在貨物送達前提前付款，或是在貨物送達當下，立即以現金方式支付貨款。本研究計畫將針對製造商的生產-行銷管理問題，在追求折現利潤最大的前提下，探討當原料供應商對製造商提出部分貨款須提前支付，部分貨款須當場現金支付，及部分貨款給予延遲付款優惠的付款方式；而製造商亦提供部分延遲付款給其顧客的情況下，製造商該如何擬訂其生產計畫。本研究探討的產品是退化性產品，且假設產品的市場需求受到產品的價格與產品的新鮮度影響。因此，製造商在擬定生產策略時，須同時訂定產品的銷售價格，使其折現總利潤達到最大。針對上述的討論主題，本研究計畫將構建一數學模式，藉由模式的求解，提出使製造商每年折現總利潤達到最大下的最佳定價及生產策略。接著，利用數值範例和敏感度分析，分別探討當原料供應商提出不同條件的付款方式時，對製造商的訂價策略、生產計劃及總折現利潤的影響。最後，說明其在管理上的運用及意涵。

中文關鍵詞： 預先付款；現金付款；延遲付款；折現現金流

英 文 摘 要 ： There are some different payment schemes in today’s business transaction. To simulate sales and encourage customers, most suppliers usually offer their buyers a delay period in payment. On the contrary, some suppliers frequently ask their buyers to pay the purchasing cost in a fixed period before the date of delivery, or to pay the purchasing cost at the time of delivery, in order to lower or control default risks. In this project, we assume that the demand rate is a function of selling price and product freshness. The study will consider that the supplier provides various payment terms including advance payment, cash payment and credit payment to a manufacturer, as well as, the manufacturer also grants customers a partial downstream credit period. In this project, we will discuss that a manufacturer how to determine the optimal selling price and production plan for the perishable items, in order to maximize the present value of total annual profit under the various payment terms by the supplier. According to the above assumptions and conditions, this project will establish a new mathematical model to find the optimal selling price and production plan. Next, numerical examples are provided to illustrate the solution procedure. Finally, sensitivity analysis is carried out to investigate critical parameters and to discuss the managerial implication for the optimal solution.

英文關鍵詞： advance payment; cash payment; credit payment; discounted cash-flow

1. Introduction

It is a well-known fact that demand of a perishable product (e.g., vegetables, fruits, baked goods, fashion merchandise, etc.) is declining over time due to loss of freshness and quality. To quantify this phenomenon, Ghare and Schrader (1963) investigated an EOQ model with a constant rate of deterioration. Covert and Philip (1973) then expanded the constant rate of deterioration to a Weibull deterioration rate. Research publications in this field are very extensive. The reader is referred to the works of Raafat (1991), Goyal and Giri (2001), Bakker et al. (2012), and Pahl and Voß (2014). For today's health-conscious consumers, product freshness is an important factor in purchasing decisions. Product freshness degenerates over time and reaches zero at the expiration date. As a result, today's health-conscious consumers prefer a product further from its expiration date because it is fresher and can be stored longer. Sarkar (2012) proposed that deterioration rate reaches 100% at the expiration date. There are numerous other models for perishable goods that consider product freshness linked to expiration date, such as Dye et al. (2014), Teng et al. (2016), Wang et al. (2014), and Wu et al. (2014, 2017).

Both sellers and buyers use a variety of payment schemes to settle their business transactions of goods and services. Basically, there are three payment types in terms of payment time: (1) cash-on-delivery, in which the buyer pays for goods or services as soon as receiving them (i.e., cash payment), (2) permissible-delay-in-payment, in which the seller offers the buyer a short-term interest-free loan for purchasing goods or services (i.e., credit payment), and (3) cash-in-advance, in which the buyer prepays the seller for goods and services prior to the time of delivery (i.e., advance payment).

Harris (1913) applied a cash payment to determine optimal order quantity for the traditional EOQ model with a constant demand rate. Recently, Chen et al. (2016), and Wu et al. (2016) assumed cash-on-delivery business transactions, and derived optimal order quantity and shelf space for perishable goods when demand is dependent on product freshness and displayed stocks. Likewise, Dobson et al. (2017) obtained the optimal cycle length for perishable products with age-dependent demand rate. Li and Teng (2018) further explored pricing and lot-sizing decisions for perishable goods when demand depends on selling price, reference price, product freshness, and displayed stocks. More recently, Modak and Kelle (2019) expanded the inventory model from a single retail channel to a dual channel including a direct online channel when the stochastic demand depends on price and delivery time.

In review of the literature for inventory models with trade credit financing, Grubbstrom (1980) and Teng (2002) explored optimal order quantity under conditions of permissible-delay-in-payment. Chang et al. (2010) studied optimal order policies for deteriorating items in which the seller offers the buyer a permissible-delay-in-payment if the buyer's order quantity is greater than or equal to a predetermined quantity. Currently, Wu et al. (2018) developed optimal inventory policies for perishable products in which the supplier offers an upstream trade credit to the retailer and the retailer grants a downstream trade credit to customers (i.e., a two-level trade credit). Feng and Chan (2019) expanded the two-level trade credit to include joint pricing and production decisions for new products with pronounced learning-by-doing phenomenon.

Zhang (1996) proposed an advance payment for a customer to save time and money by prepaying a larger payment than the small billed amount. In addition, to avoid order cancellations, a seller frequently demands some payment when a buyer places an order. Maiti et al. (2009) compared the results for models with and without advance payment and concluded that it is more profitable to use advance payment than not. Mateut and Zanchettin (2013) found evidence that advance payments may signal buyer creditworthiness. Zhang et al. (2014) provided another benefit for the seller to ask for an advance payment, to avoid the risk of buyer's order cancellation. Taleizadeh (2017) discussed an inventory model with an advance payment when the retailer may face disruptions, in which the common decisions do not lead to optimality.

In addition, some schoolars proposed a combination of cash, credit and advance payments to reflect all kinds fo business situations. For examples, Teng (2009) proposed a cash-credit payment in which a buyer must pay some cash when placing an order and then pay the remainder in credit. Taleizadeh (2014) used an advance-cash payment to study the situation in which a gasoline supplier asks a gas station to prepay a portion of the purchasing cost when placing an order and to pay the remainder in cash-on-delivery. Eck et al. (2015) argued that firms choose cash-in-advance because it serves as a quality signal in international trade that helps to alleviate financial constraints. Teng et al. (2016) further expanded the model from an indefinitely constant deterioration rate to a definite time-varying deterioration rate linked to product expiration date. No studies in the existing literature have studied an ACC payment scheme until now, it is commonly used in business transactions. In the literature, Li et al. (2017, 2018) developed the pricing and lot-sizing EOQ model with ACC payments and without shortages. In this paper, we further expand the inventory model from an EOQ model to an EPQ model. In summary, a brief comparison among the above mentioned models is given in Table 1.

It is well-known in economics and marketing theory that the lower the price, the higher the demand. Thus, price is an important factor in consumers' purchasing decisions. Begum et al. (2012) developed an EOQ model for deteriorating items when demand is an exponential function of price and deterioration is a three-parameter Weibull distribution. Ghasemy Yaghin et al. (2014) expanded the pricing and lot-sizing model from an exponential demand to a logit demand function. Feng et al. (2017) further explored pricing and lot-sizing policies for perishable goods when demand is a function of selling price, displayed stocks and expiration date. Otrodi et al. (2019) investigated the pricing and lot-sizing problem for perishable items with multiple demand classes. Hence, we develop an EPQ model in a three-echelon supplier-manufacturer-customer chain in which (1) the manufacturer simultaneously determines selling price, production run time and replenishment cycle time as decision variables to maximize the present value of total annual profit, (2) the manufacturer sells a perishable product that degrades over time and cannot be sold after its expiration date, (3) the supplier demands the manufacturer use an ACC payment type while the manufacturer grants customers a cash-credit payment scheme, and (4) for generality, a discounted cash-flow analysis is used to reflect time value of money.

2. Notations and assumptions

The following notation and assumptions are used in the entire study.

2.1. Notation

P	production rate
v	purchasing cost of raw materials per unit in dollars, $v > 0$
α	proportion of purchasing cost to be paid in advance, $0 \leq \alpha \leq 1$
β	proportion of purchasing cost to be paid at the time of delivery, $0 \leq \beta \leq 1$
τ	proportion of purchasing cost granted a permissible delay from the supplier to the manufacturer, $0 \leq \tau \leq 1$ and $\alpha + \beta + \tau = 1$
ρ	proportion of sales revenue offered a permissible delay by the manufacturer to customers, $0 \leq \rho \leq 1$
M	upstream credit period by the supplier to the manufacturer, $M \geq 0$
N	downstream credit period by the manufacturer to customers, $N \geq 0$
r	compound interest paid per dollar per year
A	total purchasing cost of raw materials in dollars when placing an order at time $-l$
l	length of time in years during which the prepayments are paid, $l > 0$
c	production cost excluding purchasing cost per unit in dollars, $c > 0$
h	holding cost excluding interest charge per unit per year in dollars, $h > 0$

I_c interest charged by the supplier per dollar per year

I_e interest earned per dollar per year

m time to the expiration date or the maximum lifetime of product in years, *m* > 0

O ordering cost in dollars per order, *O* > 0

K setup cost in dollars per production run, *K* > 0

t_1 length of time in years during production run (decision variable)

s selling price per unit in dollars, *s* > (*v*+*c*) > 0 (decision variable)

D(*s*) annual demand rate, where $D'(s) < 0$ and $D''(s) > 0$

t time in years, $t \geq 0$

$\theta(t)$ degrading rate at time *t*, $0 \leq \theta(t) \leq 1$, $\theta'(t) \geq 0$, and $\theta(m) = 1$

$I(t)$ inventory level in units at time *t*

T length of cycle time in years, $T \leq m$ (decision variable)

PTP present value of total annual profit in dollars

Next, the necessary assumptions to build the mathematical model are given below.

2.2. Assumptions

When the purchasing cost of raw materials is high, the supplier usually demands the manufacturer pay the purchasing cost in an ACC payment scheme: (*i*) prepay α fraction of purchasing cost *A* (i.e., αA) in *l* years prior to the time of delivery, (*ii*) pay another β percentage of purchasing cost (i.e., βA) at the time of delivery (i.e., *t* = 0), and (*iii*) offer an upstream credit period of M years on the remaining τ portion of purchasing cost (i.e., τA), where $0 \leq \alpha, \beta, \tau \leq 1$, and $\alpha + \beta + \tau = 1$.

Likewise, the manufacturer also offers customers a partial downstream trade credit, in which a customer is granted a credit period of N years on ρ fraction of sales and pays the remainder (i.e., $1-\rho$ fraction of sales) in cash.

Based on traditional marketing and economic theory, the higher the price, the lower the demand. Hence, the selling price is a critical factor affecting demand. For generality, we assume that the demand function *D*(*s*) exists with $D'(s) < 0$ and $D''(s) > 0$.

A perishable product degrades (or deteriorates) gradually over time and reaches 100% at its expiration date. For generality, it is assumed that the time-varying rate of deterioration $\theta(t)$ at time *t*, $0 \leq t \leq m$, satisfies the following conditions:

$$0 \leq \theta(t) \leq 1, \quad \theta'(t) \geq 0, \text{ and } \theta(m) = 1. \tag{1}$$

Furthermore, we assume shortages are not allowed, and hence production rate

P is larger than the sum of demand rate *D*(*s*) and rate of degrading $\theta(t)$ at any time (i.e., $P > D(s) + \theta(t)$, for any *s* and *t*).

Since the product cannot be sold after its expiration date, it is assumed without loss of generality that $N \leq m$, $M \leq m$, and $T - t_1 \leq m$.

There is no replacement, repair, financing, or salvage value of perished items during the production cycle [0, *T*]. The replenishment rate of raw materials is infinite.

3. Mathematical model

Given the above notation and assumptions, the proposed EPQ inventory model for perishable products is described as follows. The manufacturer pays the supplier α proportion of the purchasing cost *A* in *l* years prior to the time of delivery. When all raw materials have arrived then the production process starts at time 0. A constant production rate *P* is considered during the production time [0, t_1]. The maximum level of on-hand inventory is shown at time t_1. The accumulated inventory is then gradually depleted to zero at time *T* due to the combination of demand and deterioration. Then the production cycle repeats. Consequently, the inventory level at time *t* is governed by the following differential equations:

$$\frac{dI_1(t)}{dt} = P - D(s) - \theta(t) I_1(t), \; 0 < t < t_1, \tag{2}$$

$$\frac{dI_2(t)}{dt} = -D(s) - \theta(t) I_2(t), \; t_1 < t < T, \tag{3}$$

with boundary conditions $I_1(0) = 0$, $I_2(T) = 0$ and $I_1(t_1) = I_2(t_1)$.

The solutions of the above differential equations are:

$$I_1(t) = e^{-\phi(t)} \int_0^t [P - D(s)] e^{\phi(v)} dv, \quad 0 \leq t \leq t_1, \tag{4}$$

$$I_2(t) = e^{-\phi(t)} \int_t^T D(s) e^{\phi(v)} dv, \quad t_1 \leq t \leq T, \tag{5}$$

and

$$\int_0^{t_1} [P - D(s)] e^{\phi(v)} dv \quad = \quad \int_{t_1}^T D(s) e^{\phi(v)} dv, \tag{6}$$

where

$\phi(t) = \int_0^t \theta(v) dv$ is a non-decreasing function of *t*, $0 \leq t \leq T$. (7)

The manufacturer's ordering time for raw materials is l years prior to the time of delivery 0. So, the present value of ordering cost (*OC*) at time 0 is:

$$OC = O e^{rl}. \quad (8)$$

On the other hand, the manufacturer sets up the manufacturing equipment at time 0, hence, the present value of setup cost (*KC*) at time 0 is

$$KC = K. \quad (9)$$

The manufacturer's present value of sales revenue (*SR*) per cycle time *T* is as follows:

$$SR = s\rho\int_{N}^{T+N} D(s)e^{-rt}dt + s(1-\rho)\int_{0}^{T} D(s)e^{-rt}dt. \quad (10)$$

The manufacturer's present value of production cost (PC_1) per cycle time *T* is as follows:

$$PC_1 = c\int_{0}^{t_1} Pe^{-rt}dt. \quad (11)$$

The purchasing cost of raw materials without considering time value of money is given by:

$$A = v\int_{0}^{t_1} P\,dt = vPt_1. \quad (12)$$

Payments for the purchasing cost of raw materials is made up of three parts: (1) the advance payment with proportion α at l years before time 0, (2) the cash payment with proportion β at time 0, and (3) the credit payment with proportion τ at time *M*, where $\alpha + \beta + \tau = 1$. Hence, the present value of purchasing cost of raw materials (PC_2) is given as:

$$PC_2 = \alpha A e^{rl} + \beta A + \tau A e^{-rM} = A(\alpha e^{rl} + \beta + \tau e^{-rM}) = vPt_1(\alpha e^{rl} + \beta + \tau e^{-rM}). \quad (13)$$

The present value of the holding cost (*HC*), excluding interest charged per cycle time *T*, is as follows:

$$HC = h\left[\int_{0}^{t_1} I_1(t)\, e^{-rt}dt + \int_{t_1}^{T} I_2(t)\, e^{-rt}dt\right]. \quad (14)$$

As for the credit payment, from the values of upstream and dowstream credit periods *M* and *N*, there are two potential cases: (1) $N \le M$, and (2) $N \ge M$. Let us discuss them accordingly. (See Reference Chang et al. (2019), the following results is obtained.)

3.1. Case 1 of $N \le M$

3.1.1. Sub-case 1.1 of $N \le M$ and $M \le T + N$

The present value of total annual profit is given by:

$$PTP_1(s,t_1,T)=\frac{1}{T}(SR-OC-KC-PC_1-PC_2-HC-CC_1)$$

$$=\frac{1}{T}\Big\{s\rho D(s)\int_N^{T+N} e^{-rt}dt+s(1-\rho)\int_0^T D(s)e^{-rt}dt$$

$$-Oe^{rl}-K-c\int_0^{t_1} Pe^{-rt}dt-vPt_1(\alpha e^{rl}+\beta+\tau e^{-rM})$$

$$-h\left[[P-D(s)]\int_0^{t_1}\int_0^{t} e^{\phi(v)-\phi(t)-rt}dvdt+D(s)\int_{t_1}^{T}\int_t^{T} e^{\phi(v)-\phi(t)-rt}dvdt\right]$$

$$-vPt_1 I_c\left[\int_{-l}^{N}\alpha e^{-rt}dt+\int_0^N \beta e^{-rt}dt\right]-(\alpha+\beta)vPt_1 I_c\int_N^{T+N}[(T+N-t)/T]e^{-rt}dt$$

$$-\tau(v+c)D(s)I_c\left[\rho\int_M^{T+N}(T+N-t)e^{-rt}dt+(1-\rho)\int_M^{T}(T-t)e^{-rt}dt\right]$$

$$+sD(s)I_e\left[\rho\int_N^{M}(t-N)e^{-rt}dt+(1-\rho)\int_0^{M} t e^{-rt}dt\right]\Big\}. \qquad (15)$$

3.1.2. Sub-case 1.2 of $N \le M$ and $M \ge T+N$

The present value of total annual profit is obtained as:

$$PTP_2(s,t_1,T)=\frac{1}{T}(SR-OC-KC-PC_1-PC_2-HC-CC_2)$$

$$=\frac{1}{T}\Big\{s\rho D(s)\int_N^{T+N} e^{-rt}dt+s(1-\rho)\int_0^T D(s)e^{-rt}dt$$

$$-Oe^{rl}-K-c\int_0^{t_1} Pe^{-rt}dt-vPt_1(\alpha e^{rl}+\beta+\tau e^{-rM})$$

$$-h\left[[P-D(s)]\int_0^{t_1}\int_0^{t} e^{\phi(v)-\phi(t)-rt}dvdt+D(s)\int_{t_1}^{T}\int_t^{T} e^{\phi(v)-\phi(t)-rt}dvdt\right]$$

$$-vPt_1 I_c\left[\int_{-l}^{N}\alpha e^{-rt}dt+\int_0^N \beta e^{-rt}dt\right]-(\alpha+\beta)vPt_1 I_c\int_N^{T+N}[(T+N-t)/T]e^{-rt}dt$$

$$+\rho sD(s)I_e\left[\int_N^{T+N}(T+N-t)e^{-rt}dt+\int_{T+N}^{M} Te^{-rt}dt\right]$$

$$+(1-\rho)sD(s)I_e\left[\int_0^{T}(T-t)e^{-rt}dt+\int_T^{M} Te^{-rt}dt\right]\Big\}. \qquad (16)$$

3.2. Case 2 of $N \ge M$

The present value of total annual profit is as follows:

$$PTP_3(s,t_1,T)=\frac{1}{T}(SR-OC-KC-PC_1-PC_2-HC-CC_3)$$

$$=\frac{1}{T}\Big\{s\rho D(s)\int_N^{T+N} e^{-rt}dt+s(1-\rho)\int_0^T D(s)e^{-rt}dt$$

$$-Oe^{rl}-K-c\int_0^{t_1} Pe^{-rt}dt-vPt_1(\alpha e^{rl}+\beta+\tau e^{-rM})$$

$$-h\left[[P-D(s)]\int_0^{t_1}\int_0^{t} e^{\phi(v)-\phi(t)-rt}\,dv dt + D(s)\int_{t_1}^{T}\int_t^{T} e^{\phi(v)-\phi(t)-rt}\,dv dt\right]$$

$$-vPt_1 I_c\left[\int_{-l}^{N}\alpha\, e^{-rt}dt + \int_0^{N}\beta\, e^{-rt}dt\right] - (\alpha+\beta)vPt_1 I_c\int_N^{T+N}[(T+N-t)/T]e^{-rt}dt$$

$$-\tau(v+c)D(s)I_c\left[\rho\left(\int_M^N T e^{-rt}dt + \int_N^{T+N}(T+N-t)e^{-rt}dt\right)(1-\rho)\int_M^T (T-t)e^{-rt}dt\right]\Bigg\}. \quad (17)$$

4. Theoretical results

In order to determine the optimal selling price s^*, production time t_1^*, and cycle time T^* which maximize the present value of total profit $PTP(s,t_1,T)$, we first find the optimal solutions for every case, respectively. Due to the complexity of the problem, we are unable to prove the present value of total profit $PTP(s,t_1,T)$ is joint concave in *s*, t_1, and *T*. However, we are able to prove that (*a*) for any given *s* and t_1, $PTP(s,t_1,T)$ is strictly pseudo-concave in *T*, and has a unique maximum solution at the critical point, and (*b*) for any given *T*, $PTP(s,t_1,T)$ is joint concave in both *s* and t_1 under certain conditions. We have the following theoretical results.

Theorem 1.

(1) For any given *T*, if $2D'(s)+sD''(s)<0$, $h>rc$, and the determinant of Hessian Matrix is positive, then $PTP_1(s,t_1,T)$ is joint concave in *s* and t_1.

(2) For any given *s* and t_1, $PTP_1(s,t_1,T)$ is strictly pseudo-concave in *T*, and hence has a unique global optimal solution T_1^*.

Theorem 2.

(1) For any given *T*, if $2D'(s)+sD''(s)<0$, $h>rc$, and the determinant of Hessian Matrix is positive, then $PTP_2(s,t_1,T)$ is joint concave in *s* and t_1.

(2) For any given *s* and t_1, if $rT<1$, then $PTP_2(s,t_1,T)$ is strictly pseudo-concave in *T*, and hence has a unique global optimal solution T_2^*.

Theorem 3.

(1) For any given T, if $2D'(s)+sD''(s)<0$, $h>rc$, and the determinant of Hessian Matrix is positive, then $PTP_3(s,t_1,T)$ is joint concave in s and t_1.

(2) For any given s and t_1, $PTP_3(s,t_1,T)$ is strictly pseudo-concave in T, and hence has a unique global optimal solution T_3^*.

5. Numerical examples

Example 1. The case of $N \le M$. The following parameter values are assumed: $D(s)=2000e^{-0.05S}$, $\theta(t)=t/m$, $\alpha=0.2$, $\beta=0.2$, $\tau=0.6$, $\rho=0.4$, annual production rate P =500 units, purchasing cost of raw materials v = \$8, unit production cost c = \$6, holding cost h = \$5 per unit per year, lead time l = 0.1 years, maximum lifetime m = 1.0 years, setup cost K = \$50 per production run, ordering cost O = \$20 per order, annual compounded interest rate r = 0.04 per dollar, downstream credit period $N=0.25$ years, upstream credit period M = 0.3 years, interest rate charged I_c = 0.05 per dollar per year, and interest rate earned I_e = 0.04 per dollar per year.

Using Theorems 1 and 2, the optimal solutions to $PTP_1(s,t_1,T)$ in (18) and $PTP_2(s,t_1,T)$ in (20) are obtained respectively as follows:

s_1 = \$34.88, t_{11} = 0.877271 years, T_1 = 1.47017 years, and $PTP_1(s_1,t_{11},T_1)$ = \$7282.53. s_2 = \$33.91, t_{12} = 0.036695 years, T_2 = 0.05 years, and $PTP_2(s_2,t_{12},T_2)$ = \$5920.33. As a result, the optimal solution to the problem is

s^* = s_1 = \$34.88, t_1^* = t_{11} = 0.877271 years, T^* = T_1 = 1.47017 years, and PTP^* = $PTP_1(s_1,t_{11},T_1)$ = \$7282.53.

Example 2. The case of $N \ge M$. It is assumed that all parameters here are the same as those in Example 1 except downstream credit period $N=0.35$ years, and upstream credit period M = 0.25 years. Applying Theorem 3, the optimal solution to $PTP_3(s,t_1,T)$ is determined as follows:

s^* = s_3 = \$34.97, t_1^* = t_{13} = 0.835538 years, T^* = T_3 = 1.39597 years, and PTP^* = $PTP_3(s_3,t_{13},T_3)$ = \$7051.35

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107年度專題研究計畫成果彙整表

計畫主持人：張春桃	計畫編號：107-2410-H-032-031-
計畫名稱：以折現現金流分析各種支付方案下退化性商品的訂價和生產策略	

成果項目			量化	單位	質化（說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文	0	篇	
		研討會論文	0		
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
國外	學術性論文	期刊論文	1	篇	Manufacturer's pricing and lot-sizing decisions for perishable goods under various payment terms by a discounted cash flow analysis. International Journal of Production Economics, 218, 83-95.
		研討會論文	0		
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
參與計畫人力	本國籍	大專生	0	人次	
		碩士生	4		聘用楊士白、陳柏瑋、王秋豐及黃佩新4位碩士班研究生擔任兼任助理。
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
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。）					