行政院國家科學委員會專題研究計畫 成果報告

考慮外包生產下的二階存貨模式(I)
研究成果報告(精簡版)

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執 行 單 位 ： 致理技術學院企業管理系(科)

計 畫 主 持 人 ： 滕慧敏
共 同 主 持 人 ： 許炳輝
計畫參與人員： 大專生-兼任助理人員：黃筱涵

報 告 附 件 ： 出席國際會議研究心得報告及發表論文

公 開 資 訊 ： 本計畫可公開查詢

中 華 民 國 101 年 09 月 06 日

中 文 摘 要 ： 越來越多的企業決策者了解到外包可以提昇競爭力，也可以維持企業的發展，將其周邊的業務及日常事物等非核心業務予以外包，只保留最精簡的人力及核心專長，來創造最高的經營績效。藉由產品的外包途徑，將可以使企業提升服務價值、提高服務速率及降低服務成本，企業也可藉由外包途徑，使自身資源專注於核心事業(Core Business)、降低企業總營運成本，以創造價值。外包對企業總體競爭力的提升，扮演關鍵性的角色及地位，所以「自製」或「外包」是企業極為重要的課題。

本研究目的係將不同需求型態分別導入存貨模式，探討在兩階供應鏈的生產系統中，考慮「自製」或「外包」的最佳策略。研究方法主要採用存貨理論模式進行研究，建立問題的數學模式，以利潤最大化（或成本最小化）為目標，運用最佳化理論求出最佳訂購量、最佳缺貨量及最佳訂購期等….。以數值範例說明所建立模型的應用情形，並對重要參數進行敏感度分析。

中文關鍵詞： 存貨控制、供應鏈管理、外包、自製、二階存貨系統、最佳訂購量,機會成本

英 文 摘 要 ： Business decision makers have come to realize that outsourcing can effectively enhance market competitiveness, and sustain the firm’s development. This study considers the trade-off between in-house production and outsourcing in a two-echelon supply chain. The objective is to optimize the total profit per unit time of the system. The deterministic model is developed. Numerical examples and sensitivity analysis are provided for illustration.

英文關鍵詞： Inventory control, outsourcing, in-house production, opportunity cost, supply chain management, two-echelon inventory system

Two-Echelon Inventory Models Considering Outsourcing Policies

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Abstract

Business decision makers have come to realize that outsourcing can effectively enhance market competitiveness, and sustain the firm's development. This study considers the trade-off between in-house production and outsourcing in a two-echelon supply chain. The objective is to optimize the total profit per unit time of the system. The deterministic model is developed. Numerical examples and sensitivity analysis are provided for illustration.

Keywords: Inventory control; Outsourcing; In-house production; Opportunity cost

1. Introduction

Business decision makers have come to realize that outsourcing can effectively enhance market competitiveness, and sustain the firm's development. In doing so, the firm expands outsourcing to products that are near-core but are not in their economic size. In recent years, many firms have undergone a series of transformation such as downsizing and reorganizing, and outsourcing has become one of the most dominant fashions. By outsourcing products, the firm's service value is ameliorated, service speed is elevated, but service cost is reduced. By the same token, the firm can distribute the resources mostly to its core task which reduce its total operating costs and generate greater value. Outsourcing plays a critical role in improving a firm's overall competitiveness. Therefore, it is a critical subject for every firm to trade off between in-house production and outsourcing.

Alvarez and Stenbacka (2007) applied a real options approach to develop a general characterization of a firm's optimal organizational mode. Bengtsson and Berggren (2008) explored the dynamics of outsourcing and production strategies in the telecom equipment industry. Kuo, et al. (2010) considered a three-tier supply chain consisting of an original equipment manufacturer, a contract manufacturer and a supplier to analyze and compare three outsourcing structures. Kaya (2011) considered an outsourcing model in which the supplier makes the effort decision and an in-house production model in which the manufacturer decides on the effort level and compared these two models with each other. Liu and Nagurney (2011) studied the impacts of foreign exchange risk and competition intensity on supply chain companies who were involved in offshore-outsourcing activities. This study considers the trade-off between in-house production and outsourcing in a two-echelon supply chain. The objective is to determine the decision variables and to optimize the total profit per unit time of the system.

2. Assumptions and Notation

The following notations are used throughout this paper:

A_i set-up cost at Stage i (i = 1, 2, 3)

h_i holding cost per unit per unit time at Stage i (i = 1, 2, 3)

d_1 original demand of in-house production per unit time

d_2 original demand of outsourcing per unit time, $d_1 > d_2$; This means that the products from outsourcer sometimes give a harmful impression to customers; In real world, the products are usually marked in the location of manufacturing factory for the customers to distinguish in-house production or outsourcing such as clothes, tennis ball.

r outsourced fraction of demand per unit time ($0 < r < 1$); decision variable

Q order quantity at Stage 1; decision variable

n number of cycles at stage 1, integer; decision variable

C_m in-house production cost per unit(\$ / unit)

C_o outsourcing cost per unit (\$ / unit)

C_p original opportunity cost; including the equipment cost and the management cost for in-house production

p selling price per unit

TR total revenue per unit time

TC total cost per unit time

$T\pi$ total profit per unit time

The model is developed with the following assumptions:

1. The original demand rates of in-house production, d_1, and the original demand rates of outsourcing, d_2, are deterministic.
2. The selling price of all items are the same regardless which is from in-house production or outsourcing.
3. Customer's demand follows a function, $d(r)$, of outsourced fraction of demand, r, such that:

   $$d(r) = (1-r)d_1 + rd_2 .$$

   Since $d_1 > d_2$, it means that more outsourced fraction leads to less customer's demand.
4. The in-house producing units are as new as the outsourcing units.
5. The lead time between Stage 1 and Stage 2 of Figure 1 is assumed to be zero.

3. Model development

In this section, the mathematical model for the problem is developed. The inventory system is referred to Figure 1. A two-echelon inventory system contains a distributor (Stage 1), a warehouse (Stage 2) consisting both an in-house production part shifted from Stage 3 and an outsourcing part, and an in-house production part (Stage 3). The distributor places orders in response to the customer's demand. For each cycle at Stage 1, Q units are ordered from Stage 2. Each cycle at Stage 2 satisfies nQ units of demand from Stage 1. Stage 2 obtains these nQ units from two sources – in-house production and an outsourcing supplier. The cycle length of Stage 2 is $nQ/d(r)$. In each cycle, Stage 2 can receive rnQ units of outsourcing inventory. The remaining $(1 - r)nQ$ units have to be manufactured from the in-house production.

If the inventory level stays positive, the inventory plot at Stage 1 would be shifted by the same amount, and there would be pipeline stock between Stage 1 and Stage 2. Since the pipeline stock cost is not relevant to the model, it would not affect this analysis. From the statement above, one has

The total revenue per unit time

TR = In-house production revenue per unit time+ Outsourcing revenue per unit time

On-hand stock at stage 1

(I)

Q

Time

On-hand and echelon stock at stage 2

2Q

Q

Echelon stock

(II)

Q

Time

On-hand stock at stage 3

2(1-r)Q

2rQ

In-house production

(III)

Time

Figure 1. Inventory system at Stage 1, 2, and 3 under *n*=2.(Please referred to Teng et al., 2011)

$$TR(r,Q) = (p - c_m)(1 - r)d_1 + (p - c_o)rd_2 \,. \tag{1}$$

The total cost per unit time TC = the setup cost per unit time (TC_1) + the holding cost per unit time (TC_2+ TC_3) + the opportunity cost per unit time (TC_4).

(a) For the three stages, the setup cost per unit time can be written as follows:

$$TC_1(Q,r,n) = \frac{A_1[(1-r)d_1 + rd_2]}{Q} + \frac{A_2[(1-r)d_1 + rd_2]}{nQ} + \frac{A_3[(1-r)d_1 + rd_2]}{nQ} \,. \tag{2}$$

(b) Holding cost:

(i) For Stages 2 and 3, the holding cost per unit time is:

$$TC_2(Q,r,n) = \frac{(n-1)Q}{2}h_2 + \frac{(1-r)nQ}{2}h_3 \,. \tag{3}$$

(ii) For Stage 1, the holding cost per unit time is:

$$TC_3(Q) = \frac{Q}{2}h_1 \,. \tag{4}$$

(c) Opportunity cost:

$$\frac{c_p}{1+kr}, \tag{5}$$

where k>0, is a constant. This means the more outsourced fraction of demand, r, leads to less opportunity cost.

From (a), (b), and (c), the total cost per unit time is

$$TC(Q,r,n) = (\frac{A_1}{Q} + \frac{A_2}{nQ} + \frac{A_3}{nQ})[(1-r)d_1 + rd_2] + \frac{Q}{2}h_1 + \frac{(n-1)Q}{2}h_2 + \frac{(1-r)nQ}{2}h_3 + \frac{c_p}{1+kr}. \tag{6}$$

The total profit per unit time is

$$T\pi(Q,r,n) = TR(r) - TC(Q,r,n). \tag{7}$$

The objective is to maximize $T\pi(Q,r,n)$.

4. Optimal solution

Due to the complexity of $T\pi(Q,r,n)$, it is hard to prove the concavity. Accordingly, a solution procedure is developed.

Solution Procedure 1

Step 1. Start with j=1.

Step 2. Set n = j, verify the concavity of $T\pi(Q,r,n)$ with respect to (Q, r) to get the optimal value of (Q_n^*, r_n^*).

Step 3. Use the result in Step 2 to calculate $T\pi(Q_n^*, r_n^*, n)$ by (7).

Step 4. j =j +1, if $\Delta T\pi(Q_n^*, r_n^*, n-1) > 0 > \Delta T\pi(Q_n^*, r_n^*, n)$, where

$\Delta T\pi(Q_n^*, r_n^*, n+1) - \Delta T\pi(Q_n^*, r_n^*, n)$, then go to Step 5. Otherwise go to Step 2.

Step 5. $T\pi(Q_n^*, r_n^*, n)$ is the optimal solution. Stop.

Example 1:

Assuming d_1 =140, d_2=100, p=60, c_m=30, c_o =35, A_1 = 25, A_2 = 100, A_3 = 50, h_1 = 2, h_2 = 1, h_3 = 0.3, c_p =3000, k=9.

For n=2 (n=1 refer to Table 1), one has

$$T\pi(Q,r,n) = 4200 - 1700r - \frac{100(140-40r)}{Q} - \frac{3Q}{2} - 0.3(1-r)Q - \frac{3000}{1+9r}.$$

$$\partial T\pi/\partial Q = \frac{100(140-40r)}{Q^2} - 1.8 + 0.3r.$$

$$\partial T\pi/\partial r = -1700 + \frac{4000}{Q} + 0.3Q + \frac{27000}{(1+9r)^2}.$$

If $0<r<1$, then

$$\text{Hessian matrix value} = \frac{97200000(140-40r)}{Q^3(1+9r)^3} - (\frac{-4000}{Q^2} + 0.3)^2$$

$$\geq \frac{97200000(100)}{Q^3(10)^3} - (\frac{-4000}{Q^2} + 0.3)^2$$

$$= \frac{-0.09Q^4 + 2400Q^2 + 9720000Q - 16000000}{Q^4}.$$

Since the denominator of Hessian matrix value, Q^4 is positive, we only need to estimate the positive interval of numerator ($-0.09\ Q^4+2400\ Q^2+9720000Q-16000000$). From Figure 2, the positive interval is $2<Q<500$. Therefore, the positive-definite Hessian matrix results in optimal (Q_2^*, r_2^*) values as $2<Q<500$ and $0<r<1$. By setting $\partial T\pi/\partial Q = 0$ and $\partial T\pi/\partial r = 0$, one has Q_2*=86.3, r_2*=0.34, and $T\pi$ =\$2590. For n=1, 3, 4, and 5, the solution is listed as follows in Table1:

Table 1. The solution procedure of maximizing $T\pi$.

d_1 =140, d_2=100, p=60, c_m=30, c_o =35, A_1 = 25, A_2 = 100, A_3 = 50, h_1 = 2, h_2 = 1, h_3 = 0.3, c_p =3000, k=9.			
n	Q	r	$T\pi$
1	141.9	0.341	2571
2	**86.3**	**0.341**	**2590***
3	64.2	0.342	2588
4	52.2	0.342	2581
5	44.6	0.343	2571

From Table 1, the optimum is n*=2, Q*=86.3, r*=0.34, and $T\pi$ *=\$2590.

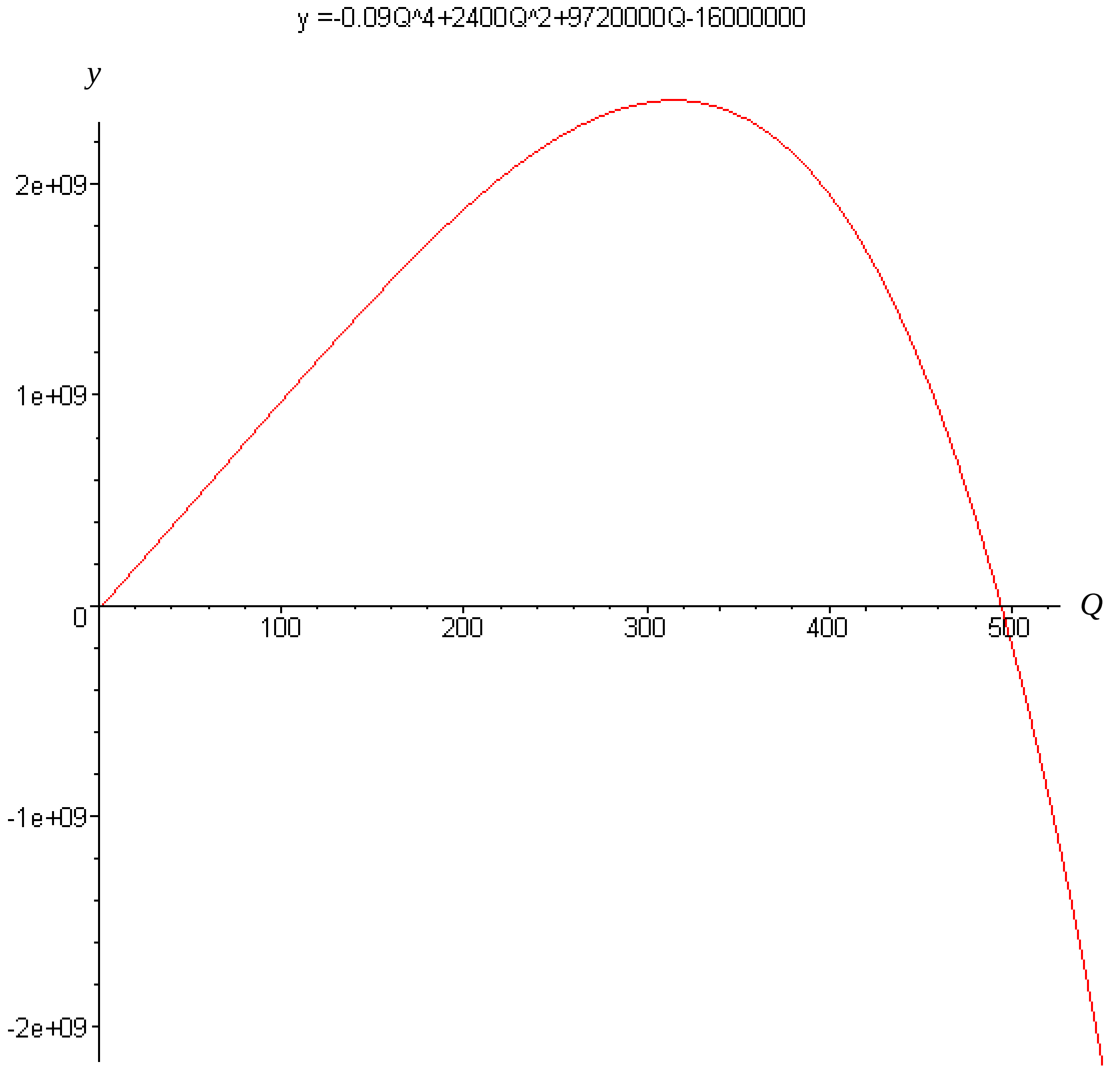


Figure 2. Graph of $y = -0.09\,Q^4+2400\,Q^2+9720000Q-16000000$.

5. Conclusion

Most of the papers available in literature address the problem for outsourcing with empirical research. The literature on model development is very limited. This paper applies the past empirical results to develop a profit model.

In the recent years, due to limited resources, outsourcing plays a critical role in improving a firm's overall competitiveness. The firm can distribute the resources mostly to its core task, reduce its total operating costs and generate greater value. However, there exist both the proposed advantages and the suspected disadvantages of outsourcing. This paper considers the trade-off between in-house producing and outsourcing in a two-echelon supply chain to develop a deterministic model for the system. Solution procedure is developed. Numerical examples and sensitivity analysis are provided for illustration. From sensitivity analysis, we can see the trend of outsourced fraction, r. The results obtained in this paper will provide managerial insights to administrative personnel in decision making. Further research can be done to consider the stochastic demand.

References

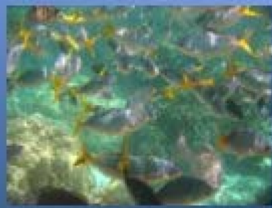
Alvarez, Luis, H. R., & Stenbacka, R. (2007). Partial outsourcing: A real options perspective . *International Journal of Industrial Organization*, 25(1), 91-102.

Bengtsson, L., & Berggren, C. (2008). The integrator's new advantage – The reassessment of outsourcing and production competence in a global telecom firm. *European Management Journal*, 26(5), 314-324.

Guo, p., Song, J. S., & Wang, Y. (2010). Outsourcing structures and information flow in a three-tier supply chain. *International Journal of Production Economics*, 128(1), 175-187.

Kaya, O. (2011). Outsourcing vs. in-house production: a comparison of supply chain contracts with effort dependent demand. *Omega*, 39, 168–178.

Liu, Z., & Nagurney, A. (2011). Supply chain outsourcing under exchange rate risk and competition. *Omega*, 39(5), 539-549.



Agenda

July 16, 2012 (Monday)

Session A2 10:00-12:00 Room: Ming's VIP Room

Session Chair: Yuehjen E. Shao Fu Jen Catholic University

Two-Echelon Inventory Models Considering Outsourcing Policies

Hui-Ming Teng Chihlee Institute of Technology
Ping-Hui Hsu De Lin Institute of Technology

Revisiting An Economic Order Quantity (EOQ) for Items with Imperfect Quality and Inspection Errors

Ping-Hui Hsu De Lin Institute of Technology
Hui-Ming Teng Chihlee Institute of Technology
Hui Ming Wee Chung Yuan Christian University

A Conceptual Model for Mitigating SC Risks

Marivic Villanueva Padilan Chung Yuan Christian University
Hui Ming Wee Chung Yuan Christian University

A Study on Change Point Identification for an Attribute Process

Yuehjen E. Shao Fu Jen Catholic University

Innovative Nurse Scheduling Method for Impartial Schedules

Feng-Cheng Yang National Taiwan University
Wei-Ting Wu National Taiwan University

An Integrated Production-Inventory Model with Imperfect production Processes for Products Sold with Warranty

Kuo-Lung Hou Overseas Chinese University
Yung-Fu Huang Chaoyang University of Technology
Li-Chiao Lin National Chinyi University of Technology

2-rainbow Domination Number on General Graphs

Kung Jui Pai	Ming Chi University of Technology
Cherng Min Ma	Ming Chi University of Technology
Ro Yu Wu	Lunghwa University of Science and Technology

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Hui-Ming Teng

Two-Echelon Inventory Models Considering Outsourcing Policies

In Recognition of Participation and Valuable Contribution

Conference Chair

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Two-Echelon Inventory Models Considering Outsourcing Policies

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Abstract

Business decision makers have come to realize that outsourcing can effectively enhance market competitiveness, and sustain the firm’s development. This study considers the trade-off between in-house production and outsourcing in a two-echelon supply chain. The objective is to optimize the total profit per unit time of the system. The deterministic model is developed. Numerical examples and sensitivity analysis are provided for illustration.

Keywords: Inventory control, outsourcing, in-house production, opportunity cost

1. Introduction

Business decision makers have come to realize that outsourcing can effectively enhance market competitiveness, and sustain the firm's development. In doing so, the firm expands outsourcing to products that are near-core but are not in their economic size. In recent years, many firms have undergone a series of transformation such as downsizing and reorganizing, and outsourcing has become one of the most dominant fashions. By outsourcing products, the firm's service value is ameliorated, service speed is elevated, but service cost is reduced. By the same token, the firm can distribute the resources mostly to its core task which reduce its total operating costs and generate greater value. Outsourcing plays a critical role in improving a firm's overall competitiveness. Therefore, it is a critical subject for every firm to trade-off between in-house production and outsourcing.

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The following notations are used throughout this paper:

A_i set-up cost at Stage i (i = 1, 2, 3)

h_i holding cost per unit per unit time at Stage i (i = 1, 2, 3)

d_1 original demand of in-house production per unit time

d_2 original demand of outsourcing per unit time, $d_1 > d_2$; This means that the products from outsourcer sometimes give a harmful impression to customers; In real world, the products are usually marked in the location of manufacturing factory for the customers to distinguish in-house production or outsourcing such as clothes, tennis ball.

r outsourced fraction of demand per unit time ($0 < r < 1$); decision variable

Q order quantity at Stage 1; decision variable

n number of cycles at stage 1, integer; decision variable

C_m	in-house production cost per unit (\$ / unit)
C_o	outsourcing cost per unit (\$ / unit)
C_p	original opportunity cost; including the equipment cost and the management cost for in-house production
p	selling price per unit
TR	total revenue per unit time
TC	total cost per unit time
$T\pi$	total profit per unit time

The model is developed with the following assumptions:

1. The original demand rates of in-house production, d_1, and the original demand rates of outsourcing, d_2, are deterministic.
2. The selling price of all items is the same regardless which is from in-house production or outsourcing.
3. Customer's demand follows a function, $d(r)$, of outsourced fraction of demand, r, such that:
   $d(r) = (1-r)d_1 + rd_2$
   Since $d_1 > d_2$, it means that more outsourced fraction leads to less customer's demand.
4. The in-house producing units are as new as the outsourcing units.
5. The lead time between Stage 1 and Stage 2 of Figure 1 is assumed to be zero.

3. Model Development

In this section, the mathematical model for the problem is developed. The inventory system is referred to Figure 1. A two-echelon inventory system contains a distributor (Stage 1), a warehouse (Stage 2) consisting both an in-house production part shifted from Stage 3 and an outsourcing part, and an in-house production part (Stage 3). The distributor places orders in response to the customer's demand. For each cycle at Stage 1, Q units are ordered from Stage 2. Each cycle at Stage 2 satisfies nQ units of demand from Stage 1. Stage 2 obtains these nQ units from two sources – in-house production and an outsourcing supplier. The cycle length of Stage 2 is $nQ/d(r)$. In each cycle, Stage 2 can receive rnQ units of outsourcing inventory. The remaining $(1-r)nQ$ units have to be manufactured from the in-house production.

If the inventory level stays positive, the inventory plot at Stage 1 would be shifted by the same amount, and there would be pipeline stock between Stage 1 and Stage 2. Since the pipeline stock cost is not relevant to the model, it would not affect this analysis. From the statement above, one has

The total revenue per unit time

TR = In-house production revenue per unit time + Outsourcing revenue per unit time

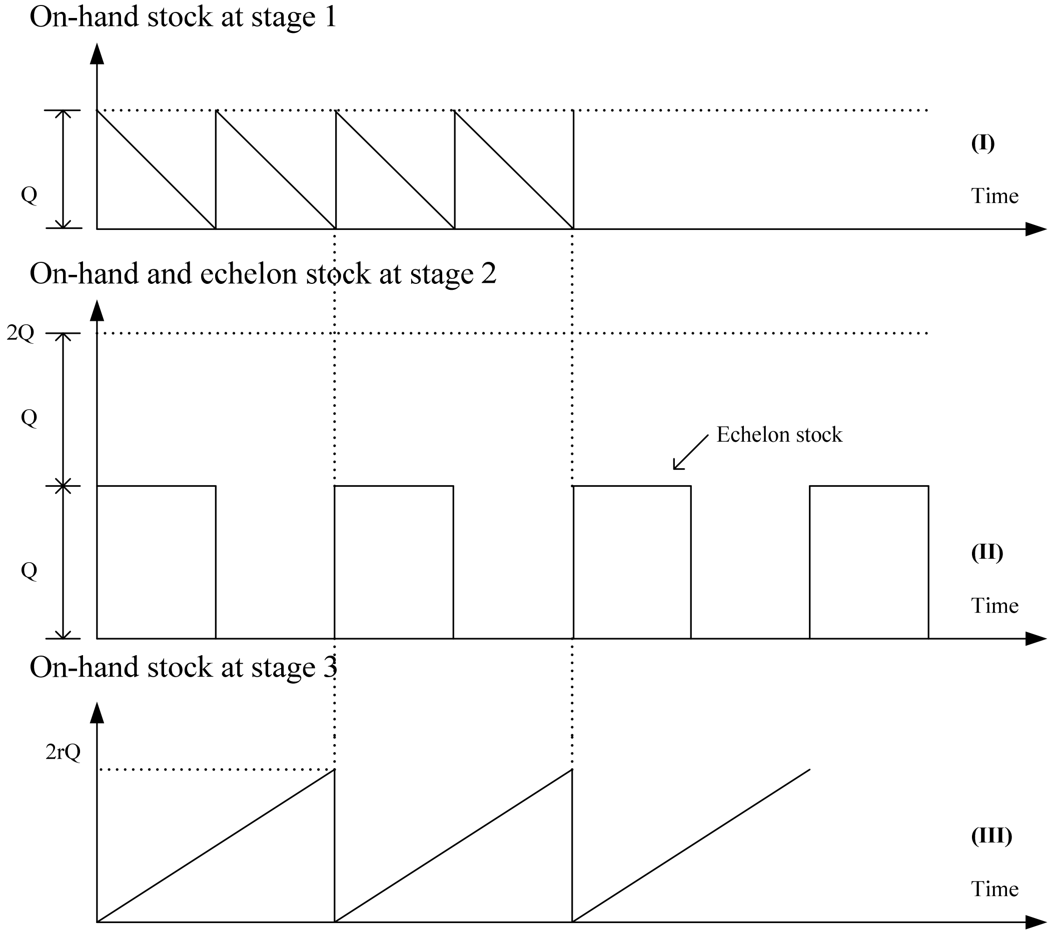

Figure 1: Inventory System at Stage 1, 2, and 3 under *n*=2.
(Please Referred to Teng et al., 2011)

$$TR(r,Q) = (p-c_m)(1-r)d_1 + (p-c_o)rd_2 \quad \text{. ....} \quad (1)$$

The total cost per unit time TC = the setup cost per unit time (TC_1) + the holding cost per unit time (TC_2+ TC_3) + the opportunity cost per unit time (TC_4).

(a) For the three stages, the setup cost per unit time can be written as follows:

$$TC_1(Q,r,n) = \frac{A_1[(1-r)d_1 + rd_2]}{Q} + \frac{A_2[(1-r)d_1 + rd_2]}{nQ} + \frac{A_3[(1-r)d_1 + rd_2]}{nQ} \quad \text{. ....} \quad (2)$$

(b) Holding cost:

(i) For Stages 2 and 3, the holding cost per unit time is:

$$TC_2(Q,r,n) = \frac{(n-1)Q}{2}h_2 + \frac{(1-r)nQ}{2}h_3 \quad \text{. ....} \quad (3)$$

(ii) For Stage 1, the holding cost per unit time is:

$$TC_3(Q) = \frac{Q}{2}h_1 . \qquad (4)$$

(c) Opportunity cost:

$$\frac{c_p}{1+kr}, \qquad (5)$$

where k>0, is a constant. This means the more outsourced fraction of demand, r, leads to less opportunity cost.

From (a), (b), and (c), the total cost per unit time is

$$TC(Q,r,n) = (\frac{A_1}{Q} + \frac{A_2}{nQ} + \frac{A_3}{nQ})[(1-r)d_1 + rd_2] + \frac{Q}{2}h_1 + \frac{(n-1)Q}{2}h_2 + \frac{(1-r)nQ}{2}h_3 + \frac{c_p}{1+kr} . (6)$$

The total profit per unit time is

$$T\pi(Q,r,n) = TR(r) - TC(Q,r,n) . \qquad (7)$$

The objective is to maximize $T\pi(Q,r,n)$.

4. Optimal Solution

Due to the complexity of $T\pi(Q,r,n)$, it is hard to prove the concavity. Accordingly, a solution procedure is developed.

Solution Procedure 1

Step 1. Start with j=1.

Step 2. Set $n = j$, verify the concavity of $T\pi(Q,r,n)$ with respect to (Q, r) to get the optimal value of (Q_n^*, r_n^*).

Step 3. Use the result in Step 2 to calculate $T\pi(Q_n^*, r_n^*, n)$ by (7).

Step 4. j =j +1, if $\Delta T\pi(Q_n^*, r_n^*, n-1) > 0 > \Delta T\pi(Q_n^*, r_n^*, n)$, where $\Delta T\pi(Q_n^*, r_n^*, n+1) - \Delta T\pi(Q_n^*, r_n^*, n)$, then go to Step 5. Otherwise go to Step 2.

Step 5. $T\pi(Q_n^*, r_n^*, n)$ is the optimal solution. Stop.

Example 1:

Assuming d_1 =140, d_2=100, p=60, c_m=30, c_o =35, A_1 = 25, A_2 = 100, A_3 = 50, h_1 = 2, h_2 = 1, h_3 = 0.3, c_p =3000, k=9.

For n=2 (n=1 refer to Table 1), one has

$$T\pi(Q,r,n) = 4200 - 1700r - \frac{100(140-40r)}{Q} - \frac{3Q}{2} - 0.3(1-r)Q - \frac{3000}{1+9r}.$$

$$\partial T\pi / \partial Q = \frac{100(140-40r)}{Q^2} - 1.8 + 0.3r.$$

$$\partial T\pi/\partial r = -1700 + \frac{4000}{Q} + 0.3Q + \frac{27000}{(1+9r)^2}.$$

If 0<r<1, then

$$\text{Hessian matrix value} = \frac{97200000(140-40r)}{Q^3(1+9r)^3} - (\frac{-4000}{Q^2} + 0.3)^2$$

$$\geq \frac{97200000(100)}{Q^3(10)^3} - (\frac{-4000}{Q^2} + 0.3)^2$$

$$= \frac{-0.09Q^4 + 2400Q^2 + 9720000Q - 16000000}{Q^4}.$$

Since the denominator of Hessian matrix value, Q^4 is positive, we only need to estimate the positive interval of numerator (-0.09 Q^4+2400 Q^2+9720000Q-16000000). From Figure 2, the positive interval is 2<Q<500. Therefore, the positive-definite Hessian matrix results in optimal (Q_2^*, r_2^*) values as 2<Q<500 and 0<r<1. By setting $\partial T\pi/\partial Q = 0$ and $\partial T\pi/\partial r = 0$, one has Q_2*=86.3, r_2*=0.34, and $T\pi$ =\$2590. For n=1, 3, 4, and 5, the solution is listed as follows in Table1:

Table 1: The Solution Procedure of Maximizing $T\pi$.

***d_1* =140, *d_2*=100, *p*=60, *c_m*=30, *c_o* =35, *A_1* = 25, *A_2* = 100, *A_3* = 50, *h_1* = 2, *h_2* = 1, *h_3* = 0.3, *c_p* =3000, *k*=9.**			
n	***Q***	***r***	$T\pi$
1	141.9	0.341	2571
2	**86.3**	**0.341**	**2590***
3	64.2	0.342	2588
4	52.2	0.342	2581
5	44.6	0.343	2571

From Table 1, the optimum is n*=2, Q*=86.3, r*=0.34, and $T\pi$ *=\$2590.

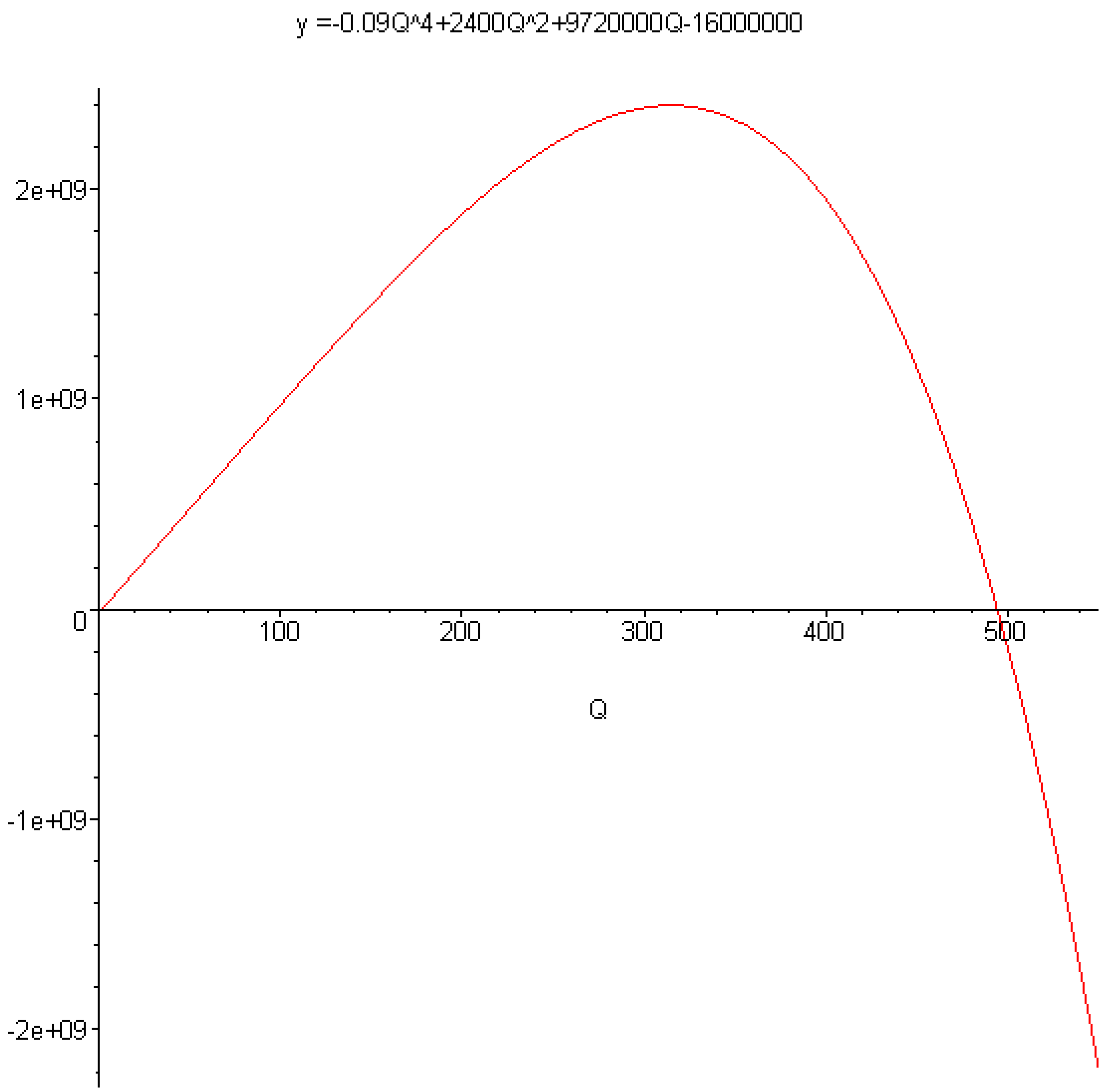

Figure 2: Graph of $y = -0.09\ Q^4 + 2400\ Q^2 + 9720000Q - 16000000$.

5. Conclusion

Most of the papers available in literature address the problem for outsourcing with empirical research. The literature on model development is very limited. This paper applies the past empirical results to develop a profit model.

In the recent years, due to limited resources, outsourcing plays a critical role in improving a firm's overall competitiveness. The firm can distribute the resources mostly to its core task, reduce its total operating costs and generate greater value. However, there exist both the proposed advantages and the suspected disadvantages of outsourcing. This paper considers the trade-off between in-house producing and outsourcing in a two-echelon supply chain to develop a deterministic model for the system. Solution procedure is developed. Numerical examples and sensitivity analysis are provided for illustration. From sensitivity analysis, we can see the trend of outsourced fraction, r. The results obtained in this paper will provide managerial insights to administrative personnel in decision making. Further research can be done to consider the stochastic demand.

References

Alvarez, L H. R., & Stenbacka, R. (2007). Partial outsourcing: A real options perspective. *International Journal of Industrial Organization*, *25*(1), 91-102.

Bengtsson, L., & Berggren, C. (2008). The integrator's new advantage - The reassessment of outsourcing and production competence in a global telecom firm. *European Management Journal*, *26*(5), 314-324.

Guo, P., Song, J. S., & Wang, Y. (2010). Outsourcing structures and information flow in a three-tier supply chain. *International Journal of Production Economics*, *128*(1), 175-187.

Kaya, O. (2011). Outsourcing vs. in-house production: a comparison of supply chain contracts with effort dependent demand. *Omega*, *39*(2), 168-178.

Liu, Z., & Nagurney, A. (2011). Supply chain outsourcing under exchange rate risk and competition. *Omega*, *39*(5), 539-549.

Teng, H. M., Hsu, P. H., Chiu, Y. F., & Wee, H. M. (2011). Optimal ordering decisions with returns and excess inventory. *Applied Mathematics and Computation*, *217*(22), 9009-9018.

附件四

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：101 年 09 月___日

計畫編號	NSC100－2218－E－263－001－		
計畫名稱	考慮外包生產下的二階存貨模式（I）		
出國人員姓名	滕慧敏	服務機構及職稱	致理技術學院企業管理系
會議時間	101 年 07 月 16 日至 101 年 07 月 18 日	會議地點	帛琉共和國
會議名稱	(中文)2012 創新與管理國際研討會 (英文) International Conference on Innovation and Management (IAM 2012)		
發表論文題目	(中文)考慮外包生產策略下的二階存貨模式 (英文)Two - Echolon Inventory Models Considering Outsourcing Policies		

一、參加會議經過

二、與會心得

感謝國科會對於此次國際會議的經費補助和支持，使我們有機會了解世界各地優秀學者的研究成果，同時面對面的進行交流與觀摩，與會者所提出的最新成果和交流思想，對提升夠提升國內的研究水準有相當大的助益。

另外、在會議中發表自己的研究成果，並與與會人士相互討論是非常難得的經驗，也提供了一些不同的思考模式，對於日後的研究方向有很大的幫助，且會議內容大部分都是尚未發表的研究成果，更啟發了我若干靈感，日後可豐富我的研究。

同時、藉由這次研討會，增加英文論文發表及闡述之經驗，由於與會人士來自於世界各地，必須使用英文進行討論，更可提昇未來在國際會議上的外語表達能力。

三、考察參觀活動(無是項活動者略)

略

四、建議

技職院校的經費及資源不足，研究工作推展不易。然而、不論大專或技職院校，私立學校任職的教師雖工作負荷很重；學生素質不高，研究助手難覓，但都有研究的意願及壓力，且各校都訂有提昇學術水準的目標。懇請相關單位日後在分配經費時，能考慮多提供一些機會給私立院校的老師，感激不盡!

五、攜回資料名稱及內容

(1) 大會議程。

(2) 論文摘要光碟

六、其他

國科會補助計畫衍生研發成果推廣資料表

日期:2012/08/02

<table>
<tr><td rowspan="3">國科會補助計畫</td><td>計畫名稱: 考慮外包生產下的二階存貨模式(I)</td></tr>
<tr><td>計畫主持人: 滕慧敏</td></tr>
<tr><td>計畫編號: 100-2218-E-263-001-　　　　學門領域: 生產系統規劃與管制</td></tr>
<tr><td colspan="2">無研發成果推廣資料</td></tr>
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100 年度專題研究計畫研究成果彙整表

計畫主持人：滕慧敏	計畫編號：100-2218-E-263-001-
計畫名稱：考慮外包生產下的二階存貨模式(I)	

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	1	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	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	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	1	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%		

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(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。)</td><td>無</td></tr>
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<tr><td>課程/模組</td><td>0</td><td></td></tr>
<tr><td>電腦及網路系統或工具</td><td>0</td><td></td></tr>
<tr><td>教材</td><td>0</td><td></td></tr>
<tr><td>舉辦之活動/競賽</td><td>0</td><td></td></tr>
<tr><td>研討會/工作坊</td><td>0</td><td></td></tr>
<tr><td>電子報、網站</td><td>0</td><td></td></tr>
<tr><td>計畫成果推廣之參與（閱聽）人數</td><td>0</td><td></td></tr>
</table>

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）

已於國際研討會中發表, 投稿中

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）

由於產業環境境的改變及國際市場競爭日趨激烈，許多企業為了提昇自身競爭能力、降低成本與風險，並增加企業的經營彈性。於是，可以使生產變得更快速、便捷的「外包」生產制度，遂成為必然的趨勢。在高度競爭的環境下，許多企業以「外包策略」來進行生產和服務，進而追求好的績效，並以此來提昇公司的核心競爭優勢。

本研究係將不同的需求型態導入存貨模式，探討在兩階供應鏈的生產系統中，考慮採取「自製」或「外包」的最佳策略。研究方法主要採用存貨理論模式進行研究，建立問題的數學模式，以利潤最大化（或成本最小化）為目標，運用最佳化理論求出最佳訂購量、最佳缺貨量及最佳訂購期等….。以數值範例說明所建立模型的應用情形，並對重要參數進行敏感度分析。

由於利潤之計算相當複雜且凸性不易證明，故建構了『解題程序』以協助最佳解之取得。研究結果顯示一階中的供應商，係依顧客的需求量訂貨。而設定相關參數值，在數值範例中依解題程序驗證，得知一階中的供應商在供應週期為 2 時，可求得的利潤為最佳。

本研究可提供給管理者作決策制訂，而目前係對確定需求求解，日後研究希望延伸至隨機性的需求存貨模式。再者、企業與服務廠商在合作時，除了要以誠信相待，外包合約如何訂定以及產品係全數外包或部份比例外包，都要審慎考慮。