行政院國家科學委員會專題研究計畫 期末報告

需求確定及不確定之不良品的最佳訂購策略

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 101-2221-E-263-001-
執 行 期 間 ：101 年 08 月 01 日至 102 年 07 月 31 日
執 行 單 位 ：致理技術學院企業管理系暨服務業經營管理研究所

計 畫 主 持 人：滕慧敏

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 ：本計畫涉及專利或其他智慧財產權，2 年後可公開查詢

中 華 民 國 102 年 08 月 08 日

中 文 摘 要 ： 本研究探討二階層供應鏈的存貨問題,模式中考慮包含不確定的需求及不確定供應(不完美產品的不良率發生為隨機的)

研究中係以數值分析方法進行,以求取最佳訂購量使預期利潤為極大化,同時再以敏感性分析來驗證.

中文關鍵詞： 不完美品質；不確定性需求；二階段供應鏈

英 文 摘 要 ： This study considers an inventory problem consisting of uncertain demand and uncertain supply (imperfect items with random defective percentage) in a two-echelon supply chain. The analytic algorithm is presented to derive the optimal order quantity such that the expected profit is maximized. Numerical example and sensitivity analysis are provided to illustrate the theory.

英文關鍵詞： imperfect quality； uncertain demand； two-echelon supply chain

Procedia Information Technology & Computer Science

00 (2013) 000-000

3rd World Conference on Innovation and Computer Sciences 2013

Optimal ordering strategy for items with imperfect quality under uncertain demand

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[a]Department of Business Administration, Chihlee Institute of Technology, New Taipei, 22050,Taiwan
[b]Department of Business Administration, De Lin Institute of Technology, New Taipei, 23654, Taiwan

Abstract

This study considers an inventory problem consisting of uncertain demand and uncertain supply (imperfect items with random defective percentage) in a two-echelon supply chain. The analytic algorithm is presented to derive the optimal order quantity such that the expected profit is maximized. Numerical example and sensitivity analysis are provided to illustrate the theory.

Keywords: imperfect quality; uncertain demand; two-echelon supply chain

1. Introduction

An era of globalization and the corresponding intense competition, consumers nowadays hold a wide range of expectation and a wide variety of products. Facing such production environment, industries need to adjust the inventory to react to customers' demand in a timely manner. Strategies to effectively control inventory and minimize operating costs thus become a critical issue.

Majority of the relevant literatures assume that suppliers provide good quality items. In practice, suppliers sometimes provide defective items due to imperfect production process and/or negligence

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by the personnel. The kinds of incident negatively affect the suppliers' inventory quantity and ordering frequency, and further damage the company' reputation. Therefore, dealing with defective items in order to maximize profit becomes an important topic.

On the issues of single-period problem with uncertain demand, most of previous studies use the well-known newsboy model. Lin and Kroll (1997) developed the single-item newsboy problem with quantity discount and a dual performance measure. Huang (2001) found out the optimal ordering quantity and pricing policy to maximize the total expected profit for perishable goods. Haji et al. (2007) considered a newsboy problem in which the suppliers offer quantity discount and the initial inventory at the beginning of the period is a random variable. Tiwari et al. (2011) derived an optimal ordering policy for an unreliable newsboy who can place two sequential orders before the start of a single selling season by using a demand forecast update. However, the single-period problem with uncertain demand and imperfect items supply has received little attention in past years.

This study, particularly, addresses a newsboy problem consisting of uncertain demand and imperfect items supply with random imperfect percentage in a two-echelon supply chain. An algorithm is presented below to derive the optimal order quantity such that the expected profit is maximized.

2. Assumptions and notations

p	retail price per unit
c	wholesale price per unit; $p>c$
s	retailer's salvage value per unit; $p>s$
r	retailer's shortage cost per unit; represents costs of lost goodwill
x	random demand faced by the retailer
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λ	random defective percentage in Q, $0 \le \lambda \le 1$
Q	retailer's order quantity.
$\underset{x}{E}(Q\|\lambda)$	retailer's expected profit with respect to random demand x

3. Modeling and analysis

In this section, we formulate expected profit model for the retailer and supplier. Before the selling period, the retailer purchases products from the supplier and sells them to its customers. Due to the imperfect production processes from the supplier, each lot produced contains random percentage, λ, of defectives. Responding to this situation and facing to customers' random demand, x, the retailer needs to place an order that yields the optimal profit.

The retailer's expected profit is as follows:

$$\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda) = \underset{\lambda}{E}\{\int_0^{(1-\lambda)Q}[(p-c)x-(c-s)(Q-x)]f(x)dx + \int_{(1-\lambda)Q}^{\infty}[(p-c)(1-\lambda)Q - r\left(x-(1-\lambda)Q\right)-(c-s)\lambda Q]\,f(x)dx\}. \tag{1}$$

$$= \int_0^{\beta}\{\int_0^{(1-\lambda)Q}[(p-c)x-(c-s)(Q-x)]f(x)dx$$
$$+\int_{(1-\lambda)Q}^{\infty}[(p-c)(1-\lambda)Q-r(x-(1-\lambda)Q)-(c-s)\lambda Q]f(x)dx\}g(\lambda)d\lambda.$$

$$\frac{\partial}{\partial Q}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda) = \int_0^{\beta}[(p-p\lambda-r\lambda+s\lambda+r-c)+(p-p\lambda-r\lambda+s\lambda+r-s)\int_0^{(1-\lambda)Q}f(x)dx]g(\lambda)d\lambda. \quad (2)$$

$$\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda) = -\int_0^{\beta}(1-\lambda)^2(p+r-s)f((1-\lambda)Q)g(\lambda)d\lambda. \quad (3)$$

Since $p>s$, therefore $\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)<0$, which leads to the function $\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ being strictly concave with respect to Q

An illustrative case study

In this section, a practical probability distribution is used to explain the results of section 3.2. The random demand x is uniformly distributed over the range 0 and K, where K is constant. That is,

$$f(x) = \frac{1}{K} \quad (4)$$

The random defective percentage$\lambda$is uniformly distributed over the range 0 and β, where β is constant. That is,

$$g(\lambda) = \frac{1}{\beta} \quad (5)$$

By setting $\frac{\partial}{\partial Q}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ =0, the optimal order quantity

$$Q^* = \frac{3K[2(p+r-c)-\beta(p+r-s)]}{2(3-3\beta+\beta^2)(p+r-s)}. \quad (6)$$

Example 1. p =700, c=500, s =50, r =25, K=15000, β=0.1,

$f(x) = \frac{1}{15000}$, and

$g(\lambda) = \frac{1}{0.1} = 10.$

From Eq.(10), one has Q^* = 4705, $\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ =$262396.

4. Sensitivity analysis

Sensitivity analysis (of section 3.2) is carried out when the parameters *p*, *s* and β are changed. Table 1, Table 2, and Table 3 illustrates the effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit. Three Figures show the retail price per unit (*p*) at 600,650, 700, 750, 800; the retailer's salvage value per unit (*s*) at 40, 50, 60 and β at 0.05, 0.1, 0.15 with other variables unchanged. It is shown that as *p* and *s* increase, the retailer's order quantity and expected profit $E_{\lambda} E_{x}(Q|\lambda)$ increase, while asβincreases, $E_{\lambda} E_{x}(Q|\lambda)$ decreases.

Table 1. Sen is for parameters *p*, *s* with β=0.05sitivity analys

c=500, r =25, K=15000, $f(x) = \frac{1}{15000}$, $g(\lambda) = 10$									
p	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$
600	40	2976	-23	50	3035	-20	60	3096	-16
650	40	3953	127028	50	4023	133066	60	4095	139301
700	40	4787	310089	50	4864	318676	60	4943	327523
750	40	5508	519253	50	5589	530398	60	5673	541856
800	40	6137	749531	50	6221	763177	60	6308	777180

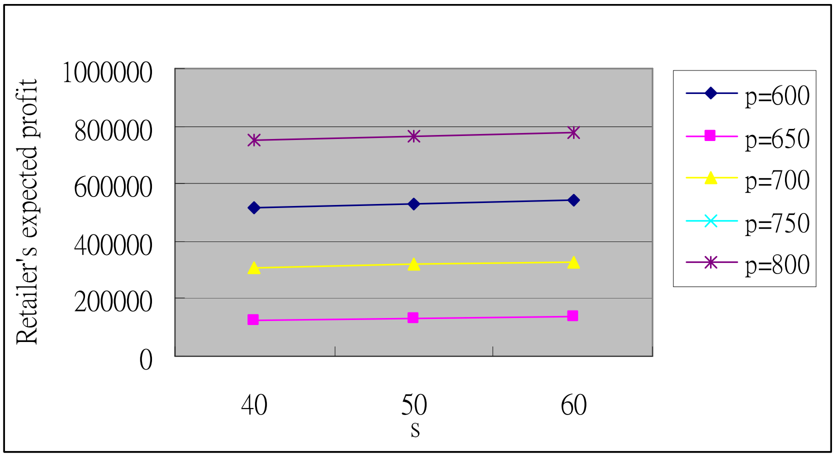

Figure 1 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.05

Table 2. Sensitivity analysis for parameters *p*, *s* with β=0.1

c=500, r=25, K=15000, $f(x)=\frac{1}{15000}$, $g(\lambda)=10$									
p	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$
600	40	2718	-57	50	2780	-54	60	2843	-50
650	40	3746	80805	50	3819	87004	60	3895	93412
700	40	4624	253513	50	4705	262396	60	4788	271552
750	40	5383	453697	50	5468	465273	60	5556	477178
800	40	6044	676107	50	6133	690314	60	6224	704898

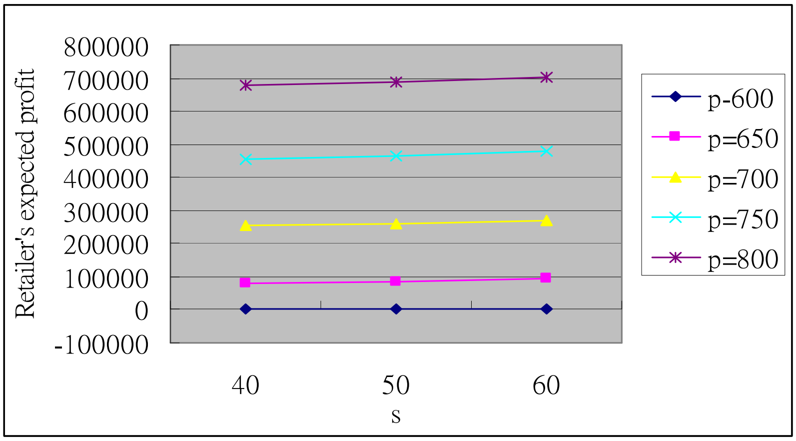

Figure 2 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.1

Table 3. Sensitivity analysis for parameters *p*, *s* with β=0.15

c=500, r=25, K=15000, $f(x)=\frac{1}{15000}$, $g(\lambda)=10$									
p	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$
600	40	2426	-89	50	2491	-86	60	2558	-82
650	40	3509	35971	50	3586	42228	60	3666	48705
700	40	4434	197412	50	4519	206496	60	4607	215868
750	40	5233	387796	50	5323	399717	60	5416	411985
800	40	5930	601594	50	6024	616287	60	6120	631378

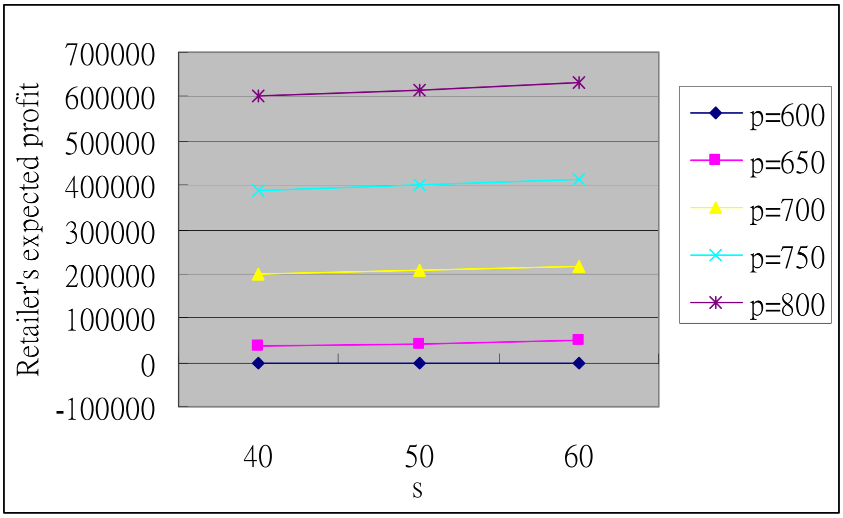

Figure 3 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.15

5. Conclusion

Supply chain risk management is mainly rooted in supply risk and demand risk. This study demonstrates a newsboy problem consisting of both random demand with uniform distribution and uncertain supply with random defective percentage in a two-echelon supply chain. An algorithm is developed to derive the optimal order quantity. Numerical example and sensitivity analysis are provided to illustrate the problem.

Acknowledgement: This work was supported by NSC 101-2221-E-263-001. They wish to express their deep appreciation to the National Science Council, ROC, for the financial support.

Reference

Haji, M., Haji, R. and Darabi, H. (2007). Price Discount and Stochastic Initial Inventory in the Newsboy Problem. *Journal of Industrial and Systems Engineering* 1(2): p.130-138.

Huang, D., Zhou, H. and Zhao, Q.H.(2011). A competitive multiple-product newsboy problem with partial product substitution. *Omega* 39 (3), p.302-312.

Lin, C.S. and Korll, D. E.(1997). The single - item newsboy problem with dual performance measures and quantity discounts. *European Journal of Operational Research* 100:562-565.

Tiwari ,D., Patil,R.and Shah,J(2011). Unreliable newsboy problem with a forecast update, *Operations Research Letters* 39: p.278–282

附件五

國科會補助專題研究計畫出席國際學術會議心得報告

日期：102 年 07 月 01 日

計畫編號	NSC101－2221－E－263－001－		
計畫名稱	需求確定及不確定之不良品的最佳訂購策略		
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副教授
會議時間	102 年 04 月 26 日至 102 年 04 月 28 日	會議地點	土耳其安達利亞
會議名稱	(中文)第三屆世界創新及電腦科技研討會 (英文)3rd World conference on innovation and computer science		
發表題目	(中文)需求不確定下之不良品的最佳訂購策略 (英文)Optimal ordering strategy for items with imperfect quality under uncertain demand		

一、參加會議經過

詳如附件所示。

二、與會心得

本次研討會係由 Academic world Education and Research Center 所承辦，共由 10 多個國家的研究人員投稿近 400 篇，其中共接受 190 篇。研討會開場係由英國 Middlesex university 的教授 Dr. Mahmet Karamanoglu 進行演講，在科學和藝術中如何取得平衡，議題相當吸引人。

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，尤其因為這次主辦國地處歐亞交界，所以有許多的發表人來自於中亞，如：羅馬尼亞、蒙古利亞、烏克蘭等。深深感受到這些國家旺盛的企圖心，甚至會準備相關投影片，利用機會來推銷他們服務的大學。

同時、在面對面的進行交流與觀摩當中，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。

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。

本次雖原訂為第二天（4月27日）報告，但因第一天有人缺席，經徵得主持人來自於羅馬尼亞的Madina Murzakhanovna同意，提前報告。

三、發表論文全文或摘要

詳如附件所列。

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。謝謝主管單位能給我機會，能在年過半百後，參與國際性的學術研討。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


3. World Conference
on Innovation & Computer Sciences
26 April - 28 April, 2013
Sentido Zeynep Golf & Spa Resort and Hotel
Belek, Antalya, Turkey
Programme

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INSODE – 2013
PROGRAMME

IMPORTANT EVENTS

23 – 28 April 2013	
08:00 – 19:00	**Registration** Sentido Zeynep Hotel Lobby

26.04.2013 10:00 – 10:30	**Opening Ceremony**	MAIN HALL

TIME	TITLE	SPEAKER	HALL NAME
26.04.2013 10:30 – 11:30 Keynote	Blending Arts and Sciences – gimmick or necessity?	Prof. Dr. Mehmet Karamanoglu Middlesex University, UK	BELEK

13:00 – 14:00	Lunch Break

TIME	TITLE	SPEAKER	HALL NAME
26.04.2013 14:00 – 15:00 **Keynote**	**The Impact of Smart Devices in Future Education**	Prof. Dr. Fahrettin Sadikoglu Near East University North Cyprus	BELEK

28.04.2013 08:30 – 18:00	**Free Historical Places Tour**	

Hall 6

Session Cahir:	Aissaoui Mouaad	
TIME	TITLE	PRESENTER(S)/AUTHOR(S)
14:00 – 14:20	An Artificial Neural Network Model for The Ampere's Law	Ömer Faruk Alçin, Deniz Korkmaz, Sami Ekici, Abdulkadir Şengür
14:20 – 14:40	Simulation Of Robotic-Arm Manipulation for Education	Mehmet Fatih Işık, Erhan Çetin, Halil Aykul
14:40 – 15:00	Tablet PCs in English Language Teaching: Benefits and Challenges	Perihan Savaş
15:00 – 15:20	The Interaction Between Space Design and Computer Technologies	Hare Kiliçaslan, Burcu Efe Ziyrek
15:20 – 15:40	An Application of Modified Assignment Algorithm with Constraints	Dilara Koca, Recai Oktaş, Sedat Akleylek
15:40 – 16:00	Future of HVDC power transmission in Africa	Aissaoui Mouaad, Tandjaoui Nacer
16:00 – 16:20	Corner Detection for Curve Segmentation	Muhammad Sarfraz

16:20 – 17:20	**Coffee Break**

SESSION – VII; 17:20 – 19:00

Hall 1

Session Cahir:	Dinara Kolshigulova	
TIME	TITLE	PRESENTER(S)/AUTHOR(S)
17:20 – 17:40	MAKING DETECTION OF EXPERT SYSTEM: Psychometric Properties	Mohsen Shokoohi-yekta, Maryam Mahmudi et al
17:40 – 18:00	Empty	
18:00 – 18:20	Empty	
18:20 – 18:40	Improvement of Mobility Management Heterogeneous Wireless Networks	Şule Öztürk, Aysel Şafak, İsmet Çağdaş Soy
18:40 – 19:00	Verbal and nonverbal expression of agreement/disagreement of Kazakh speaking and Russian speaking citizens in Kazakhstan	Dinara Kolshigulova

Hall 2

Session Cahir:	Bokuleva Bota	
TIME	TITLE	PRESENTER(S)/AUTHOR(S)
17:20 – 17:40	Modeling of Memristor by Using Artificial Neural Network	Deniz Korkmaz, Ömer Faruk Alçin, Sami Ekici
17:40 – 18:00	Influence of Persian on Hindi	Bokuleva Bota, Serikkhanovna, Avakova Raushangul Amirdinovna, Kortabayeva Gulzhamal Kydyrbaevna
18:00 – 18:20	Genetic XK-Means: A genetic XK-Means algorithm for gene clustering	Wei Wu, Huanan Wang
18:20 – 18:40	The Inventory Model and Decisions of Production with Uncertain Demand and Supply	Ping-Hui Hsu, Hui-Ming teng
18:40 – 19:00	Optimal ordering strategy for items with imperfect quality under uncertain demand	Hui-Ming Teng, Ping-Hui Hsu

INSODE
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10 March 2013

Bill to: Hui-Ming Teng

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1	Registration fee for INSODE 2013	210€		210€
			TOTAL PAID	210€

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Optimal ordering strategy for items with imperfect quality under uncertain demand

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by the personnel. The kinds of incident negatively affect the suppliers' inventory quantity and ordering frequency, and further damage the company' reputation. Therefore, dealing with defective items in order to maximize profit becomes an important topic.

On the issues of single-period problem with uncertain demand, most of previous studies use the well-known newsboy model. Lin and Kroll (1997) developed the single-item newsboy problem with quantity discount and a dual performance measure. Huang (2001) found out the optimal ordering quantity and pricing policy to maximize the total expected profit for perishable goods. Haji et al. (2007) considered a newsboy problem in which the suppliers offer quantity discount and the initial inventory at the beginning of the period is a random variable. Tiwari et al. (2011) derived an optimal ordering policy for an unreliable newsboy who can place two sequential orders before the start of a single selling season by using a demand forecast update. However, the single-period problem with uncertain demand and imperfect items supply has received little attention in past years.

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$$=\int_0^{\beta}\{\int_0^{(1-\lambda)Q}[(p-c)x-(c-s)(Q-x)]f(x)dx$$
$$+\int_{(1-\lambda)Q}^{\infty}[(p-c)(1-\lambda)Q-r(x-(1-\lambda)Q)-(c-s)\lambda Q]f(x)dx\}g(\lambda)d\lambda.$$

$$\frac{\partial}{\partial Q}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda) =$$
$$\int_0^{\beta}[(p-p\lambda-r\lambda+s\lambda+r-c)+(p-p\lambda-r\lambda+s\lambda+r-s)\int_0^{(1-\lambda)Q}f(x)dx]g(\lambda)d\lambda. \quad (2)$$

$$\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda) = -\int_0^{\beta}(1-\lambda)^2(p+r-s)f((1-\lambda)Q)g(\lambda)d\lambda. \quad (3)$$

Since $p>s$, therefore $\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)<0$, which leads to the function $\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ being strictly concave with respect to Q

An illustrative case study

In this section, a practical probability distribution is used to explain the results of section 3.2. The random demand x is uniformly distributed over the range 0 and K, where K is constant. That is,

$$f(x)=\frac{1}{K} \quad (4)$$

The random defective percentage$\lambda$is uniformly distributed over the range 0 and β, where β is constant. That is,

$$g(\lambda)=\frac{1}{\beta} \quad (5)$$

By setting $\frac{\partial}{\partial Q}\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ =0, the optimal order quantity

$$Q^*=\frac{3K[2(p+r-c)-\beta(p+r-s)]}{2(3-3\beta+\beta^2)(p+r-s)}. \quad (6)$$

Example 1. p =700, c=500, s =50, r =25, K=15000, β=0.1,

$$f(x)=\frac{1}{15000}, \quad \text{and}$$
$$g(\lambda)=\frac{1}{0.1}=10.$$

From Eq.(10), one has Q^* = 4705, $\underset{\lambda}{E}\underset{x}{E}(Q|\lambda)$ =$262396.

4. Sensitivity analysis

Sensitivity analysis (of section 3.2) is carried out when the parameters *p*, *s* and *β* are changed. Table 1, Table 2, and Table 3 illustrates the effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit. Three Figures show the retail price per unit (*p*) at 600,650, 700, 750, 800; the retailer's salvage value per unit (*s*) at 40, 50, 60 and *β* at 0.05, 0.1, 0.15 with other variables unchanged. It is shown that as *p* and *s* increase, the retailer's order quantity and expected profit $E_{\lambda} E_{x}(Q|\lambda)$ increase, while asβincreases, $E_{\lambda} E_{x}(Q|\lambda)$ decreases.

Table 1. Sen is for parameters *p*, *s* with β=0.05sitivity analys

c=500, r =25, K=15000, $f(x)=\frac{1}{15000}$, $g(\lambda)=10$									
p	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda} E_{x}(Q\|\lambda)$
600	40	2976	-23	50	3035	-20	60	3096	-16
650	40	3953	127028	50	4023	133066	60	4095	139301
700	40	4787	310089	50	4864	318676	60	4943	327523
750	40	5508	519253	50	5589	530398	60	5673	541856
800	40	6137	749531	50	6221	763177	60	6308	777180

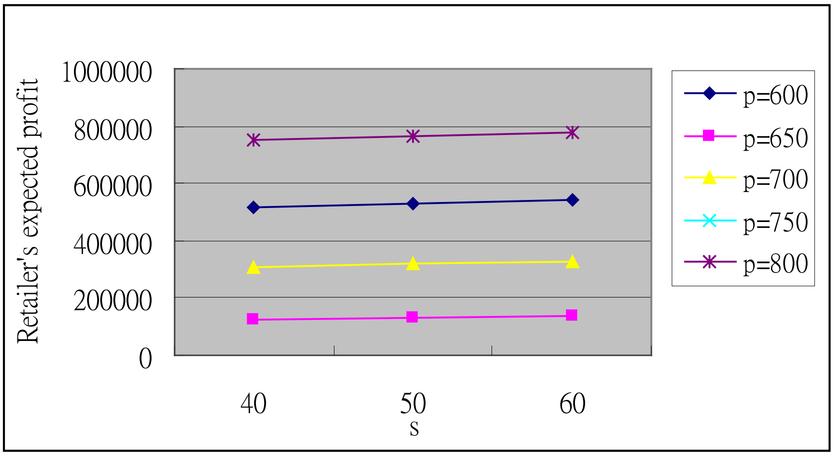

Figure 1 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with *β*=0.05

Table 2. Sensitivity analysis for parameters *p*, *s* with β=0.1

c=500, r=25, K=15000, $f(x)=\dfrac{1}{15000}$, $g(\lambda)=10$									
p	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$
600	40	2718	-57	50	2780	-54	60	2843	-50
650	40	3746	80805	50	3819	87004	60	3895	93412
700	40	4624	253513	50	4705	262396	60	4788	271552
750	40	5383	453697	50	5468	465273	60	5556	477178
800	40	6044	676107	50	6133	690314	60	6224	704898

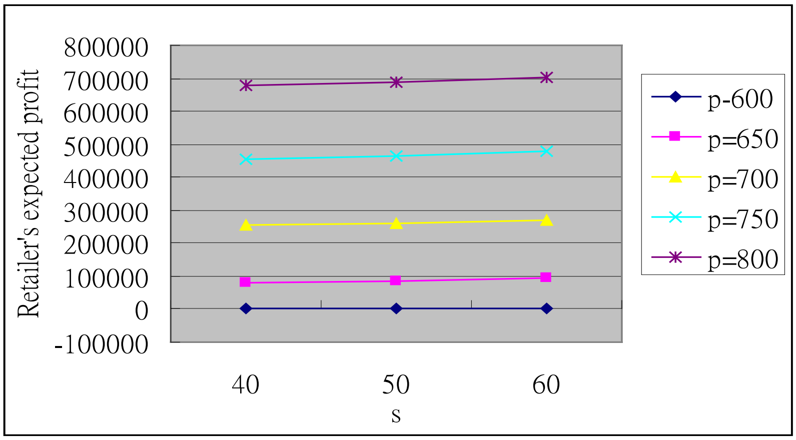

Figure 2 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.1

Table 3. Sensitivity analysis for parameters *p*, *s* with β=0.15

c=500, r=25, K=15000, $f(x)=\dfrac{1}{15000}$, $g(\lambda)=10$									
p	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$	s	Q^*	$E_{\lambda}E_{x}(Q\|\lambda)$
600	40	2426	-89	50	2491	-86	60	2558	-82
650	40	3509	35971	50	3586	42228	60	3666	48705
700	40	4434	197412	50	4519	206496	60	4607	215868
750	40	5233	387796	50	5323	399717	60	5416	411985
800	40	5930	601594	50	6024	616287	60	6120	631378

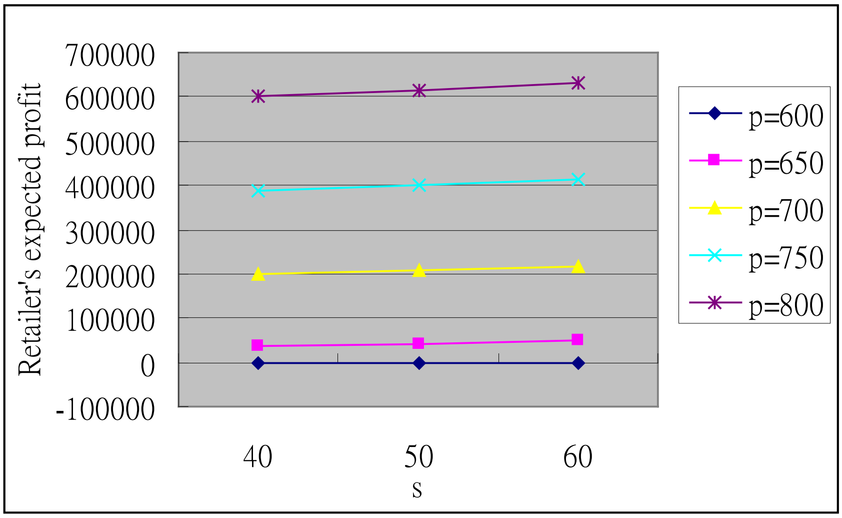

Figure 3 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.15

5. Conclusion

Supply chain risk management is mainly rooted in supply risk and demand risk. This study demonstrates a newsboy problem consisting of both random demand with uniform distribution and uncertain supply with random defective percentage in a two-echelon supply chain. An algorithm is developed to derive the optimal order quantity. Numerical example and sensitivity analysis are provided to illustrate the problem.

Acknowledgement: This work was supported by NSC 101-2221-E-263-001. They wish to express their deep appreciation to the National Science Council, ROC, for the financial support.

Reference

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Optimal ordering strategy for items with imperfect quality under uncertain demand

Hui-Ming Teng
Ping Hui Hsu

Agenda

- **Abstract**
- **Introduction**
- **Assumptions and notations**
- **Modeling and analysis**
  - **An illustrative case study**
- **Sensitivity analysis**
- **Conclusion**

Introduction

1. **Consumers hold a wide range of expectation and a wide variety of products**
2. **Industries need to adjust the inventory to react to customers' demand in a timely manner**
3. **Strategies to effectively control inventory and minimize operating costs become a critical issue**

4. **Majority of the relevant literatures assume that suppliers provide good quality items. In practice, suppliers sometimes provide defective items due to imperfect production process and/or negligence by the personnel**
5. **Dealing with defective items in order to maximize profit becomes an important topic**
6. **Single-period problem with uncertain demand, most of previous studies use the newsboy model**

- **This study, addresses a newsboy problem consisting of uncertain demand and imperfect items supply with random imperfect percentage in a two-echelon supply chain.**
- **An algorithm is presented below to derive the optimal order quantity such that the expected profit is maximized.**

Assumptions and notations

p	retail price per unit
c	wholesale price per unit; $p>c$
s	retailer's salvage value per unit; $p>s$
r	retailer's shortage cost per unit; represents costs of lost goodwill
x	random demand faced by the retailer
$f(x)$	the probability density function of x
λ	random defective percentage in Q, $0 \le \lambda \le 1$
Q	retailer's order quantity.
$E_x(Q\|\lambda)$	retailer's expected profit with respect to random demand x

Modeling and analysis

- We formulate expected profit model for the retailer and supplier.
- Before the selling period, the retailer purchases products from the supplier and sells them to its customers.
- Due to the imperfect production processes from the supplier, each lot produced contains random percentage,, of defectives.
- Responding to this situation and facing to customers' random demand, *x*, the retailer needs to place an order that yields the optimal profit.

The retailer’s expected profit is as follows:

$$
\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda)=\underset{\lambda}{E}\Big\{\int_{0}^{(1-\lambda)Q}[(p-c)x-(c-s)(Q-x)]f(x)dx
+\int_{(1-\lambda)Q}^{\infty}[(p-c)(1-\lambda)Q-r\big(x-(1-\lambda)Q\big)-(c-s)\lambda Q]f(x)dx\Big\}. \qquad (1)
$$

$$
=\int_{0}^{\beta}\Big\{\int_{0}^{(1-\lambda)Q}[(p-c)x-(c-s)(Q-x)]f(x)dx
+\int_{(1-\lambda)Q}^{\infty}[(p-c)(1-\lambda)Q-r\big(x-(1-\lambda)Q\big)-(c-s)\lambda Q]f(x)dx\Big\}g(\lambda)d\lambda
$$

$$\frac{\partial}{\partial Q}\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda) =$$

$$\int_0^{\beta}[(p-p\lambda-r\lambda+s\lambda+r-c)+(p-p\lambda-r\lambda+s\lambda+r-s)\int_0^{(1-\lambda)Q}f(x)\text{d} \tag{2}$$

$$\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda) = -\int_0^{\beta}(1-\lambda)^2(p+r-s)f((1-\lambda)Q)g(\lambda)d\lambda. \tag{3}$$

Since *p*>s, therefore $\frac{\partial^2}{\partial Q^2}\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda)$ <0, which leads to the function $\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda)$ being strictly concave with respect to *Q*.

An illustrative case study

The random demand x is uniformly distributed over the range 0 and K, where K is constant. That is,

$$f(x) = \frac{1}{K} \tag{4}$$

The random defective percentage λ is uniformly distributed over the range 0 and β, where β is constant. That is,

$$g(\lambda) = \frac{1}{\beta} \tag{5}$$

By setting $\frac{\partial}{\partial Q} \underset{\lambda}{E} \underset{x}{E}(Q|\lambda)$ =0, the optimal order quantity

$$Q^* = \frac{3K[2(p+r-c)-\beta(p+r-s)]}{2(3-3\beta+\beta^2)(p+r-s)} . \tag{6}$$

Example 1. $p=700$, $c=500$, $s=50$, $r=25$, $K=15000$, $\beta=0.1$

$$f(x)=\frac{1}{15000},$$ and

$$g(\lambda)=\frac{1}{0.1}=10.$$

one has $Q^*=4705$,

$$\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda)=\$262396.$$

Example 1. p =700, c=500, s =50, r =25, K=15000, β=0.1,

$$f(x) = \frac{1}{15000},$$ and

$$g(\lambda) = \frac{1}{0.1} = 10.$$

one has

$$Q^* = 4705,$$

$$\underset{\lambda}{E}\,\underset{x}{E}(Q|\lambda) = \$262396.$$

Sensitivity analysis

Table 1. Sen is for parameters *p*, *s* with β=0.05sitivity analys

$c=500, r=25, K=15000, f(x)=\frac{1}{15000}, g(\lambda)=10$									
p	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$
600	40	2976	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
650	40	3953	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
700	40	4787	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
750	40	5508	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800	40	6137	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

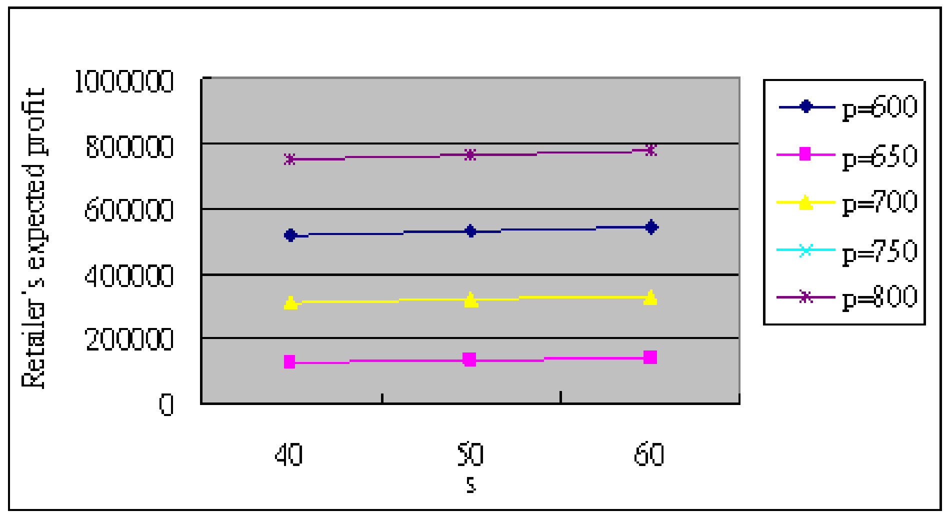

Figure 1. The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with $\beta=0.05$

Sensitivity analysis

Table 2. Sensitivity analysis for parameters *p*, *s* with β=0.1

c=500, r=25, K=15000, $f(x)=\dfrac{1}{15000}$, $g(\lambda)=10$

p	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$	s	Q^*	$E_\lambda E_x(Q\|\lambda)$
600									
650									
700									
750									
800									

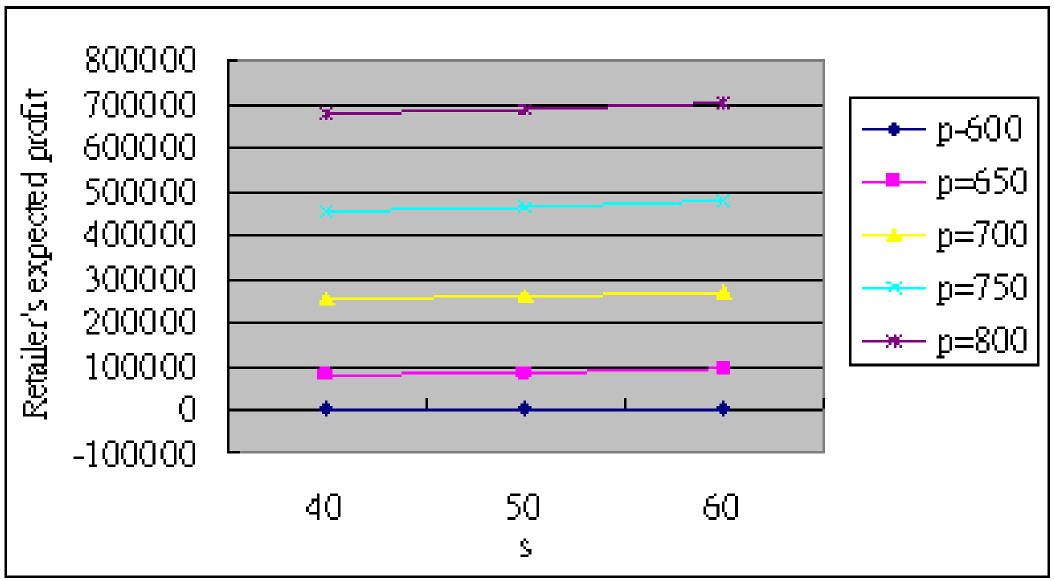

Figure 2. The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.1

Sensitivity analysis

Table 3. Sensitivity analysis for parameters *p*, *s* with β=0.15

$c=500, r=25, K=15000, f(x)=\frac{1}{15000}, g(\lambda)=10$		
p	s	Q^*
600	40	24
650	40	35
700	40	44
750	40	52
800	40	59

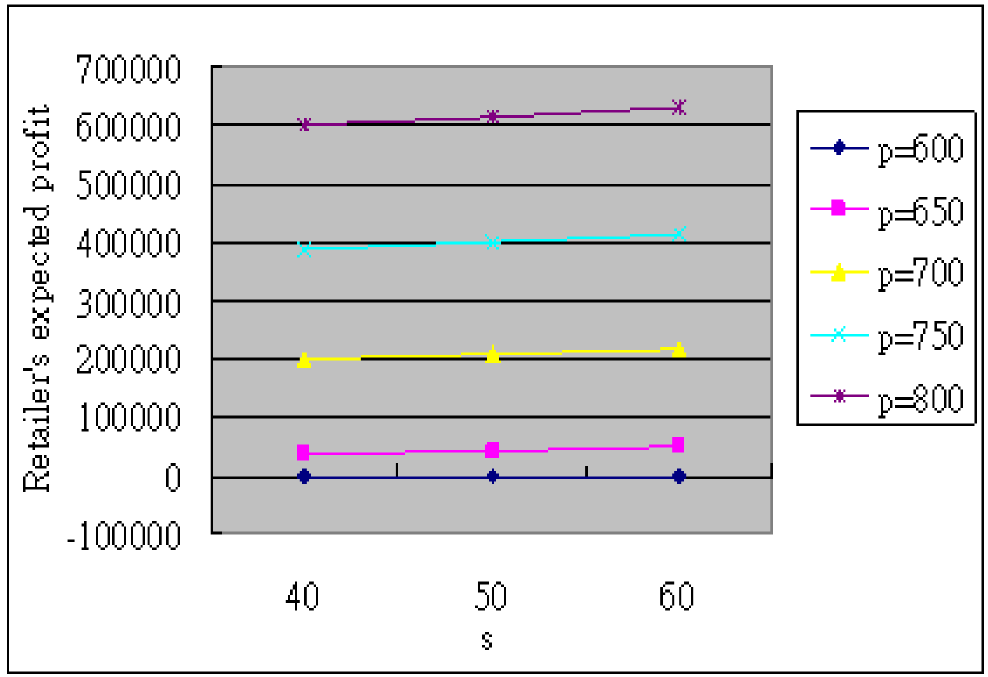

Figure 3 The effect of retail price per unit *p* and salvage value per unit *s* on the order quantity and expected profit with β=0.15

Conclusion

- **Supply chain risk management is mainly rooted in supply risk and demand risk.**
- **This study demonstrates a newsboy problem consisting of both random demand with uniform distribution and uncertain supply with random defective percentage in a two-echelon supply chain.**
- **An algorithm is developed to derive the optimal order quantity.**
- **Numerical example and sensitivity analysis are provided to illustrate the problem.**

Q & A

國科會補助計畫衍生研發成果推廣資料表

日期:2013/07/22

<table>
<tr><td rowspan="3">國科會補助計畫</td><td>計畫名稱: 需求確定及不確定之不良品的最佳訂購策略</td></tr>
<tr><td>計畫主持人: 滕慧敏</td></tr>
<tr><td>計畫編號: 101-2221-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>
</table>

101 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：101-2221-E-263-001-
計畫名稱：需求確定及不確定之不良品的最佳訂購策略	

成果項目			量化：實際已達成數（被接受或已發表）	量化：預期總達成數(含實際已達成數)	量化：本計畫實際貢獻百分比	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）
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	0	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%	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）