行政院國家科學委員會專題研究計畫　成果報告

品質與前置時間在供應鏈模式之影響

計畫類別：個別型計畫
計畫編號：NSC93-2416-H-032-002-
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計畫主持人：吳坤山

計畫參與人員：歐陽良裕，和家慧

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行政院國家科學委員會補助專題研究計畫 成果報告

品質與前置時間在供應鏈模式之影響

計畫類別：■個別型計畫　　□整合型計畫

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行政院國家科學委員會專題研究計劃成果報告

品質與前置時間在供應鏈模式之影響

The impact of quality and lead time on the supply chain model

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計劃主持人：吳坤山 淡江大學企業管理學系(所)教授
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中文摘要

本計劃主要是考慮當需求不確定，且前置時間的長度可控制及買方收到的批量中含有不良品的情況下，如何整合買方和賣方的製造與訂購策略，並提出兩個整合存貨模型。首先，我們假設前置時間內的需求量服從常態分配，其次探討前置時間內需求量的機率分配為未知的情形，並且利用大中取小分配不拘程序求解。我們亦分別針對此兩種情形(前置時間內需求量的機率分配為常態分配或分配不拘)建立求得最適生產、訂購策略之演算法，並利用數值範例說明買賣雙方整合後的利益，確實是高於整合前的個別利益。同時，本研究也將分析各參數變動對於決策所造成的影響，作為提供給管理者之重要參考依據。

關鍵詞：整合存貨模式，不良品，前置時間，趕工成本，大中取小分配不拘程序。

ABSTARCT

This proposal investigates the integrated vendor-buyer inventory policy for defective items in buyer's arrival order lot with controllable lead time and stochastic demand. We derive integrated inventory models with partial backlogging, in which the order quantity, reorder point, lead time and the number of shipment from vendor to buyer are decision variables. We first assume that the lead time demand follows a normal distribution, and then relax the assumption about the form of the distribution function of the lead time demand and apply the minimax distribution-free procedure to solve the problem. We also develop an effective algorithm to obtain the optimal production/ordering strategy for each case (the lead time demand follows normal distribution or distribution free), and numerical examples are used to illustrate the benefits of integration. Furthermore, for all models proposed in this project, the effects of parameters will be also included for the decision-making references.

Keywords: integrated inventory model, defective items, lead time, crashing cost, minimax distribution-free procedure

SOURCE AND PURPOSE

The traditional approach of a buyer to vendor relations in the business is to play one off against the other to try and get a better deal. But, through the Japanese experience of using Just-In-Time (JIT) production, it shows that to form partnerships between vendor and buyer is helpful in determining economic order quantity (EOQ) and achieving tangible benefits for both sides. Many researchers have shown that buyer and vendor can obtain greater benefit through strategic cooperation with each other. Goyal [1] first developed an integrated inventory model for a single supplier–single customer problem. Later, Banerjee [2] proposed a model by assuming that the vendor is manufacturing at a finite rate and considered a joint economic-lot-size model where a vendor produces to order for a buyer on a lot-for-lot basis. Then, Goyal [3] relaxed the lot-for-lot policy and suggested that the vendor's economic production quantity per cycle should be an integer multiple of the buyer's purchase quantity. Hill [4] extended the concept and proposed a more general shipping policy which the ith shipment size should be (first shipment size)$\times y^{i-1}$, where $1 \leq y \leq$(production rate/demand rate). At the same year, Ha and Kim [5] developed an integrated JIT lot-splitting model and attested that multiple shipments in small lots is a better policy than existing approach. Goyal and Nebebe [6] further presented an alternative production-shipment policy. They assumed that buyer will received the order quantity in separate shipments which the first shipment will be of small size followed by equal sized shipment of size: (first shipment size) × (production rate/demand rate). Lately, Kelle *et al.* [7] proposed a different policy which the buyer's order is delivered in n shipments of size q and the vendor's production lot size is an integer multiple of the shipment size, mq, and m can be different from n. Previous researches on the integrated vendor-buyer inventory problem most focused on the production shipment schedule in terms of the number and size of batches transferred between both parties under perfect quality.

However, perfect product quality is a common unrealistic assumption. As a result of imperfect production process of the vendor, and/or damage in transit, an arrival order lot often contains some defective items. These defective items will impact the on-hand inventory level, the number of shortages and the frequency of orders in the inventory system. Therefore, production/shipment policy determined by conventional integrated inventory models may be inappropriate for the situation in which an arrival lot contains some defective items. Porteus [8] illustrated a modified EPQ model with imperfect production process and showed a significant relationship between quality and lot size. Schwaller [9] extended EOQ models by assuming a given portion of defective items in incoming lots and the inspection cost consists of a fixed per-lot inspection cost and a fixed unit inspection cost. Paknejad *et al.* [10] derived a modified EOQ model with stochastic demand and constant lead time, and considered the number of defective items in a lot to be a random variable. Ouyang *et al.* [11] then extended the model with partial backlogging. Salameh and Jaber [12] proposed a modified EPQ/EOQ model by accounting for imperfect quality items and assumed that the poor-quality items will be sold as a single batch by the end of the screening process. Wu and Ouyang [13] further generalized Paknejad *et al.*'s [10] model by adding the assumptions of shortage allowance and controllable lead time. These previous models tackled defective items searching for an optimal solution from only the vendor's or buyer's point of view. This one-sided optimal strategy can be improved through forming effective alliance with other party. In a recent paper, Huang [14] developed an integrated vendor-buyer cooperative inventory model for items with imperfect quality and assumed that the number of defective items followed a given probability density function. However, both shortages and lead time reduction are not considered in Huang's [14] model.

Recently, some models considering lead time as a decision variable have been developed. As the consequence of related researches, we conclude that lead time is an important issue and its control leads to many benefits. In fact, lead time usually consists of the following elements: set-up time, process time, wait time, move time, and queue time (Tersine [15]). In many practical situations, lead time can be reduced by adding additional crashing cost; in other words, it is controllable. By shortening the lead time, we can lower the safety stock level, reduce the stock-out loss and improve the customer service level so as to gain competitive advantages in business. Liao and Shyu [16] have initiated a study on lead time reduction by presenting a probability inventory model in which lead time is the unique decision variable and the order quantity is predetermined. In their model, lead time can be decomposed into several components, each of which has a different crashing cost. Later, Ben-Daya and Raouf [17] extended Liao and Shyu's [16] model by considering both lead time and ordering quantity as decision variables where shortages are neglected. Ouyang *et al.* [18] generalized Ben-Daya and Raouf's [17] model by allowing shortages with partial backorders. Then, Ouyang and Wu [19] relaxed the assumption about the form of the probability distribution of lead time demand and only assume that its first two moments are given, and applied the minimax distribution-free procedure to solve the distribution-free model. The above inventory models explain the importance of lead time control, but focused on determining optimal policy for the buyer only and the reorder point was not taken into consideration.

In this article, we assume that buyer will receive the order quantity in separate equal sized shipment and each arrival lot may contain some defective items, and the number of defective items in an arrival lot is a random variable. We also assume that the buyer inspects all the items before selling and defective items in each lot will be discovered and returned to the vendor at the time of delivery of the next lot. Hence, buyer will have extra cost in inspection of each lot and both parties will have treatment cost for the defective items. Besides, inventory is continuously reviewed, and a successive shipment is scheduled to arrive when the inventory level falls to the reorder point. Consequently, we consider an integrated vendor-buyer inventory model with a mixture of backorders and lost sales in which the order quantity, reorder point, lead time and number of shipment from vendor to buyer are decision variables. We first assume that the lead time demand follows a normal distribution, and then try to find the optimal replenishment policy. Next, we relax this assumption and merely assume that the first and second moments of the probability distribution of lead time demand are known and finite, and then solve this inventory model by using the minimax distribution-free approach. Furthermore, numerical examples are provided to illustrate the results and the effects of parameters.

References

1. Goyal SK (1976) An integrated inventory model for a single supplier-single customer problem. *Int J Prod Res* **15(1)**: 107-111.
2. Banerjee A (1986) A joint economic-lot-size model for purchaser and vendor. *Decis Sci* **17**: 292-311.
3. Goyal SK (1988) A joint economic-lot-size model for purchaser and vendor: a comment. *Decis Sci* **19**: 236-241.
4. Hill RM (1997) The single-vendor single-buyer integrated production-inventory

model with a generalized policy. *Eur J Oper Res* **97**: 493-499.

5. Ha D and Kim SL (1997) Implementation of JIT purchasing: an integrated approach. *Prod Plan Control* **8(2)**: 152-157.
6. Goyal SK, Nebebe F (2000) Determination of economic production-shipment policy for a single-vendor-single-buyer system. *Eur J Oper Res* **121**: 175-178.
7. Kelle P, Al-khateeb F, Miller PA (2003) Partnership and negotiation support by joint optimal order/setup policies for JIT. *Int J Prod Econ* **81-82**: 431-441.
8. Porteus EL (1986) Optimal lot sizing, process quality improvement and setup cost reduction. *Oper Res* **34(1)**: 137-144.
9. Schwaller RL (1988) EOQ under inspection costs. *Prod Invent Manag* **29(3)**: 22-24.
10. Paknejad MJ, Nasri F, Affisco JF (1995) Defective units in a continuous review (*s*,*Q*) system. *Int J Prod Res* **33**: 2767-2777.
11. Ouyang LY, Chuang BR, Wu KS (1999) Optimal inventory policies involving variable lead time with defective items. *Opsearch* **36(4)**: 374-389.
12. Salameh MK, Jaber MY (2000) Economic production quantity model for items with imperfect quality. *Int J Prod Econ* **64**: 59-64.
13. Wu KS, Ouyang LY (2001) (*Q*,*r*,*L*) Inventory model with defective items. *Comput Ind Eng* **39**: 173-185.
14. Huang CK (2002) An integrated vendor-buyer cooperative inventory model for items with imperfect quality. *Prod Plan Control* **13(4)**: 355-361.
15. Tersine RJ (1994) *Principles of Inventory and Materials Management*. New York: North-Holland.
16. Liao CJ, Shyu CH (1991) An analytical determination of lead time with normal demand. *Int J Oper Prod Manag* **11**: 72-78.
17. Ben-Daya M, Raouf A (1994) Inventory models involving lead time as a decision variable. *J Opl Res Soc* **45(5)**: 579-582.
18. Ouyang LY, Yeh NC, Wu KS (1996) Mixture inventory model with backorders and lost sales for variable lead time. *J Opl Res Soc* **47**: 829-832.
19. Ouyang LY, Wu KS (1998) A minimax distribution free procedure for mixed inventory model with variable lead time. *Int J Prod Econ* **56-57**: 511-516.
20. Montgomery DC, Bazaraa MS, Keswani AK (1973) Inventory models with a mixture of backorders and lost sales. *Nav Res Log* **20**: 255-263.
21. Hadley G, Whitin T (1963) *Analysis of Inventory Systems*. New Jersey: Prentice-Hall.
22. Gallego G, Moon I (1993) The distribution free newsboy problem: review and extensions. *J Opl Res Soc* **44(8)**: 825-834.
23. Ouyang LY, Chen CK, Chang HC (1999) Lead time and ordering cost reductions in continuous review inventory systems with partial backorders. *J Opl Res Soc* **50**: 1272-1279.

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. It is now being submitted to International Journal of Advanced Manufacturing Technology.