行政院國家科學委員會專題研究計畫　成果報告

含有不良品及可控制前置時間之二階供應鏈存貨模式之研究

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含有不良品及可控制前置時間之二階供應鏈存貨模式之研究

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行政院國家科學委員會專題研究計劃成果報告

含有不良品及可控制前置時間之二階供應鏈存貨模式之研究

The study of two-echelon supply chain inventory model with defective items and controllable lead time

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中文摘要

傳統的存貨模式大都是基於買方或賣方單方面的考量，來探討生產及訂購策略等問題，如此往往使雙方資訊無法整合而造成損失。近年來，及時化的製造策略受到廣泛利用，由於其專注於買方與賣方的整合，因此需要買方與賣方能夠充分合作，方可利用雙方資訊的整合，訂定合理的長期採購合約，做到真正的及時化採購，從而降低相關存貨系統的總成本。

近年來，有關整合性的存貨模式愈來愈受到重視。過去的相關研究大多著重於買賣雙方最適訂購、生產與運送批量的決定，並未考慮到當批量中含有不良品時對整合買賣雙方總成本的影響。在實務上，因為生產製造過程的瑕疵，管理維護不當，或是運送過程的不小心，買方經常會在訂購批量中發現不良品。

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。在本研究中，我們採部份檢查(sub-lot inspection)的策略來檢查批量中的不良品項。針對此檢查策略，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：整合性存貨模式、不良品、前置時間、部分檢查、大中取小分配不拘程序

ABSTARCT

In traditional, most inventory models considered so far assume only one single facility (e.g., a buyer or a vendor) managing its inventory policy so as to minimize its own cost or maximize its own profit. This one-side-optimal-strategy is not suitable for today's global markets anymore. Recently, the issue of JIT has received a lot of interest. Most JIT research has been focused on the integration between vendor and buyer. Once the long-term relationship between both facilities has been built up, both parties can cooperate and share information to reach better benefits. By applying information technologies, order processing time can be reduced and information exchange will become more conveniently, and then the ultimate goal of JIT can be fulfilled and the total costs in inventory system can be reduced.

The concept of integrated inventory management has recently attracted a great deal of attention. Previous researches on the integrated vendor-buyer inventory problem focused on the production shipment schedule in terms of the number and size of batches transferred between both parties under perfect quality. These researches do not describe the possible relationship between order lot and quality. However, defective items emerge in many practical situations. As a result of weak process control, deficient planned maintenance, inadequate work instructions and/or damage in transit, an arriving order lot often includes defective items.

This proposal intends to investigate the impact of defective items and lead time reduction on the integrated vendor-buyer production/ordering policy. In this project, to ensure the quality of products selling to end customer, the sub-lot inspection policy is considered at the buyer's end. Under this sub-lot inspection policy, we first consider the case where the demand of lead time follows a normal distribution, and then consider the case of generalized distribution function and apply the minimax distribution free procedure to solve the optimal solution. 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, sub-lot inspection, minimax distribution-free procedure

SOURCE AND PURPOSE

Buyer-vendor channel coordinate to achieve better joint profit by optimizing the inventory policy has received a significant attention among researchers during the past three decades. 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 the 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. Ha and Kim [4] extended the concept and proposed an integrated lot-splitting model of facilitating multiple shipments in small lots. Goyal and Nebebe [5] 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) $\times$ (Rate of production / Rate of demand). Recently, Kelle *et al*. [6] presented joint optimal ordering/setup policies which the buyer's order quantity is delivered in several equal sized shipments and the vendor's production lot size can also be an integer multiple of the shipment size. Previous researches on the integrated vendor-buyer inventory problem focused on the production shipment schedule in terms of the number and size of batches transferred between both parties under perfect quality. These literatures do not describe the possible relationship between order lot and quality.

As a result of imperfect production of the vendor, and/or damage in transit, an arriving order lot often contains some defective items. These defective items will impact the on-hand inventory level, service level and the frequency of orders in the inventory system. Therefore, to adjust the unrealistic assumption of perfect quality, many researchers (e.g., Schwaller [7], Paknjad *et al*. [8], Ouyang *et al*. [9], Salameh and Jaber [10], Wu and Ouyang [11], Wu and Ouyang [12]) proposed inventory models involving defective items. The relative models tackled defective items focused on joint lot sizing under an EOQ/EPQ model. In a recent paper, Huang [13] 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 [13] model.

Recently, some models considering lead time as a decision variable have been developed. Lead time usually consists of the following components: setup time, process time, wait time, move time and queue time (see Tersine [14]). In many practical situations, lead time can be reduced by adding an additional crash 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 [15] first presented a probability inventory model in which lead time is an unique decision variable. Later, Ben-Daya and Raouf [16] extended Liao and Shyu's [15] model by considering both lead time and ordering quantity as decision variables where shortages are neglected. Ouyang *et al.* [17] generalized Ben-Daya and Raouf's [16] model by allowing shortages. Then, Ouyang and Wu [18] 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 focused on determining optimal policy for the buyer only and the reorder point was not taken into consideration. Such models neglect the opportunity that buyer and vendor can cooperate together to obtain a better joint policy.

Motivated by the needs for the optimal policies that coordinate the operations of both partners (vendor and buyer) we present in this proposal an analysis of the vendor-buyer integrated inventory model with imperfect quality. We assume that the vendor delivers the order quantity to the buyer in several equal sized shipments and each arrival lot may contain some defective items. When the arrival quantity is large or the inspection process is time consuming, the buyer adopts the sub-lot sampled inspection policy to inspect the selected items. Inspection process is assumed to be non-destructive and error-free, and the defective items found are discarded. We also assumed that un-inspected defective items are not replaceable, but will cause a penalty. Therefore, the model will have an extra cost in the inspection of each lot and an extra penalty cost for un-inspected defective items. Besides, inventory is continuously reviewed, whenever the inventory level falls to the reorder point; a successive shipment is scheduled to arrive. Consequently, we consider an integrated inventory model with a mixture of backorders and lost sales in which the order quantity, reorder point, lead time and number of shipments from the vendor to buyer are decision variables. In this project, we first assume that the lead time demand follows a normal distribution, and 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 solve this model using the minimax distribution-free approach. Furthermore, numerical examples are provided to illustrate the results.

RESULT AND DISCUSSION

The purpose of this proposal is to make a systematic study for the he impact of inspection policy and lead time reduction on an integrated vendor-buyer inventory system. We assume that an arriving order contains some defective items. The buyer adopts a sub-lot sampled inspection policy to inspect selected items. In the model, the shortage during the lead time is permitted, and lead time can be reduced at an added cost. Two models are considered here. We first consider the case where the demand of lead time follows a normal distribution, and then consider the case that the form of the distribution function of lead time demand is unknown and apply the minimax distribution free procedure to solve the optimal solution. We also develop an effective algorithm to obtain the optimal ordering strategy for each case (the lead time demand follows normal distribution or distribution free). To help managers understand the effects of optimal solution on changes in the value of the different parameters associated with the inventory system, sensitivity analysis is also performed in the proposal. This research develops a more realistic inventory model, which can enhance the efficiency of an inventory manager in decision-making.

SELF-EVALUATION

This research corresponds to the original plan and has attended its aim. Hence the paper is of great academic value and suitable for publication in academic journals. This study submits in the International Journal of Systems Science and now accepts it.

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