行政院國家科學委員會專題研究計畫 成果報告

在可控制前置時間、貨幣時間價值及通貨膨脹因素下之存貨系統訂購策略

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行政院國家科學委員會專題研究計劃成果報告

在可控制前置時間、貨幣時間價值及通貨膨脹因素下

之存貨系統訂購策略

Ordering strategy of the inventory system for considering the effect of controllable lead time, time value of money and inflation

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摘　　要

在近代生產管理方面，日本企業界提出及時(Just-in-Time, JIT)存貨管理系統以提高企業的生產力，且效果頗為顯著。所謂 JIT 存貨管理系統是強調高品質、低存貨、及短的前置時間(lead time)。欲達成 JIT 的目標，投資資金以降低前置時間，被認為是可行且有效的方法；換言之，傳統存貨策略所經常假設的固定且不可控制的前置時間，事實上是可以控制的。縮短前置時間可以降低安全存量、減少資金積壓、提高對顧客的服務水準、並增加企業的競爭能力。

再者，早期的存貨管理中幾乎很少考慮貨幣時間價值的影響，因為大部份的模式都假設利率極低，因此將其視為與決策無關的項目。但是近年來，各國的物價持續上漲而金錢購買能力則不斷下跌，使得存貨過剩，導致儲存成本的增加與資金的凍結進而阻礙企業的經營與發展。另外一方面，近年來各國通貨膨脹的情況是愈來愈嚴重；因此存貨模式不能僅單單著眼於利率方面，更應同時將通貨膨脹的影響加以考慮。因此在存貨管理中將貨幣時間價值及通貨膨脹的影響加以考慮是有其必要性的。

本計劃主要嘗試建立在同時考慮可控制前置時間、貨幣時間價值與通貨膨脹因素下，缺貨數量允許部份欠撥與部份不補(銷售損失)的混合存貨模型，其中訂購量、請購點及前置時間均為決策變數。在本研究中，我們首先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)建立求得最適訂購策略之演算法，且探討參數的敏感度分析。

關鍵詞：前置時間、貨幣時間價值、通貨膨脹、大中取小分配不拘程序

ABSTARCT

Among the modern production management, the Japanese successful experiences of using Just-In-Time (JIT) production show that the advantages and benefits associated with the efforts to control the lead-time can be clearly perceived. The goal of JIT inventory management philosophies is the focus that emphasizes high quality, keeps low inventory level and lead-time to a practical minimum. Shortening the lead time is recognized as the feasible and effective way to achieve the goal of JIT. In other viewpoints, the factor (lead time) mentioned above is often assumed as fixed constant and uncontrollable in the traditional inventory models, but is controllable in practice. By reducing lead time, we can lower the safety stock, reduce the loss caused by shortage, improve the service level to the customer, and increase the competitive ability in business.

Most literature in the field of inventory management has not considered the time value of money. This has happened partly due to the belief that the consideration of the time value has insignificant influence on the decision variables. During the past years, however, monetary situation of most counties has changed; this result in a sharp decline in the purchasing power of money. An inventory is usually a large portion of a firm's asset. If it is not storage, the asset can be invested elsewhere. In addition, the situation of inflation of most counties becomes more and more serious. Hence, the inventory models have to consider the inflation also, not merely considering the time value of money. Therefore, the consideration of the effect of time value of money and inflation in inventory model is critical.

This proposal proposes the stochastic inventory mathematical model for the continuous review inventory systems under simultaneously taking account to the controllable lead time, time value of money and inflation. In the model, the shortages are allowed and the total amount of stockout during the stockout period is considered to be a mixture of backorders and lost sales. In addition, the common decision variables are the order quantity, reorder point and lead time. In this proposal, 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 algorithm to obtain the optimal ordering strategy for each case (the lead time demand follows normal distribution or distribution free). Furthermore, for all models proposed in this proposal, the effects of parameters are also included.

Keywords：lead time, time value of money, inflation, minimax distribution free procedure

SOURCE AND PURPOSE

Among the modern production management, the Japanese successful experiences of using Just-In-Time (JIT) production show that the advantages and benefits associated with the efforts to control the lead-time can be clearly perceived. The goal of JIT inventory management philosophies is the focus that emphasizes high quality, keeps low inventory level and lead-time to a practical minimum. Monden (1983) studied Toyota production system, and clearly declared that shortening lead-time is a crux of elevating productivity. During the last decade, managers have been seen the issue of managing suppliers' and manufacturers' lead-time becomes increasingly critical as more and more firms are competing a time base (Blackburn (1991), Gilmore and Pine II (1997), Merrills (1989), Peters (1994), Stalk and Hout (1990), and Weng (1996)). Lead time management issues are also examined by studying many cases of the study, for example, Weng (1998) present a case study off Circuits Atlanta Inc., a printed circuit board manufacturer located in Georgia, and by analyzing how this firm has managed to reduce lead-time.

Most deterministic and stochastic inventory models assume that the lead-time is a given parameter or a random variable (therefore it is uncontrollable), and determines the optimal operating policy on the basis of this unrealistic assumption (For example, Naddor (1966) and Silver and Peterson (1985)). In fact, in many practical situations, lead-time is not a given parameter or a random variable; it can be controlled and reduced at an added cost. Recently, some models considering lead-time as a decision variable have been developed. Liao and Shyu (1991) have initiated a study on lead-time reduction by presenting an inventory model in which lead-time is a decision variable and the order quantity is predetermined. Ben-Daya and Raouf (1994) developed a model that considered both lead-time and order quantity as decision variables. Later, Ouyang et al. (1996) and Ouyang and Wu (1997,1998,1999) have generalized the Ben-Daya and Raouf (1994) model by considering shortages in which the lead-time demand is considered a normal distribution or distribution free. Later, Moon and Choi (1998), Hariga and Ben-Daya (1999) have extended the Ouyang et al. (1996) model to relax the assumption of a given service level and treat the reorder point as a decision variable. Other papers related to this area are Lan et al. (1999), Ouyang and Chuang (2000), Ouyang (2000), Ouyang and Chang (2001), Pan and Hsiao (2001), and others.

In all of the above models mentioned, the time value of money and inflation were disregarded. If the planning horizon is short, it may be appropriate to ignore the time value of money to simplify the decision process. However, if the planning horizon is long, it is questionable that the time value of money is ignored. From the standard point of inventory analysis, it is clear that the mentioned above models can be improved by formulating it within the NPV (Net Present Value) framework that is based on a discounted cash flow (DCF) approach. Trippi and Lewin (1974) have adopted the DCF approach for the analysis of the basic EOQ model. Kim et al. (1986) extend Trippi and Lewin’s work by applying the DCF approach to various inventory system. Chung (1989) has studied the DCF approach for the analysis of the basic EOQ model in the presence of the trade credit. Haneveld and Teunter (1998) apply the DCF approach to the basic EOQ model with a Poisson demand process. After that, many research works (for example, Moon and Lee (2000), and Chung and Lin (2001)) have been devoted to incorporating the DCF approach into their inventory models under a variety of circumstances.

This paper follows the DCF approach to investigate inventory replenishment problem with controllable lead time. The objective is to simultaneously optimize the order quantity, the reorder point and the lead time. We show that the objective cost function to be minimized is jointly convex in decision variables and derivation the optimal solution. Numerical example is presented to illustrate the important issues related to the proposed model.

In this article, we first assume that the lead time demand follows a normal distribution, and find the optimal solution. And then we consider any distribution function (d.f.), say F, of the lead time demand has only known finite first and second moments (and hence, mean and variance are also known). In this situation, for convenience, we let $\boldsymbol{F}$ denoted the class of d.f. F's with finite mean DL and variance $\pm^2 L$ (where D is average demand per year; L is the length of the lead time; $\pm^2$ is variance of the demand per unit time). Our goal is to solve a mixed inventory model with time value and inflation by using the minimax distribution free approach. That is, the purpose of this model is to develop an algorithm procedure to find the most unfavorable d.f. in $\boldsymbol{F}$ for each decision variable (Q, r, L) and then minimize over the decision variables. Finally, sensitivity of the optimal solution with respective to parameters of the system is carried.

RESULT AND DISSCUSSION

This study proposes the stochastic inventory mathematical model for the continuous review inventory systems under simultaneously taking account to the controllable lead time and time value of money. In the model, the shortages are allowed and the total amount of stockout during the stockout period is considered to be a mixture of backorders and lost sales. In this paper, 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 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 values of the different parameters associated with the inventory system, sensitivity analysis is also performed in the paper. 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 attained its aim. Hence, the paper is of great academic value and suitable for publication in academic journals. International Journal of Information & Management Sciences now accepts it.

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