行政院國家科學委員會補助專題研究計畫 成果報告

在價格敏感需求及信用交易下之供應鏈存貨模式發展

研究成果報告(精簡版)

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中文摘要

在現今競爭性的市場環境，企業已經由獨立決策改變為協同合作來制定策略。為降低成本及改善服務水準，有效的供應鏈策略必須考慮在供應鏈中不同層級之間的互動關係。在複雜的供應鏈中，存貨的控制是相當困難的工作，而且對顧客的服務水準及整體供應鏈系統的成本有顯著的影響。因此，在供應鏈管理（Supply Chain Management, SCM）模式下建立適當的整合存貨模型，如何決定同一供應鏈上合作夥伴的最適庫存/訂購策略，使得存貨相關總成本為最小或總利潤為最大，是本研究的主要內容。

本計劃主要是考慮在供應商允許零售商延遲付款的情況下，嘗試建立競爭(供應商為領導者、零售商為跟隨者)及雙方合作的供應鏈存貨模型，並求出 Stackelberg 均衡解。我們將嘗試利用數學證明最佳解存在的充分且必要條件，接著建立一個演算法求出使得單位時間整合總利潤有最大值的最適解。最後，以數值範例說明求解過程，並對重要的參數值進行敏感性分析。

關鍵詞：整合存貨模型、信用交易、Stackelberg game

ABSTARCT

In current competitive market environment, enterprises have transformed from an independent decision to a collaborative decision strategy. In order to reduce cost and improve the service level, an effective supply chain strategy with interactive relation of different levels must be taken into consideration carefully. Inventory control, however, is arduous for the complex supply chain system but generates a significant influence on customer service level and overall cost. Therefore, this study deals with the major content of an integrated inventory models which built on the mode of SCM for the same supply chain partners to decide the optimal inventory and pricing strategy, as well as to achieve the minimum cost of interrelated inventory or the sum of maximum profit.

This proposal aims to develop two echelon supply chain inventory models and discuss the optimal strategies for competitive and cooperative vendor-buyer inventory systems under trade credits (supplier allows retailer for payment delay). The competitive model is analyzed as a Stackelberg game with leader of vendor (buyer as follower). Furthermore, a cooperative model is analyzed as a Pareto efficient solution by maximizing the joint profit per unit time of the vendor and buyer. We also establish an efficient algorithm to obtain the inventory policies for each case (non-cooperative and cooperative). Finally, several numerical examples and sensitivity analysis of crucial parameters are given to illustrate the theoretical results.

Keywords: Integrated Inventory Models、Trade Credit、Stackelberg Game

SOURCE AND PURPOSE

As we know, the objective of supply chain management is to be efficient and cost-effective across the entire system: total system-wide costs, from transportation and distribution to inventories, are to be minimized. The process of finding the best system-wide strategy is known as global optimization. To accomplish the target of global optimization in the field of inventory management, effective coordination plays an important role in the successful operation of modern supply chain inventory system. How to achieving effective coordination between the vendor and buyer is a current managerial concern as well as an important research issue.

An effective coordination factor plays a significant role in a supply chain inventory system is trade credit which is a practice that the vendor may provide the buyer a permissible delay in payments to influence the buyer's order behaviors. There are many studies focused on the optimal inventory policies from either the vendor's or the buyer's standpoints. Goyal (1985) developed an EOQ model under the conditions of permissible delay in payments. Aggarwal and Jaggi (1995) extended Goyal's (1985) model to consider the deteriorating items. Jamal *et al.* (1997) further generalized Aggarwal and Jaggi's (1995) model to allow for shortages. Teng (2002) amended Goyal's (1985) model by considering the difference between unit price and unit cost, and found that it makes economic sense for a well-established retailer to order less quantity and take the benefits of payment delay more frequently. From the vendor's standpoint, it will provide a permissible delay depending on the order quantity to ensure an increase in sales. Chang *et al.* (2003) developed an EOQ model for deteriorating items under supplier credits linked to ordering quantity. Other interesting and relevant papers related to the delay in payments focused on the optimal solutions for either the vendor or the buyer such as Hwang and Shinn (1997), Sarker *et al.* (2001), Chang and Dye (2001), Abad and Jaggi (2003), Chang and Teng (2004),

Chung and Liao (2004), Ouyang *et al.* (2005), Teng *et al.* (2006, 2007), Teng and Chang (2008) and their references.

From the above mentioned studies, it is clear that either the vendor or the buyer can earn profits under a trade credit of permissible delay in payments by seeking the optimal replenishment and payment policies. In additions, Goyal (1976) firstly developed a single-supplier and single-customer inventory problem from an integrated standpoint. Subsequently, Banerjee (1986) extended Goyal's (1976) model and assumed that the supplier followed a lot-for-lot shipment policy with respect to the buyer. Goyal (1988) illustrated that the inventory cost can be reduced if the supplier's economic production quantity (EPQ) is an integer multiple of the retailer's order quantity. Recently, Chen and Kang (2007) first incorporated the permissible delay in payments into the vendor-buyer integrated model. Luo (2007) studied the benefit of coordinating single vendor-buyer supply chain models through the use of credit period. Lately, Ho *et al.* (2008) analyzed the optimal pricing, shipment and payment policy for an integrated supplier-buyer inventory model when the supplier offers not only a cash discount but also a permissible delay. There are many related articles in the integrated vendor-buyer inventory models such as Kelle et al. (2003), Pan and Yang (2002), Wee and Chung (2007), Rau and OuYang (2008), and others. Nevertheless, most studies to discuss the inventory problem under trade credits just from individual or integrated standpoints.

The main purpose of this paper is to developed competitive and cooperative inventory and payment polices in a two-stage supply chain under trade credits. The competitive model is analyzed as a Stackelberg game with leader of vendor (buyer as follower). The Stackelberg game framework has been adopted by many previous studies such as Monahan (1984), Rosenblatt and Lee (1985), Lee and Rosenblatt (1986), Kim and Hwang (1988), Drezner and Wong (1989), Parlar and Wang (1994), Weng (1995), Viswanathan and Wang (2003). Furthermore, a cooperative model is analyzed as a Pareto efficient solution by maximizing the joint profit of the retailer and supplier per unit time. Several theoretical results are developed for these two models. Finally, several numerical examples and sensitivity analysis of crucial parameters are given to illustrate the theoretical results.

RESULT AND DISCUSSION

The purpose of this proposal is to make a systematic study for developing two echelon supply chain inventory models. We discuss the optimal strategies for competitive and cooperative vendor-buyer inventory systems under trade credits, in which the competitive model is analyzed as a Stackelberg game and the cooperative model is analyzed as a Pareto efficient solution by maximizing the joint profit per unit

time of the vendor and buyer. We also establish an efficient algorithm to obtain the inventory policies for each case (non-cooperative and cooperative).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.

REFERENCES

[1] Abad, P.L., Jaggi, C.K., *A joint approach for setting unit price and the length of the credit period for a seller when end demand is price sensitive*, International Journal of Production Economics, Vol. 83, pp. 115-122, 2003.

[2] Aggarwal S.P., Jaggi C.K., *Ordering policies of deteriorating items under permissible delay in payments*, Journal of the Operational Research Society, Vol. 46, pp. 658-662, 1995.

[3] Banerjee, A., *A Joint Economic Lot Size Model for Purchaser and Vendor*, Decision Sciences, Vol. 17, pp. 292-311, 1986.

[4] Chang, C.T., Teng, J.T., *Retailer's optimal ordering policy under supplier credits*, Mathematical Methods of Operations Research, Vol. 60, pp. 471-483, 2004.

[5] Chang, C.T., Ouyang, L.Y., and Teng, J.T., *An EOQ model for deteriorating items under supplier credits linked to ordering quantity*, Applied Mathematical Modelling, Vol. 27, pp. 983-996, 2003.

[6] Chang H.J. and Dye C.Y., *An inventory model for deteriorating items with partial backlogging and permissible delay in payments*, International Journal of Systems Science, Vol. 32, pp. 345-352, 2001.

[7] Chen, L.H., Kang, F.S., *Integrated vendor-buyer cooperative inventory models with variant permissible delay in payments*, European Journal of Operational Research Vol. 183, pp. 658-673, 2007.

[8] Chung, K.J., Liao J.J., *Lot-sizing decisions under trade credit depending on the ordering quantity*, Computers and Operations Research, Vol. 31, pp. 909-928, 2004.

[9] Drezner, Z., Wong, R.T., *Multi-buyer discount pricing*, European Journal of

Operational Research, Vol. 40, pp.38-42, 1989.

[10] Goyal, S.K., *An Integrated Inventory Model for a Single Supplier- Single Customer Problem*, International Journal of Production Research, Vol. 15, pp. 107-111, 1976.

[11] Goyal S.K., *EOQ under conditions of permissible delay in payment*, Journal of the Operational Research Society, Vol. 36, pp. 335-338, 1985.

[12] Goyal, S.K., *A joint economic-lot-size model for purchaser and vendor: a comment*, Decision Sciences, Vol. 19, pp.236-241, 1988.

[13] Ho, C.H., Ouyang, L.Y., Su, C.H., *Optimal pricing, shipment and payment policy for an integrated supplier-buyer inventory model with two-part trade credit*, European Journal of Operational Research Vol. 187, pp. 496-510, 2008.

[14] Hwang H., Shinn S.W., *Retailer's pricing and lot sizing policy for exponentially deteriorating products under the condition of permissible delay in payments*, Computers and Operations Research, Vol. 24, pp. 539-547, 1997.

[15] Jamal A., Sarker B., Wang S., *An ordering policy for deteriorating items with allowable shortage and permissible delay in payment*, Journal of the Operational Research Society, Vol. 48, pp. 826-833, 1997.

[16] Kelle, P., Al-khateeb, F., Anders, M.P., *Partnership and negotiation support by joint optimal ordering/setup policies for JIT*, International Journal of Production Economics, Vol. 81-82, pp. 431-441, 2003.

[17] Kim, K.H., Hwang, H., *An incremental discount pricing schedule with multiple customers and single price break*, European Journal of Operational Research, Vol. 35, pp.71-79, 1988.

[18] Lee, H.L., Rosenblatt, M.J., *A generalized quantity discount pricing model to increasing supplier's profits*, Management Science, Vol. 32, pp.1177-1185, 1986.

[19] Luo, J., *Buyer-vendor inventory coordination with credit period incentives*, International Journal of Production Economics, Vol. 108, pp. 143-152, 2007.

[20] Monahan, J.P., *A quantity pricing model to increasing vendors profits*, Management Science, Vol. 34, pp.1398-1400, 1984.

[21] Ouyang, L.Y., Chang, C. T., Teng, J.T., *An EOQ model for deteriorating items under trade credits*, Journal of the Operational Research Society Vol. 56, pp. 719-726, 2005.

[22] Pan, J.C., Yang, J.S., *A study of an integrated inventory with controllable lead time*, International Journal of Production Research, Vol. 40, pp. 1263-1273, 2002.

[23] Parlar, M., Wang, Q., *Discounting decisions in a supplier-buyer relationship with a linear buyer's demand*, IEEE Transactions, Vol. 26, pp. 34-41, 1994.

[24] Rau, H., OuYang, B.C., *An optimal batch size for integrated production inventory policy in a supply chain*, European Journal of Operational Research, Vol. 185, pp. 619-634, 2008.

[25] Rosenblatt, M.J., Lee, H.L., *Improving profitability with quantity discounts under fixed demand*, IEEE Transactions, Vol. 17, pp. 388-395, 1985.

[26] Sarker B.R., Jamal A.M.M., Wang S., *Optimal payment time under permissible delay in payment for products with deterioration*, Production Planning and Control, Vol. 11, pp. 380-390, 2001.

[27] Teng J.T., *On the economic order quantity under conditions of permissible delay in payments*, Journal of the Operational Research Society, Vol. 53, pp. 915-918, 2002.

[28] Teng, J.T., Chang, C.T., *Optimal manufacturer's replenishment policies in the EPQ model under two levels of trade credit policy*, To appear in European Journal of Operational Research, 2008.

[29] Teng, JT., Chang, C.T., Chern, M.S. and Chan, Y.L., *Retailer's optimal ordering policies in the EOQ models with trade credit financing*, International Journal of Systems Science, Vol. 38, pp. 269-278, 2007.

[30] Teng, J. T., Ouyang, L.Y., Chen, L. H., *Optimal manufacturer's pricing and lot-sizing policies under trade credit financing*, International Transactions in Operational Research, Vol. 13, pp. 515-528, 2006.

[31] Viswanathan, S., Wang, Q., *Discount pricing decision in distribution channels with price-sensitive demand*, European Journal of Operational Research, Vol. 149, pp.571-587, 2003.

[32] Wee, H.M., Chung, C.J., *A note on the economic lot size of the integrated vendor-buyer inventory system derived without derivatives*, European Journal of Operational Research, Vol. 177, pp. 1289-1293, 2007.

[33] Weng, Z.K., *Channel coordination and discounts*, Management Science, Vol. 41, pp.1509-1522, 1995.