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Coordination policy for a two-stage supply chain considering quantity discounts and overlapped delivery with imperfect quality ☆

Tien-Yu Lin *

Department of Marketing and Supply Chain Management, Overseas Chinese University, Taichung 407, Taiwan

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ABSTRACT

Unlike the traditional integrated supplier–buyer coordination model, this research incorporates overlapped delivery and imperfect items into the production–distribution model. This model improves the observable fact that the system might experience shortage during the screening duration and also takes quantity discount into account. This approach has not been discussed in previous integrated supplier–buyer coordination models. The expected annual integrated total cost function is derived and properties and theorems are explored to help develop an algorithm. A solution procedure, free from the convexity associated with an algorithm is established to find the optimal solution. A numerical example is given to illustrate the proposed procedure and algorithm. A sensitivity analysis is made to investigate the effects of five important parameters (the inspect rate, the annual demand, the defective rate, the holding cost, and the receiving cost) on the optimal solution. Managerial insights are also discussed.

1. Introduction

The coordination effect between the supplier and buyer in a supply chain system has been recognized by many studies (e.g. Arshinder & Deshmukh, 2008; Banerjee, Kim, & Burton, 2007; Ben-Daya & Hariga, 2004; Chang, Ouyang, Wu, & Ho, 2006; Goyal & Gupta, 1989; Hoque & Goyal, 2006; Zhang, Liang, Yu, & Yan, 2007). One important benefit of this coordination is more efficient inventory management across the entire supply chain (Sajadieh, Joker, & Modarres, 2009). This coordination mechanism allows the supplier and the buyer to form a long-term production-purchasing cooperative relationship and achieve improved benefits. Numerous researchers have devoted effort to integrated optimization for inventory coordination between the supplier and buyer.

The first pioneer study by Goyal (1976) focused on an integrated model consisting of single-supplier–single-buyer supply chain system. Ever since that time several extended models focusing on perfect items were developed by many researchers (e.g. Banerjee, 1986; Chan & Kingsman, 2007; Goyal, 1987; Hsiao, 2008; Kim & Ha, 2003; Lin, 2010; Luo, 2007). Most of the above researchers considered the items to be perfect. However, the production process may deteriorate and thus defective items may occur. Unlike the above researchers focusing on perfect quality problems, Huang (2004) presented an integrated supplier–buyer model with defective items treated as a single batch that is returned to the buyer at the end of a 100% screening process. Chung (2008) developed an alternative solution method to complete and improve the solution procedure in Huang's work. Chang et al. (2006) developed an integrated supplier–buyer model for crisp and fuzzy cases under the process unreliability consideration. Lin (2009) extended the integrated supplier–buyer model into a case with defective items and inspection errors. Note that all of the above studies assumed that the number of perfect units was at least equal to the demand during the screening time. That is, there was no shortage during the screening duration. However, this assumption, as in Salameh and Jaber (2000), may not be true because defective items may be screened out under several consecutive screenings, thus leading to shortages. Thus, Papachristos and Konstantaras (2006) questioned the validity of the assumption appearing in Salameh and Jaber's (2000) work but failed to provide a solution for this defect. They merely concluded that there is no easy solution that guarantees the validity of this scenario. Recently, Maddah, Salameh, and Karame (2010) developed a practical alternative; an order "overlapping" scheme that allows meeting the demand during the screening process from the "previous order" to avoid shortages. Indeed, this method could efficiently eliminate the uncertainty of shortages because the good items provided in the previous order can be serviced during the screening period. Thus, similar to Maddah et al.'s (2010) idea, this paper employs the overlapping delivery policy, a delivery overlapping scheme that allows the buyer to meet his demand from the previous shipment during the screening period, and develops the mathematical model. The time weighted inventory for the buyer in a supply chain system is illustrated in the second part of Fig. 1.

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* Tel.: +886 4 27016855; fax: +886 4 27075420.
E-mail address: admtyl@ocu.edu.tw

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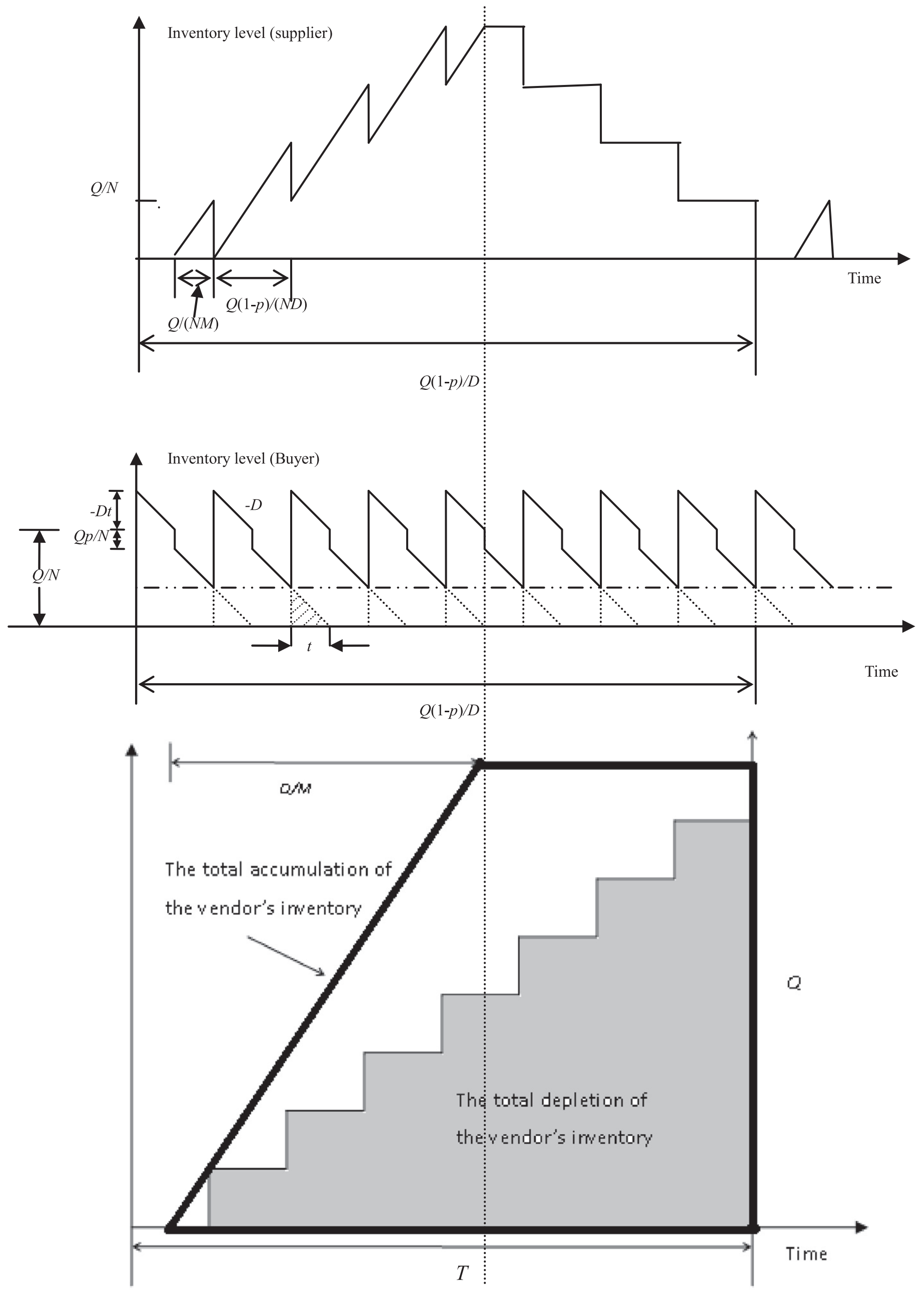

Fig. 1. Behavior of the inventory level for the supplier and buyer.

Another common unrealistic assumption in the above integrated supplier–buyer coordination model is that the direct cost of the product is irrelevant. However, in practice the supplier may employ quantity discounts to stimulate the buyer to order a larger number of items. Generally, quantity discounts can provide economic advantages for both the supplier and the buyer (Burwell, Dave, Fitzpatrick, & Roy, 1997; Ji & Shao, 2006; Qin, Tang, & Guo, 2007). The first researcher to focus on supply chain coordination with quantity discounts was Monahan (1984) in which he assumed a lot-for-lot replenishment policy for a vendor and showed that a vendor could encourage the buyer to order larger quantities by offering a price discount. Rosenblat and Lee (1986) relaxed the lot-for-lot assumption in Monahan's model and allowed the vendor to purchase an integer multiple of the buyer's order quantity. Goyal (1987) provided another model to determine the economic order policy under the quantity amount discount offered by the vendor. Recent studies have begun to consider how to realize supply chain cooperation using quantity discounts. Weng (1995) considered an all-unit and incremental quantity discount policy under single-vendor single-buyer supply system, where the buyer determined the selling price charged to customers. Chen, Federgruen, and Zheng (2001) considered a single-supplier, multiple-buyer distribution system in which a discount scheme was designed to achieve the integrated channel coordination. Klastorin, Moinzadeh, and Son (2002) tested the issue of order coordination between a supplier and multipliers in a decentralized multi-echelon inventory/distribution system in which a manufacturer offers a price discount to retailers when they coordinate the timing of their orders with the manufacturer's order cycle. Taking a different path, some researchers (e.g. Li & Liu, 2006; Tsai, 2007; Shin & Benton,