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An integrated inventory model for a single vendor and multiple buyers with ordering cost reduction

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Abstract

Forming strategic alliances and utilizing modern information technologies have been the two most important ways for firms to gain such competitive advantages as lower logistics costs and secure customers' loyalty. In this paper, we consider an integrated inventory system where a single vendor purchases and processes raw materials in order to deliver finished items to multiple buyers. The vendor and all buyers are willing to invest in reducing the ordering cost (e.g., establishing an electronic data interchange based inventory control system) in order to decrease their joint total cost. The amount of investment determines the planned ordering cost and hence affects their replenishment decisions. One major managerial implication from this ordering cost reduction is that the efforts to streamline and speedup transactions via the application of information technologies may result in a higher degree of coordination and automation among allied trading parties. An analytical model is developed to derive the optimal investment amount and replenishment decisions for both vendor and buyers. The exponential ordering cost function is then applied to our general model, and a numerical analysis is performed to provide interesting insights of the model. Numerical results show that the vendor and all the buyers can benefit directly from substantial cost savings by this ordering cost reduction investment.

Keywords: Inventory; Integrated model; Vendor; Multiple buyers; Ordering cost

1. Introduction

It has been a trend for firms to establish inter-organizational information systems with their buyers in order to gain such competitive advantages as lower logistics costs and securer customers' loyalty. One of the most contemporary information systems is to apply the electronic data interchange (EDI) technology to not only link but also automate the ordering, shipping, inquiring, and payment activities between vendor and

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buyers. An important advantage of using EDI to connect a vendor with his/her buyers is that the products consumption information from each buyer can be automatically and instantly transmitted to the vendor. Based on the information, the vendor can decide when and how many items to deliver to which buyer so that the overall system cost is optimized and the performance of inventory control can be significantly improved.

EDI systems can also result in better vendor–buyer integration and thus streamline the supply chain of traditional goods. This point is well illustrated in the channel partnership established between Levi Strauss and its retailers. Levi Strauss, an apparel manufacturer, operates the LeviLink, an EDI system linking it with its retailers, to speedup the processing of orders and to respond quickly to the customers' changing tastes [1]. The functions of LeviLink include management of inventory, management and reconciliation of purchase orders, tracking of purchase orders, processing and payment of invoices, capturing of point of sales information, and analysis of market trends. Many other successful cases of utilizing the modern information technology in operations management have also been reported [2].

In recent years, many studies have focused on the benefit from ordering cost reduction in the inventory systems but only from the single party's viewpoint (for examples, see [3–6]). However, considering the dyadic relationship between the vendor and buyer is necessary for implementing an EDI-based ordering system since the implementation needs both the trading partners to interchange transaction documents, to standardize transaction procedures, and to integrate related applications [7]. To address the vendor–buyer integration of EDI, Banerjee and Banerjee [8] consider an EDI-based vendor-managed inventory (VMI) system in which the vendor makes all replenishment decisions for his/her buyers to improve the joint inventory cost. Their work focuses solely on the inventory policy by assuming that an EDI system has already been operated between vendor and buyers and hence no ordering cost will incur for both parties.

In order to streamline the supply chain, any vendor is expected to synchronize his/her production cycles with buyers' ordering cycles as well as raw material procurement cycles so that the total inventory cost for the entire chain can be reduced. The cooperation between vendor and buyers for improving the performance of inventory control has thus received a great deal of attention from researchers. Several authors have studied the integrated inventory models in which the vendor and the buyer coordinate their production and ordering policies, in order to lower the joint inventory costs (for examples, see [9–12]). Other research works of integrated inventory models have been summarized in the related review articles [13,14]. Most previous work on integrated vendor–buyer inventory systems does not incorporate raw material procurement decisions into consideration. However, some researchers have taken the procurement of raw materials into account for developing their inventory models in which the manufacturer unifies procurement and production policies to minimize his/her own total inventory cost (for examples, see [15–19]).

In this paper, we investigate an integrated inventory system where a single vendor purchases and processes raw materials in order to deliver finished items to multiple buyers. Our work extends Banerjee and Banerjee's modes [8] to incorporate ordering cost reduction and raw material procurement into the integrated inventory decisions. Our study is motivated by the fact that more and more firms in practice have devoted tremendous efforts to reduce ordering times and costs with their trading partners but few formal models are available in the literature to evaluate those efforts. Therefore, our model serves as a pioneering work on investigating the effects of ordering cost reduction on the integrated inventory system. One major managerial implication of this ordering cost reduction is that the efforts to streamline and speedup transactions via the application of information technologies may result in a higher degree of coordination and automation between allied trading parties. Assumptions and notations used in our work are presented in the next section. In Section 3, we derive an analytical model in which the planned ordering cost is a general function of the expenditure to operate the ordering system, and also develop a solution procedure to find the optimal decisions. Then, in Section 4, we apply the special case of exponential cost function to our general model and perform a numerical analysis to gain some interesting insights. Finally, conclusions are summarized in Section 5.