Applied Mathematical Modelling 39 (2015) 6725–6737

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

Short communication

Multi-item EOQ inventory model in a two-layer supply chain while demand varies with promotional effort

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ARTICLE INFO

Article history:
Received 23 November 2012
Received in revised form 26 November 2014
Accepted 2 February 2015
Available online 25 February 2015

Keywords:
Collaborative system
Non-collaborative system
Promotional effort
Supply chain

ABSTRACT

In this study, we propose an economic order quantity inventory model of multi-items in a two-layer supply chain where demand is sensitive to promotional effort. In this inventory model, the supplier offers a delay period to the retailer for paying the outstanding amount of the purchasing cost for the finished products. The profit functions of the supplier and the retailer are formulated by considering the setup cost, holding cost, selling price, and promotional cost shared by the members. We also compare collaborative and non-collaborative systems in terms of their average profits. Numerical examples are provided to illustrate the use of the proposed model.

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1. Introduction

A supply chain is a network that typically comprises suppliers, producers, distributors, and retailers. A major issue in supply chain management research is supply chain coordination. Frequently, coordination among members is a major source of benefits, which are shared by the partners in the chain. In a globalized and competitive business environment, the coordination of supply chains is a great challenge. The supply chain can be coordinated in several ways. Zhou and Li [1] showed that the coordination between both parties in the ordering strategy increases the expected profit for the retailer as well as for the entire supply chain. Furthermore, He et al. [2] addressed the channel coordination problem in a supply chain with stochastic demand, which is sensitive to both the sales effort and retail price. It is important to note that the two classical coordination strategies, i.e., the returns policy and the revenue sharing contract, can coordinate the members of the chain, but these strategies fail when the demand depends on both the retail price and retailer's sales effort. Therefore, He et al. [2] explored other types of contracts such as a returns policy with revenue sharing, a returns policy with sales rebate and penalty, and a revenue sharing contract with a sales rebate and penalty. They concluded that a returns policy with a sales rebate and penalty is better for coordination and it obtains improvements in the supply chain. Subsequently, Cai et al. [3] proposed a two-echelon supply chain model where a supplier sells to multiple buyers who are faced with the newsvendor problem. Basically, they studied the effects of two advance ordering strategies: (1) when the natural leader (one of the buyers) orders products before the selling season only one time, and (2) when the natural leader orders the products in advance two times. Using their model, they showed that the supplier achieves greater profits with the second strategy. Liu et al. [4] investigated an online dual channel system for a supply chain that comprises one manufacturer and one retailer. In this chain, the manufacturer sells products using the following two selling channels: (1) a traditional retail store and (2) an e-channel. The

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http://dx.doi.org/10.1016/j.apm.2015.02.004
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manufacturer may or may not be the owner of the traditional channel. They determined the optimal production and pricing strategies when the manufacturer employed these two channels. Chen et al. [5] performed another interesting study related to channel coordination via revenue-sharing contracts.

In all companies, it is common to implement promotional efforts in several forms (e.g., free gifts, better services, warranty, rebates, displays, returns policies, and delay-in-payment) to enhance the successful sales of products. In this context, Nair and Tarasewich [6] discussed the optimal design for promotional efforts such as free gifts, discounts, and special services. Subsequently, Krishnan et al. [7] considered the promotional strategies that can maximize revenues, including price costs, displays, free goods and advertising. Jaber et al. [8] reduced the system entropy or disorder in the production system by applying the first and second laws of thermodynamics to obtain higher profits than the classical approaches used in economic order quantity (EOQ)/economic production quantity inventory models. Their observations suggest that large lots are cheaper to control than small ones and that reducing the size of the lot without considering the entropy cost may yield results that are the opposite of those expected. Sun [9] determined the relationships among the behavior of customers with different types of promotions and showed that promotions have a greater impact on stronger brands. Sana and Chaudhuri [10] presented an inventory model for stock where the demand is sensitive to advertising. Szmerekovsky and Zhang [11] considered the pricing strategy and two-tier advertising level between one manufacturer and one retailer when the customers' demands depend on the retail price and advertising by both the manufacturer and the retailer. Xie and Wei [12] determined the optimal collaborative advertising strategies and equilibrium pricing in a two-layer supply chain. Moreover, Ramanathan and Muyldermans [13] applied structural equation modeling to investigate the effects of promotions and other activities on the sales of soft drinks. Subsequently, Sana [14] investigated a multi-item EOQ model for deteriorated and ameliorating items where the time-varying demand is influenced by business initiatives such as advertising media and the efforts of salesmen. Chen et al. [5] analyzed a decision-making problem related to profit sharing for two firms, where they employed both the centralized and decentralized regimes of the channel. More recently, Sana [15,16] proposed an inventory model that determines the retailer's optimal order quantity for similar products. This inventory model assumes that space is limited and that the demand for items depends on the display stock level, selling price, and initiatives by salesmen.

In practice, suppliers usually offer a delay period to retailers for paying the outstanding amount of the purchasing costs to boost the sales of their products. During this period, the retailer can earn interest from selling items; otherwise, the retailer has to pay interest to the supplier for late payment. This strategy reduces the purchasing cost of the retailer indirectly and encourages the retailer to buy more. Jaber and Osman [17] proposed a two level (supplier–retailer) supply chain coordination approach in order to minimize the cost of the chain, by incorporating a permissible delay in the payment strategy. Subsequently, Chan et al. [18] integrated a single-vendor and multi-buyer supply chain by synchronizing the ordering and production cycles, where they considered delayed payments based on the buyers' ordering intervals. Tsao [19] determined the optimal pricing and ordering policy in order to maximize the profit of a two-level supply chain when the supplier offers a cash discount to a specific retailer (a comparatively senior company with a greater market share and less pressure on the investment of capital) and a credit period to another (a comparatively junior company with a smaller market share and more pressure on capital investment). Moussawi-Haidar and Jaber [20] presented a nonlinear mathematical programming model and proposed a solution procedure for determining the optimal operational and financial decisions by integrating the cash management and inventory lot sizing problems. Moussawi-Haidar et al. [21] investigated a three-level supply chain, which comprised a capital-constrained supplier, a retailer, and a financial intermediary (bank), where they aimed to coordinate their decisions to minimize the total supply chain costs while the supplier allowed a delay in payments to the retailer. Recently, Jiangtao et al. [22] investigated a multi-item inventory model of the stock-dependent demand for perishable items using two-level trade credit policies and a restriction on the inventory capacity. Given a supply chain environment with one manufacturer and one retailer, Cárdenas-Barrón and Sana [23] proposed a production-inventory model that includes variable procurement costs, sales teams' initiatives, sensitive demand, backordering, variable production rate, and production lot size, where backordering occurs only at the retailer. In their production-inventory model, the decision variables comprise the production rate, production lot size, and sales teams' initiatives. Three strategies were investigated for a centralized supply chain.

In the present study, we propose an inventory model for a two-stage supply chain (supplier–retailer) with multiple items. This inventory model allows a delay in payments of the outstanding amount of the purchasing cost for products by the retailer. The supplier procures the finished products by assembling the raw materials for all the items. These raw materials are stored at the beginning of the production cycle when a payment is received in cash to purchase the raw materials required for the order. The demand of the end customers depends partly on the promotional activity, which is shared by both of the members of the chain according to their negotiations. As a result, the production rate of the supplier varies with their promotional activities. Therefore, the supplier starts production of the finished products and the stock level of raw materials decreases over time, while the finished products accumulate with the production run-time. After producing the complete lot size, i.e., at the end of the production cycle, the whole lot is delivered to the retailer. Because a delay in payment is offered by the supplier to the retailer, the supplier has to wait up to the delay time to receive the sales price. Thus, the interest on the purchasing costs of the raw materials up to the delay period is considered in this model. The retailer may earn interest from the sales items up to the delay time but interest is charged for late payments by the retailer. Finally, the average profit functions of both members are analyzed in centralized and decentralized systems.

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