Chapter 9
Differential Return on Investment Optimization:
Pricing, Lotsizing, and Shipment Considerations in a Two-Echelon Supply Chain

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ABSTRACT

A two-echelon supply chain is studied that involves a retailer who faces demand from two or more market segments and enable to set different prices and marketing expenditures and a supplier who desires to find optimal number of shipments through an integrated system. A new mixed-integer non-linear fractional programming (MINLFP) model is developed. In order to solve the resultant MINLFP model, the constrained non-linear programming model is reformulated as an unconstrained one using penalty terms. Two meta-heuristics, namely simulated annealing (SA) and imperialist competitive algorithm (ICA), are applied to solve the relaxed unconstrained model. Numerical results show that ICA can reach better solutions in comparison with SA. However, SA has the ability of providing more robust solutions which are converged to a good solution. The chapter concludes with superiority of SA.

INTRODUCTION AND BACKGROUND

An up-to-date review by Chen and Simchi-Levi (2012) reveals there is a growing literature in presenting and analyzing optimization models integrating pricing and lotsizing policies. In today's global markets, the revenue management (RM) models are becoming a powerful instrument, where a retail industry desires to provide different levels of marketing mix (named four P's: price, product, promotion and place) to different market segmentations (i.e. channels). Since the pioneering review research of Kleijn and Dekker (1998), the concept of inventories' price differentiation has been one of the most pervasive activities in both the marketing and operations academic literature and practice.

One of the underlying principles of RM is to divide a single market into multiple sub-markets/segments and then set different prices in each sub-market. Price differentiation is a powerful way for sellers to improve their profitability (Phillips, 2005). Sen and Zhang (1999) considered the newsboy problem with multiple demand classes, where demands were realized sequentially and demand dependency was modeled through the diversion. Zhang and Bell (2007) extended the newsvendor problem with backlogged demand to the case where the single product can be sold to different demand classes at different prices. Zhang et al. (2010) evaluated the simultaneous determination of price and inventory replenishment in a two-segment market with a fence. All of these research papers focus on profit aspects of the retailer/manufacturer without any other criterion.

Ghasemy Yaghin et al. (2013) presented a joint pricing and lot-sizing model with multiple demand classes to set different prices and marketing expenditure in each sub-market. Traditionally, numerous papers have employed the profit maximization or cost minimization as their objective in designing and analyzing inventory models. Many researchers also optimized the inventory systems under return on investment (ROI) maximization. As Lenskold (2003) mentions, it is completely reasonable, and highly beneficial, to expect a return on investment for each incremental marketing dollar spent. An inventory model using the criterion of ROI maximization is proposed by Schroeder and Krishnan (1976). Also, Rosenberg (1991) compares and contrasts profit maximization versus return on inventory investment with respect to logarithmic concave demand functions. Otake et al. (1999) proposed an ROI maximization model with the lot size and setup cost reduction investment as the strategic joint decision variables. Otake and Min (2001) constructed and analyzed inventory and investment in quality improvement policies under ROI maximization.

Li et al. (2008) constructed and analyzed inventory and capital investment in setup and quality under ROI maximization. Wee et al. (2009) proposed a joint replenishment model under profit and ROI maximization. Ghasemy Yaghin et al. (2013) developed a return on inventory investment (ROII) maximization model in inventory-marketing problems under uncertainty to manage some marketing mix. Literature review on integrated models involving inventory-related decision, starting with Goyal (1976) and Banerjee (1986), reflects various mathematical and heuristic techniques developed to implement specific strategies. Good state-of-the-art review papers on integrated decision making on inventory management known as joint economic lot size (JELS) models and methodologies can be found in Ben-Daya (2008) and Glock (2012). Recently, Ghasemy Yaghin et al. (2014) have improved the marketing aspects of existing JPLM models in an integrated two-echelon supply chain in which a very interesting demand function is used to formulate the customer behaviour in a more realistic way while maximizing the system's total profit. Hammami and Frein (2014) have presented an optimization model for the design of global supply chains where the emphasis is made on transfer pricing for both tangible and intangible elements. Qin (2014) has considered the pricing and lot-sizing problem for products with

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