Chapter 12
A Hybrid Fuzzy Multiple Objective Approach to Lotsizing, Pricing, and Marketing Planning Model

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ABSTRACT
Given high variability of demands, a manufacturer has to decide about the products’ prices and lotsizing from a supplier. Due to imprecise and fuzzy nature of parameters such as unit costs and marketing function, a hybrid fuzzy multi-objective programming model including both quantitative and qualitative objectives is proposed to determine the optimal price, marketing expenditure, and lotsize. Considering pricing, marketing, and lotsizing decisions simultaneously, the model maximizes the profit, return on inventory investment (ROII) (as a financial performance criterion), and total customer satisfaction under general demand function with a time-varying pattern in fuzzy environment. After applying appropriate strategies to defuzzify the original model, the equivalent multi-objective crisp model is then transformed by a fuzzy goal programming method. A soft computing, particle swarm optimization (PSO) is applied to solve the final crisp problem. An industrial case study is provided to show the applicability and usefulness of the proposed model and solution method. Finally, concluding remarks are reported.

1. INTRODUCTION
Traditional inventory models focus on effective replenishment strategies and typically assume that a commodity’s price is exogenously determined. In recent years, however, a number of industries have used innovative pricing strategies to manage their inventory effectively (Chen and Simchi-Levi, 2004). The benefits can be significant, including not only potential increases in profit, but also other improvements such as changes in demand levels or reduction in production variability, resulting in more efficient supply chains. For manufacturing
industries, the coordination of price decisions with other aspects of the supply chain such as production and distribution is not only useful, but also essential. This integration of pricing, production and distribution decisions in retail or manufacturing environments is still in its early stages in many companies, but it has the potential to radically improve supply chain efficiencies in the same way as revenue management has changed airline, hotel and car rental companies (Chan et al., 2004).

The integration or coordination of production and marketing functions has been known to be crucial in practice for diminishing their conflicts and increasing a firm’s profit by reducing opportunity losses incurred from separate or independent decision-making (Freeland, 1982; Kotler, 1971; Porteus and Whang, 1991; Kunreuther and Richard, 1971; Lee and Kim, 1993; Kim and Lee; 1998). One important area is joint pricing and lot sizing model (JPLM), which concerns simultaneous determination of an item’s price and lot size or economic order quantity (EOQ) to maximize a firm’s profit for constant but price-dependent demands over a planning horizon. Marketing expenditures which include the advertisement and promotion directly affect the demand of an item. The manufacturing companies increase the advertisement cost and give some advantages (like promotion and incentives) to their sales representatives according to their performances. The effort expended in marketing production is an important factor that is considered in JPLM. The marketing effort influences demand and, consequently, the firm profit. Marketing effort motivates sales and influences potential consumers with an immediate reason to buy (Huang and Li, 2001).

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. An inventory model using the criterion of ROI maximization is proposed by Schroeder and Krishnan (1976). Also, Rosenberg (1991) compares and contrasts profit maximization vs. 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. Recently, 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. Although the above researches are abundant, few studies have simultaneously considered profit and ROI maximization as performance criteria for the shortage constrained inventory model (Wee et al., 2009).

It is often difficult to determine the actual inventory parameters of the inventory problem. So the inventory cost parameters are assumed to be flexible, i.e., fuzzy in nature (Mandal et al., 2005). Due to the limitation on historical data, most of the input data and related parameters are not known with certainty because of incompleteness and/or unavailability of required data and expressed by imprecise terms (e.g., around $200). In addition, the decision maker (DM) often can not fit some probability distribution with certainty for uncertain parameters. The decisions made on the basis of stochastic models can only take the form of a distribution function, which can do little to help decision making in practical situations. However, such fuzziness in the critical data can not be represented in a deterministic or stochastic formulation and therefore the corresponding optimal results may not serve the real purpose of modeling. In reality, data on marketing expenditure are less readily available. Therefore, real-life scenarios require marketing parameters to be of imprecise type i.e. uncertainty is to be imposed in non-stochastic sense. Furthermore, a DM often has vague goals such as “This profit
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