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A comparison between two pricing and lot-sizing models with partial backlogging and deteriorated items

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Abstract

Recently, Abad [2003. Optimal pricing and lot-sizing under conditions of perishability, finite production and partial backordering and lost sale, European Journal of Operational Research, 144, 677–685] studied the pricing and lot-sizing problem for a perishable good under finite production, exponential decay, partial backordering and lost sale. In this article, we extend his model by adding not only the backlogging cost but also the cost of lost goodwill. We then analytically compare the net profits per unit time between Abad's (2003) model and Goyal and Giri's [2003. The production-inventory problem of a product with time varying demand, production and deterioration rates. European Journal of Operational Research, 147, 549–557] model. In Abad's model, the cycle starts with an instant production to accumulate stocks, then stops production to use up stocks, and finally restarts production to meet the unsatisfied demands. By contrast, in Goyal and Giri's model, the cycle begins with a period of shortages, then starts production until accumulated inventory reaches certain level, and finally stops production and uses up inventory. Our theoretical results show that there is no dominant one between these two models. Furthermore, we provide certain conditions under which one model has more net profit per unit time than the other. Finally, we give several numerical examples to illustrate the results.

Keywords: Inventory; Pricing; Partial backlogging; Deteriorating items

1. Introduction

Many researchers have studied inventory models for deteriorating items such as volatile liquids, blood banks, medicines, electronic components and fashion goods. Ghare and Schrader (1963) were the first proponents for developing a model for an exponentially decaying inventory. They categorized decaying inventory into three types: Direct spoilage, physical depletion and deterioration. Next, Misra (1975) developed an economic order quantity (i.e., EOQ) model with a Weibull deterioration rate for the perishable product but he did not consider backordering. Dave and Patel (1981) considered an EOQ model for deteriorating items

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with time-proportional demand when shortages were prohibited. Sachan (1984) then generalized the EOQ model to allow for shortages. Later, Hariga (1996) generalized the demand pattern to any log-concave function. Teng et al. (1999) and Yang et al. (2001) further generalized the demand function to include any non-negative, continuous function that fluctuates with time. Recently, Papachristos and Skouri (2003) extended Wee's (1999) deteriorating EOQ model with quantity discount, pricing and partial backordering to allow for the demand rate to be a convex decreasing function of the selling price.

Abad (1996) established the optimal pricing and lot-sizing EOQ policies under conditions of perishability and partial backordering. Then Abad (2000) extended the optimal pricing and lot-sizing EOQ model to an economic production quantity (i.e., EPQ) model. Balkhi and Benkherouf (1996) developed a general EPQ model for deteriorating items where demand and production rates are time varying, but the rate of deterioration is constant. Balkhi (2001) then further generalized the EPQ model to allow for time-varying deterioration rate. Concurrently, Yan and Cheng (1998) considered a perishable single-item EPQ model in which production rate, demand rate and deterioration rate are assumed to be functions of time, and shortages are partially backlogged. Other recent articles related to this research area were written by Abad (2001), Chang and Dye (1999), Papachristos and Skouri (2000), Skouri and Papachristos (2003), Teng et al. (2002), Yang and Wee (2003) and Wee and Law (1999). In addition, Raafat (1991), and Goyal and Giri (2001) wrote two excellent surveys on the recent trends in modeling of continuously deteriorating inventory.

Recently, Abad (2003) studied the pricing and lot-sizing problem for a perishable good under finite production, exponential decay and partial backordering and lost sale. He assumed that customers are impatient and the backlogging rate is a negative exponential function of the waiting time. In addition, he assumed that the customers are served on first come first served basis during the shortage period. Then he provided a solution procedure to obtain the optimal price and lot-size that maximizes the net profit per unit time. However, he did not include the shortage cost for backlogged items and the cost of lost goodwill due to lost sales into the objective. If the objective does not include these two costs, then it will alter the optimal solution and overestimate the net profit. To correct them, in this paper, we add both the shortage cost for backlogged items and the cost of lost goodwill due to lost sales into the objective suggested by Abad (2003).

In Abad (2003), the production-inventory model starts with an instant production to accumulate stocks, then stops production to use up stocks, and finally restarts production to meet the unsatisfied demands. In fact, Abad's production-inventory model is similar to that in Balkhi and Benkherouf (1996). Lately, Goyal and Giri (2003) investigated a similar production-inventory problem in which the demand, production and deterioration rates of a product were assumed to vary with time. However, pricing was not under consideration and the backlogging rate was assumed to be a constant fraction. They then proposed a new production-inventory model in which the cycle begins with a period of shortages, then starts production until accumulated inventory reaches a certain level, and finally stops production and uses up inventory. Finally, Goyal and Giri (2003) provided a numerical example to show that their model outperforms Balkhi and Benkherouf's model (1996) in terms of the least expensive total cost per unit time.

In this paper, we first extend Abad's (2003) pricing and lot-sizing model by adding not only the shortage cost for backlogged items but also the cost of lost goodwill due to lost sales into the objective. Next, we establish a new modeling approach as in Goyal and Giri (2003) to the same pricing and lot-sizing inventory problem. We then characterize the optimal solution to both distinct models, and prove that both two models provide the same profit if all parameters are constant. However, if any single parameter is varying with time, then the performances of these two models are varied. Furthermore, we obtain some theoretical results that show the conditions under which one model has more net profit per unit time than the other. Finally, we provide several numerical examples to illustrate the results, and conclusions are made.

2. Assumptions and notations

The following assumptions are similar to those in Abad's (2003) model.

(1) The planning horizon is infinite.
(2) The initial and final inventory levels are both zero.