ABSTRACT

This paper describes two heuristics for the basic economic order quantity and economic production quantity with partial backordering that use the time between orders and the percentage of demand filled from stock as the decision variables. Tests of the heuristics on a set of problems generated by using different values for six situational characteristics indicate that both heuristics should perform well as long as the critical value of the backordering rate is positive and very well if it is at least 0.50.

Keywords: EOQ, EPQ, Heuristics, Inventory Control, Partial Backordering

1. INTRODUCTION

Harris’s (1913) classic economic order quantity (EOQ) model forms the basis for many other models that relax one or more of its assumptions. One assumption, instantaneous delivery, was relaxed by Taft (1918), who used a finite production rate, leading to the basic economic production quantity (EPQ) model. An assumption of both of these models is that stockouts are not permitted. Relaxing this assumption led to models for the two basic cases for stockouts: backorders and lost sales. Recognizing that not all customers are willing to wait for delivery led to the development of models for partial backordering, in which a fraction of stockouts are backordered and the rest are lost sales.

Montgomery, Bazarra, & Keswani (1973) were the first to develop and solve a model for the basic EOQ with partial backordering (EOQ-PBO), with others (Rosenberg, 1979; Park, 1982; Park, 1983; Wee, 1989; Pentico and Drake, 2009) that took different approaches appearing subsequently. Mak (1987) added...
partial backordering to the basic EPQ model (EPQ-PBO), with other authors (e.g., Zeng, 2001; Pentico, Drake, & Toews, 2009) developing models using different approaches.

While these papers used different notation and decision variables and, to some extent, made different assumptions about costs or other model features, they have two things in common. First, they all assumed that \( \beta \), the percentage of demand backordered during the stockout period, is a constant. Second, their solution procedures determine the optimal decision variable values by substituting the parameter values into closed-form expressions.

Although Montgomery et al. (1973) also included a model that recognized that a customer’s willingness to wait for delivery might depend on how long he or she would have to wait, the next to include this idea was Abad (1996), who combined a backordering rate that changes according to either an exponential or rational function of the time to delivery with deteriorating inventory and pricing decisions. Since Abad (1996), using a time-dependent backordering rate function either within the structure of a basic EOQ or EPQ model (see San-José, Sicilia, & García-Laguna, 2005a; San-José, Sicilia, & García-Laguna, 2005b; San-José, Sicilia, & García-Laguna, 2006; San-José, Sicilia, & García-Laguna, 2007; and Toews, Pentico, & Drake, 2011) or in combination with other complicating model features, such as product deterioration, demand that changes either with time or the inventory level, or pricing, has been the more common assumption in modeling either the EOQ or EPQ with partial backordering. A comprehensive review of deterministic partial backordering models may be found in Pentico and Drake (2011).

Because of their more complicated model structures, partial backordering models that include either time-based backordering rate functions or additional considerations are more difficult to solve. Except for the models for which the only enhancement is a backordering rate that is a linear function of the time to delivery (Montgomery et al., 1973; San José et al., 2007; and Toews et al., 2011) and a model for the EPQ-PBO in which the constant backordering rate changes when production starts (Pentico et al., 2011), none of these models can be optimized by substituting the model parameters into closed-form equations. They require more complicated search procedures, which are less likely to be used in practice since, as stated by Woolsey and Swanson (1975): “People would rather live with a problem they cannot solve than accept a solution they cannot understand.” This suggests the desirability of developing heuristics, especially for the more complicated problem scenarios with non-linear time-based backordering rate functions or additional model features like product deterioration or non-constant demand.

Our purpose in this paper is to begin this heuristic-development process by proposing and testing two relatively simple heuristics for the basic EOQ-PBO and EPQ-PBO with a constant \( \beta \), even though these problems can be optimally solved using closed form expressions. We explain the rationale behind the heuristics and show, by means of a numerical study, the conditions under which they should perform almost as well as an optimization model and the conditions under which they probably will not. Our expectation is that we and other researchers will be able to extend these heuristics to the more complicated scenarios that do not have closed-form solutions.

The heuristics are based on the optimization models in Pentico and Drake (2009) for the EOQ-PBO and in Pentico et al. (2009) for the EPQ-PBO. Thus we start with a brief review of those two models and their equivalents for the no backordering (NBO) and full backordering (FBO) cases.

2. USING THE CYCLE LENGTH AND FILL RATE TO MODEL THE EOQ-PBO AND EPQ-PBO

Some authors who developed models for the EOQ or EPQ with partial backordering began by using the classic decision variables for the EOQ and EPQ with full backordering: \( Q \), the
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