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Int. J. Production Economics 90 (2004) 361–367

international journal of production economics

www.elsevier.com/locate/dsw

Inventory control with a modified Croston procedure and Erlang distribution

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Received 16 August 2002; accepted 19 March 2003

Abstract

This paper considers an inventory control system, primarily for a finished goods inventory. The purpose is to create a procedure that can handle both fast-moving items with regular demand and slow-moving items. The suggested procedure should be easy to implement in a modern computerized ERP-system. Essentially, the system is a periodic review system built around a Croston forecasting procedure. An Erlang distribution is fitted to the observed data using the mean and variance of the forecasted demand rate. According to probabilities for stock shortages, derived from the probability distribution, the system decides if it is time to place a new order or not. The Croston forecasting method is theoretically more accurate than ordinary exponential smoothing for slow-moving items. However, it is not evident that a Croston forecasting procedure (with assumed Erlang distribution) outperforms ordinary exponential smoothing (with assumed normal distribution) applied in a ''practical'' inventory control system with varying demand, automatically generated replenishment, etc. Our simulation study shows that the system in focus will present fewer shortages at lower inventory levels than a system based on exponential smoothing and the normal distribution.

Keywords: Forecasting; Inventory; Intermittent demand; Erlang distribution; Croston

1. Introduction

Jonsson (2000) and Jonsson and Mattsson (2002) present a survey of used techniques for production and inventory control in 400 Swedish companies. Their study shows that many companies involved in the manufacturing and supply environment perform poorly when it comes to updating parameters used for inventory control, e.g. the reorder points in the year 1999 were even more scarcely updated than in a similar study 5 years ago. The companies answered that most of the items reorder points were not even updated once a year. A forecasting module, which automatically updates safety stocks and reorder points, would in our opinion, decrease inventory levels and inventory shortages for most items with changing demand.

We suppose that the low usage of automatic reorder point updates in practical applications is due to the difficulty for ordinary exponential smoothing to handle slow-moving items; and the difficulty in a practical application to decide which forecast interval to use (Segerstedt, 2000).

This paper considers the problem of forecasting and managing an inventory consisting of articles that can be both slow moving and fast moving. For fast-moving items, many methods for

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0925-5273/03/$ - see front matter
doi:10.1016/S0925-5273(03)00053-7

inventory control have been developed. The method that is most commonly used is the Exponential smoothing forecasting procedure in combination with an assumption that the demand size for the items belongs to the normal distribution. This method of controlling inventories works quite well for the fast-moving items. However, problems arise when the demand becomes intermittent. Intermittent demand seems to appear at random and there are many periods, i.e. production days, weeks or even months that do not show any demand at all. Another problem is that when there is a demand during one period this demand can be greater than one unit.

Another important issue to discuss is what statistical distribution to use for items with intermittent demand. The most common assumption is that the demands for these items are normally distributed. However, e.g. Burgin (1975) has investigated the applicability of the gamma distribution for inventory control. His findings were that the gamma distribution was better suited for representing the demand of different items than the normal distribution. This is due to the fact that the gamma distribution is defined only for non-negative values and that it need not be symmetrical all the time. Both these facts are important when discussing the demand of an item. The fact that the gamma distribution is not defined for negative values implies that there is no negative demand, which is a reasonable assumption to make. Of course in some cases negative demand might occur due to customers returning their products but that is another problem. Burgin also states that the symmetrical shape of the normal distribution is a disadvantage when representing intermittent demand and that the gamma distribution, which is not symmetrical, is more appropriate for the representation of intermittent demand.

2. Theoretical background

2.1. Exponential smoothing

The exponential smoothing forecasting technique is widely spread in practice, in literature and in textbooks (e.g., Nahmias, 2001; Silver et al., 1998; Axsäter, 2000). Ordinary exponential smoothing is defined as follows:

$$F_{t+1} = F_t + \alpha(X_t - F_t),$$
$$\mathrm{MAD}_{t+1} = \mathrm{MAD}_t + \beta(|X_t - F_t| - \mathrm{MAD}_t), \qquad (1)$$

where F_t is the exponential smoothing estimate of mean demand for period t; X_t is the real demand for an item at time t; MAD_t is the exponential smoothing estimate of Mean Absolute Deviation for period t; α is the smoothing parameter for mean demand, and β is the smoothing parameter for MAD.

Since the exponential smoothing technique is so well known the procedure presented in this article will be compared to the exponential smoothing technique.

2.2. Modified Croston procedure

The exponential smoothing technique was proved to be inappropriate for use on items with intermittent demand by Croston (1972). Instead, Croston proposed a method that could handle the difficulties of intermittent demand. This method has been known as the Croston forecasting technique. The main change that Croston introduced was that the forecast is renewed only when there is a demand (a withdrawal from inventory) and not when the forecast time interval has passed like with ordinary exponential smoothing. Croston's method not only focuses on the size of the order, his model also takes the time between orders into consideration. This made the model suitable for forecasting items that have intermittent demand patterns.

Segerstedt (2000) presents a modification of Croston's method. This paper will focus and use the model of Segerstedt, which we call modified Croston. Syntetos and Boylan (2001) argue they have found a bias in the Croston method and they also suggest a modification of the original method of Croston. Our modification is based on an effort to construct an as uncomplicated and useful practical forecasting method as possible, able to treat both slow-moving and ordinary-moving items, with no more parameters than necessary. The way we modify Croston's method avoids the