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A note on the categorization of demand patterns

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Viewpoints

A note on the categorization of demand patterns

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The accuracy of a forecasting method for a particular product depends on the characteristics exhibited by the product's demand history. Consequently, demand time series are sometimes divided into several discrete categories in order to assign the best forecasting method.

The idea of categorizing demand patterns initially appeared in Williams (1984), who studied the classification of products by demand type, stock control policies for different categories of products, and methods of forecasting demand for the different categories of products. Similar ideas of categorizing demand patterns for the purpose of forecasting and inventory control are considered in Eaves and Kingsman (2004).

A new approach to this problem was recently provided by Syntetos *et al* (2005) (hereafter SBC). SBC categorize demand based on the expected mean square error of each forecasting method under some assumptions. They compare Croston's (1972) method (hereafter CRO) and a bias-adjusted version of Croston's method due to Syntetos and Boylan (1999) (also known as the 'approximation method' (Eaves and Kingsman, 2004; Syntetos, 2001) and hereafter referred to as SBA). From this comparison they propose the four discrete categories of demand shown in Figure 1 which

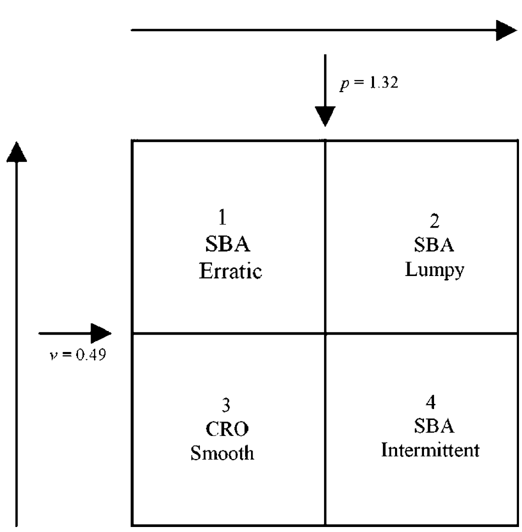

Figure 1 The SBC categorization scheme for CRO and SBA methods for forecasting intermittent demand data.

they label 'erratic', 'lumpy', 'smooth' and 'intermittent'. The four quadrants are uniquely specified by two parameters p and v, where p is the average inter-demand interval and v is the squared coefficient of variation of the demand when it occurs.

SBC argue that CRO should only be used for smooth demand series and that demand series from the other three quadrants are best forecast using SBA. The threshold values defining the quadrants are given as $p=1.32$ and $v=0.49$, respectively.

Both CRO and SBA use a smoothing constant α for producing exponentially smoothed (Makridakis *et al*, 1998) estimates of positive demands. They both also use the parameter p to denote the average inter-demand interval. The parameter α is usually restricted to the range (0, 1) and $p \geqslant 1$ by definition.

Assuming that demand data are independent and identically distributed, SBC showed that the theoretical mean squared error (MSE) of CRO was greater than that of SBA when

$$v > \frac{(p-1)\left[\dfrac{4(p-1)}{(2-\alpha)} - \dfrac{2-\alpha}{p-1} - p(\alpha-4)\right]}{\dfrac{p(\alpha-4)(2p-\alpha)}{2-\alpha}} \qquad (1)$$

(This is Equation (8) in SBC.)

We simplify (1) by rewriting it as

$$v > \frac{4p(2-p) - \alpha(4-\alpha) - p(p-1)(4-\alpha)(2-\alpha)}{p(4-\alpha)(2p-\alpha)} \qquad (2)$$

This defines the region of the parameter space where SBA produces better forecasts than CRO. Figure 2 shows the boundary of the region for several values of α. Note that this graph corresponds to the 'Smooth' region of Figure 1.

The limiting value of p is obtained when $v=0$ and $\alpha=0$ giving $p=4/3$ (not 1.32 as given by SBC). When $p=1$ and $\alpha=0$, we find the maximum value of $v=0.5$ (not 0.49 as given by SBC) for which CRO can be better than SBA.

SBC propose using CRO for all values of p and v shown in Figure 2. However, for most of this region, SBA is actually more accurate. Furthermore, Figure 2 shows that there are only two demand categories ('smooth' and 'lumpy') that can be associated with these two methods of forecasting intermittent demand. To summarize, when using the CRO and SBA methods, use SBA unless p and v fall below the line in Figure 2.

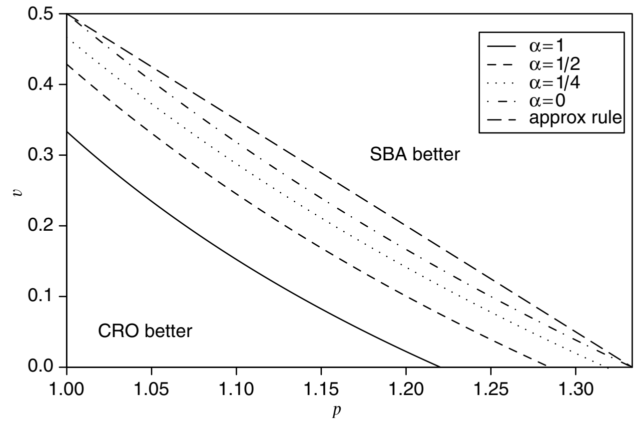

Figure 2 Parameter space for which each forecasting method is better than the other.

Possibly SBC used their four-quadrant approach to enable a simple rule to be implemented. We suggest that a simple but more accurate rule can be derived by dividing the quadrant diagonally into two. In this case, the rule is to use SBA whenever $v > 2-(3/2)p$. This approximation is also shown in Figure 2. Since α is usually small (less than 0.3) for intermittent demand data, this approximation is quite good. In any case, the comparative advantage of one method over the other in the space between the approximate rule and the true boundary will be small.

One of the assumptions underlying the SBC analysis (and Croston's (1972) original analysis) is that it assumes that the demand values are independent. This is clearly never true, and if it was true we would simply use the historical mean as the best predictor rather than any more sophisticated forecasting method. In fact, it has recently been shown by Shenstone and Hyndman (2005) that Croston's method (as originally proposed in 1972) and related methods cannot be optimal for *any* time series of demand, regardless of their time series properties. Consequently, we suggest that a more useful line of research may be to find forecasting methods that are optimal assuming realistic properties of demand time series.

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Reply to Kostenko and Hyndman

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We thank AV Kostenko and RJ Hyndman for their comments and constructive criticism on our paper published last year in *JORS* (Syntetos *et al*, 2005), where a demand categorization scheme was developed to facilitate the selection of forecasting methods.

As we pointed out in our paper, demand categorization has received very limited attention in the academic literature despite its importance for many inventory management computerized applications. It is pleasing, therefore, that Kostenko and Hyndman (KH) have developed an intuitively appealing extension of our work. In fact, the theoretically coherent delineation of the 'smooth' demand region was identified as an area of practical importance and worthy of further research by Syntetos (2001). He considered some possible forms of the 'optimal lines' for delineating the regions (see Figure 1), but without analyzing their functional equations further.

We expect that the new rule proposed by KH will yield greater forecast accuracy than the original rule. Simulations are required on theoretically generated and empirical data in

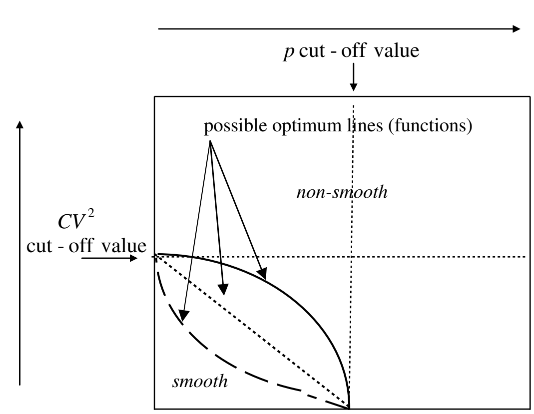

Figure 1 Delineation of the 'smooth' demand quadrant (Syntetos, 2001, p 316).