International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 8 No. 1 Sep. 2014, pp. 237-242

http://www.ijias.issr-journals.org/

Forecasting of Sporadic Demand Patterns with Spare Parts

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ABSTRACT: Items with irregular and sporadic demand profiles are frequently tackled by companies, given the necessity of proposing wider and wider mix, along with characteristics of specific market fields (i.e., when spare parts are manufactured and sold). Furthermore, a new company entering into the market is featured by irregular customers' orders. Hence, consistent efforts are spent with the aim of correctly forecasting and managing irregular and sporadic products demand. In this paper, the problem of correctly forecasting customers' orders is analyzed by new method. Specifically, new proposal forecasting method (i.e., CUM modCr Method) for items are empirically analyzed and tested in the case of data coming from the industrial field and characterized by intermittence. Hence, in the conclusions section, new method produces better results than the existing method.

KEYWORDS: Croston's Method; forward coverage; irregular demand; spare part; service parts inventory.

1 INTRODUCTION

In the recent competitive environment, where manufacturing and service companies operate in unstable sectors, managing irregular and sporadic demand patterns represents an increasingly frequent and complex issue. Startup productions, multiechelon supply chains or spare parts production, and selling are some examples of market fields characterized by intermittent demand profiles.

Accurate forecasting of demand is one of the most important aspects in inventory management. However, the characteristic of spare parts makes this procedure especially difficult. Up to now, Croston's method is the most widely used approach for irregular demand forecasting.

This paper studies and compares different forecasting techniques. Levén and Segerstedt (2004) suggested a modification of the Croston method where a demand rate is directly calculated when a demand has happened. The idea with the modification in Levén and Segerstedt (2004) is that time between demand and demand size is not independent. But this modification has shown poor results. Therefore Wallström and Segerstedt (2010) suggest another modification, "a forward coverage" instead of a "backward coverage".

In this paper suggest another method, cumulative mean of demands. These different techniques are compared with Mean Squared Error (MSE).Using a numerical experiment, show that the new forecasting method is better than the "forward Coverage" (Wallström and Segerstedt (2010) method.

2 LITERATURE REVIEW

A most adopted technique for short-term forecasting is the single exponential smoothing (SES) from Brown (1959, 1962). The limited computational effort and low requirement of memory storage appropriate for yesterdays restricted computer capacity was an advantage compared to moving averages. The ability for SES to forecast an item when the forecasting time periods often have zero demand, slow moving items or intermittent demands, has been questioned. Croston (1972) presented a method that separates the forecasts in two parts; in time between withdrawals or demand and demand size. The forecasts are updated only when there is a demand. The usefulness of Croston's method is verified by e.g. by Willemain et al (1994). Levén and Segerstedt (2004) suggested a modification of the Croston method where a demand rate is directly calculated when a demand has happened. Syntetos and Boylan (2005) recommended an adjustment of the Croston method due to a systematic error notified by Syntetos and Boylan (2001).

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For a literature review about previous studies with similarities to this investigation we refer to Wallström and Segerstedt (2010).

NOTATION

X_t	Demand in period t
$\hat{X}_t$	Demand forecast in period t
α	Smoothing parameter, value 0-1
β	Smoothing parameter, value 0-1
t_n	Time period for the latest demand
t_{n-1}	Time period for the previous demand
$t_n - t_{n-1}$	Inter–demand interval between the latest and previous demand
$\hat{d}_t$	Forecast of the demand rate in period t
N	Number of demand occasions, N ≤ T
X_n	Demand in demand occasion n
$\hat{p}_t$	Estimated probability of demand for period t

3 FORECASTING METHODS

3.1 CROSTON'S METHOD

The Croston method is a forecasting approach that was developed to provide a more accurate estimate for products with intermittent demand.

The Croston method consists of two main steps. First, Croston method calculates the mean demand per period by separately applying exponential smoothing. Second, the mean interval between demands is calculated. This is then used in a form of the model to predict the future demand.

Let Y(t) be the estimate of the mean size of a nonzero demand, let P(t) be the estimate of the mean interval between nonzero demands, and let Q be the time interval since the last nonzero demand.

If X (t) = 0 then
$Y(t) = Y(t-1)$ $P(t) = P(t-1)$
$Q = Q + 1$
Else
$Y(t) = \alpha X(t) + (1-\alpha)Y(t-1)$
$P(t) = \alpha Q + (1-\alpha)P(t-1)$
$Q = 1$

The estimate of mean demand per period

$$M(t) = Y(t)/P(t) \quad (1)$$

3.2 Modified Croston (ModCr)

Levén and Segerstedt (2004) [3] presented another modification of Croston's idea. Every time there is a demand a new experienced demand rate is calculated. The update occurs when there is a demand, but maximum is once per time unit (e. g. day or working day). If there are several demands during a time unit, the demands are added together. The demand rate is the quotient between the demand and the inter-demand interval:

If X t= 0, then dˆt +1 = dˆt , (2)

If X t ≠ 0 , then dˆt +1 = dˆt + α $\frac{\mathrm{Xn}}{\mathrm{tn-tn-1}} - \mathrm{d\hat{}t}$ (3)

The idea of ModCr is that in many practical occasions the size of the withdrawal or demand is not independent of the time between withdrawals. However this idea has shown unsatisfactory results, overestimation of demand (cf. Boylan and Syntetos (2007), Teunter and Sani (2009) [7], Wallström and Segerstedt (2010)) [8].

3.3 Modified Modified Croston (mod ModCr)

Wallström and Segerstedt (2010) [8] in their tests discovered a difference, between the mean of the different ModCr's demand rates and the mean demand rate for the whole time horizon. This indicated that ModCr is wrongly designed; if the time between demands and demanded quantity not are independent then eq. (5) may model reality better than eq. (3):

If X t= 0 , then dˆt +1 = dˆt , (4)

If X t ≠ 0 , then dˆt +1 = dˆt + α $\frac{\mathrm{Xn-1}}{\mathrm{tn-tn-1}} - \mathrm{d\hat{}t}$ (5)

If time between demands and demanded quantity are independent then a construction like equation (3) or (5) is of less important; but if they are dependent the construction is crucial. Eq. (3) makes an assumption of a "backward coverage", the new demand, or withdrawal, covers a demand that has already been experienced, but eq. (5) Assumes that the current withdrawal, or demand, will cover demand until the next withdrawal, a "forward coverage".

3.4 CUM Modified Modified Croston (MA mod ModCr)

The proposal method has been calculated by calculating the mean of time between demand and demand size.By applying Moving Average of past two months demands to mod ModCr ,to show that the new Procedure better than the mod ModCr.

Using ratio of the mean square forecast error (MSE) from the mod mod ModCr method and the mod ModCr's method as a measure of the improvement, we can evaluate the efficiency of the modified one.

The modification of modModCr Method works as follows:

If X t= 0 , then dˆt +1 = dˆt , (6)

If X t ≠ 0 , then dˆt +1 = dˆt + α $\frac{\sum_{I=1}^{n} \mathrm{Xi}}{\mathrm{N\,i}} - \mathrm{d\hat{}t}$ (7)

The value of α that minimizes the MSE can be obtained through Solver in Excel commercial software.

4 Collection and Preliminary Analysis of Data

4.1 Mean Square Error (MSE)

In this section present and discuss the different measures use in the forthcoming analyses. Common measures for forecasting errors and its variability are MSE and also Mean Absolute Deviation (MAD). Silver et al (1998) recommend the use of MSE, because MSE is related to standard variation of forecast errors. However MSE is more sensitive to outliers and errors smaller than one due to the squared Function.

4.2 Numerical Example

Table 1 gives an example about the intermittent demand data.

Table 1. Intermittent demand data

Month	Demand	Month	Demand
1	0	13	0
2	0	14	0
3	19	15	3
4	0	16	0
5	0	17	0
6	0	18	19
7	4	19	0
8	18	20	0
9	17	21	0
10	0	22	5
11	0	23	4
12	0	24	5

Table 2 and 3 give the results of the "forward Covrage"(mod ModCr)method and the modified one that are computed based on the above data.

Table 2. The result of mod ModCr's method

Month	Demand	$\hat{d}_{t+1} = \hat{d}_t + \alpha \frac{X_{n-1}}{t_n - t_{n-1}} - \hat{d}_t$ α=0.3	MSE
1	0	0.00	0.00
2	0	0.00	0.00
3	19	0.00	361.00
4	0	0.00	0.00
5	0	0.00	0.00
6	0	0.00	0.00
7	4	0.00	16.00
8	18	1.20	282.24
9	17	6.24	115.78
10	0	6.24	38.94
11	0	6.24	38.94
12	0	6.24	38.94
13	0	6.24	38.94
14	0	6.24	38.94
15	3	4.37	1.87
16	0	4.37	19.10
17	0	4.37	19.10
18	19	3.06	254.12
19	0	3.06	9.36
20	0	3.06	9.36
21	0	3.06	9.36
22	5	2.14	8.17
23	4	3.00	1.00
24	5	3.30	2.89
MSE			**54.33**

Table 3. The result of modified model

Month	Demand	$\hat{d}_{t+1} = \hat{d}_t + \alpha \frac{\sum_{i=1}^{n} X_i}{N_i} - \hat{d}_t$ α=0.3	MSE
1	0	0.00	0.00
2	0	0.00	0.00
3	19	2.85	260.82
4	0	2.85	8.12
5	0	2.85	8.12
6	0	2.85	8.12
7	4	3.15	0.73
8	18	3.96	197.16
9	17	4.95	145.30
10	0	4.95	24.50
11	0	4.95	24.50
12	0	4.95	24.50
13	0	4.95	24.50
14	0	4.95	24.50
15	3	4.77	3.14
16	0	4.77	22.75
17	0	4.77	22.75
18	19	4.75	203.04
19	0	4.75	22.56
20	0	4.75	22.56
21	0	4.75	22.56
22	5	4.54	0.21
23	4	4.39	0.15
24	5	4.30	0.49
MSE			**44.63**

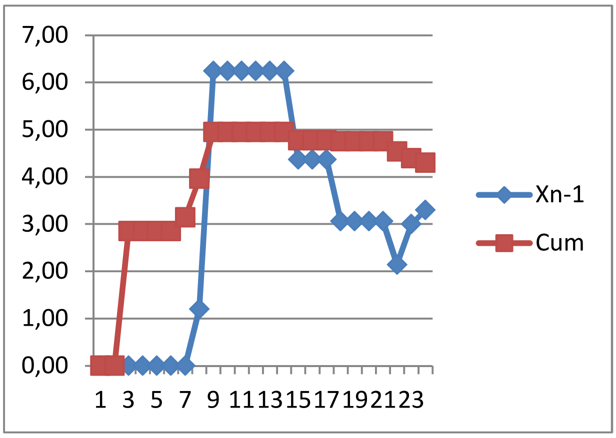

Fig. 1. The comparison between the mod ModCr method and the modified one(forecast)

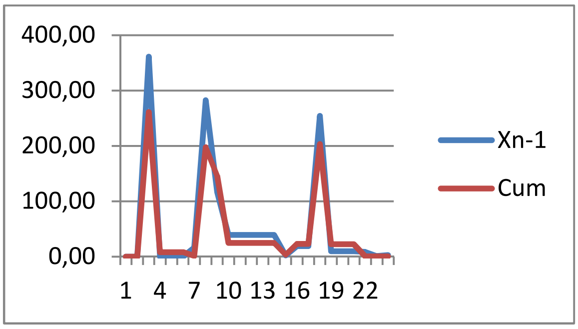

Fig. 2. The comparison between the mod ModCr method and the modified one(MSE)

Table 2 and 3 show that MSE of the modified Croston's method is smaller than that of the original one with optimal value of α (0.3), namely 44.63 compared with 54.33. From the numerical results, point out that the modified method brings out the better outcome as opposed to the original Croston's method regarding to MSE Criterion.

5 Conclusion

In this paper, propose a new forecasting approach to deal with the intermittent demand problem. Traditional statistical forecasting methods such as "Forward Coverage" (mod ModCr) that work well with normal and smooth demands do not give the accurate results with intermittent data. Numerical experiments show that the proposed method give the better mean square error when we compare with the traditional one. For further studies, the more appropriate assumption of lead time demand's distribution is expected to be stated so that the better results can be found.

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