Forecasting Intermittent Demand for Spare Parts

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ABSTRACT
Croston (1972) [2] presented an idea and method to separate ordinary exponential smoothing in two parts;In the time between demand, or withdrawals, and demand size. The idea with the modification in Levén and Segerstedt (2004) [3] is that time between demand and demand size is not independent. But this modification has shown poor results. Therefore Wallström and Segerstedt (2010) [8] suggest another modification, "forward coverage".

By applying moving average of past two months demands to "forward Coverage" (Wallström and Segerstedt (2010)) [8] method, shows that the new one produces better forecast, if the time between demands and demanded quantity are not independent. The different techniques are compared Mean Squared Error (MSE).

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

1. INTRODUCTION
Inventory with irregular demands are quite popular in practice. Item with intermittent demand include spare parts, heavy machinery, and high-priced capital good. Data for such items is composed of time series of non-negative integer values where some values are zero.

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 techni ques. Levén and Segerstedt (2004) [3] 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) [3] is that time between demand and demand size is not independent. But this modification has shown poor results. Therefore Wallström and Segerstedt (2010) [8] suggest another modification, "a forward coverage" instead of a "backward coverage",

In this paper suggest another method, mean of time between demand and demand size for the past two month's demands. These different techniques are compared with Mean Squared Error (MSE) Mean Absolute Deviation (MAD).Using a numerical experiment, shows that the new forecasting method is better than the "forward Coverage" (Wallström and Segerstedt (2010)) [8] method.

Notation

Xt	Demand in period t
Xˆ t	Demand forecast in period t
α	Smoothing parameter, value 0-1
β	Smoothing parameter, value 0-1
tn	Time period for the latest demand
tn−1	Time period for the previous demand
tn − tn−1 ,	Inter-demand interval between the latest and previous demand in period t Forecasted inter-demand intervals in period t Forecast of the demand rate in period t
β	Smoothing parameter for inter-demand intervals, value 0-1
N	Number of demand occasions, N ≤ T
X n	Demand in demand occasion n
pˆ t	Estimated probability of demand for period t
T	Number of time periods, T ≥ N

2. FORECASTING METHODS
2.1 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.

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If X (t) = 0 then
Y(t) = Y(t-1)
P(t) = P(t-1)
Q = Q + 1
Else
Y (t) = αX(t) + (1-α)Y(t-1)

P(t)= αQ + (1-α)P(t-1)

Q = 1
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The estimate of mean demand per period

M(t) = Y(t)/P(t)

2.2 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 ,

If $X_t \neq 0$, then $\hat{d}_{t+1} = \hat{d}_t + \alpha \left(\frac{X_n}{t_n - t_{n-1}} - \hat{d}_t \right)$ (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].

2.3 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 ,

If $X_t \neq 0$, then $\hat{d}_{t+1} = \hat{d}_t + \alpha \left(\frac{X_{n-1}}{t_n - t_{n-1}} - \hat{d}_t \right)$

(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".

2.4 MA Modified Modified Croston (MA mod ModCr)

(1)

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:

(2)

If X t= 0 , then dˆt +1 = dˆt , (6)

If $X_t \neq 0$, then $\hat{d}_{t+1} = \hat{d}_t + \alpha \left(\frac{(X_n + X_{n-1})/2}{t_n - t_{n-1}} - \hat{d}_t \right)$ (7)

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

3. FORECAST ACCURACY

3.1 Mean Square Error (MSE)

In this section present and discuss the different measures we 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)[13] 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. NUMERICAL EXAMPLE

Table 1 gives an example about the intermittent demand data.

(4)

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	$\hat{d}_{t+1} = \hat{d}_t + \alpha \left(\frac{X_{n-1}}{t_n - t_{n-1}} - \hat{d}_t \right)$ α=0.3	MSE
1	0	0	0.00
2	0	0	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

Table 3. The result of modified model

Month	Demand	$\hat{d}_{t+1} = \hat{d}_t + \alpha \left(\frac{(X_n + X_{n-1})/2}{t_n - t_{n-1}} - \hat{d}_t \right)$ α=0.3	MSE
1	0	0	0.00
2	0	0	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	2.60	1.97
8	18	5.12	165.98
9	17	8.83	66.72
10	0	8.83	78.00
11	0	8.83	78.00
12	0	8.83	78.00
13	0	8.83	78.00
14	0	8.83	78.00
15	3	6.63	13.19
16	0	6.63	43.98
17	0	6.63	43.98
18	19	7.49	132.42
19	0	7.49	56.14
20	0	7.49	56.14
21	0	7.49	56.14
22	5	5.99	0.99
23	4	5.55	2.39
24	5	5.23	0.05

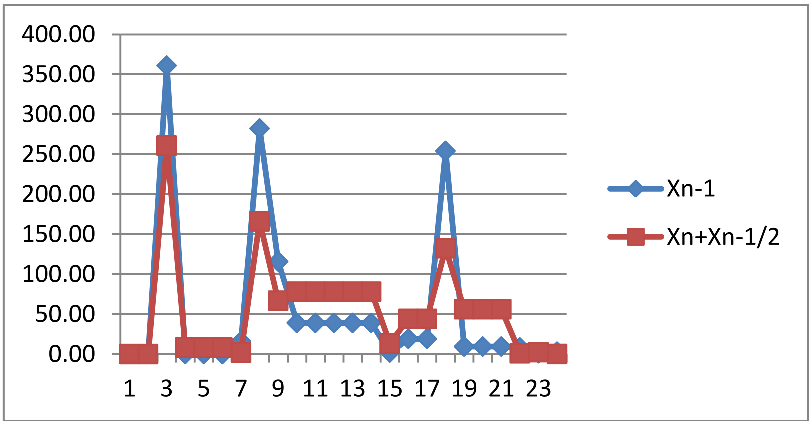

Fig. 1. The comparison between the mod ModCr method and the modified one

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), 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.

6. REFERENCES

[1] Brown R. G., 1959. Statistical forecasting for inventory control. New York: McGraw- Hill

[2] Croston J. D., 1972. Forecasting and Stock Control for Intermittent Demands.

[3] Operational Research Quarterly, 42 (3), 289-303.

[4] Levén E., Segerstedt A., 2004. Inventory control with a modified Croston procedure and Erlang distribution. International Journal of Production Economics, 90, 361-

[5] 367.

[6] Levén E., Segerstedt A., 2012. Study of different variants of Croston forecasting methods: Results and Data. Working Paper Industrial Logistics, Luleå University of Technology.

[7] Montgomery D. C., 2005. Strategic Introduction to Statistical Quality Control (5th ed.). Hoboken, NJ: John Wiley & Sons.

[8] Syntetos A.A., Boylan J.E., 2001. On the bias of intermittent demand estimates.

[9] International Journal of Production Economics, 71, 457-466.

[10] Teunter, R., Duncan, L. 2009. Forecasting intermittent demand: a comparative study.

[11] Journal of the Operational Research Society, 60, 321-329

[12] [8]. Wallström P., Segerstedt A., 2010. Evaluation of forecasting error measurements and techniques for intermittent demand. International Journal of Production Economics, 128 (2), 625-636.

[13] S. Makridakis, "Accuracy measures: theoretical and practical concerns," International Journal of Forecasting, vol. 9, no. 4, pp. 527–529, 1993.

[14] P. R. Winters, "Forecasting sales by exponentially weighted moving averages," Management Science, vol. 6, pp. 324–342, 1960.

[15] L. Shenstone and R. J. Hyndman, "Stochastic models underlying Croston' method for intermittent demand forecasting," Journal of Forecasting, vol. 24, pp. 389–402, 2005.

T. R. Willemain, C. N. Smart, J. H. Shockor, and P. A. DeSautels, "Forecasting intermittent demand in manufacturing: a comparative evaluation of Croston's method," International Journal of Forecasting, vol. 10, no. 4, pp. 529–538, 1994.