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A note on models for a family of products with shelf life, and production and shortage costs in emerging markets

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Recently, the economic lot scheduling problem (ELSP) with common cycle time and shelf life restrictions has attracted the attention of several researchers. In this paper, a comparative study of solutions given by Xu and Sarker (2003) [Computers & Operations Research 30 (6), 925-938] with the results given by Viswanathan and Goyal (2000) [International Journal of Production Research, 38 (4), 829-836] are presented. Additionally, the paper makes some observations about two mathematical expressions, which contain a technical shortcoming.

1. Introduction

Papers that address with the economic lot size problem with common cycle time and shelf life constraints include Silver (1989), Sarker and Babu (1993), Silver (1995), Viswanathan and Goyal (1997), Viswanathan and Goyal (2000) and Chowdhury and Sarker(2001), Sharma (2004) just to name a few. Recently, Xu and Sarker (2003) present an inventory model, which deals with a manufacturing system that produces a family of items with a cycle time (T). Furthermore, it considers that all items are manufactured in each cycle time and only one item has a finite shelf life of S_i years as constraint. Xu and Sarker (2003)'s inventory model considers the four classical costs: setup cost, holding cost, shortage cost and production cost.

This paper makes some observations about two equations of Xu and Sarker (2003) and gives a comparative study of the solutions to a numerical example by two different approaches. First, it will be presented the observations about Eq. (8) and the constant factor K_1 in the Eq. (19) and Eq. (20). Later, the solutions will be given by both approaches: Xu and Sarker (2003) and Viswanathan and Goyal (2000).

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2. Discussion

Readers interested in Xu and Sarker (2003) may be interested in the paper by Viswanathan and Goyal (2000) because both papers deal with the same type of inventory problem. The main difference between both inventory models is that Viswanathan and Goyal (2000)'s model finds the optimal value for the shortages level of each product. On the other hand, Xu and Sarker (2003)'s model requires a given shortage level. Furthermore, it is worth to mention that Sharma (2004) is another research paper that addresses this type of inventory problem. Sharma (2004) also optimizes the shortages level for each product. Cárdenas-Barrón (2006) concludes that both models, Viswanathan and Goyal (2000) and Sharma (2004), are more effective than the model given in Xu and Sarker (2003).

In developing of their model, Xu and Sarker (2003) used the following nomenclature:

D_i demand for the item i (i = 1,2,3,..., N) (units/year)
P_i production rate for item i (units/year)
T cycle time (in year)
t_i product - setup (loading and unloading) time for item i (in year)
c production cost for operating the machine (including product setup) (dollars/year)
A_i machine - setup cost for item i (dollars)
H_i hodidng cost for item i (dollars/unit/year)
S_i Shelf life of item i (years)
b_i shortage amount of item i per production cycle (units/year)
π_i shortage(penalty) cost for item i (dollars/unit/year)
N number of items on each cycle time T
$r_i = D_i / P_i$
$r_j = D_j / P_j$
$r_j' = D_j / P_j'$

Eq. (8) of Xu and Sarker (2003) should be:

$$T \le \frac{S_j\left(\frac{H_j + \pi_j}{\pi_j}\right)}{1 - D_j / P_j}$$

The above equation was developed by Viswanathan and Goyal (2000).

The expression for constant K_1, on page 933, in Eq. (19) and Eq. (20) of Xu and Sarker (2003) is not independent of T such as the authors stated. Due to the fact that it contains the variable T. Therefore, the mathematical expression for K_1 should be:

$$K_1 = \frac{H_j\left[S_j D_j\left(\frac{1-r_j}{1-r_j'}\right) - b_j\right]^2}{2S_j D_j\left(\frac{1-r_j}{1-r_j'}\right)} + \frac{\pi_j {b_j}^2}{2S_j D_j\left(\frac{1-r_j}{1-r_j'}\right)} + c\sum_{\substack{i=1 \\ i \neq j}}^{N} r_i + c$$

which actually is independent of *T*. Now let us consider the example solved by Xu and Sarker (2003) with production cost for operating the machine of c=$5000/year. Other relevant data is given in Table 1. The example given in Xu and Sarker (2003) is solved using the model proposed by Viswanathan and Goyal (2000). The results by both approaches are shown in Table 2. It might be appropriate to point out that to find the solution is necessary to use the algorithm of Viswanathan and Goyal (1997) because the model with backorders is the same as the one for the model without backorders with a modified holding cost and modified shelf life.

Table 1
A 3-family of products (data from Xu &Sarker (2003))

Item i	Demand D_i (units/year)	Time T_i	Setup cost A_i	Holding cost H_i	Production rate P_i	Shelf life S_i(year)	Shortage b_i (units/year)	Shortage cost π_i (dollar/unit/year)
1	1000	0.0005	70	10	3000	0.20	50	15
2	500	0.0010	80	12	2500	0.11	50	20
3	700	0.0015	135	15	2500	0.20	50	25

Table 2
A comparative study of the solutions of the example by both approaches

Xu and Sarker (2003)	Viswanathan and Goyal (2000)
TC(T)= 6791.788 $/year	TC(T)= 6720.053 $/year
T= 0.22 years	T= 0.22 years
b1= 50 units/year assumed value	b1= 58.67 units/year optimal value
b2= 50 units/year assumed value	b2= 33.00 units/year optimal value
b3= 50 units/year assumed value	b3= 41.58 units/year optimal value

3. Conclusion

It might be appropriate to point out that Viswanathan and Goyal (2000) and Sharma (2004) models are more effective than the model proposed by Xu and Sarker (2003) because both inventory models determine the optimal shortages level for each product. On the other hand, the inventory model of Xu and Sarker (2003) needs a given shortages level for each item.

Finally, the readers can note that there is a difference in the total cost of inventory systems by both approaches. The readers can draw their own conclusions about the relative advantage of Viswanathan and Goyal (2000) versus Xu and Sarker (2003).

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