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by The Jin Ai

An Appropriate Lot Sizing Technique for Decreasing Demand

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Abstract. This paper is concern with the inventory planning of products and theirs corresponding components in theirs end-of-life phase. Following the common planning technique, the Material Requirements Planning (MRP), especially in the lot sizing steps, there are several lot sizing technique that are available to be applied. This paper is trying to find an appropriate lot sizing technique to be applied for the product that has decreasing demand pattern and its component. An empirical study is conducted to be applied for five products using five lot sizing techniques, which are Silver Meal 1, Silver Meal 2, Least Unit Cost, Part Period Balancing, and Incremental technique. The computational study concludes that Incremental lot sizing technique is suitable for this situation.

Keywords: lot sizing, MRP, decreasing demand.

1. INTRODUCTION

In a common supply chain operations, Materials Department of manufacturing company has responsibility to provide materials or components for production. Demand for materials from Production Control Department are always fluctuated by weekly, daily, or even hourly. Production Control Department as an internal customer always checks the requirements of the components and asks the Materials Department to provide the requirements.

There is a situation happened in dependent demand problem when the demand of parent follows certain pattern, such as lumpy demand. Pujawan and Kingsman (2003) explained this is a situation where a demand for an item or component does not occur every period, but rather, there is a large proportion of periods having zero demand. In other case, there is also a situation when the demand of parent follows decreasing demand pattern. Demand for parent is decreasing by time and at certain time; there will be no more demand anymore. In that situation, parent is entering "end-of-life" phase. If that situation happens, there will be a high cost occurs from holding and ordering cost. The component that is purchased no longer used to build the item (parent).

Some researchers in the past have been discussed the inventory problem with decreasing demand problem. Benkherouf (1995) did a research for non-linear decreasing demand which was exponentially distributed using numerical example and his theory. His research used finite planning horizon with zero initial and final inventory. He decided the replenishment quantity to solve the problem. Benkherouf (1998) did another research with the same characteristic with the previous research, but he added Newton method to his research. The decision variable for his research was the lot size. Chu and Chen (2002) solved an exponential decreasing demand problem using his theory and Newton method. His research used finite planning horizon with zero initial and final inventory. He decided the replenishment quantity. It is noted that, all model solved in Benkherouf (1995), Benkherouf (1998), and Chu and Chen (2002) are deterministic.

Hill et. al. (1999) solved a poisson decreasing demand problem using numerical example and dynamic programming. His research used finite planning horizon with zero initial and final inventory which inventory stock as the decision variable. Different with previous authors, he solved a stochastic model. Ouyang et. al. (2005) solved an exponential decreasing demand problem and constructed EOQ model. They solved the problem by using numerical example and EOQ calculation, then decided the replenishment quantity. Pujawan and Kingsman (2003) solved a lumpy demand problem using lot sizing techniques and decided which lot sizing technique was appropriate to lumpy demand problem.

Goyal and Giri (2003) solved a linear decreasing demand problem by using 5 different methods: Silver; CLUC; CTPP; YZR; and Numerical method. The characteristic of the problem were finite planning horizon with zero initial and final inventory. They decided the number of replenishment quantity. Sicilia et. al. (2011) did a research of exponentially decreasing demand by using numerical example. Theirs research categorized as

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deterministic model. Wee (1995) did a research in exponential – deterministic decreasing demand problem by using numerical example, Newton, and Hollier-Mark. The characteristic of the problem was finite planning horizon with zero initial and final inventories. He decided the lot size in his research. Zhao *et al.* (2001) did a research in linear decreasing demand and construct an Eclectic model. He conducted Silver, CLUC, CTPP, YZR and Ritchie's Cubic methods. Theirs research used finite planning horizon with zero initial and final inventory. They decided the replenishment quantity as the decision variable of the problem. It was similar from the previous research, but Yang *et al.* (2002) did a research with Parametric Model to determine the replenishment quantity.

After reviewing some papers on decreasing demand problem above, this paper is trying to fill the gap on finding the best lot sizing techniques for decreasing demand problem. An empirical testing methods are conducted by using an example data from 5 items of component and 5 different lot sizing techniques: Silver Meal 1 (SM1), Silver Meal 2 (SM2), Least Unit Cost (LUC), Part Period Balancing (PPB), and Incremental (ICR).

2. EMPIRICAL TESTING METHODOLOGY

The lot sizing problem is exist in a manufacturing company, in which some final products of the company are facing decreasing demand pattern. Each final product consists of a main component that is independent from other product In the testing, there are two alternative solution models conducted to solve the decreasing demand problem. Solution Model 1 is conducted to the problem using 5 different lot sizing techniques only for the components; parents are solved using Lot for Lot (LFL) technique. While, Solution Model 2 is conducted to the problem using 5 different lot sizing technique not only for components, but also for the parents. Both parent and component are solved using similar technique, i.e. if a parent is being solved using LUC, its component also being solved using LUC.

After the calculation of order quantity for each solution model is obtained, the results are compared using Total Cost (TC) calculation see equation (1). The lowest Total cost obtained represents the suitable lot sizing technique for solving decreasing demand problem with dependent demand characteristic. The expression of Total Cost (TC) can be seen in equation 1.

$$Total\ Cost\ (TC) = \sum_{0}^{j}(A + (h \qquad (1)$$

i item index, i = 1,2,3,4, and 5

j time index j = 1,2,3,..., n

h holding cost per item i

A ordering cost, it has the same value for each item

S_{ij} inventory on hand per item i per time j

TC Total Cost

Before lot sizing procedures are applied, the demand trend and distribution are checked to ensure the problem follows the decreasing demand problem. Microsoft Excel worksheet is created for assisting the calculation of the order size and the total cost occurred.

There are 5 lot sizing techniques categorized in heuristic calculation and being used in this paper. Lot sizing technique is used to calculate the number of order quantity for each item. The calculation formulas for those techniques are explained as below.

2.1. Silver Meal 1 (SM1)

The objective of the Silver Meal 1 rule is to minimize the sum of ordering and holding cost per period. Based on that objective, the decision for the number of order quantity is taken from the order quantity that provides a minimum periodic cost. The calculation is presented in the equation below.

$$SM1 \rightarrow \min\left[\left(\frac{A+\sum_{1}^{j}(h.S_{ij})}{\sum_{1}^{j} n_j}\right)\right] \qquad (2)$$

2.2. Silver Meal 2 (SM2)

The objective of the Silver Meal 2 rule is the same with Silver Meal 1, to minimize the sum of ordering and holding cost per period. But, in this method zero demands are excluded from calculating the periodic cost. The decision for the number of order quantity is taken from the order quantity that provides a minimum periodic cost.

2.3. Least Unit Cost (LUC)

The objective of the Least Unit Cost rule is to minimize cost per unit incurred in one order that covers some periods. The decision for the number of order quantity is taken from the order quantity that provides a minimum periodic cost. The calculation is presented in the equation below.

$$LUC \rightarrow \min\left[\left(\frac{A+\sum_{1}^{j}(h.S_{ij})}{\sum_{1}^{i} n_i}\right)\right] \qquad (3)$$

2.4. Part Period Balancing (PPB)

The principle of the Part Period Balancing rule is to minimize the difference between ordering and inventory holding cost. Based on that objective, the decision for the number of order quantity is taken from the order quantity that provides a minimum periodic cost. The

Table 1. Total Cost Comparison for Solution Model 1

	SM1	SM2	LUC	PPB	ICR
Component A	$ 576.24	$ 560.53	$ 559.91	$ 644.00	$ 506.70
Component B	$ 819.07	$ 836.54	$ 946.17	$ 924.33	$ 831.82
Component C	$ 320.95	$ 326.90	$ 379.74	$ 266.94	$ 269.94
Component D	$ 690.89	$ 659.18	$ 567.44	$ 653.65	$ 637.19
Component E	$ 301.12	$ 309.87	$ 321.33	$ 354.28	$ 315.96
Total	***$ 2,708.26***	***$ 2,693.02***	***$ 2,774.59***	***$ 2,843.19***	***$ 2,561.61***

**) In thousands dollar*

Table 2. Total Cost Comparison for Solution Model 2

	SM1	SM2	LUC	PPB	ICR
Component A	$ 632.08	$ 1,029.94	$ 956.87	$ 546.28	$ 467.27
Component B	$ 1,615.57	$ 1,995.07	$ 858.84	$ 652.69	$ 691.08
Component C	$ 233.83	$ 344.53	$ 360.78	$ 349.44	$ 190.86
Component D	$ 291.73	$ 284.85	$ 483.57	$ 442.43	$ 463.23
Component E	$ 334.75	$ 318.01	$ 290.98	$ 255.56	$ 147.70
TOTAL	***$ 3,107.96***	***$ 3,972.40***	***$ 2,951.05***	***$ 2,246.40***	***$ 1,960.13***

**) In thousands dollar*

calculation is presented in the equation below.

$$PPB \rightarrow \min \left| A - \textstyle\sum_1^j (h \,.\, S_{ij}) \right| \qquad (4)$$

2.5. Incremental (ICR)

The principle of the Incremental rule is to make an order should cover the *n*th demand if the incremental inventory holding cost incurred by doing so is less than or equal to the ordering cost.

$$ICR \rightarrow \textstyle\sum_1^j (h \,.\, S_{ij}) \leq A \qquad (5)$$

3. EMPIRICAL TESTING RESULTS

The problem example that is used in this paper is exponentially distributed and follow decreasing demand trend. This characteristic is provided from model development calculation.

MRP Sheets has been constructed to determine the number of order quantity for 5 Components with 5 different lot sizing techniques: Silver Meal 1(SM1); Silver Meal 2(SM2); Least Unit Cost (LUC); Part Period Balancing (PPB); and Incremental (ICR) method. Total cost for 130 weeks demands is calculated using Microsoft© Excel 2007. The comparison of total cost for solution model 1 is presented in Table 1.

From Table 1, the minimum total cost for Component A is from Incremental method with $ 506.70 thousands. For Component B, the minimum total cost is from Silver Meal 1 method with $ 819.07 thousands. The minimum total cost for Component C is optimized by using Part Period Balancing method with $ 266.94 thousands. Least Unit Cost method gives the minimum total cost for Component D with $ 567.44 thousands. While, for Component E the minimum total cost is achieved from Silver Meal 1 with $ 301.12 thousands. The optimum solution for alternative solution 1 is achieved from total sum of 5 Components using Incremental method with $ 2,561.61 million. While, the combination from minimum total cost of 5 lot sizing techniques gives $ 2,461.27 million. It is $ 100.64 thousands less than using incremental method.

MRP Sheets has been constructed to determine the number of order quantity for 5 Components with 5 different lot sizing techniques: Silver Meal 1(SM1); Silver Meal

2(SM2); Least Unit Cost (LUC); Part Period Balancing (PPB); and Incremental (ICR) method. Total cost for 130 weeks demands is calculated using Microsoft© Excel 2007. The comparison of total cost for solution model 2 is presented in Table 2.

From Table 7.2, the minimum total cost for Component A is from Incremental method with $ 467.27 thousands. For Component B, the minimum total cost is from Part Period Balancing method with $ 652.69 thousands. The minimum total cost for Component C is optimized by using Incremental method with $ 190.86 thousands. Silver Meal 2 method gives the minimum total cost for Component D with $ 284.85 thousands. While, for Component E the minimum total cost is achieved from Incremental method with $ 147.70 thousands. The optimum solution for solution model 2 is achieved from total sum of 5 Components using Incremental method with $ 1,960.13 million. While, the combination from minimum total cost of 5 lot sizing techniques gives $ 1,743.36 million. It is $ 216.76 thousands less than using incremental method. The results from two solution model using Incremental (ICR) method give the minimum total cost with $ 2,561.61 and $ 1,960.13 million. But, the result from solution model 2 is lower than solution model 1 with $ 601.48 thousands difference. It represents that the solution model 2 is the optimum solution to solve decreasing demand problem.

4. CONCLUSION

After conducting two solution models for inventory policy with decreasing demand problem by using some lot sizing techniques in Microsoft Excel, both solution models give the same result that Incremental method provides the lowest Total Cost (TC). Decreasing demand problem with dependent demand characteristic and exponentially distributed can be solved using Incremental technique.

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