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Macro Economic Variable Base Inventory Control Model for Perishable Items

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Abstract : In production systems there are situations in which it is not possible to have a single rate of production throughout the production period and the same cost for each individual unit over the decades. Items are produced at different rates and at different sub-periods so as to meet the requirement. The costs incurred changes as the time progresses due to inflation. The price may vary for each unit depending not only on inflation but also various factors as demand, availability, working unit, setup place etc. This paper models a situation by assuming constant rate of demand, varying rates of production and a constant inflation rate. Special cases are also discussed and a case study is done.

Key words: EOQ, Inflation

1. INTRODUCTION

Inventory is item which has some economic value and it is a service to production. It is a just sort of investment in the form of raw material, tools, gauges, supplies etc., In process inventories are the semi finished goods at various stages of manufacture. The output of the machine fed to another machine for further processing. Raw materials become work in progress at the end of first operation and remain in that classification until they become piece parts of finished goods.

1.1 INVENTORY MODELS:

Economic lot size of an item depends on Possibility of placing repeat orders, Nature of demand, Availability of discount and Single or multiple product manufacture. Based on these the inventory models can be classified as:

A. Static Inventory models:

It is applicable in case where only one order can be placed to meet the demand. Repeat orders are either impossible or too expensive. Typical examples of items under this group are perishable goods like bread, vegetables etc., seasonal products like coolers, umbrellas, crackers, sweaters, rain coats etc.

B. Dynamic Inventory models:

If the inventory is plotted against time, the result looks like a saw tooth pattern. Starting from the instant when inventory OA is in stores, it consumes gradually in a quantity from A along AD at a uniform rate. Until point D is reached and again the inventory rises to the original level when a fresh stock is received. It is applicable for items where repeat orders can be placed to replenish stock.

1.2 TOTAL INVENTORY COST (TIC):

The costs that are affected by firm's decision to maintain a particular level of inventory are called cost associated with inventories or relevant inventory costs. Total inventory costs consist of Purchase cost, Ordering cost, Inventory carrying cost and Shortage cost.

If unit cost of an item depends on the quantity purchase, i.e., price discounts are available, then it is necessary to formulate an inventory policy which takes into consideration the purchase cost of the item held in stock also. The total inventory cost is given by

TIC = Purchase cost + Total variable cost of managing the inventory

1.3DETERMINING EOQ FOR INVENTORY MODEL WITH UNIFORM DEMAND:

The fixed order quantity system is based on selecting that order quantity which will minimize the total variable cost of managing the inventory. In determining the EOQ it is assumed that the cost of managing the inventory costs is Ordering Cost and Carrying cost. The ordering cost and the inventory cost have been plotted with respect to quantity in a lot. Total cost is calculated by adding ordering cost and carrying cost.

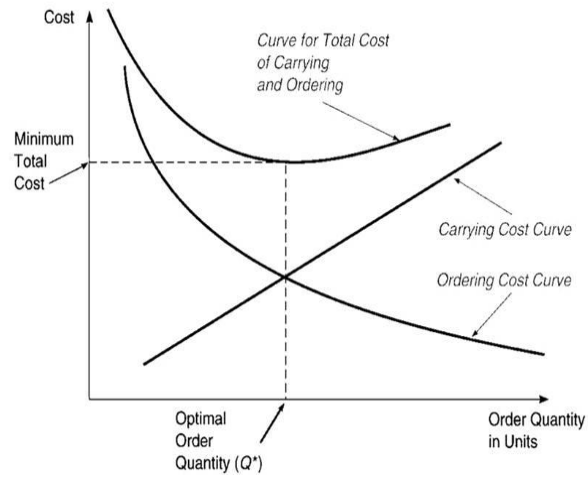
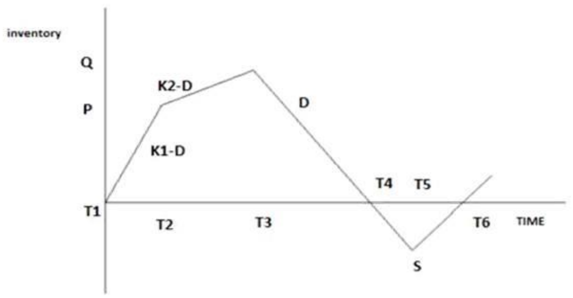


Figure 1: Total cost against order quantity

2. MODEL FORMATION

The effect of deterioration of physical goods cannot be disregarded in many inventory systems. Deterioration is defined as decay, damage or spoilage. Food items, photography film, products pharmaceuticals, chemicals, electronics and radioactive substances are some examples. Items in which sufficient deterioration may occur during the normal shortage period of the units and consequently the loss must be taken into account while analyzing the inventory system. A new model has been developed where in we have considered that production starts at $T=T_1$ i.e. inventory level at the point is 0. Production starts with a rate of k1 till the inventory reaches level p. As soon as the production begins it starts to satisfy the demand. The demand rate is assumed to be constant and denoted by a variable 'd'. As soon as the inventory level reaches p the production rate changes to K2. Production rate remains at K2, till the inventory level reaches q. q will be higher than p because the production rates k1, k2 are greater than demand rate r. when the inventory level reaches q, production stops and the inventory level reduces because of demand and deterioration. At some point of time inventory level reaches 0. Shortages are allowed till the inventory level reaches s. The production again starts with a rate of k1 till the inventory level reaches zero. Back ordering and discounts is allowed in this period.



3.

Figure 2: Graphical representation of the model

4. TOTAL COST WITHOUT CONSIDERING INFLATION:

$$\text{Total cost} = hp\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) + \frac{hpe_0T_1}{1}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) - \frac{hpe_0}{2}\left(\frac{t^2e^{Rt}}{R} - \frac{2te^{Rt}}{R^2} + \frac{2e^{Rt}}{R^3}\right) + hz\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) - \frac{he_0z}{2}\left(\frac{t^2e^{Rt}}{R} - \frac{2te^{Rt}}{R^2} + \frac{2e^{Rt}}{R^3}\right) + \frac{he_0T_2z}{1}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) - \frac{e_0hp(T_2-T_1)}{1}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) + \frac{e_0sh}{1}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) + \frac{e_0Dh}{2}\left(\frac{t^2e^{Rt}}{R} - \frac{2te^{Rt}}{R^2} + \frac{2e^{Rt}}{R^3}\right) - \frac{e_0qzh}{k_2}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) - e_0DhT_3\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) - \frac{hD}{1}\left(\frac{te^{Rt}}{R} - \frac{e^{Rt}}{R^2}\right) + \pi D\left(\frac{(T_5-T_4)e^{RT_5}}{R} - \frac{e^{RT_5}}{R^2}\right) + \frac{\pi De^{KT_4}}{R^2} + \frac{\pi(K_1-D)(RT_6e^{KT_6}-e^{KT_6})}{R^2} - \frac{\pi(K_1-D)(RT_5e^{KT_5}-e^{KT_5})}{R^2} + ST_5 - ST_6$$

5. OPTIMAL SOLUTION:

To get the optimum inventory quality differentiate total cost with respect to zero and setting equal to zero then we get the optimum inventory quality or optimum economic order quality (q*)

Optimum economic batch quantity (q*) without inflation:

$$(q^*) = \sqrt{\frac{D_TC_0K_2}{e_0zh\left(\frac{e^{Rt}}{R^2} - \frac{te^{Rt}}{R}\right)}}$$

Let $X = \frac{D_TC_0k_2}{e_0zh}$

$G = e^{Rt}\left(\frac{1}{R^2} - \frac{t}{R}\right)$

Therefore the Optimum inventory Quantity $(q^*) = \sqrt{\frac{X}{G}}$

Optimum economic batch quantity (q*) with inflation:

$$(q^*) = \sqrt{\frac{D_TC_0K_t}{e_0zh\left(\frac{e^{Rt}}{R^2} - \frac{te^{Rt}}{R}\right)}}$$

The Optimum inventory Quantity $(q^*) = \sqrt{\frac{X}{G}}$ (where $X = \frac{D_TC_0k_t}{e_0zh}$ and $G = e^{Rt}\left(\frac{1}{R^2} - \frac{t}{R}\right)$

6. CASE STUDY

A case study is done for the above developed model on fast moving commodity milk. For this, a mother diary processing unit at Hayatnager was visited and milk is considered for the study. The raw milk which is collected from the village through collection centers is processed, packed and transported to chilling centers. The total cost of the milk is calculated and the inventory level is checked. The inventory status on day 1 at 11.00 A.M is zero. Here the milk is produced at a rate of K1 till it reaches an inventory level 'p'. From the data the average milk processed in this phase is 36000Lit. After 3.00 P.M the inflow of the milk increases with result in change of production rate K2. From the data, the acquired milk processed during this phase is 84000Lit. The demand rate for mother diary milk is forecasted to be 140000 Liters, and is assumed to be constant.

Calculation of K1

Milk produced during phase 1= 36000Lit
Time taken for processing = 4 hrs
Production rate K1 = $\frac{\textit{milk processe during phase 1}}{\textit{time taken for processing}}$

Calculation of K2

Milk produced during phase 2= 840000Lit
Time taken for processing = 5 hrs
Production rate K2 = $\frac{\textit{milk processe during phase 2}}{\textit{time taken for processing}}$

Calculation of deteriorating factor

e is calculated by assuming that milk gets decay in 36hrs
$e_0 = 0.0277\text{Lit/hrs}$
Demand rate = 5833.33 Lit/hrs
Time period for zero inventory level is calculated as 3.42 hrs

Table 1: The EOQ values for decreasing G values

S.no	R	G	q*(Lit/order)
1	-0.01	9838.73	10822
2	-0.02	2443.12	21827
3	-0.03	1058.34	33163
4	-0.04	576.046	44951
5	-0.05	354.5	57301
6	-0.06	235.462	70309
7	-0.07	164.7	84067
8	-0.08	119.055	91673
9	-0.09	89.245	114204
10	-0.1	68.007	130760

7. CONCLUSION:

The EBQ for variable production rate with shortages for deteriorating items is determined considering the inflation factor and money values**.** It is observed that EBQ is increasing with decreasing (i-r) value. The developed model is tested for milk commodity whose deteriorating rate is high comparative with other perishable products like pharmaceutical items and beverages. The model is limited to two different production rates with shortages and constant deterioration.

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