A CONCEPTUAL & CONTEXTUAL ANALYSIS OF INVENTORY MANAGEMENT
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**A CONCEPTUAL AND CONTEXTUAL ANALYSIS OF INVENTORY MANAGEMENT**

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CHAPTER 4

A CONCEPTUAL AND CONTEXTUAL ANALYSIS
OF INVENTORY MANAGEMENT

4.1.0 Introduction

4.1.1 In order to do justice to the study, there should be some discussion on conceptual and contextual analysis of "Inventory Management". Again, in order to make a meaningful approach to the conceptual and contextual analysis of inventory management, it is also imperative to understand the working capital theory and the main ingredients with which it is composed of. Working capital, in common parlance, may be taken as the funds needed for meeting the day-to-day requirements of an enterprise. Adequately supplied, carefully administered, working capital can make a substantial difference between the success and failure of an enterprise. When working capital is varied relative to sales, the profit position is affected. Furthermore, if the flow of funds, created by the movement of working capital through the various operational processes, is interrupted, the turnover of working capital and return on investments decrease. It is important therefore for management to pay particular attention to the planning and control of working capital. (1)

4.2.0 Working capital various concepts

4.2.1 Working capital may be interpreted in two ways (2): * Conventional Balance Sheet Concept and * Operating Cycle Concept.

Each of these above concepts is dealt in following paragraphs.
4.3.0 The Balance Sheet Concept

4.3.1 The Balance Sheet Concept of working capital may be further subdivided into:

* The Gross Concept and
* The net concept.

As per "Gross" concept, the working capital is nothing but aggregate of Current Assets. As per "Net" concept, working capital is represented by the excess of Current Assets over Current Liabilities. Economists like Mead (3), Malott (4), and Barker, and Field (5), support the "Gross" interpretation. The reason they place are (6):

(i) Profits are earned with the help of the assets which are partly fixed and partly current. To a certain degree, the similarity that can be observed in fixed and current assets is that both are partly borrowed and both yield profit over and above the interest costs. Logic then demands that current assets should be taken to mean the working capital of the firm.

(ii) With every increase in funds (short terms), the gross working capital will increase, while according to the net concept of working capital, there will be no change in the funds available for the operating manager.

(iii) The management is more concerned with the total current assets as they constitute the total funds available for operating purposes than with the sources from which the funds came;

(iv) The net concept of working capital has relevance when the form of organisation is single entrepreneurship or partnership. In other words, a close contact is involved

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between the ownership, management and control of the enterprise.

4.3.2 As against the above view, authors like Guthmann and Dougall (7) Howard (8) and Grass (9) consider the "Net" concept as the correct concept of working capital. Financial analyst like Park and Gladson (10) Kennedy and Mc Mullen (11) Gole (12) and economists like Lincoln (13) and Saliers (14) also support the view. The argument they place are (15):

(i) In the long-run what matters is the surplus of current assets over current liabilities.

(ii) It is this concept which helps creditors and investors to judge the financial soundness of the enterprise.

(iii) What can always be relied upon to meet the contingencies is the excess of current assets over current liabilities, since it is not to be returned; and

(iv) This definition helps to find out the correct financial position of companies having the same amount of current assets.

4.3.3 In order to get rid of the ambiguity of definition of working capital, Kuchhal suggested that "total current asset" may be referred as "Gross Working Capital" whereas the working capital as per "Net" concept may be referred to as "Net working capital" (16). But the important aspect is that the "Gross Working capital" and "Net Working capital" concepts have the specific use in finance. When the purpose is to calculate the amount of current assets which are to be used to optimise the productivity of the enterprise, gross concept is to be used. But when the
objective is to evaluate the liquidity position of an undertaking, the most pertinent concept would be "Net Working Capital".

4.3.4 There is still another view. (17) According to that the "Net working Capital" may be referred to as the "qualitative" and the "Gross Working capital" as the "quantitative" aspect of the working capital. Whatever may be the case, the "Gross" or "Net" concept, the "Qualitative" or "Quantitative" aspect of the working capital is derived from Balance Sheet items and is thus known as Balance sheet concepts of working capital.

4.4.0 The Operating Cycle (OC) Concept

4.4.1 One of the causes for failing in operational liquidity resulting higher borrowing in public sector enterprise is long operating cycle. Operating cycle represents the period during which investment of one unit of money will remain blocked in the normal course of operation till its recovery as revenue. (18) So, working capital is required to support all operational activities of the firm. According to "Accounting Research Bulletin No 43", "the average intervening period between the acquisition of materials or services entering this process and the final cash realisation constitutes an operating cycle" (19). The total operating cycle is divided into four important stages (20).

(i) Raw materials and stores inventory stage
(ii) Work in progress stage.
(iii) Finished goods inventory stage; and
(iv) Book debts stage

Thus the total period of the operating cycle measured in number of days may be mathematically given as:
\[ t = (r-c) + h + f + b \]

where

\( t \) = the total period of the operating cycle measured in number of days

\( r \) = number of days of raw materials and stores consumption requirements held in raw material and stores inventory

\( c \) = the number of days of purchases, credits allowed by the trade creditors;

\( w \) = the number of days cost of production held in work in progress.

\( f \) = the number of days cost of sales kept as finished goods inventory and

\( b \) = the number of days sales in book debts (21)

Stagewise OC periods may be calculated from the published profit and loss account and balance sheet. The calculation of operating cycle period does not therefore require any extra data.

4.5.0 Composition of Working Capital

4.5.1 Whether it is Balance Sheet Concept or Operating Cycle Concept, everywhere the major ingredient for decision is "Current Asset". In the case of "Net Working Capital concept", along with "Current Asset" component we should know the "Current Liabilities" also. International Accounting Standard 22, paragraph 21 gives the details of items included in the Current Assets and paragraph 22 gives the details of the items included in the Current Liabilities (22).

4.6.0 Current Assets

4.6.1 Without going through the details of the definition
given by International Accounting Standard 22, current assets are those assets which will normally be turned into cash within a short period of time, say within one accounting year. The current assets include the following:

* Inventories
* Sundry debtors (net of provisions)
* Bills Receivable
* Advances/Inter-Company Loan (short term)
* Marketing securities (ie surplus cash invested in government and other securities which can be liquidated without loss of time)
* Prepayments
* Accrued Incomes
* Cash at Bank
* Cash in hand

The most important characteristic of current assets is that they constantly change their forms within a short period of time. As for example, cash is transferred to raw materials, raw materials then change to "Work in progress", which in turn transforms to "Finished Goods". Finally, finished goods, when sold, are either converted into cash or into cash through debtors in case of credit sales. Usually, the conversion from one form to other takes place within one accounting year. But in some cases, it may involve more than one accounting year (say, tobacco companies keep their raw material stock for more than a year).

4.7.0 Current Liabilities

4.7.1 Current liabilities, are those obligations of the firm which are normally payable in the ordinary course of business.
within a short period of time, say, within one accounting year, normally out of the income of the business. They include:

- Trade creditors
- Bills payable
- Outstanding or accrued expenses
- Short-term loans
- Taxation
- Dividends
- Bank overdraft (of temporary nature)
- Outstanding liabilities currently payable, (eg settlement of an action, amount payable in respect of compensation etc)

4.7.2 The word ‘normal’ used earlier is to be considered carefully in the context of working capital. The basic idea is that for determining working capital, the items which are not considered ‘normal’ should be excluded from current assets and current liabilities in the ordinary course of operations of the firm. As for example the following should be excluded from current assets:

- Obsolete stock items, if any
- Debts not expected to be received within a reasonably current period.
- Investments of long term nature
- Cash earmarked for the purchase of fixed assets or for liquidation of a long-term liability eg. redemption of debentures (23).
4.8.0 Inventories - a closer look

4.8.1 The study of the structure of working capital will reveal that "Inventories" occupy a most strategic position in the working capital whichever way we try to interpret it, i.e., by "Balance Sheet" or by "Operating Cycle".

4.8.2 "Inventories" as mentioned in paragraph 4 of International Accounting Standard 2 "are tangible property:

(a) held for sale in the ordinary course of business
(b) in the process of production for such sale or
(c) to be consumed in the production of goods and services for sale". (24)

4.8.3 The above definition shows that inventories may be classified broadly in four heads:

* Raw materials
* Supplies (Stores & Spares)
* Work-in-progress and
* Finished goods

Raw materials are those items which are processed at different stages of production to give the final output.

Supplies generally means the stores and spares and all other goods which are usually not to be processed but are needed for producing goods and services.

Work-in-progress are items which mean raw materials upon which one or more operations have been performed causing a change in the form, size, physical or chemical properties.

Finished goods include completely manufactured and inspected goods that are ready for sale. (25)

The above classification surely helps in indentifying the area of
control, but item wise control may better be established by using Operations Research (OR) models. In the following few paragraphs we shall dwell on that area.

4.9.0 Why Inventory?

4.9.1 The basic question that may be asked at this point is that why should we keep inventory? Inventory is held due to the following reasons:

* To meet the uncertainties in demand and supply.
* To take advantage of cost benefits of bulk purchase.
* To decouple the successive operations.

4.9.2 In the case of raw material, in order to provide the uninterrupted supply there must be some inventory. To obtain the quantity discounts, to meet the seasonal fluctuations of demand and supply, the inventory is a must. Similarly stores and spares also are to be stocked to meet the uncertain and random demands due to break-downs. Works-in-progress are to be accumulated at different stages to decouple the subsequent operations. Finished goods are to be kept in finished goods stores to provide the customer "off the shelf" supply. Again it may be that procurement is cheaper if it is done in economic lot size. So the extra items not needed presently may have to be carried in the store still it may turn out to be economical. This may act as protective buffer for future demand.

4.10.0 The criteria of optimality (26)

4.10.1 The above mentioned compelling reasons for maintaining inventory of four classes do not however suggest any organisation to do over investment on inventory. This is due to the fact that if too much inventory is kept, then although the probability of
having a shortage is very low, but cost of holding will be very high. As against this when the inventory is low, the cost of holding may be low, but the probability of being out of stock is very high i.e the stock out cost would be very high.

4.10.2 The criterion of optimality of the inventory level thus depends upon balancing these two opposing costs namely:

* Cost of having the item, when not needed (Storage cost)
* Cost of not having the item when needed (Shortage cost)

The above two costs may be hypothetically illustrated as follows:

![Diagram](https://via.placeholder.com/150)

'TQ' is the optimum inventory level, where the total cost is minimum.

4.10.3 O R models on inventory management helps in achieving a balance to optimise these two conflicting objectives. Jannis C Paul et al (27) emphasised this process of balancing as an essence of inventory management. "By its nature, inventory management is the arbitrator between diametrically opposing forces". In practice, the accurate determination of shortage cost is not possible and in the garbage of shortage of any item many of the managerial inefficiencies may be covered. So it is usually assumed that shortages are not allowed. So in place of shortage cost curve another cost curve may be drawn which has also the similar characteristics that is "Ordering cost curve". If the ordering quantity is large for each order then there will be lesser number of orders in a year and the total ordering cost.
will be less, but storage cost will be high. Again if the ordering quantity is less, more number of orders are to be placed which means more ordering cost but in that case the storage cost will be less. Thus the optimal quantity or "Economic ordering quantity" (EOQ) will be that quantity where the storage cost (or inventory carrying cost) and ordering cost totalled together is minimum. Operations Research models are available for determining the "Economic ordering quantity". Some generalised models have been developed in the following paragraphs.

4.11.0 The Systems Approach to Inventory Management

4.11.1 The definition of a 'system' as has been given in the booklet Management Information System part 1, Published by the Institute of Cost & Works Accountants, London, as "A set of things connected, associated or interdependent so as to form a complex unity". This "complex unity" can be broken down into 3 component parts - input, process and output as shown in the following diagram.

```
Input -- Process --> Output
```

The desired output is usually the starting point. 'Input' & 'Process' will be regulated to obtain the desired output. Whenever we consider a system, along with the inputs, process and output we shall have to look at the "constraints" in the environment.
4.11.2 The management of inventory may also be studied in the light of "System" because inventory management may also be broken down to three similar components viz.

```
- A pool of Resources
  Supply → Demand
  in stores
```

Suppliers are supplying to the stores and the production shops are demanding at the stores. Inventory control is nothing but maintaining a desired level of inventory at the stores, by controlling the input i.e. supply and meeting the output requirement i.e. demands of the shops (28).

4.12.0 Decision Variables

4.12.1 There are two basic decision variables—"When to Order" and "How much to order". But these two decisions are solely dependent on the overall objective of "maintaining a desired inventory level". The systems approach will help us in determining that optimum desired inventory level.

4.13.0 Factors Affecting Inventory Situation

4.13.1 Inventory has a close relationship with the demand pattern and the supply pattern, or in other words, the nature of lead time i.e. the time-lag between the placement of order and receiving the goods. Each of these two factors—demand and lead time may be studied under any of the following situations:
(a) Under certainty - the demand pattern or the lead time is completely known.

(b) Under risk - Probability distribution of demand pattern or the lead time is known from past data.

(c) Under uncertainty - Nothing is known about the demand pattern or the lead time durations.

Again decisions may have to be taken once only in the lifetime of the system i.e. "Static Decision" or it may have to be taken periodically, based on the feedback available. Then it is "Dynamic Decisions".

4.14.0 Advantages of Systems Approaches

4.14.1 Depending upon "Static" & "Dynamic" decisions and 3 different situations for each of "Lead Time" and "Demand", there are 18 possible combinations and each of them would result in a complex inventory model. The Systems approach prevents this complication. Here the inputs and the outputs are considered separately. The level of the resource pool is then determined considering the interaction of the two. In systems language it is called "Systems Analysis" and the "Systems Synthesis". The complex system is first segmented or partitioned. We study the pieces separately and try to improve them. Then we reassemble them. The former is called System Analysis and the latter the System Synthesis.

4.15.0 The Input

4.15.1 As mentioned earlier lead time can be considered under 3 situations - "under certainty", "under risk" and "under uncertainty". If the lead time is under uncertainty, nothing much can be done. When the lead time is completely known - there is no problem, because we know exactly when to place the order. So the problem remains only when we know the probability distribution of
different lead time over a period of time. This situation may be better tackled with the concept of "Service level".

\[
\text{Service level} = \frac{\text{No. of times the demand is satisfied}}{\text{No. of times the demand is made}}
\]

Let us explain this with an example as given below:

In the subsequent table the first two columns give the summary of 50 deliveries of an item over a year. From the frequency column, the probability and from it subsequently the cumulative probability of different lead times may be calculated.

<table>
<thead>
<tr>
<th>Lead time in days</th>
<th>Frequency</th>
<th>Probability</th>
<th>Cumulative probability</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>.32</td>
<td>.32</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>.24</td>
<td>.56</td>
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<td>.24</td>
<td>.80</td>
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<tr>
<td>13</td>
<td>4</td>
<td>.08</td>
<td>.88</td>
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<td>17</td>
<td>3</td>
<td>.06</td>
<td>.94</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>.06</td>
<td>1.00</td>
</tr>
<tr>
<td>50</td>
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If the management decides that they will operate at 88% service level, then corresponding to the cumulative probability 88, the lead time would be 13 days. Then for all practical purposes 13 days would be considered as fixed lead time, but some buffer stock will have to be built up for the odds that may happen for receiving the item beyond 13 days. Since 88% service level has been taken, only in 12% of the cases there is a probability that the item may reach after 13 days. The past data shows that beyond 13 days, it may go maximum up to 20 days. So the amount of buffer stocks to be maintained in the pool, may be calculated as follows:

\[
\text{Buffer stock due to lead time} = S_e = (\text{Maximum lead time} - \text{lead time corresponding to service level}) \times \text{Average daily}
\]

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consumption \times (1 - \text{cumulative probability corresponding to service level}) \text{ i.e.} \\
S_e = (20 - 13) \times \text{Average daily consumption} \times (1 - .88)

Thus the situation under risk may be divided into two parts - one may be treated as situation under certainty, and the other would be a buffer at the resource pool to take care of the uncertainty.

4.16.0 \textbf{The Costs}

4.16.1 It is obvious that the decisions on inventory control are entirely based on minimising the total cost. So we should first determine what are the different costs to be considered.

The inventory related costs can be classified into two types - supply based costs and demand based costs. There are two supply based costs - order cost and carrying cost. Similarly there are two demand based costs - under stock cost and overstock cost.

4.16.2 \textbf{Order Cost} : This includes the costs involved in preparation of the order, receipt of the commodity, clerical, stationary, transport and other expenses for expediting the order. This is dependent on the number of orders placed and not on the volume of order. Marginal concepts may be used to have a better estimate of this cost factor.

4.16.3 \textbf{Carrying Cost} : The components of carrying cost (also known as inventory carrying cost or storage cost) are as follows:

(i) Cost of capital (capital tied up in inventory, an opportunity cost)

(ii) Cost of storage and maintenance (expenses incurred in warehouse, rent, fire proofing, insurances and other facilities, like clerical, stationary etc.)
(iii) Cost of spoilage, (breakage, pilferage, loss due to perishable nature, obsolescence etc.)

All these costs depend upon the number of units stored and the length of time for which they are stored.

4.16.4 Under Stock Cost: The demand based costs are determined based on estimated demand and the actual demand. So if the actual demand is more than the estimated demand then only there will be under stock cost or stock out cost. This is an opportunity lost in earning that profit from the production or the extra cost involved for procurement to retain the flow of production. If the loss is for a longer future, the cost may be estimated by calculating the present worth, but in practice accurate determination of shortage cost is not possible.

4.16.5 Over Stock Cost: It is there when estimated demand is more than the actual demand. It is similar to the carrying cost, but limited to the period so long the excess stock over the estimated demand is carried over.

4.17.0 The Output

4.17.1 Combining the two types of decisions - static & dynamic and 3 types of demand situations - certainty, risk and uncertainty, 6 types of inventory models may be obtained. In the table below gives different decision situation, different costs involved and techniques to be applied:
4.17.2 The situation of static decision and uncertainty in demand may be handled by subjective approach. After assigning the subjective values to the variables, the problem may be handled by game theory or by statistical decision theory. However because of the subjective nature, we have kept this situation out of our discussion.

4.17.3 Again the situation of dynamic decision and uncertainty in demand can not exist in reality because if we are uncertain about the demand pattern, what is the use of having periodic decisions. Dynamic decision are taken only when the past performances throw some light upon the future behaviour.

4.17.4 Thus out of the six models mentioned above, three models exist in reality and we will discuss those models in the following sequence.

(1) Dynamic decision and certainty in demand pattern;
(2) Static decision and Risk in demand pattern.
(3) Dynamic decision and Risk in demand pattern.
4.18.0 Dynamic Decision and Certainty in Demand

4.18.1 He shall develop a generalised model when there is a simultaneous procurement and meeting the demand. Then we shall derive different specific models as situation demands.

Assumptions

(a) Demand is deterministic and uniform (r units/unit time)
(b) Finite procurement rate (k units/unit time), k > r
(c) Storage or Inventory Carrying Cost (C_i /unit/time)
(d) Shortage or out of stock cost (C_2 /shortage)
(e) Ordering cost (C_3 /order)

Let $M_i = \text{Maximum inventory or peak inventory}$

$M_s = \text{Maximum shortage}$

Let the initial inventory be zero and the procurement starts at time $t = 0$. Let the procurement last for a time $t_1$. During this period the net procurement rate at which the inventory is building is $(k-r)$, after meeting the demand as and when it occurs.

The ending inventory after time $t_1 = (k-r)t_1$ is maximum inventory $M_i$ ...

$t_1$ is the time required to build up the peak inventory.

At time $t_2$, the procurement is stopped and the stocks are allowed to deplete for a time $t_2$, when the inventory level falls to zero. Time $t_2$ is given by $rt_2$ and $(k-r)t_1 = rt_2$.

After inventory level has fallen to zero, the shortages accumulate for a time $t_3$. Then the procurement is started again. In time $t_4$, all the shortages which are incurred in time $t_3$ are completely satisfied at the rate of $(k-r)$ units per unit time, so that, at the end of this time, the inventory level is zero. This
completes one cycle. As above,

\[ r t_3 = (k - r) t_4 = \text{peak shortage} = Ms \]

Again \( q = \text{Total demand in one cycle} = \text{total procuremnt in one cycle} \)

or \( q = r (t_1 + t_2 + t_3 + t_4) = k (t_1 + t_4) \)

\[ T = \text{Total cost per unit time} = \frac{\text{Total cost per cycle}}{\text{Length of one cycle}} \]

Total cost per cycle = Order cost + storage cost + shortage cost

\[ = c_3 + c_1 \Delta ABC + c_2 \Delta CED \]

\[ = c_3 + c_1 \frac{1}{2} \left( t_1 + t_2 \right) M_i + c_2 \frac{1}{2} \left( t_3 + t_4 \right) Ms \]

\[ = c_3 + c_1 \frac{1}{2} \left( \frac{1}{k-r} + \frac{1}{r} \right) M_i^2 + c_2 \frac{1}{2} \left( \frac{1}{k-r} + \frac{1}{r} \right) Ms^2 \]

\[ = c_3 + \frac{1}{2} \frac{1}{r \left( 1 - r/k \right)} \left[ c_1 M_i^2 + c_2 Ms^2 \right] \]

\[ T = \frac{c_3 + \frac{1}{2} \frac{1}{r \left( 1 - r/k \right)} \left[ c_1 M_i^2 + c_2 Ms^2 \right]}{t_1 + t_2 + t_3 + t_4} \]

\[ t_1 + t_2 + t_3 + t_4 = \frac{M_i + Ms}{r \left( 1 - r/k \right)} \]

\[ \therefore T = \frac{2 c_3 \left( 1 - r/k \right) + c_1 M_i^2 + c_2 Ms^2}{2 \left( M_i + Ms \right)} \]

To get the minimum value of \( T \), we must have \( \frac{\partial T}{\partial M_i} = \frac{\partial T}{\partial Ms} = 0 \)

Now \( \frac{\partial T}{\partial M_i} = 0 \) gives

\[ (M_i + Ms) 2 c_1 M_i - N = 0 ........ (3) \]

and \( \frac{\partial T}{\partial Ms} = 0 \) gives

\[ (M_i + Ms) 2 c_2 Ms - N = 0 ........ (4) \]

Where \( N \) is the numerator of \( T \).

From (3) and (4) we get

\[ C_1 M_i = C_2 Ms \] .......... (5)

Substituting for \( Ms \) from (5) in (3)
\[ 2C_1M_i^2 \left( \frac{C_1 + C_2}{C_2} \right) = 2rC_3 \left( 1 - \frac{r}{k} \right) + C_1M_i^2 \left( \frac{C_1 + C_2}{C_2} \right) \]

\[ M_i = \sqrt{\frac{2rC_3}{C_1} \left( 1 - \frac{r}{k} \right) \frac{C_2}{C_1 + C_2}} \]

Similarly, \( M_s = \sqrt{\frac{2rC_3}{C_2} \left( 1 - \frac{r}{k} \right) \frac{C_1}{C_1 + C_2}} \)

Total amount produced = \( k \left( t_1 + t_4 \right) = EOQ \)

\[ = \frac{1}{\left( 1 - \frac{r}{k} \right)} \left( M_i + M_s \right) \]

\[ = \sqrt{\frac{2rC_3}{C_1} \frac{1}{\left( 1 - \frac{r}{k} \right)} \frac{C_1 + C_2}{C_2}} \]

**Some particular cases**

Case (i) Procurement is instantaneous and shortages are not allowed

i.e. \( k = q \) and \( C \longrightarrow \infty \), then \( Ms = 0 \) and \( Mi = q \)

\[ T(q) = \frac{rC_3}{q} + \frac{1}{2} C_1 q \]

Optimal \( q = \sqrt{\frac{2rC_3}{C_1}} \)

Case (ii) Procurement is instantaneous and shortages are allowed.

Here \( k \longrightarrow \infty \)

\[ T(Mi, Ms) = \frac{2rC_3 + C_1M_i^2 + C_2M_s^2}{2 \left( M_i + M_s \right)} \]

Optimal values of \( Mi \) and \( Ms \) are given by

\[ Mi = \sqrt{\frac{2rC_3}{C_1} \cdot \frac{C_2}{C_1 + C_2}} \quad \text{and} \quad Ms = \sqrt{\frac{2rC_3}{C_2} \cdot \frac{C_1}{C_1 + C_2}} \]
Case (iii) Shortages are not allowed, procurement is not instantaneous

i.e., \( C_2 \rightarrow \infty \), then \( M_s \rightarrow 0 \)

\[
T(M_i) = \frac{2 \, r \, C_3 \, (1 - r/k) + C_1 \, M_i^2}{2 \, M_i}
\]

Optimal value of \( M_i \) = \( \sqrt{\frac{2 \, r \, C_3}{C_1} \, (1 - r/k)} \)

4.19.0 Static Decision and Risk in Demand Pattern

4.19.1 When a new equipment is purchased, along with the main equipment, about 5 to 10 percent of the equipment cost is spent for purchasing insurance spares. These spares are to be procured by taking an one time decision. At that time if the procurement is less, items may have to be procured later at higher cost and if the procurement is more, those will have to be sold at scrap value. This is an example of "Static Decision and Risk in Demand" situation. The forecast of the demands with probability may be obtained and we may plot them as below:
Thus from the curve say \( p(S) \) is the probability that the demand is 'S' units or more. Let \( K_u \) is the unit under stock cost, i.e. \( K_u \) amount of profit would be lost per unit of understocking and \( K_o \) is the unit overstock cost i.e. \( K_o \) amount of losses would occur if the over stock is sold at the salvage value. Then the expected profit \( E(S) \) may be written as

\[
E(S) = K_u p(S) - K_o \left[ 1 - p(S) \right]
\]

Where \([1-p(s)]\) is the probability of not using the 5th unit. \( E(S) \) must be greater than zero, if the 5th unit is to produce a profit,

\[
p(S) \geq \frac{K_o}{K_u + K_o}
\]

So the policy would be to procure the maximum quantity 'S', so that the probability of the using 'S' units or more is greater than,

\[
\frac{K_o}{K_u + K_o}
\]

4.2.0 Dynamic decisions and risk in demand pattern

4.2.1 Here the supply based costs i.e. the order cost and carrying costs as well as the demand based costs i.e. over stock cost and under stock costs become relevant.

Total cost = order cost + Carrying cost + Overstock cost + Under stock costs.

We divide the problem in 2 stages:

Stage I - Certainty in Demand, Dynamic in Decision

Stage II - Risk in Demand, Dynamic in Decision

Stage I: we shall determine Economic Order Quantity i.e. Q.

If we know the total demand in a year we may know also the review period \( P \) i.e.

\[
\frac{\text{Total demand}}{\text{EOQ}} = X \text{ say, then } \frac{365 \text{ days}}{X} = P
\]
Now P & Q being known we will go for stage II.

Stage II: One of the factors "P" or "Q" will have to be kept constant and the other factor will vary to take care of the demand under risk situation. At each case we will determine the mean demand plus the buffer for the risk demand.

P - System: This is called "fixed Order Period System". We determine the "Desired Inventory Level" (DIL). After the specified period "P", the inventory positions will be reviewed and the shortfall from the DIL will be ordered. To calculate the Desired Inventory Level

1. The demand distribution for the period "Lead time + Order period (P)" will have to be determined.

2. This demand distribution curve is a normal curve. A service level (say 95.%) is chosen to locate the maximum demand that may take place during "Lead time + Order period".

3. The DIL would be the maximum demand that may take place and is calculated as the mean demand during "Lead time + Order period" plus standard normal deviate for the given service level multiplied by the standard deviation for the demand distribution.

Q - System: This is called "Fixed Order Quantity System". In this case we determine the "Reorder Level". A constant watch is kept over the inventory level and whenever the level comes below the "Reorder Level" an order is placed which is equal to quantity "Q" i.e. economic ordering quantity.
To calculate Reorder Level

(1) The demand distribution for the period of "Lead Time" is determined.

(2) This demand distribution curve is a normal curve. A service level is chosen to locate the maximum demand that may take place during the lead time.

(3) The "Reorder Level" would be the maximum demand that may take place during this "Lead Time Period" and is calculated as mean demand during the lead time plus standard normal deviate for the given service level multiplied by the standard deviation for the distribution.

4.21.0 The Process

4.21.1 The process part, i.e. the pool of resources is composed of 3 parts, namely:

(i) Buffer stock due to lead time fluctuations.

(ii) Stock corresponding to the mean expected demand.

(iii) Buffer stock for the risk demand;

Thus, the whole inventory management is reduced to three elements—inputs, process and outputs, of which the inputs and the outputs will determine what should be the inventory level.

4.22.0 Selective Inventory Control

4.22.1 The biggest problem in applying these models is that the decisions are to be taken for each individual items. In reality an inventory controller has to control large number of items. Now all the items are not of equal importance. So the importance of different items has to be established by "Selective Inventory Control". There are several techniques available to categorise the inventories for the purpose of
4.23.0 **A B C analysis**

4.23.1 Volfredo Pareto while studying the distribution of wealth and income in Italy, observed that a very large percentage of the total national income was concentrated in a small percentage of population. Statistically he expressed this relationship as 80 percent of the income was being accounted for by 20 percent of population. This 80-20 relationship popularly known as "Pareto's Law" is being extended little more to get the A B C Analysis. Pareto's principle identifies the "vital few and trivial many" but in A B C analysis, the vitals are more sharpened as 'A' items and in between "Vital few" and "trivial many" one more category 'B' items has been brought in.

4.23.2 A B C analysis is done on the basis of consumption value of inventories. The consumption values are arranged in descending order. Cumulative consumption values are then converted to cumulative percentages respectively. A,B,C classifications are then done based on the cumulative percentage figures. There is no hard and fast rule for the break points to divide the inventories, but usually it is found as follows:
i.e. about 7-8% of total number of items account for about 70% of consumption value and those are called 'A' type items. The next, about 20% of the items account for about next 20-25% of the total consumption value and those are called 'B' type items and the rest large number of items cater for a small percentage of consumption value and those are called 'C' type items. The nature of distribution of consumption value will depend upon the industry to which an enterprise belongs and the degree of control will depend upon the management policy.

4.23.3 Hax and Candeá (30) mentioned that highly technological industries tend to have small percentage of class A items. Magee and Goodman (31) have mentioned in their book that "inventories of consumer goods will typically show a lesser concentration in the top items than will an inventory of industrial items". Peterson Rein and Silver (32) stated that nature of industry affects the distribution of usage value (same as consumption value). He has given in his book the "Distribution by value curves of industrial and consumer inventory".

4.24.0 Limitations of ABC Analysis

4.24.1 A B C analysis considers importance from the point of view of consumption value only, ignoring other factors like criticality of the item, type of source from which it is procured (imported, government or from open market), movement, unit value of an item, and its availability etc. A B C analysis when used along with these classification brings forth more effectiveness in identifying the control areas.
4.25.0 VED (Vital Essential and Desirable) Analysis

4.25.1 Usually in spare parts some items are so critical that non availability of these items may create serious problems in production. These items may be of very less consumption value ie. it may belong to 'C' item, but from production point of view is very important. Bureau of Public Enterprises has defined criticality classification under 3 heads "Vital", "Essential" & "Desirable".

**Vital:** The vital spares are those the absence of which even for very short duration will stop production and where the cost of lost production is very high. These spares quite often make the difference between the company being in surplus or deficit.

**Essential:** The essential spares are those, the absence of which cannot be tolerated for more than a few hours or a day. The cost of lost production is high and the spares are essential for the operations of the company.

**Desirable:** The "Desirable" spares are those, which are definitely needed, but their absence for even a week or so will not stop the production.

These types of analysis may lead to some subjective decisions. So, it is determined usually by committee, where members are from production, maintenance and materials management etc.

4.26.0 FSN (Fast, Slow and Non-moving) analysis

4.26.1 Movement (demand) of item during a period is the basis of this classification. There is no hard and fast rule for categorising an item as fast moving or slow moving, but several authors have suggested their criteria for categorisation. Peterson, Rein and Silver (33) suggests that if an item has a
demand for more than 10 units during its lead time it should be treated as fast-moving and for demands less than 10 units during the lead time should be treated as slow-moving items. Gopal Krishnan and Sandilya suggested that an item with zero issue during past two years should be treated as non-moving, up to 10 issues during past two years as slow-moving and more than 10 issues, as fast-moving items (34).

4.27.0 XYZ Analysis

4.27.1 The basis of this classification is on the values of items in the store at a given point of time, say at the end of financial year. Cut-off points are decided for dividing the total value of inventories into three categories. This analysis along with FSM analysis helps in determining obsolete items.

4.28.0 SDE (Scarce-Difficult-Easy to procure) Analysis

4.28.1 Items where special efforts are required to procure is categorised as 'Scarce' items. Obviously for 'scarce' items sufficient safety stocks should be maintained and alternate source should be developed. Opposite to it, items which are available "off the shelf" easily are categorised as "Easy" items. In between lies "Difficult" items. A combination of ABC and SDE analysis gives a good idea about the safety stock to be maintained itemwise.

4.29.0 HML (High-Medium and Low unit value) Analysis

4.29.1 By this analysis inventories are classified according to their unit value as high, medium or low valued items. These analysis identifies the sanctioning authority for purchase and helps in identifying the administrative leadtime for approval.
4.30.0 *SOs (Seasonal-off seasonal) Analysis*

4.30.1 Seasonal and off seasonal demand of items or output require two different approaches to control inventory. Management policy to these items are very important. In some cases the raw material availability is seasonal and in some cases the finished goods demands are seasonal. So, after identifying by SOs analysis treatments are to be done as per management policy.

4.31.0 *Golf (Government-Ordinary-Local-foreign Source of Supply) Analysis*

4.31.1 This analysis is done on the basis of source of supply. Quite often the nature of source determines the leadtime and availability. So this analysis will help the inventory controller in developing the suitable procurement policy.

4.32.0 *Tandon and Chore Committee Recommendation*

4.32.1 It has been mentioned in 1.8.1 that the Reserve Bank of India (R.B.I.) constituted a Study Group to frame guidelines for follow up of bank credit. The banker used to lend against inventory and the borrower was also in a position to procure raw materials on credit basis. This was encouraging double financing and the borrower could divert the funds for non-approved uses without the banker's knowledge.

4.32.2 Tandon Committee classified inventory into the following five categories:

(a) Flabby inventory, resulting out of ineffective inventory management mainly in the area of raw materials and finished goods.
(b) Profit making inventory, which means realisation of profit caused by inflation for simply holding the item.

(c) Safety inventory, which is needed to protect against the failure of supply of raw materials or sudden rise in demand.

(d) Normal inventory, needed for having normal production or marketing plan.

(e) Excessive inventory, which is to be carried even by efficient management as strategic material.

Tandon Committee suggested that a banker should cut down flabby inventory, discourage profit making inventory, bring down safety inventory using experience and judgment. The remaining part would fluctuate as per demand and production plan. The Committee suggested norms for current assets holding for few key industries. But it may be presumed that these norms are based on total capacity utilisation. Moreover the norms are developed from banker's point of view. In this study, we have tried to establish an internal control system in inventory management for an organisation. This therefore differs basically from the approach taken by the Tandon and the Chore Committee which tried to look at the matter from the banker's point of view.

4.33.0 Collateral Studies

4.33.1 Apart from the reference given a good number of books have been studied where the problems of working capital management have been dealt with as a part of Financial Management. Books which come under this category are by authors like Hunt & Pearson (35), Guthmann & Dougall (36), Walker (37), Archer and Ambrosio (38), D Donnel and Goldberg (39), Louis K Brandt (40), James C. Van Horne (41), Weston and Brigham.
4.33.2 A good number of books have dealt the working capital management problem exclusively, e.g. Chitnis (44), Dileep R. Mehta (45), Keith V. Smith (46), James Men Stancil (47), Beraneck (48), Leslie R. Howard (49) and V. E. Ramamoorthy (50). The views of those authors have helped in understanding the conceptual framework.

4.33.3 Several publications have been studied where the management of different individual components of working capital have been dealt with, e.g. Bhabatosh Banerjee (51), Heirman, Harold, J and Alan K. Mc Adams (52), etc. Extensive studies have been done in the area of inventory management in Operations Research. The notable books are by Starr & Miller (53), Walter E. Willets (54), Dean S. Ammer (55), Buchan and Koenigsberg (56), A R Palit (57), P. Gopalakrishnan and M. Sundaresan (58), etc. Worth mentioning articles are by the authors Charles W. Haley (59), Dean S. Ammer (60), Paul Neuman (61), Robert J. Shaw (62), P. S. Rao (63), G V. Chelapathi Rao (64), P. J. Fernandes (65) and S. Ramaswamy (66).

4.34.0 Conclusions

4.34.1 By applying suitable selective control techniques, items may be identified where proper inventory control should be established. Then by using the appropriate OR models, inventory control norms may be established. To what extent these scientific inventory control techniques are already in use in public sector enterprises cannot be determined from the annual reports. Our present study is also not a survey to estimate to what extent the public sector enterprises are using these scientific techniques. This study is meant to develop some methodology for determining the value of ideal inventory in
absolute terms which in turn may help in establishing effective control on inventory. These have been dealt in the subsequent chapters.
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