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## Abstract

In this chapter, the concept of inventory is discussed which is central to materials management function. The definition of inventory and various types of inventories – raw materials, finished goods, in-process inventory, MRO inventory, etc. – are outlined. The need to keep inventory and the functions of inventory as a decoupling agent to enable various subsystems in a supply chain to be decoupled are described. The inventory-related cost parameters are listed along with methods of estimating these. Other situational parameters like demand and lead times also need to be estimated. Before an inventory model is employed for optimal operation of the inventory system, an appropriate inventory policy has to be selected. Three types of inventory policies are described, and their relative strengths and weaknesses are discussed. A taxonomy of inventory models is presented to give an overview of a plethora of inventory models available in inventory management literature. However, the right choice of the inventory model is crucial for the success of inventory management.

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## Keywords

Inventory policy • Carrying cost • Ordering cost • Shortage cost • Taxonomy • Inventory model

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## 2.1 What Is Inventory?

Inventory or stock (in common terms) is considered to be the central theme in managing materials. The inventory turnover ratio (ITR) is a barometer of performance of materials management function. In the generally understood term, inventory means a physical stock of goods kept in store to meet the anticipated demand. However, from materials management perspective, an apt definition of inventory is “a usable but idle resource having some economic value.” This brings to the fore a paradox in the concept of inventory perceived as a “necessary evil.”

It is necessary to have physical stock in the system to take care of the anticipated demand because nonavailability of materials when needed will lead to delays in production or projects or services delivered. However, keeping inventory is not free because there are opportunity costs of “carrying” or “holding” inventory in the organization. Thus, the paradox is that we need inventory, but it is not desirable to have inventory. It is this paradoxical situation that makes inventory management a challenging problem area in materials management. It also makes a high inventory turnover ratio as a desirable performance indicator.

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## **2.2 Types of Inventories**

Employing the generic definition of inventory, a large spectrum of situations can be structured as inventory management problems. These include the following:

- (a) Raw materials inventory as input to manufacturing system.
- (b) Bought-out-parts (BOP) inventory which directly go to the assembly of product as it is.
- (c) Work-in-progress (WIP) or work-in-process inventory or pipeline inventory.
- (d) Finished goods inventory for supporting the distribution to the customers.
- (e) Maintenance, repair, and operating (MRO) supplies. These include spare parts, indirect materials, and all other sundry items required for production/service systems.

It may be noted that the basic definition of inventory being a “usable but idle resource” remains valid irrespective of the type of inventory being managed.

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## **2.3 Why Do We Need Inventories?**

From the resource management point of view, we should not have inventories as these constitute the idle resources. However, if we did not have inventories, there will be shortages, production delays, and project delays. Some of the reasons for having inventories in the production/service system are as follows:

1. Time lag between placing orders and getting supplies at the point of consumption – Whenever we place a replenishment order, there is a time lag between placing the order and getting the materials at the point of use. This is called “replenishment lead time.” In most cases the lead time is nonzero, and at times it is quite high. This necessitates holding of inventory to take care of demand during the lead times.
2. Variability of lead times – In most cases, particularly in Indian supply environment, there is some degree of variability in lead times because the supply environment is perhaps “just-in-case” (JIC) type. Inventory has to be maintained as a shield to cope with the supply uncertainty. Inventory is the premium an

organization pays for operating in a just-in-case supply environment. If there was no such uncertainty and if demand and supply are deterministic, then in just-in-time (JIT)-type environment, no or low inventory will be required. The greater the amount of supply uncertainty, the greater the amount of additional inventory required.

3. Demand variability – If either we are unable to estimate the demand correctly or if there are uncertainties in demand, additional inventory will be required to act as a shield to absorb the demand variability. The greater the demand variability, the greater the amount of additional inventory required.
4. Seasonal inventory – If the demand is cyclic or seasonal, then sometimes building inventory in the lean period to meet the peak period demand is employed as a strategy in aggregate production planning. This strategy results in inventory in some part of the year.
5. Pipeline inventory – This is the inventory due to the distribution of a product or a commodity over long distances, so that the “goods in transit” become substantially important. This constitutes the pipeline inventory. In the context of production processes, this is called in-process inventory or work in progress (WIP) which is also inventory in terms of idle resource blocked in the nonproductive form. This can be reduced by making the supply chain move faster.
6. Other factors – Sometimes inventory is maintained to take care of other situational parameters such as inflationary pressures, shortage of materials in the markets, and quantity discounts to encourage bulk purchasing or simply the desire to spend the budget allocated for materials before the end of the financial year resulting in large and at times unnecessary purchases which eventually become dead stock.

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## 2.4 Just-in-Time or Zero-Inventory Essentials

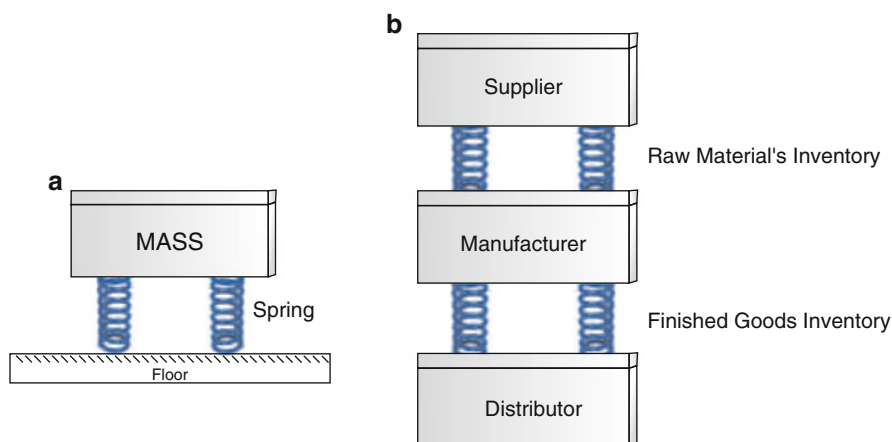
Just-in-time (JIT) is one of the most talked about topics in materials planning primarily due to its tremendous success in the context of Japanese companies. JIT or zero-inventory system is an idealized concept of inventory management wherein we are able to supply whatever material is required, wherever required, and whenever required just in time with 100 % supply assurances without keeping any inventory on hand. Obviously, from the resource management point of view, nothing can be better than this, as there are no inventories, no shortages, and no replenishment orders placed. However, this concept necessitates that the suppliers (vendors) are local and are 100 % dependable; orders splitting with small orders without additional transportation costs is feasible, i.e., frequent deliveries are economically viable, and the requirements are firmly known. This also calls for a single vendor base and having long-term relationship with the vendor who has to be a quality vendor. This also requires that the vendor has sufficient capacity to supply anytime without passing on the costs of overcapacity to the buyer. Vrat (2011) has shown that the supply of oxygen to the human body is perhaps the perfect example of a JIT/zero-inventory system, and from this analogy, a number of prerequisites for

the success of JIT can be visualized. In uncertain demand and supply environment, JIT is not feasible. Thus, inventory management in uncertain supply environment is JIC type in which minimization of the total expected system cost becomes an important objective.

## 2.5 Functions of Inventory: A Mechanical Analogy

In order to gain further insights into the functions/role of inventory in an organization, a mechanical analogy has been proposed. This perceives the role of inventory as to decouple the two subsystems, so that a subsystem is not directly coupled to another subsystem. Specifically the mechanical analogy is from a “mass-dashpot” or a “mass-spring” systems used in mechanical vibrations. It is known in mechanical systems that the role of a spring or a “dashpot” or “shock absorber” is to absorb the vibrations caused by imbalance of forces in a dynamical system, so that these are not allowed to be passed on to the other subsystem. Figure 2.1a, b shows the analogy of such mechanical systems with the inventory. In a directly coupled system, the vibrations in a subsystem get transferred to another subsystem. A spring/dashpot or a shock absorber decouples it to an extent. Similarly in an organization inventory of raw materials or bought-out parts decouples supply subsystem from production subsystem. This means that even if supply disruptions take place, raw materials inventory will enable production operations to go on up to a limit. Similar decoupling function is provided by in-process inventory to decouple one department or a machine from the other. The finished goods inventory decouples the production subsystem from the distribution/sales subsystem. The spares inventory decouples the maintenance subsystem from the production subsystem.

Developing this analogy further, the design of the mechanical springs/dashpots/shock absorber will depend upon the degree of imbalance and the amplitude of



**Fig. 2.1** (a) Mass-spring system. (b) Inventory for decoupling function

vibrations. The greater the extent of vibrations, the stronger is the spring design required for a stated level of decoupling desired. The higher the decoupling desired, the more robust the design of the spring and hence the costlier it will be. Seen in this perspective, optimal inventory level is analogous to optimal design of the mechanical spring or the shock absorber. Thus, inventory is required in an organization to “absorb” the “vibration” caused by “uncertainties” of demand and supply to provide a required degree of decoupling (level of service).

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## 2.6 What Is an Inventory Problem?

Naddor (1966) suggested that we have an inventory problem when we need to decide about (a) when to initiate a purchase order [when to buy] and (b) how much to buy [determine the lot size].

In solving these twin problems of decision making, we need to develop a model of inventory. A rational scientific approach to decision making calls for developing an inventory model which links up the objective function with the decision variables (e.g., lot size and reorder point) and various inventory-related cost parameters as well as situational variables such as demand, uncertainty of demand, lead time, uncertainty of lead time, constraints (if any), and any other relevant data such as quantity discounts or inflationary trend.

An inventory model is a model which attempts to link up primarily the following three types of inventory-related costs in which at least one is subject to control. In decision-making models, at least one variable must be controllable; otherwise, it is only a descriptive model of the system. The three costs are as follows:

- (a) Inventory carrying costs or holding cost – This is the estimated or imputed cost of holding or carrying a unit of material in the form of inventory for a unit period of time. This is a function of the price of the material held in stock per unit and a fraction of carrying charge expressed as a fraction or percentage of unit price/unit time. The carrying cost is expressed as ₹per unit/unit time. For example, if the material cost is ₹1,000 per unit and if the fraction of carrying charge is 0.25 per year, then the unit carrying cost is ₹250 per unit/year. The fraction of carrying charge is contingent upon a number of situational parameters which will be detailed out in the next section, but the cost of capital blocked in the nonproductive form (which inventories are perceived to be) is the most dominant component. This in turn requires a method of estimating these costs.
- (b) Cost of shortage or stockout – This is the estimated or imputed opportunity cost incurred if we do not have materials in stock when the demand arises. This depends upon the consequences of such a situation to arise. If we lost a customer, then it will be the opportunity cost of lost sales. If the demand remains backlogged (or back-ordered), then this will be the penalty cost (if any), loss of goodwill, cost of production or project delays, etc. Estimating the shortage cost is relatively more difficult than the carrying cost, but an approximate estimate is better than ignoring such costs altogether.

- (c) Ordering costs – Ordering or replenishment costs are the costs of efforts put in and expenses incurred when a purchase order is initiated for procurement or replenishment of inventories. The ordering cost is quite dependent on the purchase procedures and the extent of bureaucracy and paperwork involved in the processing of a purchase order. This includes administrative efforts expended in paper flow, progress chasing, inspection, and other costs which will be detailed out in the next section. However, for the sake of simplification, in many inventory models, the ordering cost is assumed to be independent of the order size and is expressed as ₹per order. Though it may not be strictly true, yet many inventory models are developed assuming this as an approximation of reality.

Naddor (1966) has denoted these costs as  $C_1$ ,  $C_2$ , and  $C_3$ , respectively. Though not a standard notation, these notations will be used throughout in this book for the sake of uniformity.

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## 2.7 Estimation of Inventory-Related Cost Parameters

Estimated or imputed costs are relevant inputs to models of decision making for rationalizing inventory policies, and hence it is important that these are properly estimated. These costs are situation specific and may be different for different items even for the same organization depending upon the nature of the item, its perishability characteristics, any special storage conditions required, and the impact of nonavailability when needed. The following discussion will perhaps enable the materials planners to estimate these costs more appropriately:

- (a) Cost of carrying inventory ( $C_1$ ): These costs need to be realistically estimated on the incremental costing basis to include those costs elements which vary directly with the amount of inventories held. These costs can be divided into the following four subcategories:
1. Capital costs – These include the opportunity loss due to the return on investment of this fund in an alternate way; if it is own capital or the interest paid on the borrowed capital (cost of capital). This is the most dominant component of carrying cost and may nearly be half of the total carrying cost.
  2. Storage costs – Costs associated with the need to house inventories in a physical storage facility. The cost components could be amortized cost of land, building, storage equipment, and creating special storage environment like temperature and humidity control and costs due to leasing or renting storage space or depreciation, insurance, taxes, utilities, etc.
  3. Service costs – Cost of hiring persons to process inventory transactions, materials handling, receiving and storage, retrieval and issue of physical inventory, and any other cost of service.
  4. Risk costs – These are associated with the risk of obsolescence or shrinkage of inventory due to pilferage, spoilage, damage, disappearance (such as evaporation during storage), stock-dependent consumption, and perishability or devaluation of selling price.

Depending upon the nature of item stocked, the carrying cost may vary from 15 to 50 % of the value of stock per year. In highly perishable situation, it could be even more. In many illustrative examples, a figure of 25 % is assumed. However, it is only an illustrative figure. The actual cost may be estimated specific to the item. Love (1979) has cited studies suggesting that the companies generally underestimate the carrying costs and that the capital cost is roughly 50 % of the total cost of carrying inventory while the remaining three categories are essentially comparable. A simple heuristic way to estimate carrying cost would then be to double the cost of capital blocked in inventory and add extra for additional risks involved due to pilferage, perishability, obsolescence, stock-dependent consumption rate, etc., as the case may be.

(b) Cost of shortage ( $C_2$ ): Cost of shortage is the opportunity cost of not having materials when required. This includes tangible and intangible cost components and is relatively difficult to estimate. In inventory models, it is divided into two categories – when the backlogging is allowed and when a shortage leads to lost sales. Under the backlogging (or back-ordering) situation, it is estimated as number of unit short and the duration of the backlogging. Thus, it is expressed as  $C_2 = ₹/\text{unit short/unit time}$ . The shortage cost could be estimated on the basis of four possible scenarios as follows:

1. When remedial action is possible for a purchased item to prevent shortage such as emergency purchase with cost consequences of premium material price, loss of purchase quantity discount, extra ordering cost, and rush shipment. Alternatively it could mean the use of a substitute item, which may be of higher cost including any adaptation costs.
2. Remedial action for manufactured item in preventing a shortage is to give overtime at higher rate, subcontracting, emergency hiring, inferior quality, or use of a substitute item.
3. When no remedial action is possible in the case of purchased item – it includes the extra costs due to penalty cost of late deliveries, special delivery when item arrives, loss of goodwill, lawsuit, extra paperwork, and long-term loss of customers.
4. When remedial action is possible to prevent a shortage in manufacturing context – it includes opportunity cost of production downtime, idle labor, equipment, failure to meet delivery schedules, and unsafe conditions resulting in losses and damages.

In the case when backlogging is not allowed, shortage results in lost sales and the unit of  $C_2$  changes to ₹/unit short. The opportunity costs of lost sales are loss of contribution margin, lost customers in the future due to loss of goodwill, etc.

Though estimation of shortage cost is difficult, yet it must be recognized as a factor relevant to inventory planning because “some concern” for shortage cost is better than “no concern.” It is quite obvious that the range of variation of  $C_2$  is quite high – from minor irritation or inconvenience to catastrophic failures. However, from the perspective of prevention and failure costs computed under “cost of

quality” in TQM literature, one can roughly estimate that normally shortage cost could be 10 times the cost of carrying inventory  $C_1$ . Thus,  $(C_2/C_1)$  ratio could be 10 in many situations, but it is only an “imputed cost.” However, the organization’s concern for customer satisfaction (which includes on time deliveries) is an important policy variable for estimating shortage cost. For a customer-sensitive company  $(C_2/C_1)$ , ratio is high.

There may be a wrong perception that being a difficult-to-measure cost, shortage cost should not be included in the inventory models. Such an assumption indirectly attributes a cost value to the shortage cost. If we ignore it altogether, then we are imputing value of  $C_2 = 0$ . However, if we say that being of serious concern in inventory planning, we should not allow shortages to occur, in that case we are imputing infinite cost to shortage at  $C_2 = \infty$ . Both these extremes are not good. Hence, a normal  $(C_2/C_1)$  ratio of 10 may be taken as a rough guide and it may be adjusted on either side of this value depending upon the specific situation. For vital or critical items, it could be more than 10, and for desirable items, it could be less than 10. We may alternatively prescribe service levels to impute this cost. A desired level of service may be easier to prescribe but eventually gets translated to imputing a value to shortage cost  $C_2$ . Hence, either way, it is acceptable.

(c) Ordering cost ( $C_3$ ):

The cost of ordering ( $C_3$ ) is also called as cost of replenishing an order. For manufactured item within the company, it may have the same meaning as the cost of production setup. For the purchased items, it is the administrative cost of processing the order for approval, order placement (paper work, communication), shipment – (freight, postage, demurrage, pickup), cost at the time of receiving the shipments (paperwork, document preparation, materials handling, inspection); billing cost, which includes the labor and overhead costs. A detailed checklist of tasks required to process an order and attributing costs to it can help.

One of the biggest advantages of e-procurement is the reduction in paperwork and reduced internal lead time of replenishments. Since ordering costs involve identifying specific tangible activities in the procurement process, this cost is relatively easy to estimate as compared to the cost  $C_2$  or  $C_1$ .  $C_3$  also depends upon the process of procurement. If it is manual and bureaucratic,  $C_3$  is high; alternatively if it is simplified and computerized, it may be quite low. These costs are assumed to be fixed and expressed as  $C_3 = ₹/\text{order}$ , independent of the order size.

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## 2.8 Inventory Models

An inventory model attempts to represent an inventory problem to facilitate decision making. Typically, the inventory model enables us to rationally decide (a) how much to buy (b) and when to buy. In order to answer these questions, we need to develop inventory model which combines decision variables with situational parameters. The situational parameters are demand; lead time;  $C_1$ ,  $C_2$ ,



and  $C_3$ ; unit purchase price; and any uncertainties associated with demand and lead times. It may also include any special feature such as quantity discounts, inflationary factors, budget or space constraints, etc.

Naddor (1966) defines inventory model as a mathematical relationship which involves three inventory-related costs  $C_1$ ,  $C_2$ , and  $C_3$ , and at least two of these should be under control. If all the three are subject to control, it is termed as type (1, 2, 3) inventory model. If  $C_1$  and  $C_3$  are relevant ( $C_2 = \infty$ ), then it is type (1, 3) inventory model.

There have been different approaches to classify inventory models. These have been differently classified by various authors such as Naddor (1966), Love (1979), Starr and Miller (1975), and Fabrycky and Banks (1967). Hollier and Vrat (1978) proposed an approach to classify the inventory models depending upon the decision variables and the situational parameters including the inventory policies employed as operating doctrine in the management of inventories.

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## 2.9 Inventory Policies

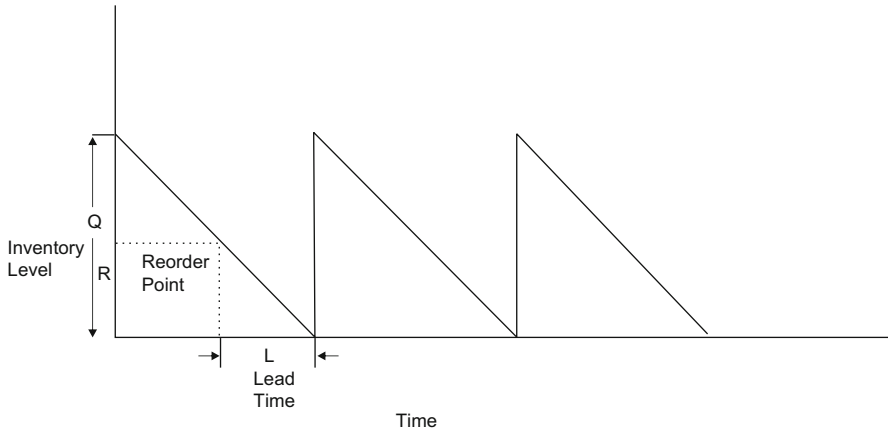
Inventory policy is an operating framework or a standard operating procedure (SOP) in implementing an inventory model. Obviously, the inventory model will depend upon the choice of inventory policy adopted. Typically, an inventory policy results in an inventory graph as a function of time. This visually depicts how the inventory status changes over time and when does procurement intervention take place.

In practice, three inventory policies are normally employed. These are described as follows:

### 1. Economic Order Quantity (EOQ)-Reorder Point (ROP) Policy

Under this policy, the inventory status is continuously monitored. Whenever the inventory level falls to a predetermined level called as reorder point (ROP), a replenishment order of fixed quantity called economic order quantity (EOQ) is placed. Thus EOQ ( $Q$ ) and ROP ( $R$ ) are the two decision variable involved in solving the problem of how much to buy and when to buy. Figure 2.2 shows the graphical operation of the ( $Q, R$ ) policy. Such inventory model must have ( $Q, R$ ) as decision variables.

Since this policy requires that the inventory levels be continuously monitored, it calls for keeping a constant watch at stock levels, while in a computerized inventory control, it is easy; in manual systems its administrative costs of operation could be more. To ease this situation, a very ingenious method of manual monitoring of this policy has been evolved and is in practice for long and is called the “two-bin” policy. Under the two-bin policy, total stock is kept in two bins. The second bin keeps the stock required during the lead time, and the first bin contains the  $Q$  minus the stock in the second bin. The consumption is met from the first bin until it gets totally consumed. The moment it happens, the reorder point is deemed to have been reached, and a replenishment order of size ( $Q$ ) is placed. During the replenishment period, the demand is met from the second bin.



**Fig. 2.2** EOQ-ROP policy

Of course with the computerization of inventory records, the stock status can be continuously monitored easily without the two-bin policy, because in the two-bin policy one has to keep two storage units for each item. EOQ policy is perhaps the most talked about policy in inventory control literature and is the oldest scientific model of inventory control.

## 2. Periodic Review Inventory Policy

The stock status is periodically reviewed under this policy after a fixed time interval ( $T$ ). When the review period is reached, the order is placed which is determined by the following relationship:

$$Q = \text{order quantity} = (S - X)$$

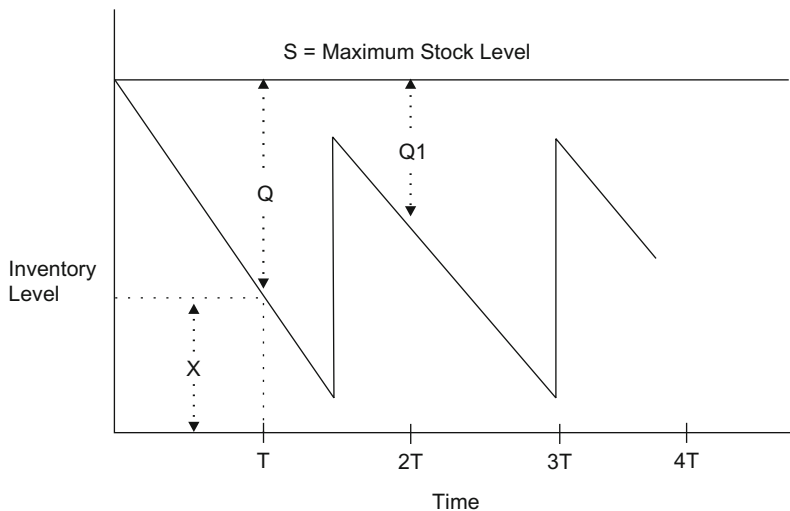
where  $S$  = maximum stock level (or order up to level)

$X$  = stock on hand at the time of review

Figure 2.3 illustrates the periodic review policy graphically.

Under this policy,  $S$ , the maximum stock level and the time interval between two reviews ( $T$ ) are the two decision variables for optimization. Therefore, it is also called as  $(S, T)$  policy. Operation of this policy is relatively easy because status of inventory is taken only after a fixed time interval. However, this policy is quite sensitive to the consumption during the review cycle. If stock on hand is high, the order quantity for the next period is low and vice versa. However, under this policy, an order has to be mandatorily placed even if the stock levels are quite high at the review period due to which the order size is a small quantity.

In order to simplify the model, one may specify one of the decision variables  $S$  or  $T$ . Naddor (1966) called it  $(S_p, T)$  policy if  $S$  is prescribed and  $T$  is the only decision variable. If  $T$  is prescribed, then it is called  $(S, T_p)$  policy with  $S$  as a decision variable.



**Fig. 2.3** Periodic review inventory policy

### 3. Optional Replenishment Policy

This is a variant of periodic review inventory policy wherein there are two levels of inventory identified as  $S$  (the maximum level) and  $s$  (the minimum level). The stock levels are periodically examined at fixed time interval  $T$ . However, if the stock levels are more than the minimum level ( $s$ ) at the time of review, the replenishment decision is deferred to the next review cycle, and no order is placed because the current stock is deemed to be adequate for the time being until the next review cycle. If, at the time of review, the stock level ( $X$ ) is less than or equal to ( $s$ ), then the order quantity  $Q$  is determined so that it raises the stock level to  $S$ .

Thus under this policy,

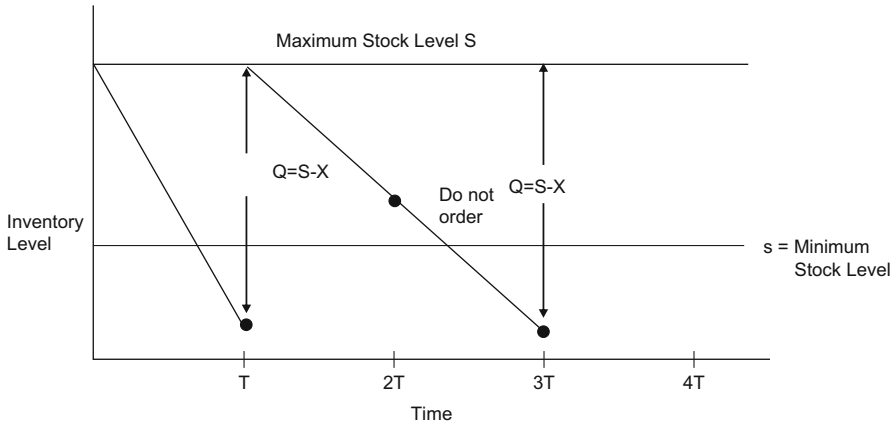
$$Q = S - X \text{ if } X \leq s$$

$$= 0 \text{ if } X > s$$

Figure 2.4 depicts the operation of this policy graphically.

This policy is also called as minimum-maximum stock level policy or  $(s, S)$  policy. Here the decision variables are  $s$ ,  $S$ , and  $T$ . This is also called as optional replenishment policy because there is an option of skipping the replenishment decision to the next review period if the current inventory on hand is more than the minimum level prescribed. Thus, intuitively, this would appear to be better than  $(S, T)$  policy provided  $(s, S)$  and  $T$  are optimized.

There may be other variants of these three basic policies, but the most common policies are only these. The inventory model to be developed depends upon the choice of inventory policy. Hence, we have to first decide the inventory policy to be employed before we develop an inventory model for optimal choice of the decision variables.



**Fig. 2.4** Optional  $(s, S)$  inventory policy

It has been shown in the inventory control research that if  $(s, S, T)$  are optimized, then the optional replenishment policy is the best among the three policy options outlined above. However, as will be seen later, optimization of these three decision variables simultaneously leads to a very complex model of inventory in case of probabilistic demand and lead times. For practical purposes, EOQ-ROP policy is a good choice for high usage value items, while  $(S, T)$  policy is good for low usage value items.  $(s, S)$  policy may be employed for very high usage value items where modeling complexity will be justifiable even if one may have to resort to simulation to optimize decision variables.

## 2.10 Taxonomy of Inventory Models

There is enormous amount of scientific literature available on inventory models. It is difficult to compile and present all these models in a single treatise. However, a structured portrayal of the taxonomy of these models gives a very good overview of the plethora of inventory models available on scientific inventory management. Figure 2.5 depicts such a taxonomy in a treelike structure. These models can be broadly classified as single purchase decisions (static) models or repetitive purchase (dynamic) models; other major grouping could be “deterministic” inventory models vs. probabilistic inventory models. Further branching can be done on the basis of number of items (single vs. multiple), number of sources of supply (single vs. multiple), number of echelons (single vs. multi-echelon) and other situational variables such as quantity discounts, budget constraints, etc.

In this book, we will attempt to discuss some of these inventory models, but an exhaustive coverage is neither possible nor desirable in a single book on inventory control. Unfortunately, particularly in developing economies, these models are not

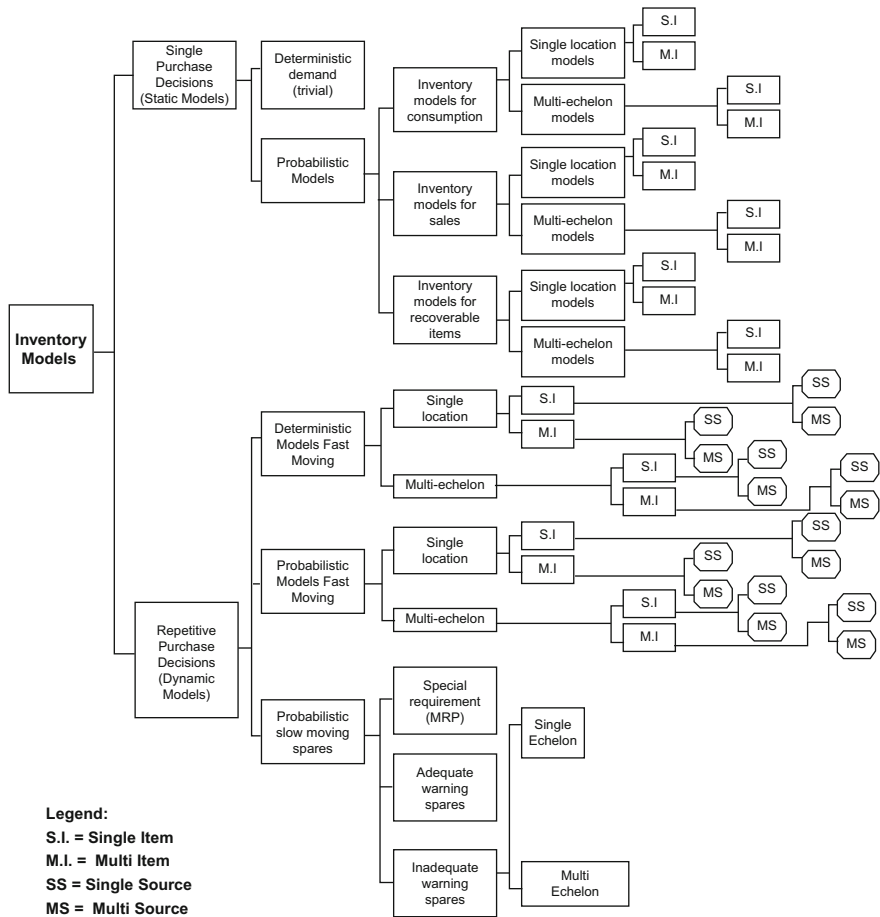


Fig. 2.5 Taxonomy of inventory models

frequently used, and paradoxically, a huge number of inventory models in research literature remain itself as inventory (a usable but idle resource) due to non-implementation of these.

## 2.11 Summary and Concluding Remarks

In this chapter, the concept of inventory is discussed which is central to materials management function. The definition of inventory as a “usable but idle” resource is highlighted, and various types of inventories – raw materials, finished goods, in-process inventory, MRO inventory, etc. – are outlined. The need to keep inventory is detailed, and function of inventory as a decoupling agent is illustrated through a mechanical analogy. Inventories enable various subsystems in a supply

chain to be decoupled to a certain extent as a dashpot or a shock absorber decouples two mechanical subsystems. The inventory-related cost parameters are listed along with methods of estimating these. Other situational parameters like demand and lead times also need to be estimated. Before an inventory model is employed for optimal operation of the inventory system, an appropriate inventory policy has to be selected. Three types of inventory policies are described, and their relative strengths and weaknesses are discussed.

A taxonomy of inventory models is presented to give an overview of plethora of inventory models available in inventory management literature. Some of these will be discussed in detail in the subsequent chapters. However, the right choice of the inventory model is crucial for the success of inventory management. Selective inventory management is necessary because indiscriminate rigor in inventory control for all items could be counterproductive. The next chapter focuses on these issues.

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## 2.12 Conceptual Questions

1. Why is inventory a “necessary evil” with uncertain demand and lead time situations?
2. What are the different kinds of inventories?
3. How does inventory decouple various subsystems in a supply chain?
4. What cost factors influence cost of carrying cost? If the item is perishable in nature, what influence will it have on estimating the inventory carrying cost?
5. Why is it more difficult to estimate shortages cost in an inventory system? What aspects are necessary to be captured in such a cost estimation?
6. How does e-procurement and process simplification impact the cost of ordering?
7. What is an inventory model? Which decisions are facilitated by an inventory model?
8. Describe three types of inventory policies and compare their strengths and weaknesses.
9. What is JIT? Is JIT realizable in a chaotic supply environment?
10. What are major situational parameters that need to be estimated for the development of inventory models?

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## 2.13 Case Study

After completing MBA degree from a reputed business school, Rajeev was hired as a consultant to find out how the performance of a company, typically conservative in its management approach, could improve in the emerging competition in the market. The company, family owned, had been in business for 60 years and grew slowly to reach the current level of 500 employees. The company was manufacturing control system devices for process industry and was unmindful of

the role materials planning could play in enhancing performance. However, faced by tough competition, they hired Rajeev for suggesting strategic interventions to ensure that this company – Durga Enterprises – survives in the market.

While pursuing his MBA course, Rajeev had learnt that successful companies have very high inventory turnover ratio as compared to the unsuccessful companies. He had read a research paper which opined that “if unsuccessful companies improved their inventory management performance at par with the successful ones, they could double their sales with no extra inventory on hand or reduce inventory by 50 % for the same level of sales turnover.”

Rajeev started studying the present system of materials planning in Durga Enterprises and was informed that right now no formal system of inventory planning exists. Top management commitment was to give some overall inventory budget limits, arbitrarily set either in terms of number of days of consumption in stock or overall financial limit on stock held.

Durga Enterprises product mix contained 70 items and large product variety. It was found that no effort on standardization was made. There were no cost estimates available for holding inventory or procurement order processing. Shortage was expected to be avoided, but no costs were imputed to it. As a consultant, Rajeev studied the current practice and soon realized that there were no efforts made to forecast the demand of the products or components. The company has a purchase manager who will buy exactly as per the number required in the manufacturing order. As per the process sheet, the materials received, after checking, were sent to the store or shop floor and in case of bought-out parts directly to assembly stage.

The company did not maintain data for stock on hand or frequency of shortages. Many times sales were lost to the competitors due to nonavailability of finished stock when required, and at the same time inventory levels were high for some other parts, materials, and components. There was no formal production planning and inventory control function. Order quantity was based on gut feel and previous experience, with some informal consultation with the shop floor engineers.

Rajeev’s assignment to suggest improvements in the material planning function was triggered off due to conflict of opinion among the executives of Durga Enterprises. While many were satisfied with business-as-usual scenario of functioning, some senior executives were concerned about the current situation where shortages and excess inventory situations are being encountered quite frequently due to the lack of a formal system of inventory control. Initial meetings of the consultant with the executives revealed that orders were lost and purchase was not efficient or using economy of scale. Lead times were not known, and a lot of follow-up was needed to get some urgently required parts and materials. There were also allegations of pilferage wastages, excess freight charges, and shortage of some badly needed materials. Fifteen percent of total cost was estimated to go for transportation of materials. However, others felt that there was “no problem” with the present system of procurement, storage, and issue of materials and some customer losses are inevitable because “you cannot satisfy everyone.”

1. As a consultant, how should your study begin? Will a SWOT analysis of the situation help to give you future lead?
2. How will you establish needed cost data for inventory-related cost parameters? Should these cost data be very accurate?
3. Would you recommend same inventory policy and frequency of orders for all items in the entire item ranges?
4. How will you convince the executives opposing the idea of formal systems of inventory control to change their stand? How will the company benefit from scientific management of materials?
5. How will you benchmark the inventory turnover ratio of Durga Enterprises with a similar nature of business to estimate the quantum of potential improvements, if things are “streamlined”?

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## References

- Fabrycky WJ, Banks J (1967) *Procurement and inventory systems: theory and analysis*. Reinhold Publishing Corporation, New York
- Hollier RH, Vrat P (1978) A proposal for classification of inventory systems. *Omega* 6(3):277–279
- Love S (1979) *Inventory control*. McGraw Hill Book Company, New York
- Naddor E (1966) *Inventory systems*. Wiley, New York
- Starr MK, Miller JW (1975) *Inventory control: theory and practice*. Prentice Hall of India, New Delhi
- Vrat P (2011) Inventory models and human body food supply chain: some managerial insights. *Ind Eng J* II(27):8–16



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