CHAPTER 13
INVENTORY MANAGEMENT

KEY IDEAS

1. **Purpose of Inventory.** Inventories are held for a variety of reasons, such as meeting anticipated demand, smoothing production, decoupling internal operations, protecting against stockouts, taking advantage of quantity discounts, and hedging against price increases.

2. **Requirements for Inventory Management.** The requirements for effective inventory management are an accounting system to keep track of on-hand and on-order merchandise, reliable forecasting of demand, estimates of lead times between placing an order and receiving goods, and lead-time variability, estimates of inventory holding costs, ordering costs and shortage (backorder) costs, and a classification system.

3. **A-B-C Classification.** The A-B-C approach can be used to classify inventory items according to some measure of importance. Very often that measure is annual dollar volume, which is the product of unit cost for an item and its annual demand or usage. After determining each item’s annual dollar volume, the resulting values are arrayed from high to low. Generally there will be a small percentage of items (10% to 15%) with relatively high annual volumes. These should be classified as A items, and given disproportionately high attention by management. At the other end of the scale will be a large percentage of items (around 50% to 60%) that have relatively low annual volume. These should be classified as C items and given disproportionately low attention by management. The middle group in terms of annual volume (25% to 40%) should be classified as B items and given moderate attention by management. Once the allocation has been made, a prudent manager will review the grouping and may adjust the placement of some items on the basis of other information not reflected in annual dollar volume.

4. **Various EOQ Models.** The question of how much to order is often answered using some form of an Economic Order Quantity (EOQ) model. The fundamental versions of the deterministic EOQ model include:
   a. EOQ for purchased end items or semi-finished goods acquired from outside vendors.
   b. Economic Production Quantity (EPQ) for internal production orders in batch processing and non-instantaneous replacement.
   c. EOQ for quantity discounts.

   In versions a and b the order quantity is set at a level such that total holding costs = total ordering costs; the cost of the unit is considered indirectly, but only insofar as it is used to calculate holding cost. However, in version c, the EOQ is a quantity that minimizes the sum of three costs: acquisition, holding, and ordering costs.

5. **Reorder Points (ROP).** An EOQ model tells you how much to order, but it does not say when to place an order. With uncertainties in delivery schedules and usage rates, there is no guarantee that there will always be material in stock to service production operations. This is where reorder point (ROP) models come into the picture. There are four versions of ROP:
   a. constant demand rate and lead time
   b. variable demand, constant lead time
   c. constant demand, variable lead time
   d. variable demand and variable lead time

   The demand rate is the usage or sales per day. The lead time is length of time between placing the order and receiving the goods. The approach to the constant demand, constant lead time case is simple: place the order when the stock gets to a level such that what is in stock now will all be used up when the new shipment arrives. The other three ROP models, however, add realism by
introducing uncertainty into one or both of the elements that determine demand during lead time, and allowing the decision maker to set a safety stock as a buffer against that uncertainty. The size of this safety stock depends upon whether the uncertainty is in the demand rate, the lead time, or both, and how much risk of a stockout the decision maker finds acceptable. In all three models involving uncertainty, the fundamental relationship is:

\[ \text{ROP} = \text{Expected demand during lead time} + \text{Safety stock}. \]

6. **Service Level.** The size of the safety stock is determined by the order cycle service level, or the probability of not experiencing a stockout. Restated: Service level = 1.00 – Stockout risk.

7. **Assumptions of ROP Models.** There are two fundamental assumptions of ROP models with uncertainty: daily demands during lead time are independent, and daily demand rates and/or the length of order lead time, if variable, are normally distributed.

8. **Service Level versus Shortages.** While the order cycle service level model discussed previously can express what the probability of a shortage (the stockout risk), it does not express by how much the system can expect to be short.

Table 12-3 gives the unit normal loss function, \( E(z) \), associated with both the corresponding \( z \)-value and the lead time service level (LTSL). For a normally distributed lead-time demand, \( E(z) \) is a scale factor that is multiplied by \( \sigma_{dLT} \) to calculate the expected shortage in lead time, \( E(n) \).

The expected annual shortage, \( E(N) \), is the product of \( E(n) \) and the number of cycles in a year, \( D/Q \).

Since \( E(N) = (1 - SL_{annual})D \)

\[ SL_{annual} = 1 - E(N)/D \]

\[ SL_{annual} = 1 - E(n)/Q \]

\[ SL_{annual} = 1 - (E(z) * \sigma_{dLT}/Q) \]

9. **Fixed Order Interval Model.** When ordering is constrained to fixed times, the fixed-order-interval model applies. With the fixed-order-interval model, the safety stock is greater than with the other models, because the ordering is done at fixed time intervals regardless of the stock level.

10. **Single-period Inventory Model.** The single-period model is appropriate for cases in which one order is to be placed that is intended to satisfy demand for an entire period. The period can be a day, week, or other interval. Often, the items involved are perishable (e.g., fresh seafood), or otherwise have a limited shelf life (e.g., daily newspapers). Other examples include spare parts for equipment and inventories of rental equipment. Regardless of the application, the single-period model involves computation of a theoretical service level, which is the ratio of unit shortage cost to the sum of unit shortage and excess costs.