MODULE

III

Inventory Management Tools and Techniques

Learning Objectives

After completing this module, you will be able to

- List and describe tools and techniques of inventory management
- Understand the steps in calculating the standard deviation of the forecast error
- Write the formula for economic order quantity (EOQ)

FORECASTING AND DETERMINING INVENTORY LEVELS

In this module, various tools and techniques will be reviewed for determining the appropriate levels of inventory to buffer against fluctuations in demand and supply.

Forecasting is critical to estimating future demand. This estimate may be developed by using mathematical formulas, data from informal sources or a combination of both. Forecasting is key to all aspects of a successful business-planning system. As customers place more demands and require faster deliveries, the ability to forecast as accurately as possible is essential.

For forecasts to be usable, they must be based on timely data gathered in a consistent manner. A good forecasting process must include

- The use of forecasting tools e.g., using historical results to predict future sales
- The creation and collection of information
- The management of this information
- The making of well-informed decisions about what you need to produce

Forecasting is meaningful only if it helps to

- Improve customer service
- Reduce inventory
- Increase productivity
- Improve the deliveries from suppliers

Every good forecast includes an estimate of the forecast error. The forecast error is the difference between what you thought you were going to ship and what you actually shipped. In order to improve sales forecasts, you will first need to calculate the forecast error (actual sales minus forecasted sales equals forecast error). The larger the forecast error, the higher the level of inventory needed to satisfy customers.

Storage Costs

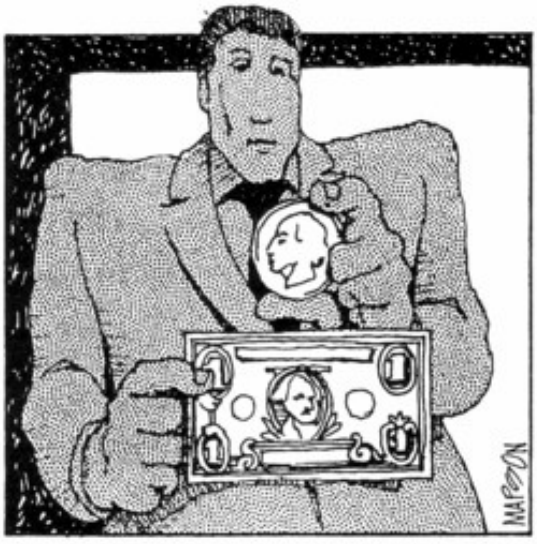
- Utilities
- Warehouse/stockroom personnel
- Maintenance of building and equipment
- Warehouse security

Stockout Costs

- Expediting costs
- Freight premiums
- Back-order processing
- Difficult to determine because of intangible costs such as lost sales and customer goodwill

Transportation Costs

- Inventory tied up in transit
- Spoilage
- Damage
- Insurance
- Theft
- Handling



LOT SIZE AND SAFETY STOCK

Once the levels of inventory are determined, the next step is to calculate in what quantities the inventory will be replaced. This is called lot sizing. The lot size is the amount of material to be ordered from a supplier or produced internally to meet demand.

There are nine major types of lot-size methods, which fit into the following two categories:

- **Demand-based methods (static):** Order quantities are kept constant.
  - Fixed order quantity: min/max
  - Economic order quantity (EOQ): is calculated periodically and used as fixed order quantity during interim
- **Discrete method (dynamic):** Order quantities vary.
  - Period order quantity
  - Lot-for-lot
  - Periods of supply
  - Least unit cost
  - Least total cost
  - Part-period balancing
  - Wagner-Whitin algorithm

Selecting the appropriate mix of lot-sizing methods will help to reduce ordering, setup and carrying costs, as well as reduce the overall levels of work-in-process inventory.

Each type of lot sizing methods will be reviewed using the information on page 41.

Lot Sizing Examples

All examples use the same set of forecast requirements:

- Starting inventory = 800 units
- Order cost = $20
- Item cost = $2.50
- Annual carrying cost = 22%

Fixed Order Quantity

Fixed order quantity method will always suggest planned orders be released for a predetermined fixed quantity. The predetermined quantity can be established based on experience and/or the use of the economic order quantity technique. In the example below, the fixed order quantity is 300. (The actual MRP logic is explained in Module VI under MRP/DRP.) The reader, if unfamiliar with MRP logic, should read pages 97–101.

Fixed Order Quantity

Safety stock = 40
Order quantity = 300
Lead time = 2

		Periods					
		1	2	3	4	5	6
Forecast demand		380	320	300	200	230	320
Scheduled receipts							
Projected available	800	420	100	100	200	270	250
Net requirements				–200	–100	–30	–50
Planned order receipts				300	300	300	300
Planned order releases		300	300	300	300		

LOT SIZE AND SAFETY STOCK (continued)

Economic Order Quantity

The economic order quantity (EOQ) is the other type of demand-based or static formula. This calculation establishes the amount to be purchased or manufactured by determining the minimal cost of purchasing or building with the cost to carry the inventory.

The formula may be used to determine the minimum units to be purchased or built, or the minimum cost in dollars. Following are the two variations of this formula.

The EOQ Formula (Units and Dollars)

1. Units: $EOQ = \sqrt{\frac{2US}{IC}}$

where
- U = Annual usage in units
- S = Setup or ordering costs
- I = Inventory carrying cost
- C = Unit Cost

2. Dollars: $EOQ\$ = \sqrt{\frac{2AS}{I}}$

where
- A = Annual usage in dollars
- S = Setup or ordering cost
- I = Inventory carrying cost

Economic Order Quantity

Annual usage = 3480
Order quantity = 500
Lead time = 2

		Periods					
		1	**2**	**3**	**4**	**5**	**6**
Forecast demand		380	320	300	200	220	320
Scheduled receipts							
Projected available	800	520	200	400	200	480	160
Net requirements				–100		–20	
Planned order receipts				500		500	
Planned order releases		500		500			

$A = 290 \times 12 = 3480$ EOQ =

$$\sqrt{\frac{2US}{CI}} = \sqrt{\frac{2 \times 3480 \times 20}{2.50 \times .22}} = \sqrt{253,091} = 503 \text{ (rounded to 500)}$$

The next six lot-sizing techniques are called discrete or dynamic lot-sizing techniques, because the lot sizes (quantity to be ordered) will vary.

LOT SIZE AND SAFETY STOCK (continued)

Period Order Quantity

Period order quantity is a lot-sizing technique in which the lot size is equal to the requirements for a given number of periods into the future. In the example below the number, of periods is determined to be 4.

Period Order Quantity

Order quantity = 630
Lead time = 2

		Periods					
		1	2	3	4	5	6
Forecast demand		130	160	120	260	130	120
Scheduled receipts							
Projected available	370	240	80	590	330	200	80
Net requirements				–40			
Planned order receipts				630			
Planned order releases		630					

$$POQ = \frac{EOQ}{\text{Average Period Usage}} = \frac{648}{162} = 4 = \begin{matrix}\text{Number}\\ \text{of future}\\ \text{periods}\\ \text{covered}\end{matrix}$$

The period order quantity is similar to the period of supply, except the order cycle is based on the EOQ calculation. The order frequency as well as the order quantities are scheduled using this method. The lot size of 630 covers four periods (period 3, 120 + period 4, 260 + period 5, 130 + period 6, 120 = 630).

Lot-for-Lot

This is an MRP lot-sizing technique commonly used in Just-in-Time (JIT) situations, in conjunction with safety stock. In this method, the planned orders are generated equal to the net requirements in each period. The safety stock level is determined by the standard deviation discussed earlier or is based on experience or trial and error.

Lot-for-Lot

Safety stock = 40
Order quantity = L4L
Lead time = 2

		Periods					
		1	2	3	4	5	6
Forecast demand		380	320	300	200	230	320
Scheduled receipts		380	320				
Projected available	40	40	40	40	40	40	40
Net requirements				–300	–200	–230	–320
Planned order receipts				300	200	230	320
Planned order releases		300	200	230	320		

Note that the lot-size quantity matches the amount required to meet the demand and cover the safety stock quantities.

LOT SIZE AND SAFETY STOCK (continued)

Periods of Supply

This method simply establishes—primarily through experience—an order quantity that will cover a predetermined period of time. In the example below it is for three periods.

Periods of Supply

Safety stock = 40
Order quantity = POS = 3
Lead time = 2

		Periods				
		1	2	3	4	5
Forecast demand		380	320	300	200	220
Scheduled receipts						
Projected available	740	360	40	470	270	50
Net requirements				–300		
Planned order receipts				720		
Planned order releases		720				

Note that the 730 will cover the demand for periods three, four, and five (300 + 200 + 220 = 720). The only difference between this method and period order quantity is that this method uses experience rather than the EOQ formula.

Least Unit Cost

The least unit cost method adds ordering cost and inventory-carrying cost for each trial lot size and divides by the number of units in the lot size. The lot size with the lowest unit cost is chosen.

Least Total Cost

The least total cost lot-sizing technique calculates the order quantity by comparing the set (or ordering) costs and the carrying costs for various lot sizes, and selects the lot size where these costs are most nearly equal.

Part-Period Balancing

This technique is similar to the least total cost method. However, this method employs a routine called look ahead/look back. When the look ahead/look back feature is used, a lot quantity is calculated, and before it is firmed up, the next or previous period is reviewed to determine whether it would be economical to include either in the current lot.

Wagner-Whitin Algorithm

The final method is the Wagner-Whitin algorithm. This is a very complex method that evaluates all possible ways to cover the requirements in each period of the planning horizon.

EXERCISE 1: Calculations

Complete the following calculations. See pages 112–113 in the back of the book for the correct answers.

1. Determine the following order quantities, based on dollars and units.

EOQ Example

U = Annual usage in units = 5,500

A = Annual usage in dollars = $60,000

S = Setup cost/ordering cost = $100

I = Inventory carrying cost = $0.20

C = Unit cost = $10

A. Dollars

Dollars: $EOQ\$ = \sqrt{\frac{2AS}{I}}$

where: A = Annual usage in dollars
B = Setup or ordering cost
I = Inventory carrying cost

B. Units

Units: $EOQ = \sqrt{\frac{2US}{IC}}$

where: U = Annual usage in units
S = Setup or ordering cost
I = Inventory carrying cost
C = Unit Cost

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$$\text{Dollars: EOQ\$} = \sqrt{\frac{2AS}{I}}$$

where: A = Annual usage in dollars
B = Setup or ordering cost
I = Inventory carrying cost

B. Units

$$\text{Units: EOQ} = \sqrt{\frac{2US}{IC}}$$

where: U = Annual usage in units
S = Setup or ordering cost
I = Inventory carrying cost
C = Unit Cost

2. Calculate the standard deviation of the forecast error and mean absolute deviation (MAD). Complete the tables below with your calculations.

Time Period	Forecast	Sales	Forecast Error	Forecast Error^2
1	500	600		
2	500	500		
3	500	400		
4	500	450		
5	500	700		
6	500	600		
7	500	550		
8	500	500		
9	500	350		
10	500	450		
Total	5,000	5,100		

A. Calculate the standard deviation forecast error.

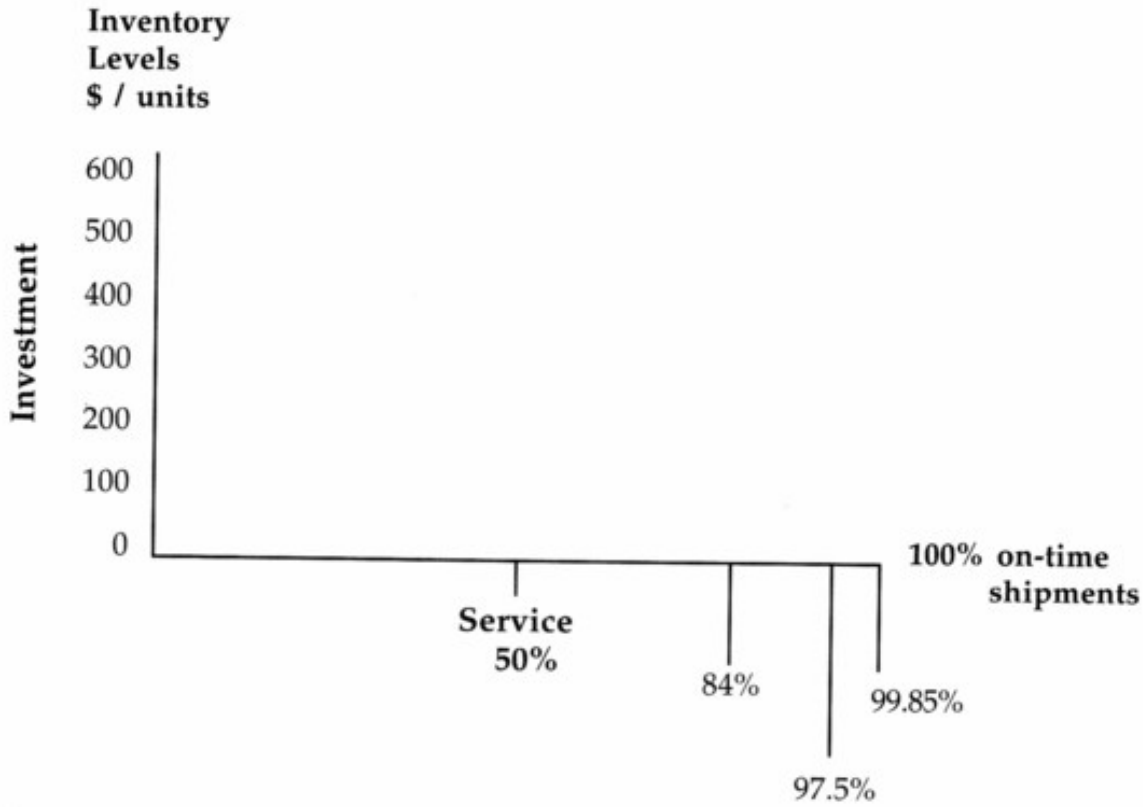
B. Calculate the mean absolute deviation (MAD).

EXERCISE 2: Fill In the Blanks

Part A: *Using the Customer Service Level Table below, plot the amount of inventory that will be needed to provide various levels of on-time shipments. Complete the chart below, which reinforces this concept. See page 113 in the back of the book for the correct answer.*

Standard Deviation	Mean Absolute Deviation	Customer Service Level
0.00	0.00	.50
1.00	1.25	.84
2.00	2.50	.975
3.00	3.75	.9985

Customer Service Level Table



Part B: How much inventory would be needed to cover six standard deviations, which would give a customer service level of as close to 100 percent as possible? _____

Remember, these inventory levels represent one positive deviation.

If you don't like the answer, try improving your forecast model.

EXERCISE 3: Choose the Correct Answer

Answer the following questions. See page 113 in the back of the book for the correct answers.

1. MAD is

A. Mean absolute deviation
B. Not as precise as the standard deviation
C. Easier to calculate than standard deviation
D. All of the above

2. Using the following customer service level table, and assuming the standard deviation was 200 and MAD was 160, determine the inventory level of three positive deviations.

Inventory Level (units)	Standard Deviation	Mean Absolute Deviation	Customer Service Level
0	0.00	0.00	.50
200	1.00	1.25	.84
400	2.00	2.50	.975
600	3.00	3.75	.9985

A. 3 positive standard deviations equal 600
B. An inventory level of 200 equal a MAD factor of 1.25
C. One positive standard deviation equals 1.25 MAD
D. All of the above

3. All of the following are types of lot-sizing techniques *except*

A. Least unit cost
B. Least cost
C. Part period balancing
D. EOQ

EXERCISE 3 (continued)

4. Which of the following are included in storage costs?

A. Utilities
B. Warehouse/stockroom personnel
C. Warehouse security
D. All of the above

5. All of the following are included in stockout costs *except*

A. Expediting cost
B. Back orders
C. Interest expense
D. Freight premiums