Determining How Much of an Item to Order
By Jon Schreibfeder

There are two questions buyers must consider when reordering products:

- When to reorder a product
- How much of a product to reorder when the product is reordered

When to reorder a product was discussed in module #4. Placing replenishment orders at the right time helps prevent stockouts. How much of an item to order is discussed in this module. This decision plays a big part in determining the profitability associated with sales of the item.

You buy an item for $1.00 and sell it for $2.00. You made a 100% profit….. well, not exactly. Despite what your salespeople may truly believe in their hearts, a distributor incurs costs other than what they pay the vendor when buying and maintaining a product for stocked inventory. These costs can be divided into two categories: the cost of ordering the material and the cost of carrying and maintaining the inventory in the company's warehouse. If you add these costs to the amount paid to the vendor (the "incoming cost"), you get the total cost for the material:

Incoming Cost (what you pay the vendor)
+ Cost of Ordering
+ Carrying Cost

Total Cost of Inventory

The incoming cost is the replacement or "landed" cost per piece. It includes all costs directly related to a specific replenishment shipment (including freight, inspection, repackaging, etc.).

The Cost of Ordering Inventory

The cost of ordering, also known as the "R" or replenishment cost, includes all the expenses involved in issuing, processing and receiving a replenishment order. These costs include the time and materials spent:

- Deciding what products need to be replenished
- Issuing the purchase order
- Expediting the purchase order (if necessary)
- Processing the receiving paperwork for the shipment
- Approving the vendor's invoice for payment
- Processing the vendor payment

The cost of ordering is expressed as the amount (e.g., in dollars or euros) necessary to process *a line item* on a purchase order. This is based on the idea that you spend about the same amount of

time reordering a product regardless of the quantity ordered. But processing a purchase order with 100 line items will usually take more time than processing a five line purchase order.

The cost of ordering is calculated by dividing the total annual cost of ordering stocked products by the total number of purchase order line items for stocked products issued in the past 12 months:

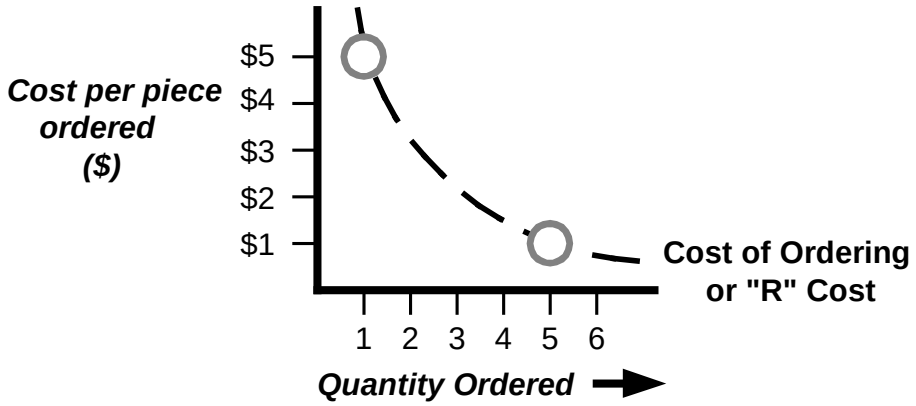
$$\frac{\textbf{Total Annual Cost of Ordering Activities for Stocked Products}}{\textbf{Number of Purchase Order Line Items Issued for Stocked Products in the Past 12 Months}}$$

For example, if the annual cost of all ordering activities is $125,000 and a total of 25,000 stocked line items were listed on purchase orders issued during the last 12 months, the cost of ordering each line item would be:

$$\frac{\textbf{Total Annual Cost of Replenishment Activities}}{\textbf{Purchase Order Line Items Issued (12 Months)}} = \frac{\textbf{\$125,000}}{\textbf{25,000}} = \textbf{\$5 per line item}$$

For most distributors, the cost of ordering is currently between $5.00 and $8.00 (US) for each purchase order line item. A questionnaire for calculating the R cost for your organization is available in the resource section of the Effective Inventory Management web site (www.effectiveinventory.com).

Again, notice that the cost of ordering is expressed *per purchase order line item*. It is not the cost of issuing an entire purchase order or the cost of obtaining a single piece of a product. If you order one piece or one hundred pieces of an item on a single line of a purchase order, the cost of ordering is the same. But, the larger the purchase quantity, the lower the cost of ordering *per piece.* If only one piece is ordered, that piece must absorb the entire ordering cost. If two pieces are ordered, each piece absorbs half the cost of ordering. If 1,000 pieces are ordered, each piece absorbs 1/1000 of the ordering cost. The following graph illustrates how the cost of ordering, per piece, decreases as the quantity purchased increases:



If one piece is ordered, the cost of ordering per piece is five dollars. If five pieces are ordered, the ordering cost drops to one dollar per piece. The greater the quantity purchased on a replenishment order, the lower the ordering cost per piece,

The Inventory Carrying Cost

The third element in the total cost of inventory is the carrying cost. The inventory carrying cost, also known as the "K" cost, is accumulation of all the expenses incurred maintaining stocked inventory in your warehouse. Elements of the inventory carrying cost include:

- Moving material from receiving to its proper bin location and shifting it to other warehouse locations as necessary
- Insurance on inventory and inventory taxes (if applicable)
- Rent and utilities for the portion of your warehouse used to store material
- Physical inventory and cycle counting
- Inventory shrinkage and obsolescence
- Opportunity cost of the money invested in inventory. That is, how much could you make if the money tied up in inventory was invested in a relatively safe, income producing investment.

The cost of carrying inventory grows as the investment increases. The more you buy, the longer it takes to sell the shipment. While part of the shipment remains in your warehouse it is "absorbing" the elements of the carrying cost like a sponge. Your money is tied up, you have to count it, it is taking up space, it is subject to shrinkage and obsolescence, etc.

Because of the direct relationship between the total value of inventory and the cost of maintaining that warehouse stock, the inventory carrying cost is expressed as a percentage of the average value of stocked inventory. Typically, the annual inventory carrying cost will be between 14% and 24% of the average value of stocked inventory. That means that it usually costs between 14 cents and 24 cents to maintain a dollar's worth of inventory in a warehouse for an entire year. For example, if a distributor has an average inventory investment of $1,000,000, the annual carrying cost will be between $140,000 and $240,000. A questionnaire for calculating the K cost for your organization is available in the resource section of the Effective Inventory Management web site (www.effectiveinventory.com).

The following illustration adds the inventory carrying cost to the graph of the cost of ordering:

Don't misread the graph. Ordering one piece will not result in a carrying cost of one dollar. Carrying costs are calculated on the *average* value of stocked inventory.

The Total Cost of Inventory

If you add the amount paid for the material (including freight, if applicable) to the cost of ordering and carrying cost, the result is the total cost for the material:

Notice that the quantity associated with the lowest total cost (i.e., where the total cost curve is at its lowest point) is the same quantity associated with the intersection of the carrying cost and cost of ordering curves.

The EOQ Formula

It is not necessary to develop a graph to derive the economic order quantity for each item. The EOQ formula calculates the purchase quantity that results in the lowest total cost:

$$\sqrt{\frac{24 * \text{COST OF REORDERING (R)} * \text{FORECAST DEMAND}}{\text{COST OF CARRYING INVENTORY (K)} * \text{UNIT COST}}}$$

In the formula, the "24" in the numerator is a constant value; it won't ever change. The cost of reordering and the cost of carrying inventory are previously described. The forecast demand is the prediction of what you will sell or use this month or in a future month. Forecast demand is discussed in module #3 of this series. The unit cost is the replacement or landed cost per piece.

Working with the EOQ Formula

Let's look at several examples of how recommended purchase quantities are calculated using the economic order quantity formula:

Example #1: Product A120

Forecast Demand	=	25 pieces per month
Unit Cost	=	$10.00
Cost of Ordering	=	$ 5.00
Carrying Cost	=	20%

$$\sqrt{\frac{24 * \$5.00 * 25}{.20 * \$10.00}}$$

$$\sqrt{\frac{3000}{2.0}}$$

$$\sqrt{1{,}500}$$

EOQ = 38.7 (rounded to 39 pieces)

The economic order quantity is suggesting that when stock of item #A120 is replenished, you order 39 pieces. As the demand forecast for the product is 25 pieces per month (or 0.83 pieces per day), this order quantity represents about a 47 day supply (39 ÷ 0.83 = 47 day supply).

The economic order quantity will vary depending on the total cost of the product passing through inventory each month. This value can be calculated by multiplying the demand forecast by the unit cost. In the example above, $250 (25 pieces * $10 cost) pass through inventory each month. The higher the value of product passing through inventory, the smaller the economic order quantity (in terms of day's or week's supply) of the product.

Let's look at another example. Here the unit cost is $50.00, much higher than the $10.00 used in the first example:

Example 2: #B240

Forecast Demand	=	25 pieces per month
Unit Cost	=	$50.00
Cost of Ordering	=	$ 5.00
Carrying Cost	=	20%

$$\sqrt{\frac{24 * \$5.00 * 25}{.20 * \$50.00}}$$

$$\sqrt{\frac{3000}{10}}$$

$$\sqrt{300}$$

EOQ = 17.3 (rounded to 17 pieces)

The economic order quantity suggests that when you replenish stock of product #B240, you order 17 pieces or about a 20 day supply (17 pieces ÷ 0.83 pieces/day = 20 day supply). This is less than one half of the 47 day supply the EOQ suggested for the first item. Why? Well, while $250 of the first item passes through inventory each month, $1,250 of second item is sold, transferred or used internally. Remember, THE GREATER THE NUMBER OF DOLLARS OF A PRODUCT PASSING THROUGH INVENTORY, THE SMALLER THE ECONOMIC ORDER QUANTITY. That is, in terms of day's or week's supply of the product.

You may be confused. Isn't it common sense to buy a lot of what sells? Let's look at it from another angle. The EOQ suggests that a distributor should order less of a fast-moving product, more often. Remember that you invest in inventory and expect to earn a return on your investment. Every time you sell a product, you (hopefully) get back what you paid the vendor and earn a profit. If you buy a dollar of inventory from a vendor and then sell it, you have "turned" that dollar once. That is, the dollar's back in your bank account (hopefully accompanied by a profit) and can be used again. If you buy more inventory with that dollar and then sell it, you've turned that dollar again. Every time you "turn" a dollar, you have an opportunity to earn a profit. Those profits are used to pay salaries, other expenses, and hopefully provide a return on investment to the owners.

Perhaps a distributor's goal is to turn their inventory over six to eight times a year. This means that $1,000,000 dollars of stocked inventory should generate between $6,000,000 and $8,000,000 dollars in sales (at cost). But almost every organization has products that are sold or used only once a year, or may not sell at all. Inventory for these slow-moving products may turn once annually, or not turn at all. Popular, fast moving, inventory items must turn more than eight times a year to make up for the slow-moving inventory. If you order a two-week supply of a popular product when it is time to replenish stock, you will turn the inventory of that product up to 26 times a year (depending on the amount of safety stock maintained to protect customer service)!

Notice that the economic order quantity is concerned with the total cost of goods sold of a product passing through your warehouse, not the unit cost of each piece. In the next example, the product has a very low unit cost, but very high monthly demand:

Forecast Demand = 2,500 pieces per month
Unit Cost = $0.10
Cost of Ordering = $ 5.00
Carrying Cost = 20%

$$\sqrt{\frac{24 * \$5.00 * 2500}{.20 * \$0.10}}$$

$$\sqrt{\frac{300,000}{.02}}$$

$$\sqrt{15,000,000}$$

EOQ = 3,873

Demand of 2500 pieces per month is about 83 pieces per day. Despite the fact that the unit cost of the item is only 10 cents, the EOQ formula suggests that you order a 47 day supply of the item ($2500 ÷ 83 pieces/day = 47 day supply). This is because $250 of the item passes through inventory each month. The results are like those in the first example in which the product had identical total dollar movement.

What will the EOQ formula suggest for an item that is slow moving and inexpensive? Let's look at an item that has a unit cost of 10 cents but monthly demand of only 25 pieces per month:

Forecast Demand = 25 pieces per month
Unit Cost = $0.10
Cost of Ordering = $ 5.00
Carrying Cost = 20%

$$\sqrt{\frac{24 * \$5.00 * 25}{.20 * \$0.10}}$$

$$\sqrt{\frac{3000}{.02}}$$

$$\sqrt{150,000}$$

EOQ = 387.3 (rounded to 387 pieces)

An economic order quantity of 387 pieces is greater than a 15 month supply (387 ÷ 25 per month). More than a year's worth of a product! Who would ever buy that much of one item? Keep in mind that your cost of one year's worth of the product is $30.00. This amount is

calculated by multiplying 12 (months) times 25 (monthly demand) times 10 cents (the unit cost). This small investment for a year's worth of the product makes sense, considering the cost of ordering the product is about $5 every time it appears on a purchase order.

Limits of the Economic Order Quantity Formula

The economic order quantity is a mathematical equation. It will always provide the replenishment quantity that provides the lowest total cost. But sometimes the result is not a practical stocking quantity. For this reason, many distributors apply the following limits to the results of the EOQ formula:

* REDUCE THE EOQ QUANTITY, IF NECESSARY, TO EQUAL A MAXIMUM OF "X" TIMES THE DEMAND FORCAST. In the last example, the calculated economic order quantity was greater than one year's supply of the product. This assumes that demand, unit cost, the reordering cost, and carrying cost will remain constant for the entire year. While the reordering cost and carrying cost change infrequently, the forecast and the unit cost of many items will fluctuate on a regular basis. And it is an unfortunate fact that inventory shrinkage (loss, theft, breakage, etc.) and obsolescence increase dramatically when inventory remains in a warehouse for an extended period of time. For this reason, best practice is to put an upper limit on the replenishment quantity. Most companies will limit the economic order quantity to equal a three to six-month supply of a product.

* THE EOQ WILL BE INCREASED, IF NECESSARY, TO EQUAL DEMAND DURING THE UPCOMING ORDER CYCLE. The order cycle is the amount of time necessary to build a target order with the vendor. If you order a vendor line once a month, you want to order at least enough of a product to meet your needs until you can place another order with the vendor. That is, you don't want to order a one-week supply of an item in that vendor line just once a month.

* LIMIT THE EOQ TO THE SHELF LIFE OF THE ITEM. If a product has a shelf life of three months, you never want to order a six-month supply, regardless of the results of the EOQ formula. Most companies specify a shelf life in their computer equal to half the actual shelf life of the product. After all, very few people want to buy a product the day before its expiration date.

* LIMIT THE EOQ TO AVAILABLE STORAGE SPACE. This is particularly true for large, bulky items or material that needs to be stored in a special environment. You don't want to order a two-month supply of an item if you only have available space for a one-month supply.

* ROUND THE EOQ TO THE NEAREST PACKAGE QUANTITY. If a product comes in a vendor package of 144 pieces, you probably cannot order an economic order quantity of 131 pieces or 165 pieces. The EOQ should be rounded to the nearest multiple of the vendor's standard package quantity. But, when a product needs to be replenished, at least one vendor package must be ordered, regardless of the EOQ quantity.

The EOQ modified by these limits is commonly referred to as the standard order quantity or SOQ.

Ordering to Minimize Your Total Inventory Investment

The EOQ is designed to maximize your organization's profitability by determining the lowest total cost of inventory. However, sometimes companies emphasize "cash flow management" over profitability. That is they are willing to sacrifice some profit dollars in order to invest smaller amounts in inventory.

If you find yourself in this situation, closely examine the EOQ quantities calculated by your computer system in terms of the day's supply of inventory it represents:

[EOQ ÷ (Monthly Forecast ÷ 30)]

The monthly forecast is divided by 30 to calculate an approximate forecast per day. For example:

EOQ = 60
Monthly Forecast = 45

[60 ÷ (45 ÷ 30)]
[60 ÷ 1.5/Day] = 40 Day Supply

A monthly forecast of 45 pieces is about 1.5 pieces per day. The EOQ of 60 represents a 40 day supply (60 pieces ÷ 1.5/day). Compare the results to the value of the product sold or used during the order cycle for vendor line. For example, you may receive shipments from the primary vendor for this line every 10 days. If you include this item on each order, you can order a ten day supply (10 Days * 1.5/Day = 15 pieces). Compare the value of the EOQ and order cycle replenishment quantities. This particular product costs $7.50 per piece:

EOQ Value = 60* $7.50 = $450
Order Cycle Qty Value = 10 * $7.50 = $75

This lower 10 day reorder quantity of this product results in buying $375 less inventory and would not affect either anticipated lead time usage or safety stock quantity. These are elements of the order point quantity which will ensure that you reorder the product at the "right" time in order to avoid a stockout. Replacing the EOQ with the order cycle quantity for many items can substantially reduce the amount of money you have to invest in inventory.

Though you will not be buying to achieve the lowest total cost for each piece of the product and maximize your profitability, buying just enough to last during the order cycle will reduce necessary cash outlays and increase your inventory turnover (i.e., your opportunities to earn a profit from every dollar of your average inventory investment). This may be just the remedy for a company having cash flow challenges.

Test Your Knowledge

1) What is the EOQ of an item with the following variables:

   Forecast = 90 per month (i.e., 3 pieces per day)
   K Cost = 18% per year
   R Cost = $6 per line item
   Unit Cost = $20 per piece

2) Using the data from question #1, if the carrying cost were raised to 20% would the EOQ increase or decrease? By how much?

3) Using the data from question #1. if the cost of reordering was reduced to $5 per line item would the EOQ increase or decrease? By how much?

4) If you could order from this vendor 12 times a year, how would the EOQ be adjusted?

Answers:

1) What is the EOQ of an item with the following variables:

Forecast = 90 per month (i.e., 3 pieces per day)
K Cost = 18% per year
R Cost = $6 per line item
Unit Cost = $20 per piece
EOQ = 60 pieces

$$\sqrt{\frac{24 * \$6 * 90}{.18 * 20}}$$

$$\sqrt{\frac{12960}{3.6}}$$

$$\sqrt{3600}$$

EOQ = 60 pieces

2) If the carrying cost were raised to 21% would the EOQ increase or decrease? By how much? Decrease to 57 pieces (it is more expensive to carry inventory)

$$\sqrt{\frac{24 * \$6 * 90}{.20 * 20}}$$

$$\sqrt{\frac{12960}{4.0}}$$

$$\sqrt{3240}$$

EOQ = 56.9 ≈ 57 pieces

3) If the cost of reordering was reduced to $5 per line item would the EOQ increase or decrease? By how much? Decrease to 55 pieces (it is less expensive to reorder products so you can do it more often)

$$\sqrt{\frac{24 * \$5 * 90}{.18 * 20}}$$

$$\sqrt{\frac{10800}{3.6}}$$

$$\sqrt{3000}$$

EOQ = 54.7 ≈ 55 pieces

4) If you could order from this vendor 12 times a year, how would the EOQ be adjusted?
Ordering 12 times a year equates to a 30 day order cycle. You would have to increase the quantity ordered to equal 90 pieces or a one month supply.