A MODERN VIEW OF inventory

How do you decide what level of stock is right for you?

BY SCOTT W. HADLEY

People who believe you can't have too much of a good thing obviously haven't worked with inventory! Operations managers know inventory dispels this adage and face the constant challenge of keeping inventory levels as low as possible without increasing overall costs or negatively impacting product availability. This isn't an easy job, especially since inventory rears its head throughout any organization—from raw materials, to work-in-process, to finished goods.

"Making the Supply Chain Management Business Case" in the April 2004 issue of *Strategic Finance* made the point that effective inventory management is critical to overall corporate performance. Savvy supply chain management (SCM) techniques drive profits. In fact, companies using advanced SCM techniques are 40% more profitable than companies that don't.

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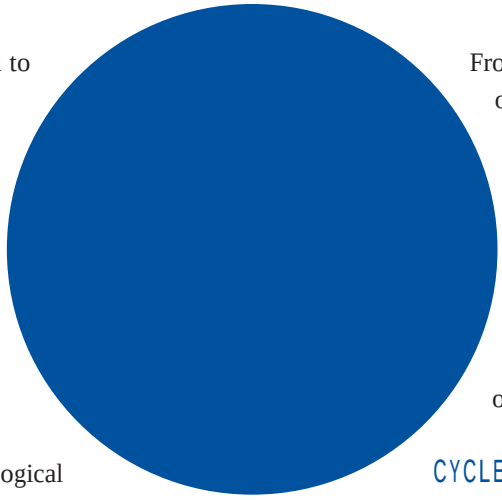


This time around I'll motivate you to review—and challenge—the techniques and processes that support inventory management policies and practices by walking you through the following topics:

- The role of inventory,
- The basis and motivation for commonly used techniques to determine inventory policy, and
- The potential impact that technological advances can have in these areas.

I hope this article whets your appetite for an article in a future issue that will look more deeply at the actual techniques and underlying calculations.

First, let's look at the role of inventory. Although inventory plays a variety of crucial roles, there are two main types—cycle inventory and safety or safety stock inventory.

Table 1

DEPARTMENT	ECONOMIES OF SCALE
Purchasing	◆ Spread fixed order placement costs (decreasing overall per-unit cost) ◆ Exploit quantity discounts ◆ Exploit short-term discounts and trade promotions
Manufacturing	◆ Long production runs ◆ Fewer and less-costly changeovers ◆ Increased throughput ◆ Lower per-unit manufacturing costs
Distribution	◆ Lower material handling costs per unit ◆ Lower per-unit transportation costs (for example, truckload vs. less-than-truckload)
Sales	◆ Spread fixed sales costs per order (decreasing per unit costs)

From one perspective, inventory allows organizations to reduce total costs through achieving wide-scale operational efficiencies and economies of scale. From another perspective, safety or safety stock inventory acts as insurance by improving product availability and buffering against the everyday uncertainty the organization faces.

CYCLE INVENTORY

Cycle inventory allows a company to minimize *total* supply chain costs. This is based on the assumption that the future unfolds as expected (for example, future demand, yields, costs are all known in advance). Yes, you have a crystal ball. Still, virtually every operations department can realize benefits in one way or another if using cycle inventory techniques. Table 1 shows economies of scale that the purchasing, manufacturing, distribution, and sales departments can realize when they use the cycle inventory approach.

The natural question that arises is, "How much should be ordered and when?" Over the years, professionals have used various approaches and techniques to answer questions such as how much inventory should be on hand for each item at each location now and in the future.

To answer these questions and maximize the benefit from advances in cycle inventory planning, it's necessary to eliminate as much uncertainty from the system as possible. You can make a significant impact by understanding and reducing inventory uncertainty. How? By focusing on inventory uncertainty holistically or by focusing on any of the three main sources contributing to inventory uncertainty:

- Demand uncertainty,
- Supply uncertainty, and
- Inventory accuracy.

We'll look at three techniques that can help you determine how much and when to order—economic order quantity (EOQ), material requirements planning (MRP), and advanced planning and scheduling (APS).

Economic Order Quantity

Early techniques for determining optimal order quantities for each item were based on computing the economic order quantity, which is the quantity that minimizes the total ordering plus holding costs for each item at each location.

To determine the timing of individual orders, this technique uses either a continuous or a periodic review process. Using a continuous review process, you would place an order as soon as the inventory level declined to the reorder point—which was computed as the amount of inventory needed to cover the order lead time. Under a periodic review process, you place orders on a periodic basis (for instance, each Monday) by determining the quantity you need to bring inventory up to the appropriate level. EOQ's shortcoming? Since it's computed at the individual item level, EOQ doesn't account for resource interdependencies and the organization's dynamics.

Material Requirements Planning

Material requirements planning differs from EOQ because it addresses the interdependence of materials and accommodates the production process. MRP, including bill of materials (BOM), provides much better period-by-period insight into the requirements of items and materials whose demand depends on the demand of other items.

For instance, the production of finished goods creates a dependent demand for subassemblies, which, in turn, creates requirements for raw materials. MRP gives much better insight into the specific demand for items during certain periods on an ongoing basis. The quantity of the order is computed using lot-sizing techniques. Similar to EOQ techniques, lot-sizing techniques focus on balancing order costs and holding costs.

Unfortunately, MRP assumes unlimited resources such as production and storage capacity, which results in identifying excessive demand during periods of undercapacity. Furthermore, MRP focuses only on dependent demand and doesn't consider finished-goods distribution. Using the same underlying principles as MRP, distribution requirements planning (DRP) addresses finished-goods distribution and inventory planning.

To drive the MRP and DRP processes, you need to forecast future demand for finished goods. Many different forecasting techniques and applications can provide these forecasts, but forecasting—demand planning in general—is still an area needing significant development in terms of software applications.

Advanced Planning and Scheduling

Over the past decade or more, the area of advanced planning and scheduling has emerged to address the shortcomings of many techniques, including MRP and DRP. Early APS development concentrated on finite scheduling, which took into account that resources had capacities and were limited. Finite scheduling and other applications continue to be developed to better predict inventory, production, and distribution requirements, including costs, capacities, and other restrictions.

Over the past few years, there have been dramatic improvements in APS applications for developing realistic cost-optimized plans that achieve desired customer service targets. These tools use deterministic data (such as forecast demand, production rates, and costs) as the basis for developing the plans. From the inventory perspective, these tools determine the desired cycle inventory to minimize total supply chain costs.

For any given inventory item it's difficult to find a hard and fast rule for deciding which method you should use to determine cycle inventory. Table 2, however, provides some characteristics that you should consider before choosing a technique.

Table 2

TECHNIQUE	ITEM CHARACTERISTICS
EOQ	◆ Low value ◆ High volume ◆ Smooth and stable demand ◆ Stable supply ◆ Commodity ◆ Indirect materials
MRP	◆ Dependent demand ◆ Medium-low value ◆ Critical items with stable supply ◆ Direct materials
APS	◆ High value ◆ Variable cost ◆ Critical items with long lead time ◆ Resource intensive (e.g., consumes significant resources) ◆ Capacity-constrained production environment ◆ Unstable supply ◆ Direct materials

The true role of safety inventory is to ensure that adequate inventory exists (i.e., product availability) to maintain desired service levels.

Effective planning of cycle inventory is critical to minimizing total supply chain costs and driving business value. As I mentioned, techniques and applications (for example, APS) are continually being developed to achieve additional cost savings.

SAFETY INVENTORY

When discussing cycle inventory we gave ourselves the luxury of assuming that we could predict the future with certainty, but, as we all know, "Only two things in life are certain—death and taxes." Despite uncertainty, safety inventory allows operational activities to execute as planned even though deviations occur. The philosophy is that the added carrying costs of safety inventory are significantly less than the cost of inefficiencies that would result from stockouts resulting from unplanned deviations.

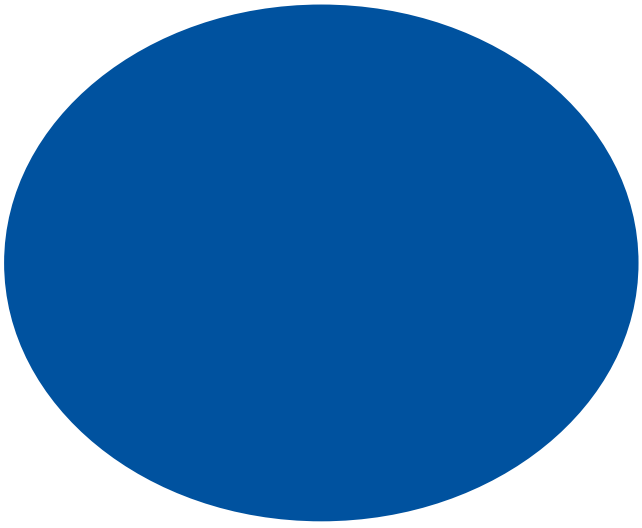
Keep in mind that the true role of safety inventory is to ensure that adequate inventory exists (i.e., product availability) to maintain desired service levels. That means there needs to be adequate inventory to satisfy the prescribed level of customer demand and enough raw materials to serve the production activities.

To maintain appropriate service levels, you must hold safety inventory to cover for demand uncertainty, supply uncertainty, and inventory (in)accuracy.

- Demand uncertainty arises because you can never anticipate or forecast demand with 100% accuracy. When actual demand exceeds the forecast, you must cover the excess.
- Supply uncertainty arises for a number of reasons, including:
  - Supplied quantities differ from planned and ordered quantities.
  - Delivery dates may vary from the requested date.
  - Supply may not meet quality specifications and be unusable.

  In each of these situations you must hold additional inventory to cover the gap between the expected supply and actual supply.
- Inventory (in)accuracy occurs when actual physical inventory differs from reported inventory on which the plans were developed.

Safety inventory's role is to address *inventory* uncertainty! Many people tend to lose sight of the true role of safety inventory and use demand uncertainty as the driver when conducting safety stock analyses. The reason? Demand often experiences the greatest uncertainty and directly impacts inventory. It's probably no surprise, then, that several techniques for calculating optimal safety inventory levels have been developed over time, with more focused on demand uncertainty and not so much on supply uncertainty and inventory accuracy—and definitely not on total inventory uncertainty. You can add to this the fact that techniques and tools for optimizing safety inventory levels aren't taking full advantage of the available projected inventory information created by other tools, such as APS and DRP.



As with cycle inventory, a natural question arises with safety inventory: "For each item, at each location, how much safety inventory should be on hand now and in the future?" Two common measures for expressing safety inventory are absolute cover and periods cover. Absolute cover expresses safety inventory as an explicit number of units, such as 1,000 cases. Periods cover expresses safety inventory as a certain number of periods of forecast demand. For example, two months' cover would be calculated as the expected demand over the next two-month period. Since expected demand fluctuates over time, safety inventory also fluctuates when using a periods cover policy. This is most effective when dealing with demand that fluctuates over time, like seasonal items such as raincoats, snow shovels, or wool

sweaters. Techniques for determining the appropriate level, either in absolute or periods cover terms, vary from "rules of thumb" to sophisticated statistical analysis. Let's now look at demand variability and forecast error analysis.

Demand Variability

The early techniques used demand variability as a surrogate for demand uncertainty and essentially assumed that demand was constant yet subject to random variation. The variation was presumed to follow a normal distribution (recall your Statistics 101 course), with the mean representing the level of demand and the standard deviation representing a measure of the variability range. Statistical tables help mine what the appropriate inventory level should be to achieve the desired service levels. Unfortunately, this technique assumes demand is constant over time and doesn't include positive or negative growth trends or seasonality. This assumption is a definite drawback.

Forecast Error Analysis

The next stage of statistical techniques was significant. Where the original techniques used demand variation as a surrogate for demand uncertainty, the next group of techniques focused on developing a better understanding of the actual uncertainty by observing the gap between expected and actual demand. A primary goal of demand planning applications is to reduce demand uncertainty through improved forecast accuracy.

It's interesting to look at the difference between forecasts in cycle inventory and safety inventory. Cycle inventory is determined based on forecast demand, while safety inventory is determined based on forecast error (the gap between the forecast and actual demand). When implemented correctly, techniques based on analysis of forecast error give rise to much more robust safety inventory levels, but the drawback to forecast error analysis is that it focuses on a surrogate measure to determine safety inventory requirements.

Recall that the role of safety inventory is to ensure that adequate inventory exists to achieve desired service levels. In other words, the role of safety inventory is to cover *inventory* uncertainty—not just uncertainty in demand or supply. Focusing solely on demand uncertainty isn't the objective of safety inventory. Demand is a major source of uncertainty, but so are supply uncertainty and inventory accuracy.

That's why you should determine safety inventory levels on the analysis of the inventory uncertainty—the gap between the expected, or planned, inventory levels and the actual inventory. Techniques similar to those for analyzing forecast error can be developed for analyzing inventory error.

THE GREATER OPPORTUNITY—REDUCING UNCERTAINTY

Executing a plan with minimal deviation is important to delivering business value.

The root cause of deviating from a plan rests in uncertainty—events or circumstances that are unforeseen or not accounted for during the planning activity. For instance, assume that actual demand exceeds the planned demand. In the absence of safety inventory this would give rise to an inventory shortage, and, to satisfy the demand, you'd create a rush production order, which, in turn, impacts the production plan. Generally speaking, the overall impact of executing an unplanned activity is significantly more expensive than executing that same activity when it's planned. Reducing uncertainty improves the probability of adhering closely to the plan.

When you manage inventory effectively by reducing uncertainty, you help drive corporate profitability. Cycle inventory does this by realizing economies of scale and operational efficiencies, which drives down cost of goods sold. On the other hand, safety inventory buffers against uncertainty in inventory levels that results from unplanned deviations in supply, demand, and data. This facilitates effective and efficient reaction to the dynamics of the business environment while maintaining desired levels of service.

Through advances in technology, companies can use many tools and techniques that support inventory management practices. Focusing on inventory uncertainty rather than demand uncertainty will give rise to more robust and effective inventory policies. Go for it! ■

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