A Measured Approach to Food-Inventory Management

At what stock level should a food-service manager reorder a given food item? The best reorder point is one that provides some safety stock, but doesn't overfill the freezer

by **Behshid Farsad**
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DO THESE STATEMENTS sound familiar? "We have too much capital tied up in inventory." "We have excessive inventory of certain items." "We are always out of some ingredients." "Our inventory turnover is almost two weeks, but the competition has a four-day inventory turnover." "Every week my managers make several trips to the grocery store to purchase small quantities of out-of-stock items." "We often lose customers because we are out of the menu item they select." They probably do if you are like hundreds of food-service operators around the country.[1] These declarations are indicators of serious inventory problems. What

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[1]The results of a survey of commercial food-service establishments conducted by the authors in early 1992 revealed that "inventory problems" is the primary concern of managers and supervisors. Over 73 percent of the surveyed food-service establishments reported that they ran out of stock on at least two main items every week. About 51 percent of these businesses regularly transferred in understocked items from other locations within the chain, and 38 percent visited a grocery store or a designated food warehouse at least once a week.

makes this situation so frustrating are the contradictions: having too much inventory of some items but constantly running out of others, or having a slow inventory-turnover rate but at the same time not being able to produce all of the menu items.

Food-service inventory problems are generally related to inaccuracies in determining when to order and how much to purchase, resulting in mistakes in determining the optimum stock that should be on hand for each item or ingredient. The optimum inventory that should be on hand for each item is the amount that is needed to fulfill customer demand between the vendor's scheduled deliveries. Determining the correct inventory on hand is difficult, since there are many factors that influence the process. Those factors include making a correct prediction of the sales mix; maintaining adequate receiving, storing, and issuing controls; vendor reliability and efficiency; correctly predicting customers' desires; and knowledge and application of production controls. This article will address the issue of when to order, leaving the issue of forecasting how much to purchase for another time.

It is possible to reduce the uncertainty of when to reorder foodstuffs by carefully analyzing the answers to such questions as: What is the customer demand for a specific menu item on a particular day or week? Which day of the week generates the most demand for certain menu items? Should a lunch or dinner special be offered to reduce the inventory of specific products? Should dead or slow-moving menu items be removed from the menu or perhaps packaged as a promotion? These questions can be answered with confidence by establishing a systematic and self-correcting management strategy regarding inventory.

Why Have Inventory?

The question of why we need an inventory may seem trivial, but it is a necessary starting point. In most organizations, inventory is needed to protect the supply-production-distribution system from demand fluctuations. Adequate inventories insulate one part of the supply-production-distribution system from the next, allowing each to work independently, absorb the shock of forecasting errors, and permit the effective use of resources when demand fluctuations occur. Furthermore, the correct inventory level helps meet the expected customer demand (distribution), establishes a smoother production process (production), and occasionally acts as a hedge against unexpected price increases or product shortages (supply).

Although it may be a feasible practice for a handful of food-service establishments to achieve vendor agreements by implementing a modified version of zero inventory, a more realistic situation is that each establishment bears the responsibility of carrying and storing an adequate stock level for all items.[2]

Inventory is considered to be an immediate asset that is reduced during the production process. This reduction is expected to lead to sales, in turn generating revenues and eventually profit. Inadequate control of inventory may result in either an understock or an overstock, either of which bears associated costs. Overstock costs include the opportunity cost of lost investment from using working-capital funds for the asset and the expense of inventory obsolescence, spoilage, and theft. Understock costs include additional handling and transportation costs, gross profit lost on missed sales, and customer dissatisfaction. Overstocking and understocking inventory may be avoided by developing systematic inventory management with the following two objectives:

(1) Achieve an optimum (not a minimum) level of inventory, answering the question of how much to purchase; and

(2) Reduce operating costs associated with inventory such as the cost of ordering, storage, and maintaining an excess supply (safety stock), addressing the issue of when to order.

While how much to purchase can be answered using a forecasting method, when to order must be answered by determining the correct inventory-reorder point. Even though we have separated them here for ease of discussion, a forecasting method and a reorder point are two inseparable objectives of any inventory-management system since inventory costs are directly affected by the level (amount) of inventory on hand.

Types of Inventory

Accounting for inventories can be perpetual or periodic. The perpetual method (also known as continuous or cumulative) requires additions and subtractions to each product as transactions occur. This method can facilitate management control and decision making through the analysis of interim financial reports, which can be prepared without the benefit of a physical inventory count. Perpetual inventory systems provide information on the current level and total value of inventory for each item, as

[2] The major ideas of zero inventory or stockless production were put into place between 1960 and 1972 on Toyota's automobile production lines in Japan. The goal of stockless production is to carry only enough inventory on hand to meet the customer demand on a specific day. Stockless production transfers to the vendor the responsibility of carrying and storing an adequate level of inventory on all requested items. Although a modified version of this concept has successfully been implemented by a small number of major hotel chains, it is not a common practice in the food-service industry.

well as its past usage. Periodic inventory procedures, in which items are counted every so often, do not require this immediate updating of inventory values and quantity levels when an item is added to or subtracted from stock. Financial statements incorporating all changes in the inventory quantities and values are generated when the stock (inventory) is physically counted at the end of a specific period.

Under generally accepted accounting principles (GAAP), use of a perpetual inventory method does not preclude the need for applying a periodic inventory method (physical count) to issue audited financial statements. Most food-service organizations use both a periodic inventory method and a perpetual method, capitalizing on the opportunity to provide timely information to managers through the use of perpetual methods and responding to the requirements of a publicly held corporation by using a periodic method.

Maintaining an accurate inventory level is a difficult and cumbersome process for a food-service organization. It requires a thorough understanding of inventory concepts and maintaining up-to-date periodic-demand estimates. In many food-service organizations, proper inventory-management policies and procedures can be established using elementary management-science or operations-research techniques applied to the inventory. These inventory techniques are classified into two general categories:

(1) Techniques using deterministic inventory models; and
(2) Techniques using probabilistic inventory models.

Deterministic models represent a general form of inventory-management techniques that are inappropriate for most commercial food-service operations since they do not consider demand fluctuations and usage variations for specific items. In those cases the customer demand or usage rate is known prior to the start of the production process, a situation that may be true for certain food items, catering functions, or institutional food-service operations. Two applications of deterministic models are known as basic economic order quantity and economic production lot size.

Probabilistic models assume that customer demand and usage rates are unknown and that demand and usage can only be estimated by considering a probability of occurrence or weighted value. These models are appropriate for the majority of commercial food-service operations.

Inventory's Anatomy

Historically, most food-service establishments use a modified cyclical process of inventory control where the inventory is built up to a certain level when an order is delivered and depleted as demand occurs. The manager will place another order, the inventory will again be built up, and the cycle starts over. If the establishment runs out of an item before receiving the next delivery, it would attempt either to get it transferred in from another store (if it is part of a chain) or purchase a small quantity from the local grocery store. If the manager is not able to restock the item, all menu items affected by this shortage are struck from the menu.

In this type of inventory system, the answer to the first question of the inventory-management system, how much to purchase, is either "equivalent to the usage during the previous period" or "an estimate based on the manager's value judgment." The answer to the second question, when to order, is either "whenever the vendor agreed to deliver" (e.g., every Monday and Thursday) or "whenever the restaurant ran out of the item." This type of inventory system, which could be called inventory management by gut feeling or simply guesstimation is unfortunately accepted and used by many food-service establishments.

The complexity of the food-service industry mandates the use of more scientific methods to address the many issues of inventory management. The level of management sophistication in the industry has increased dramatically in recent years, primarily due to employing better educated managers and the availability of advanced computer-based equipment. Most food-service managers are using some type of point-of-sale terminals or computer-based information systems, for example, to generate both daily and periodic information regarding their operations. The inventory model that follows uses some of that technical sophistication to address the issue of when to order.

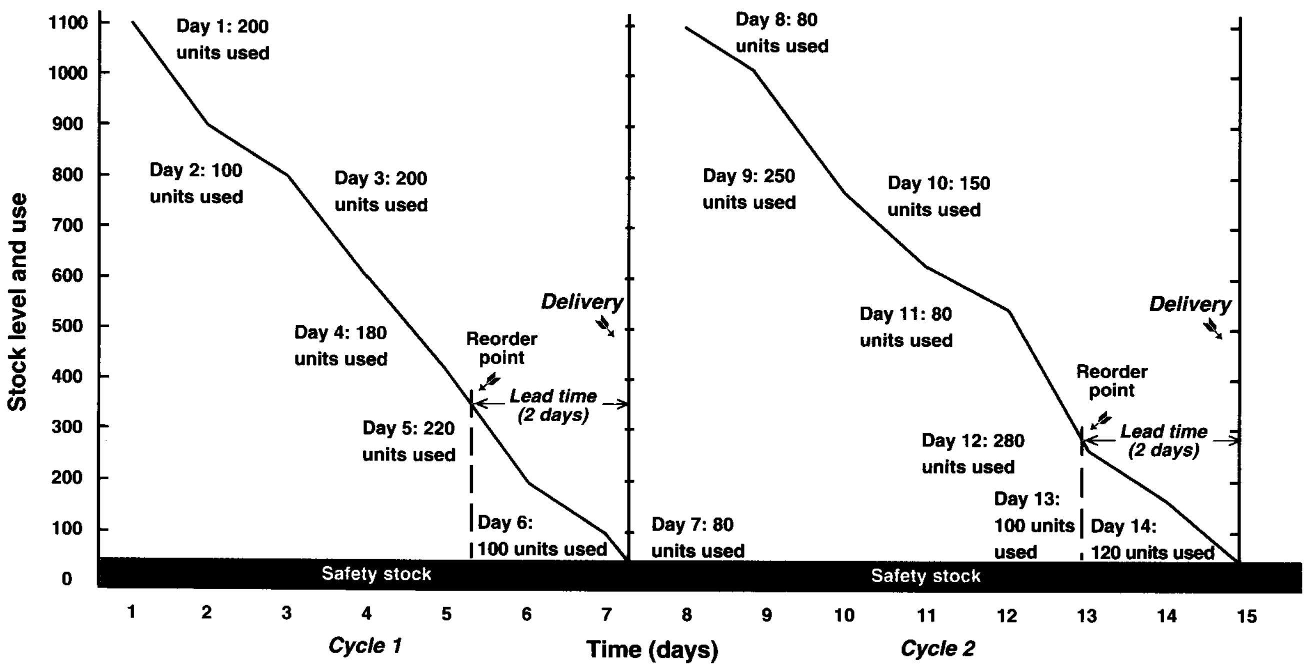
Constructing a Model

A food-service operator needs fully to understand such factors as reorder point, active stock, safety stock, risk of stockout, demand size, demand pattern, replenishment pattern, and lead time to control and maintain a solid inventory-management system. An inventory model consists of the following five major components:

(1) *Maximum inventory level on hand:* This is the maximum or desired level of inventory that can be held on premises. Once this inventory becomes available for production it is called active stock.

(2) *Demand and depletion rate:* The inventory is depleted as demand occurs. The higher the rate of demand, the faster the inventory is reduced. Demand rate, referring to the magnitude of demand, has

EXHIBIT 1
Graphic representation of inventory management



the dimension of quantity. When the demand is the same from period-to-period it is called constant demand (e.g., ten units every week), otherwise it is called variable or fluctuating demand (e.g., ten units one week and five units the next week). The demand size per unit of time is called the demand rate.

(3) *Reorder point:* To build an item's inventory to the desired level, the item is replenished periodically. This replenishment takes place when the inventory is reduced to a certain level, called the optimum inventory level on hand. Optimum inventory level and reorder point are the same. A replenishment order should be placed when an item's quantity reaches the optimum inventory level.

(4) *Replenishment size, pattern, and lead time:* Replenishment size refers to the quantity or size of the order to be received and added to the inventory, which can be either a constant or a variable amount. Replenishment pattern refers to how the units are added to the inventory (e.g., as part of a batch recipe). Replenishment lead time or reorder lead time is the length of time between the decision to replenish an item and its actual availability for production. This is extremely important for correct calculation of replenishment lead time since a box of frozen steaks, say, cannot be considered as available for production until the steaks are thawed. Therefore, the thawing period needs to be added to the delivery time. In this case if the delivery time is two days and the thawing process will take one day, the total replenishment lead time should be considered as three days.

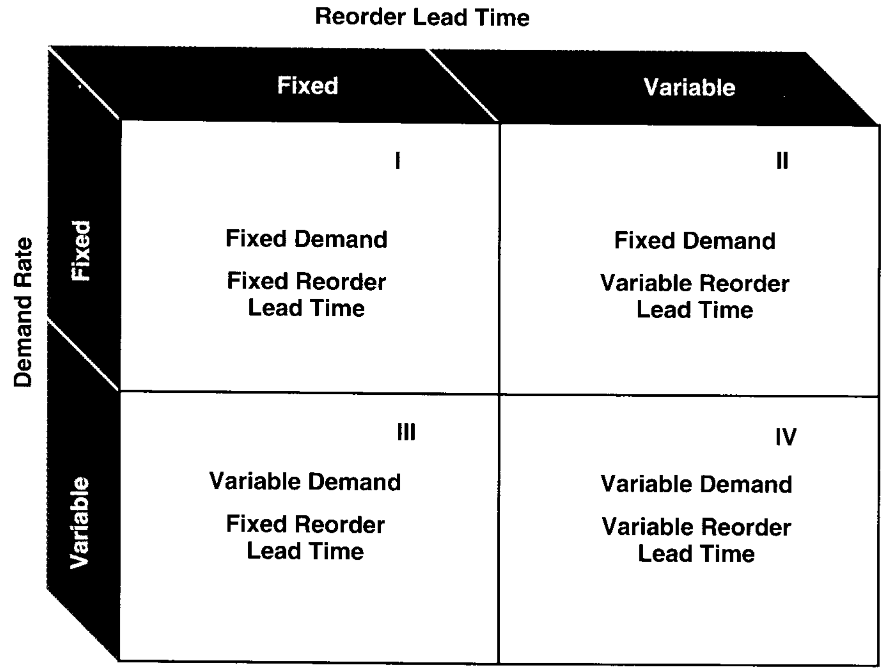
(5) *Safety-stock quantity:* Shortages can be eliminated or at least reduced by deliberately increasing the inventory level above the expected use level. Excess inventory (safety stock) is usable when the actual demand is higher than the estimated demand or the delivery lead time is longer than in the projected (or agreed upon) lead time. A graphic illustration of the item reorder point is shown in Exhibit 1.

What is the optimum reorder point? To answer that question a manager should first look at the four interrelated determinants of the reorder-point quantity. These determinants are: **(a)** the item's average demand rate (usage between the vendor's scheduled deliveries); **(b)** the item's reorder lead time (vendor's scheduled delivery days); **(c)** the type of demand rate and reorder lead time (variable or constant); and **(d)** the degree of risk that management is willing to take by having out-of-stock items.

Considering those determinants the reorder point is described by one of the following four scenarios. Exhibit 2 shows four possible combinations of demand rate and reorder lead time.

(1) In cell one, the item's demand rate and the reorder lead

EXHIBIT 2
Demand rate and reorder lead time matrix



time are both constant. This means that there is no fluctuation in either the demand rate or the reorder lead time, and so there is no stockout risk. This situation is found in certain institutional food-service operations, such as nursing homes, that have a fixed number of residents or those that operate primarily by reservation only. It is inappropriate, however, to apply this methodology to the vast majority of food-service operations. In this situation the reorder point can simply be computed by multiplying the daily demand (D) by the item reorder lead time (LT). For example, if the demand rate for a certain item (say, ground beef) is 60 pounds per day and the lead time for vendor delivery (including preparation time) is two days, an order must be placed no later than when the on-hand inventory reaches 120 pounds.

(2) Cell two shows the case where the item's demand rate is constant and the reorder lead time is variable from order to order. Both a constant demand rate and a variable reorder lead time are unusual for most commercial food-service operations.[3]

(3) In cell three, the item's average demand rate and the reorder lead time both fluctuate. Although most commercial food-service operations have a variable demand rate, a variable reorder lead time is unusual.

(4) Cell four shows the item's average demand rate varying from day to day while the reorder lead time is fixed. This is the most common scenario for commercial food-service operations. Most vendors agree to deliver on a particular day of the week and the food outlet must maintain a quantity of safety stock to accommodate demand fluctuations. In this situation it is assumed that item demand during the reorder lead time is composed of a series of independent average daily usages that can be described statistically by a normal distribution. Each product's reorder point (ROP = the optimum level or inventory on hand) can be computed by taking the average daily demand ($\bar{D}$) of each product multiplied by the product reorder lead time (LT). For example, if the daily demand rate for ground beef based on the sales analysis of all menu items containing ground beef during the past week was 48, 56, 64, 80, 52, 68, and 52 pounds and the lead time for vendor delivery (including preparation time) is two days, an order must be placed when on-hand inventory reaches 120 pounds. Mathematically, this can be expressed as: $ROP = (\bar{D})\,x\,(LT)$, where the average daily demand ($\bar{D}$) equals $[(48 + 56 + 64 + 80 + 52 + 68 + 52) \div 7]$, or 60 pounds. Therefore, the reorder point for ground beef is $(60)\,x\,(2)$, or 120 pounds.

Safety stock. Since in this scenario the item demand rate exhibits a degree of variability, a manager must avoid or minimize the risk of running out of stock of a particular item by setting aside an additional amount of product to meet expected but unknown demand variations. That additional amount of inventory is called safety stock. Maintaining safety stock is a survival issue in today's intensely competitive food-service environment, because it helps management avoid disappointing customers due to items' unavailability. Safety stock is computed based on an item's service level, which is the probability that the average demand rate will not exceed the supply on hand during the item's reorder lead time. The amount of safety stock is expressed by a Z score, as we will explain next.

[3] We contacted ten major food distributors or brokers listed in the 1992 edition of *Thomas Food Industry Register* for their delivery rules, regulations, and schedules. Six offer seven-day delivery schedules as long as a minimum-order limit is met. The minimum order limit ranges from $250 and $600 per order, depending on the vendor. Two of these six vendors also levy a "truck surcharge" for weekend delivery.

EXHIBIT 3
Sample Z scores

PROBABILITY (%)	Z VALUE	PROBABILITY (%)	Z VALUE
100	3.09	92	1.41
99	2.33	91	1.34
98	2.06	90	1.29
97	1.88	89	1.23
96	1.75	88	1.18
95	1.64	87	1.13
94	1.55	86	1.08
93	1.47	85	1.04

Shown here are Z scores for the most common percentages used by food-service organizations. Z scores below 85 percent are very close together and those slight differences will not affect the calculated results.

EXHIBIT 4
Standard-deviation example for ground beef

Day	Daily demand (D)	Mean demand ($\bar{D}$)	Deviation ($D-\bar{D}$)	Deviation squared $(D-\bar{D})^2$
1	48	60	-12	144
2	56	60	-4	16
3	64	60	4	16
4	80	60	20	400
5	52	60	-8	64
6	68	60	8	64
7	52	60	-8	64
Σ	*420*	*NA*	*NA*	*768*

N (number of observations) = 7

$\bar{D}$ (Average demand) = 420 ÷ 7 = 60

$$\sigma D = \sqrt{\frac{[\Sigma (D-\bar{D})]^2}{N}} = \sqrt{\frac{768}{7}} = \sqrt{109.7} = 10.47$$

Let us assume that managers of the food-service establishment in our example above decided that they did not want to have a stockout risk of greater than 5 percent on menu items containing ground beef as a recipe component. Turning that around, the managers are saying that they want a 95-percent certainty that they'll be able to serve ground-beef items at all times. Rather than dealing with extremely complex statistics to make that probability a usable number, we can take advantage of the fact that mathematicians have already converted various probability levels to numbers that we can plug into our formula. That statistic is known as a Z score, and it is available from mathematics textbooks or books on managerial statistics (see Exhibit 3). Using the Z scores, the managers find that a 95-percent probability level equates to a Z score of 1.65. The standard deviation of the demand for ground beef usage for the past seven days has been computed to be 10.47 pounds per day (see Exhibit 4).[4]

The safety stock is calculated by multiplying the Z score representing the desired service level by the square root of the lead time (LT) by the standard deviation of the demand during the lead time (σD). Mathematically, the safety-stock level can be expressed as:

Safety stock = [(Z) x (√LT) x (σD)].

Therefore, the new reorder point, incorporating a provision for safety stock, can be calculated by adding the expected demand to cover the lead time period plus the computed safety stock. Mathematically, this process applied to our example can be represented as follows:

$$\text{Reorder point (ROP)} = (\bar{D} x LT) + [(Z)\ x\ (\sqrt{LT})\ x\ (\sigma D)]$$
$$= (60)\ x\ (2) + [(1.65)\ x\ (1.41)\ x\ (10.47)]$$
$$= 120 + 24.35$$
$$= 144.35,$$

or 145 pounds of ground beef.

That amount includes 25 pounds of safety stock that statistically assures the managers that they won't be out of stock more than 5 percent of the time between deliveries. If we were to reduce the expected service level to 90 percent (10-percent stockout risk, Z score of 1.29), the safety stock would be reduced to 19 pounds and the reorder point to 139 pounds, as shown here:

$$\text{Reorder point (ROP)} = (60) \times (2) + [(1.29) \times (1.41) \times (10.47)]$$
$$= 120 + 19$$
$$= 139 \text{ pounds of ground beef.}$$

Worth the Trouble

Inventories are essential to most food-service outlets, and managers cannot escape the need to control this asset. The interrelationships of inventory with each facet of the business environment increases the complexity of solving inventory problems. The approach that we offer here is intended to make the question of when to reorder less of mystery and more of a science. While the statistic may seem initially complicated, a computer spreadsheet will make it easy to calculate the standard deviation of usage for each food item. In a subsequent article, we will deal with the calculations for how much to order each time. **CQ**

[4]The standard deviation [SD or sigma (σ)] is the square root of the mean of the individual deviations (from the mean) squared. It is a precise measure of dispersion that takes in all the values contributing to the computation of the mean. The steps to calculate the standard deviation are: **(1)** Determine the mean of the series (total pounds of ground beef used during the past seven days divided by seven). **(2)** Take the difference between the mean and each observation ($D - \bar{D}$) in the series. **(3)** Square and add up the differences $[\Sigma(D - \bar{D})^2]$ and divide by the total number of observations (n). **(4)** Compute the square root of the result in number (3) above. Finally, note that the variance is the square of the standard deviation (σ^2). The term ANOVA (analysis of variance) has been derived from this concept.