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Logistics, Inventory Control, and Supply Chain Management

by Frank Dooley

Many argue that the focus point (and perhaps the linchpin) of successful supply chain management is inventories and inventory control. So how do food and agribusiness companies manage their inventories? What factors drive inventory costs? When might it make sense to keep larger inventories? Why were food companies quicker to pursue inventory reduction strategies than agribusiness firms?

In 1992, some food manufacturers and grocers formed Efficient Consumer Response to shift their focus from controlling logistical costs to examining supply chains (King & Phumpiu, 1996). Customer service also became a key competitive differentiation point for companies focused on value creation for end consumers. In such an environment, firms hold inventory for two main reasons, to reduce costs and to improve customer service. The motivation for each differs as firms balance the problem of having too much inventory (which can lead to high costs) versus having too little inventory (which can lead to lost sales).

A common perception and experience is that supply chain management leads to cost savings, largely through reductions in inventory. Inventory costs have fallen by about 60% since 1982, while transportation costs have fallen by 20% (Wilson, 2004). Such cost savings have led many to pursue inventory-reduction strategies in the supply chain. To develop the most effective logistical strategy, a firm must understand the nature of product demand, inventory costs, and supply chain capabilities.

Firms use one of three general approaches to manage inventory. First, most retailers use an inventory control approach, monitoring inventory levels by item. Second, manufacturers are typically more concerned with production scheduling and use flow management to manage inventories. Third, a number of firms (for the most part those processing raw materials or in extractive industries) do not actively manage inventory.

Many agribusiness firms do not actively manage inventory. This does not mean that they ignore inventory. Rather, they hold large inventories because any potential savings from inventory reductions are far outweighed by the inventory-induced reductions in production, procurement, or transportation costs. Often economies of size cause long productions runs which lead to inventory accumulation. Simultaneously, seasonality leads to inventory buildups of key inputs like seed as well as outputs like corn. Economies in procurement such as forward buying in the food industry and quantity discounts increase inventories. Similarly, unit trains and other forms of bulk shipping discounts contribute to inventory buildups.

Yet, such firms must be alert to changing conditions that may require more exact inventory management. One example would be if crops are marketed as small lots of value-added grain instead of commodities. Production proliferation in the seed industry may be another instance. Finally, whether due to food safety concerns, GMOs, food labeling, or the growth of organic food markets, identity preservation requires more precise inventory control.

The Importance of Demand

Inventory management is influenced by the nature of demand, including whether demand is derived or independent. A derived demand arises from the production of another product. For example, when John Deere knows its demand for a tractor, it can simply compute the demands for the parts, materials, and components needed to produce that tractor. Manufacturers of all sizes use such calculations which are part of flow management to manage inventories, schedule deliveries for inputs, and manage capacity. Flow management software has evolved from Materials Requirements Planning (or MRP) in the 1960s to the much more complex Enterprise Resource Planning (or ERP) of the 1990s. A flow management system is set in

motion by the demand for end products.

Independent demand arises from demand for an end product. End products are found throughout a supply chain. Wheat is an end product for a grain elevator, as is flour for a miller or cereal for a grocer. By definition, an independent demand is uncertain, meaning that extra units or safety stock must be carried to guard against stockouts. Managing this uncertainty is the key to reducing inventory levels and meeting customer expectations. Supply chain coordination can decrease the uncertainty of intermediate product demand, thereby reducing inventory costs.

Customer Service and Inventory

The availability of inventory provides customer service. The Item Fill Rate (IFR) measures how often a particular product (often called a stock keeping unit or SKU) is available. A common metric of customer service, IFR is expressed as the percentage of time that a customer can obtain the item they seek. A firm may set its customer service order policy at 95%, seeking to fill 95% of the orders for an item from inventory.

However, life is a bit more complicated. A customer might not obtain what they seek for several reasons. The seller may have run out of a product due to an inaccurate forecast. Or the supplier may have shipped an incorrect package size or flavor. Products in inventory may be unfit for sale because of damage or an expired shelf life. Finally, a seller may not have the capability to accurately track inventory in their stores or distribution centers.

To avoid shortfalls or stockouts, firms carry extra inventory known as safety stock. As more customer service is provided, a firm can expect sales to increase (Figure 1). However, as a firm tries to provide perfect customer service, logistical costs increase exponentially. Also, if a firm holds too much inventory, it can lead to low inventory turnover and hide operational problems. For example, carrying too much stock means that you might not discover that your supplier is frequently late with delivery times.

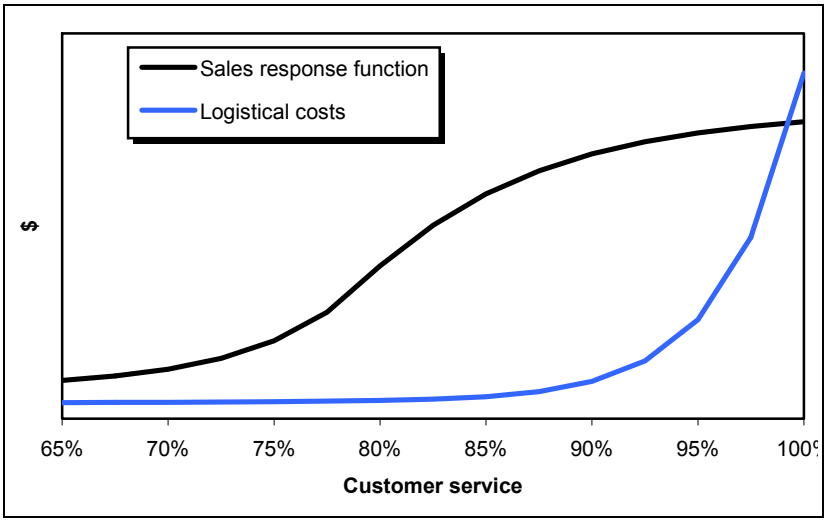

Figure 1. Incremental sales and logistical costs.

The Product Life Cycle, Demand Uncertainty, and Inventory

The structure of independent demand and logistical requirements vary by stage in the product life cycle (introduction, growth, maturity, and decline). During introduction, logistics must support the business plan for product launch, while preparing to handle potential rapid growth by quickly expanding distribution. At market maturity, the logistical emphasis shifts to become cost driven. In the decline stage, cash management, inventory control, and abandonment timing become critical. Over-abundance of products in the late maturity or decline stage will eventually result in obsolete products. The obvious difficulty is predicting how long each stage will last and how abruptly sales will fall in the decline stage.

The life cycle strategy typically involves getting to profitability quickly recuperating startup costs, then sustaining high profits for as long as possible, and finally acting decisively for products in decline to minimize losses. Understanding this life cycle can help managers select logistical tactics, inventory levels and supply chain designs. The ultimate goal for companies should be to have just enough inventory to satisfy consumer demand.

Another life cycle attribute is that demand uncertainty shifts as we progress through time. Product managers face substantial uncertainty during the introduction and growth stages, relative stability during maturity, and increasing uncertainty in decline. This uncertainty drives forecasting accuracy and the level of safety stock required to meet customer service expectations.

The coefficient of variation (CV) measures the stability of a product's demand, comparing the variability in demand to the size of the average demand (Figure 2). High demand

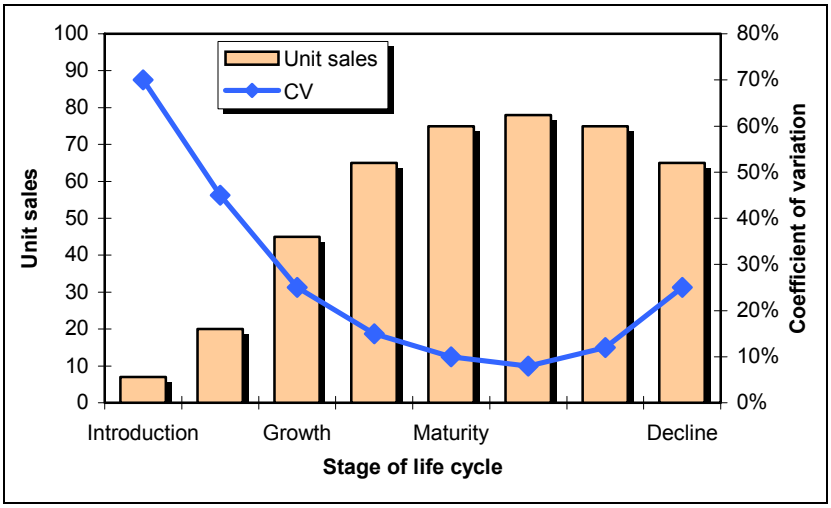

Figure 2. Product life cycle and uncertainty.

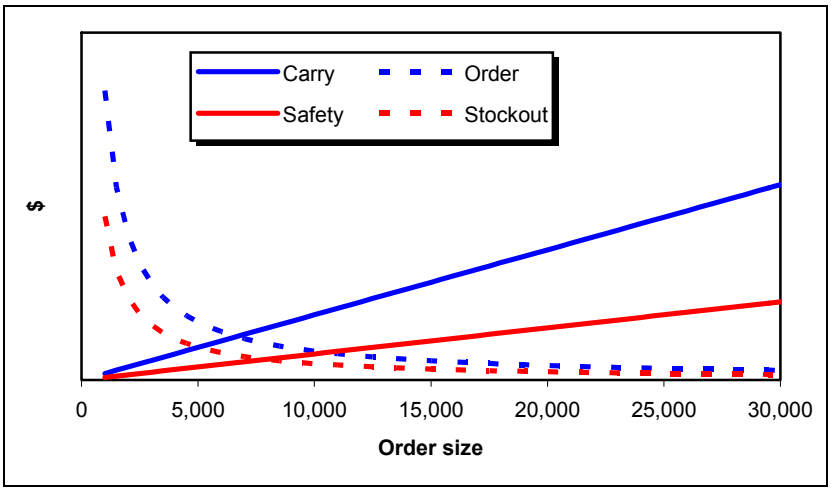

Figure 3. Inventory costs by order size.

variability in the introductory stage means it is difficult, if not impossible, to forecast demand. Thus, high levels of inventory must be held to meet even minimal customer service levels. In contrast, lower variability during maturity means that demand forecasts are quite accurate. However, inventory levels may still be large because they are based on larger sales volumes.

In addition to the vagaries associated with product life cycle stage, two other sources of uncertainty also drive the level of inventory. First, demand can vary from day to day, week to week, or seasonally. Second, there may be variability in lead time, or the time from when an order is placed until delivery is made.

Forecasting demand used to be more exact because products stayed in the mature product life cycle phase for a long time. Today many companies find it far more difficult to forecast sales because of product proliferation. Product line extensions result in more products that cannibalize sales and shorten the life cycle. Thus, more sales are coming from products in the erratic earlier stages of life, as opposed to sales from products in the mature stage of the life cycle.

Inventory Costs

Different models are used to manage inventory for products that are continually available (like milk) or products available for limited time (like seed). The Economic Order Quantity (EOQ) model determines the least cost level of inventory to carry, as well as costs. News Vendor models are used for products only available for a single period.

EOQ and News Vendor models have proved useful for managing inventory for many years, analyzing tradeoffs among major cost components. These models are robust and easy to customize to particular industries. Their approach to costing is similar reflecting levels of inventory, as well as shipping costs or quantity discounts.

Inventory costs fall into three classes: 1) carrying costs of regular inventory and safety stock; 2) ordering or setup costs; and 3) stockout costs. Inventory control systems balance the cost of carrying inventory against the costs associated with ordering or shortfalls (Figure 3).

First, carrying cost (or a cost to hold inventory) is comprised of capital costs, service costs, storage costs, and risk costs. A carrying cost involves the opportunity cost for holding inventory. If the firm did not have money tied up in inventory, it could either use the savings to make investments in other assets or pay down debt. Thus, a firm should first determine what it would do with any savings from a reduction in inventory. If the dollars are used to buy capital equipment, an appropriate opportunity cost is the firm's hurdle rate or its "required rate of return." If the dollars are used to pay down debt, the interest rate on the loan should be used to value the inven-

tory. The other three aspects of carrying cost are non-capital costs.

The service costs are often masked in a firm's fixed costs. A firm should determine how much of its insurance and tax expense is associated with inventory. This is especially important in states that have an inventory tax. A firm has cash outlays for warehouses and materials handling equipment, either owning or leasing space from a distributor. In either case, the firm should determine how much is spent on space. Inventory risk reflects characteristics of the product. Some items are more prone to be stolen, others are more likely to be damaged, yet others may become obsolete before a sale is made. In any case, risk means that if too much inventory is held, a certain proportion of the inventory will be unavailable for production or sale.

To determine the cost of carrying inventory, one needs to know the average quantity of inventory, an inventory carrying cost (as a percent of product cost), and the average cost per unit of inventory. If a firm plans to use inventory reductions to fund other capital assets, inventory carrying cost might be 30% (25% for an opportunity cost and 5% for the service, space, and risk costs). If the firm plans to use the savings to reduce debt, the appropriate rate might be 12% (7% for the interest rate and 5% for the other costs). Regardless of the carrying cost rate being used, as a firm holds more inventory, carrying cost increases (Figure 3).

Firms carry extra inventory to guard against uncertain events. Known as safety stock, the purpose of this inventory is to provide protection against stockouts. Safety stock is costed just like regular inventory, it is an interest rate times the level of safety stock. The level of safety stock required to guard against a stockout depends upon the customer service level, the standard deviation of demand of the product, and lead time. Let's explain in greater detail.

Assume that it takes 10 days from the time an order is placed until a shipment arrives and that on an average 20 cases are sold each day. Thus, over the 10 days that we are waiting for the delivery (our lead time), we expect to sell 200 cases. If we trusted our forecast, supplier, and trucking company, we would simply hold 200 cases for the 10 days. But we realize that forecasts are inaccurate, some suppliers are unreliable, and shipping times vary. If less is sold than expected during the 10 days or if the shipment arrives early, we will still have inventory on the 10^{th} day and no customer service problems are encountered. However, if sales are above expectations during the 10 days or deliveries are late, we might run out (or stockout) of product.

Managing the uncertainty surrounding safety stock is the key to reducing inventory levels. But in today's competitive environment, it is difficult to lower safety stock requirements for two reasons. First, some buyers (especially large retailers) are requiring higher customer service levels, which raise safety stock levels. Second, the product mix for many firms includes more new products with the corresponding greater demand variability. Thus, most firms seeking to reduce safety stock can only do so by focusing on aggressively cutting lead times.

The second cost to consider is ordering costs. Ordering costs include a cost for transmitting the order, receiving the product and placing it into storage, inbound transportation, and processing the invoice. Recent advancements in information technology have lowered this cost by a factor of six for many industries. A manufacturer uses the cost of a production setup instead of an ordering cost.

Finally, stockout costs involve lost sales when no inventory is on hand. Such costs fall as inventory (and customer service) levels increase. The relationship between stockout costs and inventory depends upon the accuracy of the demand forecast and the ability of the firm to recognize and react to a change in demand. Stockout costs depend on how a customer reacts to a stockout, the frequency of stockouts, and the availability of substitute products. Stockout costs can be very high if a lack of substitute products means that a customer will switch suppliers. In contrast, if buyers simply substitute a different product, stockout costs may be inconsequential.

In practice, many firms do not assess stockout costs because different divisions of a firm cannot reach agreement on what is the cost of running out. Marketing may desire a very high stockout cost to force a penalty cost on running out. Operations or finance may resist this as it leads to inventory buildups.

Service level goals can differ by the value placed on stockouts and indirectly carrying costs. A high stockout valuation will result in higher inventories and higher service levels. One way to evaluate an inventory management policy is to choose a service level target. From this target, the inventory policy will determine the inventory requirements and associated costs of providing that level of service. A higher service level implies that more inventory will be held as safety stock. The tradeoff decision occurs at the point where the cost of carrying extra safety stock balances the stockout cost.

Closing Thoughts

Inventory levels are affected by customer service expectations, demand uncertainty, and the flexibility of the supply chain. For products with relatively certain demand and a long product life, it should be relatively easy to maintain desirable customer service standards even as inventories are reduced. However, for products characterized by erratic demand, a short life cycle, or product proliferation, a more responsive supply chain and larger buffer inventories may be needed to meet a desired customer service level.

Consumers are demanding more customer service from firms throughout the supply chain. Firms with high customer service levels may gain a competitive advantage over those that do not have the supply chain capabilities in place or the ability to manage them. Firms who understand their demand recognize stockout costs and carry appropriate levels of inventory are ultimately better able to effectively manage inventory and provide the desired service level to customers. As industrialization affects agribusiness and agriculture in general, the importance of customer service and competitiveness will become critical for firms and supply chains.

For More Information

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