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## Chapter 5: Inventory Management & Bullwhip Effect

### Objectives

- Understand the role and functions of inventory.
- Examine the purpose and types forecasting.
- Able to compute simple forecasting.
- Examine bullwhip effect and analyse solutions.

### 1. Introduction

Inventory represents the largest single investment in assets for most manufacturers, wholesalers and retailers. In most industries, customers have become accustomed to high levels of customer service and product availability.

Many organizations have to stock higher inventory levels. Inventory investment can represent over 20 to 30% of manufacturers' total assets, and more than 50 percent of wholesalers' and retailers' total assets.

Because capital invested in inventories must compete with other investment opportunities available to the firm, and because of the out-of-pocket costs associated with holding inventory, strategic inventory management is an important business activity.

We will discuss the functions of inventory and competitive drivers before delving into forecasting and bullwhip effect.

### 2. Functions of Inventories

#### 2.1 Transportation Economies

Transportation economies are possible for both the physical supply system and the physical distribution system. In the case of physical supply, small orders from a number of suppliers may be shipped to a consolidation warehouse near the source of supply; in this way the producer can achieve a truckload or carload shipment to the plant, which is normally a considerably greater distance from the warehouse. The warehouse is located near the sources of supply so that the LTL rates apply only to a short haul, and the volume rate is used for the long haul from the warehouse to the plant.

#### 2.2 Supporting Production

Short production runs minimize the amount of inventory held throughout the logistics system by producing quantities near to current demand. But there are increased costs of set-ups and line changes associated with short production runs.

On the other hand, the production of large quantities of product results in a lower per-unit cost.

### **2.3 Purchasing Economies**

Warehousing is also necessary if a company is to take advantage of quantity purchase discounts on raw materials or other products. Not only is the per-unit price lower as a result of the discount but if the company pays the freight, transportation costs will be less on a volume purchase because of transportation economies. Similar discounts and savings can accrue to manufacturers, retailers, and wholesalers. Once again, however, those savings must be weighed against the added inventory costs that will be incurred as a result of larger inventories.

### **2.4 Constant Supply**

Holding inventories in warehouses may be necessary in order to maintain a source of supply. For example, the timing and quantity of purchases is important in retaining suppliers, especially during periods of shortages. It also may be necessary to hold an inventory of items that may be in short supply as the result of damage in transit, vendor stock-outs, or a strike against one of the company's suppliers.

### **2.5 Customer Service Level**

Customer service policies, such as a 24-hour delivery standard, may require a number of warehouses.

The majority of firms use warehousing in order to accomplish least total cost logistics at some prescribed customer service level. The use of warehousing enables management to select the transport modes and inventory levels that, when combined with communication and order processing systems and production alternatives, optimize total costs while providing a desired level of customer service.

## **3. Competitive Drivers of Carrying Inventory**

### **a. Inventory**

A lower than average inventory results in lower flexibility but lower inventory costs.

### **b. Systems**

Systems become obsolete faster.

### **c. Suppliers**

These get absorbed or are out of business.

### **d. Process**

Shorter PLC and time compression require stricter schedule compliance.

**e. Quality**

Lower average inventory and JIT policy have less room for inventory inaccuracy.

**f. Organization**

Resistance to change.

**g. Facilities**

Outsourcing makes it easier for firms not to own facilities.

#### **4. What is the Cost of Carrying Inventory?**

- Capital cost.
- Inventory service cost.
- Storage space cost.
- Inventory risk cost.

Because of the high cost of inventory, therefore, firms attempt to keep the right quantity and right timing for customers. One such method is the use of forecasting.

#### **5. Forecasting Techniques**

Proper demand forecasting enables better planning and utilization of resources for business to be competitive. Forecasting is an integral part of demand management since it provides an estimate of the future demand and the basis for planning and making sound business decisions.

A mismatch in supply and demand could result in excessive inventory and stock outs and loss of profit and goodwill.

Both qualitative and quantitative methods are available to help companies forecast demand better.

Since forecasts are seldom completely accurate, management must monitor forecast errors and make the necessary improvement to the forecasting process.

The following forecasting techniques are available to managers.

##### **5.1 Judgment Methods**

These methods are used when there is no relevant historic data. Judgement methods rely a lot on views and opinions which are subjective.

Naive extrapolation. The application of a simple assumption about the economic outcome of the next time period, or a simple, if subjective, extension of the results of current events.

Sales-force composite. A compilation of estimates by salespeople (or dealers) of expected sales in their territories adjusted for presumed biases and expected changes.

## 5.2 Projective Forecasting

There are 2 simple techniques which qualify as projective forecasting and these are:

- a. Simple average
- b. Moving average

## 5.3 Simple Average

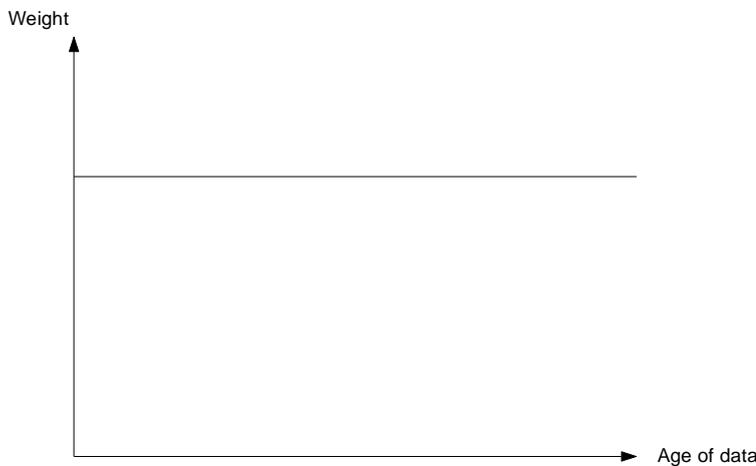


Figure 5-2: Simple Average Weighting

Period	1	2	3	4	5	6
D(t)	1	1	2	2	3	3
F(t)	-	-	1.3	1.5	1.8	2.4
% Diff			35%	25%	40%	20%

Table 5-1: Errors in Simple Average

Period	1	2	3	4	5	6
D(t)	4	6	7	8	9	12
F(t)	-	-	5	5.7	6.3	6.8
% Diff			29%	29%	30%	43%

Table 5-2: Errors in Simple Average

## 5.4 Moving Average

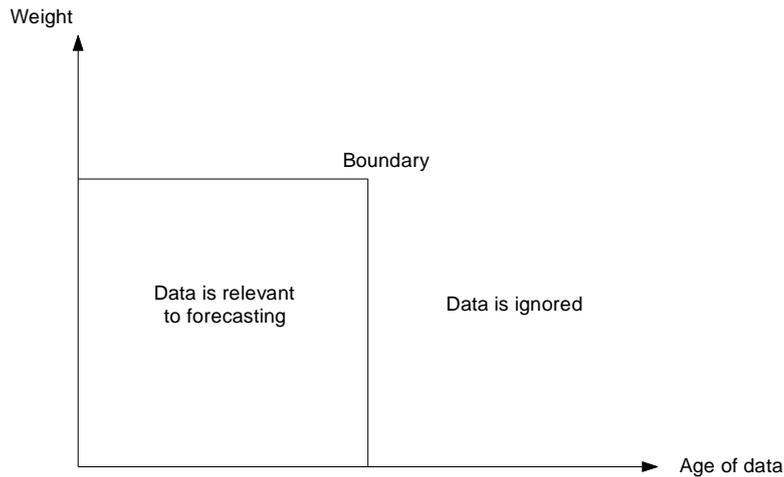


Figure 5-3: Moving Average Weighting

Using a 3-month moving average method,

T	1	2	3	4	5	6
D(t)	1	1	2	2	3	3
F(t)	-	-	-	1.3	1.7	2.3
% Diff				35%	43%	23%

Table 5-3: Errors in Moving Average

T	1	2	3	4	5	6
D(t)	4	6	7	8	9	12
F(t)	-	-	-	5.6	7	8
% Diff				30%	22%	33%

Table 5-4: Errors in Moving Average

## 5.5 Bullwhip Effect

The bullwhip effect is an observed phenomenon in forecast-driven distribution channel. It refers to a trend of larger and larger swings in inventory in response to changes in customer demand (demand variability), as one looks at firms further back in the supply chain for a product (wikipedia date accessed 1 June 2014).

Demand variability can create the bullwhip effect. A successful sales promotion can reverberate up the supply chain to disrupt inventory, production and supply ordering.

Variations due to weather and natural disasters, industrial accidents and fires, worker strikes, changes in customs and duty fees or other politically initiated unknowns all change available supply. Shortage of just one material causes a ripple in the opposite direction, driving up demand as each link increases orders to hedge against

shortages.

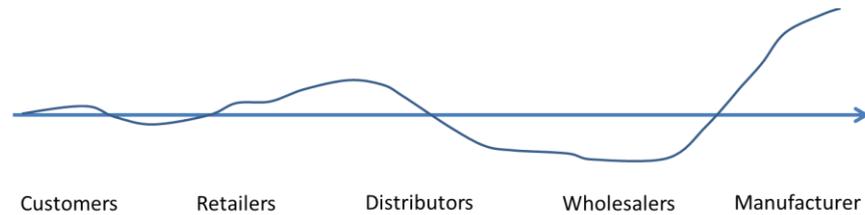


Figure 5-4: Bullwhip Effect

As shown in Figure 5-4, the bullwhip effect occurs when the demand order variabilities in the supply chain are amplified as they moved up the supply chain.

Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies.

We examine the bullwhip effect by visiting the first recorded history of the effect at Procter & Gamble (P&G):

Logistics executives at P&G examined the order patterns for one of their best-selling products, Pampers.

Its sales at retail stores were fluctuating, but the variabilities were certainly not excessive.

However, as they examined the distributors' orders, the executives were surprised by the degree of variability.

When they looked at P&G's orders of materials to their suppliers, such as 3M, they discovered that the swings were even greater.

At first glance, the variabilities did not make sense. While the consumers, in this case, the babies, consumed diapers at a steady rate, the demand order variabilities in the supply chain were amplified as they moved up the supply chain.

P&G called this phenomenon the "bullwhip" effect.

## 5.6 Causes of Bullwhip Effect

Based on the P&G case and other cases, the four major causes of the bullwhip effect are:

- **Demand forecast updating**

Forecasting, production scheduling, capacity planning, inventory control, and material requirements planning are operational activities. Forecasting is often based on the order history from the company's customers and prospects.

An important factor is each forecaster's thought process in projecting the demand pattern based on what he or she observes.

When a downstream operations person places an order, the upstream person processes that piece of information as a signal about future product demand.

Based on this signal, the upstream person readjusts his or her demand forecasts and, in turn, the orders placed with the suppliers of the upstream operation.

The perception will modify future orders.

- **Order batching**

In a supply chain, each company places orders with an upstream organization using some inventory monitoring or control.

Demands come in, depleting inventory, but the company may not immediately place an order with its supplier. It often batches or accumulates demands before issuing an order.

Consider a company that orders once a month from its supplier. The supplier faces a highly erratic stream of orders.

There is a spike in demand at one time during the month, followed by no demands for the rest of the month. Of course, this variability is higher than the demands the company itself faces.

Periodic ordering amplifies variability and contributes to the bullwhip effect.

- **Price fluctuation**

Manufacturers and distributors periodically have special promotions like price discounts, quantity discounts, coupons and rebates.

All these promotions result in price fluctuations. The result is that customers buy in quantities that do not reflect their immediate needs; they buy in bigger quantities and stock up for the future.

The shipment quantities from the manufacturer to the distributors, reflecting orders from the distributors to the manufacturer, varied more widely. When faced with such wide swings, companies often have to run their factories overtime at certain times and be idle at others.

## **5.7 Solutions**

The solutions are summarized below:

<b>Causes of Bullwhip</b>	<b>Information Sharing</b>	<b>Actions</b>
Demand forecast	<ul style="list-style-type: none"> <li>• Understand system dynamics</li> <li>• Use POS</li> <li>• EDI</li> <li>• Computerized ordering</li> </ul>	<ul style="list-style-type: none"> <li>• VMI</li> <li>• Discount for info sharing</li> </ul>
Order batching	<ul style="list-style-type: none"> <li>• EDI</li> <li>• Internet ordering</li> </ul>	<ul style="list-style-type: none"> <li>• Discount for TL / CL assortment</li> <li>• Delivery appointment</li> <li>• Consolidation</li> </ul>
Price fluctuations		<ul style="list-style-type: none"> <li>• CPFR</li> <li>• Frequent low prices</li> </ul>

## 6. Conclusion

We have covered the aspect of inventory in terms of its functionality, its costs and value to organizations. Forecasting is an important part of the management of inventory. The methods covered are basic such as judgmental methods and simple averaging and moving average.

Managing inventory can create problems within supply chains. One of its effects is bullwhip. The causes and solutions to overcome these causes are addressed in this chapter.

We now move on to managing inventory from a lean perspective. JIT will be covered in the next chapter.