

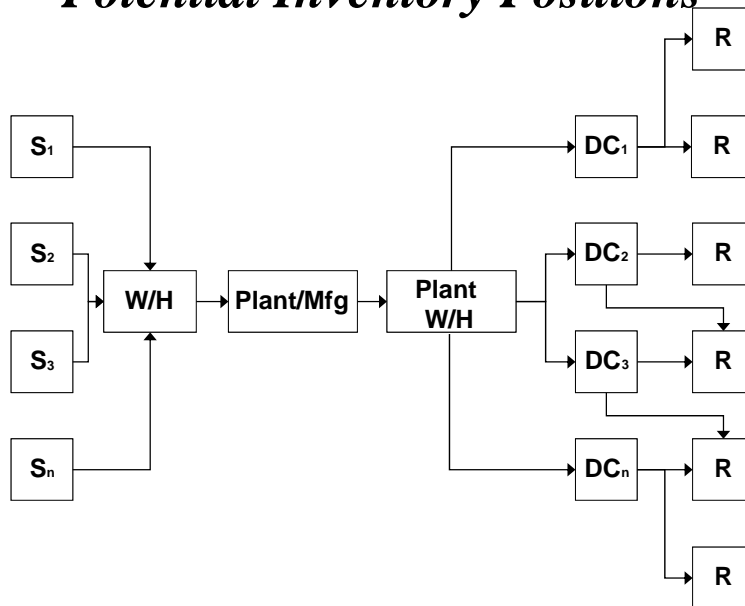
Chapter 6

Inventory in the Logistics System



- Overview and Importance
- Functional Types
- Reasons to Carry Inv.
- Inv. Cost Types
- Classifying Inv.
- Evaluating Effectiveness
- Trends in Inv. Mgt.

Potential Inventory Positions



Overview and Importance

- Inventory - “Double-Edge Sword”

- Inventory as a Percent of U.S. GNP (next slide)
- Factors Affecting Aggregate Expenditures on Inventory
 - Transportation deregulation
 - Communications and information technologies
 - Improvements in “inventory velocity”
 - Product proliferation
 - Interest rates/cost of capital

Ratio of Total U.S. Inv. to GDP

Year Ending	GDP (\$ trillion)	Inventory (\$ billion)	Inv. as a % of GDP
1980	2.80	692	24.7%
1985	4.21	847	20.1%
1990	5.80	843	14.5%
1991	5.99	875	14.6%
1992	6.32	944	14.9%
1993	6.64	1076	16.2%
1994	7.05	1127	15.9%
1995	7.40	1211	16.4%
1996	7.81	1240	15.9%
1997	8.32	1280	15.4%
1998	8.79	1323	15.1%
1999	9.30	1379	14.8%
2000	9.96	1485	14.9%

Key Inventory Trends

- Dollar Value of U.S. Inventory Continues to Rise
- Inventory/GNP or Inventory/Sales Ratios are Decreasing
- Inventory Carrying Costs are Increasing as Percent of Total Distribution Cost
- Acquisition of Higher-Value, Lower-Weight Products Will Result in Higher Costs of Carrying Inventory
- Reinforced Need for Effective Approaches to Inventory Segmentation, such as ABC Analysis

Selected Financial Data, 2002-03

Company	Current Sales (\$ billion)	Total Assets (\$ billion)	Average Inventory (\$ billion)	Inv. as a % of Total Assets
Manufacturing				
Ford Motor	162.4	276.5	6.2	2.2%
General Electric	125.6	575.2	9.2	1.6%
Kraft	29.7	57.1	3.4	6.0%
Sony	58.5	61.8	7.48	12.1%
Wholesalers and Retailers				
Fleming Co.	15.6	3.7	1.0	27.6%
K-Mart	37.0	14.3	5.8	40.6%
Kroger	49.0	18.1	4.1	22.4%
Best Buy	20.9	7.7	2.0	26.0%
Toys 'R Us	11.3	9.4	2.2	23.4%

Example: Inventory Calculations

- Inventory Carrying Cost
 = Dollar value of inventory
 x percentage carrying cost

- Example

If dollar value of inv. = \$50,00

And carrying cost = 22% of product value

Then _____ Inventory Carrying Cost

=

=

Example: Inventory Calculations

(Continued)

- Inventory Turnover = $\frac{\text{Sales}}{\text{Average Inventory}}$

- Example: K-Mart

1992 Sales = \$38.8 billion

1992 Avg. Inv. = \$8.8 billion

Inventory Turnover = $\frac{\$38.8 \text{ billion}}{\$8.8 \text{ billion}}$

= turns/year

Some Real World Examples*

Company	5-Year TSR	Revenue/ Capital	Inventory Turnover
BEST BUY	52%	15.6	8.2
CIRCUIT CITY	-8%	5.6	5.5
DELL	50%	17.7	63.7
COMPAQ	-8%	3.5	14.9
HERMAN MILLER	15%	4.0	25.3
HON INDUSTRIES	4%	2.9	16.3
WAL-MART	31%	3.8	7.2
K MART	-7%	3.5	4.2

*As of December 31, 2001.

Source: Stephen Timme, FinListics Solutions

Example: Inventory Calculations

(Continued)

- Average Day's Inventory on Hand = $\frac{\text{Avg. Inv.}}{\text{Sales}} \times 365$
- Example: K-Mart (cont.)

1992 Sales = \$38.8 billion

1992 Avg. Inv. = \$8.8 billion

Avg. Day's IOH = $\frac{\$8.8}{\$38.8} \times 365$

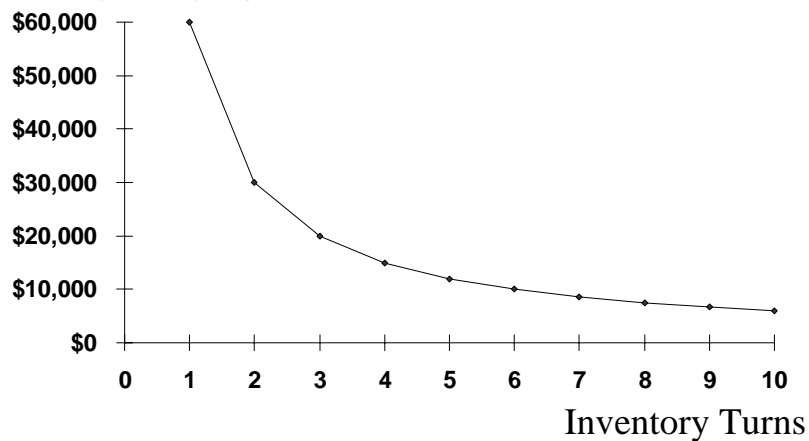
= Days

Saving Inventory Dollars by Increasing Inventory Turns

Inventory Turns	Average Inventory	Carrying Cost at 30%	Carrying Cost Savings
1	\$200,000	\$60,000	----
2	100,000	30,000	\$30,000
3	66,667		
4	50,000	15,000	5,000
5	40,000	12,000	3,000
6	33,333	10,000	2,000
7	28,571	8,571	1,429
8	25,000	7,500	1,071
9	22,222	6,667	833
10	20,000	6,000	667

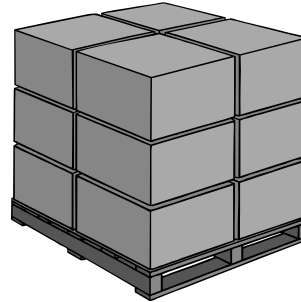
Saving Inventory Dollars by Increasing Inventory Turns

Inventory Carrying Cost

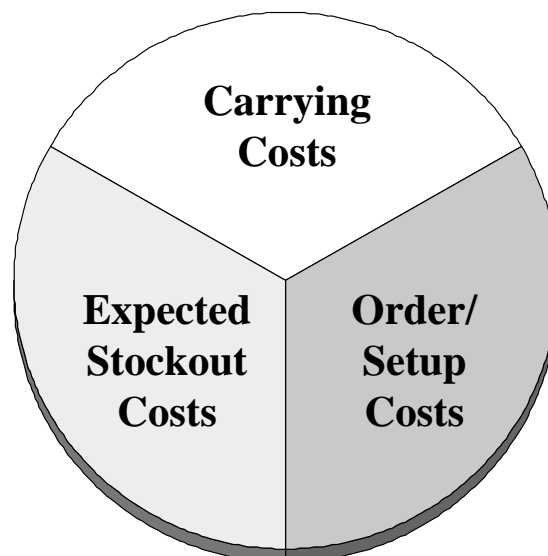


Functional Types of Inventory

- Cycle stock
- In-process stock (Goods-In-Process, WIP, In-Transit)
- Safety (buffer) stock
 - Demand and/or lead time uncertainty
 - Customer service
- Seasonal stock
- Promotional stock
 - Sales and deals
- Speculative stock
 - Fluctuating price and/or availability
 - When using long supply lines
- Dead stock



Inventory Costs



Inventory Carrying Costs

① Capital Costs

- Expressed as percentage of product value
- Based on value of average inventory
- rate is most appropriate
 - =minimum rate of return on new investments
- Observations
 - *Interest rates not entirely valid*
 - *Industry averages misleading*
 - *Most companies calculate incorrectly*
 - *Rule of thumb of 25% can be very misleading*
 - *Range of percentages found in textbooks can justify nearly any inventory policy*

Inventory Carrying Costs

(Continued)

② Storage Space Cost

- Consider only variable portion
- Will differ between public and private warehousing

③ Inventory Service Cost

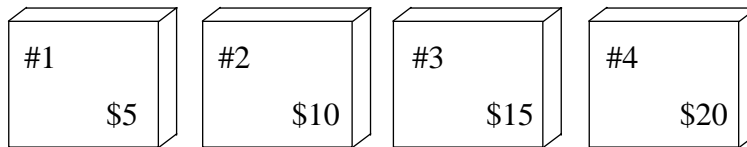
④ Inventory Risk Cost

- Deterioration
- Obsolescence
- Damage
- Pilferage and theft

Calculating Carrying Cost

① Identify Item Value

- **FIFO** (*higher inventory valuation when prices are rising - and vice-versa*)
- **LIFO** (*lower inventory valuation when prices are rising - and vice-versa*)
- **Average Cost**



Calculating Carrying Cost

(Continued)

② Measure Carrying Cost Components

Example:

Capital Cost	20%
Storage Space	8%
Inv. Service	4%
Inv. Risk	6%
	38%

③ Multiply Percent by Value

Example:

$$\begin{aligned}
 &\text{Value} = \$50 \text{ per item} \\
 &\text{Inventory Carrying Cost} \\
 &= (\$50)(.38) \\
 &= \$19.00 \text{ per item/per year}
 \end{aligned}$$

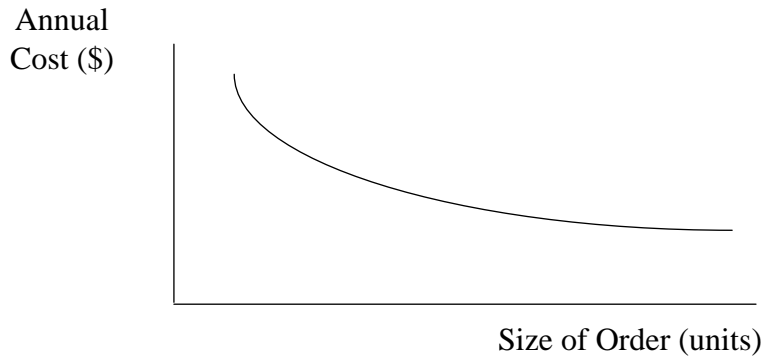
Rationale for Carrying Inventory

- Purchase Economies
- Transportation Savings
- Reduce Risk

Inventory In-Transit vs. In the DC

Inventory Carrying Cost	Inventory In-Transit vs. Inventory in DC
Capital	Same
Storage	Not relevant to inventory in-transit
Service	Taxes - not relevant Insurance - need to consider
Risk	Exposure is <u>less</u> for inventory in-transit

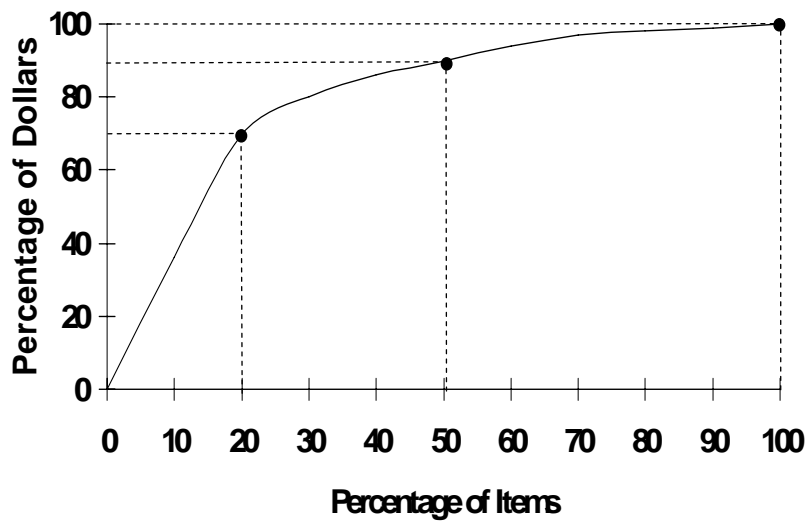
Order / Setup Cost



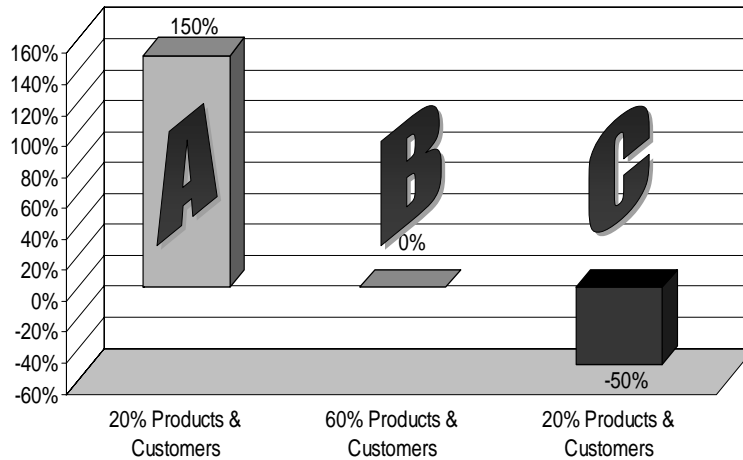
Note: Order / setup cost reflects:

- Fixed costs (e.g., information and communications technology)
- Variable costs (e.g., reviewing stock levels, order processing/ preparation expense, etc.)

ABC Inventory Classification



ABC's Financial Facts of Life



Source: Stephen Timme, *FinListics Solutions*.

Measuring Effectiveness of Inventory Management

- End-Users Satisfied?
- Frequent Need for “Backordering” or “Expediting”?
- Order Cancellations?
- Inventories Available at “Right” Locations?
- Measures of Inventory Turnover
 - Too low?
 - Too high?

Symptoms of Poor Inventory Mgt

- Increasing back-order status
- increasing dollar investments in inventory with back-orders remaining constant
- High customer turnover rate
- Increasing number of orders being canceled
- Periodic lack of sufficient storage space
- Wide variance in inventory turnover among distribution centers and among major inventory items
- deteriorating relationships with middlemen as typified by dealer cancellations and declining orders
- Inventories rising faster than sales
- Customers not satisfied
- Inventory turnover too low

Current Inventory Trends

- Shifting Inventory Positioning
 - From retailers to distributors
 - From distributors to manufacturers and suppliers
 - Out of the system whenever possible
- Accelerating use of point-of-sale (POS) and real-time information to make inventory replenishment decisions; company processes for order processing and inventory management are being integrated
- New providers of inventory services
 - Wholesalers in support of retailers
 - 3rd party/contract logistics suppliers
 - Other supplier firms in complementary businesses
- Search for effective, contemporary approaches to inventory management and control

Chapter 7

Inventory Decision Making



- Fundamental Approaches
 - Fixed Order Quantity
 - Fixed Order Interval
- Inventory at Multiple Locations
- Time Based Approaches
 - QR and ECR
- Comparison of Various Methods

Fundamental Approaches

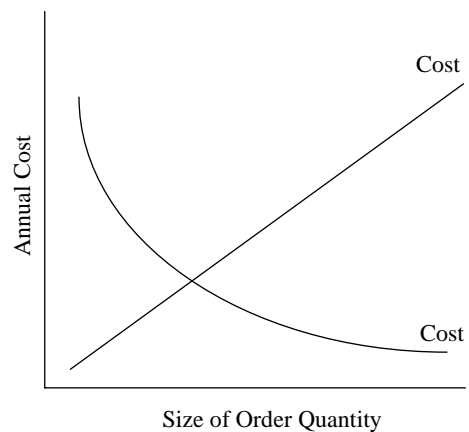
- Nature of Demand
 - Independent vs. Dependent
- Driver or Trigger of Order
 - Pull vs. Push or Hybrid
- Company or Supply Chain Philosophy
 - Systemwide vs. Single-Facility Solution

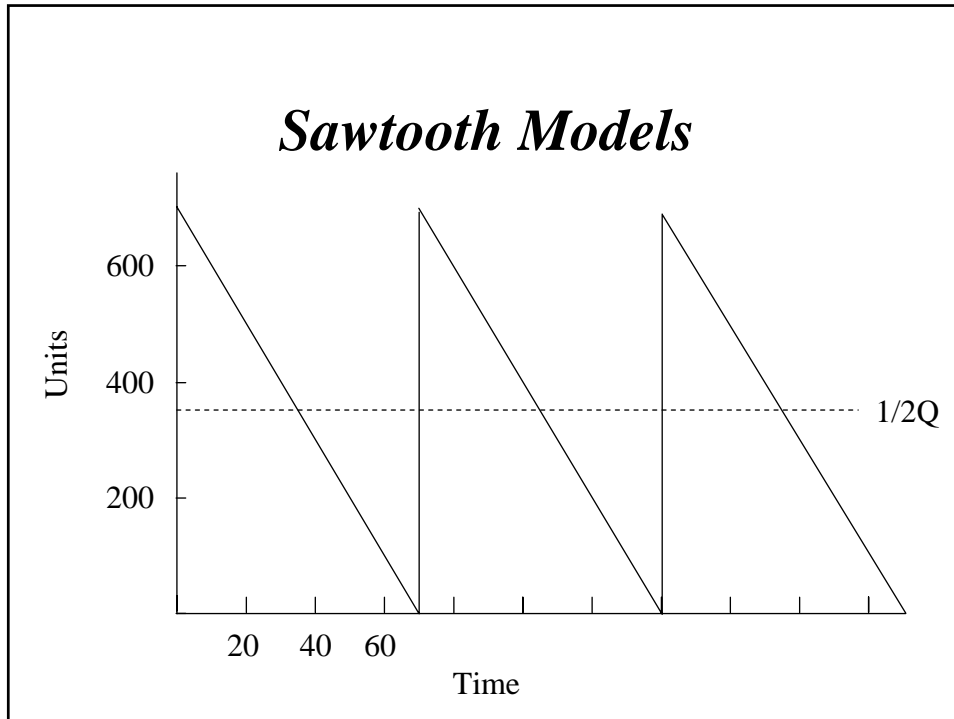
Fixed Order Quantity (EOQ) Approach

- Key Questions:
 - How much to reorder?
 - When to reorder?
 - Total cost?
- Two Tradeoffs
- Principle Assumptions (CBL, pp. 195)
 - Demand is continuous, constant, and known in advance
 - Lead time is constant and known in advance
 - Price of item is independent of order quantity

Basic Tradeoffs

- As order quantity (EOQ) increases:
 - Annual inventory carrying cost also increases
 - Annual ordering cost decreases
 - Example: CBL, pp. 196-198





Mathematical Formulation

- Total Annual Cost = Annual Inventory Carrying Cost + Annual Ordering Cost
- Letting TAC = Annual Total Cost (\$)
 - R = Annual demand (units)
 - A = Cost of placing a single order (\$)
 - V = Value of one unit of inventory (\$)
 - W = Inventory carrying cost as a % of product value
 - Q = EOQ
- Then: $TAC = 1/2 QVW + A (R/Q)$
- and: the EOQ that minimizes the TAC is:

$$Q = \sqrt{\frac{2RA}{VW}}$$

Example of EOQ

R = Annual demand = 600 units

A = Order cost = \$4/order

V = Product value = \$240/unit

W = inventory carrying cost = 20% = 0.20

$$Q = \sqrt{\frac{2RA}{VW}} = \sqrt{\frac{2(600)4}{(240)(0.20)}} = \sqrt{\frac{4,800}{48}}$$

$$= \sqrt{100} = 10 \text{ units}$$

Example of TAC:

R = Annual demand = 600 units

A = Order cost = \$4/order

V = Product value = \$240/unit

W = inventory carrying cost = 20% = 0.20

Then:

$$\begin{aligned} \text{TAC} &= 1/2 QVW + A (R/Q) \\ &= 1/2 (10) (240) (0.20) + (4) (600/10) \\ &= 240 + 240 \\ &= \$480 \end{aligned}$$

Determining the Reorder Point

The Goal is to have a shipment of EOQ units to arrive as the
Balance-On-Hand = 0

Reorder Point (ROP)

= minimum amount of inventory to last during the replenishment or lead time
= [Lead time length (in days)] X [Demand per day (in units per day)]

Continuing Example: (Assume 300 days per year)

Lead time length = 12 days

Then Demand per day = 600 / 300

= 2 units/day

ROP = (12 days) (2 units/day)

ROP = **24 units**

Additional exercises to do at home: CBL, pp. 230, #7 and 8

EOQ Review

- Perhaps the most well-know, traditional approach to managing inventory
- computes an “optimum” value for the economic order quantity (EOQ) based on a trade-off of two types of cost:
 - Inventory carrying cost
 - Ordering cost or setup cost
- Replenishment orders placed when inventory-on-hand reaches a pre-determined “ROP”
- currently declining in popularity and frequency of use:
 - Too much emphasis on carrying inventory
 - Not very useful for systems with multiple distribution centers
 - Greater emphasis today on approaches which “synchronize” delivery of shipments with timing of actual need (e.g., JIT)

Related Concepts

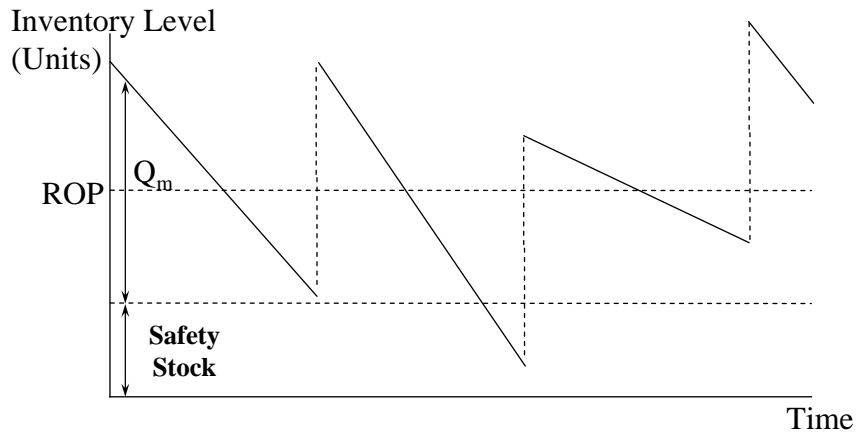
- “Two-bin” system
- “Min-max” system
 - demand may occur in larger increments than with the traditional EOQ approach

EOQ in Condition of Uncertainty

- Uncertainty = variation in demand and/or lead time
- Requires holding of safety stock inventory
- Policy: Cost of carrying safety stock should be balanced with expected cost of stockouts
- Average inventory = $1/2 \text{ EOQ} + \text{Safety Stock}$
 - skip CBL, pp. 205-211 on “how to calculate example”

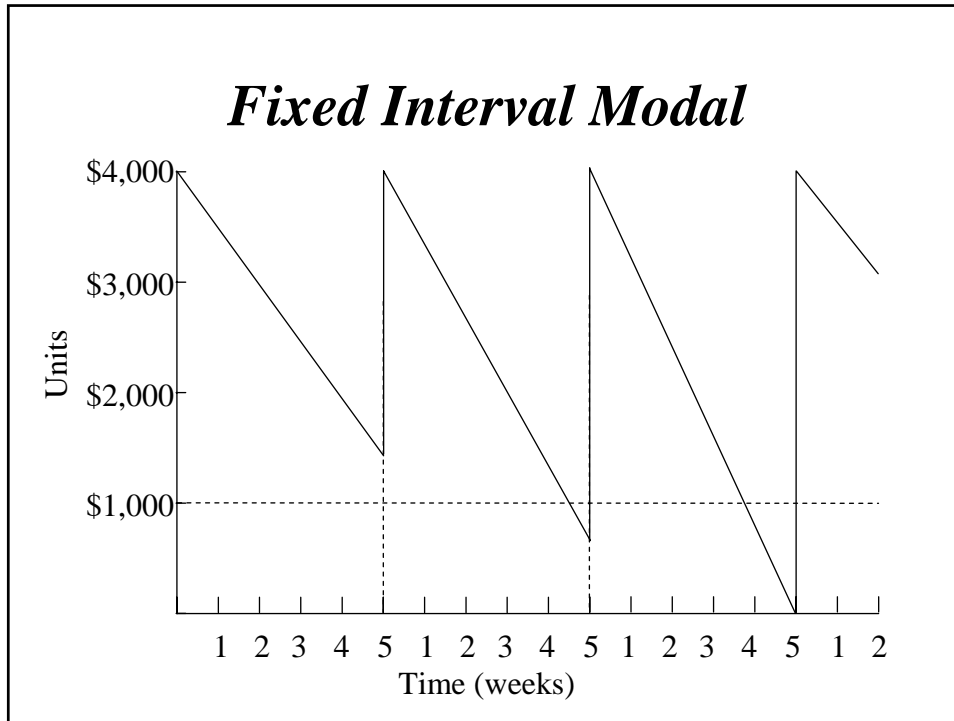
Inventory Model Under Conditions of Uncertainty

- EOQ is still the amount ordered each time
- Assumes that over time, uncertainty periods balance out



Fixed Order Interval

- Involves ordering of inventory at fixed or regular intervals
- Amount order depends on how much is on-hand at the time of ordering (NOT EOQ)
- Implications:
 - Does not require close surveillance of inventory levels
 - Inventory monitoring less expensive
 - Over time, it results in higher safety stock levels



***Inventory at Multiple Locations
Square Root Rule***

- How does total inventory change as the number of stocking points changes?
- Let:
 - n_1 = number of existing facilities
 - n_2 = number of future facilities
 - x_1 = total inventory in present facilities
 - x_2 = total inventory in future facilities

$$x_2 = x_1 \sqrt{\frac{n_2}{n_1}}$$

Example: Square Root Law

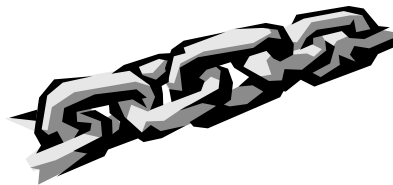
- Currently, the company has 50,000 units located in 3 facilities. The company plans to expand to 27 locations. How will this affect total inventory?

$$x_2 = x_1 \sqrt{\frac{n_2}{n_1}} = 50,000 \sqrt{\frac{27}{3}}$$

$$= 50,000 \sqrt{9} = \mathbf{150,000 \text{ units}}$$

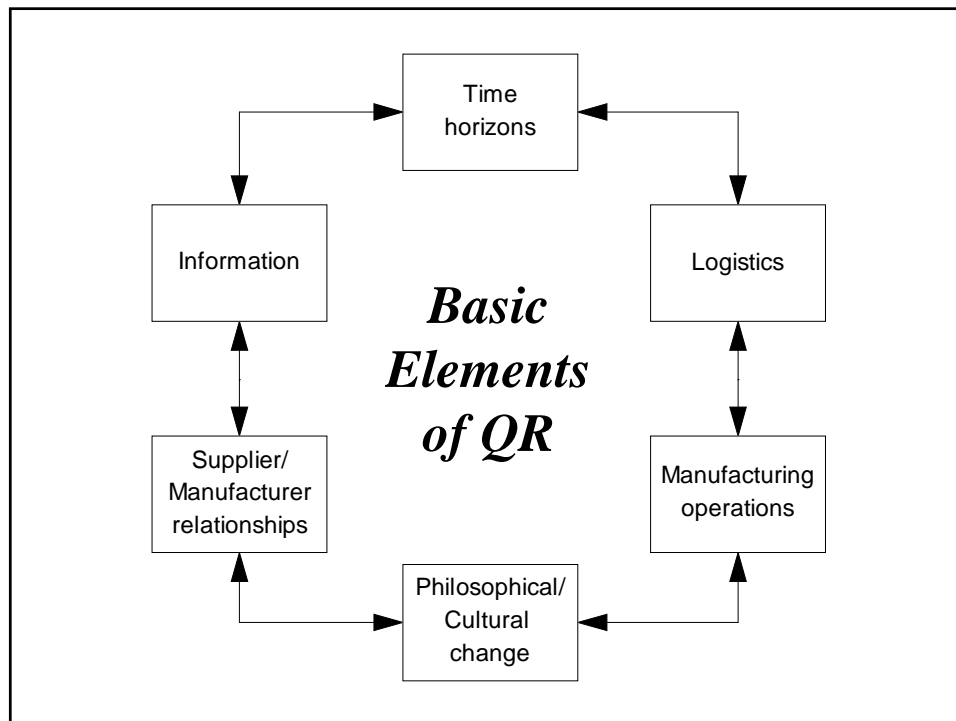
Time Based Approaches to Replenishment Logistics

- Continuous Replenishment (CRP) Inventory Systems
- Flow-Through Logistics Systems
- Pipeline (Supply Chain) Logistics Organizations
- Pipeline Performance Measures



Quick Response (QR)

- QR is a method of maximizing the efficiency of the supply chain by reducing inventory investment where partners commit to meet specific service performance criteria.
 - shorter, compressed time horizons
 - Real-time information by SKU
 - Seamless logistics network
 - Partnership relationships throughout the supply chain
 - Commitment to Quality



QR Profit Sources

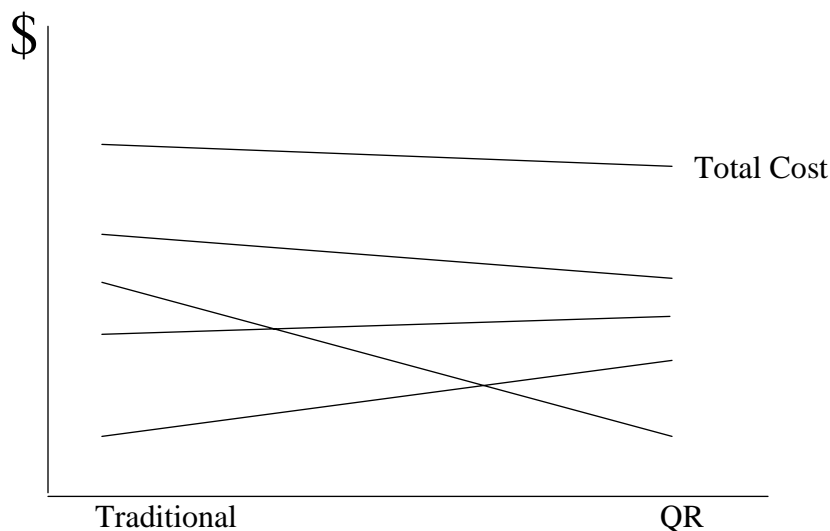
Faster Order Placement
Shorter Lead Times **➔** Reduced Cycle Stock

Rapid Reaction to Demand
More Reliable Lead Times **➔** Reduced Safety Stock

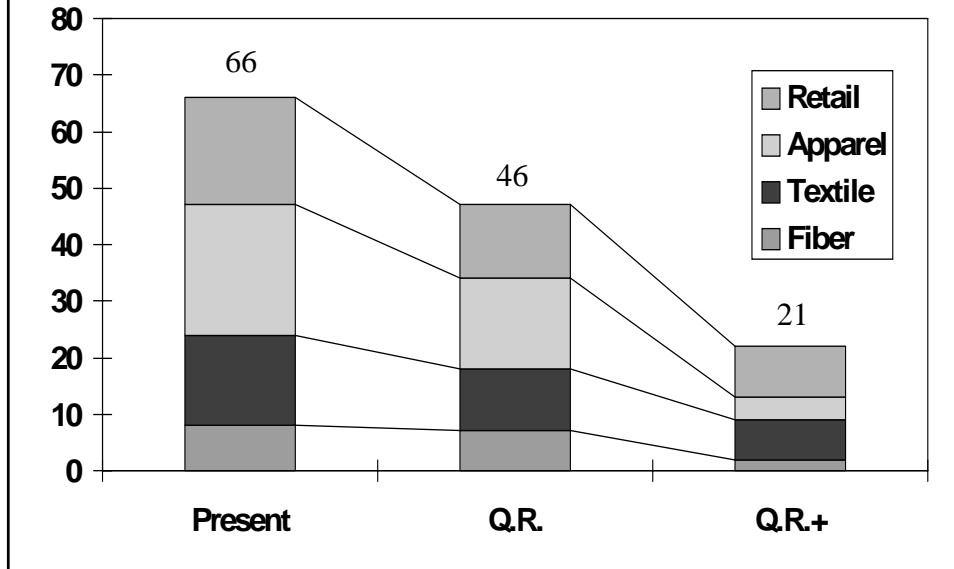
Fast Response to
Sales Trends **➔** Lower Markdowns
Higher Sales

Higher Sales
Lower Markdowns **➔** Greater Profitability
Reduced Total
Channel Costs

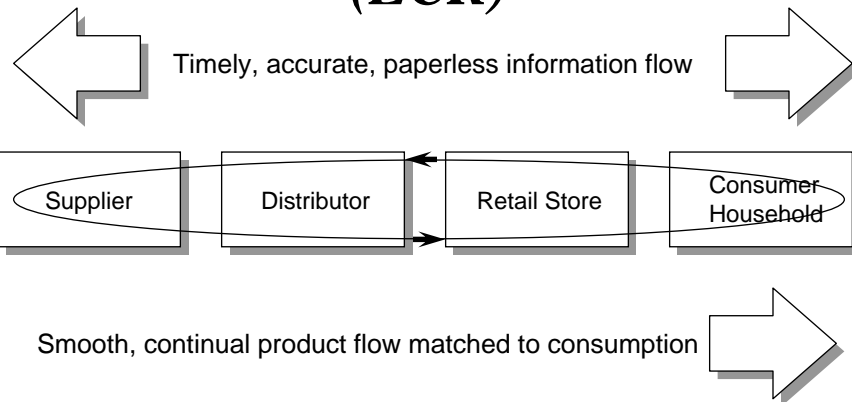
QR Overall Cost/Revenue Implications



Time Savings from QR



Efficient Consumer Response (ECR)



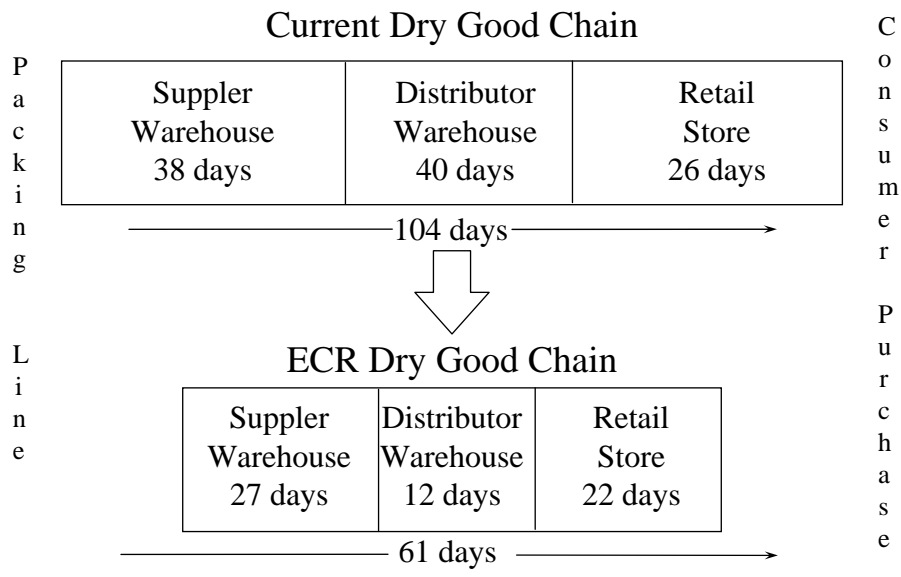
Source: Kurt Salmon Associates, Inc. Efficient Consumer Response: Enhancing Consumer Value in the Grocery Industry

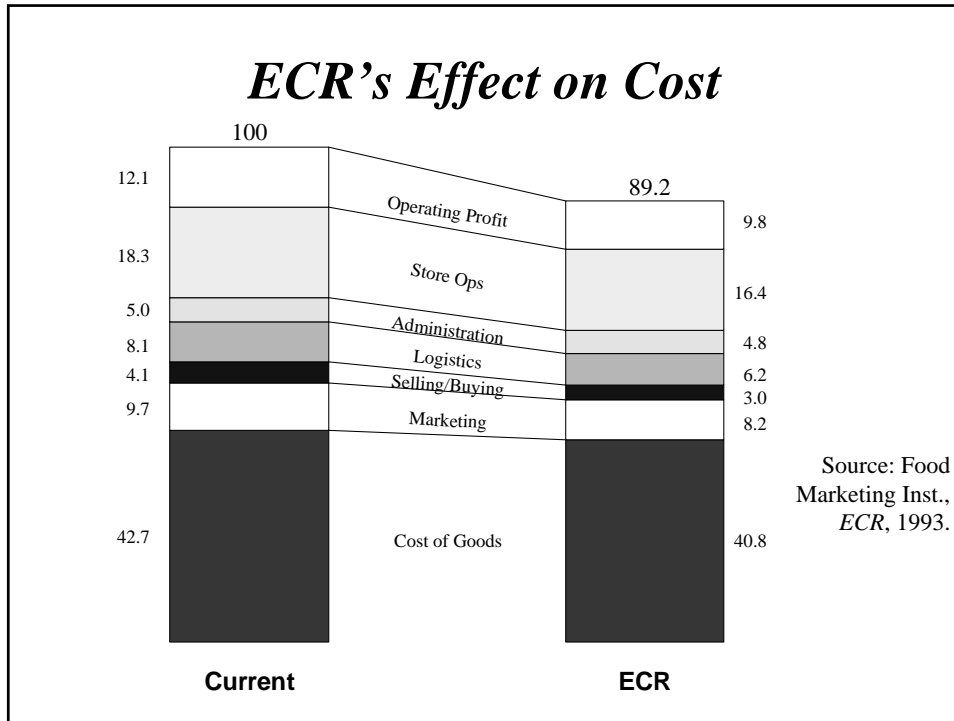
ECR

- **Components**
 - Category management (Managing product groups as strategic business units)
 - Integrated electronic data interchange (EDI)
 - Activity-Based Costing (ABC)
 - Continuous replenishment programs
 - Flow-through cross-dock replenishment

- **Benefits**
 - Better - products, assortments, in-stock performance, and prices
 - Leaner, faster, more responsive, less costly supply chain
 - Improved asset utilization

ECR Impact on Dry Grocery Chain





Comparing EOQ and MRP

<u>EOQ</u>	<u>MRP</u>
<ul style="list-style-type: none"> • Independent demand • Pull/push • Sales forecast based on past experience • Single facility 	<ul style="list-style-type: none"> • Dependent demand • Push • Requirements based on current and future demand • Entire system

Comparisons of Approaches

	Push vs. Pull	Dependent vs. Indep.	Systemwide vs. Single
EOQ	Pull/Push	I	Single
JIT	Pull	D	Single
MRP	Push	D	System
DRP	Push	I	System

Source: C. John Langley, Jr.