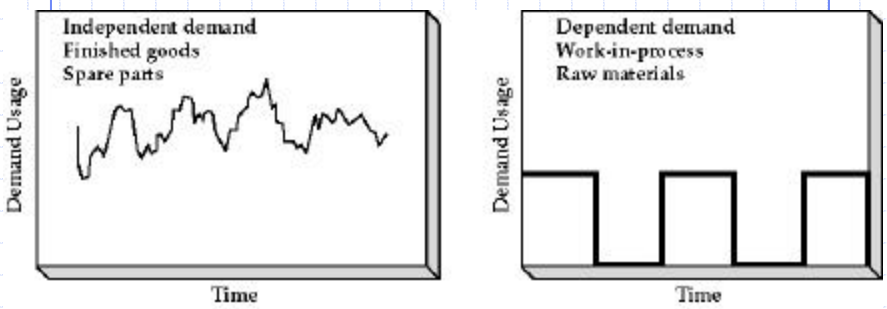
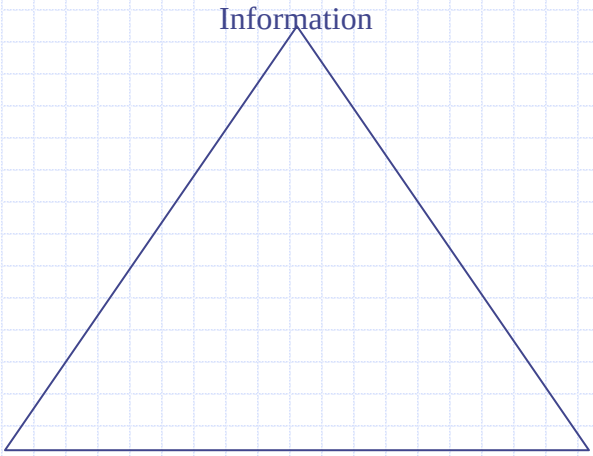
Independent-Demand Inventory



1

LOVEJOY'S LAW

(as used by Dell Computer)



2

"The secret to Dell's flexible manufacturing is holding almost no inventory. Outside suppliers take that risk."

Business Week, March 29, 1999, p. 106.

3

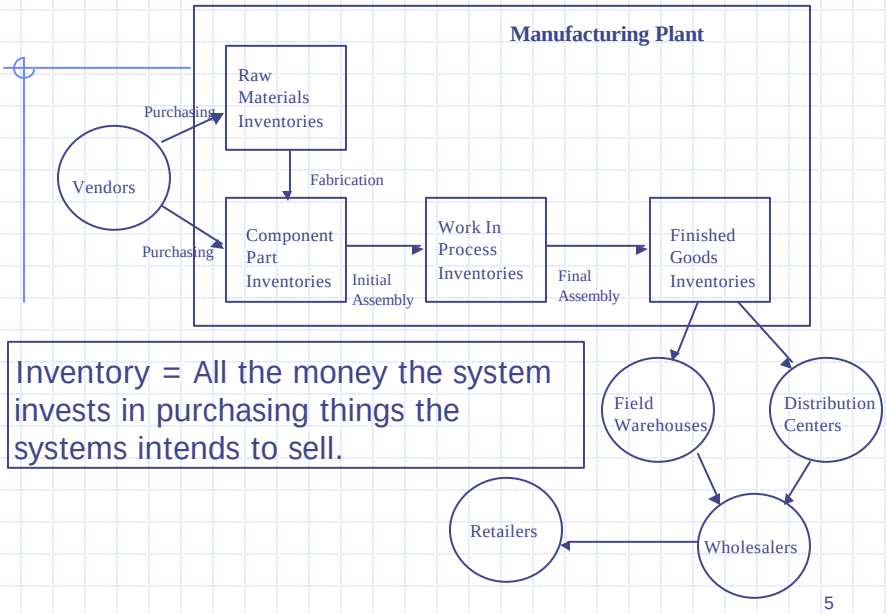
Dell to Detroit: Get Into Gear Online!

"The other thing that kind of pops out in this is the amount of assets that are tied up [in the old system]. … So the biggest item on the balance sheet of these car manufacturers is inventory. … It's not just their inventory, it's the dealer inventory, it's the in-transit inventory, it's inventory anywhere in the system from the components all the way through to the end customer.

Source: Wall Street Journal, 12/1/99, p. B1/B4.

4

Types of inventory



Inventory = All the money the system invests in purchasing things the systems intends to sell.

Source: Markland, Vickery & Davis, Operations Management, p. 430.

5

	Type of Process / Industry			
Characteristics	Job Shop	Batch Flow	Assembly	Process
Number of customers	Many	Many, but fewer	Less	Few
Product differentiation	Customized	Less customized	More standardized	Standardized
Material requirements	Difficult to predict	More predictable	Predictable	Very predictable
Inventories				
raw materials	Small	Moderate	Varies, frequent deliveries	Large, continuous deliveries
WIP	Large	Moderate	Small	Very small
Finished goods	None	Varies	High	Very high
Scheduling	Uncertain, frequent changes	Frequent expediting	Often established in advance	Inflexible
Operations Challenges	Increasing labor and machine utilization, fast response, breaking bottlenecks	Balancing stages, designing procedures, responding to diverse needs	Rebalancing line, productivity improvement, adjusting staffing levels, morale	Avoiding downtime, timing expansions, cost minimization

Source: table 3.2, p. 38, Inventory Management and Production Planning and Scheduling, Silver, Pyke and Peterson

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Inventory Planning Decision Variables

Service requirements
- Customer expectations
- Competitive practices
- Customer promise time required
- Order completeness required
- Ability to influence and control customers
- Special requirements for large customers

Demand patterns
- Variability
- Seasonality
- Extent of deals and promotions
- Ability to forecast
- Any dependent demand?
- Substitution?

Cost Factors
- Stockout
- Carrying costs
- Expediting
- Write-offs
- Space
- Spoilage

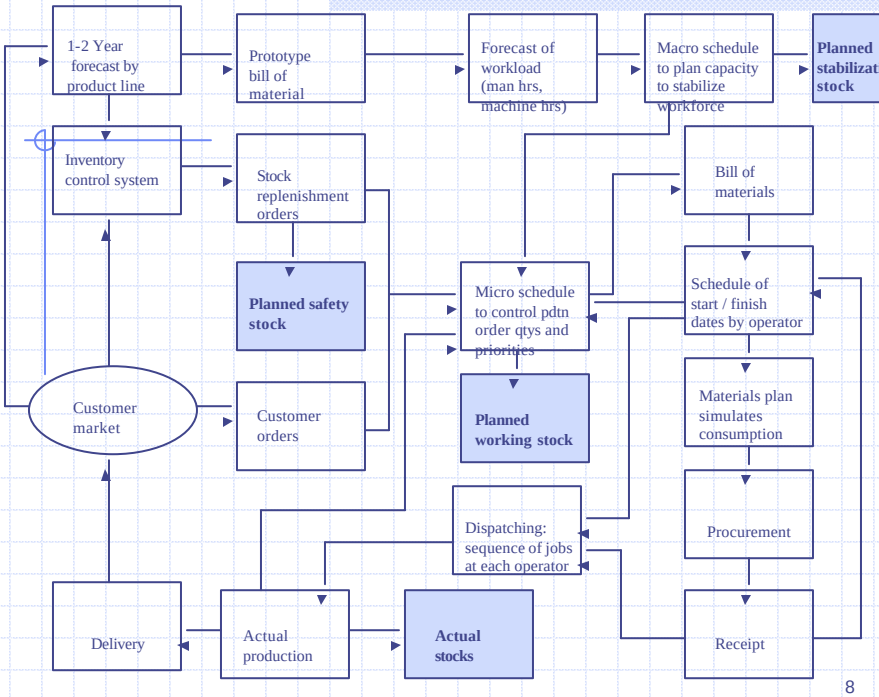
Customer Ordering Characteristics
- Order timing
- Order size
- Advanced information for large orders
- Extent of open or standing orders
- Delay in order processing

Supply Situation
- Lead times
- Reliability
- Flexibility
- Ability to expedite
- Minimum orders
- Discounts
- Availability
- Production versus non-production

Nature of the Product
- Consumable
- Perishable
- Recoverable / repairable

7

Source: p. 49, Inventory Management and Production Planning and Scheduling, Silver, Pyke and Peterson



8

Robert Brown, Management Decisions for Production Operations, p. 155

Purpose of Inventories

- To protect against uncertainties
- To allow economic production and purchase
- To cover anticipated changes in demand or supply
- To provide for transit

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Inventory Cost Structures

- Item cost
- Ordering (or setup) cost
- Carrying (or holding) cost:
  - Cost of capital
  - Cost of storage
  - Cost of obsolescence, deterioration, and loss
- Stock out cost

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Continuous Review System

- Assumption of “constant demand” is relaxed.
- Monitoring of “on hand” stock position in a continuous system
- *Q system* (another name for continuous review system)

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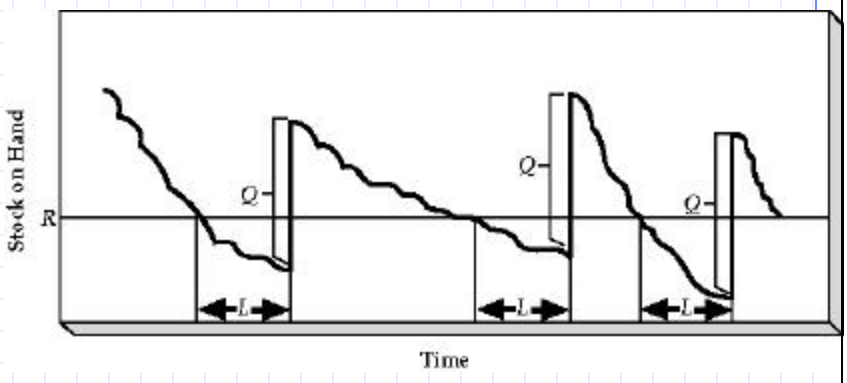
A Continuous Review (Q) System



R = Reorder Point
Q = Order Quantity
L = Lead time

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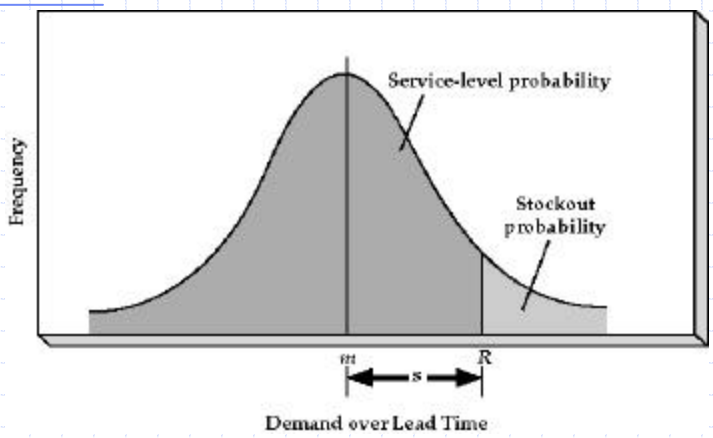
Probability Distribution of Demand over Lead Time



m = mean demand *R* = Reorder point *s* = Safety stock

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EOQ Model - Economic Order Quantity Assumptions

- Demand rate is constant, recurring, and known.
- Lead time is constant and known.
- No stockouts allowed.
- Material is ordered or produced in a lot or batch and the lot is received all at once
- Unit cost is constant (no quantity discounts)
- Carrying cost depends linearly on the average level of inventory
- Ordering (setup) cost per order is fixed
- The item is a single product

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Notations and measurement units in EOQ

D = Demand rate, units per year

S = Cost per order placed, or setup cost, dollars per order

C = Unit cost, dollars per unit

i = Carrying "interest" rate, percent of dollar value per year

Q = Lot size, units

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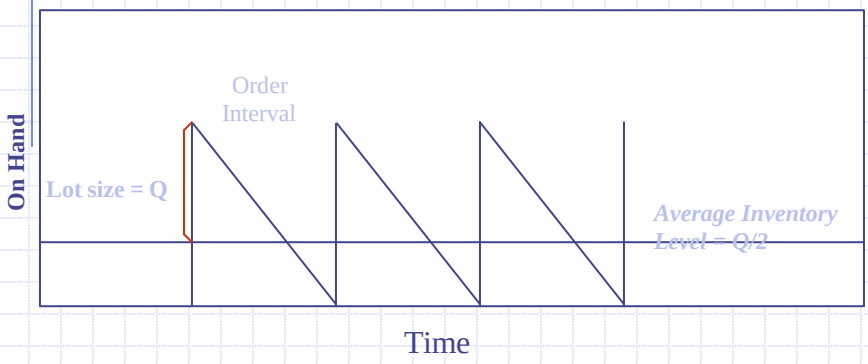
EOQ Inventory Levels



Source: Schroeder, Operations Management, Figure 15.5.

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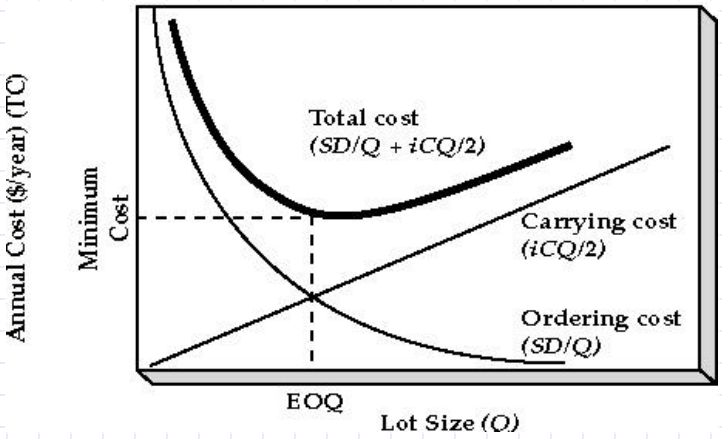
Total Cost of Inventory



Source: Schroeder, Operations Management, Figure 15.6.

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Key Formulas

Quantity

$$Q=\sqrt{\frac{2DS}{iC}}$$

Reorder Point

$$R=m+s \quad where$$

$$s=z\,s$$

Inventory Level

$$I=Q/2+zs$$

Inventory Investment

$$(Q/2)C+(zs)C$$

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Example

Given: annual demand is 4000, set up cost is $100, Item cost is $266.67, facility is open 5 days a week, 50 weeks / year, lead time is 9 days with a standard deviation of demand of 2 units per day, 95% service level carrying cost of 30% per year.

Find order quantity and reorder point.

19

A toy manufacturer uses approximately 32,000 silicon chips annually. The chips are used at a steady rate during the 240 days the plant operates. Annual carrying cost is 30%. The chips cost $2 each. The ordering cost is $24.

Compute Q and the Annual Total Cost for Carrying & Ordering based on optimal Q value.

20

Periodic Review Sysem

- All assumption of EOQ (except that demand is constant and “no stockout”) remains in effect.
- Also known as “P System” or “Fixed-order-Interval System”

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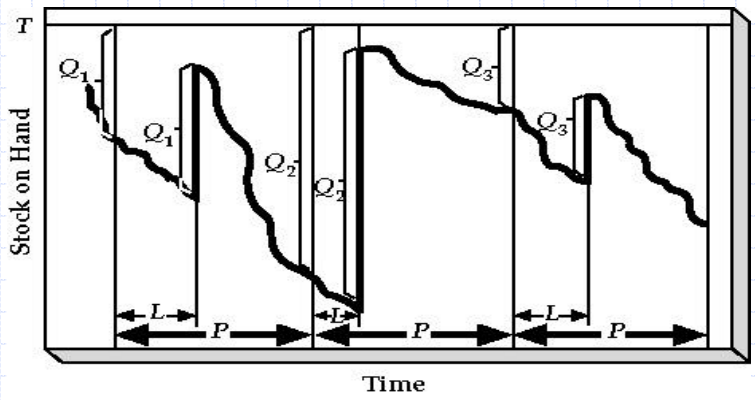
A Periodic Review (P) System



22

"Time Between Orders (P) and Target Level (T) Calculation

$$P = \sqrt{\frac{2S}{iCD}}$$

$$T = m' + s',$$

$$\text{where } s' = zs'$$

Where:

m' = average demand over P+L

s' = safety stock

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Example

Given: average annual sales is 200 units,
Order costing cost is $25 per order,
Carrying cost is 25% per year,
Item cost is $400 per unit,
Lead time is 4 days,
Standard deviation of daily demand is 0.1 units,
Working days per year is 250.

Determine P system characteristics for a 95% service level.

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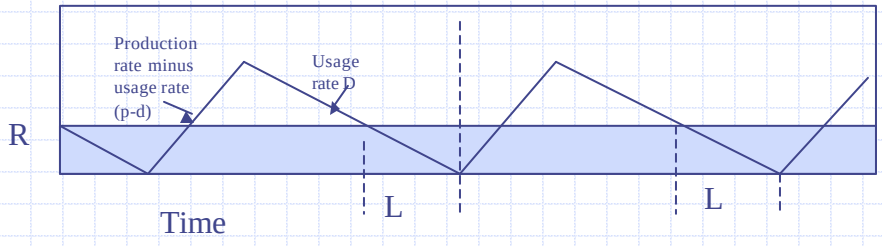
Uniform Lot Delivery

$$Q = \sqrt{\frac{2DS}{iC\left(1 - \frac{D}{P}\right)}}$$



25

A company is both a producer and consumer of brass couplings. The firm operates 220 days a year and uses the couplings at a rate of 50 per day. Couplings can be produced at a rate of 200 per day. Annual carrying cost is 25% and couplings cost $4 each. Machine set up costs are $35 per run.

What is the economic run size?

26

Using P and Q System in Practice

- Use P system when orders must be placed at specified intervals.
- Use P systems when multiple items are ordered from the same supplier (joint-replenishment).
- Use P system for inexpensive items.

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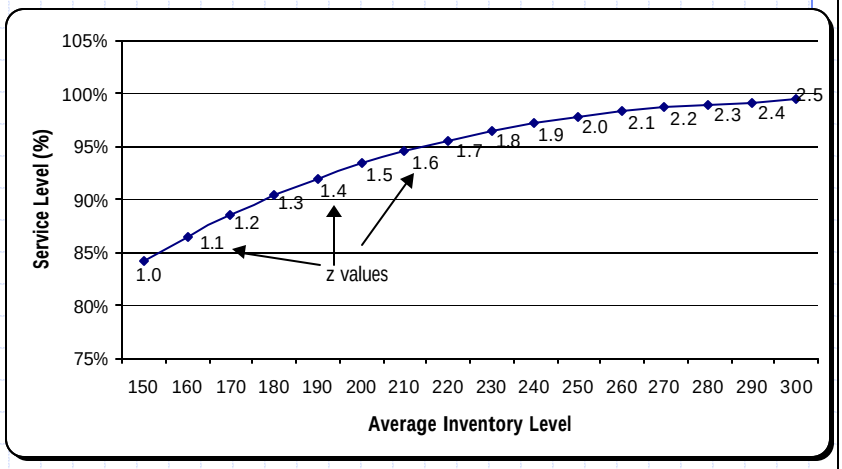
Service Level versus Inventory Level



$Q = 100$

$s = 100$

Source: Schroeder, Operations Management, Figure 15.10.

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Special purpose models: "newsboy" model

Notation:
x = random variable for demand
G(x) = cumulative function of demand
g(x) = density function of demand
c_o = cost per unit left over
c_s = cost per unit of shortage
Q = order quantity

$$G(Q^*) = \frac{c_s}{c_o + c_s}$$

Source: Hopp and Spearman, Factory Physics, p. 72-76.

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Scenario

Suppose it takes $1 to make and distribute an item with a $2 selling price and a $0.50 discounted selling price.

Further suppose the demand can be approximated by a normal distribution with a mean of 10,000 and a standard deviation of 1,000. How many to order?

If demand is less than 10000, then lose 0.50 per unit.
If demand is more than 10000, then $1 per unit in lost sales.

Co = 1 - .5 = .5
Cs = 2 - 1 = 1

Source: Hopp and Spearman, Factory Physics, p. 72-76.

30

$$G(Q^*) = \frac{c_s}{c_o + c_s}$$

Z value with an area to the left of

$$\Phi\left(\frac{Q^* - m}{s}\right) = \frac{Cs}{Cs + Co} = \frac{1}{1 + .5} = .67$$

$$\Phi(.44) = .67$$

$$.44 = \frac{Q^* - 10000}{1000}$$

$$Q^* = 10,440$$

Source: Hopp and Spearman, Factory Physics, p. 72-76.

Exercise

An airconditioning company is considering the purchase of portable a/c manufactured in Japan. Each unit will cost $80 and it will be sold for $125. The company does not want to carry surplus a/c over until the next year. Thus all supplies will be sold to a wholesaler who has agreed to take the excess units for $50 per unit. Assume the a/c demand can be modeled using a normal distribution with a mean of 20 and a standard deviation of 6. What is the recommended order quantity?

Answer = 21.5 or 22.

Source: James Evans, OM, p. 496.

Exercise

A popular newsstand in a large metropolitan area is attempting to determine how many copies of the Sunday paper it should purchase each week. Demand for the Sunday paper can be approximated with a normal distribution with a mean of 450 and a standard deviation of 100. The newspapers cost the newsstand 35 cents and they are sold for 50 cents a copy. The newsstand does not receive any value from surplus papers and thus absorbs a 100% loss on all unsold papers.

Answer = 398

Source: James Evans, OM, p. 496.

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Insights from Newsboy Model

1. With uncertain demand, the order quantity depends on both the distribution of demand and the relative costs of overproducing versus under-producing.

2. In general, increasing the variability of demand will increase the order quantity and therefore increase the likelihood that actual demand is far from what is ordered. This implies that mean and variance of total cost will increase with variability of demand.

Source: Hopp and Spearman, Factory Physics, p. 72-76.

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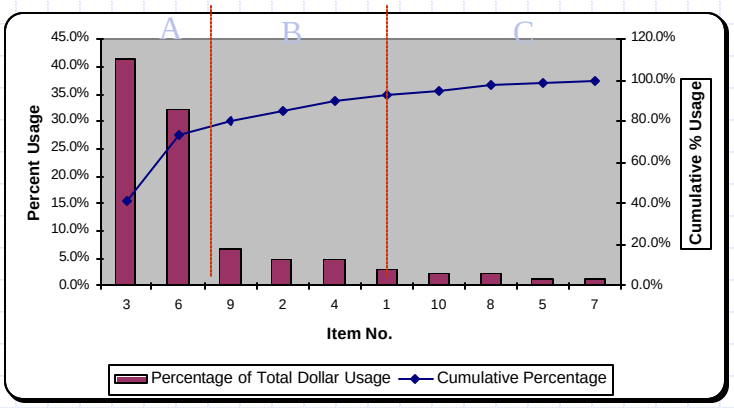
ABC Chart

- Based on “Pareto” concept (80/20 rule)
- Classification of items as A, B, or C



Source: Schroeder, Operations Management, Table 15.4.

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