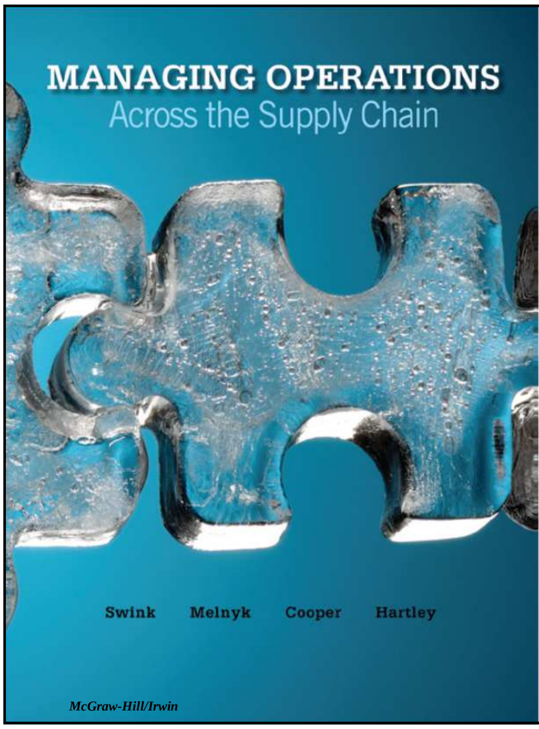

CHAPTER FOURTEEN

Independent Demand Inventory Planning

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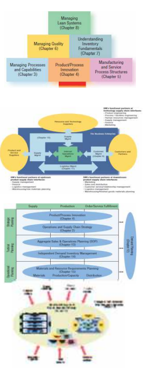
Where We Are Now



Chapter	Relationships	Sustainability	Globalization	Organizational Culture/Ethics	Change Management	Measurement
Part 1 Supply Chain: A perspective for Operations Management						
1. Introduction to Managing Operations Across the Supply Chain	X	X	X			
2. Operations and Supply Chain Strategy	X	X	X	X	X	X
Part 2 Foundations of Operations Management						
3. Managing Processes and Capabilities	X					X
4. Product/Process Innovation	X	X	X		X	
5. Manufacturing and Service Process Structures	X		X	X		X
6. Managing Quality	X	X	X	X	X	X
7. Understanding Inventory Fundamentals	X		X			X
8 Lean Systems	X		X	X	X	X
Part 3 Integrating Relationships Across the Supply Chain						
9. Customer Management	X					X
10. Supplier Management	X	X	X	X		X
11. Logistics Management	X	X	X			
Part 4 Planning of Integrated Operations Across the Supply chain	X					
12. Demand Planning: Forecasting and Demand Management	X		X			X
13. Sales and Operations Planning	X		X			X
14. Independent Demand Inventory Planning	**X**					**X**
15. Materials and Resource Requirements Planning	X		X			X
Part 5 Managing Change in Supply Chain Operations						
16. Project Management	X	X	X	X	X	X
17. Evolving Business Models and Change Drivers in the Supply Chain	X	X	X	X	X	

14–2

Learning Objectives

1. Describe elements of an inventory policy
2. Explain differences between inventory planning models
3. Calculate inventory policy parameters
4. Determine cost of firm's service level
5. Explain cost/benefit of strategies
6. Describe inventory planning techniques

14–3

Inventory Control Objectives

- We need to answer the following questions in order to balance supply and demand, and balance costs and service levels.
  - –*When* do I order?
  - –How *much* do I order?
  - –*Where* do I deploy the inventory?

14–4

Inventory Management

- ***Independent Demand***: demand is beyond control of the organization

- ***Dependent Demand***: demand is driven by demand of another item

14–5

Continuous Review Model

- ***Continuous Review***: inventory levels are constantly monitored to determine when to place a replenishment order

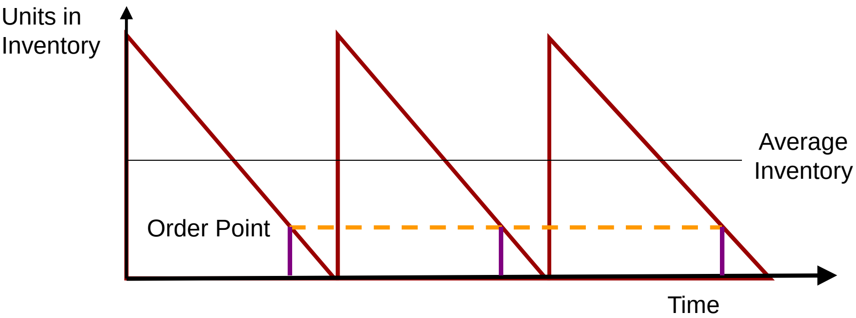


Figure 14-1

14–6

Total Acquisition Costs

- ***Total Acquisition Costs***: sum of all relevant annual inventory costs
  - **Holding costs**: associated with storing and assuming risk of having inventory
  - **Ordering costs**: associated with placing orders and receiving supply

TAC = annual ordering cost + annual carrying cost

14–7

Total Acquisition Costs

TAC = annual ordering cost + annual carrying cost
$= C_o\ (D/Q) + UC_i * Q/2$

$N = D/Q$

$I = Q/2$

Where:

N = orders per year
D = annual demand
Q = order quantity

I = average inventory level
C_o = order cost per order
U = unit cost
C_i = % carrying cost per year

14–8

Total Acquisition Costs

If we need 3,000 units per year at a unit price of $20 and we order 500 each time, at a cost of $500 per order with a carrying cost of 20%, what is the TAC?

$N = D/Q = 3000 / 500 = 6$ order per year

$\bar{I} = Q/2 = 500 / 2 = 250$ average inventory

TAC = ordering cost + carrying cost
= $C_o (D/Q) + (U\ C_i)(Q/2)$
= $50 (3000/500) + ($20*25%)*(500/2) = **$1,300**

Where:

$N = D/Q$ $Q = 500$ $\bar{I} = Q/2$ $U = \$20$
$D = 3{,}000$ $C_o = \$50$ $C_i = 25\%$

Example 14-1

14–9

Total Acquisition Costs

If we need 3,000 units per year at a units price of $20 and we order ***200*** each time, at a cost of $50 per order with a carrying cost of 20%, what is the TAC?

$N = D/Q = 3000 / 200 = 15$ order per year

$\bar{I} = Q/2 = 200 / 2 = 100$ average inventory

TAC = ordering cost + carrying cost
= $C_o (D/Q) + (U\ C_i)(Q/2)$
= 50 (3000/200) + ($20*25%)*(200/2) = **$1,150**

Where:

$N = D/Q$ $Q = 500$ $\bar{I} = Q/2$ $U = \$20$
$D = 3{,}000$ $C_o = \$50$ $C_i = 25\%$

Example 14-2

14–10

Economic Order Quantity (EOQ)

- ***Economic Order Quantity (EOQ)***: minimizes total acquisition costs; point at which holding and orders costs are equal
- ***How much*** **to order**

D = Annual Demand
C_o= Ordering cost
U = Unit cost
C_i = Holding cost

$$EOQ = \sqrt{\frac{2DC_o}{UC_i}}$$

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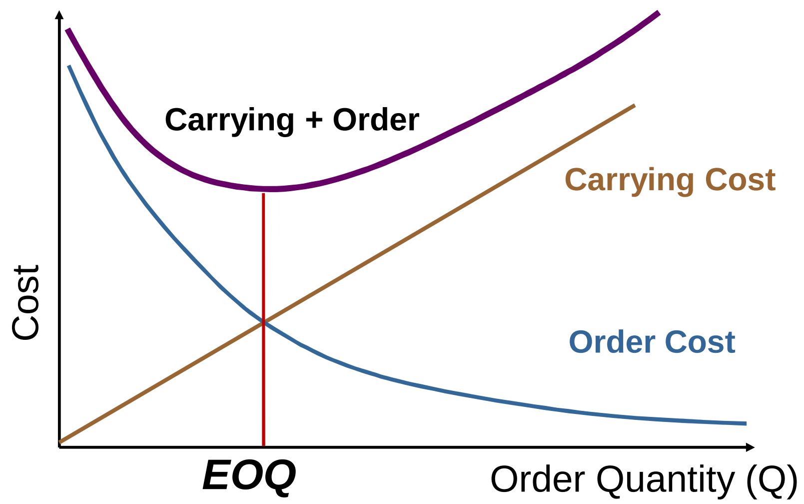
Economic Order Quantity (EOQ)



14–12

Economic Order Quantity (EOQ)

- If we need 3,000 units per year at a unit price of $20, at a cost of $50 per order with a carrying cost of 20%, what is lowest TAC order quantity?

$$EOQ = \sqrt{\frac{2DC_o}{UC_i}} = \sqrt{\frac{2 * 3000 * 50}{20 * 25\%}}$$

$$= 273.86 \Rightarrow 274$$

D = 3,000
C_o = $50
U = $20
C_i = 25%

Example 14-3

Reorder Point – No Uncertainty

- ***Reorder Point***: minimum level of on-hand inventory that triggers a replenishment
- *When* to order

$$ROP = (\bar{d})\bar{t}$$

$\bar{d}$ = average demand per time period
$\bar{t}$ = average supply lead time

Reorder Point – No Uncertainty

If you use 10 units per day, and the lead time for resupply is 9 days, how low can your inventory get before placing a new order?

$$ROP = (\bar{d})\bar{t}$$
$$= 9 * 10$$
$$= 90$$

$\bar{d} = 10$
$\bar{t} = 9$

Example 14-4

EOQ Extensions

- Assumptions underlying EOQ:
  - No quantity discounts
  - No lot size restrictions
  - No partial deliveries
  - No variability
  - No product interactions

Total Acquisition Costs

$$TAC \quad + C_o\left(\frac{D}{Q}\right) + U\,C_i\left(\frac{Q}{2}\right) + pD$$

C_o = Ordering cost
D = Annual demand
Q = Order quantity
U = Unit cost
C_i = Holding cost
p = unit purchase cost

14–17

Total Acquisition Costs

If we need 3,000 units per year at a unit price of ***$19***, at a cost of $50 per order with a carrying cost of 20%, what is TAC with a Q=1,000?

$$TAC = C_o\left(\frac{D}{Q}\right) + U\,C_i\left(\frac{Q}{2}\right) + pD$$

$$= \$50\left(\frac{3{,}000}{1{,}000}\right) + \$19 * 20\%\left(\frac{1{,}000}{2}\right) + \$19 * 3000$$

$$= \$59{,}050$$

TAC at unit cost $20 = **$61,098**, new price saves **$2,048**

Where: C_o = $50 D = 3,000 Q = 1,000
U = $19 C*i* = 20% p = $19

Example 14-5

14–18

Price Discounts & Lot Sizes

- Determining best price break quantity:
  1. Identify price breaks/lot size restrictions
  2. Calculate EOQ for each price/lot size
  3. Evaluate viability of each option
  4. Calculate TAQ for each option
  5. Select best TAQ option

Production Order Quantity

- ***Production Order Quantity***: most economical order quantity when units become available at rate produced

D = Annual Demand
C_o = Ordering cost
C_i = Holding cost
U = Unit cost
d = daily rate of demand
p = daily rate of production

$$Q_p = \sqrt{\frac{2DC_o}{C_i U\left(1-\frac{d}{p}\right)}}$$

Production Order Quantity

Q_p= EOQ
D = 500,000
C_o= $2,000
C_i = 25%
U = $10
d = 2,000
p = 5,000

$$Q_p = \sqrt{\frac{2DC_o}{C_iU\left(1-\frac{d}{p}\right)}}$$

$$= \sqrt{\frac{2*500{,}000*\$2{,}000}{25\%*\$10\left(1-\frac{2{,}000}{5{,}000}\right)}}$$

$$= 36{,}514.84 \quad = \quad 36{,}515$$

Example 14-6

Demand During Lead Time

- Variation can occur in both demand rates and lead times

$$\sigma_{ddlt} = \sqrt{\bar{t}\sigma_d^2 + \bar{d}^2\sigma_t^2}$$

σ_{ddlt} = standard deviation of demand during lead time
$\bar{t}$ = average lead time
σ_d^2 = standard deviation of demand
$\bar{d}$ = average demand
σ_t^2 = standard deviation of lead time

Demand During Lead Time

Average demand is 10 units day with standard deviation of 1.5, and lead time of 10 days with standard deviation of 2.5 days

$$\sigma_{ddlt} = \sqrt{\bar{t}\sigma_d^2 + \bar{d}^2\sigma_t^2}$$

$\bar{t}$ = 10 days
σ_d^2 = 1.5 units
$\bar{d}$ = 10 per day
σ_t^2 = 2.5 days

$$= \sqrt{9(1.5^2) + 10^2(2.5^2)}$$

$$= 25.4\,units$$

Example 14-7

14–23

Determining Service Levels

- ***Service Level Policy***: determining the acceptable stockout risk level

$$SS = z\,\sigma_{ddlt}$$

SS = Safety stock
z = standard deviations needed for service level
σ_{ddlt}= standard deviation of demand during lead time

14–24

Determining Service Levels

Standard deviation of demand during lead time is 25.4 units, acceptable stock out level is 5% (95% service level). From the z table = 1.65

$$SS = z\sigma_{ddlt}$$
$$= 1.65 * 25.4$$
$$= 42\ units$$

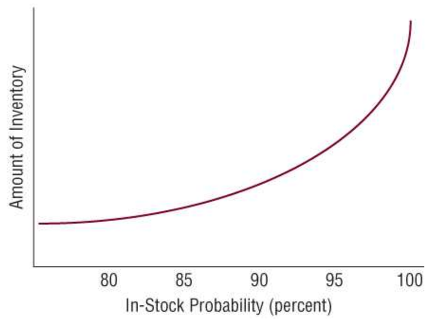
Safety stock carrying cost:

$19 * 42 units * 20% = $159.60 year

Example 14-8

Economic Order Quantity (EOQ)

FIGURE 14-4
Relationship between Inventory Investment and Product Availability



Revisiting ROP and Average Inventory

- Considering uncertainty

ROP = Reorder point
$\bar{d}$ = average lead time
$\bar{t}$ = average demand
SS = Safety stock
Q = order quantity

$$ROP = \left(\bar{d}\ x\ \bar{t}\right) + SS$$

$$average\ inventry = \frac{Q}{2} + SS$$

$$ROP = (10 * 9) + 42 = 132\,units$$

$$average\,inventory = \left(\frac{1000}{2}\right) + 42 = 542$$

Example 14-9

Periodic Review Period

- ***Order Interval***: fixed time between inventory review, on-hand level is unknown during this ***uncertainty period***

UP = Uncertainty period
OI = Order interval
$\bar{t}$ = average lead time
$\bar{d}$ = average lead time
z = standard deviations needed for service level
σ_{ddlt} = standard deviation of demand during lead time
A = inventory on hand

$$UP = OI + \bar{t}$$

$$Q = \bar{d}(UP) + z\sigma_{ddlt}\sqrt{UP} - A$$

Periodic Review Model

- Orders are placed every 30 days and average lead time is 9 days. Standard deviation of demand is 1.5 units.

UP = Uncertainty period
OI = 30 days
$\bar{t}$ = 9 days
σ_d = 1.5 units

$$UP = OI + \bar{t}$$
$$= 30 + 9 = 39\,days$$

$$\sigma_{ddlt} = \sqrt{(UP)\sigma_d^2}$$
$$= \sqrt{(39)(1.5^2} = 9.37$$

Example 14-10 14–29

Periodic Review Period

- There are currently 105 units in stock

UP = 39 days
OI = 30 days
$\bar{t}$ = 9 days
$\bar{d}$ = 10 units
z = 95% = 1.65
σ_{ddlt} = 9.37
A = 105

$$Q = \bar{d}(UP) + z\sigma_{ddlt}\sqrt{UP} - A$$
$$= 10(39) + 1.65(9.37)\sqrt{39} - 105$$
$$= 390 + 97 - 105$$
$$= 382\,units$$

Example 14-11 14–30

Single Period Inventory Model

- ***Single Period Inventory Model***: items are ordered once, and have little left over value *(newsvendor problem)*
- ***Target Service Level**: probability of meeting demand*

$$C_{stockout} = Unit\ selling\ \ price - Unit\ \cos t$$

$$C_{overstock} = Unit\ \cos t + Disposal\ \cos t - Salvage\ \cos t$$

$$(1 - TSL)(C_{stockout}) = TSL\ (C_{overstock})$$

$$TSL = \frac{C_{stockout}}{C_{stockout} + C_{overstock}}$$

Single Period Inventory Model

- Units cost $10 and sell for $30, unsold units have no value, and no disposal or salvage value

$$C_{stockout} = Unit\ selling\ \ price - Unit\ \cos t$$

$$C_{overstock} = Unit\ \cos t + Disposal\ \ \cos t - Salvage\ \cos t$$

$$TSL = \frac{C_{stockout}}{C_{stockout} + C_{overstock}}$$

$$C_{so} = \$30 - \$10 = \$20$$

$$C_{os} = \$10 - 0 - 0 = \$10$$

$$TSL = \frac{\$20}{\$20 + \$10} = .667$$

Example 14-12

Impact of Location on Inventory

- ***Square Root Rule***: estimation of impact of changing the number of locations on inventory

$$SS_n = \frac{\sqrt{N_n}}{\sqrt{N_e}} \times SS_e$$

SS_n = safety stock of the new number of locations

N_n = total number of new locations

N_e = number of existing locations

SS_e = system safety stock for existing locations

14–33

Impact of Location on Inventory

- A single warehouse currently has 1,000 units of safety stock. How much is needed if a second warehouse is added?

SS_n = safety stock of the new number of locations

N_n = 2

N_e = 1

SS_e = 1000

$$SS_n = \frac{\sqrt{N_n}}{\sqrt{N_e}} \times SS_e$$

$$= \frac{\sqrt{2}}{\sqrt{1}} x1000$$

$$= 1{,}410$$

Example 14-13

14–34

Inventory and Locations

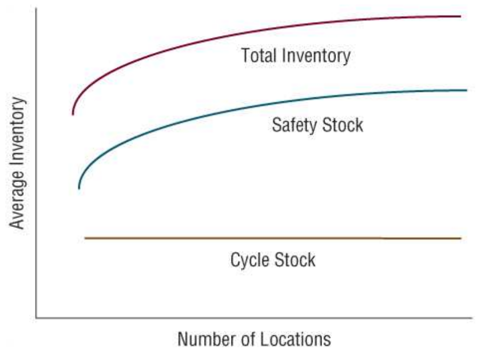


FIGURE 14-5
Inventory Related to Number of Locations

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Reducing Inventory Costs

- **Managing Cycle Stock**: reducing lot sizes
- **Managing Safety Stock**: using ABC analysis and reducing lead time
- **Managing Locations**: balance inventory, lead time and service levels
- **Implementing Inventory Models**: matching management system to specific items

14–36

Independent Demand Inventory Planning Summary

1. Determines how much and when to order
2. Continuous systems monitor on-hand levels
3. Safety stock levels are linked with service levels
4. Periodic systems count inventory at specific intervals
5. Inventory policy parameters vary by model
6. Production and economic order quantities are similar
7. Number of storage locations impact inventory levels
8. Managers should work to reduce inventory levels

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