Exam 3 Review

BUS ADM 475
Spring 2018
Managing Economies of Scale in a Supply Chain: Cycle Inventory
Role of Cycle Inventory in a Supply Chain

• *Lot* or *batch size* is the quantity that a stage of a supply chain either produces or purchases at a time.

• *Cycle inventory* is the average inventory in a supply chain due to either production or purchases in lot sizes that are larger than those demanded by the customer.

  Q: Quantity in a lot or batch size
  D: Demand per unit time
Inventory Profile

If $Q=1000$ and $D=100$, each replenishment lot arrives every 10 days.
Cycle Inventory & flow time

Cycle inventory = \frac{\text{lot size}}{2} = \frac{Q}{2}

If Q = 1000, Cycly inventory = 1000/2 = 500

Average flow time = \frac{\text{average inventory}}{\text{average flow rate}}

Average flow time resulting from cycle inventory = \frac{\text{cycle inventory}}{\text{demand}} = \frac{Q}{2D}

If D=100, Average flow time = 500 / 100 = 5 days
Cycle Inventory

• Lower cycle inventory has
  – Shorter average flow time
  – Lower working capital requirements
  – Lower inventory holding costs
  – But, we have to order more frequently!
Cycle-inventory related costs

- **Average price paid per unit purchased** is a key cost in the lot-sizing decision
  
  Purchasing price = \( \$C/\text{unit} \)

- **Fixed ordering cost** includes all costs that do not vary with the size of the order but are incurred each time an order is placed
  
  Fixed ordering cost = \( \$S/\text{lot} \)

- **Holding cost** is the cost of carrying one unit in inventory for a specified period of time
  
  Holding cost = \( \$H/\text{unit/year} = hC \)
Economic Order Quantity (EOQ)

• Lot sizing for a single product (EOQ)

• Basic assumptions
  – Demand is steady at $D$ units per unit time
  – No shortages are allowed
  – Replenishment lead time is fixed and known
Economic Order Quantity (EOQ)

Annual material (purchase) cost = $CD$

Number of orders per year = $\frac{D}{Q}$

Annual ordering cost = $\left(\frac{D}{Q}\right)S$

Annual holding cost = $\left(\frac{Q}{2}\right)H = \left(\frac{Q}{2}\right)hC$

Total annual cost, $TC = CD + \left(\frac{D}{Q}\right)S + \left(\frac{Q}{2}\right)hC$
Economic Order Quantity (EOQ)

• The *economic order quantity* (EOQ)

Optimal lot size, \( Q^* = \sqrt{\frac{2DS}{hC}} \)

• The optimal number of orders per year

\[
 n^* = \frac{D}{Q^*} = \sqrt{\frac{DhC}{2S}}
\]
EOQ Example

**Example 1** Demand for the Deskpro computer at Best Buy is 1,000 units per month. Best buy incurs a fixed order placement, transportation, and receiving cost of $4,000 each time an order is placed. Each computer costs Best Buy $500 and the retailer has a holding cost of 20 percent. Evaluate the number of computers that the store manager should order in each replenishment.

**Annual demand**, $D = 1,000 \times 12 = 12,000$ units

$S = $4,000, \: C = $500, \: h = 0.2$

**Optimal order size**

$$Q^* = \sqrt{\frac{2 \times 12,000 \times 4,000}{0.2 \times 500}} = 980$$
EOQ Example

Cycle inventory \[= \frac{Q^*}{2} = \frac{980}{2} = 490\]

Number of orders per year \[= \frac{D}{Q^*} = \frac{12,000}{980} = 12.24\]

Annual ordering and holding cost \[= \frac{D}{Q^*} S + \left(\frac{Q^*}{2}\right) hC = 97,980\]

Average flow time \[= \frac{Q^*}{2D} = \frac{490}{12,000} = 0.041 \text{ yr} = 0.49 \text{ month}\]
EOQ Example

• If lot size reduced to $Q = 200$ units

Annual inventory-related costs = $\frac{D}{Q^*} S + \left( \frac{Q^*}{2} \right) hC$

$$= \frac{12,000}{200} (4000) + \left( \frac{200}{2} \right) (0.2)(500) = 250,000$$

• Compared with $Q^* = 980$ units,
  Annual inventory-related costs = 97,980
Lot Size and Ordering Cost

• If the lot size $Q^* = 200$, how much should the ordering cost be reduced?

Desired lot size, $Q^* = 200$
Annual demand, $D = 1,000 \times 12 = 12,000$ units
Unit cost per computer, $C = $500
Holding cost per year as a fraction of inventory value, $h = 0.2$

\[
S = \frac{hC(Q^*)^2}{2D} = \frac{0.2 \times 500 \times 200^2}{2 \times 12,000} = $166.7
\]
Lot Sizing with Multiple Products

• Lot sizes and ordering policy that minimize total cost

\( D_i \): Annual demand for product \( i \)
\( S \): Order cost incurred each time an order is placed, independent of the variety of products in the order
\( s_i \): Additional order cost incurred if product \( i \) is included in the order
Lot Sizing with Multiple Products

- Two approaches
  1. Each product manager orders his or her model independently
  2. The product managers jointly order every product in each lot
Multiple Products Ordered and Delivered Independently

**Example:** Best Buy sells three models of computers, Litepro, Medpro, and Heavypro. Their respective annual demands are as follows:

\[ D_L = 12,000/\text{yr}, \quad D_M = 1,200/\text{yr}, \quad D_H = 120/\text{yr} \]

Furthermore, common fixed ordering cost per order is

\[ S = $4,000 \]

Product-specific fixed ordering cost per order:

\[ s_L = $1,000, \quad s_M = $1,000, \quad s_H = $1,000 \]

Holding cost per year as a fraction of the product cost:

\[ h = 0.2 \]

Unit cost: \[ C_L = $500, \quad C_M = $500, \quad C_H = $500 \]
Multiple Products Ordered and Delivered Independently

Example 3:
Fixed ordering cost for Litepro = $S + S_L = 4000+1000 = $5000
Fixed ordering cost for Medpro = $S + S_M = 4000+1000 = $5000
Fixed ordering cost for Heavypro = $S + S_H = 4000+1000 = $5000

Now, we can use EOQ equation to compute optimal order size for each product.
Multiple Products Ordered and Delivered Independently

<table>
<thead>
<tr>
<th></th>
<th>Litepro</th>
<th>Medpro</th>
<th>Heavypro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand per year</td>
<td>12,000</td>
<td>1,200</td>
<td>120</td>
</tr>
<tr>
<td>Fixed cost/order</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Optimal order size</td>
<td>1,095</td>
<td>346</td>
<td>110</td>
</tr>
<tr>
<td>Cycle inventory</td>
<td>548</td>
<td>173</td>
<td>55</td>
</tr>
<tr>
<td>Annual holding cost</td>
<td>$54,772</td>
<td>$17,321</td>
<td>$5,477</td>
</tr>
<tr>
<td>Order frequency</td>
<td>11.0/year</td>
<td>3.5/year</td>
<td>1.1/year</td>
</tr>
<tr>
<td>Annual ordering cost</td>
<td>$54,772</td>
<td>$17,321</td>
<td>$5,477</td>
</tr>
<tr>
<td>Average flow time</td>
<td>2.4 weeks</td>
<td>7.5 weeks</td>
<td>23.7 weeks</td>
</tr>
<tr>
<td>Annual cost</td>
<td>$109,544</td>
<td>$34,642</td>
<td>$10,954</td>
</tr>
</tbody>
</table>

Total annual cost = $155,140

Table 1
Lots Ordered and Delivered Jointly

\[ S^* = S + s_L + s_M + s_H \]

Annual fixed order cost = \((S^*)n\)

Annual holding cost = \(\frac{D_L hC_L}{2n} + \frac{D_M hC_M}{2n} + \frac{D_H hC_H}{2n}\)

Total annual cost = \(\frac{D_L hC_L}{2n} + \frac{D_M hC_M}{2n} + \frac{D_H hC_H}{2n} + (S^*)n\)

\[ n^* = \sqrt{\frac{D_L hC_L + D_M hC_M + D_H hC_H}{2S^*}} \]

In general, \(n^* = \sqrt{\frac{\sum_{i=1}^{k} D_i hC_i}{2S^*}}\)
Products Ordered and Delivered Jointly

\[ S^* = S + s_A + s_B + s_C = $7,000 \text{ per order} \]

\[ n^* = \sqrt{\frac{12,000 \times 100 + 1,200 \times 100 + 120 \times 100}{2 \times 7,000}} = 9.75 \]

Annual fixed order cost = 7,000 x 9.75 = $68,250

Annual ordering and holding cost
= $61,512 + $6,151 + $615 + $68,250 = $136,528

- Recall when order them independently, total annual cost is $155,140
Optimal Order Sizes: Order jointly

Q* for Litepro = $D_L / n^* = 12000 / 9.75 = 1,230$
Q* for Medpro = $D_M / n^* = 1200 / 9.75 = 123$
Q* for Heavypro = $D_H / n^* = 120 / 9.75 = 12.3$
# Products Ordered and Delivered Jointly

<table>
<thead>
<tr>
<th>Order Jointly</th>
<th>Litepro</th>
<th>Medpro</th>
<th>Heavypro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand per year ($D$)</td>
<td>12,000</td>
<td>1,200</td>
<td>120</td>
</tr>
<tr>
<td>Order frequency ($n*$)</td>
<td>9.75/year</td>
<td>9.75/year</td>
<td>9.75/year</td>
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<tr>
<td>Optimal order size ($D/n*$)</td>
<td>1,230</td>
<td>123</td>
<td>12.3</td>
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<tr>
<td>Cycle inventory</td>
<td>615</td>
<td>61.5</td>
<td>6.15</td>
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<tr>
<td>Annual holding cost</td>
<td>$61,512</td>
<td>$6,151</td>
<td>$615</td>
</tr>
<tr>
<td>Average flow time</td>
<td>2.67 weeks</td>
<td>2.67 weeks</td>
<td>2.67 weeks</td>
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</table>

<table>
<thead>
<tr>
<th>Order Independently</th>
<th>Litepro</th>
<th>Medpro</th>
<th>Heavypro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order frequency</td>
<td>11.0/year</td>
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<td>1.1/year</td>
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<td>7.5 weeks</td>
<td>23.7 weeks</td>
</tr>
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</table>
Review Chapter 8 Practice Problem on aggregating orders

Review HW 3 Question 1 on separate ordering
Managing Uncertainty in a Supply Chain
Safety Inventory

PowerPoint presentation to accompany Chopra and Meindl Supply Chain Management, 6e
The Role of Safety Inventory

- Safety inventory is carried to satisfy demand that exceeds the amount forecasted
  - Raising the level of safety inventory increases product availability and thus the margin captured from customer purchases
  - Raising the level of safety inventory increases inventory holding costs:
    - short life cycles, new products in market
Replenishment Policies

1. Continuous review
   - Inventory is continuously tracked
   - Order for a lot size $Q$ is placed when the inventory declines to the reorder point ($ROP$)

2. Periodic review
   - Inventory status is checked at regular periodic intervals
   - Order is placed to raise the inventory level to a specified threshold
Determining the Appropriate Level of Safety Inventory

- Evaluating Safety Inventory Given a Continuous Review Policy

Expected demand during lead time = \( D \times L \)

Safety inventory, \( ss = ROP - D \times L \)
Two Cases

• Uncertainty only in Demand (D)
• Uncertainty in both Demand (D) and Lead time (L)
Uncertainty only in Demand (D)
Evaluating Demand Distribution Over $L$ Periods

$$D_L = DL \quad \sigma_L = \sqrt{L} \sigma_D$$
Determining the Appropriate Level of Safety Inventory

Average demand per week, $D = 2,500$
Standard deviation of weekly demand, $\sigma_D = 500$
Average lead time for replenishment, $L = 2$ weeks
Reorder point, $ROP = 6,000$
Average lot size, $Q = 10,000$

Safety inventory, $ss = ROP - DL = 6,000 - 5,000 = 1,000$
Cycle inventory $= Q/2 = 10,000/2 = 5,000$
Determining the Appropriate Level of Safety Inventory

Average inventory = cycle inventory + safety inventory
                = 5,000 + 1,000 = 6,000

Average flow time = average inventory/throughput
                  = 6,000/2,500 = 2.4 weeks
Determining the Appropriate Level of Safety Inventory

- Evaluating Cycle Service Level Given a Continuous Review Policy

\[
CSL = \text{Prob}(\text{ddlt of } L \text{ weeks } \leq ROP) \\
CSL = F(ROP, D_L, \sigma_L) = \text{NORMDIST}(ROP, D_L, \sigma_L, 1)
\]

(ddlt = demand during lead time)
Determining the Appropriate Level of Safety Inventory

\[ Q = 10,000, \quad ROP = 6,000, \quad L = 2 \text{ weeks} \]
\[ D = 2,500/\text{week}, \quad \sigma_D = 500 \]

\[ D_L = D \times L = 2 \times 2,500 = 5,000 \]
\[ \sigma_L = \sqrt{L} \sigma_D = \sqrt{2} \times 500 = 707 \]

\[ CSL = F(ROP, D_L, \sigma_L) = \text{NORMDIST}(ROP, D_L, \sigma_L, 1) \]
\[ = \text{NORMDIST}(6,000, 5,000, 707, 1) = 0.92 \]
Determining the Appropriate Level of Safety Inventory

- Evaluating Required Safety Inventory Given a Desired Cycle Service Level

Desired cycle service level = \( CSL \)
Mean demand during lead time = \( D_L \)
Standard deviation of demand during lead time = \( \sigma_L \)

\[
\text{Probability}(\text{demand during lead time} \leq D_L + ss) = CSL
\]

- Identify safety inventory \( ss \) so that

\[
F(D_L + ss, D_L, s_L) = CSL
\]
Determining the Appropriate Level of Safety Inventory

\[ s_s = F_s^{-1}(CSL) \times \sigma_L = F_s^{-1}(CSL) \times \sqrt{L} \sigma_D \]

\[ = NORMSINV(CSL) \times \sqrt{L} \sigma_D \]
Determining the Appropriate Level of Safety Inventory

\[ D = 2,500/\text{week}, \ \sigma_D = 500, \ \text{CSL} = 0.9, \ L = 2 \text{ weeks} \]

\[ D_L = DL = 2 \times 2,500 = 5,000 \]

\[ \sigma_L = \sqrt{L} \sigma_D = \sqrt{2} \times 500 = 707 \]

\[ s_s = F_s^{-1}(\text{CSL}) \times \sigma_L = \text{NORMSINV}(\text{CSL}) \times \sigma_L \]

\[ = \text{NORMSINV}(0.90) \times 707 = 906 \]
Computing safety stock and ROP using normal table

- Look up CSL as the probability in normal table and find the associated z-score.

Safety Stock = \( z_{\text{score}} \times \text{standard dev. of demand during lead time} \)

ROP = Safety stock + D*L
Impact of Desired Product Availability and Uncertainty

- As desired product availability goes up the required safety inventory increases

<table>
<thead>
<tr>
<th>Fill Rate</th>
<th>Safety Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>97.5%</td>
<td>67</td>
</tr>
<tr>
<td>98.0%</td>
<td>183</td>
</tr>
<tr>
<td>98.5%</td>
<td>321</td>
</tr>
<tr>
<td>99.0%</td>
<td>499</td>
</tr>
<tr>
<td>99.5%</td>
<td>767</td>
</tr>
</tbody>
</table>

TABLE 12-1
Key Point

The required safety inventory grows rapidly with an increase in the desired product availability.
Impact of Desired Product Availability and Uncertainty

- Goal is to reduce the level of safety inventory required in a way that does not adversely affect product availability:
  1. Reduce the supplier lead time $L:$ Retailer Zara
  2. Reduce the underlying uncertainty of demand (represented by $\sigma_D$)
The required safety inventory increases with an increase in the lead time and the uncertainty of periodic demand.
Uncertainty in both Demand (D) and Lead time (L)
Impact of Supply Uncertainty on Safety Inventory

- We incorporate supply uncertainty by assuming that lead time is uncertain

\[ D: \text{Average demand per period} \]
\[ \sigma_D: \text{Standard deviation of demand per period} \]
\[ L: \text{Average lead time for replenishment} \]
\[ s_L: \text{Standard deviation of lead time} \]

\[ D_L = DL \]
\[ \sigma_L = \sqrt{L\sigma_D^2 + D^2s_L^2} \]
Impact of Lead Time Uncertainty on Safety Inventory

Average demand per period, $D = 2,500$
Standard deviation of demand per period, $\sigma_D = 500$
Average lead time for replenishment, $L = 7$ days
Standard deviation of lead time, $s_L = 7$ days

Mean ddlt, $D_L = DL = 2,500 \times 7 = 17,500$

Standard deviation of ddlt $\sigma_L = \sqrt{L\sigma_D^2 + D^2s_L^2} = \sqrt{7 \times 500^2 + 2,500^2 \times 7^2} = 17,500$
Impact of Lead Time Uncertainty on Safety Inventory

- Required safety inventory

\[ ss = F_{S}^{-1}(CSL) \times \sigma_{L} = NORMSINV(CSL) \times \sigma_{L} \]

\[ = NORMSINV(0.90) \times 17,500 \]

\[ = 22,491 \text{ tablets} \]

<table>
<thead>
<tr>
<th>( s_{L} )</th>
<th>( \sigma_{L} )</th>
<th>( ss ) (units)</th>
<th>( ss ) (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>15,058</td>
<td>19,298</td>
<td>7.72</td>
</tr>
<tr>
<td>5</td>
<td>12,570</td>
<td>16,109</td>
<td>6.44</td>
</tr>
<tr>
<td>4</td>
<td>10,087</td>
<td>12,927</td>
<td>5.17</td>
</tr>
<tr>
<td>3</td>
<td>7,616</td>
<td>9,760</td>
<td>3.90</td>
</tr>
<tr>
<td>2</td>
<td>5,172</td>
<td>6,628</td>
<td>2.65</td>
</tr>
<tr>
<td>1</td>
<td>2,828</td>
<td>3,625</td>
<td>1.45</td>
</tr>
<tr>
<td>0</td>
<td>1,323</td>
<td>1,695</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Computing safety stock and ROP using normal table

• Look up CSL as the probability in normal table and find the associated z-score.

Safety Stock = z_score * standard dev. Of demand during lead time

ROP = Safety stock + D*L
Key Point

A reduction in supply uncertainty can help to dramatically reduce the required safety inventory without hurting product availability.
10 Resource Planning
Bill of Materials

- Bill of Materials
  - A record of all components of an item, the parent-component relationship and the usage quantities are derived from engineering and process design.
• **Parent**
  - An product that is manufactured from one or more components

• **Component**
  - An item that goes through one or more operations to be transformed into or become part of one or more parents
Example 1

• Determine the quantities of B, C, D, E, and F needed to assemble ten X's, if you have the following in inventory:

<table>
<thead>
<tr>
<th>Component</th>
<th>On hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>8</td>
</tr>
<tr>
<td>E</td>
<td>60</td>
</tr>
</tbody>
</table>

Level

0

1

X

B (2)

C

2

D (3)

E

E (2)

F (2)

3

E (4)
Thus, given the amounts of on-hand inventory, 10 Xs will require

- B: 16
- C: 0
- D: 40
- F: 0
- E: 116 (=16+100)
Developing an MPS

• **Gross requirements**: Total expected demand derived from all parent production plans in a time period.

• **Scheduled receipts**: Open orders already scheduled to arrive from vendors or elsewhere in the pipeline by the beginning of a period.

• **Planned receipts**: The quantity to be planned, which is expected to be received by the beginning of the period.

• **Planned order releases**: Planned amount to order in each time period; planned receipts offset by lead time.
Developing an MPS

- **Projected on-hand inventory**: Expected amount of inventory that will be on hand at the end of each time period after gross requirements have been satisfied:

\[
\text{Projected on-hand inventory at end of week } t = \left( \text{Inventory on hand at end of week } t-1 \right) + \left( \text{Scheduled and planned receipts in week } t \right) - \left( \text{Gross requirements in week } t \right)
\]
Planning Factors

• Lot-sizing rules
  – Fixed order quantity (FQO) rule maintains the same order quantity each time an order is issued
  • Could be determined by quantity discounts, truckload capacity, minimum purchases, or EOQ
# MRP Explosion

**Item:** C  
**Description:** Seat subassembly  
**Lot Size:** 230 units  
**Lead Time:** 2 weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross requirements</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>120</td>
<td>0</td>
<td>150</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>Scheduled receipts</td>
<td>230</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Projected on-hand inventory</td>
<td>37</td>
<td>117</td>
<td></td>
<td>117</td>
<td></td>
<td>117</td>
<td></td>
<td>117</td>
</tr>
</tbody>
</table>

**Explanation:**  
Gross requirements are the total demand for the two chairs. Projected on-hand inventory in week 1 is 37 + 230 – 150 = 117 units.
Item: C  
Description: Seat subassembly

Lot Size: 230 units  
Lead Time: 2 weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross requirements</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>120</td>
<td>0</td>
<td>150</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>Scheduled receipts</td>
<td>230</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Projected on-hand inventory</td>
<td>37</td>
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<td>117</td>
<td>227</td>
<td>227</td>
<td>77</td>
<td>187</td>
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<td>Planned receipts</td>
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<td></td>
<td></td>
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<tr>
<td>Planned order releases</td>
<td>230</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Without a planned receipt in week 4, a shortage of 3 units will occur: $117 + 0 + 0 - 120 = -3$ units. Adding the planned receipt brings the balance to $117 + 0 + 230 - 120 = 227$ units.

The first planned receipt lasts until week 7, when projected inventory would drop to $77 + 0 + 0 - 120 = -43$ units. Adding the second planned receipt brings the balance to $77 + 0 + 230 - 120 = 187$ units.
Planning Factors

• Lot-sizing rules

  - Periodic order quantity (POQ) rule allows a different order quantity for each order issued but issues the order for predetermined time intervals

\[
(\text{POQ lot size to arrive in week } t) = (\text{Total gross requirements for } P \text{ week, including week } t) - (\text{Projected on-hand inventory balance at end of week } t-1)
\]
Planning Factors

Using $P = 3$:

$$(\text{POQ lot size}) = \left( \text{Gross requirements for weeks 4, 5, and 6} \right) - \left( \text{Inventory at end of week 3} \right)$$

$$(\text{POQ lot size}) = (120 + 0 + 150) - 117 = 153 \text{ units}$$
# Planning Factors

Using POQ Rule

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*Figure 11.13*
Planning Factors

- Lot-sizing rules
  - Lot-for-lot (L4L) rule under which the lot size ordered covers the gross requirements of a single week

\[
\begin{align*}
\text{(L4L lot size to arrive in week } t) &= \left( \text{Gross requirements for week } t \right) - \left( \text{Projected on-hand inventory balance at end of week } t - 1 \right) \\
\text{(L4L lot size)} &= \left( \text{Gross requirements in week 4} \right) - \left( \text{Inventory balance at end of week 3} \right) \\
\text{(L4L lot size)} &= 120 - 117 = 3 \text{ units}
\end{align*}
\]
## Planning Factors

**Item:** Ladder-back chair  
**Order Policy:** L4L  
**Lead Time:** 2 weeks

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*Figure 11.14*
Also, review Chapter 10 practice problem and HW 3 Question 4.