TAM 125/225, LECTURE # 19 (3/13/12)

Agenda:

1. Complete the Facilities Design process (done; see above)

2. HW #7, Problems 2, 3 (Facilities Design)

3. Transportation
   - Review
   - HW #7, Prob. 4 (Transportation)

4. Cisco Internships → e-mail
   - Resume
   - Transcript
   - Senior

5. Project
   (a) See Integration/Final Report instructions in HW #7
   (b) Quick project reviews with instructor this afternoon (3:30-6:30 PM)

6. TAM 225 (HW #7, Prob. # 4)

7. Return graded HW to class
HW # 7

Problem 2

Sun-Oil facilities problem, "worked-out" in Chap 5 (Network Design in a SC)

Suggestions: There are 5 supply regions $\Rightarrow$ 5 plants

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>$y_1 \in (0,1)$</td>
<td>$z_1 \in (0,1)$</td>
</tr>
<tr>
<td>Plant 2</td>
<td>$y_2 \in (0,1)$</td>
<td>$z_2 \in (0,1)$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Plant 5</td>
<td>$y_5 \in (0,1)$</td>
<td>$z_5 \in (0,1)$</td>
</tr>
</tbody>
</table>

Total Cost $C = \sum_{i=1}^{5} (f_i) y_i^{\text{low}} + \sum_{i=5}^{5} (f_i) z_i^{\text{high}} + \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$

Cell B3 in Excel
HW #7, Prob. 3

DRY-ICE problem

This problem was formulated in-class in Lecture #18 (3/8/12)

Comment: on doing double summations: Example

\[ \sum_{i=1}^{4} \left[ \sum_{j=1}^{3} X_{ij} c_{ij} \right] \]

\[ = \sum_{i=1}^{4} \left( X_{i1} c_{i1} + X_{i2} c_{i2} + X_{i3} c_{i3} \right) \]

\[ = \left[ \sum_{i=1}^{4} (X_{i1} c_{i1}) \right] + \left[ \sum_{i=1}^{4} (X_{i2} c_{i2}) \right] + \sum_{i=1}^{4} (X_{i3} c_{i3}) \]

result has 12 terms
Transportation: Watch the transportation lecture (3/1/12) webcast

Quick review:

(a) Compare different modes of transportation (air, water, rail, truck, ...) to determine that the corresponding lot-size to minimize total cost = (transportation cost + cycle inventory holding cost + safety inventory holding cost + in-transit inventory holding cost).

See Example 13.1 (Eastern Electric) in the Transportation chapter of the text.
(2) Investigate aggregation in Space (Spatial) or Time (Temporal)
HW #7, Prob. 4 ("Books-on-line")

Define the problem:

There are many possible scenarios for locating warehouses, including the current scenario (warehouse in the "West").

Determine the scenario that minimizes total cost:

1. transportation cost

2. inventory holding costs
   - cycle inventory
   - safety inventory

3. plant cost
   - fixed ($200,000 + x)
   - variable (0.01y)
Process:

1. Collect all the necessary information in the problem statement

2. Assumptions?

3. Process:

3A. Explore different scenarios for locating warehouses in zones

<table>
<thead>
<tr>
<th>Zone W</th>
<th>Zone C</th>
<th>Zone E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1) Current Scenario

2) 1 warehouse in the center

3) a warehouse in each zone

4) other (?)
(b) For each scenario, calculate all relevant costs

- Transportation
- Inv. holding cost
  - Cycle
  - Safety
- Warehouse operating cost
- Warehouse fixed cost

(c) Decide on the time-basis (annual? monthly? weekly?) for computing all relevant costs

Since demand is given on a weekly basis, perform all calculations on a weekly basis.

(Caution: Cycle & Safety Inv holding costs are annual costs must be converted to a weekly basis)
(1) For each scenario, calculate the **total cost per week**
(or total weekly cost)

\[
\text{Total cost} = \text{Transportation cost per week} \quad (O1)
\]

\[
+ \text{Cycle inv. cost per week} \quad (O2)
\]

\[
+ \text{Safety inv. cost per week} \quad (O3)
\]

\[
+ \text{Warehouse cost of operation per week} \quad (O4)
\]

\[
+ \text{Warehouse fixed cost per week} \quad (O5)
\]

(2) Choose the scenario that minimizes total weekly cost
Implementation

Develop the necessary equations

(1) Transportation costs

Average Weekly demand for each zone = $D_w$ books/week

Average # of books per order = 4 books/order

\[ \text{Average # of orders for each zone} = \frac{D_w}{4} \text{ orders/week} \]

Transportation cost per order = $c_l$ $\frac{\text{dollars}}{\text{order}}$

\[ l = 1, 2, 3 \]

\[ l = 1 \text{ (shipping within the same zone)} \quad c_1 = \$2/\text{order} \]

\[ l = 2 \text{ (adjacent zones)} \quad c_2 = \$3/\text{order} \]

\[ l = 3 \text{ (non-adj. zones)} \quad c_3 = \$4/\text{order} \]

\[ \text{Weekly transportation costs to meet demand in each zone} = \left( \frac{D_w}{4} \right) (c_l) \]
Scenario 1

Transp. Cost

\[ \frac{(50,000)(C)}{4} \times \frac{(50,000)(C_2)}{4} \times \frac{(50,000)(C_3)}{4} \]

\[
\text{Total transportation cost (weekly)} = \$117,500
\]

Inventory Holding Costs

Replenishment Policy: Periodic

\[ T = 1 \text{ week (review interval)} \]

\[ \text{Annual Cycle Inventory holding cost } \zeta = \left( \frac{Q_L}{2} \right)(hC) \]

for Periodic Review

\[ Q_L = \frac{DW}{T} \]

(eq. 11.17)

\[ \text{average lot size aggregated} \]
for Scenario 1, 1 warehouse in the west serves demand for all 3 regions

\[(Dw)_{agg} = 50,000 \times 3 = 150,000\]

\[Q_L = DT = (150,000)(1) = 150,000\]

\[h = 0.25\]

\[C = \$10\]

Weekly cycle inv \[\text{holding cost} = \left(\frac{Q_L}{2}\right)(hC)\]

Result: \[\$3600/\text{week}\]
Annual safety inventory holding cost = \((ss)\ hC\)

where \(ss\) = \([\sigma_{L+T}]_{agg}^{-1} f z \] \((CSL)\) \(\text{desired}\)

For Scenario 1,

\[
\frac{2}{\left(\sigma_{L+T}\right)_{agg}^2} = \left(\sigma_{L+T}\right)_{W}^2 + \left(\sigma_{L+T}\right)_{C}^2 + \left(\sigma_{L+T}\right)_{E}^2
\]

\[
\sqrt{(T+L)(1+1)}
\]

\[
\sigma_{L+T} = \sqrt{2} \sigma_{W}, \text{ for each region}
\]

Given: \(\sigma_{W} = 25000\)

\[
\sigma_{L+T} = \sqrt{2} (25000) = 50000
\]

\[
\Rightarrow \left(\sigma_{L+T}\right)_{agg}^2 = \left(50000\right)^2 + \left(50000\right)^2 + \left(50000\right)^2
\]

\[
\Rightarrow \left(\sigma_{L+T}\right)_{agg} = \sqrt{3}(50000) = 61237.24
\]
\[ SS = (\sigma_{L+T})_{Agg} \int_{2}^{\left(\frac{(C_{S,L})_{desired}}{\sigma}\right)} \]

\[ (C_{S,L})_{desired} = 99.7\% \Rightarrow \int_{2}^{\left(\frac{0.997}{\sigma}\right)} \]

\[ 2.75 \]

\[ SS = (\sqrt{3})(50000)(2.75) \]

**Scen. 1:**

\[
\begin{align*}
\text{Annual safety involding cost} & = (SS)(H) \\
\text{Weekly safety inventory cost} & = \frac{(SS)(H)}{52} \\
\text{Result (Scenario 1)} & \rightarrow $11,450
\end{align*}
\]

\[ \sigma_{T+L} = (\sigma_{w})\cdot\text{square root}(T+L). \]
\[ \sigma_{T+L} = (\sigma_{w})\cdot\text{square root}(2) \]
\[ \sigma_{T+L} = \text{square root}(2)\cdot(25,000) \]
\[ (\sigma_{T+L})_{agg} = 61,237.24 \]

Weekly Safety Holding Cost = $8,089.74
Weekly warehouse operating cost:

\[ y = 0.01y \]

\[ y = \text{# of books shipped} \]

Scenario:

\[ y = (50,000) \times 3 = 150,000 \]

\[ Dw \quad \text{(for each zone)} \]

Weekly w. oper. cost = \((0.01)(150,000)\)

= $1500

Given \rightarrow Fixed cost of warehouse = $200,000 + x

\[ x = \text{Warehouse capacity} \]

Given \rightarrow 1.5 [Replenishment Order + safety stock]
Assumption:

$\text{replenishment order} = \text{lot-size}\]

$= Q_l$

Then $x = 1.5\left[Q_l + SS\right]$

Fixed cost of warehouse = $200,000 + 1.5\left[Q_l + SS\right]$

Assumption:

This fixed cost will be spread out (equally) over 10 years

Fixed cost of warehouse per week = \frac{\text{Fixed Cost of warehouse}}{10\text{years}\times 52\text{weeks}}

Result = $1500
For scenario 1, the total weekly cost is:

\[ \text{cost} = (D_1 + D_2 + D_3 + D_4 + D_5) \]

\[ \text{Dominant} \]

\$112,500 \quad \$3600 \quad \$115450 \quad \$1500 \quad \$1500 \quad \$8089.74 \]