DSS5202 Sustainable Systems Analysis
Assignment #4 Solutions

Question 1.

SG Capacity = 328,000.
Total demand = 140,000 + 80,000 + 108,000 = 328,000.
Hence the supply-demand is **balanced.**

Formulation

Sets

C = set of customers
D = set of distribution centers

Parameters

c_{ij} Transportation cost from DC i to customer j, $\forall\, i \in D,\ \forall\, j \in C$
e_i Transportation cost from SG to DC i, $\forall\, i \in D$
d_j Demand at customer j, $\forall\, j \in C$
s_i Capacity at DC i, $\forall\, i \in D$
f_i Fixed operating cost at DC i if in operation, $\forall\, i \in D$
g Capacity at SG.

Decision Variables

x_{ij} Quantity shipped from DC i to customer j, $\forall\, i \in D,\ \forall\, j \in C$
y_i Quantity shipped from SG to DC i, $\forall\, i \in D$

$$z_i = \begin{cases} 1 & \text{if DC } i \text{ is operated} \\ 0 & \text{otherwise} \end{cases}$$

Model

$$\text{Min} \sum_{i \in D} e_i y_i + \sum_{i \in D} \sum_{j \in C} c_{ij} x_{ij} + \sum_{i \in D} f_i z_i$$

s.t. $\sum_{i \in D} x_{ij} = d_j$ $\forall\, j \in C$ // Demand of customer is satisfied.

$\sum_{j \in C} x_{ij} \le s_i z_i$ $\forall\, i \in D$ // Capacity of DC not exceeded

$\sum_{j \in C} x_{ij} = y_i$ $\forall\, i \in D$ // Conservation of flows at DC

$\sum_{i \in D} y_i \le g$ // Capacity of SG not exceeded

$x_{ij} \ge 0$ $\forall\, i \in D,\ \forall\, j \in C$
$y_i \ge 0$ $\forall\, i \in D$
$z_i \in \{0, 1\}$ $\forall\, i \in D$

Optimal Solution:

Optimal Total Monthly Cost: USD 8,076,600.00
Distribution Centers to Open: Switzerland and California

Quantity shipped from Singapore to the Distribution Centers:

Distribution Center	Number of vials per month
Switzerland	210,000
California	118,000
New York.	0
Total	328,000

Quantity shipped from Distribution Centers to Key Markets

From \ To	Brazil	Japan	Russia	Total
Switzerland	102,000	0	108,000	210,000
New York	0	0	0	0
California	38,000	80,000	0	118,000
Total	140,000	80,000	108,000	328,000

Question 2

SG Capacity = 300,000 < Total demand = 328,000
Some of the customers will not get their full demand.

We modify two constraints in Q1 model as follows:

$$\sum_{i \in D} x_{ij} \le d_j \qquad \forall j \in C \qquad \text{// The demand may not be all met}$$

$$\sum_{i \in D} y_i = g \qquad \text{// SG produces at full capacity}$$

Optimal Solution:

Optimal Total Monthly Cost: USD 7,438,200.00
Distribution Centers to Open: Switzerland and California

Quantity shipped from Singapore to the Distribution Centers:

Distribution Center	Number of vials per month
Switzerland	210,000
California	90,000
New York.	0
Total	300,000

Quantity shipped from Distribution Centers to Key Markets

From \ To	Brazil	Japan	Russia	Total
Switzerland	102,000	0	108,000	210,000
New York	0	0	0	0
California	10,000	80,000	0	90,000
Total	112,000	80,000	108,000	300,000

Brazil will only receive a total of only112,000 instead of 140,000.

Question 3.

Advantages: The optimal solution provides the ***lowest possible total cost*** solution without being constrained by other customer or business considerations.

Disadvantage: The solution does not consider customers with different priorities and customer relationships. This may impact the company's future relationship with key customers.

Question 4.

Possible improvements:

1. For each customer determine the maximum level of shortfalls permitted based on the customer's importance to the company. Modify the constraint for each customer.
2. Reformulate the problem as a goal programming problem. The customers' orders are the goals and set penalty costs for under-supply deviation from the goal.
3. Add a second objective function on the cost of the slacks for each of the customer demand constraints. Find a preferred or compromised solution using any multi-objective optimization algorithm.
4. Etc