Analysis

Stationary demand wants to propose a redesigned distribution network based on Zone Skipping that incorporates the new USPE rates and preserved the final delivery, while reducing the distribution costs. As a transportation analyst, Stationary demand wants us to analyze the committee's claims

- Whether Zone skipping would be a profitable strategy?

- If yes, then which of the distributive justice facility should be utilized?

- Which distributor should be served by which facility (or directly from source)?

Method

Current Network Model

Let the source is i, distributors are j. According to the current network the cost of logistics can be calculated by,

$$\sum_n \sum_j \max(D_{jn} r_{ij}, r_{ij}^{min})$$

where,
D_{jn} = demand of shipment n for distributor j,
r_{ij} = USPE rate/pound as per contract to move from source to distributors,
r_{ij}^{min} = Minimum rate/pound to move from source to distributors

Redesigned Network Model

Let, k is Distribution strategy facilities. Now, The Decision Variables are-

$$X_k = \begin{cases} 1 & \text{if facility k is chosen} \\ 0 & \text{otherwise} \end{cases}$$

$$Y_j = \begin{cases} 1 & \text{if distributor j is served by source directly} \\ 0 & \text{otherwise} \end{cases}$$

$$Z_{jk} = \begin{cases} 1 & \text{if distributor j is served by facility k} \\ 0 & \text{otherwise} \end{cases}$$

$$TL_k = \text{number of truck loads sent to location k}$$

The variable that are introduced for linearize it,

$$T_{jn} = \begin{cases} 1 & \text{if order amount exceeds minimum rate from source i to distributor j} \\ 0 & \text{otherwise} \end{cases}$$

$$T'_{jn} = \begin{cases} 1 & \text{if order amount exceeds minimum rate from facility k to distributor j} \\ 0 & \text{otherwise} \end{cases}$$

The given values are -
S = Fixed Setup Cost (Scaled to weekly)
D_{jn} = Demand of distributor j at n number
r_{ij} = Rate/pounds of USPE according to Contract

r_{ij}^{min} = Minimum rate of USPE according to Contract
r_{kj} = Rate/pounds of USPE for General People
r_{kj}^{min} = Minimum rate of USPE for General People
n_j = Number of shipments for distributor j
d_{ik} = Distance from source i to location k
h_k = Handling Cost/shipment for facility k
r_k = Rate/mile for facility k
ρ = Distance factor to convert geo-distance to transportation distance
L_k = Maximum number of truck that can be send to one location k

According to the Redesigned network based on the Zone Skipping, the cost of logistics /week (*which can later on multiplied by 52 to get annual cost*) can be calculated by,

$$\text{Min } S\sum_k X_k + \sum_n \sum_j \max(D_{jn}r_{ij}, r_{ij}^{min})Y_j + \sum_k TL_k \rho d_{ik} r_k X_k + \sum_j \sum_k n_j h_k Z_{jk} +$$
$$\sum_n \sum_k \sum_j \max(D_{jn}r_{kj}, rkj^{min})Z_{jk}$$

This equation has non-linear terms. It is linearized by the following equation:

$$\text{Min } S\sum_k X_k + \sum_n \sum_j D_{jn}r_{ij}Y_jT_{jn} + \sum_n \sum_j (1-T_{jn})r_{ij}^{min}Y_j + \sum_k TL_k \rho d_{ik} r_k X_k$$
$$+ \sum_j \sum_k n_j h_k Z_{jk} + \sum_n \sum_k \sum_j D_{jn}r_{kj}Z_{jk}T'_{jn} + \sum_n \sum_k \sum_j r_{kj}^{min}Z_{jk}(1-T'_{jn})$$

Subject to,
$$Y_j + \sum_k Z_{jk} = 1 \qquad \nabla j = 1, 2, .., 43$$

$$\sum_j \sum_n D_{jn}Z_{jk} <= 20000TL_k \qquad \nabla k = 1, 2, .., 7$$

$$X_k >= Z_{jk} \qquad \nabla j = 1, 2, .., 43, \qquad \nabla k = 1, 2, .., 7$$

$$TL_k <= L_k \qquad \nabla k = 1, 2, .., 7$$

Assumption

- The distance is taken as geo-distance (*calculated by geopy library in python*)

- $\rho = 1.14$

- The model is scaled to weekly cost

Result

Under the Current Network design, Stationary Demand's total Annual distribution cost is \$1,057,914.00. The redesigned Logistics network model shows that the facility in Tuba City, AZ would serve 18 distributors and the remaining 25 distributors will be served by Walla Walla, WA. So, None of the distributors will be served directly from the source.

The total annual cost for the redesigned Distribution Network will be \$880,791.60 which is \$177,122.4 less than the Current Network that reduces the cost by 16.74%. Which Distributors are served by which facility is given below where k_5 is Tuba City, AZ and k_7 is Walla Walla, WA.

Table 1: Decision variable X_k

Var	1	2	3	4	5	6	7
X_k	0	0	0	0	1	0	1

Table 2: Which distributor Served by which facility

j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Served By	k_7	k_7	k_7	k_5	k_5	k_5	k_5	k_7	k_7	k_7	k_7	k_7	k_7	k_7	k_5
j	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Served By	k_5	k_5	k_5	k_5	k_5	k_5	k_5	k_7	k_7	k_7	k_5	k_5	k_5	k_5	k_5
j	31	32	33	34	35	36	37	38	39	40	41	42	43		
Served By	k_7	k_5	k_7	k_7	k_7	k_7	k_7	k_7	k_7	k_7	k_7	k_7	k_7		

Here is the optimal Network for the Redesigned Logistics Distribution for stationary demand;
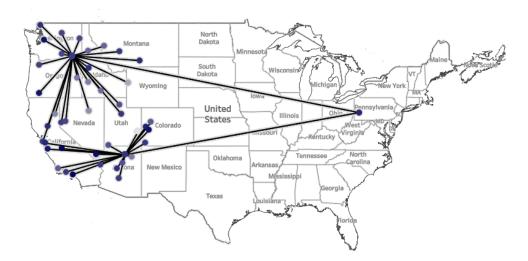

Figure 1: Optimal Network

The stakeholders who will be in the decision making process are the Stationary Demand's Production & Procurement Department, Distributing Strategy, The company sharing the transportation truck with Stationary Demand, The west coast distributors, The USPE and end customers of west Coast.

As the transportation Analyst, we have found that the Zone Skipping would be the best strategy to follow which will result in reduction in cost while keeping good relationship with the USPE. By start following the Zone Skipping strategy, These are the affects stakeholders may have -

Stationary Demand	Transportation Cost will be reduced by 16.74%
USPE	Revenue will go down slightly, margin will be almost same as before
Distributive Justice	Good business opportunity
The Other Company	Benefited by sharing Cost of transportation
West Coast Distributors	Shipments will be delayed slightly, but won't affect the service level
End Customers	Order will be received a little late

The most important factors that the committee should consider are a) maintaining better relationship with USPE, b) Make sure that the third party distribution strategy could manage the demand flow on right time.

Recommendations

- In order to navigate the shipments that will be transferred from facility to distributors, Unique identifier or label should be used that would prevent the shipment loss as we cannot use the Stationary Demand's Logo.

- The Database should be redesigned so that these shipments are captured in the information system.