Idea 1

Indices:

I: set of Manufacturing Plants, i

J: set of Distribution Centres, j

K: set of Market Zones, K

M: set of Product Types, m

S: set of disruption scenarios

Parameters:

a_i^s = 1 if Manufacturing plant i disrupted in scenario s, 0 otherwise

b_j^s = 1 if DC j disrupted in scenario s, 0 otherwise

d_{km}^s forecasted demand of product m in market zone K

f_i cost of opening manufacturing plant i

f'_j cost of opening distribution centre j

g_{im} variable cost of manufacturing product m in plant i

v_{ijm} unit cost of transporting product m from $i \to j$

v'_{jkm} unit cost of transporting product m from $j \to K$

c_i capacity of manufacturing plant

c'_j capacity of DC

w_m cost of purchasing product$_m$ from outsourced supplier

w'_{jm} cost of shipping product m from outsourced supplier to j

w''_{km} cost of shipping product m from outsourced supplier to K

u_{km} unit cost of lost sales for product m at market zone K

h_m volume of product m

Decision Variables:

U_{km}^s quantity of lost sales for product m at market zone K

$x_i = \begin{cases} 1 & \text{open plant } i \\ 0 & \text{otherwise} \end{cases}$ $\quad x'_j = \begin{cases} 1 & \text{open DC } j \\ 0 & \text{otherwise} \end{cases}$

V_m^s quantity of product m to be purchased from outsourced supplier

Q_{im}^s quantity of product m produced at plant i

Y_{ijm}^s quantity of product m to be shipped from $i \to j$

Z_{jkm}^s quantity of product m to be shipped from $j \to K$

T_{jm}^s quantity of product m to be shipped from outsourced supplier $\to j$

T'^s_{km} quantity of product m to be shipped from outsourced supplier $\to K$

* in scenario $s \in S$ *

Model

Cost of opening $= OC = \sum_{i\in I} f_i x_i + \sum_{j\in J} f'_j x_j$

Shipment costs $= SC_s = \sum_{i\in I}\sum_{j\in J}\sum_{m\in M} v_{ijm} Y^s_{ijm} + \sum_{j\in J}\sum_{k\in K}\sum_{m\in M} v'_{jkm} Z^s_{jkm}$

$+ \sum_{j\in J}\sum_{m\in M} w'_{jm} T^s_{jm} + \sum_{k\in K}\sum_{m\in M} w''_{km} T'^s_{km}$

Production costs $= PC_s = \sum_{i\in I}\sum_{m\in M} g_{im} Q^s_{im}$

Buying cost $= BC_s = \sum_{m\in M} w_m V^s_m$

Cost of lost sales $= LC_s = \sum_{k\in K}\sum_{m\in M} u_{km} U^s_{km}$

$$\min \quad OC + (SC_s + PC_s + BC_s + LC_s)\frac{1}{|S|} \quad (1)$$

$$\text{s.t.} \quad Q^s_{im} = \sum_{j\in J} Y^s_{ijm} \quad \forall\, i\in I, m\in M, s\in S \quad (2)$$

$$\sum_{i\in I} Y^s_{ijm} + T^s_{jm} = \sum_{k\in K} Z^s_{jkm} \quad \forall\, j\in J, m\in M \quad (3)$$

$$\sum_{j\in J} Z^s_{jkm} + T'^s_{km} = d^s_{km} - U^s_{km} \quad \forall\, k\in K, m\in M \quad (4)$$

$$\sum_{m\in M} V^s_m = \sum_{j\in J}\sum_{m\in M} T^s_{jm} + \sum_{k\in K}\sum_{m\in M} T'^s_{km} \quad (5)$$

$$\sum_{m\in M} h_m Q^s_{im} \le a^s_i c_i x_i \quad \forall\, i\in I$$

$$\sum_{i\in I}\sum_{m\in M} h_m Y^s_{ijm} + \sum_{m\in M} h_m T^s_{jm} \le b^s_j c'_j x'_j \quad \forall\, j\in J \quad (6)$$

$x'_j \in \{0,1\}$

$x_i \in \{0,1\}$

$Q^s_{im} \geq 0$

$Y^s_{ijm} \geq 0$

$Z^s_{jkm} \geq 0$

$T^s_{jm} \geq 0$

$T'^s_{km} \geq 0$

$V^s_m \geq 0$

$U^s_{km} \geq 0$

Additional thoughts/Assumptions

- only one facility being outsourced ⇒ add more?
  - ↳ Decision variable $\begin{cases} 1 & \text{use backup supplier} \\ 0 & \text{otherwise} \end{cases}$
  - ↳ instead of assuming availability, pay fee for backup supplier in the event of a disruption
- Left out mode of transportation → include it?
- Left out machinery types
- Keep lost sales or assume that whatever demand can't be met come from outsourcing?
- cost of "staying open" vs. facility opening problem

Idea 2

- Same sets with addition of T: set of time periods t
- Add level of suppliers?

Suppliers → Manufacturers → Distribution Centres → Market Zone

- F_m := set of components required to build product m

or • F := set of components total for all products

Decision var. regarding inventory (beginning of time t)

* r^s_{ift} = amount of component $f \in F$ at plant i at start of period t

Additional parameter

$y_{fm} = \begin{cases} 1 & \text{component } f \text{ needed to build product } m \\ 0 & \text{otherwise} \end{cases}$

Inventory at $t+1$

(Amount at t) − (amount used to build product + shipped off) + (amount ordered from suppliers) → based on forecasted demand?

* only necessary for plants