Wonder Market

Sets

S Stores : ["S0", "S1", "S2", "S3", "S4", "S5", "S6", "S7", "S8", "S9"]
D Distribution centres : ["DC0", "DC1", “DC2","DC3","DC4","DC5","DC6"]
SC Scenarios : ["SC0","SC1","SC2","SC3","SC4"]

Data

$CT_{d,s}$: The Cost of Transport from each distribution centre to each store$(d, s) \in (D, S)$

For communication 4 and 5, we only need the Cost of Transport from DC0, DC1 and DC2:

[2081, 2462, 2958, 1911, 2735, 1805, 2139, 2795, 1456, 2707],
[1094, 1267, 1996, 1091, 1520, 1016, 1200, 1880, 912, 2100],
[1418, 1604, 2877, 2566, 2113, 2578, 2570, 2900, 2478, 3379]

While from Communication 6 onwards, We need the Cost of Transport from all DC’s:

[2081, 2462, 2958, 1911, 2735, 1805, 2139, 2795, 1456, 2707],
[1094, 1267, 1996, 1091, 1520, 1016, 1200, 1880, 912, 2100],
[1418, 1604, 2877, 2566, 2113, 2578, 2570, 2900, 2478, 3379],
[1506, 1146, 1945, 2241, 1371, 2304, 2020, 2147, 2423, 2654],
[2321, 2105, 1381, 1096, 1774, 1255, 1152, 1077, 1542, 716],
[2766, 2752, 2059, 1588, 2391, 1641, 1674, 1772, 1804, 1181],
[1469, 1802, 2505, 1550, 2107, 1389, 1714, 2370, 1087, 2392]

CD_d: Capacity Limitation at each distribution centre $d \in D$

For communication 4 and 5, we only need the Capacity Limitation at DC0, DC1 and DC2:

[48, 63, 57]

While from Communication 6 onwards, We need the Cost of Transport from all DC’s:

[48, 63, 57,19, 45, 77, 77]

WD_s: Weekly Demand at each store, in truckloads $s \in S$

[12, 12, 10, 21, 6, 10, 12, 11, 8, 14]

$WS_{sc,s}$: Different weekly demand scenarios we are required to meet $(sc, s) \in (SC, S)$

[13,	12,	10,	21,	23,	10,	12,	11,	8,	14],
[12,	12,	10,	21,	6,	10,	12,	12,	8,	25],
[12,	12,	10,	21,	18,	10,	12,	15,	8,	14],
[12,	12,	10,	30,	16,	10,	12,	11,	9,	14],
[12,	12,	10,	21,	6,	10,	12,	31,	8,	14]

$Weeks_{sc}$: The number of weeks in which we have each one of the surge scenarios $sc \in SC$

[3,1,5,6,3]

Variables

$X_{d,s}$: The ratio of truckloads delivered to each store s, from each Distribution centre d $(d, s) \in (D, S)$

Y_d : A binary variable to decide which new distribution centre should be used $d \in D$

$y1_d$ and $y2_d$: Two integer variables to decide the number of full-time and part-time workers at each distribution centre $d \in D$

$w_{sc,d}$:An integer variable for the number of causal workers in each scenario at each distribution centre $(t, d) \in (SC, D)$

Objectives

From Communication 4 to Communication 7, the objective is as follows:

$$\min \sum_{d \in D} \sum_{s \in S} CT_{ds} * X_{ds} * WD_s$$

For Communication 8, the objective function is:

$$\min \sum_{d \in D} \sum_{s \in S} (CT_{ds} * X_{ds} * WD_s) + \sum_{d \in D} (4500yi_d + 2750y2_d)$$

For Communication 9, the objective function is:

$$\min (34 * (\sum_{d \in D} \sum_{s \in S} (CT_{d,s} * X_{d,s} * WD_s)) + 52 * (\sum_{d \in D} (4500yi_d + 2750y2_d))+$$

$$\sum_{sc \in SC} \sum_{s \in S} \sum_{d \in D} Weeks_{sc} * CT_{d,s} * X_{ds} * WS_{sc,s} + 2080 * (\sum_{sc \in SC} \sum_{d \in D} Weeks_{sc} * W_{sc,d}))$$

Constraints

Adding up the ratios for each store to one and meeting the weekly demands:

$$\sum_{d \in D} X_{d,s} * WD_s = WD_s \qquad \forall s \in S$$

#Constraint on the capacity demand of each distribution centre:

$$\sum_{s \in S} X_{d,s} * WD_s \leqslant CD_d \qquad \forall d \in D$$

For communication 4:

$\sum_{d \in \{1,2\}} \sum_{s \in S} X_{ds} * WD_s \leqslant 88$ where $d \in \{1,2\}$ are the distribution centres north of the river

Keep the ratios in a way that it works for 5 other scenarios:

$$\sum_{s \in S} X_{d,s} * WS_{sc,s} \leqslant CD_d \qquad \forall sc \in SC \text{ and } \forall d \in D$$

From Communication 5 onwards, we need to assign each store to just one distribution centre.In the Python code, I have used a type I SOS constraint.

For Communication 6, adding constraints for choosing one new distribution centre:

$$\sum_{d \in \{1,2,3,4\}} Y_d = 1$$

For Communication 7 onwards, adding constraints for choosing at most two new distribution centres and eliminating at most one old distribution centre:

$$\sum_{d \in \{0,1,2\}} Y_d \geqslant 2$$

$$\sum_{d \in \{3,4,5,6\}} Y_d \leqslant 2$$

Choosing 4 in total:

$$\sum_{d \in D} Y_d = 4$$

Adding constraints for only delivering from the distribution centres chosen:

$$Y_d \geqslant X_{d,s} \forall d \in D, \forall s \in S$$

Adding the constraints for the number of full-time and part-time teams at each distribution centre:

$$9 * y1 + 5 * y2 \geqslant \sum_{s \in S} X_{d,s} * WD_s, \forall d \in D$$

Adding constraints for total labour costs in surge scenarios:

$$9 * y1 + 5 * y2 + w_{sc,d} = \sum_{s \in S} X_{d,s} * WS_{sc,s} \forall sc \in SC, \forall d \in D$$

All variables are greater than or equal to zero.