**Optimization Final Project (Updated)**

*Indexed Sets*

i = plant (i = 1...5)

j = warehouses (j = 1,...4)

k = retail center (k = 1,...8)

t = year (t = 1….10)

*Data:*

Dkt = demand for retail center k in year t

Ci = capacity (units) of plant i

Kit = construction cost of plant i in year t

Oit = annual operating cost of plant i in year t

Rit = reopening cost of plant/production line i in year t

Sit = shutdown cost of plant/production line i in year t

Aijt = cost of shipping a Flugel from Plant i to Warehouse j in year t

Bjkt = cost of shipping a Flugel from Warehouse j to Retail Center k in year t

Lit = cost of alloy of plant i in year t

Uit = cost of subassemblies of plant i in year t

Dit = cost of discounted subassemblies of plant i in year t

*Objective:* minimize the total cost of meeting the expected demand over the next 10 years

min Shipping Costs + Plant Costs + Cost of Alloy + Cost of Widget Subassemblies

*Decision Variables:*

zit = units of Flugels produced by plant i in year t (500 variables)

xijt = units of Flugels shipped from plant i to warehouse j in year t (200 variables) (note: it represents inflow)

yjkt = units of Flugels shipped from warehouse j to retail center k in year t (320 variables) (note: it represents outflow)

~~I~~~~jt~~ ~~= amount of inventory stored in warehouse j in year t (40 variables)~~

(I deleted the this one above is because we can directly use x-y to get the amount of inventory stored in specific warehouse in specific year)

e1it and e2it = will be used for cost structure part. Let e1 = 1 if segment 1 is used; 0 otherwise; Let e2 = 1 if segment 2 is used; 0 otherwise. Each plant in each year have their own e (binary)

λ1it,λ2it, λ3it = will be used for the cost structure when calculating the weighted units of purchased raw materials of plant i in year t.

Pit = whether the plant i’s production line is open at the beginning of year t. 1: open, 0: close (binary) (I deleted the ‘m’ because I deleted the production line index before!)

Fit = whether the production line in the plant i is going to be shut down at the end of year t or not. 1: shut down, 0: close (binary)

Git = whether the production line in the plant i in year t is the initial construction year. 1: initial, 0: not initial (binary) (This one helps calculating reopening cost. After I read through the case again, it looks like reopening cost will occur in the initial construction of each opening period. For example, if a plant opens in year 2,3,4 and shut down in 4, and reopen in 7,8, then both year 2 and year 7 are the initial construction year and will have reopening costs)

Hit = whether the production line in the plant i was never opened before year t or not. 1: not opened before, 0: opened before (binary) (This one helps calculating the construction cost)

***Plant Cost:***

+ + + (partial obj function)

\*Note:

First part: operating cost

Second part: shut down cost

Third part: reopening cost

Fourth part: construction cost

(\*\*We need to set constraints to identify the open/close conditions!)

Constraints:

If Pit-1 == 0: Git=1. Else: Git=0 (helps identify if it is the initial construction year)

Updated: Git = 1-Pit-1 for each i and t

If >=1: Hit=0. Else: Hit=1 (if the sum of all previous Pit are >= 1 then it means the plant has operated before year t)

If Pit+1==0: Fit=1. Else: Fit=0 (If the next year the plant’s production line is not operating, then it means it has been shut down in the previous year)

Updated: Fit = 1-Pit+1 for each i and t

If Pit==0: zit=0. Else: zit>0 (a production line cannot be allowed to remain idle in a given year)

Updated: zit <= PitCi  for each i and t (Don’t exceed capacity)

(I am really really not sure if I am on the right track for these constraints….. I am using conditional statement here cause it is so hard for me to set constraints without thinking about if statements. I know we never learned using if statements in Gurobi constraints before, but when I searched on google, it seems like there are ways to include if statements in Gurobi constraints! So we can definitely try if we don’t have any other clues!)

**Material cost:**

Widget:

ait = total number of widget will be ordered

f(ait) = cost function

f(a) = Uit\*ait 0<=ait<=9,000

9000\* Uit+ Dit\*(ait-9000) 9,000<ait<=1,000,000

Three boundaries: 0 9,000 1,000,000

ait = 0 λ1it+9000 λ2it+1000000 λ3it  (number of widgets should be ordered by plant i in year t)

f(ait) = (0\*Uit) λ1it+(9000\*Uit) λ2it+[9000\* Uit+ Dit\*(1000000-9000)] λ3it (partial obj function)

Constraints:

λ1it +λ2it +λ1it=1 for each i and t

λ1it<= e1it for each i and t

λ2it<= e1it+e2it for each i and t

λ3it<= e2it for each i and t

e1it+e2it=1 for each i and t

0 λ1it+9000 λ2it+1000000 λ3it /3 = zit (the amount of widget purchased by plant i in year t divided by three equals to the unit of flugels produced by plant i in year t)

Alloy:

Lit\*zit (partial obj function)

Constraint:

4.7\* zit<=60000 for each i and t

**Shipping cost:**

+ (partial obj function)

Constraint:

for each i and t (sum of products shipped from each plant in year t equals to the amount of flugels produced by it in year t) Wilck said each plant can ship products to multiple warehouses, that’s why I sum up j for each i

for each j and t (sum of products received by warehouse j in year t equals to sum of products shipped from warehouse j in year t) cause each warehouse can ship products to multiple retail centers

<= 4000\*10 for each j (average inventory in any year to be no more than 4000 items (among all Warehouses))

<= 12\*1000 for each j and t

<= 12\*1000 for each j and t (both the flow into a warehouse and the flow out of a warehouse should not exceed an average of 1000 units per month)

for each k and t (Meet demand)

zit <= PitCi  for each i and t (Don’t exceed capacity) (added from the meeting)