Exam 1 ISE 754

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Summary of each question

Question 1:

This is a single facility location problem, to solve it we need to have monetary weights of each point (both suppliers and customers). To calculate the weights we need to have transportation rate or r ($/mi*ton). To calculate r, first, I calculated the shipment size of inbound and outbound transportations using maxpayld function in matlog and assumed total capacity of each truck is 2750 cubic ft and total weight is 25 tons and the revenue per truckload is 2$, then I used 2*(ppiTL/102.7) for revenue per truckload based on the latest ppiTL and divided by shipment size to get rate per ton. Also, to calculate the demand for the suppliers with unit "ton per year", I multiply each demand for the supplier (raw unit/product unit) to summation of customer demand with unit (product units/year) and the multiply it by its weight with unit (lb) and dividing them by 2000 to get "ton per year". After getting w, the rest of calculations is the same as single truck shipment discussed in both homeworks and scripts. My final result is the new facility should be located at "DCtc is 7.72 mi W of Oklahoma City, OK" with total cost of 4.5798e+05.

Other Assumptions:

- I used mand in aggregating data to keep the order right
- I set the ppi 141.9 for 2019 Jan
- Since lonlat2city will use uscity50k, I didn't add any other conditions for satisfying cities with at least 50 k population
- assumed total capacity of each truck is 2750 cubic ft and total weight is 25 tons and the revenue per truckload is 2$, then I used 2*(ppiTL/102.7) for revenue per truckload

Question 2:

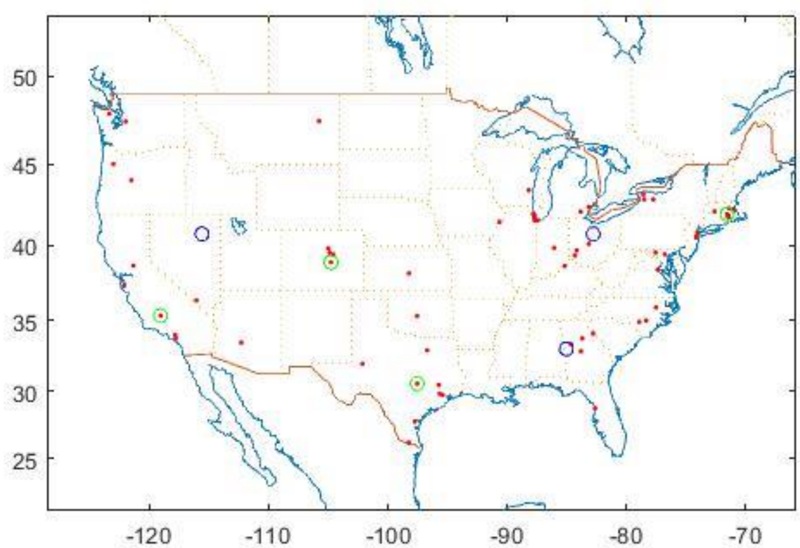
For this question, after reading all the data into MATLAB and do the geolocation, I first analyzed the data by comparing the summation of capacities for plants vs. the summation of demands for customers; I observed that the sum of total capacities is 100,000 but sum of total demand is 137,919 which is way more than the capacities. As a result, each of the current plants should produce at their maximum capacity and there will be some unmet demand remaining. First, we need to know the current allocation of demand to calculate the transport rate or r ($/unit*mi). To do so, I assumed there is no capacity involved in the problem and solve the allocation without that. After getting a flow matrix F, to calculate r, we need the total distribution cost assuming there is no capacity, because we calculated F with this assumption. To adjust distribution cost in a way to include those extra demand points, I calculate an increase by this formula:

$$increase = (difference\ between\ sum\ of\ capacity\ and\ demand) * \left(\frac{total\ distribution\ cost}{capacity}\right)$$

The second term in the above formula gives us an estimate of distribution rate for each unit and the first term is the amount of units that cost us this rate. I added this “increase” to the total distribution cost in order to get a more adjusted number for rate.
Second, I compute the fixed cost for current plants by using linear regression where x is the summation of the allocated demand in previous step for each plant and y is Total production cost given by the problem plus the increment which is computed by the following relation an explains for the cost of unmet demand (or the production that we needed to have):

$$increase = (difference\ between\ sum\ of\ capacity\ and\ demand) * \left(\frac{total\ Production\ cost}{capacity}\right)$$

We get 2.2564e+06 for the fixed cost (k), and using this fixed cost and knowing the total distribution cost, we can compute the current total cost.
After calculating the r and k, we can compute the C which is variable cost for our ufl. To solve this problem with ufl, I defined another MILP, which is basically the same as HW 6 question 5 with some new constraints. The first set of new constraints is that I set y_i for i=1,2,3 (Current plants) to be one because we want them in our company no matter what, the second set of constraints is that only for first 3 facilities we have capacity constraint (in which I assumed total demand associated with these plants should be less than or equal to their capacity) and for the rest of the variables we have regular weak form constraint. The rest of the constraints is the same as the homework problem.
After solving this, mixed integer programming with Gurobi, we get the final result of 5 extra new facility in addition to current 3 should be added where their indexes are: [16 28 47 55] and their location is shown with green circles in the graph below. Blue circles are the current ones.



Other Assumptions:

- For calculating the current cost, I assumed each plant produce what it would be producing if it didn't have the capacity. And then adjusted the y to represent this x's production cost. I used this assumption because I dropped the capacity condition for calculating r, I thought all the calculations should have the same procedure.
- Distances used in this question are all adjusted to be real road distance by multiplying them by 1.2 (circuity factor). Because I assumed this company is using real roads to deliver their products
- Sum of demand associated with each of the current facilities (1 to 3) should be smaller or equal to their capacity. (Explained above in the paragraph)
- For locations, I used uszip5 to get the data. I assumed that would be sufficient.
- For the allocation part I just used the code given in homework 5 without any capacity.

Question 3:

a) The original Problem is:

"On average, 75 tons of a product are shipped 625 miles from your manufacturing plant to your DC each year. The product is produced and consumed at a constant rate throughout the year. Currently, the product is shipped using independent P2P truckloads. What would be the impact on total annual logistics costs if the average interval between shipments was restricted to not exceeding one week and, if the shipment size is equal to one week's demand, then both TL and LTL are considered? The PPIs for TL and LTL are 2 123.4 and 141.4, respectively; a truck's cubic and weight capacities are 2,750 ft3 and 25 tons, respectively; each ton of the product is valued at $12,000; its density of 12 lb per ft3 ; the inventory carrying rate is 30%; and in-transit inventory costs can be ignored."

The colored sentences are those I will change for each of desired changes in the question. The modified question is:

"On average, 75 tons of a product are shipped 625 miles from your manufacturing plant to your DC each year. The product is produced in batches and consumed at a constant rate throughout the year. Currently, the product is shipped using independent P2P truckloads. What would be the impact on total annual logistics costs if the average interval between shipments was restricted to not exceeding twenty days and, if the shipment size is equal to one week's demand, then both TL and LTL are considered? The PPIs for TL and LTL are 2 123.4 and 141.4, respectively; a truck's cubic and weight capacities are 2,750 ft3 and 25 tons, respectively; each ton of the product is valued at $12,000; its density of 12 lb per ft3 ; The product will lose its 60% of value after 2 years the interest and warehousing carrying rates are 4% and 6%, respectively; and in-transit inventory costs can be ignored."

Mathematical representation of these changes are:

	Original	Modified
Alpha	1	0.5
tmax	7 days	20 days
h	0.3	0.04+0.06+0.6/2=0.4

b) The same procedure has been implemented in the scripts. I changed each of these parameters in 3 separate scripts to observe the change, and then added all these changes in the final script.

c) Change 1: By changing alpha from 1 to 0.5, we observe a decrease in Total Logistic Cost (without tmax constraint); a decrease in Inventory Cost (after tmax constraint); and, no change in TC (after tmax constraint). Which is obvious, since inventory cost is calculated by the following relation which has positive correlation to alpha, so when alpha decrease IC decrease too.

$$IC = vh\alpha q$$

Also, TC has no relation to alpha therefore it would not change. Based on what I just explained TLC , which is the summation of IC and TC, will decrease too.

Note that, Computation of TLC with constraint and without one is different, where in the second case (with constraint) it is calculated based on

$$TLC_{TL}(q^*_{TL}) = \frac{f}{q^*_{TL}} r_{TL} d + \alpha v h q^*_{TL}$$

where, $q^*_{TL} \propto {}^1/_{\sqrt{\alpha}}$ and therefore $TLC^*_{TL} \propto \sqrt{\alpha} + \alpha\sqrt{\alpha}$ so by decreasing alpha TLC will decrease too.

To explain this change intuitively I would say that since we don't keep inventory in the origin anymore, the inventory cost will decrease and we will have a decrease in total logistic cost as well.

Change 2: By changing tmax from 7 days to 20 days we observe an increase in inventory cost, since we need to keep the inventory for longer period now and a decrease in transportation cost, because we are sending the truck less often than before. These changes only apply to costs in the problem with constraint because we did not change anything in the problem with no constraint.

To explain this change mathematically, we can observe from the equation of TLC above that if q increase IC increase and TC decrease since they are positive and negative correlated, respectively. Where, q will increase by increasing the tmax since it is positively correlated with it.

Change 3: By adding the obsolescence rate to be 0.6/2=0.3 our total h will increase to 0.4. It means that the inventory carrying rate has increased therefore inventory cost will increase as well. And, transportation cost will not change (in the case with constraint) because it is computed separately. For the case without any constraints since the whole TLC (above formula) is positively correlated with h, it will also increase.

The last script has the all changes together.