OSDML

End Term Exam

Code:https://colab.research.google.com/drive/1Llb_xsidqJDbVOvJ3Kw8D_HjiG2FnPQg?usp=sharing

Dataset (Excel Link) :
https://1drv.ms/x/c/4adceed357c356fd/EZg_DWvZ_txFitE1hTisE6QBOaIcN08GvT-MUhCORkiyyQ?e=la4so9

Question 1: Data Exploration and Cleaning

(a) Identify each missing or contradictory entry and describe how you addressed it. (E.g., you might take an average of known values, choose a conservative capacity, or correct reversed ranges.)

For handling missing values, there were three scenarios and their solutions.

- Two values for one metric: Taken a middle of both values.
- One of the upper/lower bounds is missing: Average of the other two weeks.

Vegetable	Week 1	Week 2	Week 3	Total
Spinach	500	450	470	1420
Tomatoes	650	580	700	1930
Carrots	400	400	410	1210

Hub A

Vegetable	Week 1	Week 2	Week 3
Spinach	100–200	110–190	100–180
Tomatoes	150–300	160–310	140–290
Carrots	50–100	60–120	80–110

Hub B

Vegetable	Week 1	Week 2	Week 3
Spinach	100–200	110–190	100–180
Tomatoes	100–200	120–220	120–200
Carrots	70–140	70–160	140-160

Hub C			
Vegetable	Week 1	Week 2	Week 3
Spinach	50–90	55–95	92.5–85
Tomatoes	80–160	100–170	110–165
Carrots	40–90	40–95	50–100

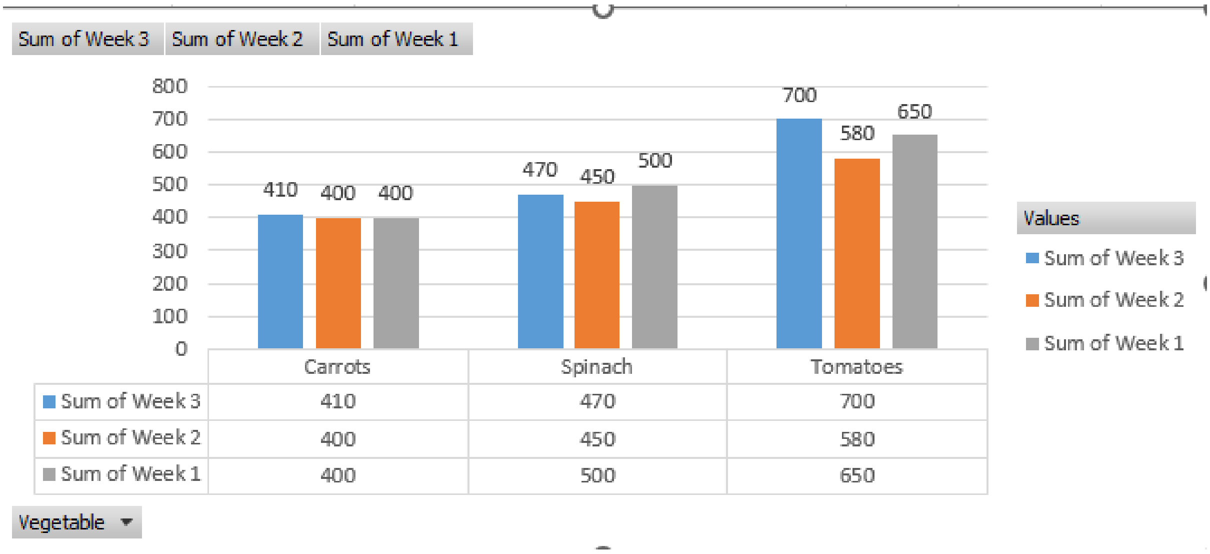
(b) Show a short descriptive summary: for each week, how many kg of each vegetable. Can be produced, and what is the plausible demand range at each hub? Summarize the cost structure.

Vegetable	Week 1	Week 2	Week 3	Total
Spinach	500	450	470	1420
Tomatoes	650	580	700	1930
Carrots	400	400	410	1210

Given the above figure, we got an idea of the total production of vegetables through the entire 3 weeks.

Tomatoes have the highest production for all 3 weeks, with the 3rd week being the maximum of all the weeks.

Carrots have the lowest production of all three. Here production units are being constant in the first two weeks, and there is not much increase in week 3.



This graph will give more idea on production levels. It gives the highest to lowest values in the table below; the graph also shows the same.

(c) Comment briefly on any assumptions (e.g., “We assume Week 3 spinach capacity is 460 kg,” or “We replaced the missing cost with 0.46, matching other data.”)

For assumptions as discussed in question 1, average of bounds is taken, and a similar method is taken for contradictory values.

Assumptions:

Production Data:

Week 3 for spinach taken as 470 ({500+450}/2)

Week 3 for Tomatoes taken as 700 ({720+680}/2)

Week 3 for Carrots taken as 410 ({400+420}/2)

Likewise for Hub Demand Data.

Question 2: Model Formulation

(a) Explain your approach to modelling the 3-week horizon. Are you doing a separate optimization per week or a single multi-period model with 3 sets of constraints (one for each week)?

I am going to take a week-wise approach, as values for each week are different. Production capacity is different for each week; its demand changes as well for vegetables.

Considering the change in values, the amount to send to the hub also changes according to demand. So I'm going with a separate week-wise approach.

(b) Define decision variables (e.g., xv,h,w for kg of vegetable v shipped to hub h in week w) and write your objective function (minimizing total cost across all weeks, or cost +carbon if you choose a multi-objective).

Here, the decision variable will be the amount sent to each hub for each vegetable.

Consider for now, that variable as x

$$\sum_{V}\sum_{H} x$$

Something like this will be the decision variable, but we need to add a cost function here.

Cost function

$$\Sigma\ (\text{cost})\ (\text{amount sent})$$

Representation

V - vegetable

H - Hubs

For every week. $\sum_{V}\sum_{H} (\text{cost})\ (\text{amount sent})$

For each week, we will calculate the cost function and minimize the function.

(c) State the constraints clearly, including production limits, demand min–max, and non-negativity. If you use or consider integer constraints, mention why.

Production constraints

Let x be production value.

$x \leq$ ~~Capacity~~ capacity of farm

Week wise

Spinach

$x_{week\,1} \leq 500$

$x_{week\,2} \leq 480$

$x_{week\,3} \leq 470$

Tomatoes

$x_{week\,1} \leq 680$

$x_{week\,2} \leq 580$

$x_{week\,3} \leq 700$

Carrots

$x_{week\,1} \leq 400$

$x_{week\,2} \leq 400$

$x_{week\,3} \leq 410$

~~Demand Constraints~~

~~Week 1~~

$\cancel{100 \leq D_S \leq 200}$

Demand Constraints

lower band < x < upper bound.

Week 1

Hub A

$100 \leq D_S \leq 200$

$150 \leq D_T \leq 300$

$50 \leq D_C \leq 100$

Hub B

$80 \leq D_S \leq 150$

$100 \leq D_T \leq 200$

$70 \leq D_C \leq 140$

September

M T W T F S S
1 2 3 4

Wk: 31

August '22

Hub C

$50 \leq D_S \leq 90$

$80 \leq D_T \leq 160$

$40 \leq D_C \leq 90$

In the demand constraints, D is the amount sent to hubs, and x consists of the sum of D_s, D_t and D_c.

Non-Negative Constraints:

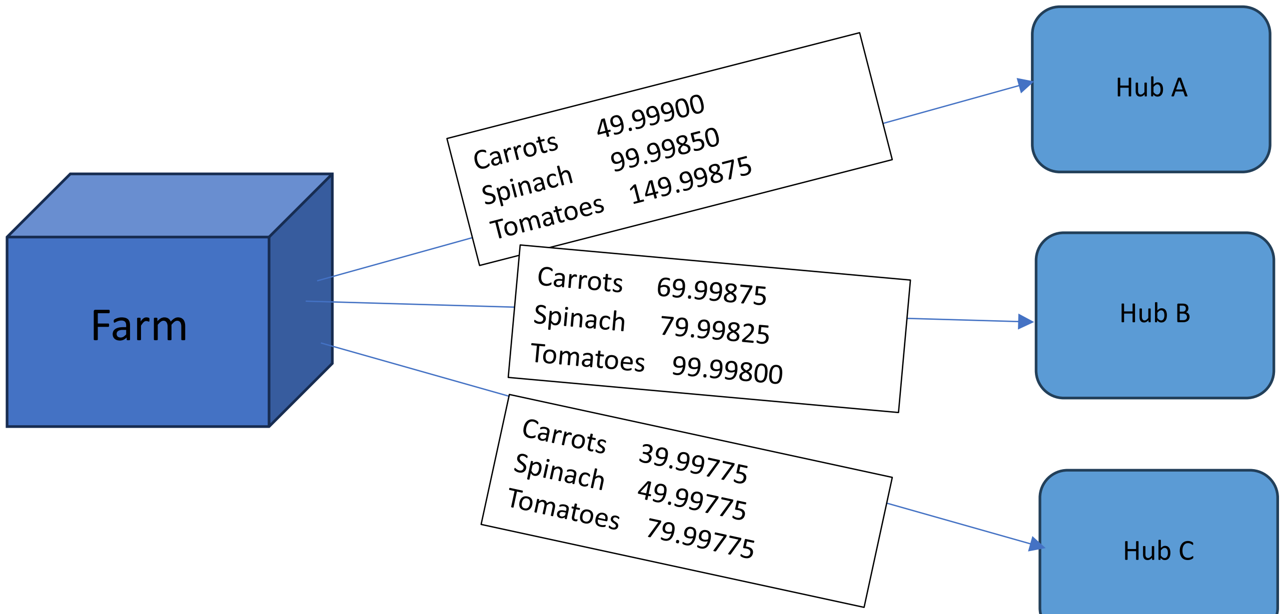
There will be no need for non-negative constraints as we have defined lower bounds in demand ranges.

Question 3: Solving and Key Results

- (a) Implement your model in a solver. Present the optimal allocations for each week: how many kg of each vegetable go to each hub, total cost, and any carbon summary if relevant.

For getting optimal solutions, I have added slack variables and penalty to the cost function. So, we get full use of the production capacity.

Why do we need to do this? Because on solving week 3 we are not getting a feasible solution for some reason, we applied a penalty constraint to the model to prevent it from overusing the production.



Note: This is for Week 1 for now. As the list would be huge to display here. Available in code.

(b) If you run separate week-by-week optimizations, compare them. If you run a single multi-week optimization, present your consolidated results.

Using a week-wise approach, I compare the cost for each week. As we move forward, the cost seems to increase each week. Here are cost references I got from solving the problem.

Week	**Cost**
1	239.494275
2	271.34455097
3	316.919596973

(c) Include a short commentary on any surprising findings (e.g., “We end up sending almost no spinach to Hub C,” or “Tomatoes are shipped only to Hub A because of cost differences.”)

Most surprising for now is that even though the demand has an upper bound and penalty constraint added to cost, most of the optimal values are nearest to the lower bounds.

Secondly, adding a penalty will make the week 3 solution feasible, but without it. It gives *@error: Solution Not Found,* which is a bit unexpected.

Question 4: Sensitivity or Scenario Testing

(a) Choose one parameter (e.g., cost to Hub C, or production capacity of tomatoes in Week). Increase or decrease it by 10 percent. Does the optimal solution change significantly?

On changing the lower bound of Hub A, week 2 Spinach We can see the change in total cost of Week 2. From 271.344 to 268.149.

(b) Provide a brief reflection on which parameters are most critical. Is there a certain route, week, or vegetable that strongly influences total cost?

Parameters that are sensitive are *lower bound parameters,* as we can see the change in total cost only after changing the lower bound of one input. Not even changing cost affected the total cost. Strange!

Question 5: Strategic Extensions

(a) Propose one extension to handle uncertain demands or multi-objective trade-offs (like carbon constraints). How might you incorporate these in your optimization model?

When getting unusual demands, we can reduce the supply flow to different hubs, as our optimal solution is already biased towards lower bounds; getting every minimum demand can be resolved by the model itself. As it is already underutilizing the production capacities.

Also, adding carbon emission as a penalty can keep it at bay if demand is too high with respect to the low cost associated with it.

(b) In a short paragraph, summarize how you would present your final recommendation to BrightGro Foods management. Mention the limitations of your model (e.g., ignoring seasonality or daily fluctuations) and how to address them in future iterations.

My recommendations after analyzing the data and studying it are to be more cautious on demand ranges and production rates. Also, having less difference between upper and lower bound ranges in demand that way, the model won't be underutilizing state because that will cause inventory costs, which are not taken into consideration here.