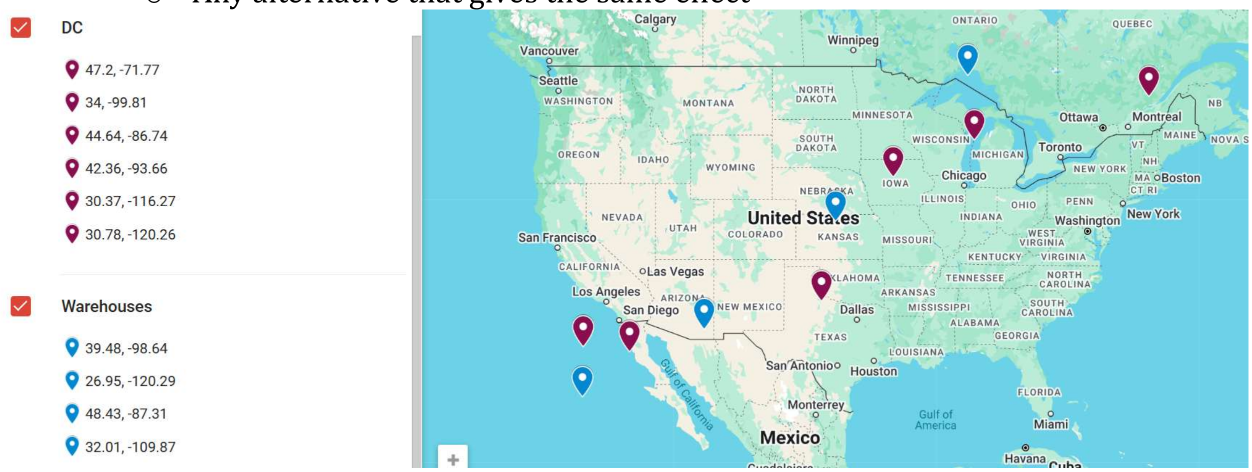
Module 09 – Fixed Charge Problem

Exploratory Data Analysis
In this section, you should perform some data analysis on the data provided to you. Please format your findings in a visually pleasing way and please be sure to include these cuts:

- *Make a visual graph of your data on a map (coordinates should be within US borders)*
    - https://mymaps.google.com/
    - Find a map with latitude/longitude and place them approximately
    - Any alternative that gives the same effect



Model Formulation
*Write the formulation of the model here before implementing it in your Excel model. Be explicit with the definition of the **decision variables, objective function, and constraints.***

Decision Variables:
Represented by the entirety of the bottom table data (the table below the data table corresponding to the Manhattan values, excluding any solved cells surrounding it) **AND** the Binary Variables (Four cells). These are the two groups of data that are being changed by each other and directly rely on one another.

Objective Function:
MIN:
$639X_1 + 616X_2 + 907X_3 + 817X_4 + 632X_5 + 799X_6 - 1399Y_1 - 2572Y_2 - 2669Y_3 - 1472Y_4$

Constraints:
C13:H16 Range, hereby referred to as Table B
Table B = integer
Table B >= 0
Sum of units sent to DC >= DC Demand
Binary Variables (bin) 0
Sum of Binary Values <= 2 (No more than two warehouses)
Linking Constraints <= 0 (Negativity)

Model Optimized for Min Costs to Supply DCs

Implement your formulation into Excel, and be sure to make it neat. This section should include:

- *A screenshot of your optimized final model (formatted nicely, of course)*
- *A text explanation of what your model is recommending*

WH --> DC	Snickerdoodle Slopes	Taffy Tundra	Mochi Metropolis	Whipped Wonderland	Soda Pop Springs	Meringue Mountains
Gumdrops Grove	68.77	27.53	51.24	42.04	7.44	3.86
Cherry Jubilee Junction	34.59	6.65	17.06	7.86	26.74	30.32
Frozen Fudge Fjords	16.77	26.93	4.36	12.42	47.02	50.6
Caramel Corn Caverns	53.29	12.05	35.76	26.56	8.04	11.62
	173.42	73.16	108.42	88.88	89.24	96.4

WH --> DC	Snickerdoodle Slopes	Taffy Tundra	Mochi Metropolis	Whipped Wonderland	Soda Pop Springs	Meringue Mountains	Sum/units per WH		Binary	Linking	Possible	Actual
Gumdrops Grove	0	0	0	0	0	0	0		0	0	1399	0
Cherry Jubilee Junction	0	0	0	0	0	0	0		0	0	2572	0
Frozen Fudge Fjords	639	0	907	817	0	0	2363		1	-2047	2669	2669
Caramel Corn Caverns	0	616	0	0	632	799	2047		1	-2363	1472	1472
DC - Sum	639	616	907	817	632	799			2			
DC - Demand	639	616	907	817	632	799	4410					
							Total -->	$50,747.15				

In short, the model we crafted is recommending a minimization of total cost, including transportation costs and the fixed setup costs. The table on top (Table A) shows the warehouses on the left and DCs along the top, with the Manhattan distance values for each of the sum of each DC below. Table B has the same labels of WH and DC, however, it includes the summation for each DC and the corresponding demand. This allows us to add the constraint that the Sum is greater than or equal to demand. Based on this, we used a solver to find optimal values for both Table B contents (not solved cells surrounding it) and the four Binary Variable cells. We also added a constraint that no more than two warehouses were to be opened. The objective function effectively takes the sum of the Table B contents times the Binary Variables, adding the total Actual costs incurred. Without constraints in place and our objective function correct, we are given a *proposed* solution of opening Frozen Fudge Fjords and Camel Corn Caverns and utilizing the network as provided above.

Model with Stipulation

Please copy the tab of your original model before continuing with the next part to avoid messing up your original solution.

Please perform 2 out of the 3 scenarios below with a short text description on what changed:

1. *Instead of only being able to open 2 warehouses, what happens to our objective function when we can open only 1 warehouse?*
2. *Right now, we have $1 per unit shipped over the distance between the warehouse and the DC. What happens to our objective function when we increase this to $30? Does your DC assignment change at all?*

3. *For the distance between each location, we used Manhattan distance, but what happens to our model if we use Euclidean distance instead? Did the change impact the model at all? Do you feel this is a better distance metric to use in this scenario?*

Stipulation #1:

What I did was create a formula below our Binary Variables that is the sum of the four Binary cell values and create a constraint on that cell. Originally, we had it set for two warehouses. For this exercise, I changed this value to one and re-ran the solver. What resulted was the solver finding Cherry Jubilee Junction as the one and only warehouse, with a new total cost of $91,791.81 ($41,044.66 increase!). All demand is still fulfilled, and the constraints are met, but this is an issue we see with only opening one warehouse. It can be optimized for some DCs but make up for the short distance ones by the need to fulfill demand at *all distribution centers.*

Stipulation #2:

After implementing the change from $1 to $30 per unit shipped, I observed the following. Of course, an increase in the total cost, as each mile shipped was multiplied by 30, but the setup costs were fixed and therefore untouched. For my data, I'm not sure if others were affected, but the DC assignments did not change; however, the total cost increased 2663.36% to $1,402,325.50.

(Both stipulations are in Excel.)

Map→**Fixed Charge Problem**