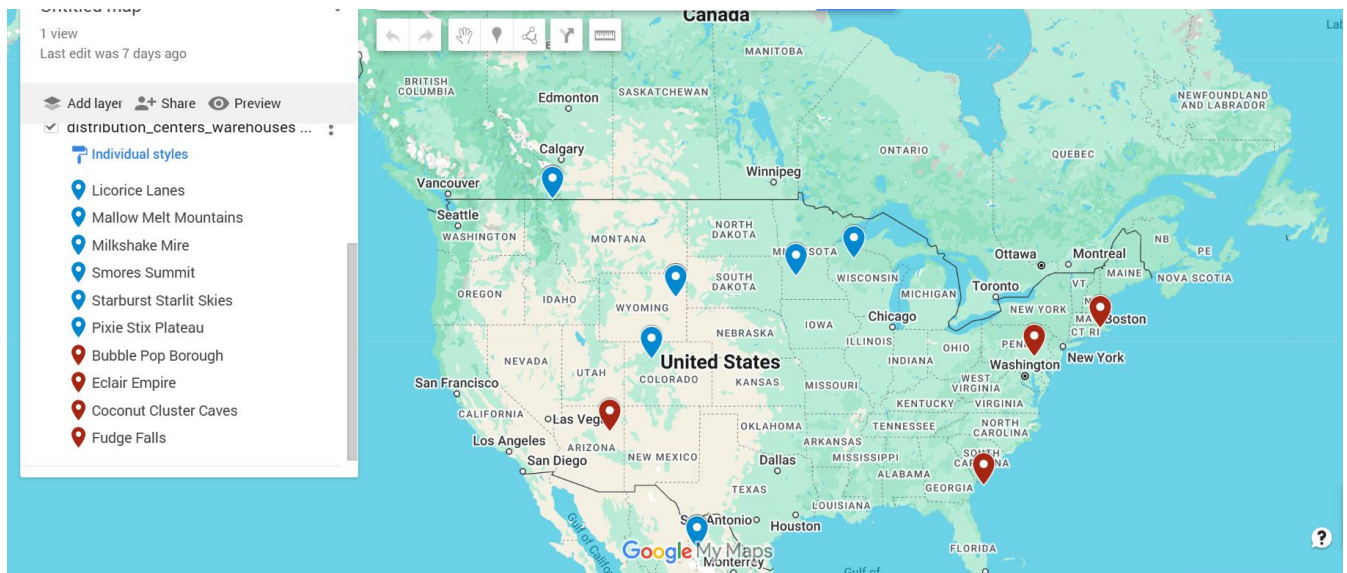


# Module 09 – Fixed Charge Problem

## 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)*
  - o <https://mymaps.google.com/>
  - o Find a map with latitude/longitude and place them approximately
  - o Any alternative that gives the same effect



## Model Formulation

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

$$\text{MIN: } X_1 + X_2 + X_3 + X_4 + 2040Y_1 + 1216Y_2 + 1615Y_3 + 2331Y_4$$

$$X_{11} + X_{21} + X_{31} + X_{41} \leq 869$$

$$X_{12} + X_{22} + X_{32} + X_{42} \leq 800$$

$$X_{13} + X_{23} + X_{33} + X_{43} \leq 519$$

$$X_{14} + X_{24} + X_{34} + X_{44} \leq 716$$

$$X_{15} + X_{25} + X_{35} + X_{45} \leq 550$$

$$X_{16} + X_{26} + X_{36} + X_{46} \leq 615$$

$$X_1 - 4069Y_1 \leq 0$$

$$X_2 - 4069Y_2 \leq 0$$

$$X_3 - 4069Y_3 \leq 0$$

$$X_4 - 4069Y_4 \leq 0$$

$$x_i \geq 0, i=1,2,3,4$$

*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

[illegible]

### Model with Stipulation

*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 only can open 1 warehouse?*** When only 1 warehouse can be opened instead of 2, the objective function increases by \$5,563. This increase occurs because a single warehouse must now serve all demand, leading to higher transportation costs, and possibly less efficient routing compared to distributing the load between two strategically located warehouses.

Warehouse	Distribution C	WH Lat	WH Long	DC Lat	DC Long	Manhattan
1 Bubble Pop Borough	1 Licorice Lanes	35.42	-110.29	43.67	-104.99	13.55
1 Bubble Pop Borough	2 Mallow Melt Mountains	35.42	-110.29	27.47	-103.35	14.89
1 Bubble Pop Borough	3 Milkshake Mire	35.42	-110.29	49.06	-114.88	18.23
1 Bubble Pop Borough	4 Smores Summit	35.42	-110.29	45.85	-90.82	29.9
1 Bubble Pop Borough	5 Starburst Starlit Skies	35.42	-110.29	44.86	-95.47	24.26
1 Bubble Pop Borough	6 Pixie Stix Plateau	35.42	-110.29	39.97	-106.95	7.89
2 Eclair Empire	1 Licorice Lanes	41.86	-71.13	43.67	-104.99	35.67
2 Eclair Empire	2 Mallow Melt Mountains	41.86	-71.13	27.47	-103.35	46.61
2 Eclair Empire	3 Milkshake Mire	41.86	-71.13	49.06	-114.88	50.95
2 Eclair Empire	4 Smores Summit	41.86	-71.13	45.85	-90.82	23.68
2 Eclair Empire	5 Starburst Starlit Skies	41.86	-71.13	44.86	-95.47	27.34
2 Eclair Empire	6 Pixie Stix Plateau	41.86	-71.13	39.97	-106.95	37.71
3 Coconut Cluster Caves	1 Licorice Lanes	40.09	-76.39	43.67	-104.99	32.18
3 Coconut Cluster Caves	2 Mallow Melt Mountains	40.09	-76.39	27.47	-103.35	39.58
3 Coconut Cluster Caves	3 Milkshake Mire	40.09	-76.39	49.06	-114.88	47.46
3 Coconut Cluster Caves	4 Smores Summit	40.09	-76.39	45.85	-90.82	20.19
3 Coconut Cluster Caves	5 Starburst Starlit Skies	40.09	-76.39	44.86	-95.47	23.85
3 Coconut Cluster Caves	6 Pixie Stix Plateau	40.09	-76.39	39.97	-106.95	30.68
4 Fudge Falls	1 Licorice Lanes	31.8	-80.39	43.67	-104.99	36.47
4 Fudge Falls	2 Mallow Melt Mountains	31.8	-80.39	27.47	-103.35	27.29
4 Fudge Falls	3 Milkshake Mire	31.8	-80.39	49.06	-114.88	51.75
4 Fudge Falls	4 Smores Summit	31.8	-80.39	45.85	-90.82	24.48
4 Fudge Falls	5 Starburst Starlit Skies	31.8	-80.39	44.86	-95.47	28.14
4 Fudge Falls	6 Pixie Stix Plateau	31.8	-80.39	39.97	-106.95	34.73

WH v DC>	1	2	3	4	5	6	sum
1	869	800	519	716	550	615	4069
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
Sum	869	800	519	716	550	615	
Demand	869	800	519	716	550	615	4069

WH v DC>	1	2	3	4	5	6
1	13.55	14.89	18.23	29.9	24.26	7.89
2	35.67	46.61	50.95	23.68	27.34	37.71
3	32.18	39.58	47.46	20.19	23.85	30.68
4	36.47	27.29	51.75	24.48	28.14	34.73

Product 1	Product 2	Product 3	Product 4
0	0	0	0

Setup costs	\$ 2,040	\$ 1,216	\$ 1,615	\$ 2,331
Actual Costs	\$ 2,040	\$ -	\$ -	\$ -

Binary	1	0	0	0	1	\$ 74,792
Linking	0	0	0	0	0	
Big M	4069	4069	4069	4069		

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?** Increasing the cost per unit-mile from \$1 to \$30 causes the total cost to increase significantly to \$1,970,881. However, the model's optimal warehouse selections and DC assignments do not change, indicating that the Warehouses chosen are still the most cost-efficient combination under both cost structures.

Warehouse	Distribution C	WH Lat	WH Long	DC Lat	DC Long	Manhattan
1 Bubble Pop Borough	1 Licorice Lanes	35.42	-110.29	43.67	-104.99	13.55
1 Bubble Pop Borough	2 Mallow Melt Mountains	35.42	-110.29	27.47	-103.35	14.89
1 Bubble Pop Borough	3 Milkshake Mire	35.42	-110.29	49.06	-114.88	18.23
1 Bubble Pop Borough	4 Smores Summit	35.42	-110.29	45.85	-90.82	29.9
1 Bubble Pop Borough	5 Starburst Starlit Skies	35.42	-110.29	44.86	-95.47	24.26
1 Bubble Pop Borough	6 Pixie Stix Plateau	35.42	-110.29	39.97	-106.95	7.89
2 Eclair Empire	1 Licorice Lanes	41.86	-71.13	43.67	-104.99	35.67
2 Eclair Empire	2 Mallow Melt Mountains	41.86	-71.13	27.47	-103.35	46.61
2 Eclair Empire	3 Milkshake Mire	41.86	-71.13	49.06	-114.88	50.95
2 Eclair Empire	4 Smores Summit	41.86	-71.13	45.85	-90.82	23.68
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4 Fudge Falls	5 Starburst Starlit Skies	31.8	-80.39	44.86	-95.47	28.14
4 Fudge Falls	6 Pixie Stix Plateau	31.8	-80.39	39.97	-106.95	34.73

WH v DC>	1	2	3	4	5	6	sum
1	869	800	519	0	0	615	2803
2	0	0	0	0	0	0	0
3	0	0	0	716	550	0	1266
4	0	0	0	0	0	0	0
Sum	869	800	519	716	550	615	
Demand	869	800	519	716	550	615	4069

WH v DC>	1	2	3	4	5	6
1	406.5	446.7	546.9	897	727.8	236.7
2	1070.1	1398.3	1528.5	710.4	820.2	1131.3
3	965.4	1187.4	1426.8	605.7	715.5	920.4
4	1094.1	818.7	1552.5	734.4	844.2	1041.9

Product 1	Product 2	Product 3	Product 4
0	0	0	0

Setup costs	\$ 2,040	\$ 1,216	\$ 1,615	\$ 2,331
Actual Costs	\$ 2,040	\$ -	\$ 1,615	\$ -

Binary	1	0	1	0	2	\$ 1,970,881
Linking	-1266	0	-2803	0		
Big M	4069	4069	4069	4069		

3. **For 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?**

