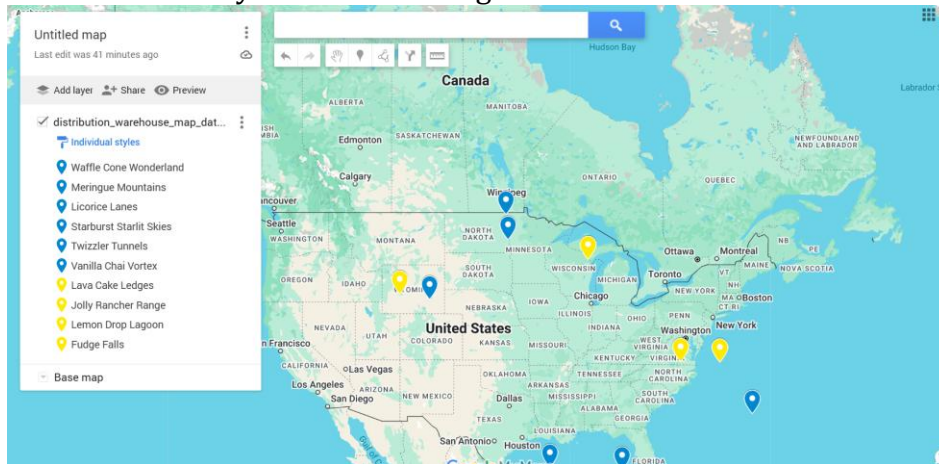


Module 09 – Fixed Charge Problem

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



- [WH & DC \(victoria\) - Google My Maps](#)

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.

$$\text{MIN: } X_1 + X_2 + X_3 + X_4 + 1399Y_1 + 2196Y_2 + 1231Y_3 + 1894Y_4$$

$$X_{11} + X_{21} + X_{31} + X_{41} \leq 867$$

$$X_{12} + X_{22} + X_{32} + X_{42} \leq 864$$

$$X_{13} + X_{23} + X_{33} + X_{43} \leq 969$$

$$X_{14} + X_{24} + X_{34} + X_{44} \leq 968$$

$$X_{15} + X_{25} + X_{35} + X_{45} \leq 605$$

$$X_{16} + X_{26} + X_{36} + X_{46} \leq 518$$

$$X_1 - 4791_1 \leq 0$$

$$X_2 - 4791_2 \leq 0$$

$$X_3 - 4791_3 \leq 0$$

$$X_4 - 4791_4 \leq 0$$

All Y_i must be binary

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

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

The model recommends selecting warehouses 2 (Jolly Rancher Range) and 3 (Lemon Drop Lagoon) to fulfill distribution demands across all distribution centers (DCs). These warehouses collectively meet the full demand of 4,791 units at the lowest total setup and transportation cost of 76,628. By activating only these two warehouses, the model avoids setup costs for warehouses 1 and 4, which remain unused. Each DC receives the exact number of units required from the selected warehouses, and the optimal assignment minimizes the total weighted Manhattan distances for deliveries. This configuration balances logistical efficiency with cost-effectiveness, ensuring all demands are met without overutilization of resources.

WH	DC	WH Lat	WH Long	DC Lat	DC Long	Manhattan
1 Lava Cake Ledges	1 Waffle Cone Wonderland	45.45	-88.1	26.85	-92.4	22.9
1 Lava Cake Ledges	2 Meringue Mountains	45.45	-88.1	48.87	-97.26	12.58
1 Lava Cake Ledges	3 Licorice Lanes	45.45	-88.1	47	-97.06	10.51
1 Lava Cake Ledges	4 Starburst Starlit Skies	45.45	-88.1	42.2	-105.8	20.95
1 Lava Cake Ledges	5 Twizzler Tunnels	45.45	-88.1	32.09	-69.68	31.78
1 Lava Cake Ledges	6 Vanilla Chai Vortex	45.45	-88.1	26.58	-84.26	22.71
2 Jolly Rancher Range	1 Waffle Cone Wonderland	36.85	-77.71	26.85	-92.4	24.69
2 Jolly Rancher Range	2 Meringue Mountains	36.85	-77.71	48.87	-97.26	31.57
2 Jolly Rancher Range	3 Licorice Lanes	36.85	-77.71	47	-97.06	29.5
2 Jolly Rancher Range	4 Starburst Starlit Skies	36.85	-77.71	42.2	-105.8	33.44
2 Jolly Rancher Range	5 Twizzler Tunnels	36.85	-77.71	32.09	-69.68	12.79
2 Jolly Rancher Range	6 Vanilla Chai Vortex	36.85	-77.71	26.58	-84.26	16.82
3 Lemon Drop Lagoon	1 Waffle Cone Wonderland	42.71	-109.2	26.85	-92.4	32.66
3 Lemon Drop Lagoon	2 Meringue Mountains	42.71	-109.2	48.87	-97.26	18.1
3 Lemon Drop Lagoon	3 Licorice Lanes	42.71	-109.2	47	-97.06	16.43
3 Lemon Drop Lagoon	4 Starburst Starlit Skies	42.71	-109.2	42.2	-105.8	3.91
3 Lemon Drop Lagoon	5 Twizzler Tunnels	42.71	-109.2	32.09	-69.68	50.14
3 Lemon Drop Lagoon	6 Vanilla Chai Vortex	42.71	-109.2	26.58	-84.26	41.07
4 Fudge Falls	1 Waffle Cone Wonderland	36.78	-73.34	26.85	-92.4	28.99
4 Fudge Falls	2 Meringue Mountains	36.78	-73.34	48.87	-97.26	36.01
4 Fudge Falls	3 Licorice Lanes	36.78	-73.34	47	-97.06	33.94
4 Fudge Falls	4 Starburst Starlit Skies	36.78	-73.34	42.2	-105.8	37.88
4 Fudge Falls	5 Twizzler Tunnels	36.78	-73.34	32.09	-69.68	8.35
4 Fudge Falls	6 Vanilla Chai Vortex	36.78	-73.34	26.58	-84.26	21.12

WHvDC>	1	2	3	4	5	6	SUM
1	22.9	12.6	10.5	21	31.78	22.71	
2	24.69	31.6	29.5	33.4	12.79	16.82	
3	32.66	18.1	16.4	3.91	50.14	41.07	
4	28.99	36	33.9	37.9	8.35	21.12	

WHvDC>	1	2	3	4	5	6	SUM
1	0	0	0	0	0	0	0
2	867	0	0	0	605	518	1990
3	0	864	969	968	0	0	2801
4	0	0	0	0	0	0	0
SUM	867	864	969	968	605	518	4791
DEMAND	867	864	969	968	605	518	4791

Setup costs	1399	2196	1231	1894			
Actual Costs	0	2196	1231	0			

Binary	0	1	1	0			
Linking	0	-2801	-1990	0			
Big M	4791	4791	4791	4791		2	76628

Model with Stipulation

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

STIPULATION #1

WH	DC	WH Lat	WH Long	DC Lat	DC Long	Manhattan
1 Lava Cake Ledges	1 Waffle Cone Wonderland	45.45	-88.1	26.85	-92.4	22.9
1 Lava Cake Ledges	2 Meringue Mountains	45.45	-88.1	48.87	-97.26	12.58
1 Lava Cake Ledges	3 Licorice Lanes	45.45	-88.1	47	-97.06	10.51
1 Lava Cake Ledges	4 Starburst Starlit Skies	45.45	-88.1	42.2	-105.8	20.95
1 Lava Cake Ledges	5 Twizzler Tunnels	45.45	-88.1	32.09	-69.68	31.78
1 Lava Cake Ledges	6 Vanilla Chai Vortex	45.45	-88.1	26.58	-84.26	22.71
2 Jolly Rancher Range	1 Waffle Cone Wonderland	36.85	-77.71	26.85	-92.4	24.69
2 Jolly Rancher Range	2 Meringue Mountains	36.85	-77.71	48.87	-97.26	31.57
2 Jolly Rancher Range	3 Licorice Lanes	36.85	-77.71	47	-97.06	29.5
2 Jolly Rancher Range	4 Starburst Starlit Skies	36.85	-77.71	42.2	-105.8	33.44
2 Jolly Rancher Range	5 Twizzler Tunnels	36.85	-77.71	32.09	-69.68	12.79
2 Jolly Rancher Range	6 Vanilla Chai Vortex	36.85	-77.71	26.58	-84.26	16.82
3 Lemon Drop Lagoon	1 Waffle Cone Wonderland	42.71	-109.2	26.85	-92.4	32.66
3 Lemon Drop Lagoon	2 Meringue Mountains	42.71	-109.2	48.87	-97.26	18.1
3 Lemon Drop Lagoon	3 Licorice Lanes	42.71	-109.2	47	-97.06	16.43
3 Lemon Drop Lagoon	4 Starburst Starlit Skies	42.71	-109.2	42.2	-105.8	3.91
3 Lemon Drop Lagoon	5 Twizzler Tunnels	42.71	-109.2	32.09	-69.68	50.14
3 Lemon Drop Lagoon	6 Vanilla Chai Vortex	42.71	-109.2	26.58	-84.26	41.07
4 Fudge Falls	1 Waffle Cone Wonderland	36.78	-73.34	26.85	-92.4	28.99
4 Fudge Falls	2 Meringue Mountains	36.78	-73.34	48.87	-97.26	36.01
4 Fudge Falls	3 Licorice Lanes	36.78	-73.34	47	-97.06	33.94
4 Fudge Falls	4 Starburst Starlit Skies	36.78	-73.34	42.2	-105.8	37.88
4 Fudge Falls	5 Twizzler Tunnels	36.78	-73.34	32.09	-69.68	8.35
4 Fudge Falls	6 Vanilla Chai Vortex	36.78	-73.34	26.58	-84.26	21.12

WHvDC>	1	2	3	4	5	6	SUM
1	22.9	12.6	10.5	21	31.78	22.71	
2	24.69	31.6	29.5	33.4	12.79	16.82	
3	32.66	18.1	16.4	3.91	50.14	41.07	
4	28.99	36	33.9	37.9	8.35	21.12	

WHvDC>	1	2	3	4	5	6	SUM
1	867	864	969	968	605	518	4791
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	867	864	969	968	605	518	4791
DEMAND	867	864	969	968	605	518	4791

Setup costs	1399	2196	1231	1894			
Actual Costs	1399	0	0	0			

Binary	1	0	0	0			
Linking	0	0	0	0			
Big M	4791	4791	4791	4791		1	93577

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 one warehouse is allowed to open, the model selects Warehouse 1 (Lava Cake Ledges), as shown in the binary row. As a result, all demand from the six distribution centers (DCs) must be fulfilled from that single location, increasing transportation distances and costs significantly. This causes the objective function value to rise to 93,577, compared to a lower value of 76,628 when two warehouses were allowed to open. In summary, restricting to one warehouse leads to a less efficient logistics configuration, driving up total costs due to longer shipping distances and the strain of centralized fulfillment.

STIPULATION #2

WH	DC	WH Lat	WH Long	DC Lat	DC Long	Manhattan
1 Lava Cake Ledges	1 Waffle Cone Wonderland	45.45	-88.1	26.85	-92.4	22.9
1 Lava Cake Ledges	2 Meringue Mountains	45.45	-88.1	48.87	-97.26	12.58
1 Lava Cake Ledges	3 Licorice Lanes	45.45	-88.1	47	-97.06	10.51
1 Lava Cake Ledges	4 Starburst Starlit Skies	45.45	-88.1	42.2	-105.8	20.95
1 Lava Cake Ledges	5 Twizzler Tunnels	45.45	-88.1	32.09	-69.68	31.78
1 Lava Cake Ledges	6 Vanilla Chai Vortex	45.45	-88.1	26.58	-84.26	22.71
2 Jolly Rancher Range	1 Waffle Cone Wonderland	36.85	-77.71	26.85	-92.4	24.69
2 Jolly Rancher Range	2 Meringue Mountains	36.85	-77.71	48.87	-97.26	31.57
2 Jolly Rancher Range	3 Licorice Lanes	36.85	-77.71	47	-97.06	29.5
2 Jolly Rancher Range	4 Starburst Starlit Skies	36.85	-77.71	42.2	-105.8	33.44
2 Jolly Rancher Range	5 Twizzler Tunnels	36.85	-77.71	32.09	-69.68	12.79
2 Jolly Rancher Range	6 Vanilla Chai Vortex	36.85	-77.71	26.58	-84.26	16.82
3 Lemon Drop Lagoor	1 Waffle Cone Wonderland	42.71	-109.2	26.85	-92.4	32.66
3 Lemon Drop Lagoor	2 Meringue Mountains	42.71	-109.2	48.87	-97.26	18.1
3 Lemon Drop Lagoor	3 Licorice Lanes	42.71	-109.2	47	-97.06	16.43
3 Lemon Drop Lagoor	4 Starburst Starlit Skies	42.71	-109.2	42.2	-105.8	3.91
3 Lemon Drop Lagoor	5 Twizzler Tunnels	42.71	-109.2	32.09	-69.68	50.14
3 Lemon Drop Lagoor	6 Vanilla Chai Vortex	42.71	-109.2	26.58	-84.26	41.07
4 Fudge Falls	1 Waffle Cone Wonderland	36.78	-73.34	26.85	-92.4	28.99
4 Fudge Falls	2 Meringue Mountains	36.78	-73.34	48.87	-97.26	36.01
4 Fudge Falls	3 Licorice Lanes	36.78	-73.34	47	-97.06	33.94
4 Fudge Falls	4 Starburst Starlit Skies	36.78	-73.34	42.2	-105.8	37.88
4 Fudge Falls	5 Twizzler Tunnels	36.78	-73.34	32.09	-69.68	8.35
4 Fudge Falls	6 Vanilla Chai Vortex	36.78	-73.34	26.58	-84.26	21.12

WHvDC>	1	2	3	4	5	6	SUM
1	687	377	315	629	953.4	681.3	
2	740.7	947	885	1003	383.7	504.6	
3	979.8	543	493	117	1504	1232	
4	869.7	1080	1018	1136	250.5	633.6	

WHvDC>	1	2	3	4	5	6	SUM
1	0	0	0	0	0	0	0
2	867	0	0	0	605	518	1990
3	0	864	969	968	0	0	2801
4	0	0	0	0	0	0	0
SUM	867	864	969	968	605	518	4791
DEMAND	867	864	969	968	605	518	4791

Setup costs	1399	2196	1231	1894			
Actual Costs	0	2196	1231	0			

Binary	0	1	1	0			
Linking	0	-2801	-1990	0			
Big M	4791	4791	4791	4791		2	2199454

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?

When the cost per unit shipped over distance increases to \$30, the objective function value increases dramatically from the previous value (under \$100,000) to 2,199,454, as shown in the updated model. This reflects the high sensitivity of total costs to per-unit shipping rates. However, despite the sharp increase in costs, the DC assignment does not change the same warehouses (Warehouse 1 and Warehouse 2) remain open, and the shipment quantities to each DC are identical to those in the original model. Even though the cost has increased significantly, the existing warehouse-to-DC allocation remains the most optimal under the new cost structure. This shows that while costs are sensitive to rate changes, the structural efficiency of the original routing still holds under higher transportation expenses.

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

3. Instead of only being able to open 2 warehouses, what happens to our objective function when we only can open 1 warehouse?
4. 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?

5. 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?

