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

- **Stars indicate warehouses**
- **Blue indicates DC's**

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.

MIN: $X_1 + X_2 + X_3 + X_4 + 2467Y_1 + 2163Y_2 + 2327Y_3 + 2213Y_4$

$X_{11} + X_{21} + X_{31} + X_{41} <= 973$
$X_{12} + X_{22} + X_{32} + X_{42} <= 805$
$X_{13} + X_{23} + X_{33} + X_{43} <= 521$
$X_{14} + X_{24} + X_{34} + X_{44} <= 550$
$X_{15} + X_{25} + X_{35} + X_{45} <= 707$
$X_{16} + X_{26} + X_{36} + X_{46} <= 959$

$X_1 - 4515Y_1 <= 0$
$X_2 - 4515Y_2 <= 0$
$X_3 - 4515Y_3 <= 0$
$X_4 - 4515Y_4 <= 0$

All Y_1 Must be binary
$X_1 >= 0$, 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*

WH			DC	WH Lat	WH Long	DC Lat	DC Long	Manhattan
Jelly River Delta	1	1	Toffee Town	43.11	-108.68	49.27	-122.21	19.69
Jelly River Delta	1	2	Mallow Melt Mountains	43.11	-108.68	46.82	-97.83	14.56
Jelly River Delta	1	3	Sherbet Shoreline	43.11	-108.68	25.36	-99.09	27.34
Jelly River Delta	1	4	Vanilla Chai Vortex	43.11	-108.68	40.47	-102.52	8.8
Jelly River Delta	1	5	Lollipop Lagoon	43.11	-108.68	48.33	-104.71	9.19
Jelly River Delta	1	6	Pixie Stix Plateau	43.11	-108.68	27.33	-79.3	45.16
Buttercream Beach	2	1	Toffee Town	36.27	-75.73	49.27	-122.21	59.48
Buttercream Beach	2	2	Mallow Melt Mountains	36.27	-75.73	46.82	-97.83	32.65
Buttercream Beach	2	3	Sherbet Shoreline	36.27	-75.73	25.36	-99.09	34.27
Buttercream Beach	2	4	Vanilla Chai Vortex	36.27	-75.73	40.47	-102.52	30.99
Buttercream Beach	2	5	Lollipop Lagoon	36.27	-75.73	48.33	-104.71	41.04
Buttercream Beach	2	6	Pixie Stix Plateau	36.27	-75.73	27.33	-79.3	12.51
Bubblegum Bay	3	1	Toffee Town	31.73	-78.78	49.27	-122.21	60.97
Bubblegum Bay	3	2	Mallow Melt Mountains	31.73	-78.78	46.82	-97.83	34.14
Bubblegum Bay	3	3	Sherbet Shoreline	31.73	-78.78	25.36	-99.09	26.68
Bubblegum Bay	3	4	Vanilla Chai Vortex	31.73	-78.78	40.47	-102.52	32.48
Bubblegum Bay	3	5	Lollipop Lagoon	31.73	-78.78	48.33	-104.71	42.53
Bubblegum Bay	3	6	Pixie Stix Plateau	31.73	-78.78	27.33	-79.3	4.92
Fizzwhiz Fjord	4	1	Toffee Town	43.92	-119.6	49.27	-122.21	7.96
Fizzwhiz Fjord	4	2	Mallow Melt Mountains	43.92	-119.6	46.82	-97.83	24.67
Fizzwhiz Fjord	4	3	Sherbet Shoreline	43.92	-119.6	25.36	-99.09	39.07
Fizzwhiz Fjord	4	4	Vanilla Chai Vortex	43.92	-119.6	40.47	-102.52	20.53
Fizzwhiz Fjord	4	5	Lollipop Lagoon	43.92	-119.6	48.33	-104.71	19.3
Fizzwhiz Fjord	4	6	Pixie Stix Plateau	43.92	-119.6	27.33	-79.3	56.89

WH > DC	1	2	3	4	5	6
1	19.69	14.56	27.34	8.8	9.19	45.16
2	59.48	32.65	34.27	30.99	41.04	12.51
3	60.97	34.14	26.68	32.48	42.53	4.92
4	7.96	24.67	39.07	20.53	19.3	56.89

Total Cost
$ 65,629.06

WH > DC	1	2	3	4	5	6	Sent by Wh
1	973	805	0	550	707	0	3035
2	0	0	0	0	0	0	0
3	0	0	521	0	0	959	1480
4	0	0	0	0	0	0	0
Sum	973	805	521	550	707	959	
Demand	973	805	521	550	707	959	

Setup Costs	2467	2163	2327	2213
Actual Costs	2467	0	2327	0

Binary	1	0	1	0	2
Linking	-1480	0	-3035	0	

The model recommends we open warehouses 1 and 3. Warehouse 1 will supply DC's 1,2,4, and 5, while warehouse 3 supplies DC's 3 and 6. With this all demand is met in the most efficient way possible.

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 only can open 1 warehouse?*

   The total cost increases by $36,607.02, making it optimal to only open one warehouse.

WH			DC	WH Lat	WH Long	DC Lat	DC Long	Manhattan
Jelly River Delta	1	1	Toffee Town	43.11	-108.68	49.27	-122.21	19.69
Jelly River Delta	1	2	Mallow Melt Mountains	43.11	-108.68	46.82	-97.83	14.56
Jelly River Delta	1	3	Sherbet Shoreline	43.11	-108.68	25.36	-99.09	27.34
Jelly River Delta	1	4	Vanilla Chai Vortex	43.11	-108.68	40.47	-102.52	8.8
Jelly River Delta	1	5	Lollipop Lagoon	43.11	-108.68	48.33	-104.71	9.19
Jelly River Delta	1	6	Pixie Stix Plateau	43.11	-108.68	27.33	-79.3	45.16
Buttercream Beach	2	1	Toffee Town	36.27	-75.73	49.27	-122.21	59.48
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Buttercream Beach	2	3	Sherbet Shoreline	36.27	-75.73	25.36	-99.09	34.27
Buttercream Beach	2	4	Vanilla Chai Vortex	36.27	-75.73	40.47	-102.52	30.99
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WH > DC	1	2	3	4	5	6
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3	60.97	34.14	26.68	32.48	42.53	4.92
4	7.96	24.67	39.07	20.53	19.3	56.89

WH > DC	1	2	3	4	5	6	Sent by Wh
1	973	805	521	550	707	959	4515
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	973	805	521	550	707	959	4515
Demand	973	805	521	550	707	959	

Setup Costs	2467	2163	2327	2213
Actual Costs	2467	0	0	0

Binary	1	0	0	0	1
Linking	0	0	0	0	

Total Cost
$ 102,236.08
$ 36,607.02

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?*

   No, it does not, because the price increase was for all warehouses if they were the cheapest at $1, they continue to be the cheapest at $30

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2	0	0	0	0	0	0	0
3	0	0	521	0	0	959	1480
4	0	0	0	0	0	0	0
Sum	973	805	521	550	707	959	
Demand	973	805	521	550	707	959	

Unit shipping Costs	30			
Setup Costs	2467	2163	2327	2213
Actual Costs	2467	0	2327	0

Binary	1	0	1	0	2
Linking	-1480	0	-3035	0	

Total Cost
$ 1,968,871.80

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?*

(x_2, y_2)

Manhattan Distance L^1

Euclidean Distance L^2

$$L^1 = |x_2 - x_1| + |y_2 - y_1|$$

$$L^2 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

(x_1, y_1)