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Module 09 – Fixed Charge Problem

Exploratory Data Analysis

distribution_center	name	demand	latitude	longitude
1	Peanut Butter Parlor	616	29.63	-82.1
2	Pudding Peaks	753	33.21	-98.38
3	Meringue Mountains	555	31.9	-112.47
4	Malted Milk Manor	933	27.75	-110.49
5	Toblerone Tower	665	28.83	-79.96
6	Milkshake Mire	616	39.91	-104.4

warehouse	name	set_up_cost	latitude	longitude
1	Buttercream Beach	2712	27.11	-96
2	Honeysuckle Hollow	2472	31.76	-73.85
3	Caramel Cascades	2033	30.57	-98.58
4	Cotton Candy Clouds	1636	33.93	-120.57
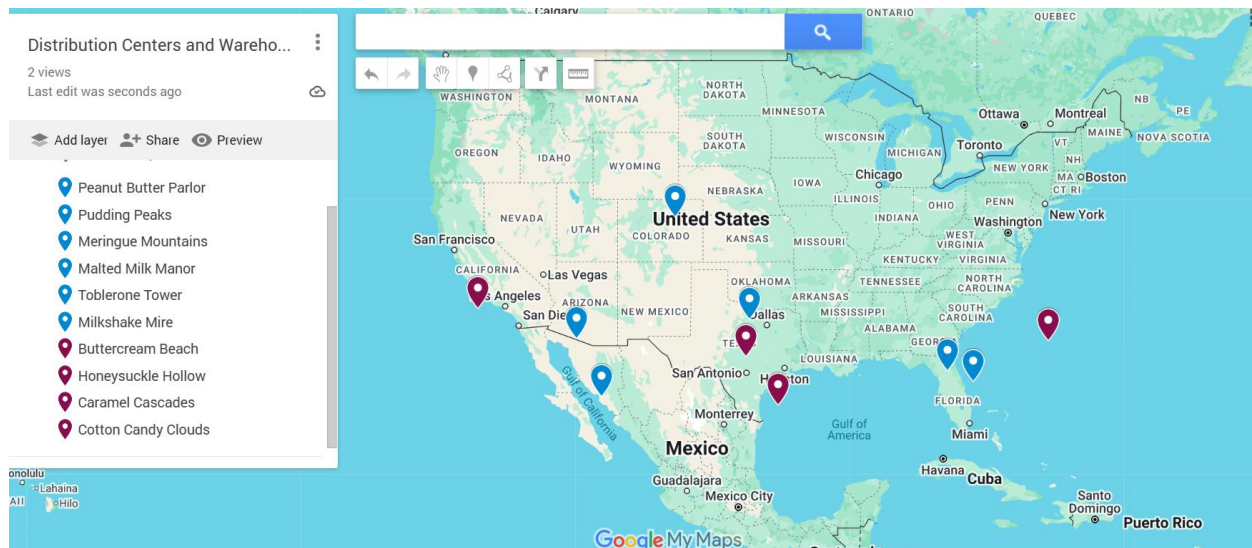
https://www.google.com/maps/d/edit?mid=1Ps45LmIXdeWEMEQC_VzbI_eX67gZEcU&usp=sharing

Model Formulation

MAX:
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.

MAX:

CONSTRAINTS:
X11+X21 +X31 +X41 = 616
X12 + X22 + X32 + X42 = 753
X13+X23 +X33 +X43 = 555
X14+X24+X34+X44= 933

X15+X25+X35+X45 = 665
X16+X26+X36+X46=616

LINKING CONSTRAINTS
X11+X12+X13+X14+X15+X16 <= 4138Y1
X21+X22+X23+X24+X25+X26 <= 4138Y2
X31+X32+X33+X34+X35+X36 <= 4138Y3
X41+X42+X43+X44+X45+X46 <= 4138Y4

Linking constraints <= 0
Units from each warehouse to distribution center >= 0

- Decision variables: Units from each warehouse to distribution center and binary variables
- Objective function: Total Cost for the Units shipped including set up cost
- Linking Constraints: The difference between the total units and the product of binary variable and the demand sum

Model Optimized for Min Costs to Supply DCs

WHvsDC		1	2	3	4	5	6
		Peanut Butter Parlor	Pudding Peaks	Meringue Mountains	Malted Milk Manor	Toblerone Tower	Milkshake Mire
1	Buttercream Beach	16.42	8.48	21.26	15.13	17.76	21.2
2	Honeysuckle Hollow	10.38	25.98	38.76	40.65	9.04	38.7
3	Caramel Cascades	17.42	2.84	15.22	14.73	20.36	15.16
4	Cotton Candy Clouds	42.77	22.91	10.13	16.26	45.71	22.15

WH v DC		1	2	3	4	5	6	
		Peanut Butter Parlor	Pudding Peaks	Meringue Mountains	Malted Milk Manor	Toblerone Tower	Milkshake Mire	Total Units
1	Buttercream Beach	0	0	0	0	0	0	0
2	Honeysuckle Hollow	616	0	0	0	665	0	1281
3	Caramel Cascades	0	753	555	933	0	616	2857
4	Cotton Candy Clouds	0	0	0	0	0	0	0
	Sum	616	753	555	933	665	616	
	Demand	616	753	555	933	665	616	

Total Cost	$50,577.95

					Binary sum	
Binary Variables	0	1	1	0	2	
Demand Sum	4138	4138	4138	4138		
Linking Costraints	0	-2857	-1281	0		
Set Up Cost	2712	2472	2033	1636		
Actual	0	2472	2033	0		

This model determines the most cost-effective way to ship products from warehouses to distribution centers while minimizing total costs, including shipping and warehouse setup fees.
The model recommends opening two warehouses—Honeysuckle Hollow and Caramel Cascades—to meet all distribution center demands. This setup results in the lowest total cost of $50,577.95, balancing shipping efficiency and fixed setup costs.

Model with Stipulation

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

By changing the constraint of the sum of the binary being <= 1, our cost goes up to $59,970 and Caramel Cascades is the only warehouse used.

WH v DC		1	2	3	4	5	6	
		Peanut Butter Parlor	Pudding Peaks	Meringue Mountains	Malted Milk Manor	Toblerone Tower	Milkshake Mire	Total Units
1	Buttercream Beach	0	0	0	0	0	0	0
2	Honeysuckle Hollow	0	0	0	0	0	0	0
3	Caramel Cascades	616	753	555	933	665	616	4138
4	Cotton Candy Clouds	0	0	0	0	0	0	0
	Sum	616	753	555	933	665	616	
	Demand	616	753	555	933	665	616	
						Total Cost	$59,970.39	
						Binary sum		
	Binary Variables	0	0	1	0	1		
	Demand Sum	4138	4138	4138	4138			
	Linking Costraints	0	0	0	0			
	Set Up Cost	2712	2472	2033	1636			
	Actual	0	0	2033	0			

2. *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?*

Switching from Manhattan to Euclidean distance in our model did not change the overall structure of the solution—both models selected the same two warehouses (Honeysuckle Hollow and Caramel Cascades) and assigned them to the same distribution centers. However, the total transportation cost decreased significantly when using Euclidean distance, dropping from $50,577.95 to $42,195.94. This cost reduction is due to the fact that Euclidean distance, which measures straight-line travel, more accurately reflects real-world transportation over longer or non-grid-based routes compared to the grid-like assumptions of Manhattan distance. Although the warehouse assignments and setup costs remained unchanged, the use of Euclidean distance resulted in a more cost-effective and realistic solution, making it a better choice for this particular scenario.

Manhattan	Euclidean
16.42	14.13
8.48	6.55
21.26	17.15
15.13	14.50
17.76	16.13
21.2	15.31
10.38	8.52
25.98	24.57
38.76	38.62
40.65	36.86
9.04	6.78
38.7	31.62
17.42	16.51
2.84	2.65
15.22	13.95
14.73	12.24
20.36	18.70
15.16	11.00
42.77	38.71
22.91	22.20
10.13	8.35
16.26	11.82
45.71	40.93
22.15	17.24

WHvsDC		1	2	3	4	5	6	
		Peanut Butter Parlor	Pudding Peaks	Meringue Mountains	Malted Milk Manor	Toblerone Tower	Milkshake Mire	
1	Buttercream Beach	14.13	6.55	17.15	14.50	16.13	15.31	
2	Honeysuckle Hollow	8.52	24.57	38.62	36.86	6.78	31.62	
3	Caramel Cascades	16.51	2.65	13.95	12.24	18.70	11.00	
4	Cotton Candy Clouds	38.71	22.20	8.35	11.82	40.93	17.24	

WH v DC		1	2	3	4	5	6	
		Peanut Butter Parlor	Pudding Peaks	Meringue Mountains	Malted Milk Manor	Toblerone Tower	Milkshake Mire	Total Units
1	Buttercream Beach	0	0	0	0	0	0	0
2	Honeysuckle Hollow	616	0	0	0	665	0	1281
3	Caramel Cascades	0	753	555	933	0	616	2857
4	Cotton Candy Clouds	0	0	0	0	0	0	0
	Sum	616	753	555	933	665	616	
	Demand	616	753	555	933	665	616	
						Total Cost	$42,195.94	
						Binary sum		
	Binary Variables	0	1	1	0	2		
	Demand Sum	4138	4138	4138	4138			
	Linking Costraints	0	-2857	-1281	0			
	Set Up Cost	2712	2472	2033	1636			
	Actual	0	2472	2033	0			