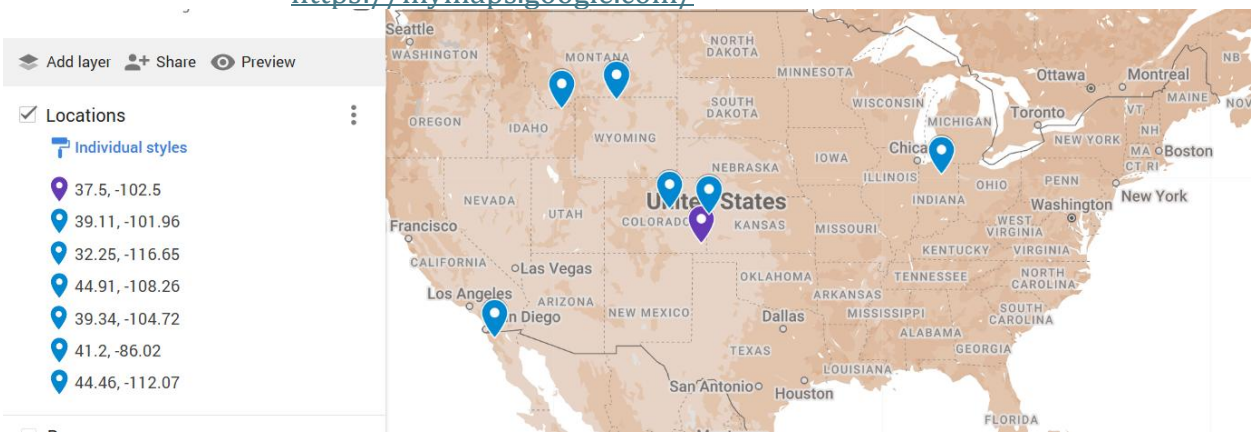
Module 10 – MOLP

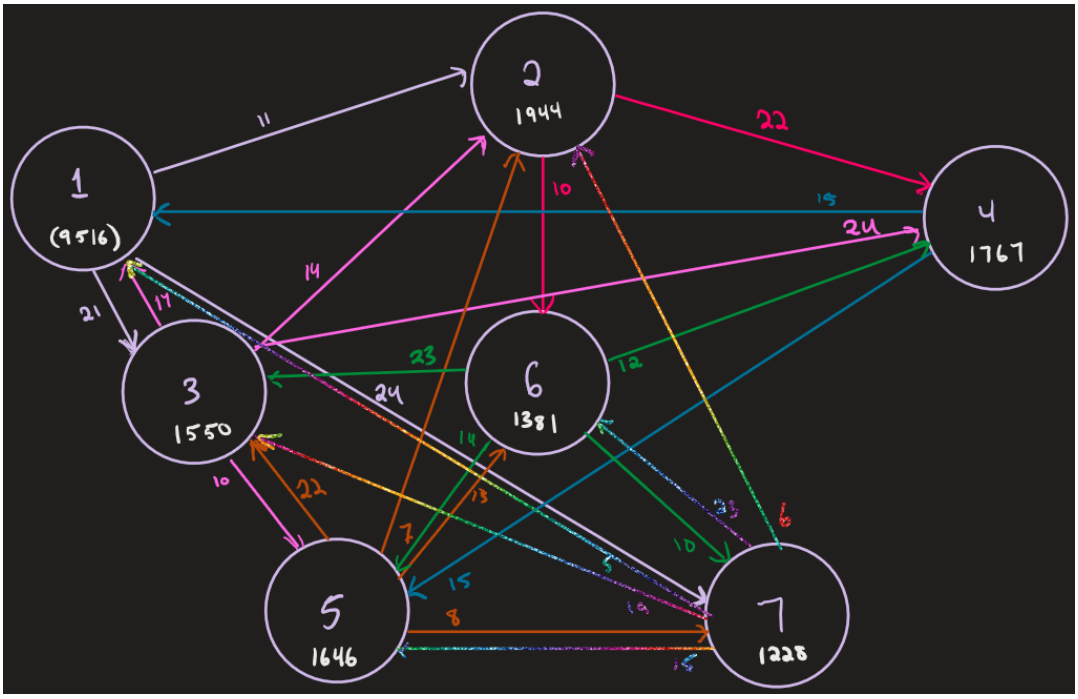
Exploratory Data Analysis

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:

- *Choose a visualization method (expect 7 nodes and ~24 arcs):*
  - ✓ ○ *Make a visual graph of your data on a map (coordinates should be within US borders)*
    - https://mymaps.google.com/



  - ✓ ○ *Make a visual graph of your data like what we saw for the sample problem*



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. For this problem, I am only asking that you perform the model formulation for the MOLP model.

Decision Variables:
Transshipment Model: The decision variables, changed by Solver, are the SHIP column B6:B29
MOLP: The SHIP column, Cell R42 (designated MiniMax value cell)

Minimize total transport costs: $Z1=(i,j)\in A\sum cijxij$

Minimize total distance: $Z\ 2\ =(i,j)\in A\ \sum\ d\ ij\ \ x\ ij$

Minimize Eco-Unfriendliness: $Z\ 3\ =(i,j)\in A\ \sum\ e\ ij\ \ x\ ij$

Minimize Congestion: $Z\ 4\ =(i,j)\in A\ \sum\ g\ ij\ \ x\ ij$

Objective Function(s):
Minimized Transport Cost: Sum product of Ship column values and unit cost
Minimized Total Distance: Sum product of Ship column values and the Euclidean distance
Maximized Eco-Friendly: Sum product of Ship column and Non-Eco-Friendly Binary Var.
Minimized Congestion: Sum product of Ship column and Congestion Binary Var.

Constraints:

Subject to:

$w\ k\ \cdot t\ k\ \ Z\ k\ -t\ k\ \leq\delta\forall k\in\{1,2,3,4\}$

Net Flow >= Supply/Demand: to meet all demand for each node
M6:M12 >= N6:N12

Ship column non-negativity constraint…
Ship >= 0

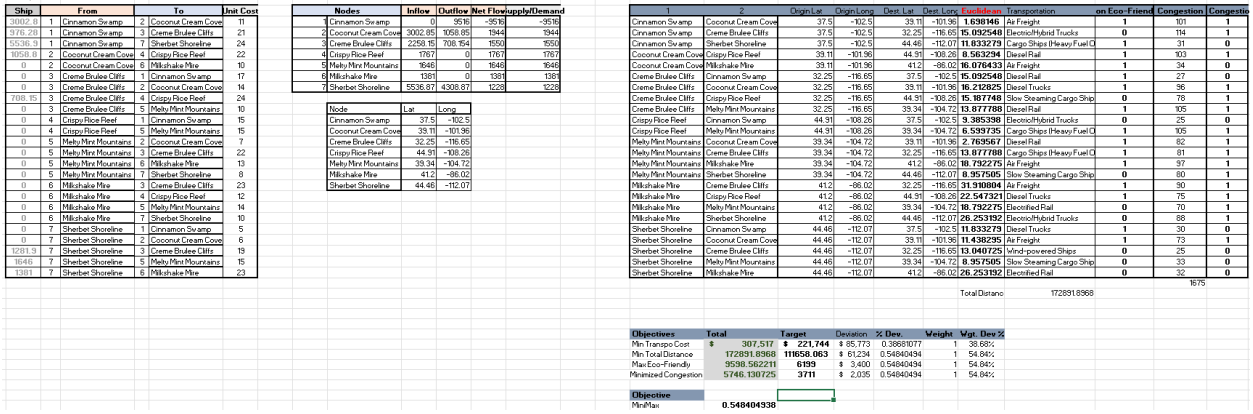
MiniMax Constraint:
Weighted Deviation % Column (all four values) <= R42 (cell designated for MiniMax)
(Remembering to add the R42 to the decision variables for this as well)

$\delta\leq R42(R42=0.25634912110734054)$

Model Optimized for Equally Weighted Objectives

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*
- ✓ - *Update your graph from the EDA section to indicate which arcs are used*



Ship		From		To	Unit Cost
3002.8	1	Cinnamon Swamp	2	Coconut Cream Cove	11
976.28	1	Cinnamon Swamp	3	Creme Brulee Cliffs	21
5536.9	1	Cinnamon Swamp	7	Sherbet Shoreline	24
1058.8	2	Coconut Cream Cove	4	Crispy Rice Reef	22
0	2	Coconut Cream Cove	6	Milkshake Mire	10
0	3	Creme Brulee Cliffs	1	Cinnamon Swamp	17
0	3	Creme Brulee Cliffs	2	Coconut Cream Cove	14
708.15	3	Creme Brulee Cliffs	4	Crispy Rice Reef	24
0	3	Creme Brulee Cliffs	5	Melty Mint Mountains	10
0	4	Crispy Rice Reef	1	Cinnamon Swamp	15
0	4	Crispy Rice Reef	5	Melty Mint Mountains	15
0	5	Melty Mint Mountains	2	Coconut Cream Cove	7
0	5	Melty Mint Mountains	3	Creme Brulee Cliffs	22
0	5	Melty Mint Mountains	6	Milkshake Mire	13
0	5	Melty Mint Mountains	7	Sherbet Shoreline	8
0	6	Milkshake Mire	3	Creme Brulee Cliffs	23
0	6	Milkshake Mire	4	Crispy Rice Reef	12
0	6	Milkshake Mire	5	Melty Mint Mountains	14
0	6	Milkshake Mire	7	Sherbet Shoreline	10
0	7	Sherbet Shoreline	1	Cinnamon Swamp	5
0	7	Sherbet Shoreline	2	Coconut Cream Cove	6
1281.9	7	Sherbet Shoreline	3	Creme Brulee Cliffs	13
1646	7	Sherbet Shoreline	5	Melty Mint Mountains	15
1381	7	Sherbet Shoreline	6	Milkshake Mire	23

	Nodes	Inflow	Outflow	Net Flow	Supply/Demand
1	Cinnamon Swamp	0	3516	-3516	-3516
2	Coconut Cream Cove	3002.85	1058.85	1944	1944
3	Creme Brulee Cliffs	2258.15	708.154	1550	1550
4	Crispy Rice Reef	1767	0	1767	1767
5	Melty Mint Mountains	1646	0	1646	1646
6	Milkshake Mire	1381	0	1381	1381
7	Sherbet Shoreline	5536.87	4308.87	1228	1228

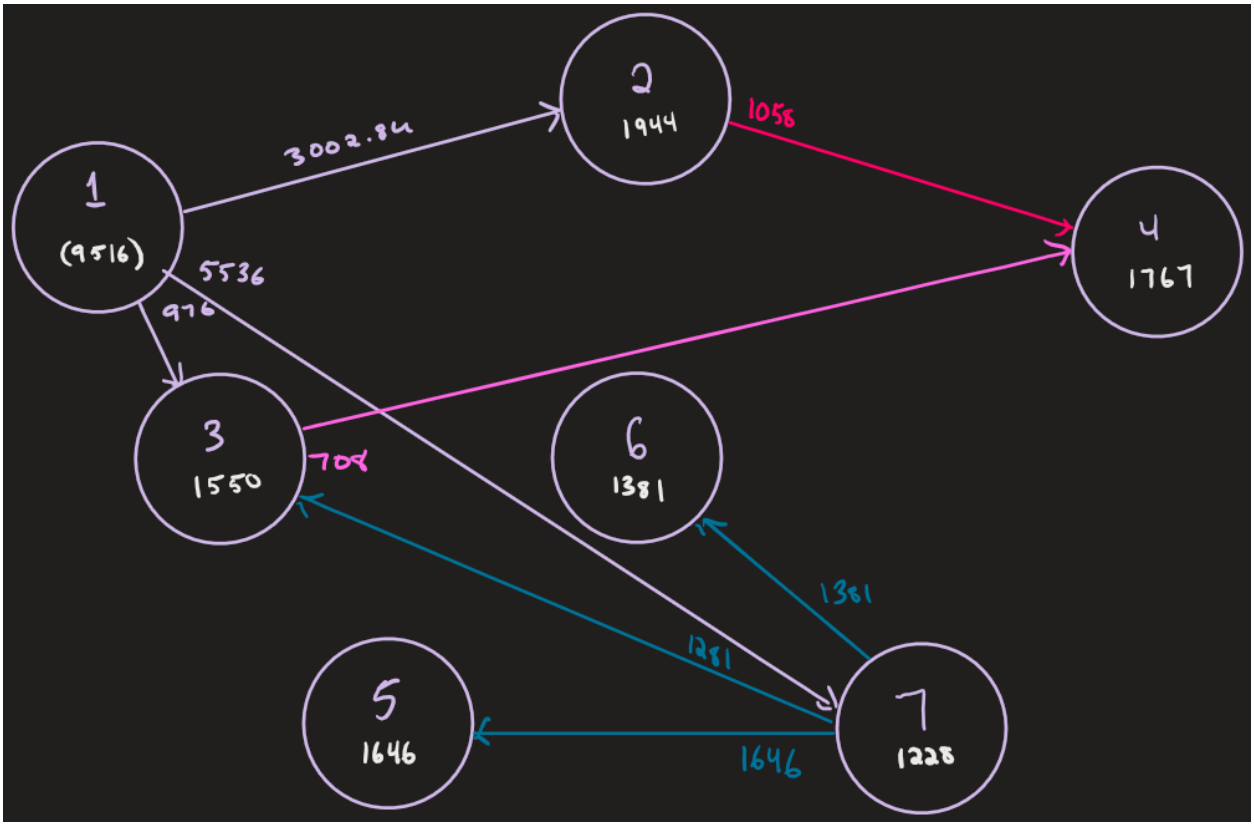
Node	Lat	Long
Cinnamon Swamp	37.5	-102.5
Coconut Cream Cove	39.11	-101.96
Creme Brulee Cliffs	32.25	-116.65
Crispy Rice Reef	44.91	-108.26
Melty Mint Mountains	39.34	-104.72
Milkshake Mire	41.2	-86.02
Sherbet Shoreline	44.46	-112.07

1	2	Origin Lat	Origin Long	Dest. Lat	Dest. Long	Euclidean	Transportation	on Eco-Friend	Congestion	Congestio
Cinnamon Swamp	Coconut Cream Cove	37.5	-102.5	39.11	-101.96	**1.698146**	Air Freight	**1**	101	**1**
Cinnamon Swamp	Creme Brulee Cliffs	37.5	-102.5	32.25	-116.65	**15.092548**	Electric/Hybrid Trucks	**0**	114	**1**
Cinnamon Swamp	Sherbet Shoreline	37.5	-102.5	44.46	-112.07	**11.833279**	Cargo Ships (Heavy Fuel O	**1**	31	**0**
Coconut Cream Cove	Crispy Rice Reef	39.11	-101.96	44.91	-108.26	**8.563294**	Diesel Rail	**1**	103	**1**
Coconut Cream Cove	Milkshake Mire	39.11	-101.96	41.2	-86.02	**16.076433**	Air Freight	**1**	34	**0**
Creme Brulee Cliffs	Cinnamon Swamp	32.25	-116.65	37.5	-102.5	**15.092548**	Diesel Rail	**1**	27	**0**
Creme Brulee Cliffs	Coconut Cream Cove	32.25	-116.65	39.11	-101.96	**16.212825**	Diesel Trucks	**1**	96	**1**
Creme Brulee Cliffs	Crispy Rice Reef	32.25	-116.65	44.91	-108.26	**15.187748**	Slow Steaming Cargo Ship	**0**	78	**1**
Creme Brulee Cliffs	Melty Mint Mountains	32.25	-116.65	39.34	-104.72	**13.877788**	Diesel Rail	**1**	105	**1**
Crispy Rice Reef	Cinnamon Swamp	44.91	-108.26	37.5	-102.5	**9.385398**	Electric/Hybrid Trucks	**0**	25	**0**
Crispy Rice Reef	Melty Mint Mountains	44.91	-108.26	39.34	-104.72	**6.539735**	Cargo Ships (Heavy Fuel O	**1**	105	**1**
Melty Mint Mountains	Coconut Cream Cove	39.34	-104.72	39.11	-101.96	**2.769567**	Diesel Rail	**1**	82	**1**
Melty Mint Mountains	Creme Brulee Cliffs	39.34	-104.72	32.25	-116.65	**13.877788**	Cargo Ships (Heavy Fuel O	**1**	81	**1**
Melty Mint Mountains	Milkshake Mire	39.34	-104.72	41.2	-86.02	**18.732275**	Air Freight	**1**	97	**1**
Melty Mint Mountains	Sherbet Shoreline	39.34	-104.72	44.46	-112.07	**8.957505**	Slow Steaming Cargo Ship	**0**	80	**1**
Milkshake Mire	Creme Brulee Cliffs	41.2	-86.02	32.25	-116.65	**31.910804**	Air Freight	**1**	90	**1**
Milkshake Mire	Crispy Rice Reef	41.2	-86.02	44.91	-108.26	**22.547321**	Diesel Trucks	**1**	75	**1**
Milkshake Mire	Melty Mint Mountains	41.2	-86.02	39.34	-104.72	**18.732275**	Electrified Rail	**0**	70	**1**
Milkshake Mire	Sherbet Shoreline	41.2	-86.02	44.46	-112.07	**26.253192**	Electric/Hybrid Trucks	**0**	88	**1**
Sherbet Shoreline	Cinnamon Swamp	44.46	-112.07	37.5	-102.5	**11.833279**	Diesel Trucks	**1**	30	**0**
Sherbet Shoreline	Coconut Cream Cove	44.46	-112.07	39.11	-101.96	**11.438295**	Air Freight	**1**	73	**1**
Sherbet Shoreline	Creme Brulee Cliffs	44.46	-112.07	32.25	-116.65	**13.040725**	Wind-powered Ships	**0**	25	**0**
Sherbet Shoreline	Melty Mint Mountains	44.46	-112.07	39.34	-104.72	**8.957505**	Slow Steaming Cargo Ship	**0**	33	**0**
Sherbet Shoreline	Milkshake Mire	44.46	-112.07	41.2	-86.02	**26.253192**	Electrified Rail	**0**	32	**0**
										1675
						Total Distance	1728918.868			

Objectives	Total	Target	Deviation	% Dev.	Weight	Wgt. Dev %
Min Transpo Cost	$ 307,517	$ 221,744	$ 85,773	0.38681077	1	38.68%
Min Total Distance	172891.8868	111658.063	$ 61,234	0.54840494	1	54.84%
Max Eco-Friendly	9538.562211	6139	$ 3,400	0.54840494	1	54.84%
Minimized Congestion	5746.130725	3711	$ 2,035	0.54840494	1	54.84%

Objective	
MinMax	0.548404938

The purpose of my model is to individually minimize the Transport Cost, minimize Total Distance, maximize Eco-Friendliness, and minimize Congestion based on the given data. From there, we implement the MOLP table, as seen on the bottom right with dark blue headings, which ultimately finds an ideal “middle-ground” where constraints are satisfied, with equal weight for each objective to find an optimal percentage of deviation from our optimized values. Meaning, no longer will each objective I identified be completely optimized. However, solver takes all four objectives into account, and finds common ground where each piece of the puzzle is further optimized from its starting point. What my model found was that 54.84% deviation from the Target objective was optimal in satisfying each objective to the best of its ability. If we changed the weights for each of these, our results would change dramatically.



Model with Stipulation

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

Alter the weights of each objective to add weight to match what matters most to you. Perhaps run a few different scenarios to see how the routes change depending on the weights. When you find a weight mix and solution that satisfies you, please write a justification on why you chose the final model/weights and about how a configured model like yours can be used for scenario planning.

Objectives	Total	Target	Deviation	% Dev.	Weight	Wgt. Dev %	Pre-Stipulation %
Min Transpo Cost	$ 258,960	$ 221,744	$ 37,216	0.16783163	1.5	25.17%	38.68%
Min Total Distance	141553.1072	111658.0634	$ 29,895	0.267737437	1	26.77%	54.84%
Max Eco-Friendly	9518.40875	6199	$ 3,319	0.535474875	0.5	26.77%	54.84%
Minimized Congestion	7685.294522	3711	$ 3,974	1.07094975	0.25	26.77%	54.84%

Objective	
MiniMax	0.267737437

After messing around with the weights a bit, I found a balance I can be happy with.

Objectives	Total	Target	Deviation	% Dev.	Weight	Wgt. Dev %	Pre-Stipulation %
Min Transpo Cost	$ 255,574	$ 221,744	$ 33,830	0.152563464	1.6	24.41%	38.68%
Min Total Distance	129547.7175	111658.0634	$ 17,890	0.160218201	1.6	25.63%	54.84%
Max Eco-Friendly	11496.02734	6199	$ 5,297	0.85449707	0.3	25.63%	54.84%
Minimized Congestion	7516.246354	3711	$ 3,805	1.025396484	0.25	25.63%	54.84%

Objective	
MiniMax	0.256349121

And right after typing that sentence, I second-guessed myself. But I left my first attempt in to show my thought process. The first thing I saw was that I decreased the

MiniMax percentage from 54.84% to 26.77%, now to 25.63%, a reduction of 46%, and saw that as I victory. Originally, I thought it'd be ideal to prioritize minimizing transport costs. Then I second-guessed myself and chose to think of myself as an employee or consultant, I would want to directly manipulate a more tangible cost. Knowing that distance and transportation cost go hand in hand when it comes to overall travel costs. I chose to reevaluate and increase the weight for transportation cost and total distance, these two taking priority. Which in turn decreases how long the not-so-eco-friendly travel methods will take, not directly optimizing an eco-friendly approach, but ultimately limiting the amount of emissions of these travel methods. And congestion took a back seat role here, not because it isn't important, but rather, it is a variable factor. For the sake of the model, congestion is one of our four objectives, but in a real-world decision, I may have a lower weight for this if we happen to incorporate multiple other objectives we must reach.

I see approaching this workshop from the mindset of a consultant as beneficial because it provides a learning experience to see how I would recommend this firm takes action within their company, what my model shows, how I interpret it (because models are not absolutes, or concrete), and what my ultimate recommendations would be. Given more time, and the incentive of a check based on a percentage of what I save the company, I would do some more tweaking to get a: 1) lower MiniMax value, and 2) work to find a more thoughtful balance between the objectives that reflects the goals of the company, and myself.