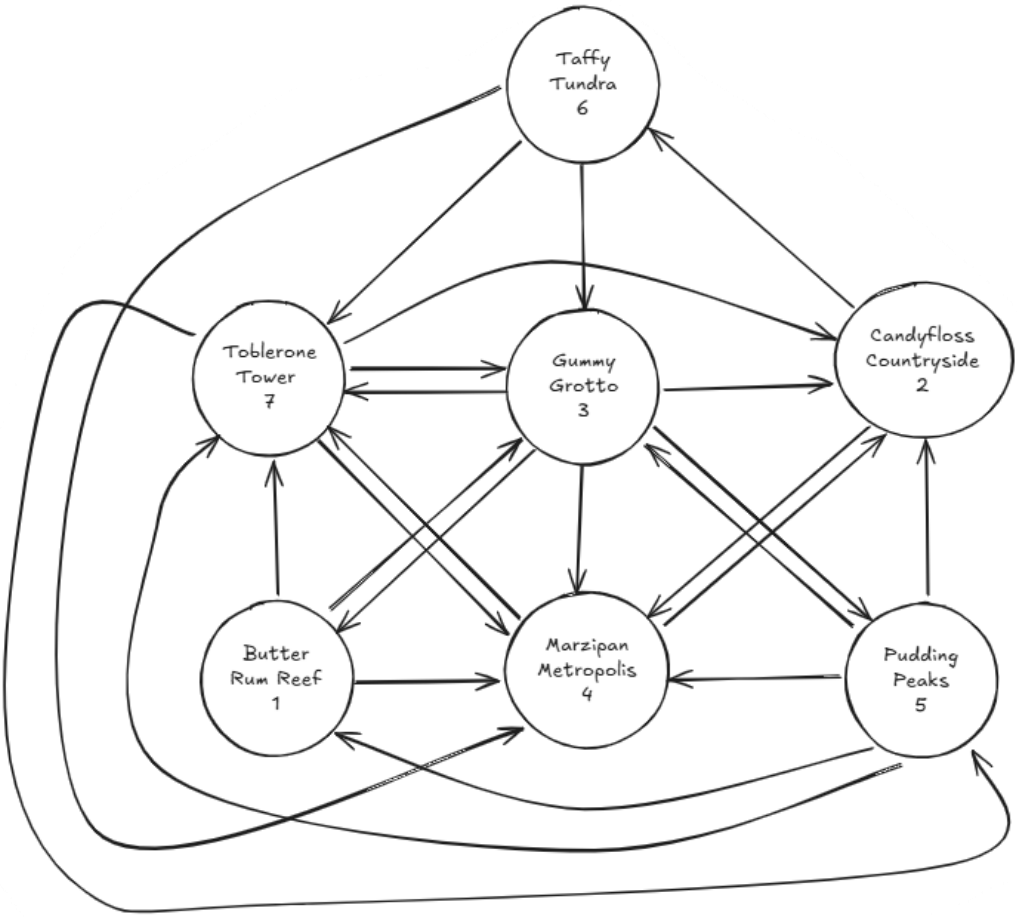
Module 10 – MOLP

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/
        - Find a map with latitude/longitude and place them approximately
        - Any alternative that gives the same effect

    - *Make a visual graph of your data like what we saw for the sample problem*
        - https://excalidraw.com
        - https://mermaid.live
        - https://dreampuf.github.io/GraphvizOnline
        - PowerPoint



Model Formulation

Write the formulation of the model 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.

MIN: Q

$$\mathbf{W_1}\left(\frac{((\mathbf{X1}*\mathbf{C1})+(\mathbf{X2}*\mathbf{C2})+..(\mathbf{X24}*\mathbf{C24}))-\mathbf{221{,}011}}{\mathbf{221{,}011}}\right)\leq Q$$

$$\boldsymbol{W_2}\left(\frac{((\mathbf{X1}*\mathbf{D1})+(\mathbf{X2}*\mathbf{D2})+..(\mathbf{X24}*\mathbf{D24}))-\mathbf{184{,}002.38}}{\mathbf{184{,}002.38}}\right)\leq Q$$

$$\boldsymbol{W_3}\left(\frac{((\mathbf{X1}*\mathbf{E1})+(\mathbf{X2}*\mathbf{E2})+..(\mathbf{X24}*\mathbf{E24}))-\mathbf{5547}}{\mathbf{5547}}\right)\leq Q$$

$$\boldsymbol{W_4}\left(\frac{((\mathbf{X1}*\mathbf{CN1})+(\mathbf{X2}*\mathbf{CN2})+..(\mathbf{X24}*\mathbf{CN24}))-\mathbf{16954}}{16954}\right)\leq Q$$

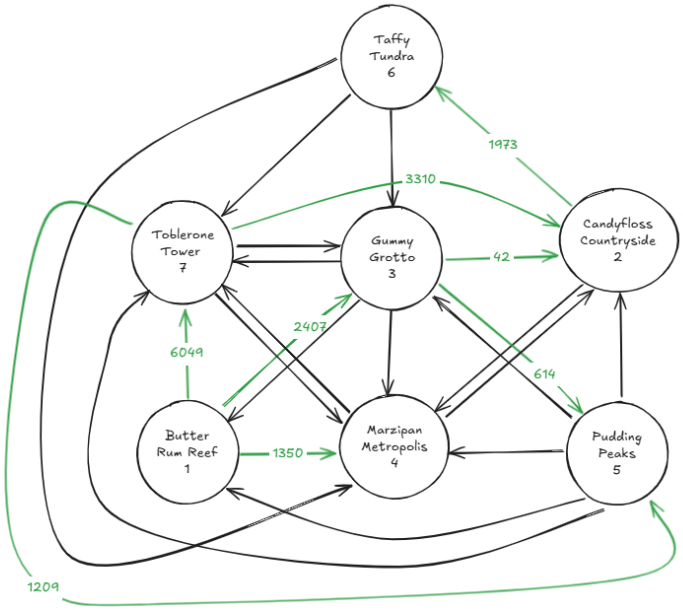
$+X_{31} +X_{51} -X_{13} -X_{14} -X_{17} \geq -9806$ } Node 1
$+X_{32} +X_{42} +X_{52} +X_{72} -X_{24} -X_{26} \geq 1379$ } Node 2
$+X_{13} +X_{53} +X_{63} +X_{73} -X_{31} -X_{32} -X_{34} -X_{35} -X_{37} \geq 1751$ } Node 3
$+X_{14} +X_{24} + X_{34} +X_{54} +X_{64} + X_{74} -X_{42} -X_{72} \geq 1350$ } Node 4
$+X_{35} +X_{75} -X_{51} -X_{52} -X_{53} -X_{54} -X_{57} \geq 1823$ } Node 5
$+X_{26} -X_{63} -X_{64} -X_{67} \geq 1973$ } Node 6
$+X_{17} +X_{37} + X_{47} +X_{57} +X_{67} -X_{72} -X_{73} -X_{74} -X_{75} \geq 1530$ } Node 7

$X_1,\ldots X24 \geq 0$
$X_1,\ldots X24 = Int$

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*

Units Shipped	from	Lat	Lon	to	Latitude	Longitude	cost_per_unit_shipped	Euclidian Distance	transportation_method	Binary	congestion_level	Binary
2407	1	37.5	-102.5	3	31.85	-93.48	11	10.64	Diesel Trucks	1	92	1
1350	1	37.5	-102.5	4	36.55	-113.64	20	11.18	Diesel Trucks	1	86	1
6049	1	37.5	-102.5	7	39.78	-94.98	22	7.86	Electric/Hybrid Trucks	0	87	1
0	2	30.08	-99.31	4	36.55	-113.64	16	15.72	Electric/Hybrid Trucks	0	70	1
1973	2	30.08	-99.31	6	43.87	-114.64	24	20.62	Cargo Ships (Heavy Fuel Oil)	1	90	1
0	3	31.85	-93.48	1	37.5	-102.5	22	10.64	Slow Steaming Cargo Ships	0	72	1
42	3	31.85	-93.48	2	30.08	-99.31	5	6.09	Diesel Trucks	1	87	1
0	3	31.85	-93.48	4	36.55	-113.64	11	20.70	Wind-powered Ships	0	88	1
614	3	31.85	-93.48	5	35.18	-109.14	11	16.01	Air Freight	1	80	1
0	3	31.85	-93.48	7	39.78	-94.98	18	8.07	Cargo Ships (Heavy Fuel Oil)	1	88	1
0	4	36.55	-113.64	2	30.08	-99.31	21	15.72	Diesel Trucks	1	106	1
0	4	36.55	-113.64	7	39.78	-94.98	19	18.94	Wind-powered Ships	0	78	1
0	5	35.18	-109.14	1	37.5	-102.5	23	7.03	Diesel Rail	1	89	1
0	5	35.18	-109.14	2	30.08	-99.31	14	11.07	Cargo Ships (Heavy Fuel Oil)	1	94	1
0	5	35.18	-109.14	3	31.85	-93.48	7	16.01	Diesel Trucks	1	35	0
0	5	35.18	-109.14	4	36.55	-113.64	12	4.70	Electrified Rail	0	97	1
0	5	35.18	-109.14	7	39.78	-94.98	16	14.89	Air Freight	1	78	1
0	6	43.87	-114.64	3	31.85	-93.48	14	24.34	Cargo Ships (Heavy Fuel Oil)	1	102	1
0	6	43.87	-114.64	4	36.55	-113.64	19	7.39	Air Freight	1	92	1
0	6	43.87	-114.64	7	39.78	-94.98	19	20.08	Diesel Rail	1	89	1
3310	7	39.78	-94.98	2	30.08	-99.31	15	10.62	Electrified Rail	0	88	1
0	7	39.78	-94.98	3	31.85	-93.48	14	8.07	Cargo Ships (Heavy Fuel Oil)	1	96	1
0	7	39.78	-94.98	4	36.55	-113.64	24	18.94	Air Freight	1	77	1
1209	7	39.78	-94.98	5	35.18	-109.14	10	14.89	Diesel Trucks	1	100	1

Nodes	Inflow	Outflow	Netflow	Supply/Demand
1	0	9806	-9806	-9806
2	3352	1973	1379	1379
3	2407	656	1751	1751
4	1350	0	1350	1350
5	1823	0	1823	1823
6	1973	0	1973	1973
7	6049	4519	1530	1530

Totals	Target Values	Deviation	% Deviation	Weight	Weighted Deviation %
$302,611.00	$221,011.00	$81,600.00	36.92%	1.00	36.92%
192175.29	184002.38	8172.91	4.44%	1.00	4.44%
7595	5547	2048.00	36.92%	1.00	36.92%
16954	16954	0.00	0.00%	1.00	0.00%

Minimax Variable	36.92%

The Model recommends that we prioritize the minimization of congestion levels because, that is the solution that keeps the other goals closest to their target values. It keeps them below 37% deviation from the original value.

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.

Units Shipped	from	Lat	Lon	to	Latitude	Longitude	cost_per_unit_shipped	Euclidian Distance	transportation_method	Binary	congestion_level	Binary
4016	1	37.5	-102.5	3	31.85	-93.48	11	10.64	Diesel Trucks	1	92	1
1350	1	37.5	-102.5	4	36.55	-113.64	20	11.18	Diesel Trucks	1	86	1
4440	1	37.5	-102.5	7	39.78	-94.98	22	7.86	Electric/Hybrid Trucks	0	87	1
0	2	30.08	-99.31	4	36.55	-113.64	16	15.72	Electric/Hybrid Trucks	0	70	1
1973	2	30.08	-99.31	6	43.87	-114.64	24	20.62	Cargo Ships (Heavy Fuel Oil)	1	90	1
0	3	31.85	-93.48	1	37.5	-102.5	22	10.64	Slow Steaming Cargo Ships	0	72	1
461	3	31.85	-93.48	2	30.08	-99.31	5	6.09	Diesel Trucks	1	87	1
0	3	31.85	-93.48	4	36.55	-113.64	11	20.70	Wind-powered Ships	0	88	1
1804	3	31.85	-93.48	5	35.18	-109.14	11	16.01	Air Freight	1	80	1
0	3	31.85	-93.48	7	39.78	-94.98	18	8.07	Cargo Ships (Heavy Fuel Oil)	1	88	1
0	4	36.55	-113.64	2	30.08	-99.31	21	15.72	Diesel Trucks	1	106	1
0	4	36.55	-113.64	7	39.78	-94.98	19	18.94	Wind-powered Ships	0	78	1
0	5	35.18	-109.14	1	37.5	-102.5	23	7.03	Diesel Rail	1	89	1
0	5	35.18	-109.14	2	30.08	-99.31	14	11.07	Cargo Ships (Heavy Fuel Oil)	1	94	1
0	5	35.18	-109.14	3	31.85	-93.48	7	16.01	Diesel Trucks	1	35	0
0	5	35.18	-109.14	4	36.55	-113.64	12	4.70	Electrified Rail	0	97	1
0	5	35.18	-109.14	7	39.78	-94.98	16	14.89	Air Freight	1	78	1
0	6	43.87	-114.64	3	31.85	-93.48	14	24.34	Cargo Ships (Heavy Fuel Oil)	1	102	1
0	6	43.87	-114.64	4	36.55	-113.64	19	7.39	Air Freight	1	92	1
0	6	43.87	-114.64	7	39.78	-94.98	19	20.08	Diesel Rail	1	89	1
2891	7	39.78	-94.98	2	30.08	-99.31	15	10.62	Electrified Rail	0	88	1
0	7	39.78	-94.98	3	31.85	-93.48	14	8.07	Cargo Ships (Heavy Fuel Oil)	1	96	1
0	7	39.78	-94.98	4	36.55	-113.64	24	18.94	Air Freight	1	77	1
19	7	39.78	-94.98	5	35.18	-109.14	10	14.89	Diesel Trucks	1	100	1

Nodes	Inflow	Outflow	Netflow	Supply/Demand
1	0	9806	-9806	-9806
2	3352	1973	1379	1379
3	4016	2265	1751	1751
4	1350	0	1350	1350
5	1823	0	1823	1823
6	1973	0	1973	1973
7	4440	2910	1530	1530

Totals	Target Values	Deviation	% Deviation	Weight	Weighted Deviation %
$281,912.00	$221,011.00	$60,901.00	27.56%	0.40	11.02%
196093.84	184002.38	12091.46	6.57%	0.30	1.97%
9623	5547	4076.00	73.48%	0.15	11.02%
16954	16954	0.00	0.00%	0.15	0.00%

Minimax Variable	11.02%

I chose these weights because I believe they are closer to where modern companies want to be, prioritizing Cost and Travel Distance (time) above all. But also, presenting and eco-forward initiative by weighing eco-friendliness and congestion levels are relatively high.

Units Shipped	from	Lat	Lon	to	Latitude	Longitude	cost_per_unit_shipped	Euclidian Distance	transportation_method	Binary	congestion_level	Binary
6926	1	37.5	-102.5	3	31.85	-93.48	11	10.64	Diesel Trucks	1	92	1
1350	1	37.5	-102.5	4	36.55	-113.64	20	11.18	Diesel Trucks	1	86	1
1530	1	37.5	-102.5	7	39.78	-94.98	22	7.86	Electric/Hybrid Trucks	0	87	1
0	2	30.08	-99.31	4	36.55	-113.64	16	15.72	Electric/Hybrid Trucks	0	70	1
1973	2	30.08	-99.31	6	43.87	-114.64	24	20.62	Cargo Ships (Heavy Fuel Oil)	1	90	1
0	3	31.85	-93.48	1	37.5	-102.5	22	10.64	Slow Steaming Cargo Ships	0	72	1
3352	3	31.85	-93.48	2	30.08	-99.31	5	6.09	Diesel Trucks	1	87	1
0	3	31.85	-93.48	4	36.55	-113.64	11	20.70	Wind-powered Ships	0	88	1
1823	3	31.85	-93.48	5	35.18	-109.14	11	16.01	Air Freight	1	80	1
0	3	31.85	-93.48	7	39.78	-94.98	18	8.07	Cargo Ships (Heavy Fuel Oil)	1	88	1
0	4	36.55	-113.64	2	30.08	-99.31	21	15.72	Diesel Trucks	1	106	1
0	4	36.55	-113.64	7	39.78	-94.98	19	18.94	Wind-powered Ships	0	78	1
0	5	35.18	-109.14	1	37.5	-102.5	23	7.03	Diesel Rail	1	89	1
0	5	35.18	-109.14	2	30.08	-99.31	14	11.07	Cargo Ships (Heavy Fuel Oil)	1	94	1
0	5	35.18	-109.14	3	31.85	-93.48	7	16.01	Diesel Trucks	1	35	0
0	5	35.18	-109.14	4	36.55	-113.64	12	4.70	Electrified Rail	0	97	1
0	5	35.18	-109.14	7	39.78	-94.98	16	14.89	Air Freight	1	78	1
0	6	43.87	-114.64	3	31.85	-93.48	14	24.34	Cargo Ships (Heavy Fuel Oil)	1	102	1
0	6	43.87	-114.64	4	36.55	-113.64	19	7.39	Air Freight	1	92	1
0	6	43.87	-114.64	7	39.78	-94.98	19	20.08	Diesel Rail	1	89	1
0	7	39.78	-94.98	2	30.08	-99.31	15	10.62	Electrified Rail	0	88	1
0	7	39.78	-94.98	3	31.85	-93.48	14	8.07	Cargo Ships (Heavy Fuel Oil)	1	96	1
0	7	39.78	-94.98	4	36.55	-113.64	24	18.94	Air Freight	1	77	1
0	7	39.78	-94.98	5	35.18	-109.14	10	14.89	Diesel Trucks	1	100	1

Nodes	Inflow	Outflow	Netflow	Supply/Demand
1	0	9806	-9806	-9806
2	3352	1973	1379	1379
3	6926	5175	1751	1751
4	1350	0	1350	1350
5	1823	0	1823	1823
6	1973	0	1973	1973
7	1530	0	1530	1530

Totals	Target Values	Deviation	% Deviation	Weight	Weighted Deviation %
$221,011.00	$221,011.00	$0.00	0.00%	0.60	0.00%
191125.03	184002.38	7122.65	3.87%	0.35	1.35%
15424	5547	9877.00	178.06%	0.02	3.56%
16954	16954	0.00	0.00%	0.03	0.00%

Minimax Variable	3.56%

this image was another of the scenarios I ran I believe this model reflects companies in the 20th century putting all their focus on minimizing the money and not caring about the impact.