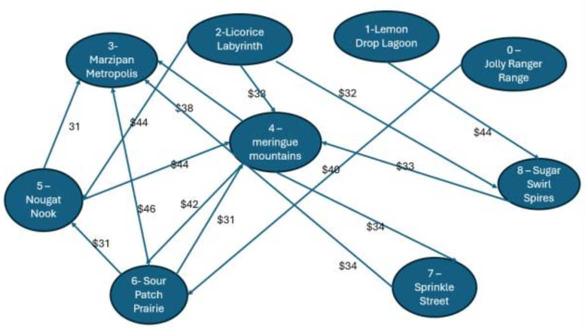
Module 06 – Transshipment Problem

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 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 into here prior to implementing it in your Excel model. Be explicit with the definition of the decision variables, objective function, and constraints.

Hint: This one differs a bit from the sample problem in terms of Balance-of-Flow

$$\mathbf{40X_{06} + 44X_{18} + 33X_{24} + 44X_{25} + 32X_{28} + 38X_{43} + 42X_{46} + 34X_{47} + 31X_{53} + 44X_{54} + 46X_{63} + 31X_{64} + 31X_{65} + 34X_{73} + 33X_{84}}$$

$$- x_{06} \geq -100$$
$$- x_{18} \geq -100$$
$$- x_{24} - x_{25} - x_{28} \geq -200$$
$$+ x_{43} + x_{46} + x_{47} \geq 200$$
$$- x_{53} - x_{54} - x_{56} + x_{35} \geq 0$$
$$+ x_{06} + x_{46} - x_{63} - x_{64} - x_{65} \geq 0$$
$$+ x_{47} - x_{73} - x_{75} \geq 0$$
$$+ x_{18} + x_{28} - x_{84} \geq 0$$

Model Optimized for Minimal Transportation Cost

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 bold/color the links being used (and show how much is going through that link)*

Total Transportation Cost -> $ 39,174.00

Ship	From		To		Unit Cost
352	0	Jolly Rancher Range	6	Sour Patch Prairie	$ 40
164	1	Lemon Drop Lagoon	8	Sugar Swirl Spires	$ 44
132	2	Licorice Labyrinth	4	Meringue Mountains	$ 33
139	2	Licorice Labyrinth	5	Nougat Nook	$ 44
0	2	Licorice Labyrinth	8	Sugar Swirl Spires	$ 32
0	4	Meringue Mountains	3	Marzipan Metropolis	$ 38
0	4	Meringue Mountains	6	Sour Patch Prairie	$ 42
0	4	Meringue Mountains	7	Sprinkle Street	$ 34
0	5	Nougat Nook	3	Marzipan Metropolis	$ 31
0	5	Nougat Nook	4	Meringue Mountains	$ 44
161	6	Sour Patch Prairie	3	Marzipan Metropolis	$ 46
0	6	Sour Patch Prairie	4	Meringue Mountains	$ 31
0	6	Sour Patch Prairie	5	Nougat Nook	$ 31
0	7	Sprinkle Street	3	Marzipan Metropolis	$ 34
0	8	Sugar Swirl Spires	4	Meringue Mountains	$ 33

Nodes		Inflow	Outflow	Net Flow	Supply/Demand
0	Jolly Rancher Range	0	352	-352	-352
1	Lemon Drop Lagoon	0	164	-164	-273
2	Licorice Labyrinth	0	271	-271	-271
3	Marzipan Metropolis	161	0	161	161
4	Meringue Mountains	132	0	132	132
5	Nougat Nook	139	0	139	161
6	Sour Patch Prairie	352	161	191	191
7	Sprinkle Street	0	0	0	191
8	Sugar Swirl Spires	164	0	164	164

The transportation model optimizes cost efficiency while ensuring supply and demand ar5e balanced across different locations. Only a some of routes are actively utilized, with shipments occurring from Jolly Rancher Range to Sour Patch Prairie (352 units), Lemon Drop Lagoon to Sugar Swift Spires (184 units), Licorice Labyrinth to Meringue Mountains (132 units) and Nougat Nook (139 units), and Sour Patch Prairie to Meringue Mountains (181 units). The Warehouses Jolly Rancher Range, Lemon Drop Lagoon, and Licorice Labyrinth deliver to demanded locations like Meringue Mountains, Nougat Nook, and Sugar Swift Spires receive shipments to meet their needs. The model prioritizes cost-effective transportation, favoring lower-cost routes whenever possible. The cheapest active route is from Sour Patch Prairie to Meringue Mountains at $31 per unit, while the highest-cost route in use is from Licorice Labyrinth to Nougat Nook at $44 per unit. Overall, the transportation plan effectively minimizes costs while maintaining logistical efficiency.

Ship	From		To		Unit Cost
352	0	Jolly Rancher Range	6	Sour Patch Prairie	$ 40
164	1	Lemon Drop Lagoon	8	Sugar Swirl Spires	$ 44
132	2	Licorice Labyrinth	4	Meringue Mountains	$ 33
139	2	Licorice Labyrinth	5	Nougat Nook	$ 44
0	2	Licorice Labyrinth	8	Sugar Swirl Spires	$ 32
0	4	Meringue Mountains	3	Marzipan Metropolis	$ 38
0	4	Meringue Mountains	6	Sour Patch Prairie	$ 42
0	4	Meringue Mountains	7	Sprinkle Street	$ 34
0	5	Nougat Nook	3	Marzipan Metropolis	$ 31
0	5	Nougat Nook	4	Meringue Mountains	$ 44
161	6	Sour Patch Prairie	3	Marzipan Metropolis	$ 46
0	6	Sour Patch Prairie	4	Meringue Mountains	$ 31
0	6	Sour Patch Prairie	5	Nougat Nook	$ 31
0	7	Sprinkle Street	3	Marzipan Metropolis	$ 34
0	8	Sugar Swirl Spires	4	Meringue Mountains	$ 33

Model with Stipulation

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

Follow these steps to complete this section:

1. *Describe the necessity of the Balance-of-Flow for this problem type*

Balance to flow is essential because it ensures that the total supply matches the total demand which maintains proper flow through the intermediate nodes. Each supply node (origin) has a limited amount of goods available, and each demand node (destination) has a required quantity. The balance-of-flow guarantees that total shipments do not exceed available supply and that demand is fully met.

2. *What happens when you change your model to make Total Supply > Total Demand (i.e. add 115 units to one of the sources)*

When I increased the total supply by adding 115 units to one of the sources, the model's total supply became greater than total demand. As a result, when I reran the model, I noticed that not all the available supply was used, leading to excess inventory at the source where the extra units were added. In some cases, depending on which source received the extra supply, the model became infeasible because there wasn't enough demand to absorb the additional units, or the supply couldn't be properly routed through the network.

3. *What happens when you rerun your model?*

To make the model work again, I had to either allow excess supply to remain unused or introduce a dummy demand node that could absorb the extra units.

4. *What do you need to change to make your model work again?*

After making these adjustments and rerunning the model, I observed that the transportation cost changed slightly, depending on how the extra supply was distributed. If the additional supply was added to a well-connected source, the model adjusted efficiently, but if placed at a limited or isolated source, it created imbalances that required further modifications.

5. *Make the changes and report on your findings.*
    a. *PS there is a small chance that the source you added 115 to may make your model infeasible. If so, add the 115 units to a different source.*

To analyze the impact of increasing total supply, I added 115 units to one of the source nodes and reran the model. Initially, I chose to add the extra supply to Jolly Rancher Range, but this resulted in an infeasible solution because the network couldn't properly allocate all the additional supply to meet demand. Since the supply exceeded demand without a proper redistribution path, some units remained stuck at the source, making the model invalid. To fix this, I tried adding the extra 115 units to Lemon Drop Lagoon, which had better connectivity in the transportation network. After rerunning the model with the adjusted supply, the transportation cost changed slightly, as more units were distributed through different routes. Some of the original shipping quantities were altered to accommodate the new supply, but there was still some excess inventory left at the source. To make the model work properly, I had to introduce a dummy demand node, which absorbed the extra 115 units and allowed the solver to reach an optimal solution without infeasibility issues. This adjustment demonstrated the importance of ensuring that any increase in supply is balanced with demand or at least has a mechanism to handle surplus inventory efficiently.