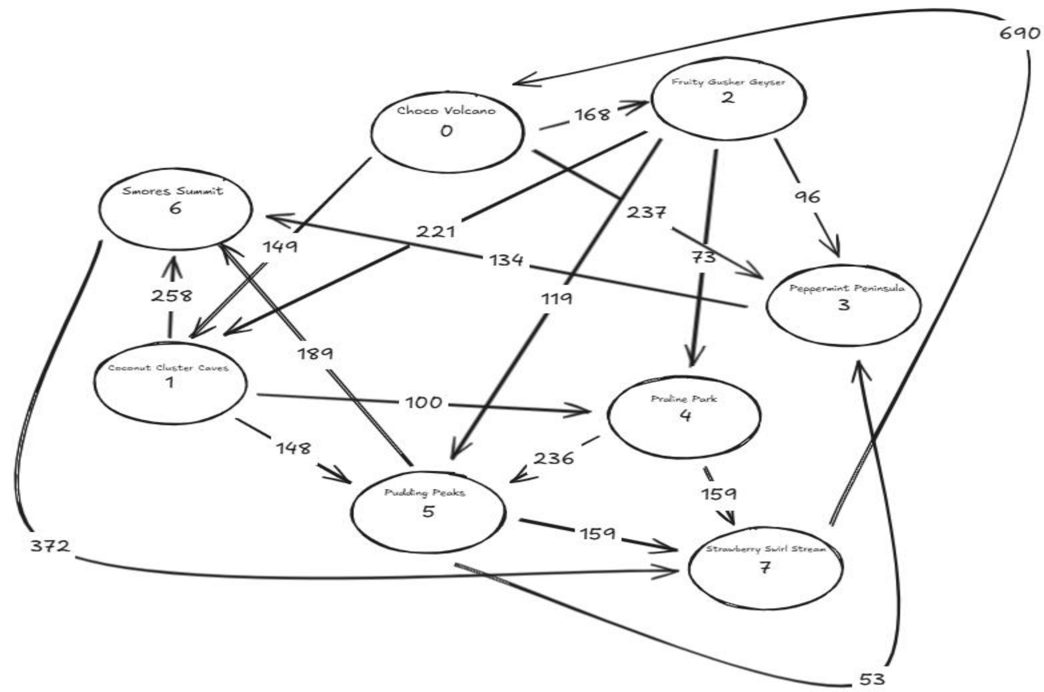
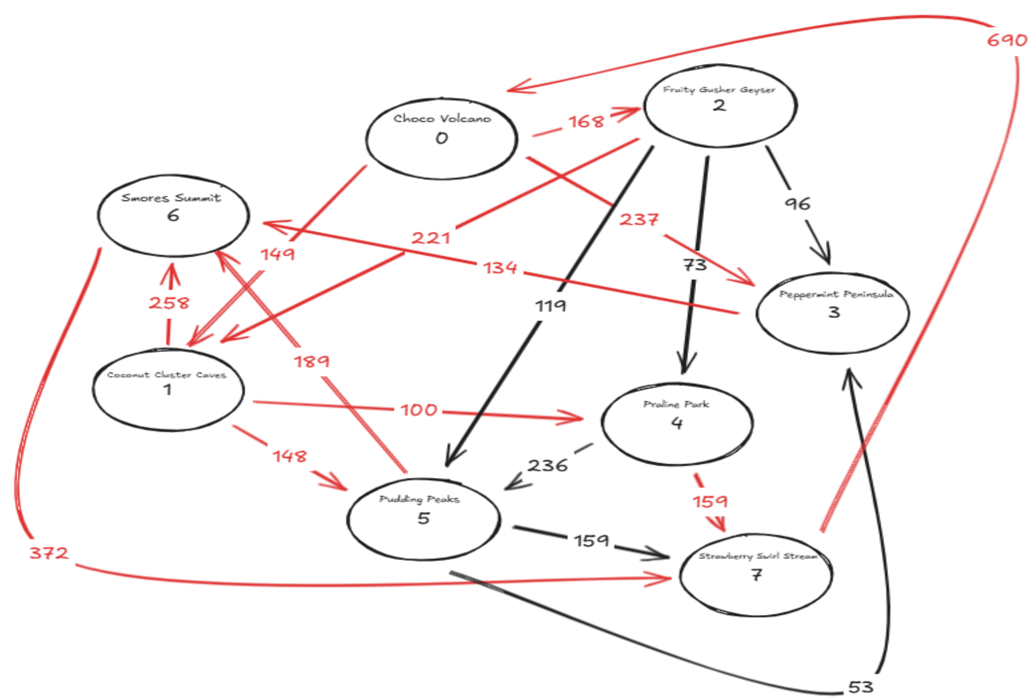
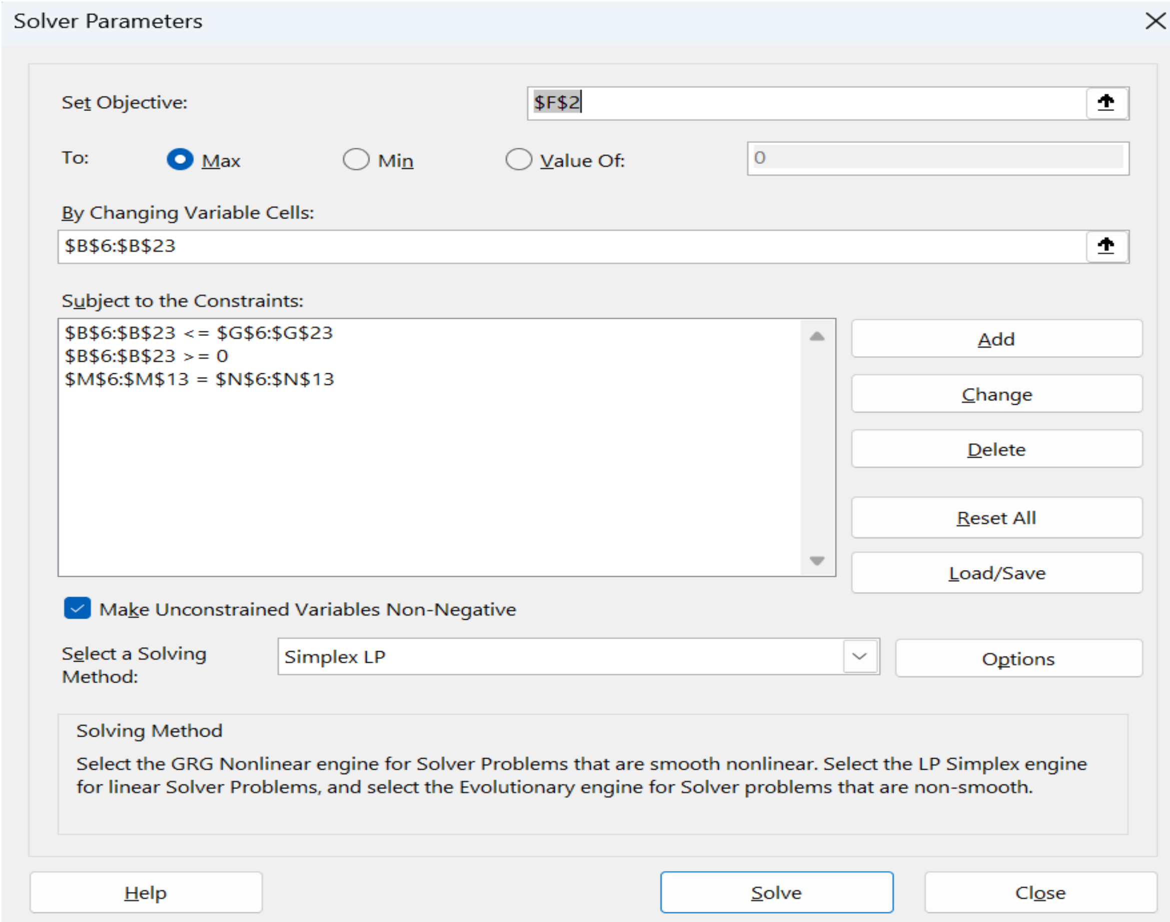
Module 07 – Maximal Flow

Exploratory Data Analysis





Model Formulation



MAX: X_{70} } **total shipping cost**

Subject to:

$+X_{70} - X_{01} - X_{02} - X_{03} = 0$	} flow constraint for node 0
$+X_{01} + X_{21} - X_{14} - X_{15} - X_{17} = 0$	} flow constraint for node 1
$+X_{02} - X_{21} - X_{23} - X_{24} - X_{25} = 0$	} flow constraint for node 2
$+X_{03} + X_{23} + X_{53} - X_{36} = 0$	} flow constraint for node 3
$+X_{14} + X_{24} - X_{45} - X_{47} = 0$	} flow constraint for node 4
$+X_{15} + X_{25} + X_{45} - X_{53} - X_{56} - X_{57} = 0$	} flow constraint for node 5
$+X_{16} + X_{36} + X_{56} - X_{67} = 0$	} flow constraint for node 6
$+X_{47} + X_{57} + X_{67} - X_{70} = 0$	} flow constraint for node 7

with the following bounds on the decision variables:

$0 \le X_{01} \le 149$	$0 \le X_{23} \le 96$	$0 \le X_{56} \le 189$
$0 \le X_{02} \le 168$	$0 \le X_{24} \le 73$	$0 \le X_{57} \le 159$
$0 \le X_{03} \le 237$	$0 \le X_{25} \le 119$	$0 \le X_{67} \le 372$
$0 \le X_{14} \le 100$	$0 \le X_{36} \le 134$	$0 \le X_{70} \le \text{inf}$
$0 \le X_{15} \le 148$	$0 \le X_{45} \le 236$	
$0 \le X_{16} \le 258$	$0 \le X_{47} \le 159$	
$0 \le X_{21} \le 221$	$0 \le X_{53} \le 53$	

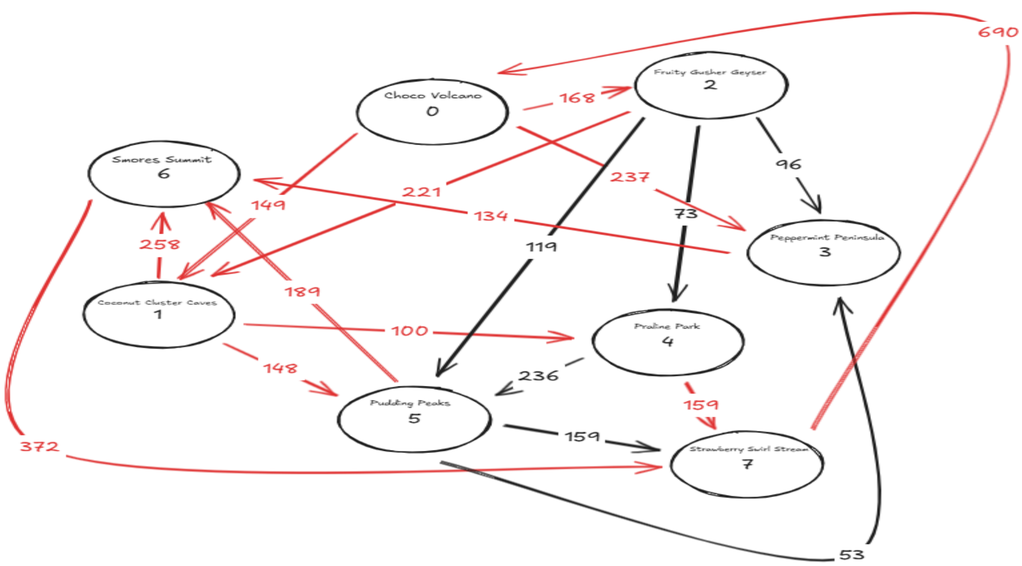
Model Optimized for Maximal Flow

Maximal Flow -> 451

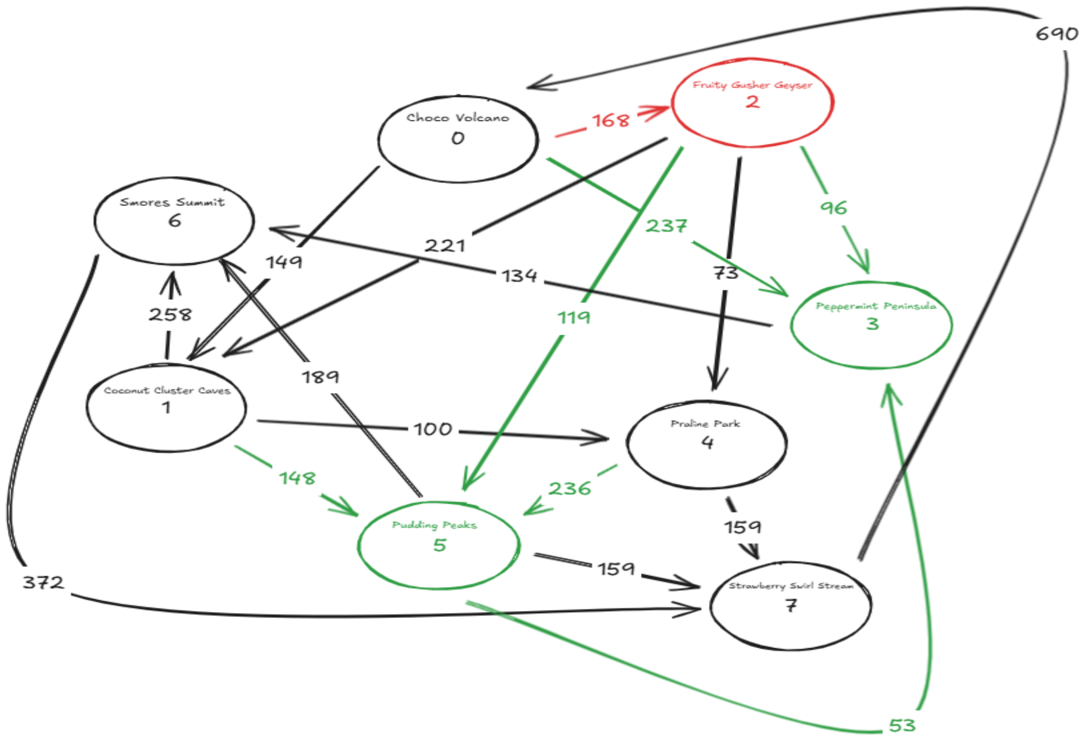
Units of Flow	Links				Upper Bound
	From		To		
149	0	Choco Volcano	1	Coconut Cluster Caves	149
168	0	Choco Volcano	2	Fruity Gusher Geyser	168
134	0	Choco Volcano	3	Peppermint Peninsula	237
100	1	Coconut Cluster Caves	4	Praline Park	100
148	1	Coconut Cluster Caves	5	Pudding Peaks	148
69	1	Coconut Cluster Caves	6	Smores Summit	258
168	2	Fruity Gusher Geyser	1	Coconut Cluster Caves	221
0	2	Fruity Gusher Geyser	3	Peppermint Peninsula	96
0	2	Fruity Gusher Geyser	4	Praline Park	73
0	2	Fruity Gusher Geyser	5	Pudding Peaks	119
134	3	Peppermint Peninsula	6	Smores Summit	134
100	4	Praline Park	7	Strawberry Swirl Stream	159
0	4	Praline Park	5	Pudding Peaks	236
0	5	Pudding Peaks	7	Strawberry Swirl Stream	159
0	5	Pudding Peaks	3	Peppermint Peninsula	53
148	5	Pudding Peaks	6	Smores Summit	189
351	6	Smores Summit	7	Strawberry Swirl Stream	372
451	7	Strawberry Swirl Stream	0	Choco Volcano	690

	Nodes	Inflow	Outflow	Net Flow	Supply / Demand
0	Choco Volcano	451	451	0	0
1	Coconut Cluster Caves	317	317	0	0
2	Fruity Gusher Geyser	168	168	0	0
3	Peppermint Peninsula	134	134	0	0
4	Praline Park	100	100	0	0
5	Pudding Peaks	148	148	0	0
6	Smores Summit	351	351	0	0
7	Strawberry Swirl Stream	451	451	0	0

The following model recommends that to optimize and magnify the Maximal Flow of goods between the distribution centers and the wholesalers (warehouse & retail locations), they must ship efficiently between the 8 locations. Following the data graph above, they must ship 149, 168, 134, 100, 148, 69, 168, 0, 0, 0, 134, 100, 0, 0, 0, 148, 351, & 451 to Nodes 0 through 7. By doing so, the Net Flow between the locations will use up as much of the supply as listed in the right portion of the screenshot, with the goal of leaving the most units of flow in from location 7 back to 0.



Identify the Bottlenecks



	Nodes	Inflow	SUM	Capacity	Classification
0	Choco Volcano	451	690	65.36%	Normal
1	Coconut Cluster Caves	317	370	85.68%	Normal
2	Fruity Gusher Geyser	168	168	100.00%	At Capacity
3	Peppermint Peninsula	134	386	34.72%	Underutilized
4	Praline Park	100	173	57.80%	Normal
5	Pudding Peaks	148	503	29.42%	Underutilized
6	Smores Summit	351	581	60.41%	Normal
7	Strawberry Swirl Stream	451	690	65.36%	Normal

In supply chain terms, a bottleneck refers to a point in the production or distribution process where the capacity is limited, causing a delay or slowdown in the overall flow of goods or services. This happens when a particular stage or resource cannot keep up with the demand or the speed of preceding or succeeding stages. As a result, it limits the efficiency of the entire supply chain.

To optimize this model, several actions can take place. Efficiency can be improved by speeding up the processing time at specified stages. For example, if quality control, manufacturing, or just transportation between nodes (locations) takes too long, efforts must be made to minimize these setbacks (bottlenecks). Additionally, resource constraints can hold efficient flow back. Not having enough raw materials or workers to meet demand can place too much stress on the operation. A truly optimized model would distribute the workload evenly to ensure the process is running smoothly and at the same pace at each level. Finally, outdated technology or workflows can slow the process, as competitors may have the technological advantage of producing and transporting products quicker and at a cheaper price. Each of these insights can balance the flow of the supply chain by reducing the bottleneck stage(s).