BSAN 740

Final Report:

THE FAST AND FURIOUS OPTIMIZATION

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1. **Briefly describe the problem and its significance (i.e., why and for whom is it important).**

Luxury car manufacturers like Tesla face complex challenges in distributing their limited production of exclusive vehicles worldwide. In this group project, we explore the strategic decisions behind allocating Tesla's Cybertruck to dealerships. We will uncover how factors like demand forecasts, transportation costs, production costs, and holding cost constraints shape this process, revealing the delicate balance between brand exclusivity and customer demand.

Problem:

The Tesla Cyber Truck sales dealership operates two factories: a local factory in Kansas City and an international factory in Taiwan. The local factory has a production capacity of 15,000 trucks, costing 55,000 dollars per truck. The international factory has a capacity of 50,000 trucks, costing 50,000 dollars per truck. The dealership can place orders from these factories up to twice per quarter. Sales are made in 10 key locations across the country:

1. **Los Angeles**: 20,000 trucks,
2. **San Francisco**: 15,000 trucks,
3. **Miami**: 6,200 trucks,
4. **Houston**: 3,000 trucks,
5. **Austin**: 2,200 trucks,
6. **Seattle**: 4,300 trucks,
7. **New York**: 3,300 trucks,

8. **Phoenix**: 2,700 trucks,
9. **Denver**: 2,400 trucks,
10. **Chicago**: 2,400 trucks

Each location incurs a holding cost of 37 dollars per day, with trucks being held for a minimum of 30 days and a maximum of 45 days. Additionally, there is a transportation cost of $1.15 per mile. The sales price per truck is 60,000 dollars.

Why did we choose this problem?

While we were sipping coffee and saw a Cyber Truck zoom by, it really put into perspective what sets luxury car manufacturing apart. These brands produce fewer vehicles, focusing on making each one unique and allowing for extensive customization. Customers often end up waiting longer than they would for standard cars, which are churned out much faster. This got us thinking about how these companies handle the long waits and why customers don't seem to mind. These cars are made with a lot more care and personal touch, which is quite different from the usual car production line. Plus, the appeal of having a car that's tailored just for them adds to the charm of luxury cars.

2. Formulate an appropriate mathematical model for the problem. What are the problem parameters, decision variables, objective function, and constraints?

Problem Parameters:

Factories:

Local Factory (Kansas City):

Production Capacity: 10,000 trucks

Cost per Truck: $55,000

International Factory (Taiwan):

Production Capacity: 50,000 trucks

Cost per Truck: $50,000

Sales Locations and Demand: Trucks are sold at various locations across the country, each with a specific demand:

Node	Supply	Demand
Kansas City	15000	0
Taiwan	50000	0
Chicago	0	2400
Denver	0	2400
Austin	0	2200
NYC	0	3300
Phoenix	0	2700
Houston	0	3000
Miami	0	6200
LA	0	20000
SFO	0	15000
Seattle	0	4300

Costs: Holding Cost: $37 per day per truck, with a minimum holding period of 30 days and a maximum of 45 days.

Transportation Cost: $1.15 per mile.

Sales Price: $60,000 per truck.

Decision variables:

- L_i - Number of trucks delivered from the local factory to location i.
- I_i - Number of trucks delivered from the international factory to location i.
- d_i - Holding time in days for location i.
- m_{ij} - Distance in miles from location i to location j.

Objective: Maximize the profit from the distribution of Tesla CyberTrucks by calculating the revenues and costs associated with the distribution from both local and international factories to various locations. The objective function can be described as:

$$\text{Maximize } 60,000 \times \sum_i (L_i + I_i) - (37 \times d_i \times \sum_i (L_i + I_i)) - (1.15 \times \sum_{ij} m_{ij}) - (50,000 \times \sum_i I_i + 55,000 \times \sum_i L_i)$$

Constraints:

1. **Factory Capacity International**: $\sum_i I_i \leq 50,000$

   This constraint ensures that the total number of trucks sourced from the international factory does not exceed its maximum capacity of 50,000 trucks.

2. **Factory Capacity Local**: $\sum_i L_i \leq 15,000$

   This limits the number of trucks sourced from the local factory to a maximum of 15,000 trucks.

3. **Demand Satisfaction**: $L_i + I_i \geq \text{demand at location } i$

   Each location *i* must receive at least *i* trucks to satisfy the local demand.

4. **Holding Days**: $30 \leq d_i \leq 45$

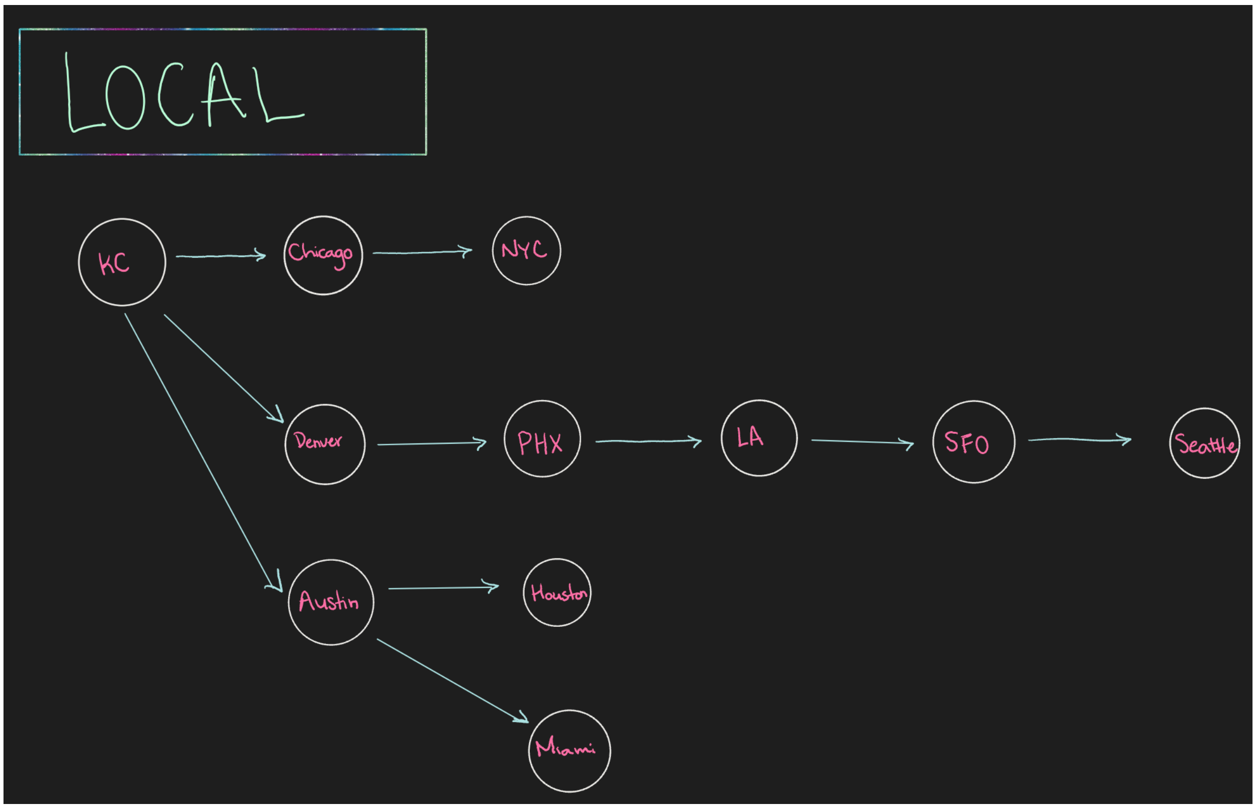
   Trucks can be held at each location for no less than 30 days and no more than 45 days.

5. **Non-negativity**: $$L_i, I_i, d_i, m_{ij} \geq 0$$

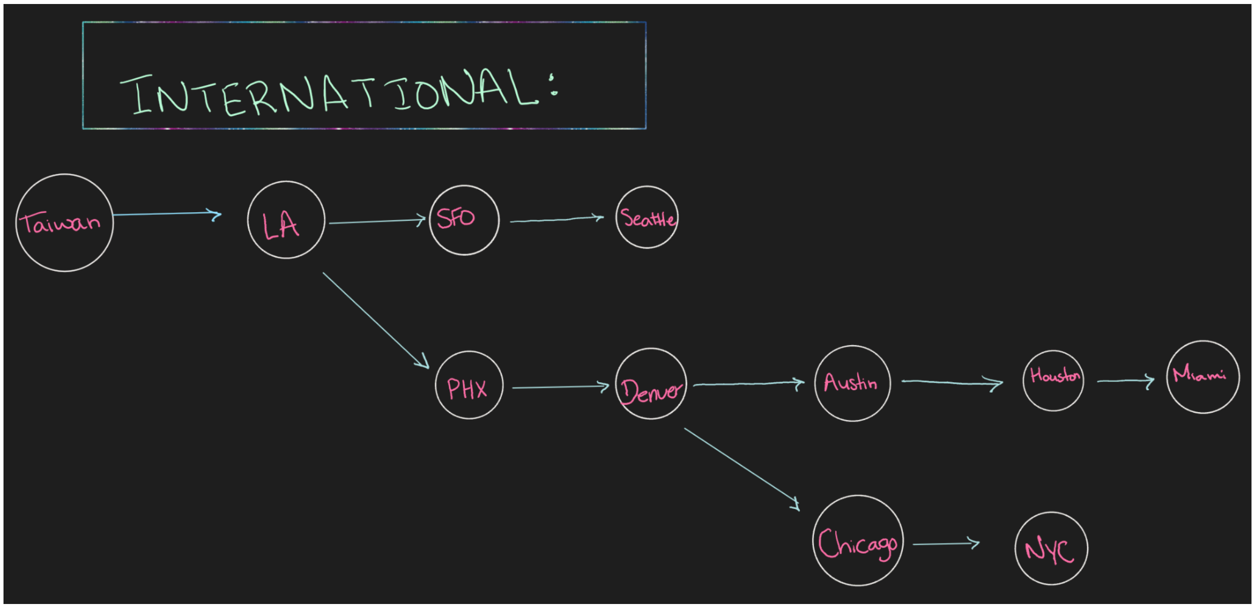
All decision variables must be non-negative.

Node Graphs:

Shipments from the local factory:



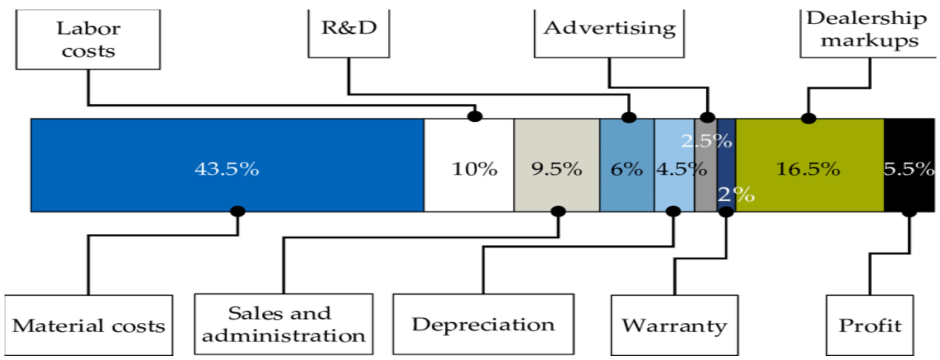
Shipments from the international factory:



3. What are your best estimates for the values of the problems and parameters? How did you arrive at these estimates? Please cite any sources that you may have used.

In our problem formulation, we assume Tesla operates two factories: one locally and one abroad. The production of a car involves a complex process, requiring parts sourced from various locations. However, in this analysis, we focus solely on the final product, omitting the detailed sourcing processes. We base our assumptions on data that suggests a significant dependence on the manufacturer, but here are the rough estimates we can consider:

1. Profit Margin: We estimate that the profit for each car is approximately 5.5%. Specifically, for the Cybertruck, the estimated profit would be around $6,000 per unit.



2. Cost Breakdown:
    - Labor and Materials: The combined cost of labor and materials is estimated to be up to $45,000.
    - Dealership Holding Costs: The cost of holding a car at a dealership is approximately $37 per car per day.
    - Shipping Costs: The average cost to ship a car is $1.15 per mile.
3. Proposed Supply Locations: The current locations under consideration for supply include Los Angeles (LA), San Francisco (SF), Miami, Houston, Austin, Seattle, New York, Phoenix, Denver, and Chicago.

The purpose of this optimization model is to aid the manufacturer in making data-driven decisions. By considering logistical constraints and market demand, the model aims to optimize the distribution of vehicles across different markets to maximize financial outcomes.

Sources:

1. Munro on what the Tesla Cyber Truck will really cost to build: Leandesign
2. Tesla Cybertruck cost to build: MotorTrend
3. Cost to manufacture a car: LLCTLCC
4. Tesla sales by state: World Population Review

4. Write a Python code to solve your mathematical formulation and identify the optimal value of your decision variables.

Done! Please refer to the ipynb file.

Optimal Objective Value: $519,005,820

Total Profit: $519,005,820.00

Total Revenue: $3,690,000,000.00

Total Production Cost: $3,132,500,000.00

Total Transportation Cost: $38,494,180.00

Average Holding Cost: $0.00

Local Factory:

Local Trucks from Kansas City to Chicago: 2400.0

Local Trucks from Kansas City to Austin: 100.0

Local Trucks from Kansas City to NYC: 3300.0

Local Trucks from Kansas City to Miami: 6200.0

Local Trucks from Kansas City to Houston: 3000.0

International Factory:

International Trucks from Taiwan to LA: 20000.0

International Trucks from LA to SFO: 15000.0

International Trucks from LA to Phoenix: 2700.0

International Trucks from LA to Seattle: 4300.0

International Trucks from LA to Denver: 2400.0

International Trucks from LA to Austin: 2100.0

5. List any *major* simplifying assumptions that were made in formulating the mathematical model and in estimating the parameter values. How confident would you be in implementing the prescription obtained from your model to address the problem?

We assumed that the distance from Taiwan to Los Angeles is 0 since we were concerned about the high transportation cost skewing the results when comparing the local to international. At the beginning, we did not have a holding days constraint which resulted in a high objective function. To simplify this we added a holding constraint. Kept holding days between 30-45 days and found an average holding cost.

We think this project is a good starting point but we will need to make more additions to the optimization code to get more accurate results. We need to consider how the international transportation cost will be included without skewing the results. In addition to that, we will also need to see how the values change depending on the different situations. It could be that the demand changes or holding days or cost changes.