BALANCING TRAILER POOL NETWORK

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BUSINESS PROBLEM

Efficient distribution of inventory is a critical challenge in logistics, as improper allocation leads to **increased operational costs, unmet demand, and low utilization.**

How can logistics companies strategically deploy their trailers to maximize customer benefits and optimize fleet utilization?

Our model uses **predictive analytics and mathematical modeling** to select priority network locations and trailer allocations using **freight market demand data, geospatial analysis, and telematics information** to determine optimal trailer placements.

METHODOLOGY

1. **Assign city tiers** based on freight market index to estimate revenue and costs at different levels.
2. **Calculate Profit** across varying numbers of demand cities by following the three stages below.
3. **Determine the optimal number of cities** to maximize profit with a correspondingly optimized trailer distribution.

Stage 1: Demand Estimation

Freight Market Data → Demand Forecasting → Select Cities → Trailer Allocation

Stage 2: Select Network Locations

Network Location Data → Assign Centroid → Prioritization Rules → Optimal Network Locations

Stage 3: Trailer Relocation

Telematics Data → Extracted Trailer Locations → Trailer Relocations with Minimum Distance → Optimal Trailer Distribution

Profit Maximization → Revenue Estimation: Tier System / Cost Minimization: Tier System → Determine Optimal Number of Demand Cities

DATA AND MODELING

DATA EXPLORATION

Network Locations

- 'Dealer' (existing dealer network) locations
- 'Own' (rented) locations

Telematics Data

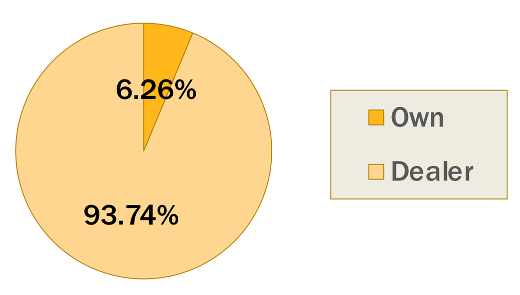
- Asset VIN
- Exact location
- Timestamp
- Motion status

Freight Market

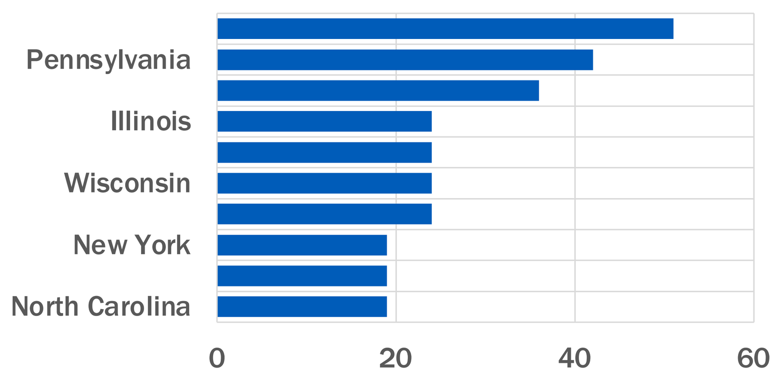
Volume indicator for Top 30 US freight markets

- City/State
- Daily Index

Most locations (~94%) are dealer owned!



Num of Locations By States



STAGE 1: DEMAND ESTIMATION

Forecasted Demand

$$e^{\sum(\ln(Xi)\times wi)}$$

x = demand on day i
w = weights for day i

Weighted Geometric Mean

Date	Weights
Day 1	0.1
Day 2	0.15
Day 3	0.2
Day 4	0.25
Day 5	0.3

Why Logarithmic?

- Captured exponential growth or decline patterns in demand
- Applied the natural logarithm(ln) to the index values for the past five days

Why Weights ?

- Higher importance to recent data
- Reduced outdated influence

Insights

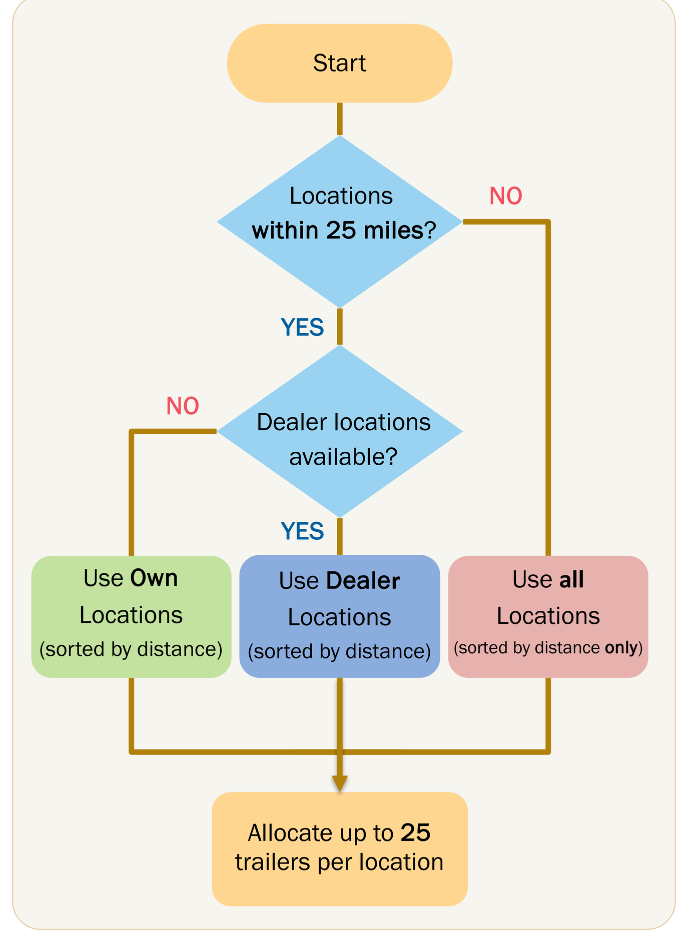
- More reliable than simple averages
- Can be extended to multiple locations for data-driven decision

Assigned Tiers

(D: Freight Market Demand Index)

		Daily Revenue	Daily Parking Cost
1	D > 200	$80	$7
2	100 < D =< 200	$50	$5
3	D <= 100	$30	$3

STAGE 2: SELECT NETWORK LOCATIONS



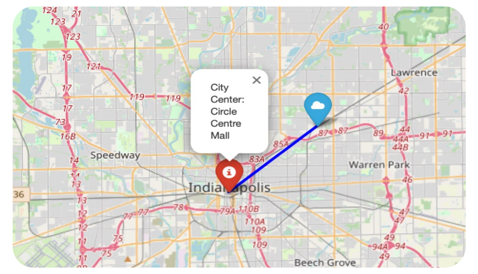
Allocation Priority Rules

1. Within 25 miles, prioritize 'Dealer' locations
2. If no 'Dealer' locations within 25 miles, Use 'Own' locations to park
3. If no locations within 25 miles, Use all network locations based on distance

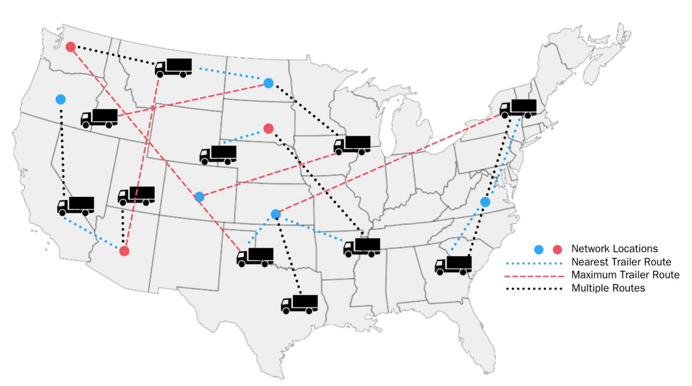
Allocation Constraint

Each location: maximum of 25 trailers

Map Demo Video !



STAGE 3: TRAILER RELOCATION



Relocation Methodology

1. Extract latest asset locations from telematics data
2. Calculate distances between assets and selected network locations
3. Set Up Objective Function: Minimize Total Relocation Cost
4. Set constraints based on trailer count and other business requirements

Objective : Minimize Total Distance Traveled

$$\min \sum_i \sum_j d_{ij} x_{ij}$$

$$x_{ij} = \begin{cases} 1 & \text{if asset } i \text{ is assigned to network location } j \\ 0 & \text{otherwise} \end{cases}$$

- i : **assets (trailers)**
- j : **network locations**
- $d(ij)$: **Euclidean distance** between i and j

Constraints

Each Asset Assigned to Exactly One Location: $\sum_j x_{ij} = 1, \forall i$

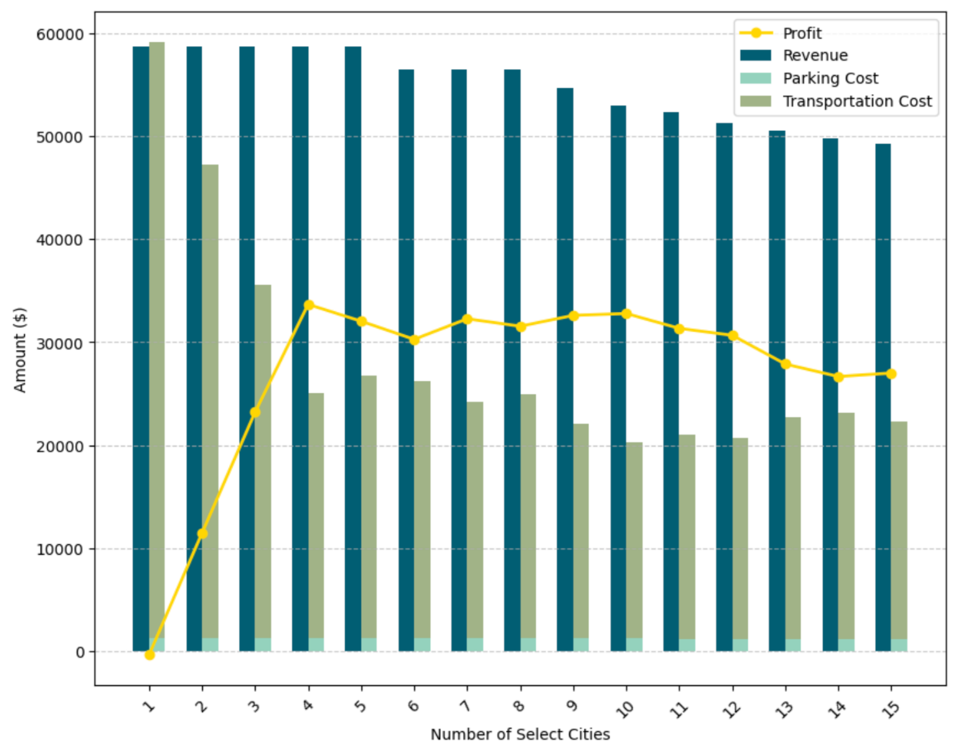
Each Network Location Receives Its Full Allocation: $\sum_i x_{ij} = Allocated\_Trailers_j, \forall j$

(Optional): Each Trailer Travels a Maximum Distance 't': $\sum_j d_{ij} x_{ij} <= t, \forall i$

OUTPUT

MODEL RESULTS

Profitability Comparison by Number of Select Cities



- **Profit:** Maximized at n=4 cities, balancing high-demand metros and manageable relevant costs
- **Revenue:** Maximized from n=1 through 5 due to choice of Tier1 demand freight metros
- **Transportation cost:** Really high at n=1, reduces with more distributed demand
- **Parking cost:** Remains stable across n=1 to 15

** Amount and number of cities scaled*

BUSINESS BENEFITS

Optimize Fleet Utilization

- Deploy trailers with maximum efficiency, minimal idle time, and reduced empty miles.

Increased Responsiveness to Demand

- Enhance response times
- Ensure service feasibility for dynamic freight demand

Profit Maximizing Distribution

- Balance high-demand metros with manageable costs.

Replicable Optimization Model

- Scalable and replicable model for application across similar contexts.

FUTURE SCOPE

Dynamic Live Asset Relocation

- Real-time optimization model using demand forecasts and telematics

Seasonal Demand Forecasting

- Leverage historical market data and advanced machine learning models

Customer Order & Subscription

- Predict company demand using subscription data and advance customer orders

Optimal Fleet Utilization

- Use only the required trailers
- Maintain a reserve for demand shifts