Multi-Ship Mode Forecasting And Optimization

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Problem Statement

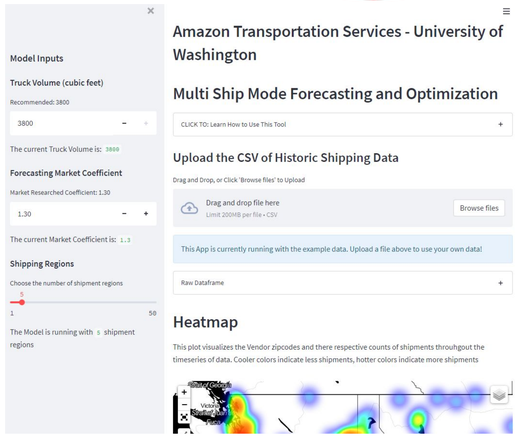
Amazon Transportation Services needs to anticipate vendor shipping demand to plan inbound transportation strategically.

Provided Data

One year (2020) of simulated **inbound** shipping data for a regional network in the Pacific Northwest.

Vendors  **Fulfillment Centers**

Web App



The final product is a tool that allows users to fine tune forecasting and fleet size optimization with industry sensitive parameters.

Ship Modes

Shipments are classified into one of **three shipmodes,** based off pallet volume ($53ft^3$)

Small Parcel (SP)
Small handheld packages
< ½ Pallet

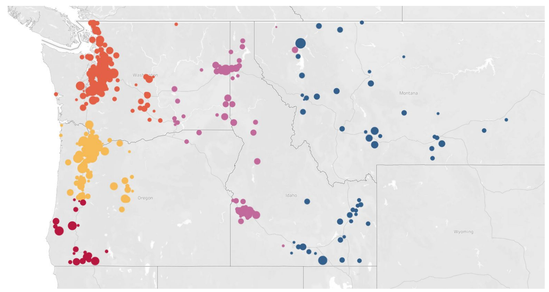
Less Than Truckload (LTL)
Multiple shipments in one truck
½ Pallet < x < 10 Pallets

Full Truckload (FTL)
One shipment per truck
> 10 Pallets

Solution

1 Clustering

➔ Historic shipment locations were clustered by coordinates into regions using the **k-means algorithm.**



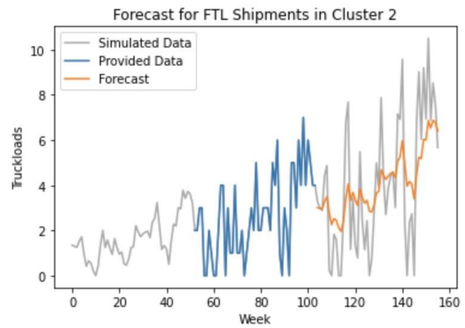
Colors: clustered regions
Dot size: number of shipments per ZIP

➔ Clustering allows for allocation decisions to be made on a subregional basis, and mitigates variance in shipping demand.
➔ The two optimization parameters that vary with cluster are **distance to fulfillment centers** and **cost of trips**.
➔ Distances are measured from cluster centroid to fulfillment center centroid.

2 Demand Forecasting

➔ Provided data was aggregated on a weekly basis, by cluster and ship mode.

➔ Data was simulated for 2019 to allow Winter-Holt's method to capture seasonality. Demand was forecasted for 2021, and data was simulated in 2021 to validate the forecast.



Metrics:
AVG. 4.01, MSE: 4.01, MAE: 1.64

➔ **Output**: Forecasted weekly truckloads, per cluster and ship mode, for the next year (2021).

3 Truckload Optimization

➔ **Inputs:**
- Forecasted weekly truckloads for each ship mode in each cluster
- Cost, distance, and truck availability

➔ **Output:**
- Quarterly truck fleet size.
- Weekly allocation of fleet (storage, operating, or third party)

➔ **Formulation:**
Minimize Total Cost
Total Cost = fleet storage cost (weekly) +
acquisition cost +
retirement cost +
fleet operating cost (weekly) +
outsourcing cost (weekly)
Constraints:
- Available fleet hours meets forecasted demand
- Fleet size for current period depends on the previous period
- Positive integers for decision variables

Results

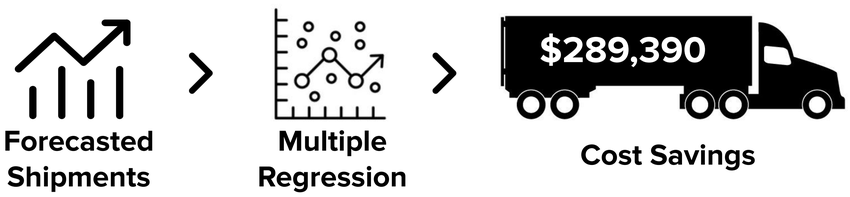
➔ **Comparison: Practical Worst Case Scenario vs Optimal Scenario**
- **Practical**: Acquire the maximum total weekly fleet size at the beginning of the year, and maintain this fleet size throughout the entire year with no outsourcing or clustering.
- **Optimal**: Dynamically adjust fleet size based on forecast and allow for outsourcing during demand spikes.

➔ **System Cost Savings With Simulated Data:** up to about **30%**
- This solution is scalable and can deliver substantial savings when informed with non-simulated data.
  - Simulated data includes **3,300 inbound shipments** for PNW regional network in the US, while Amazon Freight reportedly shipped over **4 billion packages** in the year 2020 for the United States.

Small Parcel

Amazon Freight outsources transport for SP shipments to 3P carriers

The team estimates a regional **$289,390** in lost revenue in 2021 based off of forecasted demand



Forecasted Shipments › **Multiple Regression** › **Cost Savings**

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