PLS Logistics Services Contract Risk Assessment & Integrated Pricing Model

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Problem Statement

- PLS Logistic Services connects shippers and drivers, however, *it assumes the risk in doing so, by basing the decision on live and historical car crash and weather datasets which are then factored into the optimal price using a probabilistic model*

- If risk levels for a route, given predicted data, could be known, shipper-driver contract costs can be more accurate to reflect real conditions
    - Low risk shipments can be made cheaper to offer more competitive rates, increasing quantity demanded and customer satisfaction
    - High risk shipments can have risk offsetted by an increased price (amortized cost analysis)
    - Either way, PLS will see drastic profit increases

Our Solution

Fully Functional Risk Assessment Model

- Utilizing **360 million data points** to inform our heuristic model such as:
  - Traffic data
  - Number of accidents across the entire U.S. with their coordinates, duration and distance
  - Shipping date and time
  - Cargo weight, volume, and value
  - Historical accident severity on roads, filtered by state
- Outputting values as:
  - Predicted trip duration (Google Maps API) + potential car crash delay (own calculation)
  - Length of Route (Miles)
  - Predicted weather conditions on route (Tomorrow.io)
  - Predicted # of accidents on route
  - Predicted Delay Time (hrs)
  - Data Points Considered
  - Risk assessment score (1 = neutral, < 1 = decreased risk, > 1 = increased risk)
  - Risk-adjusted price (USD)

Historical Data

- Based on 360 million traffic data points over the last 7 years, the risk assessment model calculates the increased/decreased probability of accidents happening on the inputted journey, prediction of the severity of these accidents, predicted duration of traffic delays and the distance these delays cover.
- As baselines, the training data was used in the efficient algorithms to calculate averages over the 164,000 miles of highways in the United States.
- For an inputted trip, the model selects all the corresponding data to that journey, compares this to the historical average and predicts the expected delay on the journey.

Search Algorithm For Datapoint Detection

- Along the transportation path, our search exploration exponentially reduces the search space from all car crash data points to the ones whose x and y coordinates are potentially lying close to the coordinates of the route.
- Then, the coordinates of the car crash data points are mapped and the heuristic for the optimized risk assessment of the path is established.

Risk Calculation

The following formula is used to calculate the risk:

C = historical crash severity along the path / historical average crash severity across the U.S.

D = historical crash duration along the path / historical average crash duration across the U.S.

S = historical crash distance along the path / historical average crash distance across the U.S.

N = historical total number of accidents along the path / historical total average number of accidents across the U.S.

Weighted avg = 0.2*C + 0.3*D + 0.2*S + 0.3*N

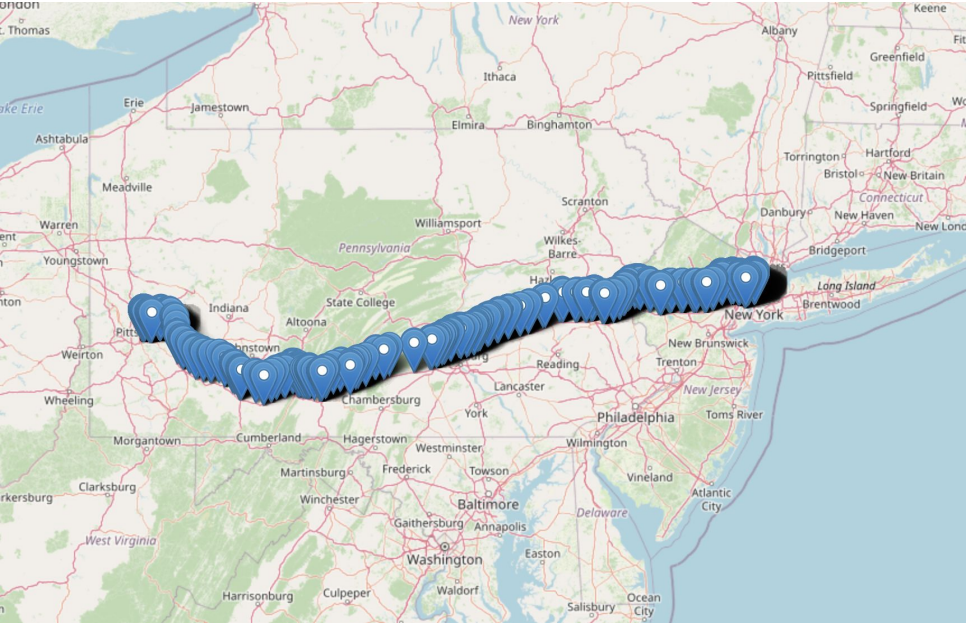
Risk factor = (Weighted avg - 1) / 10 + 1

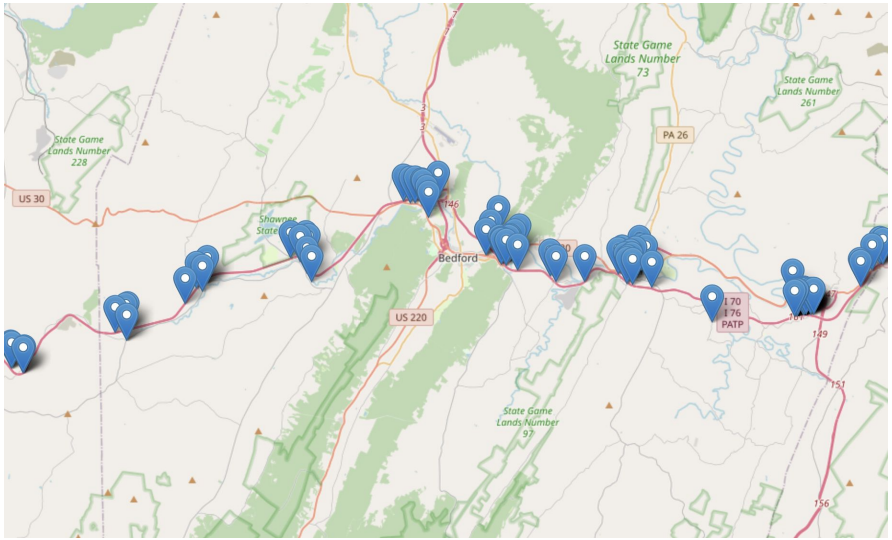
The risk factor then is used to multiply the base (market) price of shipping determined by PLS.

Historical Accident Data Point Calculation

After querying the most optimal route from Google Maps API, an optimized search algorithm finds all the accidents that happened in the last 7 years on the road. Each accident has its exact coordinates in the dataset. If it lies on the road, i.e. within a one mile radius of the road, the datapoint gets marked. Once all the data points are identified along the road, our algorithm averages all the parameters of the historical accidents. Parameters are the following: severity of the crash, distance of the crash, duration of the crash and number of crashes along the path in the last seven years. Each of these 4 parameters gets compared to the average same parameter values across the U.S. If the parameters yield a worse crash report, the risk of the route increases, hence PLS can adjust (increase) the price.

Historical Car Crash Datapoints Along Routes





Historical Crash Location Mapping

If the truck driver passes roads in Pittsburgh, all past accidents are identified along his path. The risk assessment model then evaluates crash severity, crash duration, crash distance for each datapoint and it sums up all accidents in the given cluster. Roads are scanned along the entire path of the driver and the total risk is computed based on the ratio of crash parameters along its path and the average cost data along the U.S.

Real-Time Model Updates

- Using Tomorrow.io API, live weather data is gathered to update our prediction model described before.
- When a journey, data and time is inputted, the API collects forecast data based on hourly updates and expected truck location at that time.
- For example, along a 1000 mile trip, the algorithm calculates the location where the truck will be each hour, and collects live weather forecast data to predict expected delays at each point along the trip
- When calculating the expected trip time, both historical and real-time traffic data is used in calculations based on the inputted departure date and time.

Pricing Recommendation

- Using the risk-assessment model, we can recommend a price based on historical and real-time data-driven amortized cost analysis for the corresponding risks undertaken by PLS.
- Implementing this risk analysis model into cost analysis creates a more transparent pricing scheme for PLS and its partners.
- This can be factored in to the normal contract prices to create an expectation about how much money will be saved/extra spent and how this corresponds to the contracts with other parties.
- Therefore, low risk shipments can be made cheaper to offer more competitive rates, increasing quantity demanded and customer satisfaction
- High risk shipments can have risk offsetted by an increased price (amortized cost analysis)

Example

Trip from Pittsburgh to New York

1. Address of starting location, ending location and travel start time is provided
2. Through Google Address API to generate distance, geo coordinates, and routes
3. Based on the route and predicted time, weather forecast is generated along the route
4. Thousands of data points along the route are collected using the sorting algorithm
5. Data points are inputted into risk assessment model which uses the parameters of crash severity (2.346684394216387), crash duration (32.4366576819407), number of crashes (6.83878), crash distance (1.4328248304313345) and live weather data.
6. Using baseline values from hundreds of millions of crashes against the US, the expected number of crashed, increase or decrease in delay time is calculated using a self-implemented algorithm.
7. Based on the risk assessment value (1.08499315712141567), the base value is updated accordingly

Model UI & Integration

PLS Logistics Services Contract Risk Assessment & Pricing Model

Shipping From (city)

Pittsburgh

Shipping To (city)

New York

Cargo Weight (lbs)

15000

Cargo Volume (cubic feet)

5625

Cargo Value (USD)

100000

Deliver by date (mm/dd/yyyy)

02/10/2024

Deliver by time (24hr)

17:00

Submit

PLS Logistics Services Contract Risk Assessment & Pricing Model

Model Output

Shipping From (city)
Pittsburgh

Shipping To (city)
New York

Predicted Trip Duration (hours)
6 hours 47 mins

Length of Route (miles)
371

Predicted Delay Time (hrs)
3.6971194303683736

Data Points Considered
54,098,758

Cargo Weight (lbs)
15000

Cargo Volume (cubic feet)
5625

Predicted Weather Conditions
Clear

Predicted # of Accidents
6.83878

Cargo Value (USD)
100000

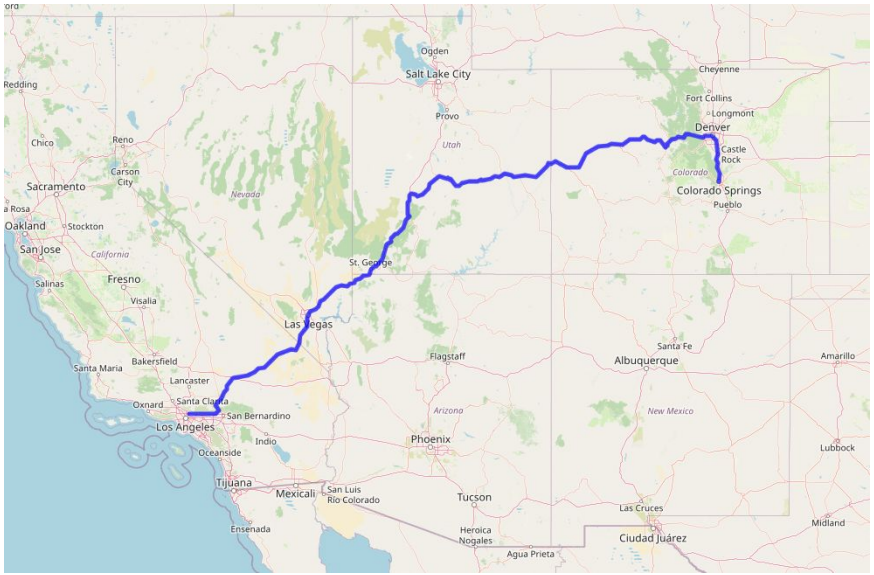
Deliver by date (mm/dd/yyyy)
02/10/2024

Deliver by time (24hr)
17:00

Risk Assessment (1 neutral risk)
1.0849931571214

Recommended Pricing (USD)
542.50

Submit



The weather prediction is calculated realtime and provides the driver with live weather information.

Even before the getting into the vehicle, the driver knows exact weather of cities along the route

In this example, El Paso, Jefferson, Summit and Eagle County will have high likelihood of snowfall.

Type 1: Rain; Type 2: Snow

The weather at El Paso County will have {'precipitationIntensity': 0.09, 'precipitationProbability': 75, 'precipitationType': 2, 'temperature': 35.94, 'windDirection': 263.63, 'windSpeed': 14.26} on your route

The weather at Jefferson County will have {'precipitationIntensity': 0.1, 'precipitationProbability': 96, 'precipitationType': 2, 'temperature': 32.63, 'windDirection': 341.67, 'windSpeed': 9.3} on your route

The weather at Summit County will have {'precipitationIntensity': 0.03, 'precipitationProbability': 85, 'precipitationType': 2, 'temperature': 18.22, 'windDirection': 319.69, 'windSpeed': 16.51} on your route

The weather at Eagle County will have {'precipitationIntensity': 0.03, 'precipitationProbability': 53, 'precipitationType': 2, 'temperature': 29.19, 'windDirection': 297.16, 'windSpeed': 10.53} on your route

The weather at Garfield County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 2, 'temperature': 36.91, 'windDirection': 222.74, 'windSpeed': 10.21} on your route

The weather at Mesa County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 41.7, 'windDirection': 247.99, 'windSpeed': 13.46} on your route

The weather at Grand County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 36.44, 'windDirection': 290.48, 'windSpeed': 8.74} on your route

The weather at Emery County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 25.68, 'windDirection': 277.86, 'windSpeed': 12.57} on your route

The weather at Sevier County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 19.91, 'windDirection': 274.04, 'windSpeed': 7.91} on your route

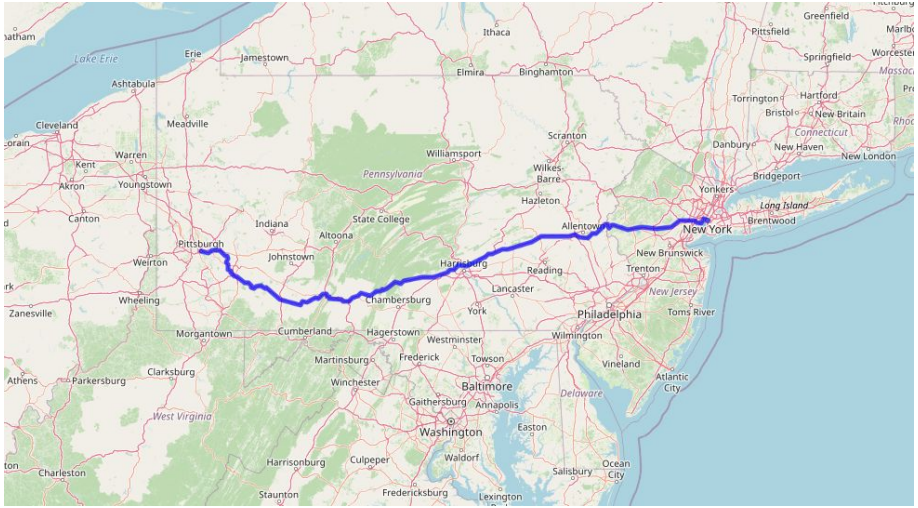
The weather at Iron County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 30.69, 'windDirection': 233.45, 'windSpeed': 7.87} on your route

The weather at Washington County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 38.62, 'windDirection': 71.07, 'windSpeed': 5.5} on your route

The weather at Clark County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 44.11, 'windDirection': 212.86, 'windSpeed': 9.5} on your route

The weather at San Bernardino County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 1, 'temperature': 41.67, 'windDirection': 200.75, 'windSpeed': 9.05} on your route

The weather at Los Angeles County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 1, 'temperature': 49.39, 'windDirection': 117.53, 'windSpeed': 9.33} on your route



Seems like a great day to be transporting!

The weather at New York County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 44.6, 'windDirection': 359, 'windSpeed': 3.36} on your route

The weather at Hunterdon County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 39.85, 'windDirection': 337.47, 'windSpeed': 7.24} on your route

The weather at Berks County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 38.92, 'windDirection': 348.47, 'windSpeed': 5.92} on your route

The weather at Cumberland County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 38.64, 'windDirection': 10.73, 'windSpeed': 5.75} on your route

The weather at Bedford County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 35.99, 'windDirection': 338.98, 'windSpeed': 5.27} on your route

The weather at Westmoreland County will have {'precipitationIntensity': 0, 'precipitationProbability': 0, 'precipitationType': 0, 'temperature': 31.81, 'windDirection': 50.13, 'windSpeed': 4.6} on your route

And as an added bonus...

Our entire UI was created using **only** CMU Graphics