Flight Delay Analysis (Unsupervised Leaning)

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Defining the Problem

- Focusing on Kansas City (MCI)
- Targeting management at Southwest Airlines
- Conditions that lead to severe delays
- Most/least reliable groups of flights offered
- Benchmarking performance

Data Description

- U.S. Department of Transportation (retrieved from Kaggle.com)
- 2015 flight data from “large US carriers”
- Collected by U.S. Department of Transportation
- 5.8 million records (subset to 77,320 – MCI Flights)
- 33 total feature columns: schedule departure time (of day), taxi time, month, etc.
- Appended Latitude/Longitude Data

Model Choice

- Looking to explore interactions that lead to longer delays
- Expect time of year & time of day to have strong effects
- information can help them to schedule flights more strategically to avoid delays
- inform certain departure/arrival cities to target/avoid, flight time of day, flight time of year, regions to avoid, and an combination of these (and other) feature columns
- show competitor airlines that are performing better/worse in certain conditions

Analysis Methods

Analysis: EDA

- 53.6 percent of MCI flights on Southwest
- Highest travel month in July (10.3 percent)
- Saturday is lowest travel day (11 percent)
- Flight distance range of 152-1499 miles - median 643 miles

Figure 2.1 – Flights by Day of Week

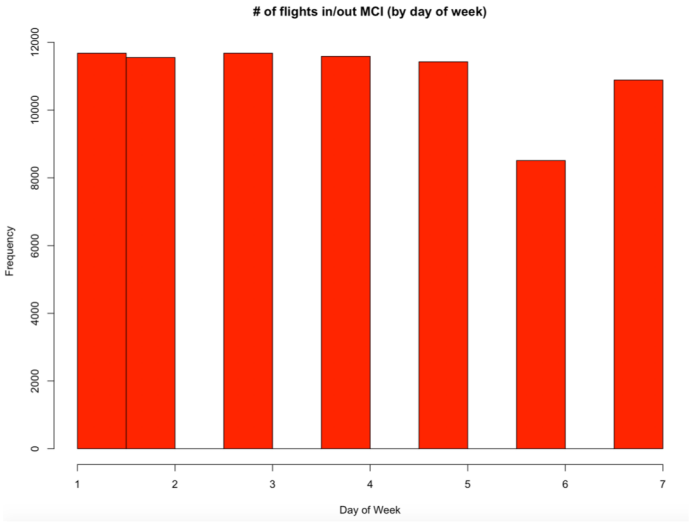
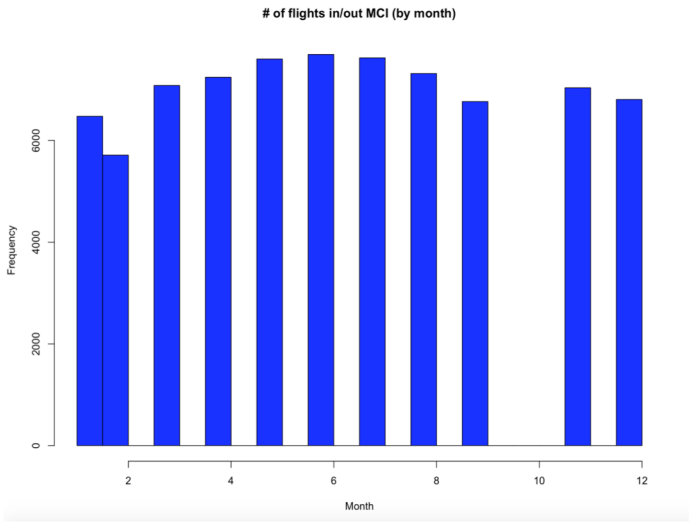


Figure 2.2 – Flights by Month



Analysis: Correspondence Analysis

- Binned continuous variables
- Ran Chi-squared significance test

Figure 3.1 – Delays by Airline

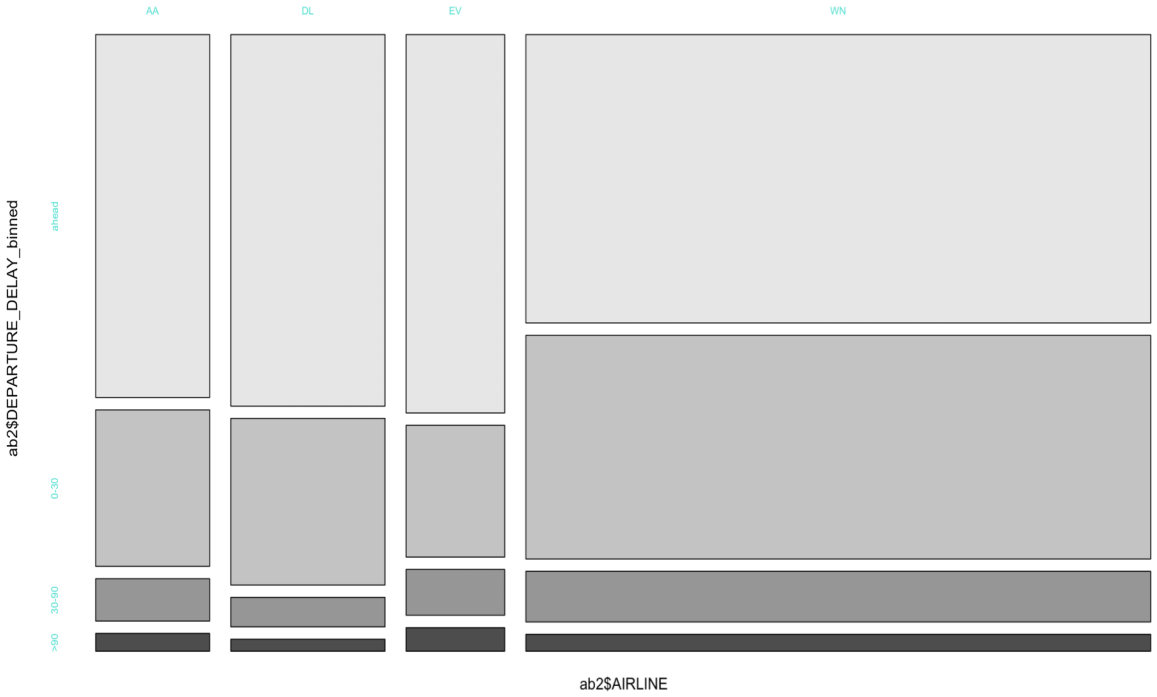
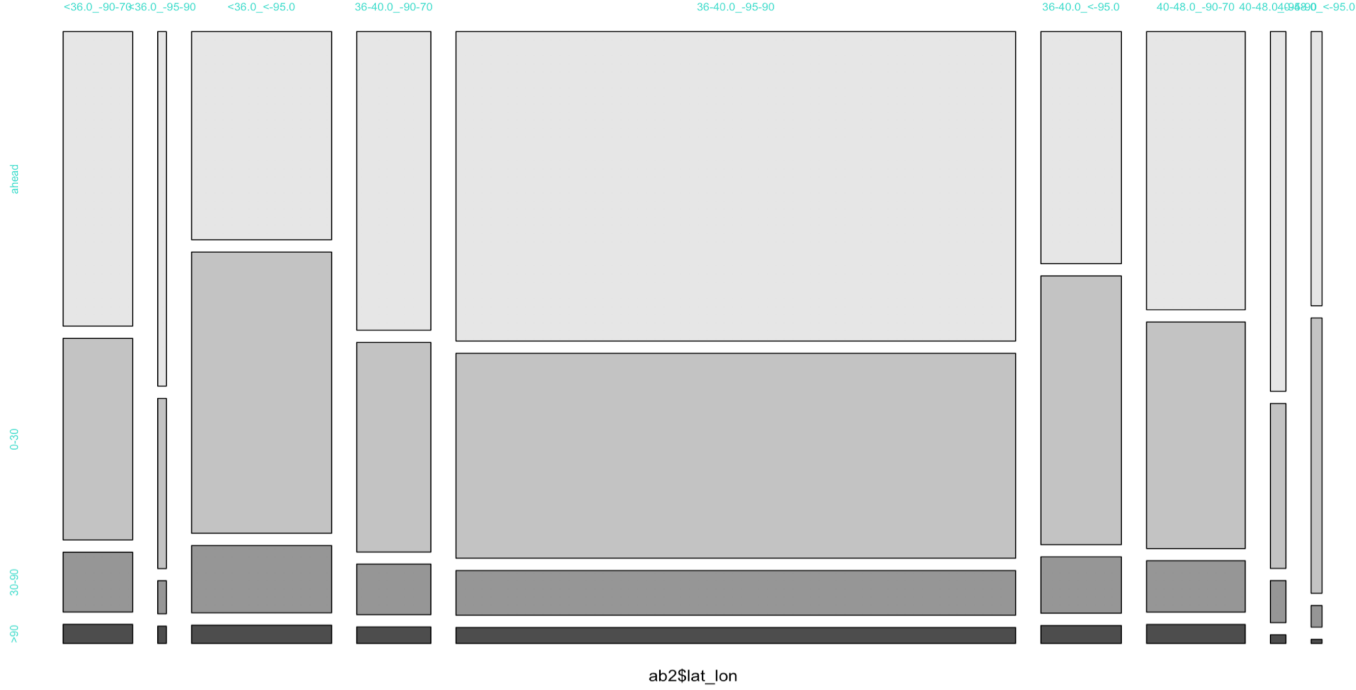


Figure 3.2 – Delays by Latitude/Longitude



Findings: Correspondence Analysis

- top 4 airlines account for 84.8% of all flights
- EV (skywest) - serves as a regional connector for American, Delta, United, and Alaskan airline
- Southwest Airlines have more intermediate delays in the southwest United States (Lat/Lon)
- 2.9 percent of Southwest flights had “severe” delays…90minuted> (Delta had just 2.1 percent)

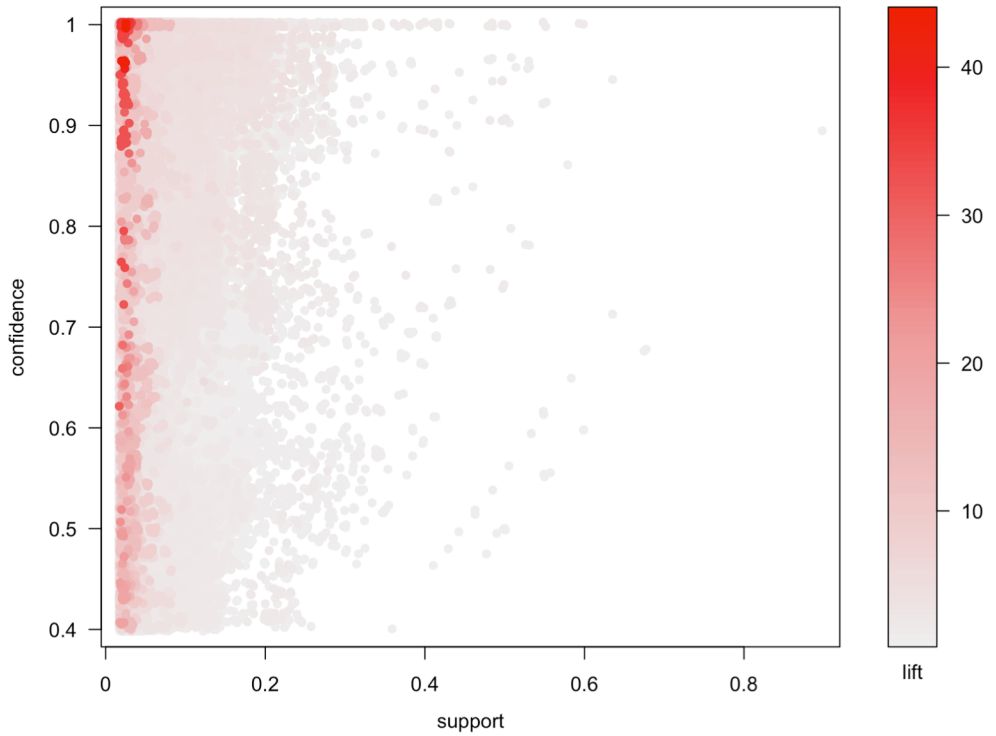
Analysis: Association Rules

- Transformed Dataset
- Initial set contained 241,489 rules (figure 4.1)
- tested several values for lift, support, and confidence. There was a tradeoff for finding rules that had a large enough sample size to be generalizable and rules that gave us high lift (odds ratios)
- Set optimal parameters: apriori(seg.trans, parameter=list(support=0.02, conf=0.4,target="rules",maxlen=4))
- Looked at effects Lat/Lon on weather delays, day of the week, and causes of long delays (10+ minutes – example below)

```
weather_rules <- apriori(sw_flights_trans, parameter = list(support =
                                0.0002, confidence = 0.20, maxlen=4), appearance=list(lhs=c("WEATHER_DELAY_binned=10+")))


weather_rules_partial <- subset(weather_rules, items %pin% "LON" |items %pin% "LAT")
inspect(sort(weather_rules_partial[1:15], by = c("lift","count", "confidence")))
```

Figure 4.1 Scatter plot for 241489 rules



Findings: Association Rules - Findings

- 13 percent more likely to be delayed 30-90 minutes on Thursday
- longer flights (1.16 lift) 2-3 hours on Saturdays
- 5.7x more likely to be on a delayed flight between 12p-9a
- South and West US more likely to get delayed for weather

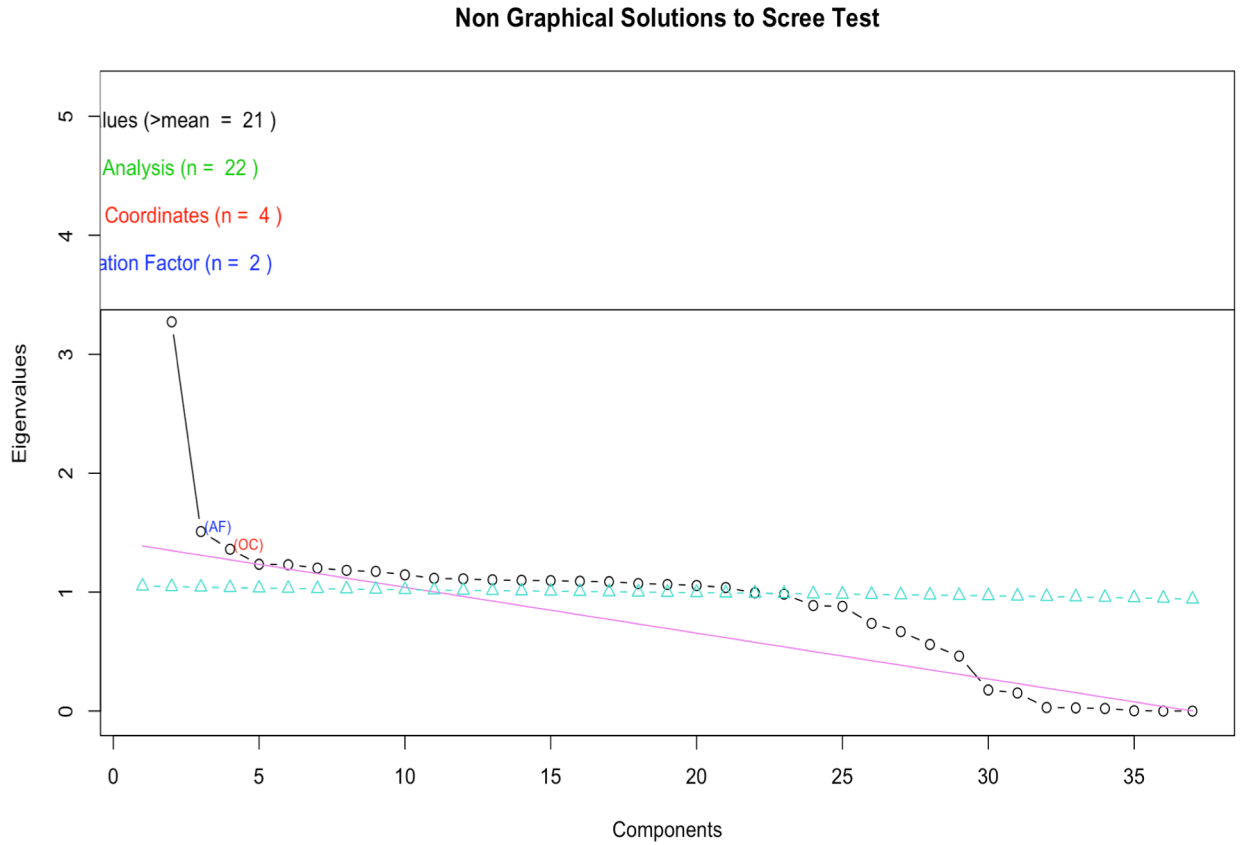
Analysis: Factor Analysis

- One-hot encoded & scaled (z-score) data
- Top 3 eigenvalues – 5.2, 3.3, 1.5

Factor Loadings

	MR1	MR2	MR3	MR4
SS loadings	5.08	3.17	0.79	0.74
Proportion Var	0.14	0.09	0.02	0.02
Cumulative Var	0.14	0.22	0.24	0.26
Proportion Explained	0.52	0.32	0.08	0.08
Cumulative Proportion	0.52	0.84	0.92	1.00

- Chose 4 factors:
  - MR1 - "timing_vs_scheduled"
  - MR2 -"time_in_air_lat/lon"
  - MR3 - "delays_taxi_time"
  - MR4 - "factor_4"



Analysis: Regression using 4 ”Factors”

- Dependent – ’departure_delay’ (continuous)
- ‘scheduled_vs_actual_timing’ had the highest positive weight (increases the delay the most)
- All factors ‘statistically significant’
- $R^2 = 0.17$

```
> summary(southwest_flights_fa.final$southwest_flights_fa_dependent)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-15.00   -3.00    0.00   10.15   10.00  495.00
```

```
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               10.16218    0.13871  73.263  < 2e-16 ***
scheduled_v_actual_timing  7.07116    0.13860  51.020  < 2e-16 ***
time_in_air_and_latlon     0.75872    0.13801   5.498 3.87e-08 ***
delays_and_taxi_time      -0.42638    0.02155 -19.783  < 2e-16 ***
MR4                      -11.11660    0.14575 -76.272  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 28.12 on 41106 degrees of freedom
Multiple R-squared:  0.1716,    Adjusted R-squared:  0.1715
F-statistic:  2129 on 4 and 41106 DF,  p-value: < 2.2e-16
```

Conclusion: Key Findings

- Delta has less “severe” delays (0.8% less)
- South & West US more prone to delays
- More likely to have long delayed (30-90 minutes) on Thursday
- 5.7x more likely to be on a delayed flight between 12a-9a

Recommendations

- Management should analyze Delta's staffing/policies
- Increase staff scheduled on Thursdays
- Look to areas other then the Southwest for expansion

Limitations & Future State

- Granularity of cause of missed flight
- Pricing Data
- Additional Cities
- Interconnection of flights w/Network Analysis – (i.e. weather in a previous city)
- New Data (2018+)