



# Increasing Profitability

Airline Carriers



# Stakeholders: Airline Carriers

## Profitability

Revenue - Costs



DELTA

Alaska  
AIRLINES

SINGAPORE  
AIRLINES



UNITED



*How to increase  
revenue?*

**spirit**



中国南方航空  
CHINA SOUTHERN



RYANAIR

Emirates



Lufthansa

*How to decrease  
costs?*

BRITISH AIRWAYS



AIRFRANCE



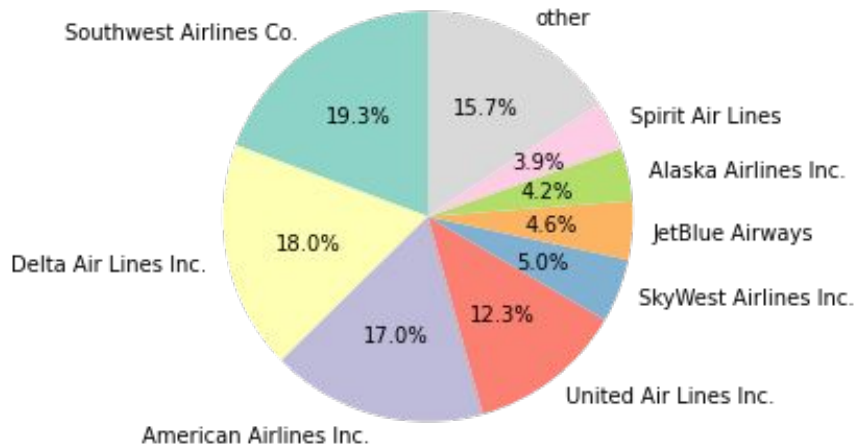
Southwest

American Airlines

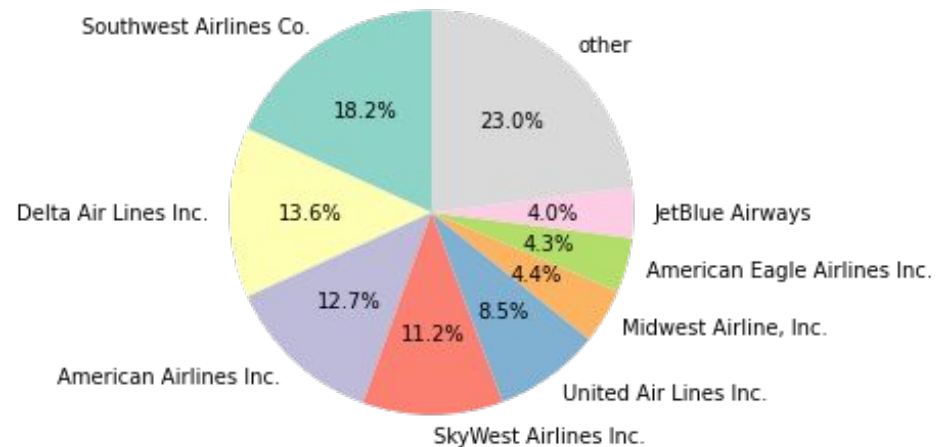


# Market Share

Distribution of Passengers Among Different Airline Carriers



Distribution of Flights Among Different Airline Carriers



# Data Set & Motivation

2019 Flights Delays - 6,489,062 rows (slimmed to 1,489,062)

Airports, Airlines, Plane Size and Weather

## Strategy

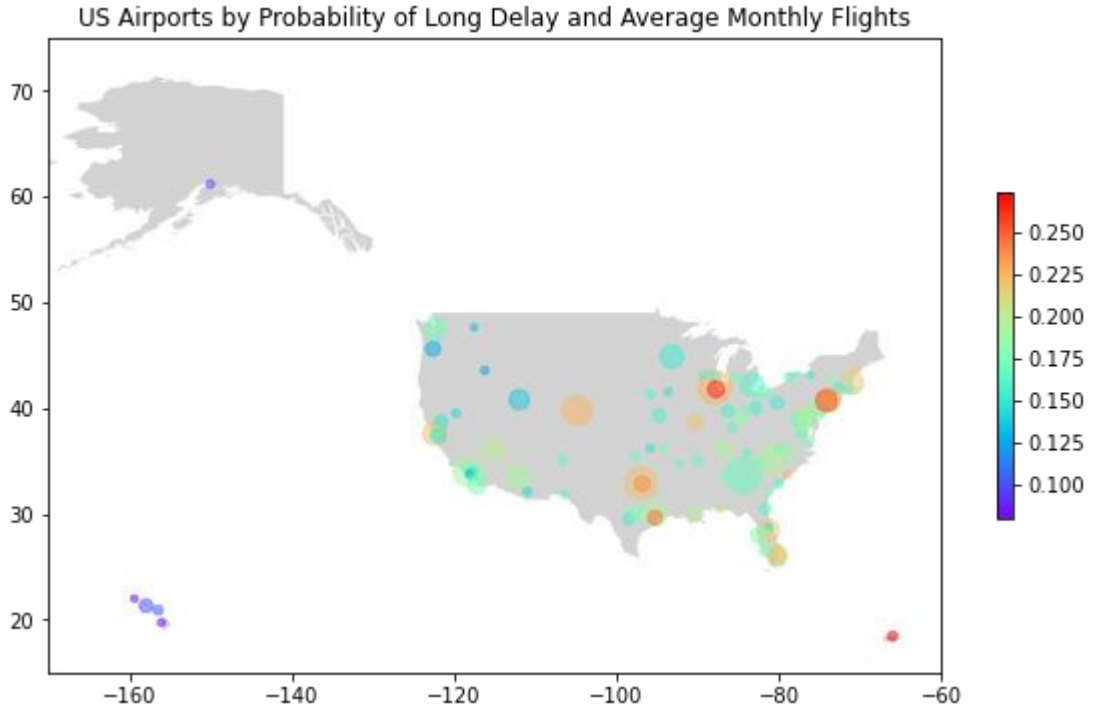
 Delays =  Reputation, Loyalty, Market Share =  Revenue

 Delays =  Rescheduling, Vouchers =  Costs

# United States Airports

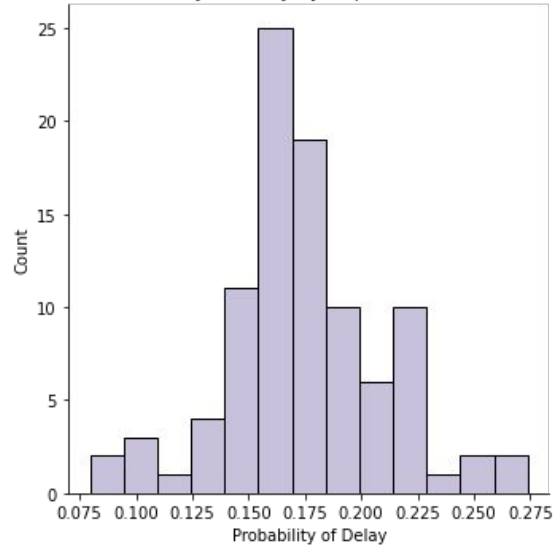
## Exploratory Data Analysis

*Do airports have different probabilities of delayed flights?*

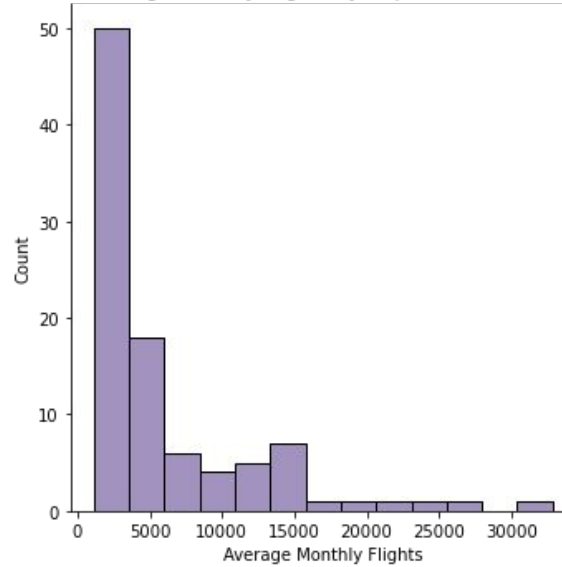


# Distributions

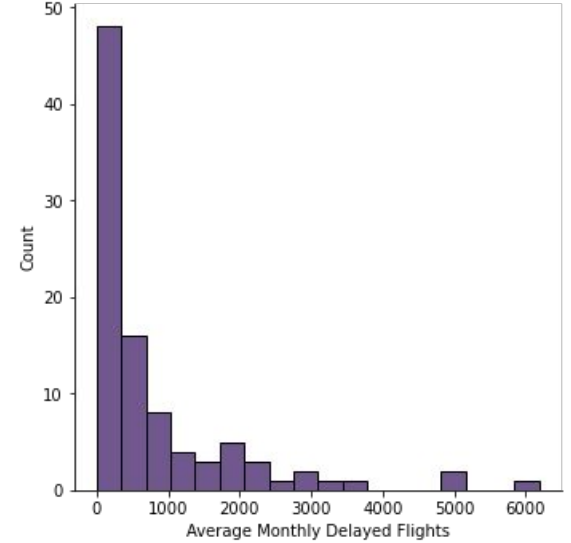
Probability of Delay by Airport Distribution



Average Monthly Flights by Airport Distribution

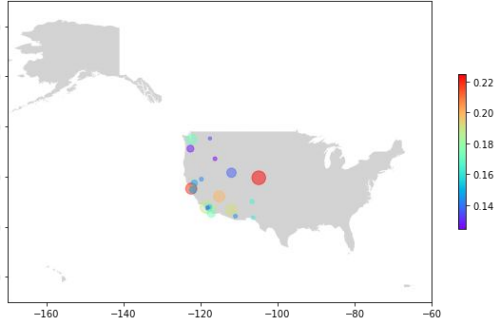


Average Monthly Delayed Flights by Airport Distribution

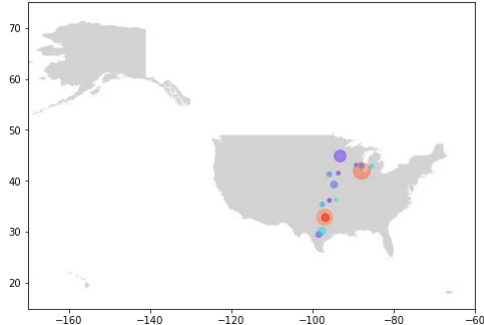


# Regions

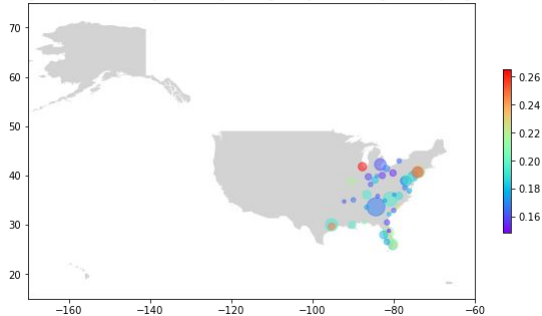
Region 1: US Airports by Probability of Long Delay and Average Monthly Flights



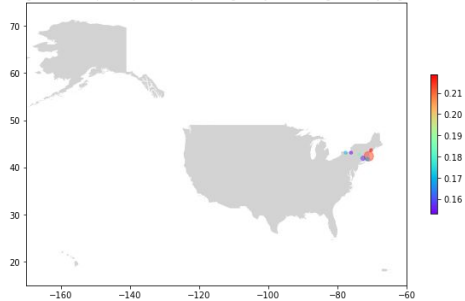
Region 3: US Airports by Probability of Long Delay and Average Monthly Flights



Region 2: US Airports by Probability of Long Delay and Average Monthly Flights



Region 5: US Airports by Probability of Long Delay and Average Monthly Flights



Region 4: US Airports by Probability of Long Delay and Average Monthly Flights



Region 6: US Airports by Probability of Long Delay and Average Monthly Flights



Region 7: US Airports by Probability of Long Delay and Average Monthly Flights

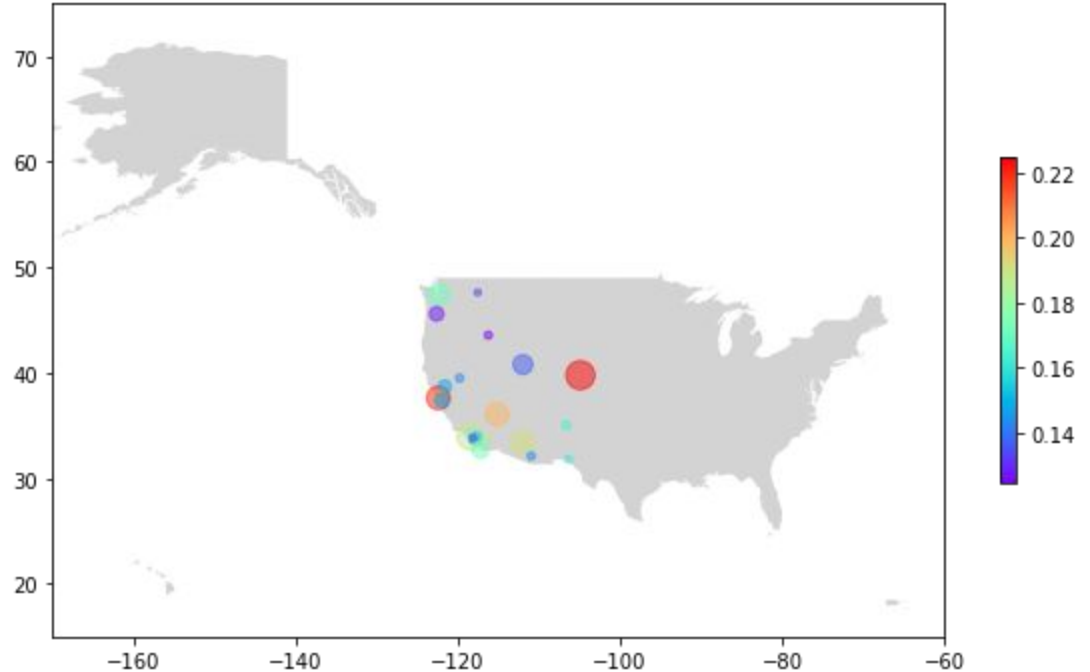


# Best Region

Average probability of  
delay:16.53%

Average Monthly  
Flights:6,483

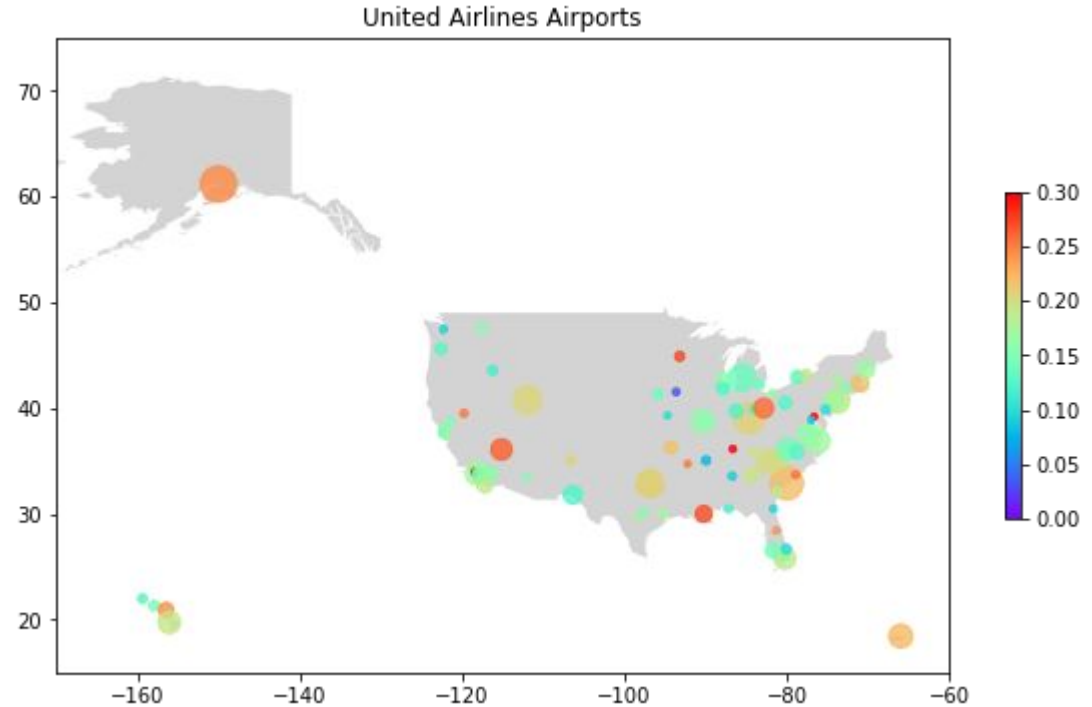
Region 1: US Airports by Probability of Long Delay and Average Monthly Flights





# Case Study

*How to decrease the number of delayed flights for United Airlines by airport selection?*



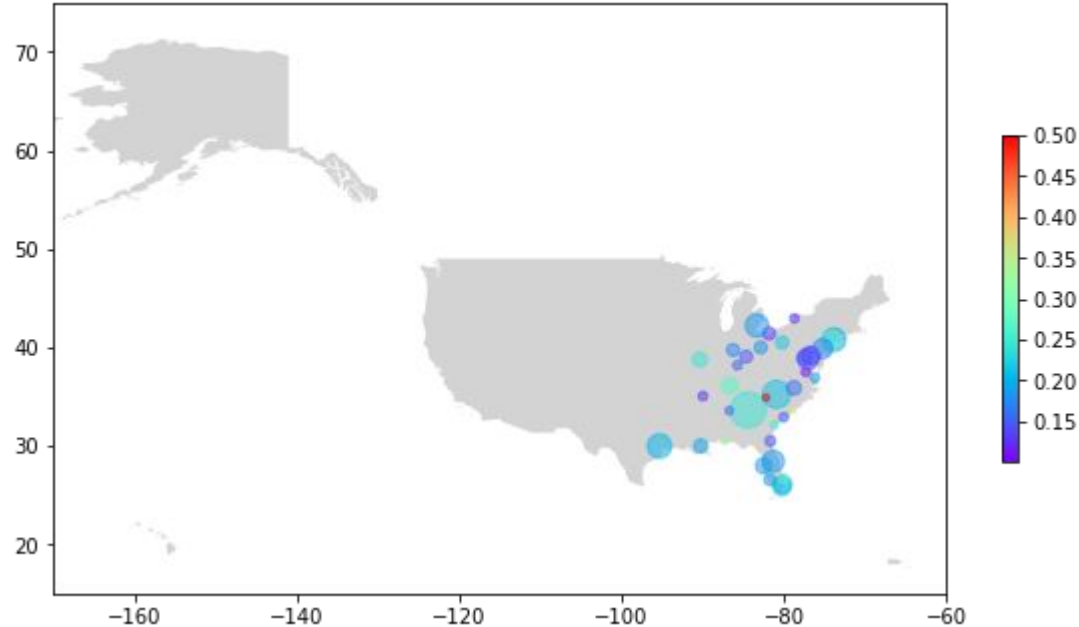
# Worst Performing Region

Average Probability of delay:  
20.0%

+1.4% Average

*How to lower probability of delays?*

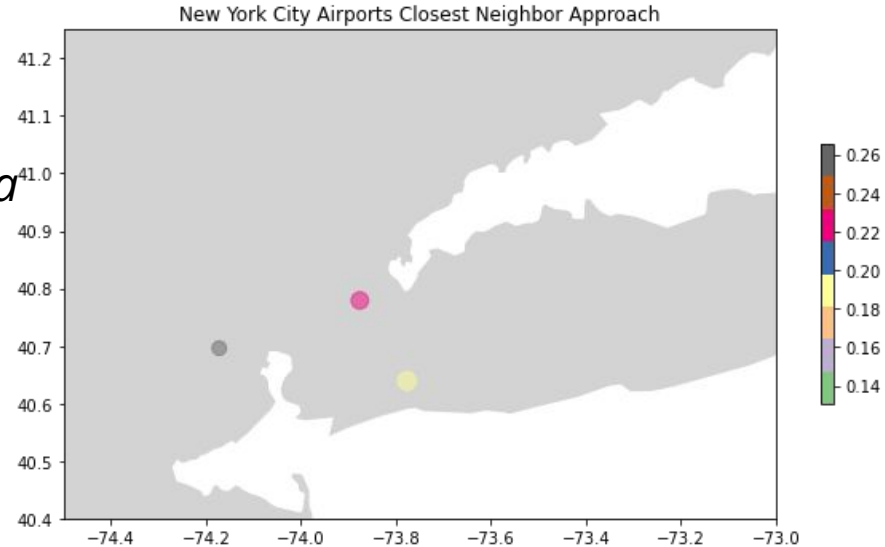
Region 2: US Airports by Probability of Long Delay and Average Monthly Flights



# Closest Neighbor Approach

## NYC area airports

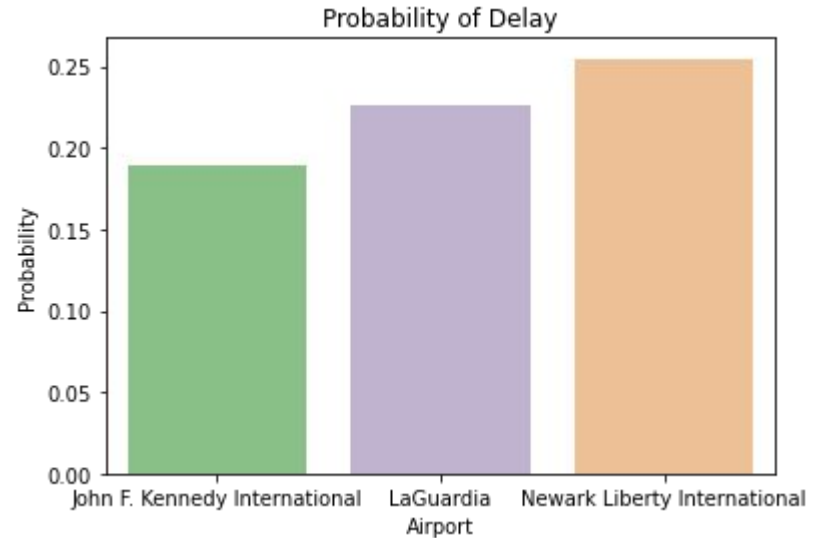
*For flights with the same destination, funnel a higher proportion of flights to the airport with a lower probability of delay.*



# Differences Between Closest Neighbor

*Consumers will attribute lower delays with the airline, not the airport*

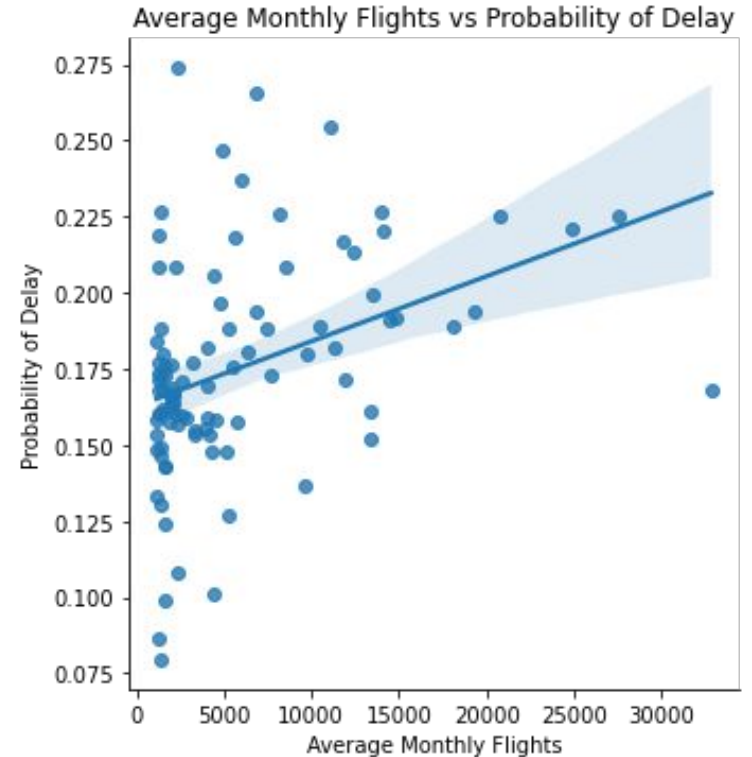
↑ **Reputation, Loyalty, Revenue**



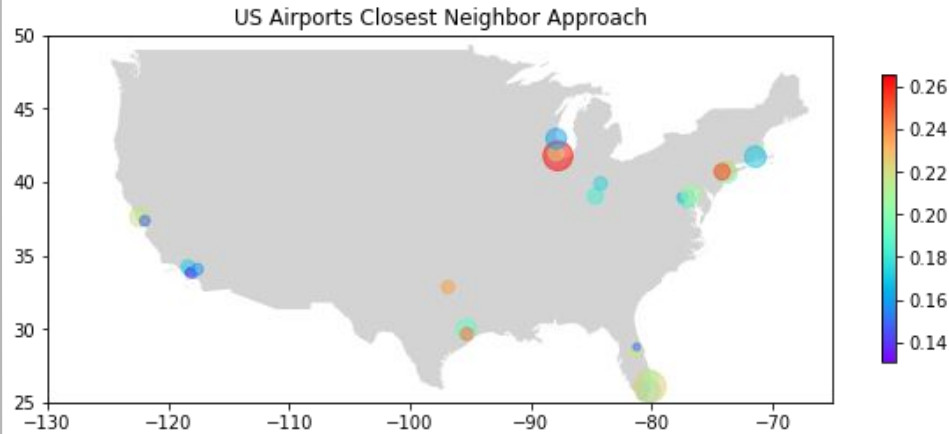
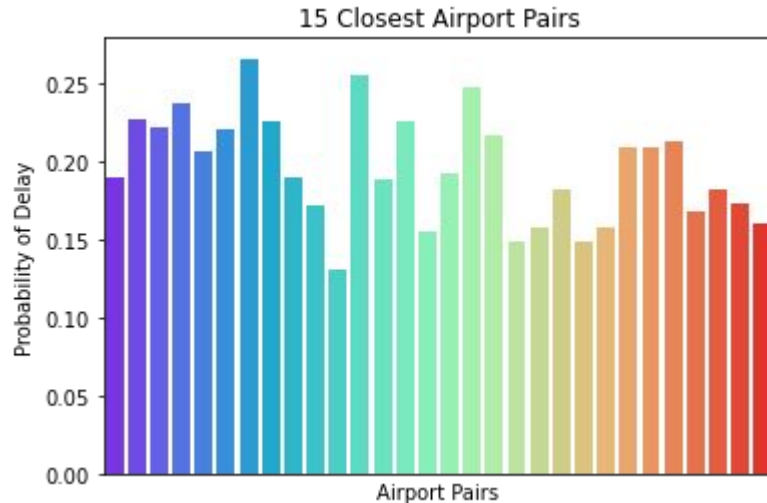
# Correlation: Delays & Flights

*Will increasing the number of flights of an airport increase the probability of delay?*

***Target smaller airports***



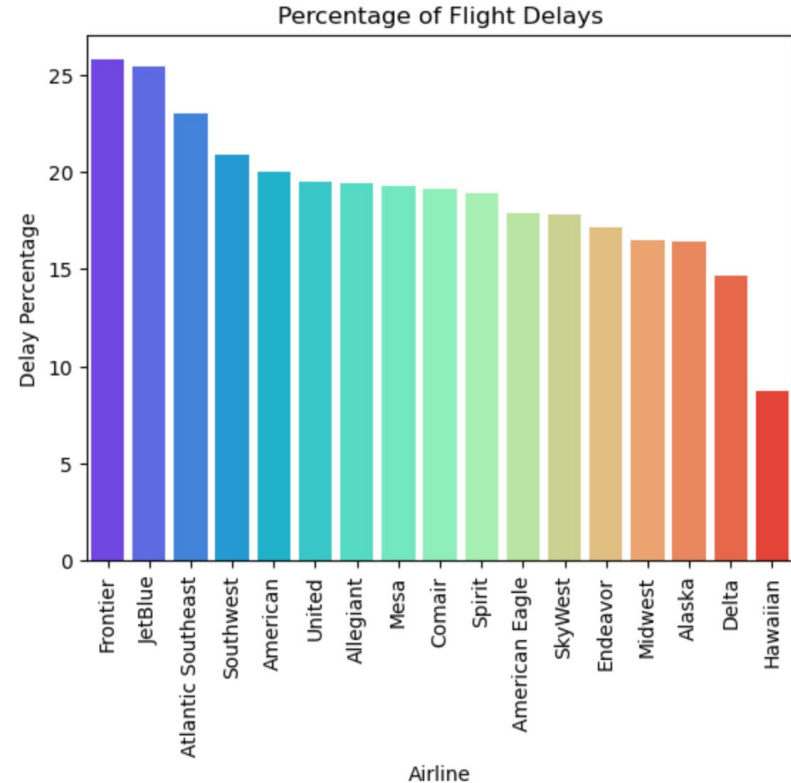
# Closest Neighbor Approach-30 airports



# United States Airlines

## Exploratory Data Analysis

*Which airlines have the most delays and what are their commonalities?*



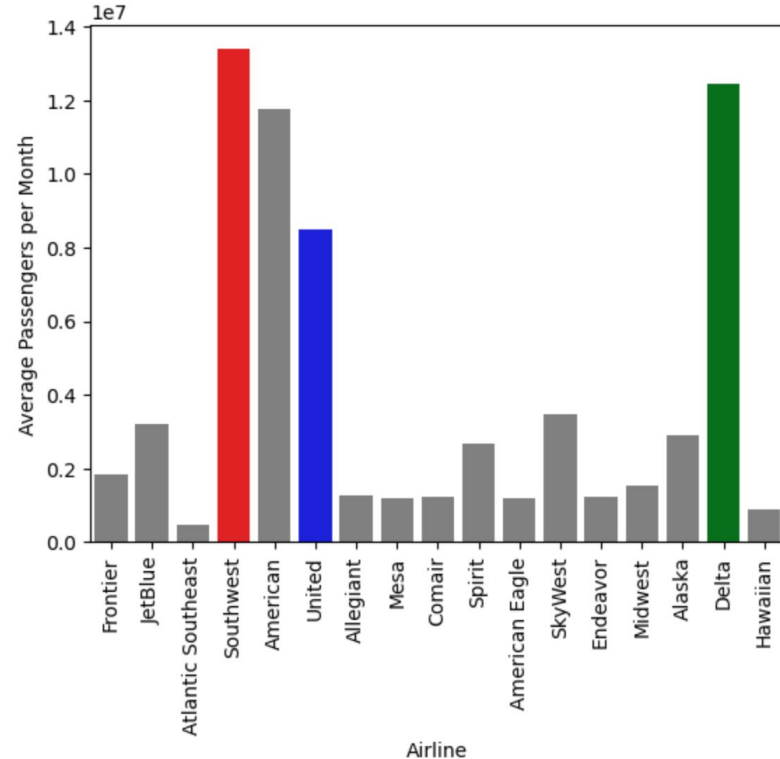
# Case Study - Setting Benchmarks

Comparing profit generating variable,  
passengers:

- United: 8,501,631
- Southwest: 13,382,999
- Delta: 12,460,183

Performance:

- -4,881,368 less than Southwest
- -3,958,552 less than Delta





# Case Study - Delays

Delay Percentages:

Maximum: 25.75%

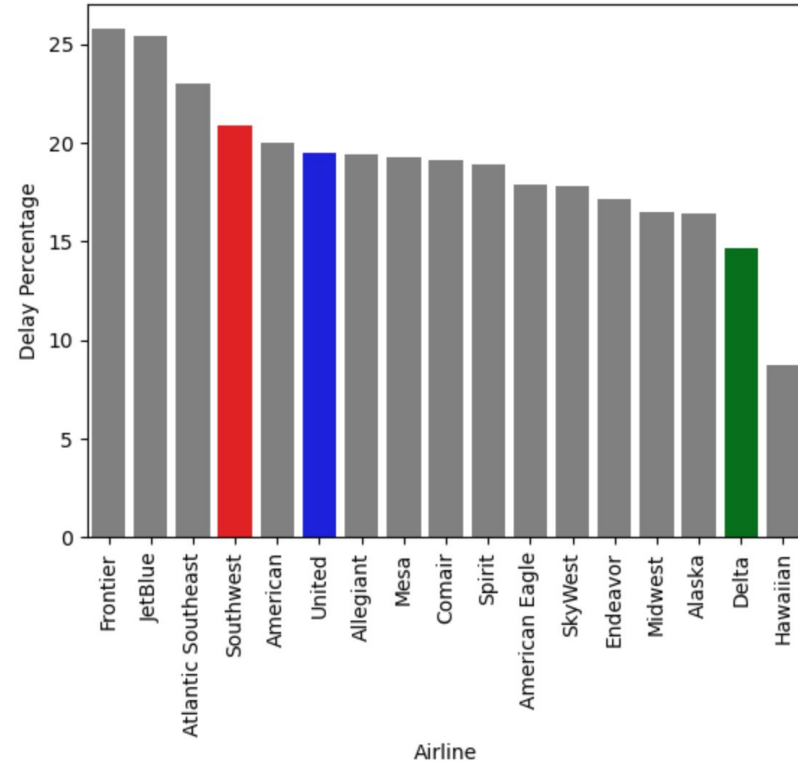
United: 19.46%

Southwest: 20.88%

Delta: 14.67%

Performance:

- -6.29% on upper bound
- +4.79% on lower bound



# Case Study - Operation Variables

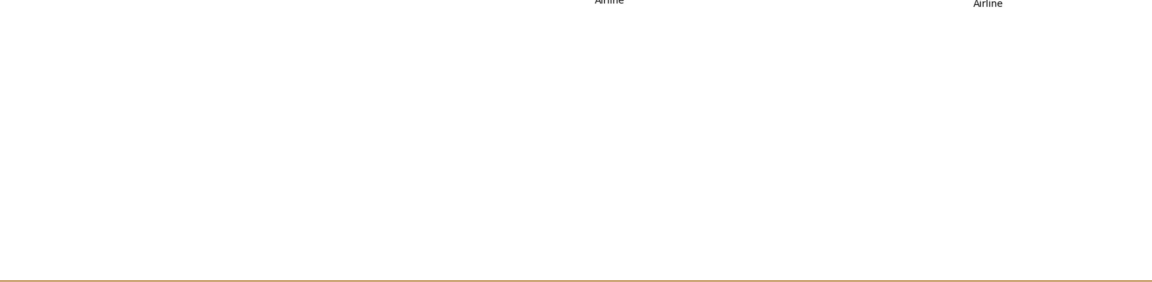
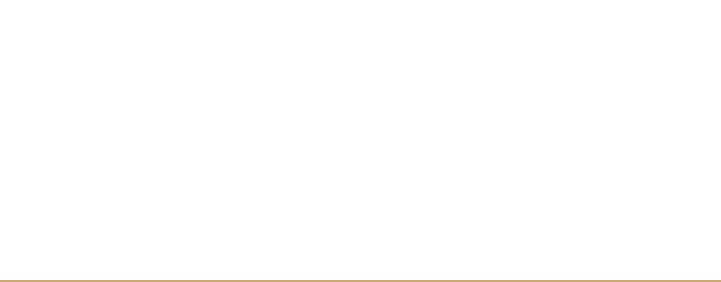
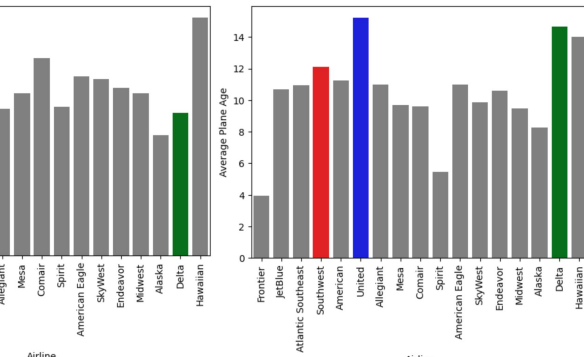
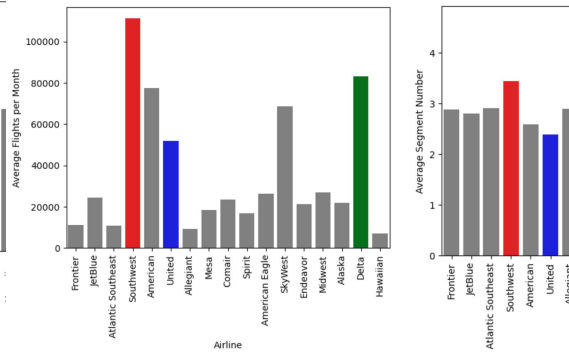
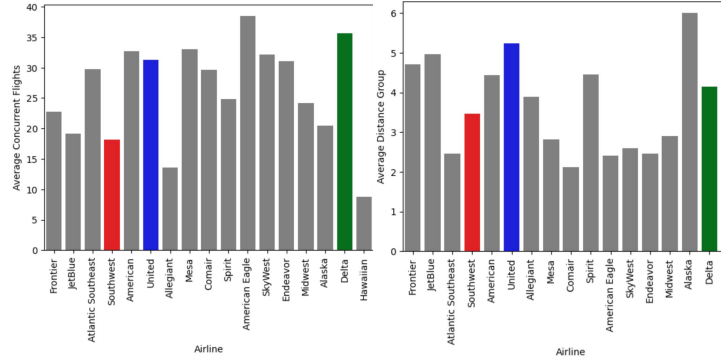
Concurrent Flights

Distance Group

Flights Per Month

Segment Number

Plane Age



# Case Study - Operation Variable of Interest

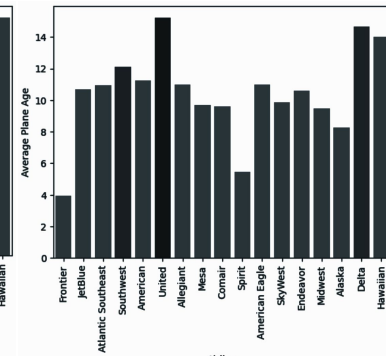
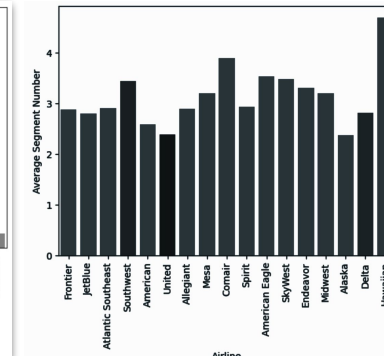
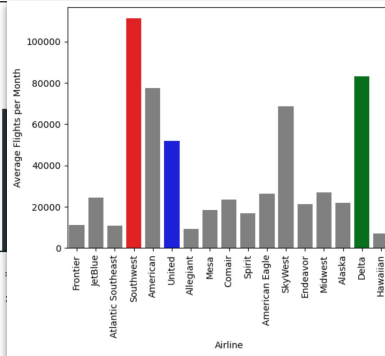
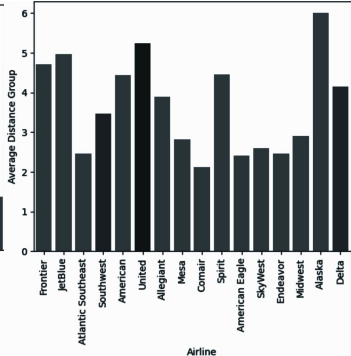
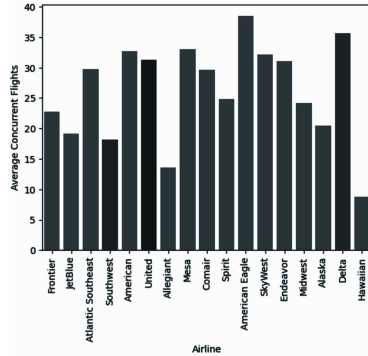
Concurrent Flights

Distance Group

**Flights Per Month**

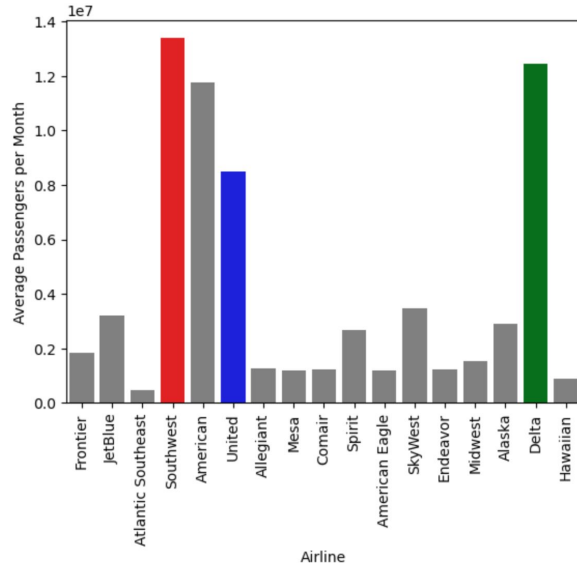
Segment Number

Plane Age

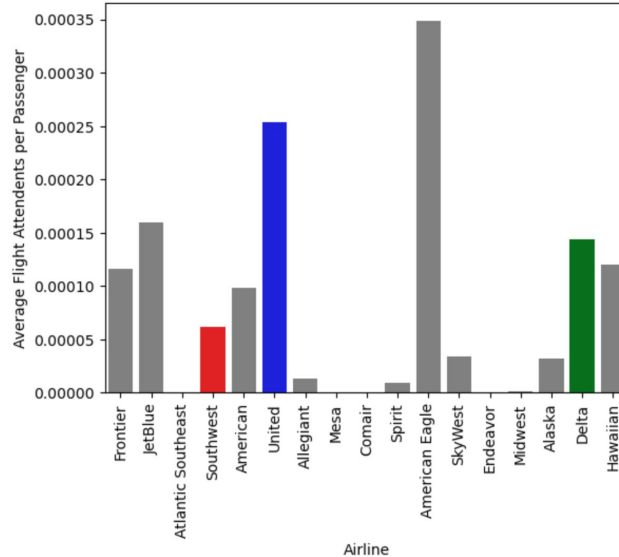


# Case Study - Human Resources Variables

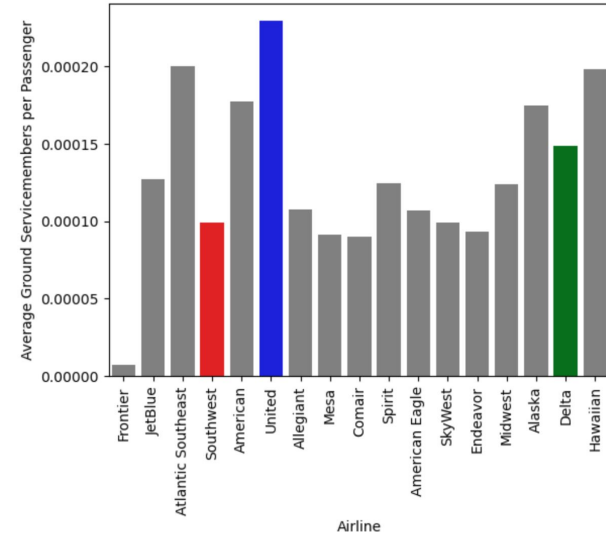
Passengers per Month



Flight Attendants per Passenger

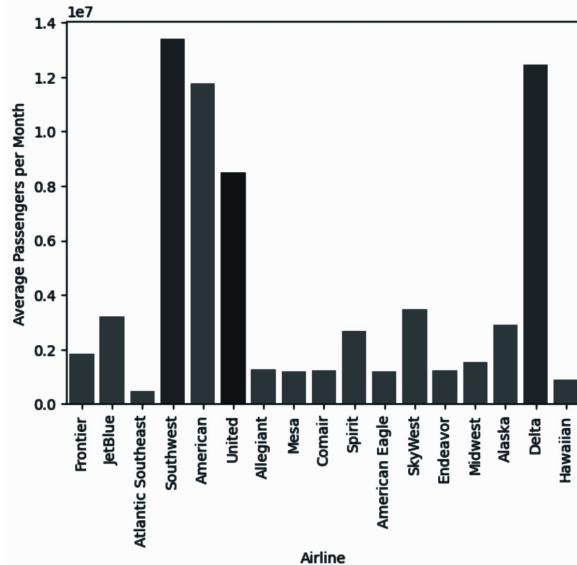


Ground Crew per Passenger

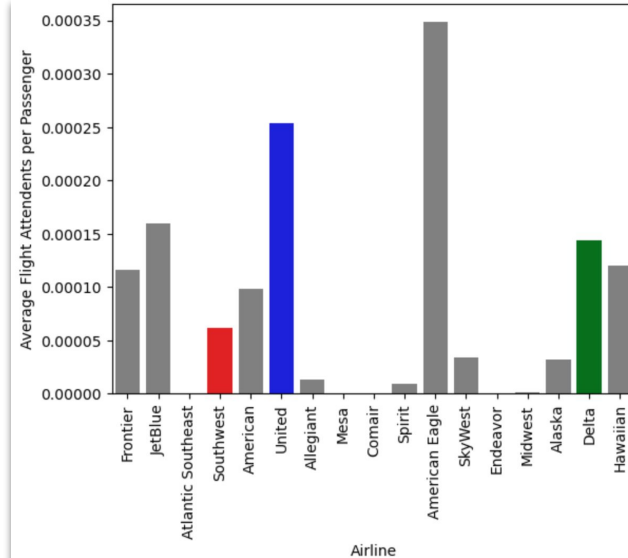


# Case Study - Human Resources VOI

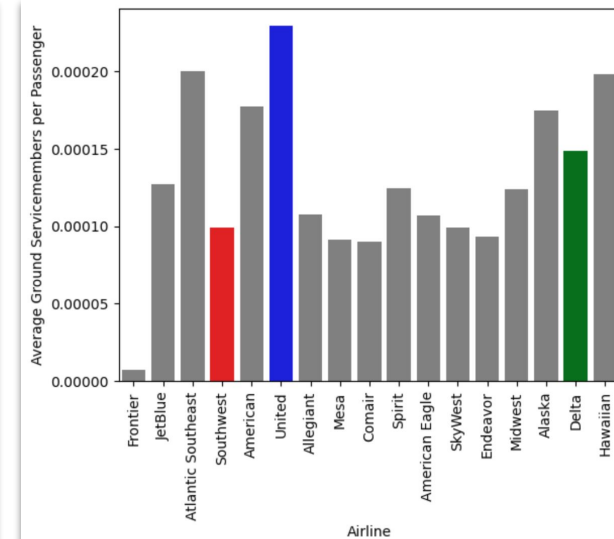
Passengers per Month



Flight Attendants per Passenger



Ground Crew per Passenger



# Case Study - Flight Attendants per Passenger

United:  $\sim 2.54e-4$

Southwest:  $\sim 6.2e-5$

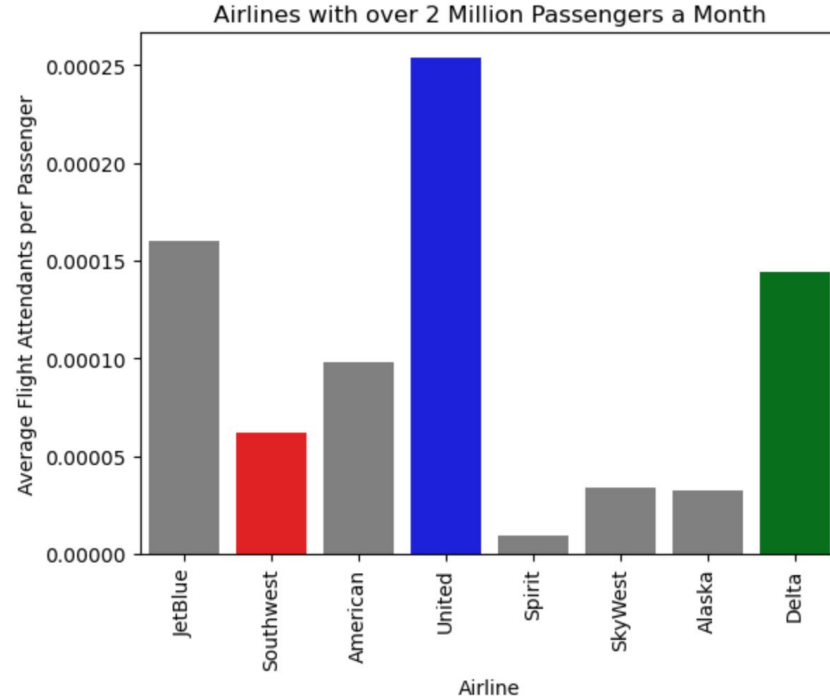
Delta:  $\sim 1.44e-4$

Average:  $\sim 8.2e-5$

Average, similar airlines:  $\sim 9.9e-5$

United is employing far more flight attendants than all of its competitors, with no discernible difference in delay time

Recommendation: United should slim down its flight attendant crews



# Case Study - Ground Crew per Passenger

United:  $2.29 \times 10^{-4}$

Southwest:  $\sim 9.9 \times 10^{-5}$

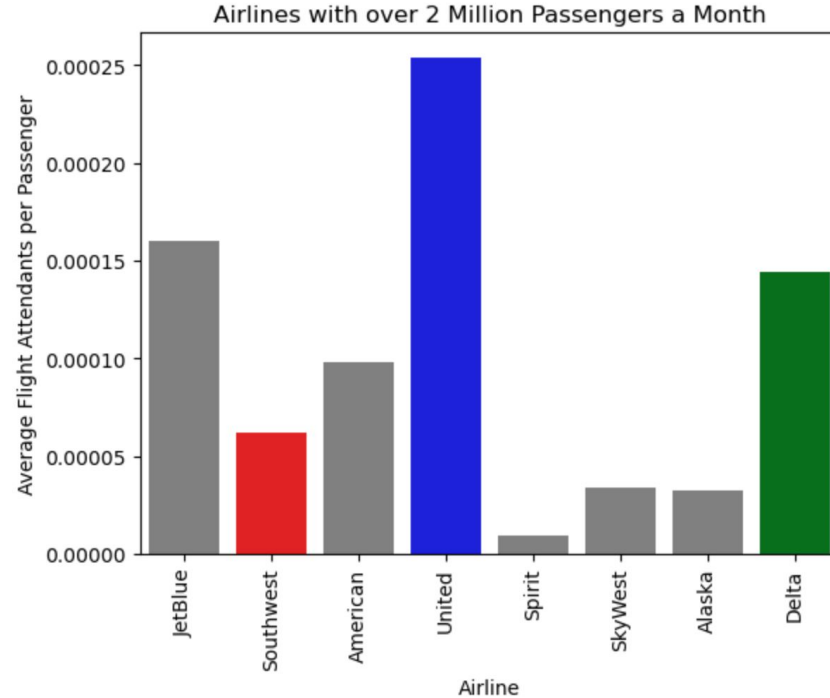
Delta:  $1.49 \times 10^{-4}$

Average:  $\sim 1.29 \times 10^{-4}$

Average, similar airlines:  $\sim 1.5 \times 10^{-4}$

Again, United is employing far more ground crew than all of its competitors, with no discernible difference in delay time

Recommendation: United should slim down its ground crews



# Case Study - Flights per Month

United: ~51,977 w/ 8,501,631 pass. (163.6 per)

Southwest: ~111,171 w/ 13,382,999 pass. (120.4 per)

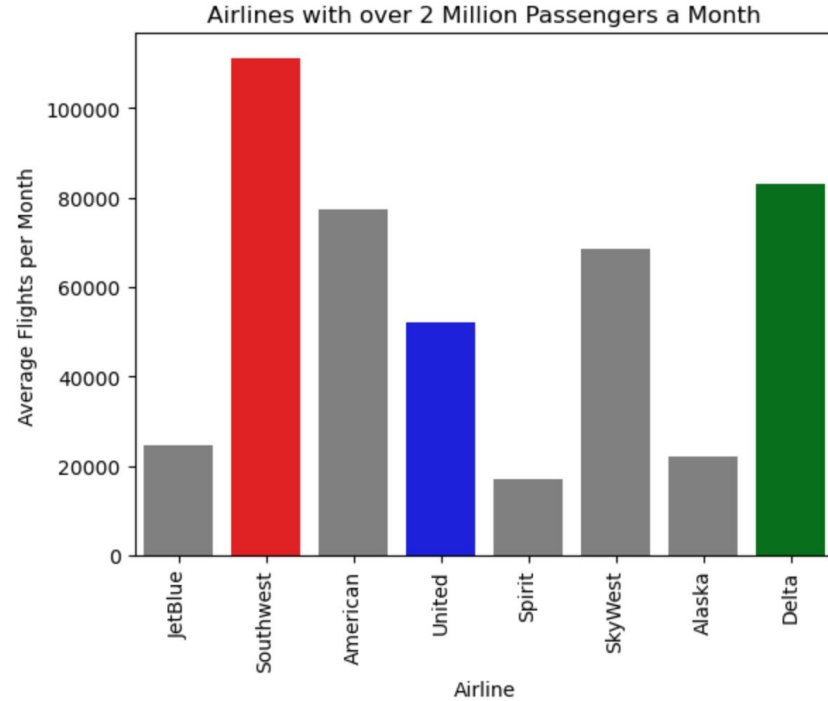
Delta: ~83,069 w/ 12,460,183 pass. (150.0 per)

Average: ~35,906 w/ 4,070,878 pass. (113.4 per)

Average, similar airlines: ~56,936 w/ 7,290,721 pass. (128.1 per)

United is operating far fewer flights than its competitors, operating with 13.6 more people per flight than delta, and 35.5 more people than similar airlines

Recommendation: United needs to start decreasing the number of people per flight by increasing the number of flights offered, or changing plane size



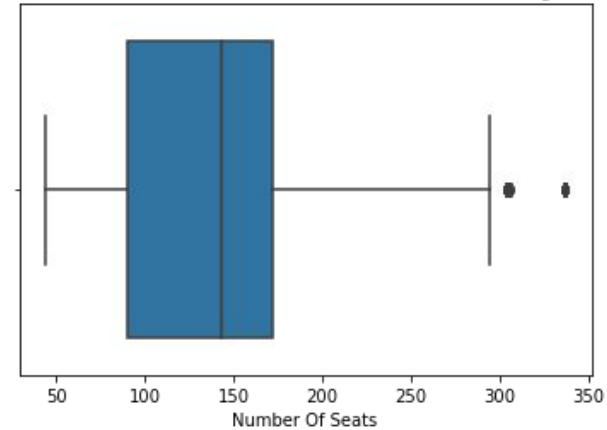


# Airplanes

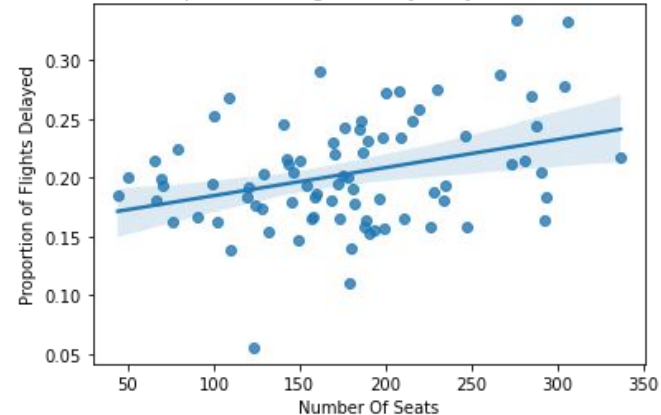
## Exploratory Data Analysis

*Does the size of the airplane affect how likely it is to be delayed?*

Distribution Of The Number Of Seats Across All Flights



Proportion Of Flights Delayed By Plane Size



# Airplanes

## Categorizing Plane Size

Small

$43 < \text{Number Of Seats} \leq 124$

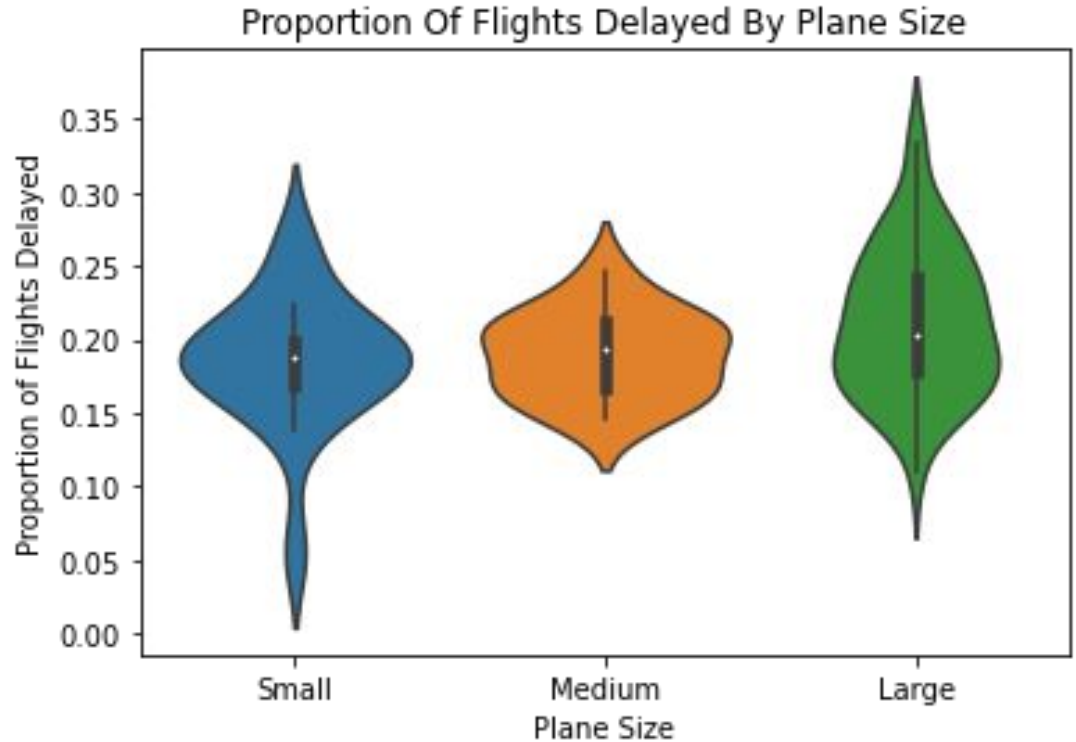
Medium

$124 < \text{Number Of Seats} \leq 158$

Large

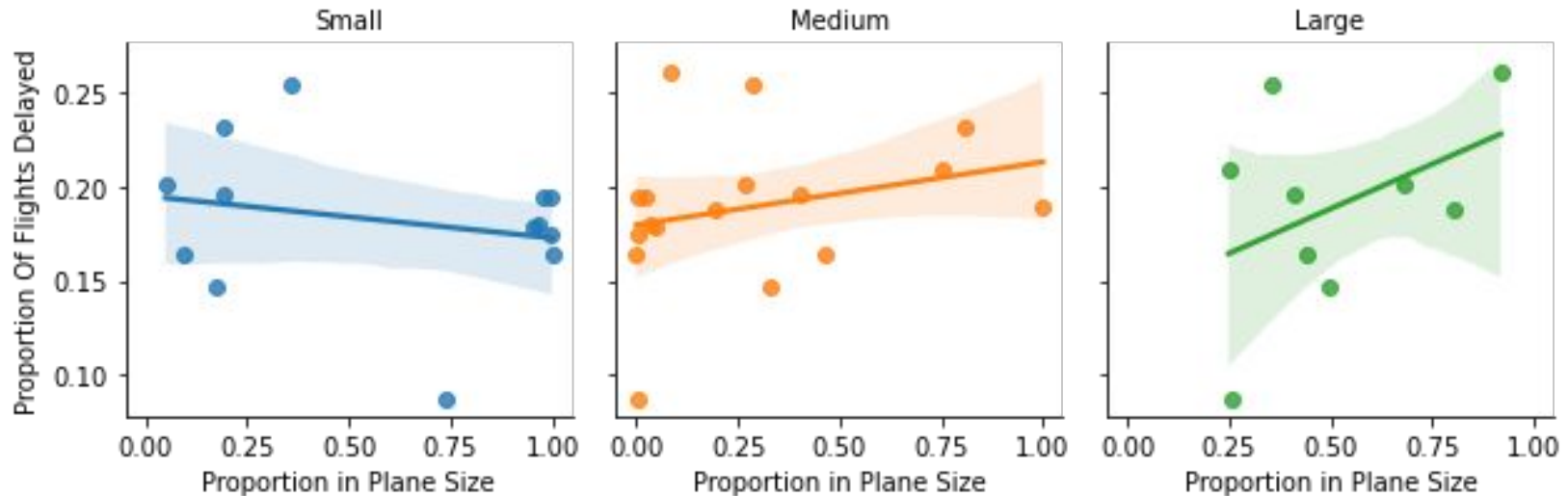
$158 < \text{Number Of Seats} \leq 337$

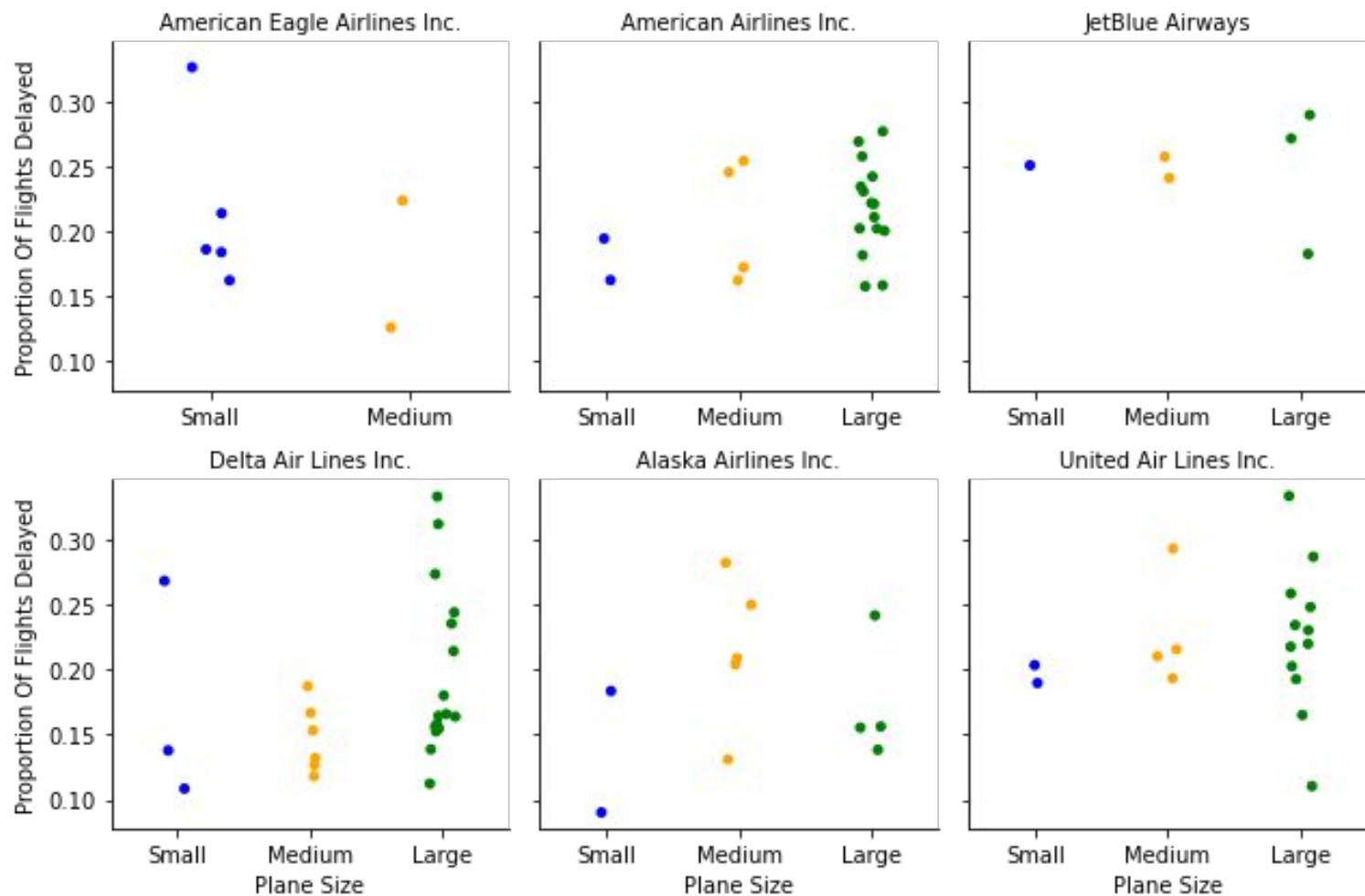
~ Same # of Flights in Each Category



# Varying By Carrier

Different plane layouts and boarding procedures likely lead to differences in performance for the same plane size





# Plane Size Options

*Does having more plane sizes lead to less delays overall?*

Delta Air Lines Inc.	25
American Airlines Inc.	21
United Air Lines Inc.	18
Alaska Airlines Inc.	11
American Eagle Airlines Inc.	7
JetBlue Airways	6
SkyWest Airlines Inc.	6
Mesa Airlines Inc.	6
Midwest Airline, Inc.	5
Endeavor Air Inc.	5
Comair Inc.	5
Hawaiian Airlines Inc.	5
Spirit Air Lines	5
Atlantic Southeast Airlines	4
Southwest Airlines Co.	4
Frontier Airlines Inc.	4
Allegiant Air	2

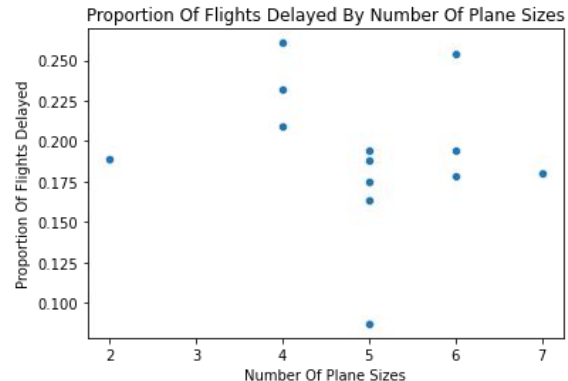
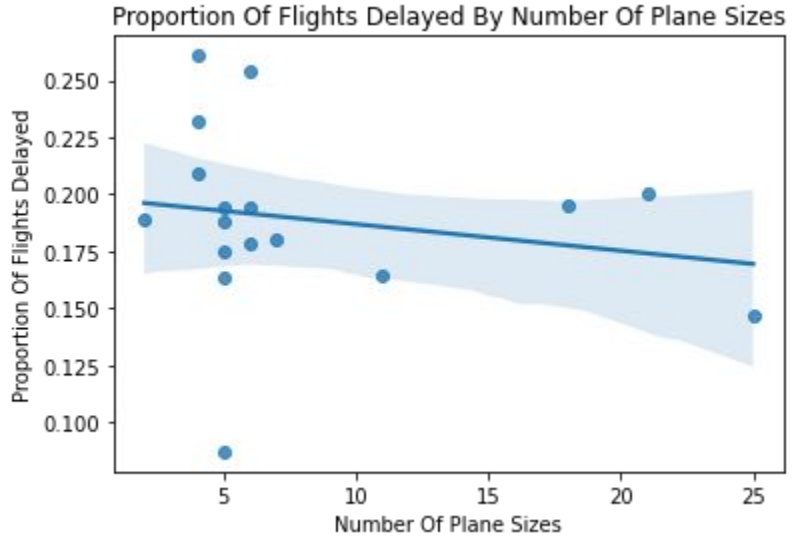
# Plane Size Options

*Does having more plane sizes lead to less delays overall?*

Correlation is very low

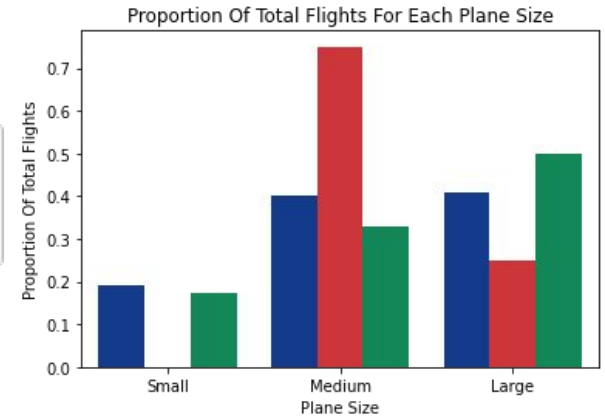
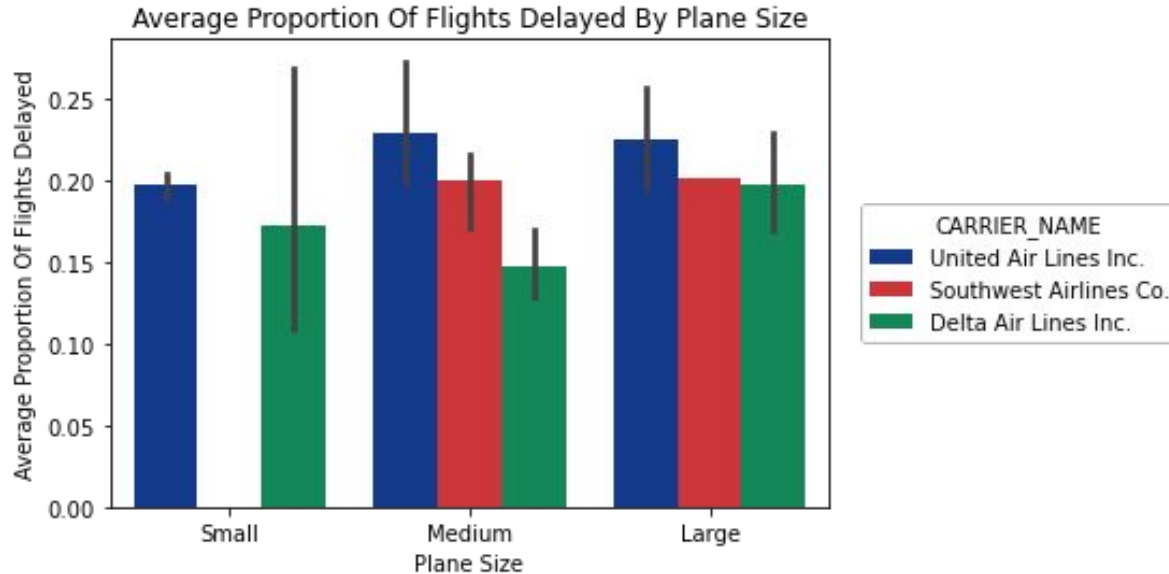
$$r^2 = 0.037269$$

No significant trend when outliers removed



# Focusing On United

*What airplanes should United Airlines purchase to decrease future delays?*



# 4th EDA: United and weather

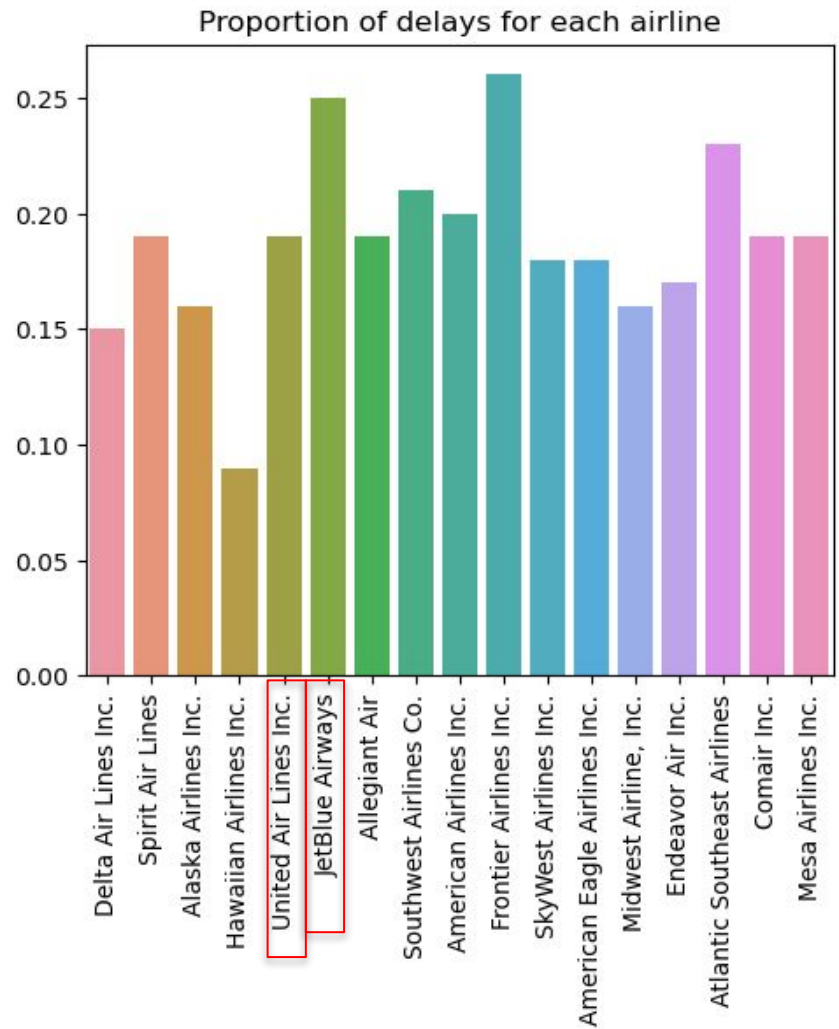
is the way United operates in different weather conditions responsible for a bigger probability of delay?

- 1) United is the 6th most likely airline to be delayed. How much of that is due to “bad” weather?
- 2) Compared to other airlines, is it the case that United flies more in bad weather?
- 3) If yes, what factors of “bad” weather are most likely to affect its
- 4) Case study of airline of biggest probability of delays and airline of lowest prob of delay : how does their weather indicator look like



# Proportion of delays for airlines

- Biggest probability of being delayed the most: **Frontier Airlines, JetBlue**
- Lowest probability of being delayed: **Hawaiian Airlines Inc**



# Creating the weather indicator

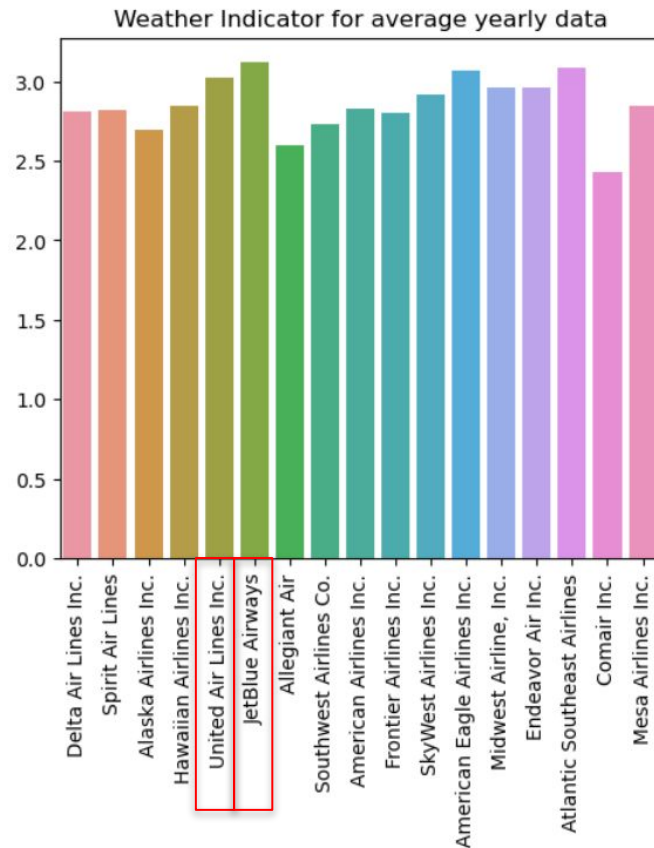
Weather indicator = (snow + rain + wind) / 3

United = **4th position**

- Flying more frequently so more flights happen in bad weather - **9%** of all flights in dataset are for United

Notice: Comair Inc <**United**< JetBlue Airways

**Conclusion 1**: United has a high weather indicator which could be causing the delays



# Does weather cause delays?

- Split data into subsets to notice monthly trends
  - Calculate delays per month and indicator per month
- Find correlation between delays and weather indicator

Weather indicator only:

Comair Inc <United< JetBlue Airways

Weather indicator + correlation:

JetBlue Airways <United< Comair Inc

**Conclusion 2:** United's delays are likely not to be due to bad weather

Endeavor Air Inc.	0.401403
Atlantic Southeast Airlines	0.396127
Comair Inc.	-0.324852
American Airlines Inc.	-0.300407
United Air Lines Inc.	-0.165776
Allegiant Air	-0.139086
Southwest Airlines Co.	0.134725
American Eagle Airlines Inc.	-0.125721
JetBlue Airways	-0.124465
SkyWest Airlines Inc.	-0.124411
Delta Air Lines Inc.	0.121742
Spirit Air Lines	-0.075680
Mesa Airlines Inc.	-0.071582
Frontier Airlines Inc.	-0.070815
Alaska Airlines Inc.	0.046326
Hawaiian Airlines Inc.	0.030387
Midwest Airline, Inc.	0.009300
dtype: float64	

**No**, United flying in an average amount of **snow**

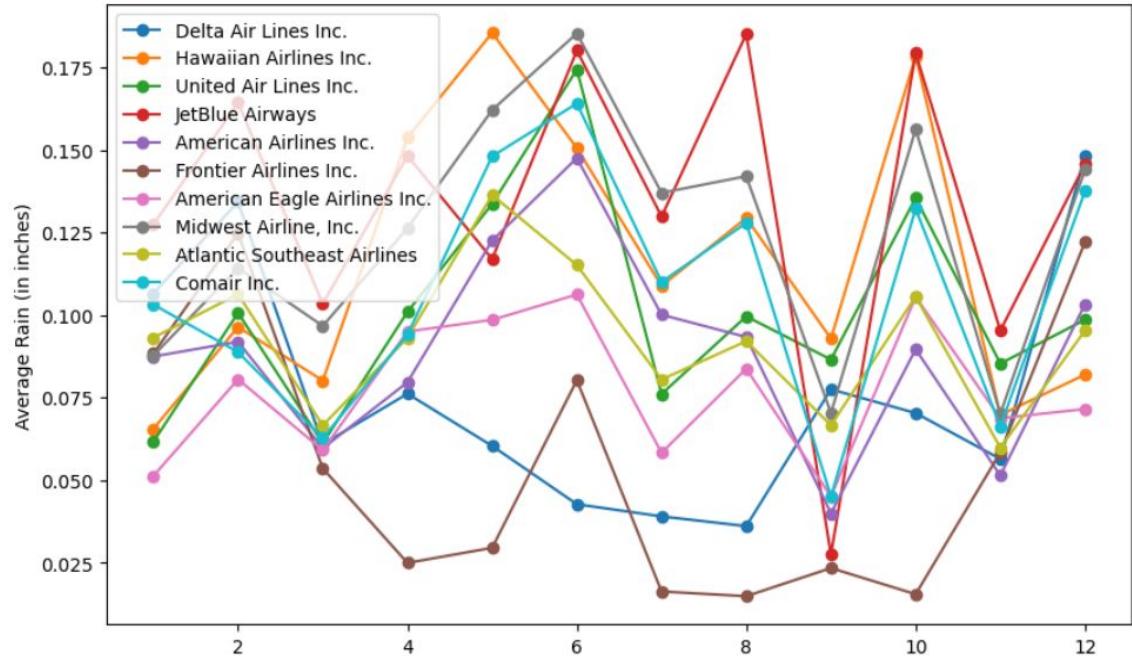
[illegible]

# *Rain:* Potential for weather recommendations?

United vs other airlines:

**Yes**, rain might be a weather factor that is weighing more heavily or the weather indicator

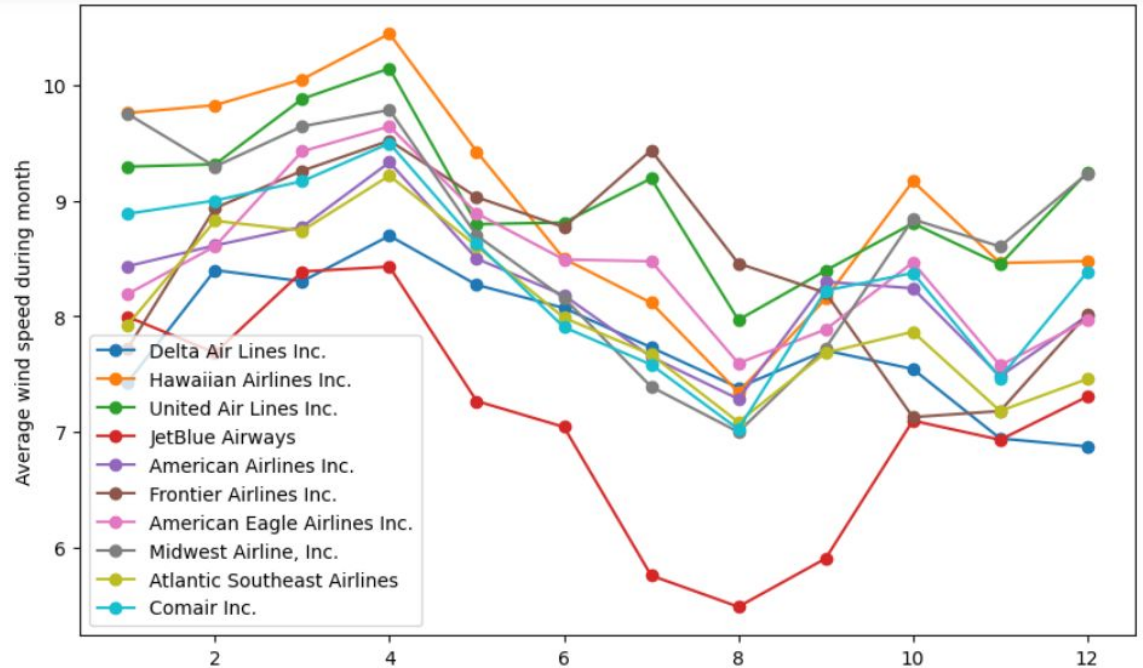
Comair Inc =United<<JetBlue Airways



# Wind: Potential for weather recommendations?

**Yes**, United is flying in highest wind speed compared to other airlines

JetBlue Airways < Comair Inc << United



# Weather takeaways

## Good things:

- It's good that United's weather **indicator correlation with delays is low** - it shows the robust systems in place that take care of random events (minimizing randomness is good)
- United can **take advantage of its relatively better performance** when it comes to delays by using the correlations found in its advertisement campaigns

## Area for growth:

- United can still maintain its average/good delays performance while it operates more flights in the winter/during bad weather – we learn from JetBlue that the weather indicator can be the highest, yet weather is even less of a reason that there are flight delays

# Summary

1. Closest Neighbor Approach
  - a. Select airports with a lower probability of delay
2. Emulate the Winners, Avoid the Losers
  - a. Fly More
  - b. Less Employees
3. Weather the Storm or Don't
  - a. Delays not due to weather - could do better with handling rain, potentially snow
4. Bigger Bang for your Buck
  - a. Purchase Smaller Planes

