Report of the Departure Delays of the United Airlines (UA)

Introduction:

In this report, the departure delays for United Airlines (Carrier code UA) have been analyzed using the nycflights13 dataset. The objective is to improve both efficiency and customer satisfaction, by understanding the relationship between departure delays and the effect of factors like time of day, time of year and few weather factors on the departure delays.

Dataset source:

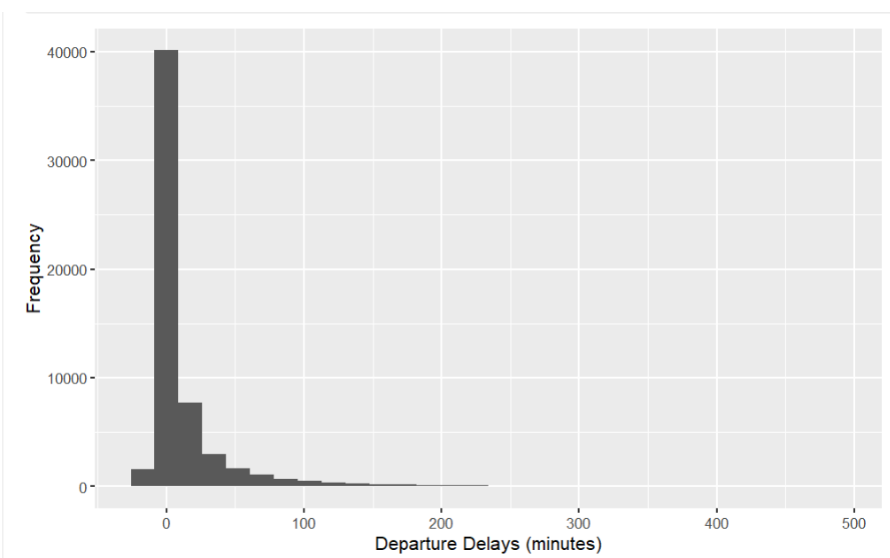
The nycflights13 dataset contains information on flight departures from three major New York City airports in 2013. For this analysis, we will focus on departure delays of flights operated by United Airlines (UA). The following variables were used in the analysis:

- dep_delay: The number of minutes that the flight was delayed in departing.
- late: A variable indicating whether the flight was delayed by more than 15 minutes.
- hour: The time of day that the flight departed (morning – 12AM to 12PM, afternoon and evening flights – 12PM to 11:49PM).
- month: The time of year that the flight departed (summer months – From Mar to Aug, Winter months – From Sep to Feb).
- temp: The temperature in degrees Fahrenheit at the time of departure
- wind_speed: The wind speed in miles per hour at the time of departure
- precip: The amount of precipitation in inches at the time of departure
- visib: The visibility in miles at the time of departure

Exploratory Data Analysis:

To analyze we will consider the "dep_delay" variable, which represents the departure delay in minutes. In some cases, we may also utilize the "late" variable which we considered for flights departed late more than 15 minutes from the scheduled flight.

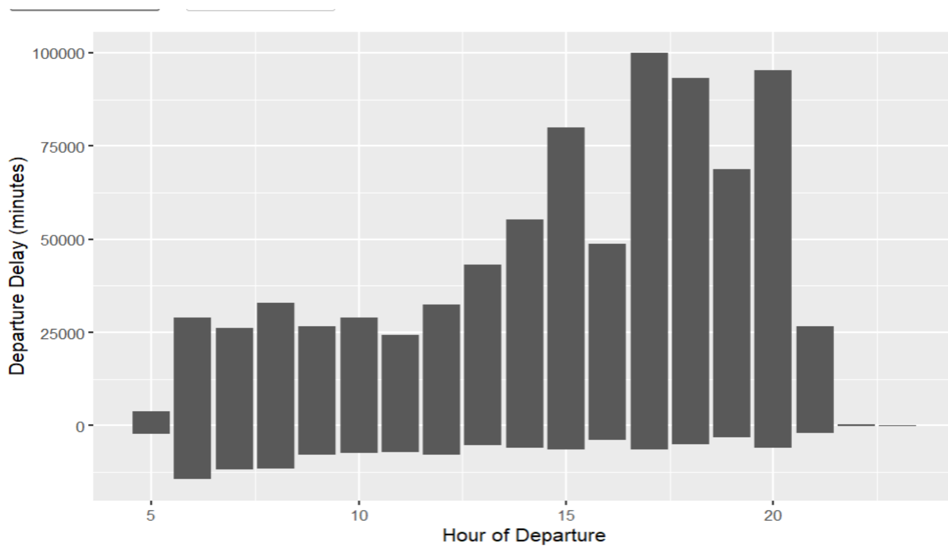
The following graph shows the distribution of the departure delays for all UA flights:



The graph suggests that departure delays are generally right skewed, with longer tails to the right. This means there are few flights with very long delays and most flights have relatively short delays.

Time of a day:

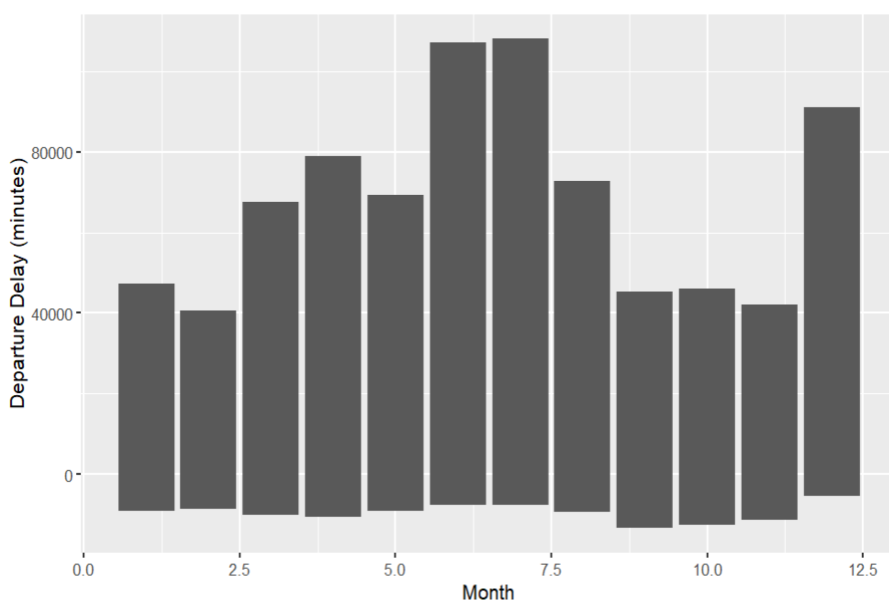
We examine the relationship between departure delays and the time of the day. The following graph shows the distribution of the departure delays at different times of a day:



As the histogram shows, departure delays tend to be higher during the afternoon and evening than at the rest of the time of the day. There are a few flights which departed early during the morning times.

Time of the year:

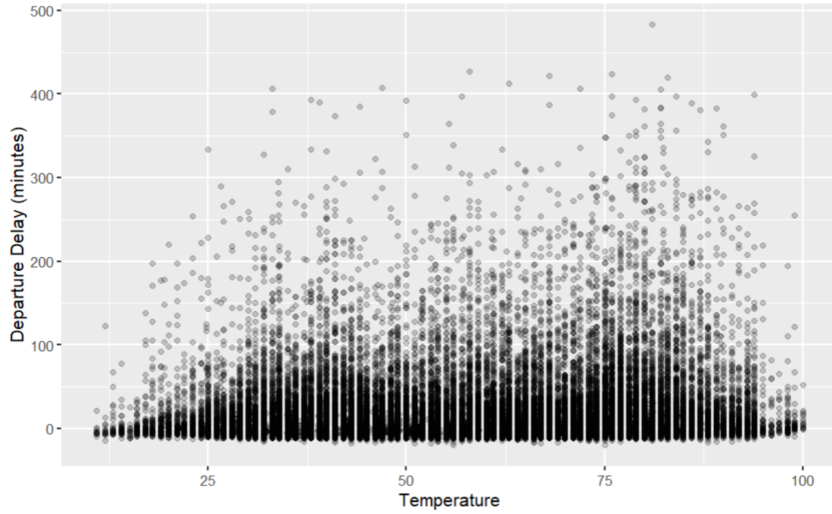
We examine the relationship between departure delays and the time of the year. The following graph shows the distribution of the departure delays at different months:



As the histogram shows, the departure delays tend to be higher in the summer and then flights are next most delayed in winter than rest of the months in the year.

Temperature:

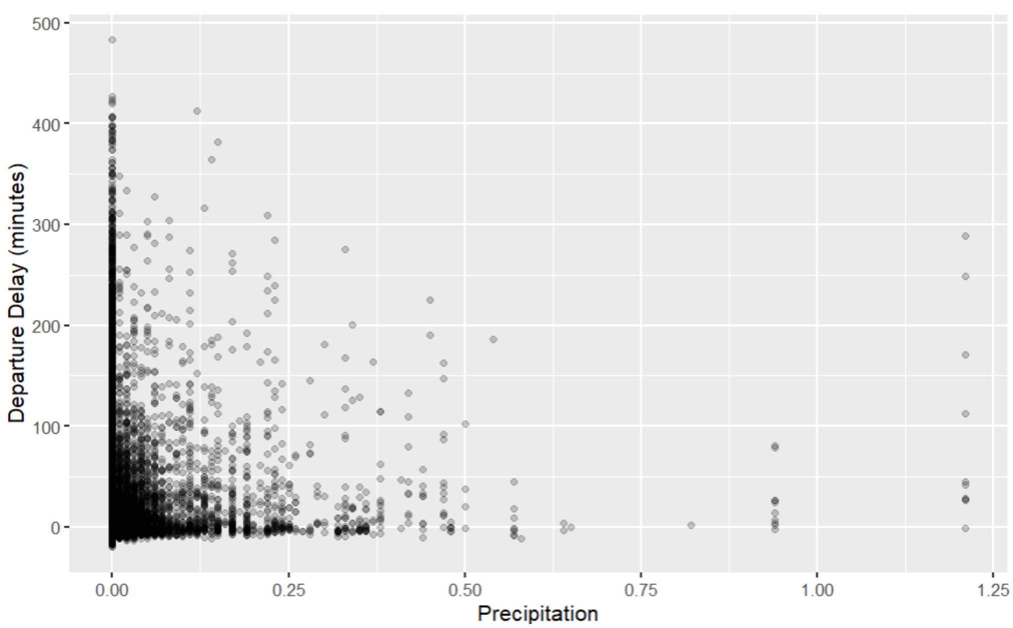
We examine the relationship between departure delays and weather conditions such as temperature. The following graph shows the effect of temperature on departure delays:



As we investigate the scatterplot, it is evident that delays are higher corresponding to extreme temperatures. This is the reason why the distribution is right skewed.

Precipitation:

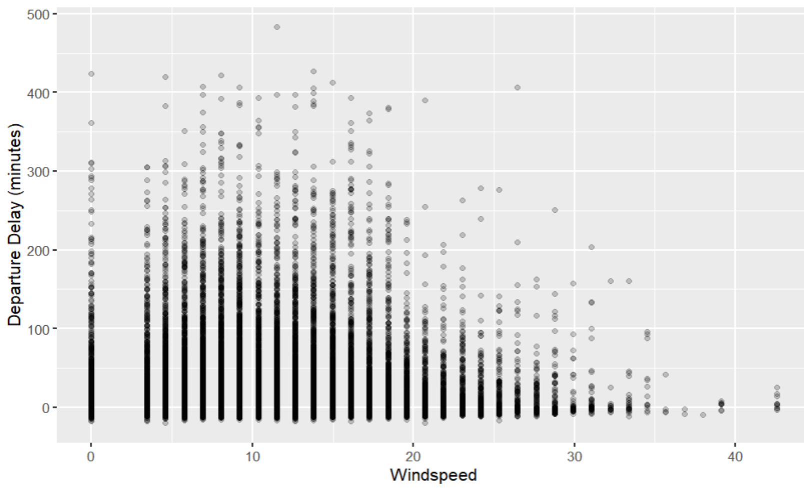
We examine the relationship between departure delays and weather conditions precipitation. The following graph shows the effect of precipitation on departure delays:



The relationship between precipitation and delays appears complex in the scatterplot. While the graph might suggest a trend towards fewer delays with higher precipitation, the permutation test indicates that higher precipitation is statistically associated with an increased likelihood of delays. This suggests a more nuanced relationship that may be influenced by other factors not readily apparent in the visualization.

Wind Speed:

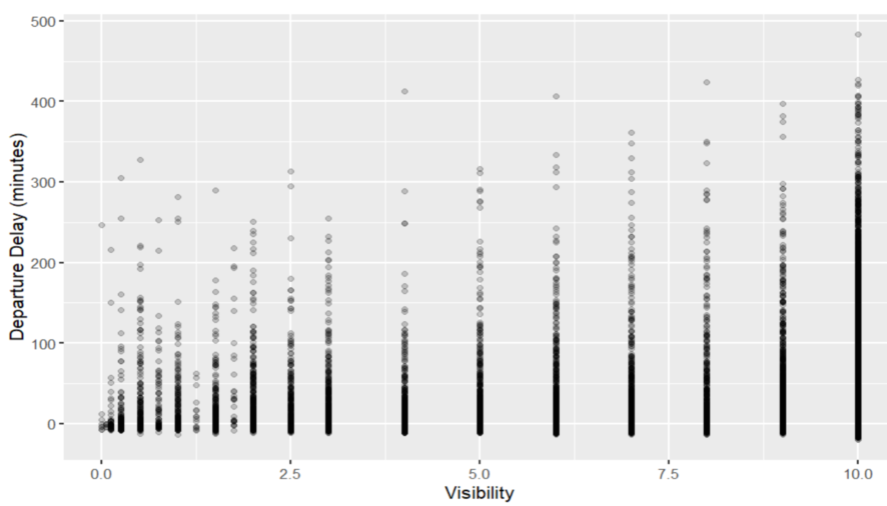
We examined the relationship between departure delays and wind speed. The following graph shows the effect of wind speed on departure delays:



The graph doesn't show a strong visual relationship between wind speed and departure delays. Delays seem to occur across all wind speeds, although there's a higher concentration of flights at lower wind speeds. There's a denser cluster of points at lower wind speeds (0-15 mph), suggesting more flights operate under these conditions. However, the permutation test indicates that higher wind speeds are statistically associated with an increased likelihood of delays, suggesting a more nuanced relationship that might not be readily apparent in this visualization.

Visibility:

We examined the relationship between departure delays and visibility. The following graph shows the effect of visibility on departure delays:



The graph suggests a trend where lower visibility is associated with a higher likelihood of departure delays. This is particularly noticeable for visibility levels below 5 miles, where the concentration of delays is higher. While the trend is visible, delays still occur across all visibility levels, even when visibility is excellent (10 miles). This indicates that other factors contribute to delays.

Permutation Tests:

We used permutation tests to confirm the statistical significance of the relationships observed to the exploratory data analysis.

The following table shows the result of the permutation test:

Variable effecting the departure delay	P-value
Time of the Day	0.002
Time of the Year	0.002
Temperature	0.002
Wind Speed	0.002
Precipitation	0.002
Visibility	0.002

The null hypothesis for this project is that there is no relationship between departure delays and the other factors being analyzed. The alternative hypothesis is that there is a relationship between departure delays and the other factors being analyzed.

As the table shows, all the relationships between departure delays and the other factors of interest have significant relationship as the p-value < 0.05 significance level. So, it is evident that all these factors influence the departure delays of United Airlines.

Conclusion:

This analysis has identified several factors associated with departure delays for United Airlines flights. Time of day, time of year, and weather conditions, including temperature, wind speed, precipitation, and visibility, all play a significant role.

Specifically, the analysis showed that:

- Departure delays tend to be higher in the afternoon and evening, and during the summer and winter months.
- Extreme temperatures, higher wind speeds, higher precipitation, and lower visibility are all associated with increased delays.

Notably, the permutation test revealed statistically significant relationships between departure delays and these factors, even when the visual trends in the graphs were not immediately apparent. This highlights the importance of considering both visual and statistical analysis to gain a comprehensive understanding of the factors influencing flight delays.

Business Suggestions:

Based on these findings, United Airlines can take several steps to mitigate delays and enhance customer satisfaction:

- **Optimize Scheduling**: Adjust flight schedules to account for peak delay periods, such as afternoons and summer months.
- **Weather Contingency Planning:** Develop robust strategies to proactively manage disruptions caused by adverse weather, such as extreme temperatures, high winds, or low visibility. This could include:
    - Investing in advanced weather forecasting technology.
    - Implementing flexible aircraft routing to avoid severe weather.
    - Optimizing ground operations to minimize delays during moderate weather conditions.
- **Proactive Communication:** Enhance communication with passengers during delays, providing regular updates and explanations. This can help manage expectations and reduce dissatisfaction.
- **Investigate Further:** Conduct additional analysis to explore other potential factors contributing to delays, such as aircraft maintenance, air traffic control, and crew scheduling.

Appendix:

The appendix of this report would include the code used for the analysis.