AirlineDelayAnalysis

2023-05-25

Loading necessary libraries

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 4.2.3
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.2.3
```

Loading data and Summarization for Airlines Delay

```
airlines_data <- read.csv("Airline_Delay_Cause.csv")
summary(airlines_data)
```

```
##       year          month     carrier          carrier_name
##  Min.   :2023   Min.   :1   Length:4612        Length:4612
##  1st Qu.:2023   1st Qu.:1   Class :character   Class :character
##  Median :2023   Median :2   Mode  :character   Mode  :character
##  Mean   :2023   Mean   :2
##  3rd Qu.:2023   3rd Qu.:3
##  Max.   :2023   Max.   :3
##
##    airport          airport_name        arr_flights        arr_del15
##  Length:4612        Length:4612        Min.   :    1.0   Min.   :   0.00
##  Class :character   Class :character   1st Qu.:   47.0   1st Qu.:   8.00
##  Mode  :character   Mode  :character   Median :   93.0   Median :  20.00
```

```
##                                      Mean   :  352.1   Mean   :  75.04
##                                      3rd Qu.:  237.0   3rd Qu.:  52.00
##                                      Max.   :18504.0   Max.   :3529.00
##                                      NA's   :5         NA's   :5
##    carrier_ct       weather_ct          nas_ct        security_ct
##  Min.   :  0.00   Min.   :  0.000   Min.   :  0.00   Min.   : 0.0000
##  1st Qu.:  2.71   1st Qu.:  0.000   1st Qu.:  1.00   1st Qu.: 0.0000
##  Median :  7.67   Median :  0.640   Median :  4.01   Median : 0.0000
##  Mean   : 25.14   Mean   :  2.474   Mean   : 21.44   Mean   : 0.2244
##  3rd Qu.: 20.65   3rd Qu.:  2.000   3rd Qu.: 12.80   3rd Qu.: 0.0000
##  Max.   :904.87   Max.   :163.000   Max.   :999.84   Max.   :14.5500
##  NA's   :5        NA's   :5         NA's   :5        NA's   :5
##  late_aircraft_ct   arr_cancelled    arr_diverted       arr_delay
##  Min.   :   0.000   Min.   :  0.0   Min.   : 0.0000   Min.   :     0
##  1st Qu.:   1.705   1st Qu.:  0.0   1st Qu.: 0.0000   1st Qu.:   436
##  Median :   5.450   Median :  1.0   Median : 0.0000   Median :  1206
##  Mean   :  25.772   Mean   :  5.8   Mean   : 0.8055   Mean   :  4997
##  3rd Qu.:  16.655   3rd Qu.:  4.0   3rd Qu.: 1.0000   3rd Qu.:  3295
##  Max.   :1550.650   Max.   :580.0   Max.   :84.0000   Max.   :337375
##  NA's   :5          NA's   :5       NA's   :5         NA's   :5
##  carrier_delay    weather_delay       nas_delay     security_delay
##  Min.   :     0   Min.   :    0.0   Min.   :    0   Min.   :   0.00
##  1st Qu.:   136   1st Qu.:    0.0   1st Qu.:   34   1st Qu.:   0.00
##  Median :   437   Median :   30.0   Median :  159   Median :   0.00
##  Mean   :  1802   Mean   :  280.6   Mean   : 1002   Mean   :  10.78
##  3rd Qu.:  1306   3rd Qu.:  182.0   3rd Qu.:  532   3rd Qu.:   0.00
##  Max.   :118554   Max.   :20423.0   Max.   :50792   Max.   :1477.00
##  NA's   :5        NA's   :5         NA's   :5       NA's   :5
##  late_aircraft_delay
##  Min.   :     0
##  1st Qu.:    89
##  Median :   369
##  Mean   :  1901
##  3rd Qu.:  1254
##  Max.   :155262
##  NA's   :5
```

```
print(length(unique(airlines_data$carrier)))
```

```
## [1] 15
```

```
print(length(unique(airlines_data$carrier_name)))
```

```
## [1] 15
```

```
print(length(unique(airlines_data$airport)))
```

```
## [1] 341
```

```
print(length(unique(airlines_data$airport_name)))
```

```
## [1] 341
```

```
print(nrow(airlines_data))
```

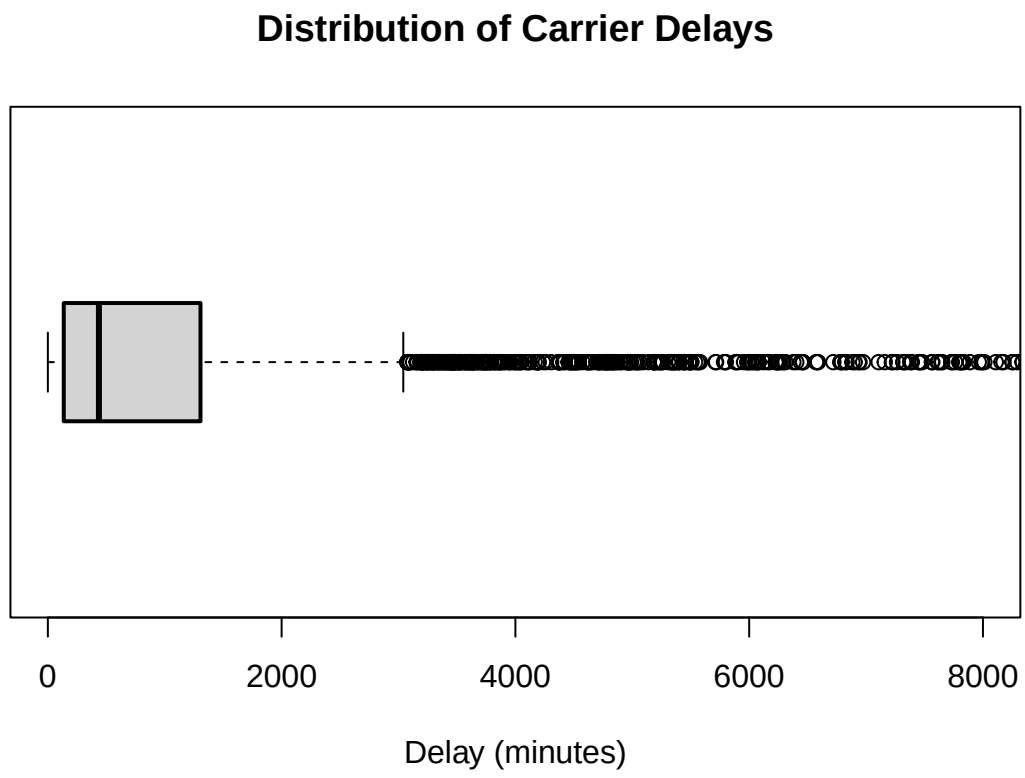
```
## [1] 4612
```

```
print(ncol(airlines_data))
```

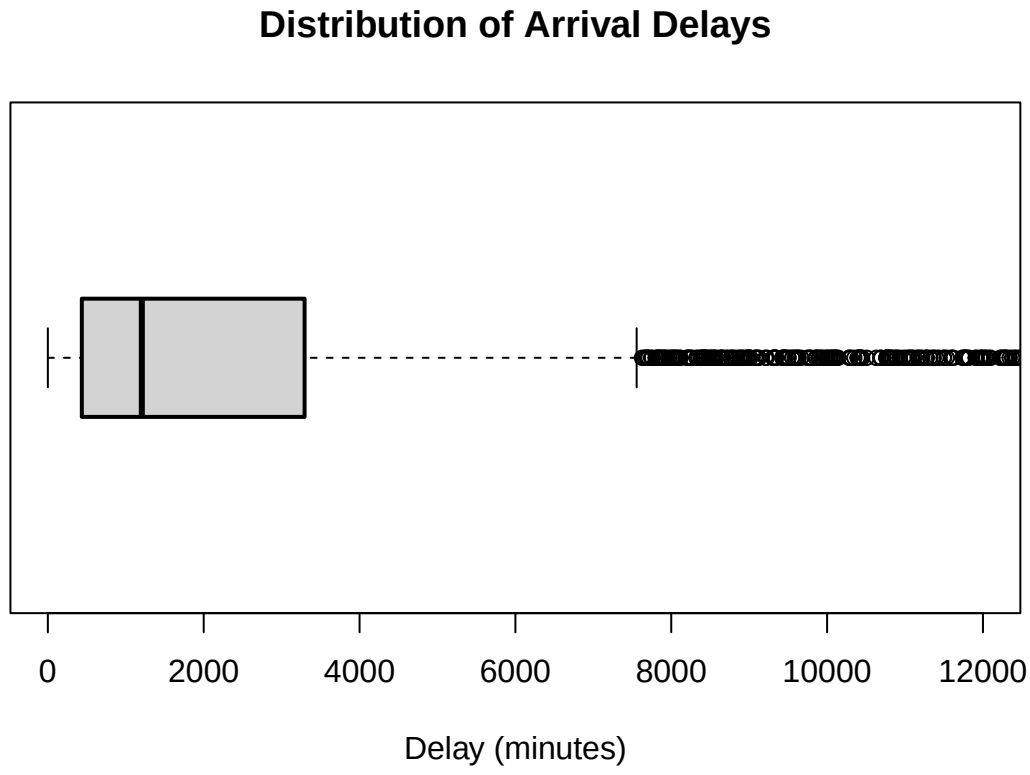
```
## [1] 21
```

Box Plots

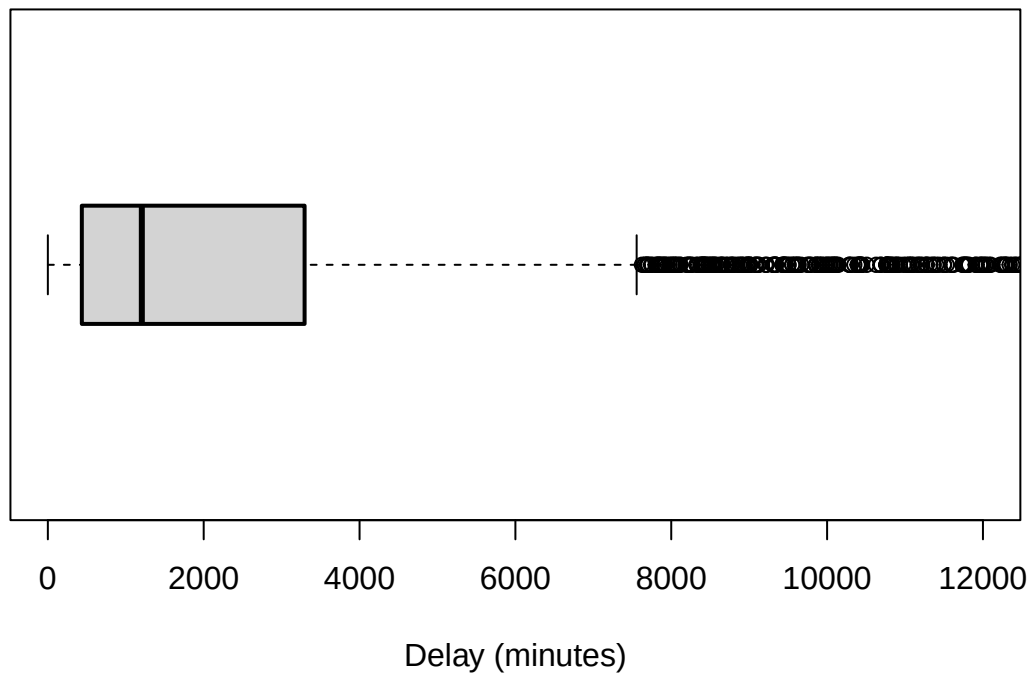
```
# Box Plot - carrier_delay
boxplot(airlines_data$carrier_delay, main = "Distribution of Carrier Delays", xlab = "Delay (minutes)"
        boxlwd = 2, outwex = 0.5, boxwex = 0.5 , outline = TRUE , horizontal = TRUE ,
        ylim=c(0,8000))
```



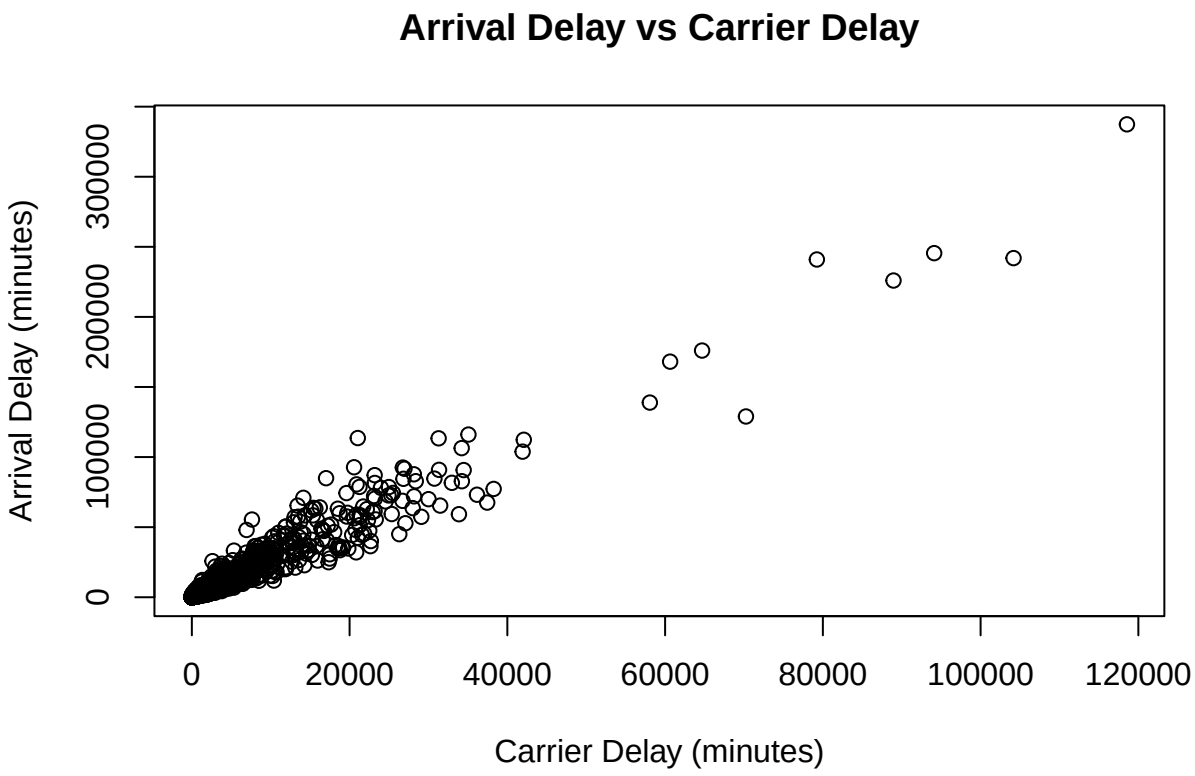

```
# Box Plot - arr_delay
boxplot(airlines_data$arr_delay, main = "Distribution of Arrival Delays", xlab = "Delay (minutes)" ,
        boxlwd = 2, outwex = 0.5, boxwex = 0.5 , outline = TRUE , horizontal = TRUE ,
        ylim=c(0,12000))
```



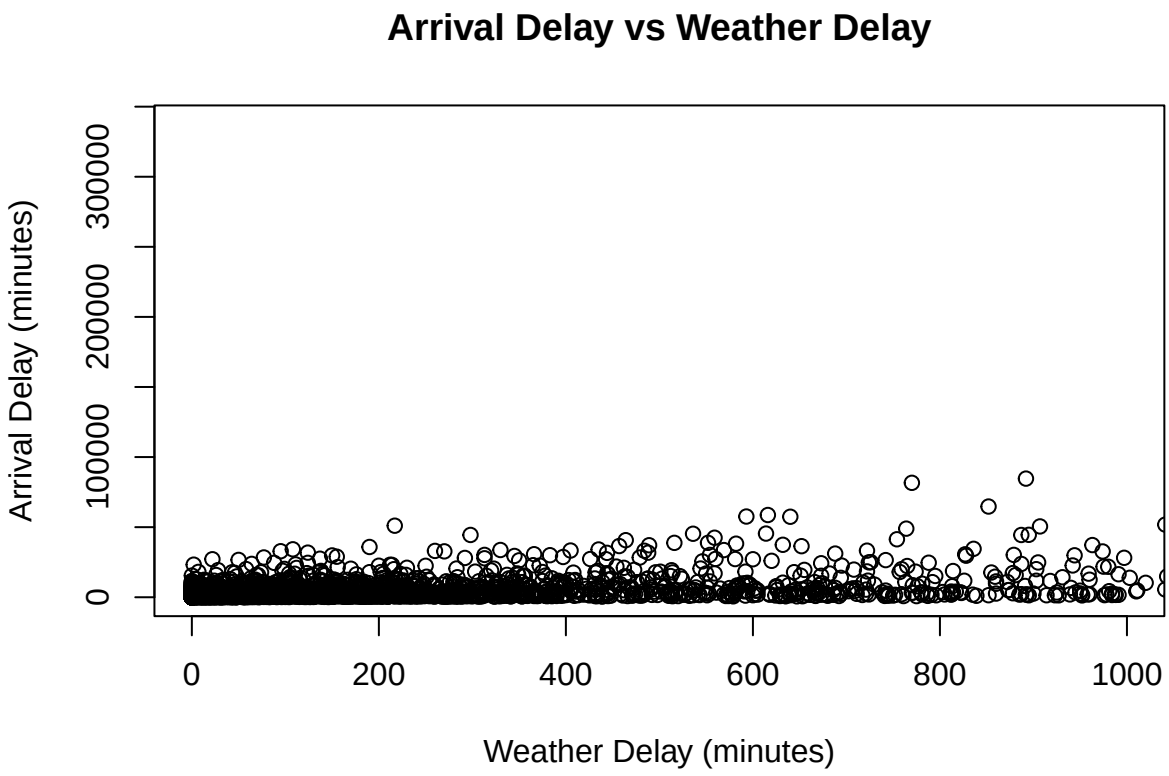

```
# Box Plot - arr_delay
boxplot(airlines_data$arr_delay, main = "Distribution of Weather Delays", xlab = "Delay (minutes)" ,
        boxlwd = 2, outwex = 0.5, boxwex = 0.5 , outline = TRUE , horizontal = TRUE ,
        ylim=c(0,12000))
```




```
# Scatter Plot
plot(airlines_data$carrier_delay, airlines_data$arr_delay,
     main = "Arrival Delay vs Carrier Delay",
     xlab = "Carrier Delay (minutes)", ylab = "Arrival Delay (minutes)")
```




```
# Scatter Plot
plot(airlines_data$weather_delay, airlines_data$arr_delay,
     main = "Arrival Delay vs Weather Delay",
     xlab = "Weather Delay (minutes)", ylab = "Arrival Delay (minutes)",
     xlim = c(0,1000))
```



Linear Regression

```
# Select the relevant columns for the linear regression analysis
airlines_data_1m <- airlines_data %>%
select (arr_delay, carrier_delay, weather_delay, nas_delay, security_delay, late_aircraft_delay)

# Fit a linear regression model
arr_carrier_model <- lm(arr_delay ~ carrier_delay , data = airlines_data_1m)
arr_weather_model <- lm(arr_delay ~ weather_delay , data = airlines_data_1m)
arr_nas_model <- lm(arr_delay ~ nas_delay , data = airlines_data_1m)
arr_security_model <- lm(arr_delay ~ security_delay , data = airlines_data_1m)
arr_aircraft_model <- lm(arr_delay ~ late_aircraft_delay , data = airlines_data_1m)

#Print the model summary
print(summary(arr_carrier_model))
```

```
##
## Call:
## lm(formula = arr_delay ~ carrier_delay, data = airlines_data_1m)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -57616   -548   -191    223  57544
##
```

```
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   215.55778   54.86562   3.929 8.66e-05 ***
## carrier_delay   2.65278    0.00974 272.365  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3528 on 4605 degrees of freedom
##   (5 observations deleted due to missingness)
## Multiple R-squared:  0.9416, Adjusted R-squared:  0.9415
## F-statistic: 7.418e+04 on 1 and 4605 DF,  p-value: < 2.2e-16
```

```
print(summary (arr_weather_model))
```

```
##
## Call:
## lm(formula = arr_delay ~ weather_delay, data = airlines_data_1m)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -110151   -2062   -1577    -206  172750
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2095.2375   160.0484   13.09   <2e-16 ***
## weather_delay   10.3403     0.1562   66.18   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10450 on 4605 degrees of freedom
##   (5 observations deleted due to missingness)
## Multiple R-squared:  0.4875, Adjusted R-squared:  0.4874
## F-statistic:  4380 on 1 and 4605 DF,  p-value: < 2.2e-16
```

```
print (summary (arr_nas_model))
```

```
##
## Call:
## lm(formula = arr_delay ~ nas_delay, data = airlines_data_1m)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -70239  -1025   -718    176 145597
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 967.63751  107.92052   8.966   <2e-16 ***
## nas_delay     4.02231    0.03233 124.428   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6988 on 4605 degrees of freedom
##   (5 observations deleted due to missingness)
```

```
## Multiple R-squared:  0.7707, Adjusted R-squared:  0.7707
## F-statistic: 1.548e+04 on 1 and 4605 DF,  p-value: < 2.2e-16
```

```
print (summary (arr_security_model))
```

```
##
## Call:
## lm(formula = arr_delay ~ security_delay, data = airlines_data_1m)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -188983   -3170   -2502    -806  276897
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3471.691    195.605   17.75   <2e-16 ***
## security_delay  141.454      4.009   35.28   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12950 on 4605 degrees of freedom
##   (5 observations deleted due to missingness)
## Multiple R-squared:  0.2128, Adjusted R-squared:  0.2126
## F-statistic:  1245 on 1 and 4605 DF,  p-value: < 2.2e-16
```

```
print (summary (arr_aircraft_model))
```

```
##
## Call:
## lm(formula = arr_delay ~ late_aircraft_delay, data = airlines_data_1m)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -26529   -672   -416    113  50317
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)         547.24086   51.70081   10.59   <2e-16 ***
## late_aircraft_delay   2.34028    0.00813  287.85   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3349 on 4605 degrees of freedom
##   (5 observations deleted due to missingness)
## Multiple R-squared:  0.9473, Adjusted R-squared:  0.9473
## F-statistic: 8.286e+04 on 1 and 4605 DF,  p-value: < 2.2e-16
```

Chi-Square Test

```r
delta <- subset(airlines_data, carrier_name == "Delta Air Lines Inc.")
american <- subset(airlines_data, carrier_name == "American Airlines Inc.")

# carrier_ct vs weather_ct
delta_table<- table (delta$carrier_ct, delta$weather_ct)
american_table <- table(american$carrier_ct, american$weather_ct)
chi_sq <- chisq.test(delta_table, american_table)
```

```
## Warning in chisq.test(delta_table, american_table): Chi-squared approximation
## may be incorrect
```

```r
print(chi_sq)
```

```
##
##  Pearson's Chi-squared test
##
## data:  delta_table
## X-squared = 90954, df = 85360, p-value < 2.2e-16
```

```r
#carrier_ct vs nas_ct
delta_table<- table (delta$carrier_ct, delta$nas_ct)
american_table <- table(american$carrier_ct, american$nas_ct)
chi_sq <- chisq.test(delta_table, american_table)
```

```
## Warning in chisq.test(delta_table, american_table): Chi-squared approximation
## may be incorrect
```

```r
print(chi_sq)
```

```
##
##  Pearson's Chi-squared test
##
## data:  delta_table
## X-squared = 146650, df = 138904, p-value < 2.2e-16
```

```r
#carrier_ct vs security_ct
delta_table <- table(delta$carrier_ct, delta$security_ct)
american_table <- table (american$carrier_ct, american$security_ct)
chi_sq <- chisq.test(delta_table, american_table)
```

```
## Warning in chisq.test(delta_table, american_table): Chi-squared approximation
## may be incorrect
```

```r
print(chi_sq)
```

```
##
##  Pearson's Chi-squared test
##
## data:  delta_table
## X-squared = 7303.2, df = 6596, p-value = 1.293e-09
```

```r
#carrier_ct vs late_aircraft_ct
delta_table <- table (delta$carrier_ct, delta$late_aircraft_ct)
american_table <- table (american$carrier_ct, american$late_aircraft_ct)
chi_sq <- chisq.test(delta_table, american_table)
```

```
## Warning in chisq.test(delta_table, american_table): Chi-squared approximation
## may be incorrect
```

```r
print(chi_sq)
```

```
##
##  Pearson's Chi-squared test
##
## data:  delta_table
## X-squared = 147352, df = 137740, p-value < 2.2e-16
```

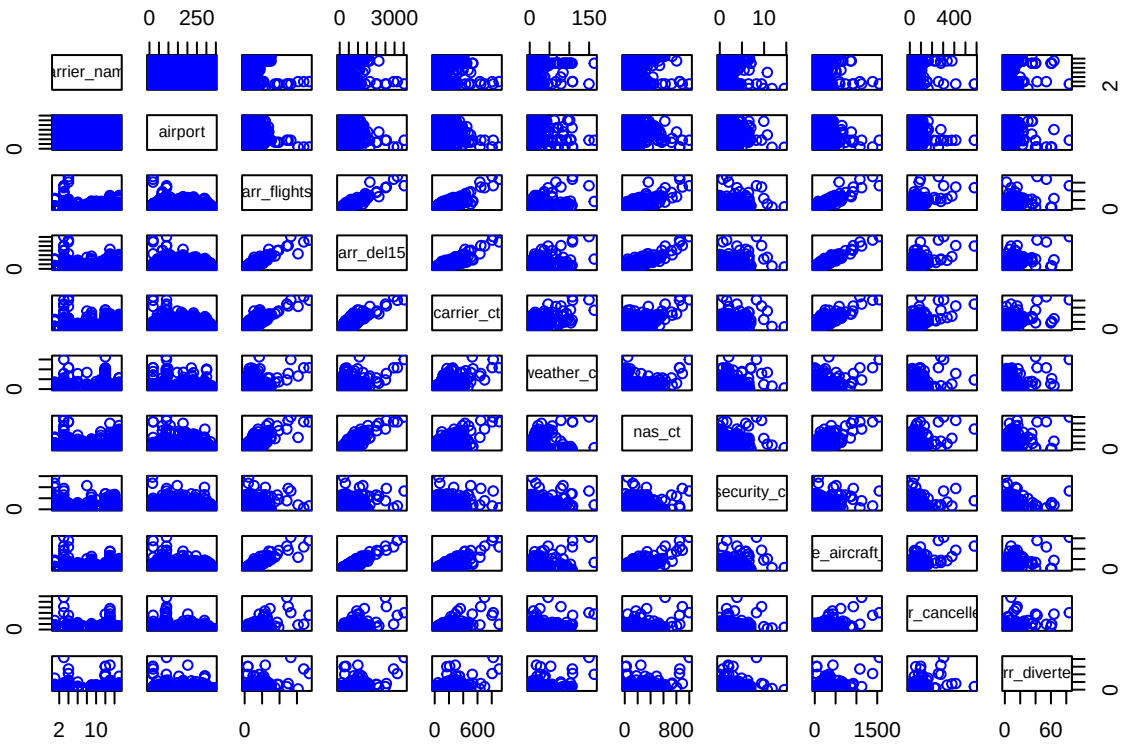
Correlation Matrix

```r
data <- airlines_data %>%
  select(carrier_delay, weather_delay, nas_delay, security_delay, late_aircraft_delay)

correlation_matrix <- cor(data, use = "complete.obs")
print(correlation_matrix)
```

```
##                     carrier_delay weather_delay nas_delay security_delay
## carrier_delay           1.0000000     0.7406985 0.7743065      0.4501237
## weather_delay           0.7406985     1.0000000 0.5202790      0.4013624
## nas_delay               0.7743065     0.5202790 1.0000000      0.3883256
## security_delay          0.4501237     0.4013624 0.3883256      1.0000000
## late_aircraft_delay     0.9234710     0.5888050 0.8175952      0.4364896
##                     late_aircraft_delay
## carrier_delay                 0.9234710
## weather_delay                 0.5888050
## nas_delay                     0.8175952
## security_delay                0.4364896
## late_aircraft_delay           1.0000000
```

```r
set.seed(1)
selected_columns_for_matrix <- c("carrier_name", "airport", "arr_flights", "arr_del15", "carrier_ct", "
subset_data <- airlines_data[, selected_columns_for_matrix]
plot(subset_data, col="blue")
```


0 250
0 3000
0 150
0 10
0 400
arrier_nam
airport
arr_flights
arr_del15
carrier_ct
veather_c
nas_ct
ecurity_c
e_aircraft
r_cancelle
rr_diverte
2 10
0
0 600
0 800
0 1500
0 60