Course_Work_2

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EUROPEAN FLIGHTS

Introduction

Covid_19 appeared as a turbulent stormy whirlwind across the globe in a pandemic rampage in the wake of the year 2020. The stormy whirlwind impact may have gone down, but the damage in the aviation industry in respect to the numbers of operated flights has not been fully recovered, particularly in Europe which is our case study.

This visualization project work will look at the various impact Covid_19 made in the 42 European Union (EU) continent countries air flights operations before, during and post Covid_19 era.This includes examining the "Departure flights", Arrival flights" and the combination of both the departure and arrival flights, known as Total flights. This data set comprises EU flights details from Jan 01, 2016 to May 31, 2022. This will be visualized with five different research questions. The dataset "flights" is available from; https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210914-1.

Research questions

1. Which EU countries operated the highest number of total flights before covid_19?
2. Which of the EU airports operated the highest numbers of flights before Covid_19, and the adopted/adjusted figures during and post_covid_19 in respect of?

   A. The airport with the highest number of total flights before Covid_19?

   B. The airport with the highest number of total flights during Covid_19?

   C. Which airport has the highest number of flights turnaround after covid_19?
3. Which country's airport quickly show the government's willingness to adjust to normal life by lifting or reducing Covid_19 restrictions?
4. Which country's airport recorded the highest flight per day recovery rate in post covid_19?
5. Has EU Aviation Industry fully recovered in the numbers of flights per day?

setwd("~/DataViz/R Script")

```
library(tidyverse)
```

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

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

## Warning: package 'tibble' was built under R version 4.2.3

## Warning: package 'tidyr' was built under R version 4.2.3

## Warning: package 'readr' was built under R version 4.2.3

## Warning: package 'purrr' was built under R version 4.2.3

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

## Warning: package 'stringr' was built under R version 4.2.3

## Warning: package 'forcats' was built under R version 4.2.3

## Warning: package 'lubridate' was built under R version 4.2.3

## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✓ dplyr     1.1.1     ✓ readr     2.1.4
## ✓ forcats   1.0.0     ✓ stringr   1.5.0
## ✓ ggplot2   3.4.1     ✓ tibble    3.2.1
## ✓ lubridate 1.9.2     ✓ tidyr     1.3.0
## ✓ purrr     1.0.1
## ── Conflicts ────────────────────────────────────────
tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all
conflicts to become errors

library(tidyr)
library(gghighlight)

## Warning: package 'gghighlight' was built under R version 4.2.3

library(gapminder)

## Warning: package 'gapminder' was built under R version 4.2.3

library(tinytex)

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

Import flights data from the flights.Csv to work environment.

```
flights <- read.csv("flights.csv")
```

Retrieve the dimension of the flights data.

```
dim(flights)
```

```
## [1] 688099     15
```

Inspect the column names in the flight data to familiarise with them.

```
colnames(flights)
```

```
##  [1] "X"              "YEAR"           "MONTH_NUM"      "MONTH_MON"
##  [5] "FLT_DATE"       "APT_ICAO"       "APT_NAME"       "STATE_NAME"
##  [9] "FLT_DEP_1"      "FLT_ARR_1"      "FLT_TOT_1"      "FLT_DEP_IFR_2"
## [13] "FLT_ARR_IFR_2" "FLT_TOT_IFR_2" "Pivot.Label"
```

The flights data frame for comprehensive view of the whole rows, columns and observations.

```
summary(flights)
```

```
##        X               YEAR        MONTH_NUM       MONTH_MON
##  Min.   :     1   Min.   :2016   Min.   : 1.000   Length:688099
##  1st Qu.:172026   1st Qu.:2017   1st Qu.: 3.000   Class :character
##  Median :344050   Median :2019   Median : 6.000   Mode  :character
##  Mean   :344050   Mean   :2019   Mean   : 6.301
##  3rd Qu.:516075   3rd Qu.:2020   3rd Qu.: 9.000
##  Max.   :688099   Max.   :2022   Max.   :12.000
##
##    FLT_DATE           APT_ICAO           APT_NAME          STATE_NAME
##  Length:688099      Length:688099      Length:688099      Length:688099
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##    FLT_DEP_1        FLT_ARR_1        FLT_TOT_1      FLT_DEP_IFR_2
##  Min.   :  0.00   Min.   :  0.00   Min.   :   0.0   Min.   :   0.0
##  1st Qu.:  5.00   1st Qu.:  5.00   1st Qu.:  10.0   1st Qu.:  38.0
##  Median : 17.00   Median : 17.00   Median :  35.0   Median :  91.0
##  Mean   : 63.24   Mean   : 63.28   Mean   : 126.5   Mean   : 143.7
##  3rd Qu.: 71.00   3rd Qu.: 71.00   3rd Qu.: 141.0   3rd Qu.: 195.0
##  Max.   :847.00   Max.   :813.00   Max.   :1628.0   Max.   :1039.0
##                                                     NA's   :479785
##  FLT_ARR_IFR_2    FLT_TOT_IFR_2    Pivot.Label
##  Min.   :  0.0    Min.   :   0.0   Length:688099
##  1st Qu.: 38.0    1st Qu.:  76.0   Class :character
##  Median : 91.0    Median : 182.0   Mode  :character
##  Mean   :143.6    Mean   : 287.3
##  3rd Qu.:195.0    3rd Qu.: 390.0
##  Max.   :817.0    Max.   :1624.0
##  NA's   :479785   NA's   :479785
```

More details from the flight dataset and the categories using glimpse.

```
glimpse(flights)
```

```
## Rows: 688,099
## Columns: 15
## $ X             <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
16, 1…
## $ YEAR          <int> 2016, 2016, 2016, 2016, 2016, 2016, 2016, 2016,
2016, 20…
## $ MONTH_NUM     <int> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1,…
## $ MONTH_MON     <chr> "JAN", "JAN", "JAN", "JAN", "JAN", "JAN", "JAN",
"JAN", …
## $ FLT_DATE      <chr> "2016-01-01", "2016-01-01", "2016-01-01", "2016-01-
01", …
## $ APT_ICAO      <chr> "EBAW", "EBBR", "EBCI", "EBLG", "EBOS", "EDDB",
"EDDC", …
## $ APT_NAME      <chr> "Antwerp", "Brussels", "Charleroi", "Liège",
"Ostend-Bru…
## $ STATE_NAME    <chr> "Belgium", "Belgium", "Belgium", "Belgium",
"Belgium", "…
## $ FLT_DEP_1     <int> 4, 174, 45, 6, 7, 98, 18, 1, 401, 3, 122, 92, 172,
276, …
## $ FLT_ARR_1     <int> 3, 171, 47, 7, 7, 99, 21, 1, 341, 4, 130, 90, 175,
236, …
## $ FLT_TOT_1     <int> 7, 345, 92, 13, 14, 197, 39, 2, 742, 7, 252, 182,
347, 5…
## $ FLT_DEP_IFR_2 <int> NA, 174, 45, NA, NA, NA, NA, NA, 401, NA, 125, NA,
NA, 2…
## $ FLT_ARR_IFR_2 <int> NA, 161, 45, NA, NA, NA, NA, NA, 306, NA, 129, NA,
NA, 2…
## $ FLT_TOT_IFR_2 <int> NA, 335, 90, NA, NA, NA, NA, NA, 707, NA, 254, NA,
NA, 5…
## $ Pivot.Label   <chr> "Antwerp (EBAW)", "Brussels (EBBR)", "Charleroi
(EBCI)",…
```

Data Dictionary

The characteristic of our variables are as stated below; what they stands for and what they mean

X is the serial number for the rows.

YEAR is an integer which reference the year flight was made.

MONTH_NUM is an numerical integer which stands for Month

MONTH_MON is a text character which represent month in a three letter code

FLT_DATE is a text character that represents the particular date of flights

APT_ICAO is a text character that represents the International Civil Aviation Organisations(ICAO) 4-letter airport designator name.

APT_NAME is a text character that the airport name.

STATE_NAME is a text character that represent the name of the country in which the airport is located.

FLT_DEP_1 is an integer that represents the number of instrument flight rules (IFR) departures as provided by network manager.

FLT_ARR_1 is an integer that represents the number of IFR arrival as provided by network manager.

FLT_TOT_1 is an integer that represents the total number of IFR movements as provided by network manager.

FLT_DEP_IFR_2 is an integer that represents the number of IFR departures as provided by the airport operator.

FLT_ARR_IFR_2 is an integer that represents the number of IFR arrivals as provided by the airport operator.

FLT_TOT_IFR_2 is an integer that represents the total number of IFR movement as provided by the airport operator.

Pivot.Label is a text character that shows the combination of name of country and airport.

Data Cleaning Let look at the number of NA (missing) values present in our data set

```
sum(is.na(flights))

## [1] 1439355

sum(is.na(flights$APT_NAME))

## [1] 0

sum(is.na(flights$STATE_NAME))

## [1] 0

sum(is.na(flights$FLT_TOT_1))

## [1] 0

sum(is.na(flights$YEAR))

## [1] 0

sum(is.na(flights$FLT_DATE))

## [1] 0
```

There are 1,439,355 NAs in flights data set, however, there are no NA values in our variable of concern.

Convert YEAR from integer to a date factor using lubridate.

```
flights$FLT_DATE <- ymd(flights$FLT_DATE)

class(flights$FLT_DATE)

## [1] "Date"
```

Research questions

1. Which EU countries operated the highest number of total flights before covid_19?

Using the total numbers of flights(departures and arrivals), arranged in descending order and rounded up to one decimal place

```
CountryTop <-
  flights %>%
  filter(YEAR >= 2016 & YEAR <= 2019) %>%
  group_by(STATE_NAME) %>%
  summarise(flights_Total = sum(FLT_TOT_1)) %>%
  arrange(desc(flights_Total)) %>%
  mutate(flights_Total = flights_Total/1000000)

CountryTop <-
  CountryTop %>%
  mutate(Round_1 = round(CountryTop$flights_Total,
                         digits = 1))
```

Convert the STATE_NAME to a factor to allow us arrange our bars in descending order.

```
CountryTop$STATE_NAME <- factor(CountryTop$STATE_NAME)
CountryTop$STATE_NAME <- fct_reorder(CountryTop$STATE_NAME,
                                     CountryTop$flights_Total)

class(CountryTop$STATE_NAME)

## [1] "factor"
```

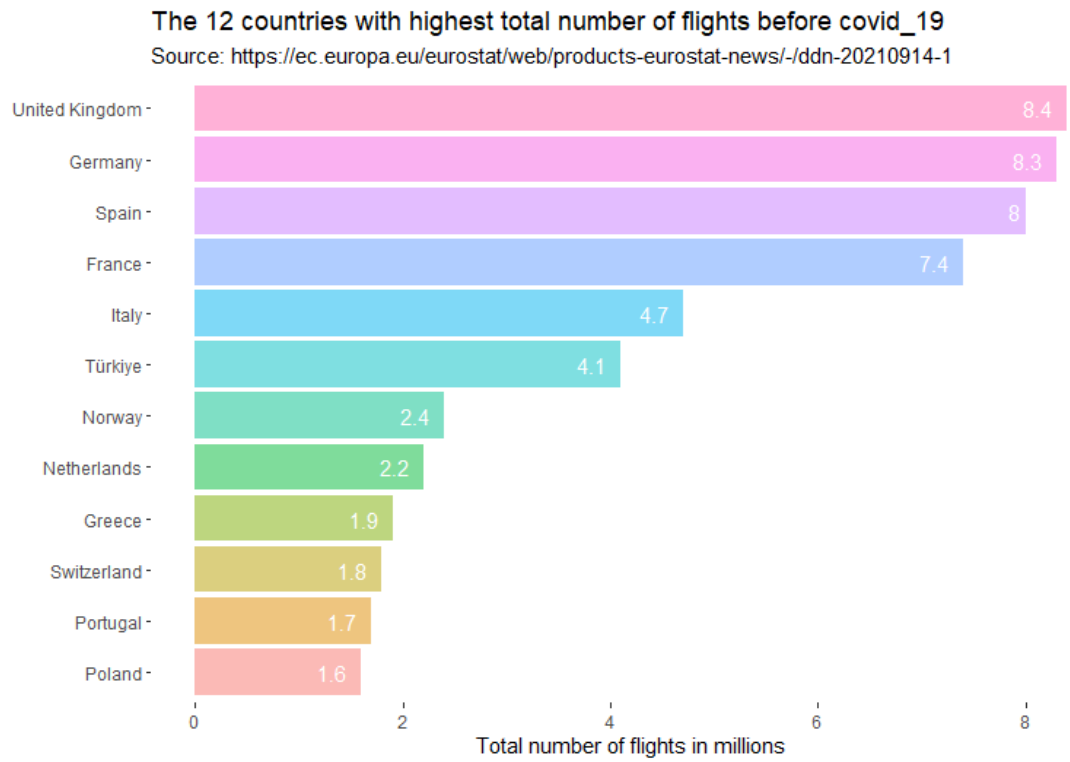
Select the list of the first 12 countries with highest total flights before Covid_19.

```
CountryTop12 <-
  CountryTop [1:12,]

list(CountryTop12)

## [[1]]
## # A tibble: 12 × 3
##    STATE_NAME     flights_Total Round_1
##    <fct>                  <dbl>   <dbl>
##  1 United Kingdom          8.35     8.4
```

```
##  2 Germany                 8.32     8.3
##  3 Spain                   8.01     8
##  4 France                  7.38     7.4
##  5 Italy                   4.73     4.7
##  6 Türkiye                 4.13     4.1
##  7 Norway                  2.39     2.4
##  8 Netherlands             2.20     2.2
##  9 Greece                  1.91     1.9
## 10 Switzerland             1.82     1.8
## 11 Portugal                1.66     1.7
## 12 Poland                  1.61     1.6
```

Graphical representation

```
ggplot(CountryTop12,
       aes(Round_1,
           STATE_NAME,
           fill = STATE_NAME)
       ) +
  geom_col(alpha = 0.5) +
  geom_text(aes(label =Round_1), stat = "identity", hjust = 1.5, colour =
"white")+
  labs(title = "The 12 countries with highest total number of flights before
covid_19",
       subtitle = "Source: https://ec.europa.eu/eurostat/web/products-
eurostat-news/-/ddn-20210914-1",
       x= "Total number of flights in millions",
       y = NULL) +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```



United Kingdom is the country with the highest number of total flights (departure and arrival) before Covid_19, a little ahead of Spain and France respectively.Italy, Turkiye, Normay, netherlands, Greece, Switzerland, Portugal, Poland respectively followed the queue.

Research question

2A.

The airport with the highest number of total flights before Covid_19?

Using mean of the total numbers of flights(departures and arrivals), arranged in descending order and rounded up to one decimal place

```
A2016_2019 <-
  flights %>%
  filter(YEAR >= 2016 & YEAR <= 2019) %>%
  select(FLT_DATE,
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
         APT_NAME
         ) %>%
  group_by(APT_NAME) %>%
```

```
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))

A2016_2019 <-
  A2016_2019%>%
  mutate(Mean_TOT_2 = round(A2016_2019$Mean_TOT, digits = 0))
```

The new data frame (A2016_2019) now has both the mean and rounded up mean of the Total flights per airport.

List the first 12 airports.

```
A2016_2019_Mean <-
  A2016_2019 [1:12,]

list(A2016_2019_Mean)

## [[1]]
## # A tibble: 12 × 3
##    APT_NAME                Mean_TOT Mean_TOT_2
##    <chr>                      <dbl>      <dbl>
##  1 Amsterdam - Schiphol       1382.       1382
##  2 Frankfurt                  1345.       1345
##  3 Paris-Charles-de-Gaulle    1338.       1338
##  4 London - Heathrow          1305.       1305
##  5 Munich                     1108.       1108
##  6 Madrid - Barajas           1096.       1096
##  7 Istanbul Atatürk           1023.       1023
##  8 Barcelona                   898.        898
##  9 Rome - Fiumicino            841.        841
## 10 London - Gatwick            777.        777
## 11 iGA Istanbul Airport        762.        762
## 12 Zürich                      730.        730
```

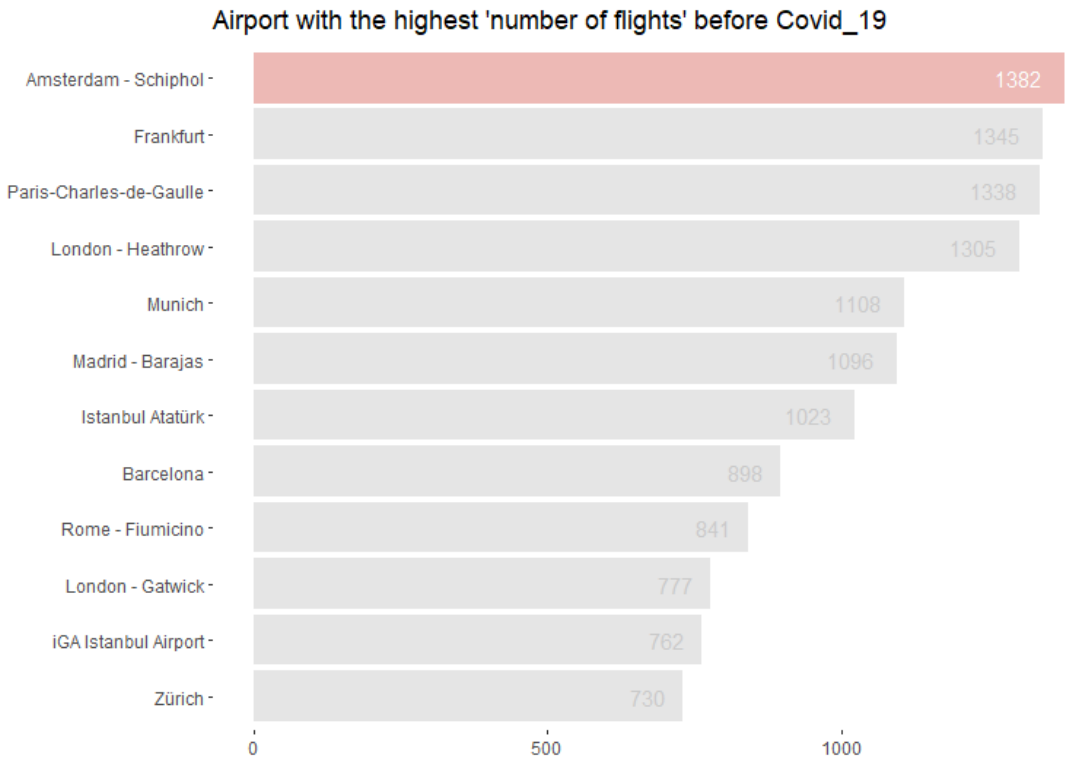
Convert the APT_NAME to a factor to allow us arrange our bars in descending order

```
A2016_2019_Mean$APT_NAME <- factor(A2016_2019_Mean$APT_NAME)
A2016_2019_Mean$APT_NAME <- fct_reorder(A2016_2019_Mean$APT_NAME,
                                        A2016_2019_Mean$Mean_TOT)

class(A2016_2019_Mean$APT_NAME)

## [1] "factor"
```

Highlight the airport with the highest flights number before Covid_19.

```
ggplot(A2016_2019_Mean,
       aes(Mean_TOT,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(alpha = 0.4) +
```

```
  geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour =
"white") +
  gghighlight(APT_NAME %in% c("Amsterdam - Schiphol")) +
  labs(title = "Airport with the highest 'number of flights' before
Covid_19",
       x= NULL,
       y = NULL) +
  theme(legend.position = "remove") +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank())
```



Amsterdam-Schiphol is the airport with the highest numbers of flights pre-covid_19. Closely followed by Frankfurt, and Paris-Charles-de-Gualle, London-Heathrow, respectively and the rest.

2B.

The airport with the highest number of total flights during Covid_19?

Using mean of the total numbers of flights(departures and arrivals), arrange in descending order and rounded up to whole number.

```
A2020_A <-
  flights %>%
  filter(YEAR == 2020) %>%
  select(FLT_DATE,
```

```
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
         APT_NAME
         ) %>%
  group_by(APT_NAME) %>%
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))

A2020 <-
  A2020_A %>%
  mutate(Mean_TOT_2 = round(A2020_A$Mean_TOT,
                            digits = 0))
```

List the first 12 airports for better comparison

```
A2020_Mean <-
  A2020 [1:12,]

list(A2020_Mean)
```

```
## [[1]]
## # A tibble: 12 × 3
##    APT_NAME                Mean_TOT Mean_TOT_2
##    <chr>                      <dbl>      <dbl>
##  1 Amsterdam - Schiphol        644.        644
##  2 Paris-Charles-de-Gaulle     603.        603
##  3 Frankfurt                   580.        580
##  4 London - Heathrow           559.        559
##  5 iGA Istanbul Airport        504.        504
##  6 Madrid - Barajas            453.        453
##  7 Munich                      394.        394
##  8 Istanbul Sabiha Gökçen      371.        371
##  9 Barcelona                   335.        335
## 10 Oslo - Gardermoen           335.        335
## 11 Athens                      298.        298
## 12 Vienna                      295.        295
```

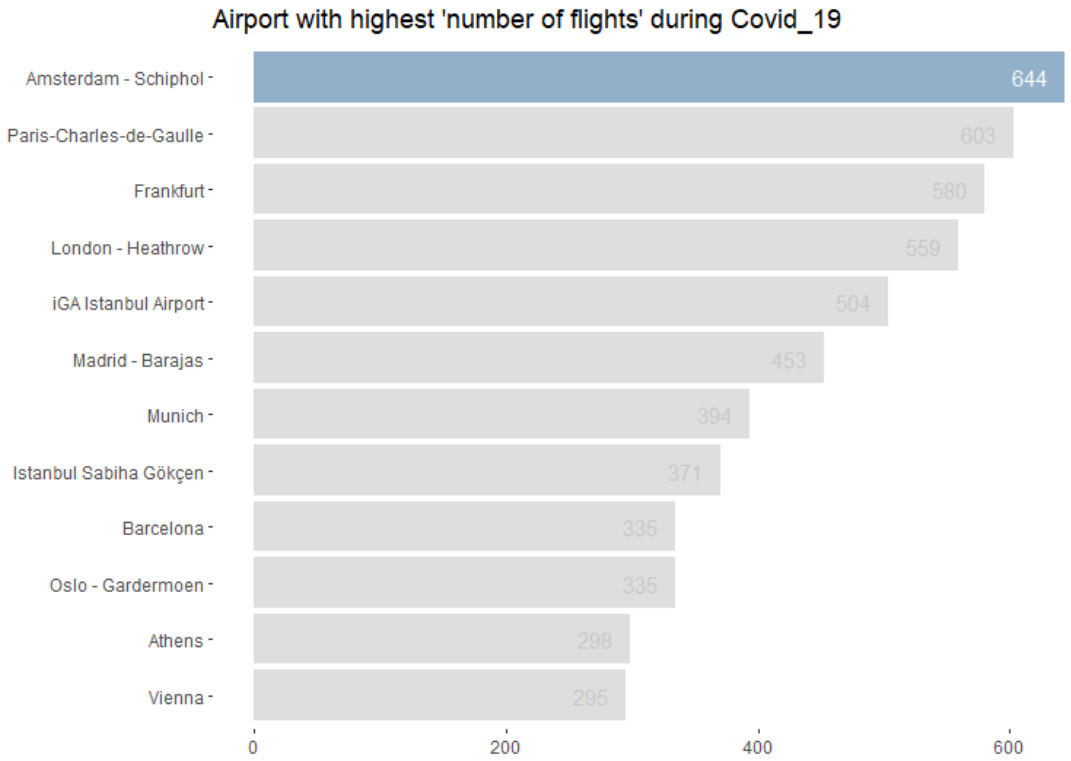
Convert the APT_NAME to a factor to allow us arrange the bars in descending order

```
A2020_Mean$APT_NAME <- factor(A2020_Mean$APT_NAME)
A2020_Mean$APT_NAME <- fct_reorder(A2020_Mean$APT_NAME, A2020_Mean$Mean_TOT)

class(A2020_Mean$APT_NAME)
```

```
## [1] "factor"
```

Let plot the graph using ggplot.

```
ggplot(A2020_Mean,
       aes(Mean_TOT,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(fill = "steelblue", alpha = 0.5) +
    geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour
= "white") +
  labs(title = "Airport with highest 'number of flights' during Covid_19",
       x= NULL,
       y = NULL) +
  gghighlight(APT_NAME == "Amsterdam - Schiphol") +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```



Amsterdam-Schiphol continued its humanitarian services even in the face of the pandemic and standing out as the airport with the highest numbers of flights mean during covid_19. Frankfurt had dropped to third, which could mean that, Germany either placed high restrictions on flights or Frankfurt city was badly affected and people boycott the airport, while France became more welcoming.

2C.

Which airport has the highest number of flights turnaround after covid_19?

Using mean of the total numbers of flights(departures and arrivals), arrange in descending order and rounded up to whole number.

```
A2021_2022 <-
  flights %>%
  filter(YEAR >= 2021 & YEAR <= 2022) %>%
  select(FLT_DATE,
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
         APT_NAME
         ) %>%
  group_by(APT_NAME) %>%
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))

A2021_2022 <-
  A2021_2022 %>%
  mutate(Mean_TOT_2 = round(A2021_2022$Mean_TOT,
                            digits = 0))
```

Let choose the first 12 airports for better representations & evaluation

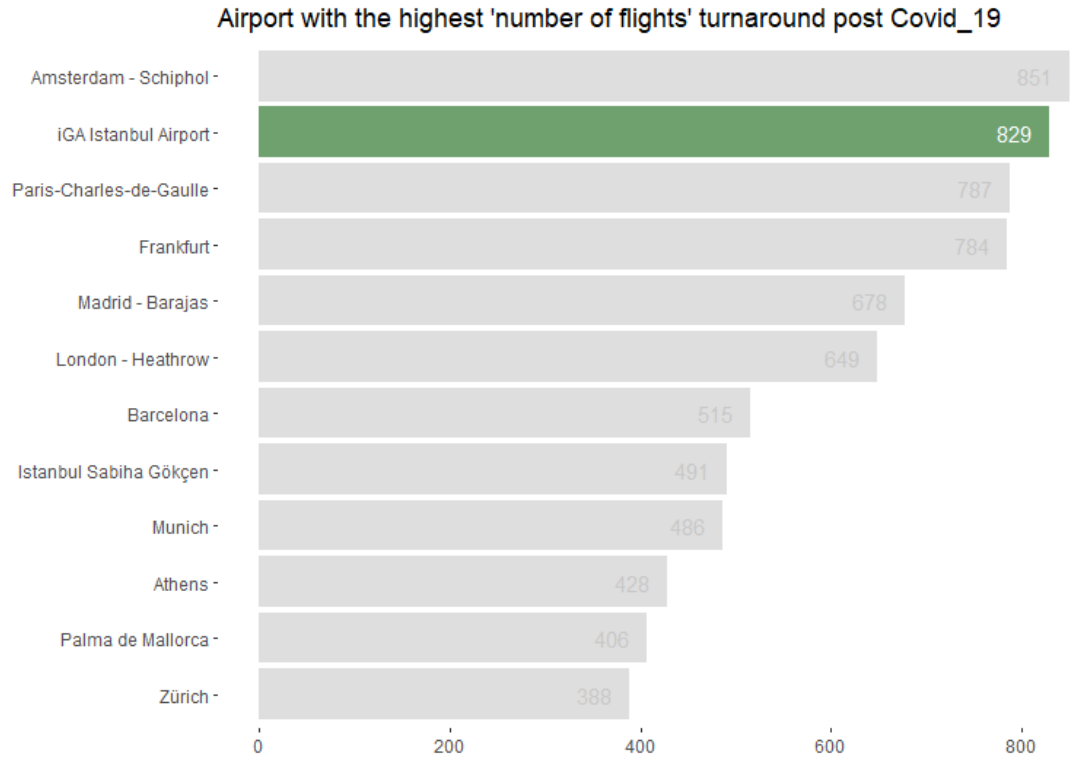
```
A2021_2022_Mean <-
  A2021_2022 [1:12,]

list(A2021_2022_Mean)

## [[1]]
## # A tibble: 12 × 3
##    APT_NAME                Mean_TOT Mean_TOT_2
##    <chr>                      <dbl>      <dbl>
##  1 Amsterdam - Schiphol        851.        851
##  2 iGA Istanbul Airport        829.        829
##  3 Paris-Charles-de-Gaulle     787.        787
##  4 Frankfurt                   784.        784
##  5 Madrid - Barajas            678.        678
##  6 London - Heathrow           649.        649
##  7 Barcelona                   515.        515
##  8 Istanbul Sabiha Gökçen      491.        491
##  9 Munich                      486.        486
## 10 Athens                      428.        428
## 11 Palma de Mallorca           406.        406
## 12 Zürich                      388.        388
```

Let convert the APT_NAME to a factor to allow us arrange our bars in descending order

```r
A2021_2022_Mean$APT_NAME <- factor(A2021_2022_Mean$APT_NAME)
A2021_2022_Mean$APT_NAME <- fct_reorder(A2021_2022_Mean$APT_NAME,
                                        A2021_2022_Mean$Mean_TOT)

class(A2021_2022_Mean$APT_NAME)
```

```
## [1] "factor"
```

```r
ggplot(A2021_2022_Mean,
       aes(Mean_TOT_2,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(fill = "darkgreen", alpha = 0.5) +
  geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour = "white") +
  gghighlight(APT_NAME == "iGA Istanbul Airport") +
  labs(title = "Airport with the highest 'number of flights' turnaround post Covid_19",
       x= NULL,
       y = NULL) +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```



Amsterdam-Schiphol maintained the leading in all the era under considerations. Surprisingly, IGA Istanbul (Turkey airport) made 2nd position which was 7th on the queue before Covid_19. Turkey Civil Aviation Industry (TCAI) made research on reason while passengers lost confidence in the flights operations. "Another important aspect for demand recovery is that airlines have to investigate the reasons behind the decrease in passenger confidence and how to regain it". (Muhammet Deveci, & et al., 2022). This obviously paid off. Also, the government provided a 24/7 5,000 square meter PCR testing center with 20,000 capacity daily inside the Istanbul Airport terminal serving the passengers. All test can do quickly with results out with delay, according of Istanbul Airport report (online)

Research question

3. Which country's airport shows the government quick willingness to adjust to normal life by lifting or reducing Covid_19 restrictions?

Choose the top 4 airports in pre_covid_19 and consider their performance during, and after covid_19 using lollypop graph.

```
A2016_2019_T4 <-
  A2016_2019_Mean [1:4,]

A2020_T4 <-
  A2020_Mean [1:4,]

A2021_2022_T4 <-
  A2021_2022_Mean [1:6,]

list(A2016_2019_T4)

## [[1]]
## # A tibble: 4 × 3
##   APT_NAME                Mean_TOT Mean_TOT_2
##   <fct>                      <dbl>      <dbl>
## 1 Amsterdam - Schiphol       1382.       1382
## 2 Frankfurt                  1345.       1345
## 3 Paris-Charles-de-Gaulle    1338.       1338
## 4 London - Heathrow          1305.       1305

New_flights <-
  merge(A2016_2019_T4,
        A2020_T4,
        by = "APT_NAME")

New_flights2 <-
  merge(New_flights,
        A2021_2022_T4,
        by = "APT_NAME")

New_flights3 <-
  New_flights2 %>%
```

```
  select(APT_NAME,
         Mean_TOT_2.x,
         Mean_TOT_2.y,
         Mean_TOT_2)
  colnames(New_flights3) <-
    c("Airport",
      "Pre_Covid",
      "Covid",
      "Post_Covid")
```

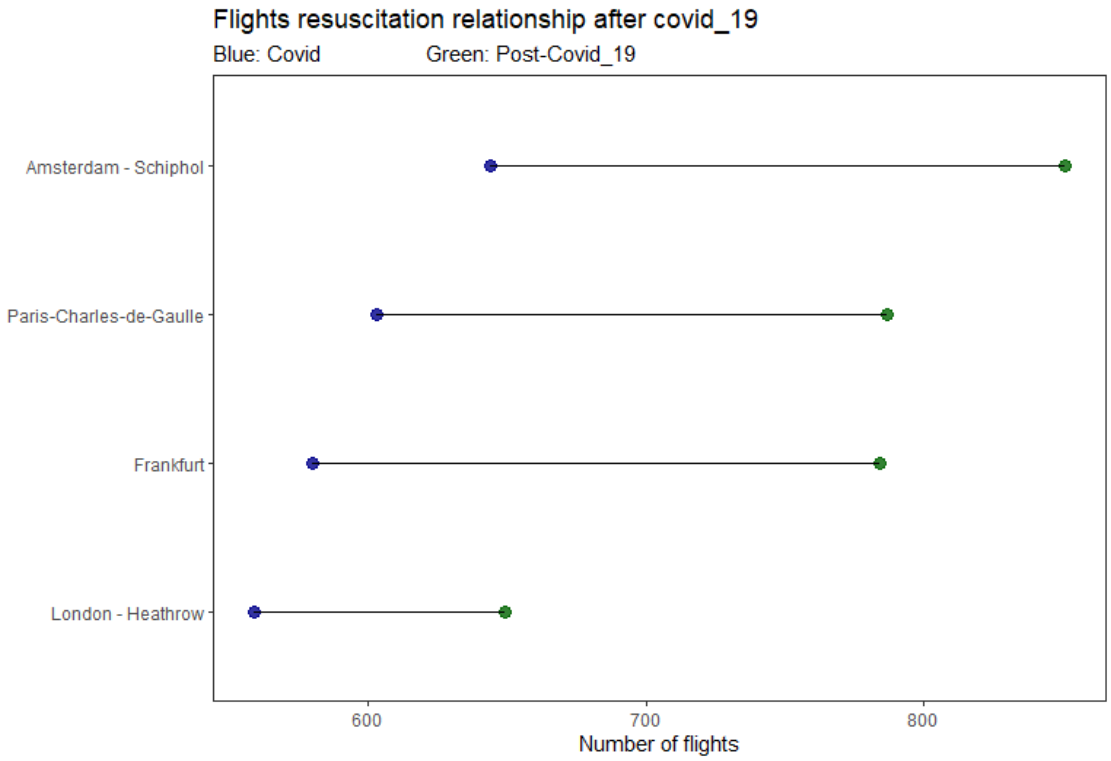
Let convert the Airport to a factor to allow arranging the lollipop in proper order

```
New_flights3$Airport <- factor(New_flights3$Airport)
New_flights3$Airport <- fct_reorder(New_flights3$Airport,
                                    New_flights3$Covid)


class(New_flights3$Airport)

## [1] "factor"

ggplot(New_flights3,
       aes(x = Airport)
       ) +
  geom_point(aes
             (y = Covid),
             colour = "darkblue",
             size = 3,
             alpha = 0.8) +
  geom_point(aes
             (y = Post_Covid),
             colour = "darkgreen",
             size = 3,
             alpha = 0.8) +
  geom_segment(aes
               (x = Airport,
                 y = Covid,
                 xend = Airport,
                 yend = Post_Covid)) +
  labs(title = "Flights resuscitation relationship after covid_19",
       subtitle = "Blue: Covid                    Green: Post-Covid_19",
        y = "Number of flights",
       x = NULL) +
  theme_bw() +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  coord_flip()
```



Netherlands (Amstedam - Schiphol airport) shows quicker willingness to adjust back to normal life ahead of others.

Research Question

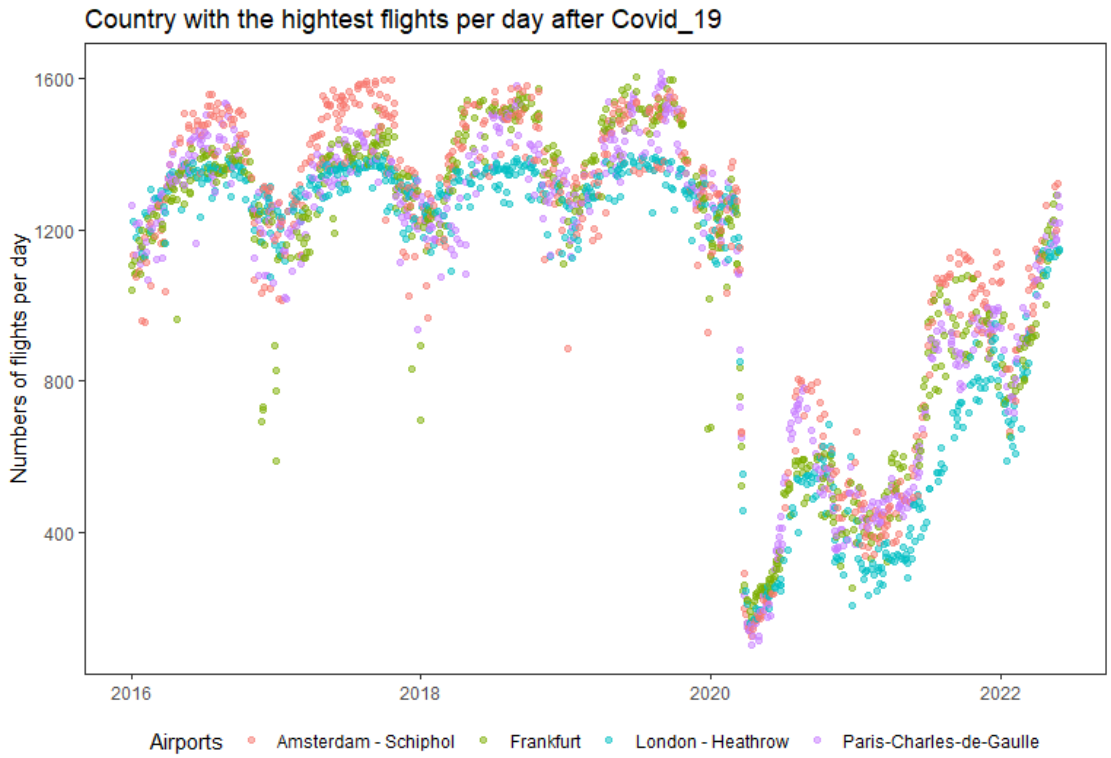
4. Which country's airport recorded the highest flight per day after (post) Covid_19.

What is the behavioural pattern of the European aviation operations before the appearance of Covid_19. in respect of

```
flights_4 <-
  flights %>%
  filter(APT_NAME == c("Amsterdam - Schiphol",
                       "Frankfurt",
                       "London - Heathrow",
                       "Paris-Charles-de-Gaulle")
           ) %>%
  select(FLT_DATE,
         YEAR,
         APT_NAME,
         FLT_TOT_1
         ) %>%
  drop_na(
  ) %>%
  rename_with(.cols = 3,
              ~"Airports")
```

```
## Warning: There was 1 warning in `filter()`.
## ℹ In argument: `==...`.
## Caused by warning in `APT_NAME == c("Amsterdam - Schiphol", "Frankfurt",
"London - Heathrow",
##     "Paris-Charles-de-Gaulle")`:
## ! longer object length is not a multiple of shorter object length

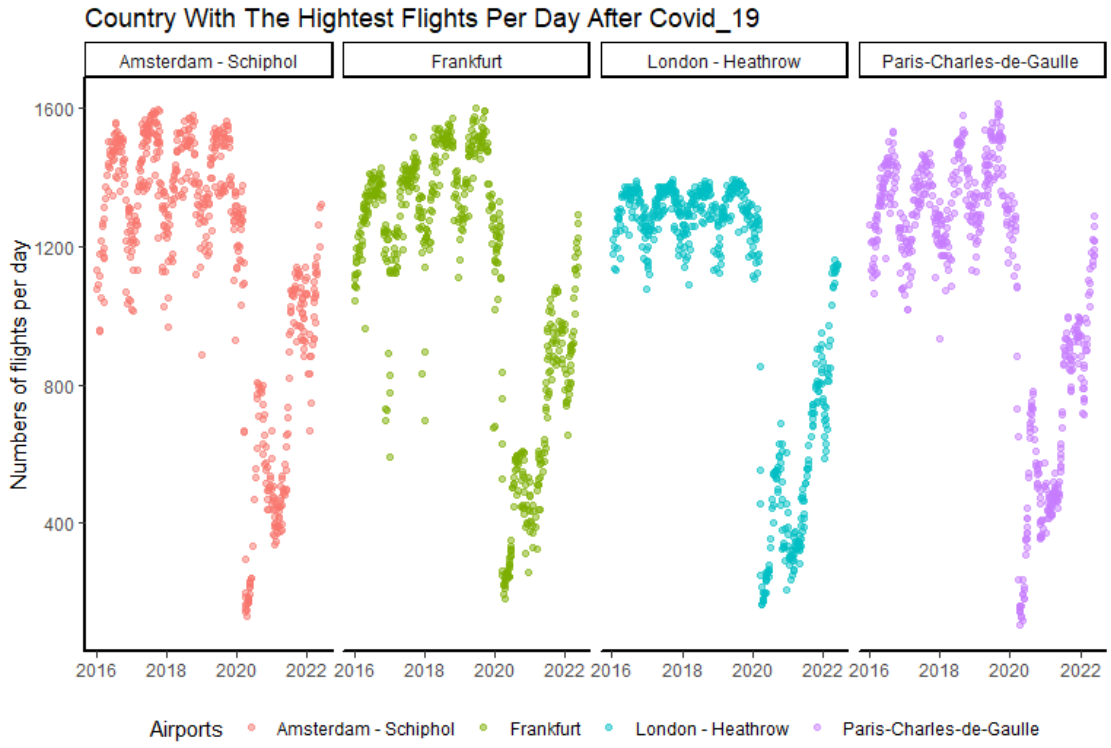
ggplot(flights_4,
       aes(
         x = FLT_DATE,
         y = FLT_TOT_1,
         colour = Airports)
       ) +
  geom_point(alpha = 0.5) +
  theme_test() +
  theme(legend.position = "bottom") +
  labs(title = "Country with the hightest flights per day after Covid_19",
x = NULL,
y = "Numbers of flights per day")
```



Using facet_wrap to segment each airport separately for better visualization.

```
ggplot(flights_4,
       aes(x = FLT_DATE,
           y = FLT_TOT_1,
           colour = Airports, )
       ) +
```

```
  geom_point(alpha = 0.5) +
  facet_wrap(~ Airports,
             ncol = 4) +
  theme_classic() +
  theme(legend.position = "bottom", names(NULL)) +
  labs(title = "Country With The Hightest Flights Per Day After Covid_19",
x = NULL,
y = "Numbers of flights per day")
```



Netherlands recorded the highest numbers of flights by day post Covid_19. (Seveno Victoria, 2022). According to Seveno V. (2022) thanks to the EU digital covid_19 certificate and the relaxation of various international travel restrictions. London - Heathrow has a 100,000 daily passengers limits up until October 2022. (Cunningham Ed, 2022), obviously the reason why they were left behind.

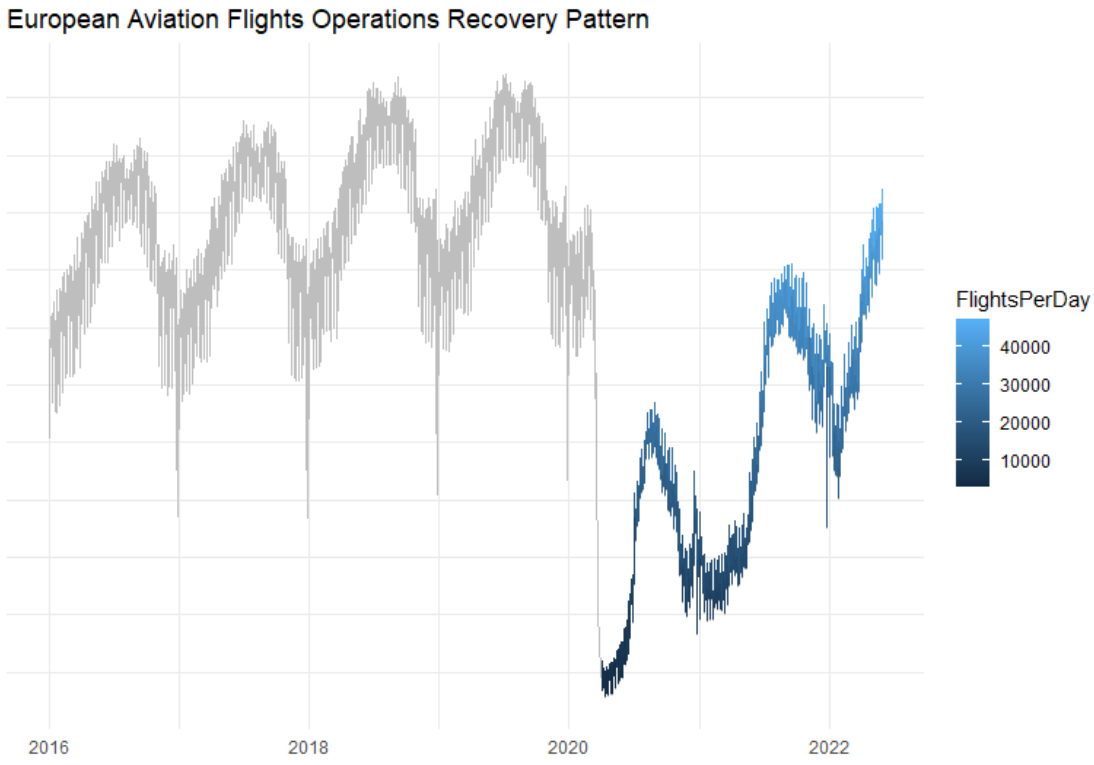
Research question

5. Has EU Aviation Industry fully recovered in the numbers of flights per day?

```
flights_Day <-
  flights %>%
  group_by(FLT_DATE) %>%
  summarise(FlightsPerDay = sum(FLT_TOT_1))

flights_Day %>%
  ggplot(aes(
    x = FLT_DATE,
    y = FlightsPerDay
```

```
    , colour = FlightsPerDay)
    ) +
  geom_line(alpha = 1) +
  gghighlight(FLT_DATE >= "2020-04-01") +
  theme_minimal() +
  theme(axis.text.y = element_blank(),
        axis.ticks.y = element_blank()) +
  labs(title = "European Aviation Flights Operations Recovery Pattern",
x = NULL,
y = NULL)
```



EU Aviation Industry has not fully recovered in it total number of flights per day compared to pre-Covid_19. There is still about 20,000 daily flights difference between pre and post-Covid_19

Conclusion

EU aviation industry is not yet where they were before Covid_19 emergence, but there have been great improvement from 2021. and there seems to be possibilities of getting there in the next 2 years or 3 years if the growth rate continues. Although, one of the imprint of covid_19 is the new wave of virtual system of meeting, learning, participation etc. if this continues, we might not experience the volumes like it use to be in EU and the globe at large.

Currently, London - Heathrow has reclaimed the position of the busiest airport as at the time of this report (April 2023), (Cunningham Ed, 2022), and has taken over from

Amsterdam - Schiphol. There will need for further investigation to get to the root cause of this. However,

---

Reference:

Instanbul Airport, Instanbul Airport Test Centre is at your services 24/7! online article, [viewed 24 April 2023] Available from: https://www.istairport.com/en/announcements/istanbul-airport-test-center-is-at-your-service-24-7?locale=en

Muhammet Deveci, & et al., (2022) Impact of COVID-19 pandemic on the Turkish civil aviation industry, Sustainable Operations and Computers, Volume 3, Pages 93-102, ISSN 2666-4127, [viewed 24 April 2023] Available from: https://doi.org/10.1016/j.susoc.2021.11.002. , https://www.sciencedirect.com/science/article/pii/S2666412721000490)), Impact of COVID-19 pandemic on the Turkish civil aviation industry - PMC (nih.gov)

Cunningham Ed, 2022, These are officially the Europe busiest airport right now. Online article [viewed: 24 April 2023] Available from: Europe's Busiest Airports include London and Amsterdam (timeout.com)

Seveno Victoria, 2022. Schiphol once again one of the Eupore's five busiest airport. Online article [viewed 24 April 2023] Available from: Schiphol once again one of Europe's five busiest airports (iamexpat.nl)

```
---
title: "Course_Work_2"
author: "Olugbenga Solesi_S2242452"
date: "2023-04-03"
output:
  word_document:
    fig_width: 8
    fig_height: 5.5
  html_document: default
  pdf_document: default
editor_options:
  markdown:
    wrap: 72
---

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```

EUROPEAN FLIGHTS

Introduction

Covid_19 appeared as a turbulent stormy whirlwind across the globe in a
pandemic rampage in the wake of the year 2020. The stormy whirlwind
impact may have gone down, but the damage in the aviation industry in
respect to the numbers of operated flights has not been fully recovered,
particularly in Europe which is our case study.

This visualization project work will look at the various impact Covid_19
made in the 42 European Union (EU) continent countries air flights
operations before, during and post Covid_19 era.This includes examining
the "Departure flights", Arrival flights" and the combination of both
the departure and arrival flights, known as Total flights. This data set
comprises EU flights details from Jan 01, 2016 to May 31, 2022. This
will be visualized with five different research questions. The dataset
"flights" is available from;
<https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210914-1>.

Research questions

1. Which EU countries operated the highest number of total flights
    before covid_19?

2. Which of the EU airports operated the highest numbers of flights before Covid_19,
and the adopted/adjusted figures during and post_covid_19 in respect of?

    A. The airport with the highest number of total flights before Covid_19?

    B. The airport with the highest number of total flights during Covid_19?

    C. Which airport has the highest number of flights turnaround after covid_19?

3. Which country's airport quickly show the government's willingness to
    adjust to normal life by lifting or reducing Covid_19 restrictions?

4. Which country's airport recorded the highest flight per day recovery
    rate in post covid_19?

5. Has EU Aviation Industry fully recovered in the numbers of flights
    per day?

```
> setwd("\~/DataViz/R Script")

```{r}
library(tidyverse)
library(tidyr)
library(gghighlight)
library(gapminder)
```

```
library(tinytex)
```

Import flights data from the flights.Csv to work environment.

```{r}
flights <- read.csv("flights.csv")
```

Retrieve the dimension of the flights data.

```{r}
dim(flights)
```

Inspect the column names in the flight data to familiarise with them.

```{r}
colnames(flights)
```

The flights data frame for comprehensive view of the whole rows, columns and observations.

```{r}
summary(flights)
```

More details from the flight dataset and the categories using glimpse.

```{r}
glimpse(flights)
```

Data Dictionary

The characteristic of our variables are as stated below; what they stands for and what they mean

X is the serial number for the rows.

YEAR is an integer which reference the year flight was made.

MONTH_NUM is an numerical integer which stands for Month

MONTH_MON is a text character which represent month in a three letter code

FLT_DATE is a text character that represents the particular date of flights

APT_ICAO is a text character that represents the International Civil Aviation Organisations(ICAO) 4-letter airport designator name.

APT_NAME is a text character that the airport name.

STATE_NAME is a text character that represent the name of the country in which the airport is located.

FLT_DEP_1 is an integer that represents the number of instrument flight rules (IFR) departures as provided by network manager.

FLT_ARR_1 is an integer that represents the number of IFR arrival as provided by network manager.

FLT_TOT_1 is an integer that represents the total number of IFR movements as provided by network manager.

FLT_DEP_IFR_2 is an integer that represents the number of IFR departures

as provided by the airport operator.

FLT_ARR_IFR_2 is an integer that represents the number of IFR arrivals as provided by the airport operator.

FLT_TOT_IFR_2 is an integer that represents the total number of IFR movement as provided by the airport operator.

Pivot.Label is a text character that shows the combination of name of country and airport.

Data Cleaning Let look at the number of NA (missing) values present in our data set

```{r}
sum(is.na(flights))
sum(is.na(flights$APT_NAME))
sum(is.na(flights$STATE_NAME))
sum(is.na(flights$FLT_TOT_1))
sum(is.na(flights$YEAR))
sum(is.na(flights$FLT_DATE))
```

There are 1,439,355 NAs in flights data set, however, there are no NA values in our variable of concern.

Convert YEAR from integer to a date factor using lubridate.

```{r}
flights$FLT_DATE <- ymd(flights$FLT_DATE)

class(flights$FLT_DATE)
```

Research questions

1. Which EU countries operated the highest number of total flights before covid_19?

Using the total numbers of flights(departures and arrivals), arranged in descending order and rounded up to one decimal place

```{r}
CountryTop <-
  flights %>%
  filter(YEAR >= 2016 & YEAR <= 2019) %>%
  group_by(STATE_NAME) %>%
  summarise(flights_Total = sum(FLT_TOT_1)) %>%
  arrange(desc(flights_Total)) %>%
  mutate(flights_Total = flights_Total/1000000)

CountryTop <-
  CountryTop %>%
  mutate(Round_1 = round(CountryTop$flights_Total,
                         digits = 1))
```

Convert the STATE_NAME to a factor to allow us arrange our bars in descending order.

```{r}
CountryTop$STATE_NAME <- factor(CountryTop$STATE_NAME)
CountryTop$STATE_NAME <- fct_reorder(CountryTop$STATE_NAME,
                                     CountryTop$flights_Total)

class(CountryTop$STATE_NAME)
```

Select the list of the first 12 countries with highest total flights before Covid_19.

```{r}
CountryTop12 <-
  CountryTop [1:12,]

list(CountryTop12)
```

Graphical representation
```{r}
ggplot(CountryTop12,
       aes(Round_1,
           STATE_NAME,
           fill = STATE_NAME)
       ) +
  geom_col(alpha = 0.5) +
  geom_text(aes(label =Round_1), stat = "identity", hjust = 1.5, colour = "white")+
  labs(title = "The 12 countries with highest total number of flights before covid_19",
       subtitle = "Source: https://ec.europa.eu/eurostat/web/products-eurostat-
news/-/ddn-20210914-1",
       x= "Total number of flights in millions",
       y = NULL) +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```

United Kingdom is the country with the highest number of total flights (departure and arrival) before Covid_19, a little ahead of Spain and France respectively.Italy, Turkiye, Normay, netherlands, Greece, Switzerland, Portugal, Poland respectively followed the queue.

Research question

2A.
The airport with the highest number of total flights before Covid_19?

Using mean of the total numbers of flights(departures and arrivals), arranged in descending order and rounded up to one decimal place

```{r}
A2016_2019 <-
  flights %>%
  filter(YEAR >= 2016 & YEAR <= 2019) %>%
  select(FLT_DATE,
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
         APT_NAME
         ) %>%
  group_by(APT_NAME) %>%
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))
```

```{r}
A2016_2019 <-
  A2016_2019%>%
  mutate(Mean_TOT_2 = round(A2016_2019$Mean_TOT, digits = 0))
```

The new data frame (A2016_2019) now has both the mean and rounded up mean of the Total flights per airport.

List the first 12 airports.

```{r}
A2016_2019_Mean <-
  A2016_2019 [1:12,]

list(A2016_2019_Mean)
```

Convert the APT_NAME to a factor to allow us arrange our bars in descending order

```{r}
A2016_2019_Mean$APT_NAME <- factor(A2016_2019_Mean$APT_NAME)
A2016_2019_Mean$APT_NAME <- fct_reorder(A2016_2019_Mean$APT_NAME,
                                        A2016_2019_Mean$Mean_TOT)

class(A2016_2019_Mean$APT_NAME)
```

Highlight the airport with the highest flights number.

```{r}
ggplot(A2016_2019_Mean,
       aes(Mean_TOT,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(alpha = 0.4) +
  geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour = "white")
+
  gghighlight(APT_NAME %in% c("Amsterdam - Schiphol")) +
  labs(title = "Airport with the highest 'number of flights' before Covid_19",
       x= NULL,
       y = NULL) +
  theme(legend.position = "remove") +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank())
```

Amsterdam-Schiphol is the airport with the highest numbers of flights pre-covid_19. Closely followed by Frankfurt, and Paris-Charles-de-Gualle, London-Heathrow, respectively and the rest.

2B.
The airport with the highest number of total flights during Covid_19?

Using mean of the total numbers of flights(departures and arrivals), arrange in descending order and rounded up to whole number.

```{r}
A2020_A <-
  flights %>%
  filter(YEAR == 2020) %>%
  select(FLT_DATE,
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
         APT_NAME
         ) %>%
  group_by(APT_NAME) %>%
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))
```

```
A2020 <-
  A2020_A %>%
  mutate(Mean_TOT_2 = round(A2020_A$Mean_TOT,
                            digits = 0))
```

List the first 12 airports for better comparison

```{r}
A2020_Mean <-
  A2020 [1:12,]

list(A2020_Mean)
```

Convert the APT_NAME to a factor to allow us arrange the bars in descending order

```{r}
A2020_Mean$APT_NAME <- factor(A2020_Mean$APT_NAME)
A2020_Mean$APT_NAME <- fct_reorder(A2020_Mean$APT_NAME, A2020_Mean$Mean_TOT)

class(A2020_Mean$APT_NAME)
```

Let plot the graph using ggplot.

```{r}
ggplot(A2020_Mean,
       aes(Mean_TOT,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(fill = "steelblue", alpha = 0.5) +
    geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour =
"white") +
  labs(title = "Airport with highest 'number of flights' during Covid_19",
       x= NULL,
       y = NULL) +
  gghighlight(APT_NAME == "Amsterdam - Schiphol") +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```
Amsterdam-Schiphol continued its humanitarian services even in the face
of the pandemic and standing out as the airport with the highest numbers
of flights mean during covid_19. Frankfurt had dropped to third, which
could mean that, Germany either placed high restrictions on flights or
Frankfurt city was badly affected and people boycott the airport, while
France became more welcoming.

2C.
Which airport has the highest number of flights turnaround after covid_19?

Using mean of the total numbers of flights(departures and arrivals), arrange in
descending order and rounded up to whole number.

```{r}
A2021_2022 <-
  flights %>%
  filter(YEAR >= 2021 & YEAR <= 2022) %>%
  select(FLT_DATE,
         MONTH_MON,
         YEAR,
         FLT_DEP_1,
         FLT_ARR_1,
         FLT_TOT_1,
         STATE_NAME,
```

```
          APT_NAME
          ) %>%
  group_by(APT_NAME) %>%
  summarise(Mean_TOT = mean(FLT_TOT_1)) %>%
  arrange(desc(Mean_TOT))
```

```{r}
A2021_2022 <-
  A2021_2022 %>%
  mutate(Mean_TOT_2 = round(A2021_2022$Mean_TOT,
                            digits = 0))
```

Let choose the first 12 airports for better representations & evaluation

```{r}
A2021_2022_Mean <-
  A2021_2022 [1:12,]

list(A2021_2022_Mean)
```

Let convert the APT_NAME to a factor to allow us arrange our bars in descending order

```{r}
A2021_2022_Mean$APT_NAME <- factor(A2021_2022_Mean$APT_NAME)
A2021_2022_Mean$APT_NAME <- fct_reorder(A2021_2022_Mean$APT_NAME,
                                        A2021_2022_Mean$Mean_TOT)

class(A2021_2022_Mean$APT_NAME)
```

```{r}
ggplot(A2021_2022_Mean,
       aes(Mean_TOT_2,
           APT_NAME,
           fill = APT_NAME)
       ) +
  geom_col(fill = "darkgreen", alpha = 0.5) +
  geom_text(aes(label = Mean_TOT_2), stat = "identity", hjust = 1.5, colour = "white")
+
  gghighlight(APT_NAME == "iGA Istanbul Airport") +
  labs(title = "Airport with the highest 'number of flights' turnaround post Covid_19",
       x= NULL,
       y = NULL) +
  theme(legend.position = NULL) +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  guides(fill = "none")
```

Amsterdam-Schiphol maintained the leading in all the era under considerations. Surprisingly, IGA Istanbul (Turkey airport) made 2nd position which was 7th on the queue before Covid_19. Turkey Civil Aviation Industry (TCAI) made research on reason while passengers lost confidence in the flights operations. "Another important aspect for demand recovery is that airlines have to investigate the reasons behind the decrease in passenger confidence and how to regain it". (Muhammet Deveci, & et al., 2022). This obviously paid off. Also, the government provided a 24/7 5,000 square meter PCR testing center with 20,000 capacity daily inside the Istanbul Airport terminal serving the passengers. All test can do quickly with results out with delay, according of Istanbul Airport report (online)

Research question

3. Which country's airport shows the government quick willingness to adjust to normal life by lifting or reducing Covid_19 restrictions?

Choose the top 4 airports in pre_covid_19 and consider their performance during and after covid_19 using lollypop graph.

```{r}
A2016_2019_T4 <-
  A2016_2019_Mean [1:4,]

A2020_T4 <-
  A2020_Mean [1:4,]

A2021_2022_T4 <-
  A2021_2022_Mean [1:6,]

list(A2016_2019_T4)
```

```{r}
New_flights <-
  merge(A2016_2019_T4,
        A2020_T4,
        by = "APT_NAME")

New_flights2 <-
  merge(New_flights,
        A2021_2022_T4,
        by = "APT_NAME")

New_flights3 <-
  New_flights2 %>%
  select(APT_NAME,
         Mean_TOT_2.x,
         Mean_TOT_2.y,
         Mean_TOT_2)
  colnames(New_flights3) <-
    c("Airport",
      "Pre_Covid",
      "Covid",
      "Post_Covid")
```

Let convert the Airport to a factor to allow arranging the lollipop in proper order

```{r}
New_flights3$Airport <- factor(New_flights3$Airport)
New_flights3$Airport <- fct_reorder(New_flights3$Airport,
                                    New_flights3$Covid)

class(New_flights3$Airport)
```

```{R}
ggplot(New_flights3,
       aes(x = Airport)
       ) +
  geom_point(aes
             (y = Covid),
             colour = "darkblue",
             size = 3,
             alpha = 0.8) +
  geom_point(aes
             (y = Post_Covid),
             colour = "darkgreen",
             size = 3,
             alpha = 0.8) +
  geom_segment(aes
               (x = Airport,
                 y = Covid,
```

```
                xend = Airport,
                yend = Post_Covid)) +
  labs(title = "Flights resuscitation relationship after covid_19",
       subtitle = "Blue: Covid                  Green: Post-Covid_19",
        y = "Number of flights",
       x = NULL) +
  theme_bw() +
  theme(panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.background = element_blank()) +
  coord_flip()
```

Netherlands (Amstedam - Schiphol airport) shows quicker willingness to adjust back to normal life ahead of others.

Research Question

4. Which country's airport recorded the highest flight per day after (post) Covid_19.

What is the behavioural pattern of the European aviation operations before the appearance of Covid_19. in respect of

```{r}
flights_4 <-
  flights %>%
  filter(APT_NAME == c("Amsterdam - Schiphol",
                       "Frankfurt",
                       "London - Heathrow",
                       "Paris-Charles-de-Gaulle")
           ) %>%
  select(FLT_DATE,
         YEAR,
         APT_NAME,
         FLT_TOT_1
         ) %>%
  drop_na(
  ) %>%
  rename_with(.cols = 3,
              ~"Airports")
```

```{r}
ggplot(flights_4,
       aes(
         x = FLT_DATE,
         y = FLT_TOT_1,
         colour = Airports)
       ) +
  geom_point(alpha = 0.5) +
  theme_test() +
  theme(legend.position = "bottom") +
  labs(title = "Country with the hightest flights per day after Covid_19",
x = NULL,
y = "Numbers of flights per day")

```

Using facet_wrap to segment each airport separately for better visualization.
```{r}
ggplot(flights_4,
       aes(x = FLT_DATE,
           y = FLT_TOT_1,
           colour = Airports, )
       ) +
  geom_point(alpha = 0.5) +
  facet_wrap(~ Airports,
             ncol = 4) +
```

```
  theme_classic() +
  theme(legend.position = "bottom", names(NULL)) +
  labs(title = "Country With The Hightest Flights Per Day After Covid_19",
x = NULL,
y = "Numbers of flights per day")
```

Netherlands recorded the highest numbers of flights by day post Covid_19. (Seveno Victoria, 2022). According to Seveno V. (2022) thanks to the EU digital covid_19 certificate and the relaxation of various international travel restrictions. London - Heathrow has a 100,000 daily passengers limits up until October 2022. (Cunningham Ed, 2022), obviously the reason why they were left behind.

Research question

5. Has EU Aviation Industry fully recovered in the numbers of flights per day?

```{r}
flights_Day <-
  flights %>%
  group_by(FLT_DATE) %>%
  summarise(FlightsPerDay = sum(FLT_TOT_1))
```

```{r}
flights_Day %>%
  ggplot(aes(
    x = FLT_DATE,
    y = FlightsPerDay
    , colour = FlightsPerDay)
    ) +
  geom_line(alpha = 1) +
  gghighlight(FLT_DATE >= "2020-04-01") +
  theme_minimal() +
  theme(axis.text.y = element_blank(),
        axis.ticks.y = element_blank()) +
  labs(title = "European Aviation Flights Operations Recovery Pattern",
x = NULL,
y = NULL)
```

EU Aviation Industry has not fully recovered in it total number of flights per day compared to pre-Covid_19. There is still about 20,000 daily flights difference between pre and post-Covid_19

Conclusion

EU aviation industry is not yet where they were before Covid_19 emergence, but there have been great improvement from 2021. and there seems to be possibilities of getting there in the next 2 years or 3 years if the growth rate continues. Although, one of the imprint of covid_19 is the new wave of virtual system of meeting, learning, participation etc. if this continues, we might not experience the volumes like it use to be in EU and the globe at large.

Currently, London - Heathrow has reclaimed the position of the busiest airport as at the time of this report (April 2023), (Cunningham Ed, 2022), and has taken over from Amsterdam - Schiphol. There will need for further investigation to get to the root cause of this. However,

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