Impact of Covid-19 on Air Traffic and Environment

MSc. Data Analytics

Database and Analytics Programming

CA2 Project Report

***Abstract*—The novel coronavirus has impacted almost all businesses from small scale to large scale. Many governments are still struggling to pull their economy back on track while struggling to control the spread. One such industry that was directly impacted is the Airline industry. Many airlines were forced to stop their flights for months due to the nationwide lockdown and closure of borders. While the pandemic caused huge losses to businesses, it had some positive impact on the environment. This proposal addresses the impact of covid on Air traffic and in turn the rate of carbon dioxide emissions from industries and Aircraft in Europe.**

I. INTRODUCTION

The world came to a standstill when the covid outbreak happened last year. With the world economy falling apart, governments are trying hard to contain the spread. Many businesses have gone bankrupt and are now in deep debt. One such industry that went flat is the Airline industry. Airlines throughout the world depend on the revenue generated by the number of passengers flying their planes. When countries announced lockdown and closed their borders, the flight services halted and almost 90% of the flights were grounded and only a few were allowed to operate to carry medical supplies and airlift-stranded people. Many of the domestic Airlines were closed permanently and other international airlines faced a huge loss. Throughout the world, cases started raising, and by the time governments realized its severity, it was too late.

World pollution rates seem to be increasing day by day. It has been a major concern since industrialization. With the same pace of increase in carbon dioxide emissions, world forums have concluded that the impact might be irreversible. The effects of the rise can be seen in terms of ozone layer depletion and temperature rise.

In this proposal, we firstly study datasets separately using visualizations and secondly analyze the impact of covid on the airline industry and environment in Europe (more specifically Ireland). The motive is to analyze the before and after effects of covid and try to identify insightful patterns out of it.

II. RELATED WORK

A. Dataset 1: World Covid Data

The first case of coronavirus was reported in December 2019 in Wuhan, China. Since then, there has been a direct impact on almost all sectors. The scenario right from the start has been clearly explained in [8]. The epidemic in several cities in China resulted in tremendous growth worldwide. Coronavirus- 2019, formally referred to as the condition (COVID-19, by WHO on February 11, 2020) It is a possible zoonosis with a low to moderate mortality rate (estimated 2% to 5%). There is currently no definitive COID-19 treatment while several medications are being investigated.

Many scholars and researchers have been trying to identify the variants, the impact of each variant, the number of cases, vaccination trials, the success rate of vaccinations, and so on. The World Health Organisation (WHO) has created many interactive dashboards to observe and report the trends. While it is hard enough to treat the infection, few to many people are asymptomatic.

A series of experiments have been carried out worldwide to quantify the extent of COVID-19 asymptomatic cases. The international electronic data databases[9] were checked for studies by two experienced research authors(MA and DBK). Between 28 and 31.4 percent of the included studies was a weighted pooled average of SARS-CoV-2 infections. Among the survey participants, the number of infections ranged from 1.4% to 78.3%. The results of this meta-analysis indicate that the weight of covid-19 asymptomatic cases is

concentrated at 28 percent to 31.3 percent during the infection.

In Ireland, a similar scenario was seen. As per [10], by July 19th, over 1700 deaths were reported from COVID-19. Almost 3000 patients were taken to the hospital. The Irish government's reaction to the crisis has been thorough and prompt. It is admirable that traditional and social media are used to educate the public. In the early stages of the pandemic, a high percentage of deaths happened in nursing homes and other residential areas that did not receive adequate treatment. The government has been praised for its adherence to a reasonably transparent data strategy and use of social media.

B. Dataset 2: Air Traffic Europe

External factors, such as fuel shortages, natural disasters, terrorist attacks, downfall in the economy, and diseases, make air traffic vulnerable, much like other sectors of the economy as explained in [11]. These factors seem to have a greater and faster effect on the air traffic industry, as unexpected rises in flight cancellations travel bans, and border closures easily impacted the airline industry. The various reactions are mostly since the Covid-19 crisis spread rapidly across the world. This paper is a first step toward recognizing the industry's viewpoint on Covid19's effect on commercial aviation. By looking at airline capacity and air freight demand for the first four months of 2020, were able to paint a picture of the shock. According to a sample of senior aviation executives, the background data provided for an evaluation of long-term Covid-19's effects. The distinction between the domestic and foreign markets, which has been illustrated in several online seminars held during the Covid-19 crisis, did not come up as clearly in the interviews, what came across was that most European countries are too small to support airlines. The results of this paper reflect a preliminary evaluation that can assist the aviation industry, as well as other relevant industries such as tourism, in preparing for the recovery period. Future research may concentrate on a variety of topics.

In article [12], the authors concluded that Air transport (both passenger and freight) accounts for a limited portion of the value-added in OECD countries (around 0.3 percent on average). Even though, it is a major driver of economic growth due to strong inter-industry linkages with both upstream and downstream sectors. Passengers' behavior has changed as a result of the COVID-19 crisis, travel restrictions, and the subsequent economic crisis, resulting in a sharp drop in demand for airline services. Due to the pandemic, a lot of passengers and tourists were more concerned about their health, and followed by heavy restrictions implemented by the government, people were not able to travel which resulted in a decline. The overall ratio was 90% down by April 2020 and was still down by 75% in August, according to IATA. In the future, policy initiatives should support the aviation industry's resilience and sustainability, and governments must strike a balance between industry support and the need to maintain competitiveness, especially when considering firm-specific steps.

C. Dataset 3: Global Co2 Emission

Many studies have been done to track and predict the impact of carbon dioxide emissions. In [14], the authors analyzed the emission rates of CO2 till 1999 and presented a forecast of world emission growth from 2000 to 2020 of 2.2% for developed countries and a 3.3% increase for developing countries. To support his forecast, the data provided by Eurostat [15] confirms that the rate of emissions was consistent with a 3-2% increase with significant variability. But the overall trend for Europe went down during 2009 due to the global financial crisis and increased for a year and the trend was downward thereafter. The rate saw further depletion due to the pandemic.

In articles [16] and [17], a global view on the impact of coronavirus on Co2 emission by various sectors like aviation, ground transportation, industries, etc has been put together clearly. We can see that the emission rate decreased rapidly with the confinement period. But only a mere change was observed in terms of overall emission. The majority of cut-off was observed for the Aviation industry and surface transport.

The International Energy Agency(IEA), has concluded that the covid pandemic has resulted in the largest ever decline in the emission rates globally. It also forecasts a predictable risk of a major jump in the demand for energy and an exponential increase in the emission rates.

These references describe the trends in global Carbon dioxide emissions. To study the trend in emission rate due to aviation in Europe, we further analyze few particular citations in detail.

D. Dataset 4: Emission from Aviation Europe

In the article [18], resourceful insights have been provided by the authors on the impact of covid in 23 European countries over 10 economic sectors. A clear-cut decrease by -12.1% of carbon dioxide emission can be seen. And The majority of the downfall happened within the first half of 2020 and

the major contributors for the change (93.7%) were Italy, France, and Spain. These were the countries that were worst affected during the first wave of the pandemic. Around 195,600 tons of carbon dioxide emission was avoided. Besides a 12% drop in overall co2 emission, around 8.5% drop in GDP was also observed. This shows that the existing economic structure is very laid back and some serious policies for climate change and financial structure have to be implemented.

III. METHODOLOGY

A. *Knowledge in Database (KDD)*

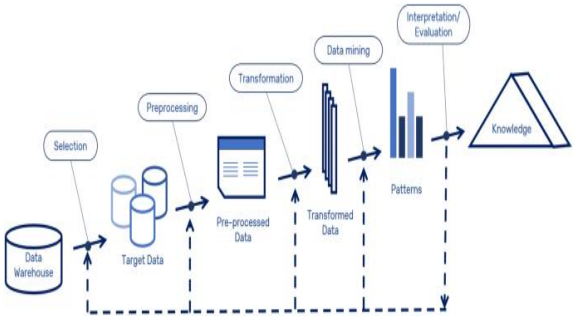

Fig. 1. KDD process flow

KDD is the process of retrieving knowledge from raw data through a series of steps. In our proposal, we have used KDD to retrieve, analyze, pre-process and integrate our data to gain intuitive insights

To implement the various aspects of our proposal we have used the following technologies:

- **Mongo DB:** A document-oriented database to store unstructured data like JSON. We have used MongoDB to store our unstructured JSON data retrieved from various sources and API.
- **PostgreSQL:** An open-source object-relational database to store data in the form of tables. We have used Postgresql to store our processed data to present combined insights of all the data gathered.
- **Python:** Python is a high-level, open-source language, used prevalently for ML and Data analytics. Throughout the process, Python has been used as the programming language for all processing purposes.
- **Microsoft Azure:** Microsoft Azure is a public cloud platform developed by Microsoft that offers a variety of cloud services like Iaas, Paas, etc. Our project has been hosted in azure with Linux implementation. Mongo DB and Postgres instances have been installed in azure.

IV. DATA MANAGEMENT

A. *Data Acquisition*

All four of our datasets were retrieved in various formats from credible government sources. Air_Traffic and Co2_emission_Europe were obtained as CSV files and were converted into JSON using python and pushed into MongoDB for initial storage.

1. *Dataset 1: World Covid Data*

The World covid data was obtained as a JSON file from0 ourworldindata [1]. It has 84097 rows and 60 columns. It contains notable columns like covid_cases_confirmed, deaths, vaccinations, age_of_patients.

2. *Dataset 2: Air Traffic Europe*

The Air traffic data was obtained from Eurocontrol [4] as CSV. The air traffic data was obtained from Eurocontrol (4) as an excel file. The dataset consists of 54538 rows and 13 columns where the useful features are listed below. Month, Airport name, the total number of flights, flight date, state name

3. *Dataset 3: Global Co2 Emission*

The Global Co2 emission dataset was obtained as a JSON file from ourworldindata [6] and downloaded from [7]. The dataset contains 56 columns and 23,708 rows in total. It contains data regarding total Co2 emission, Co2 emission due to burning gas, oil, cement, coal, nitrogen oxide.

4. *Dataset 4: Emission from Aviation Europe*

The Co2 emission due to the aviation industry in Europe was obtained as a CSV file from Eurocontrol [3] and downloaded from [4]. The dataset contains 5 columns, namely Year, month, state name, state_code, Co2 emission quantity over 5736 rows.

All the files were programmatically pushed into Mongo DB for further processing. For detailed data description, refer to the Github repository

https://github.com/SarathNCI/DAP_Project

B. *Database Management*

All the datasets obtained were either unstructured (JSON) or semi-structured (CSV). The datasets were obtained from various sources and might contain missing values, duplicates, or unwanted features. For further pre-processing, the data was

programmatically converted into JSON (CSV to JSON) and was pushed into Mongo DB collections

programmatically using python. After retrieving the data from Mongo DB further pre-processing is done separately.

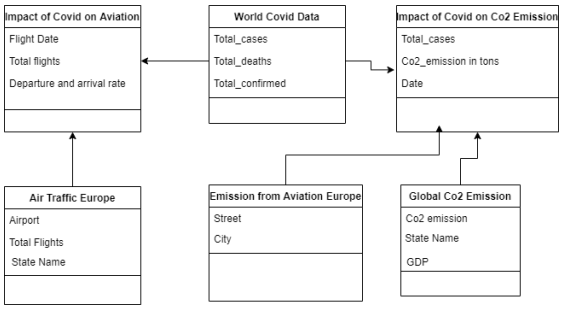

Fig. 2. Flow Diagram

V. DATA PRE-PROCESSING

All the datasets were pre-processed in 4 major steps: Check for missing data, drop unwanted columns, impute missing data, rename columns that are lengthy and erroneous.

A. Dataset 1: World Covid Data

1. For pre-processing, the covid dataset was retrieved from Mongo DB and translated into a pandas dataframe.
2. Column names are renamed for better understanding during visualization
3. We are selecting the 'world' rows by their index and dropping the respective rows.
4. Dropping the unwanted columns from the dataset

B. Dataset 2: Air Traffic Europe

1. The Air_traffic dataset was accessed from Mongo DB and being converted into the pandas dataframe for pre-processing
2. State names have been filtered and a copy of the data frame has been taken
3. Before pre-processing, using lambda function the string values are converted into an integer for a proper visualization
4. The filtered data has been saved and used for visualization

C. Dataset 4: Global Co2 Emission

1. The global Co2 emission was retrieved from Mongo DB and converted into pandas dataframe for easy processing.
2. Check for missing values: The dataframe was accessed for missing data. It was observed that around 49.1% of data was missing.
3. Before handling missing data, unwanted columns like id, consumption Co2, cumulative Co2 emission due to various sources, per_Capita data were dropped and lengthy columns were renamed
4. After dropping unwanted data, the missing values were handled by using Simple Imputation from sklearn
5. The pre-processed data was saved for the next step: visualization in a new dataframe

D. Dataset 4: Emission from Aviation Europe

1. The Co2_emission_Europe data was retrieved from Mongo DB and converted into pandas dataframe for further processing
2. There were no missing values in the data and hence this step was skipped
3. It was observed that the Co2_quantity column had commas in between which were posing as a hindrance for visualization purposes. So the comma was removed from the data using a function.
4. The upper case of the Co2 quantity column was also mismatching with the Air-traffic dataset. It was converted into the title case using toTitle() function.
5. The pre-processed data was saved for further visualization in a new dataframe

VI. VISUALIZATION

A. Dataset 1: World Covid Data

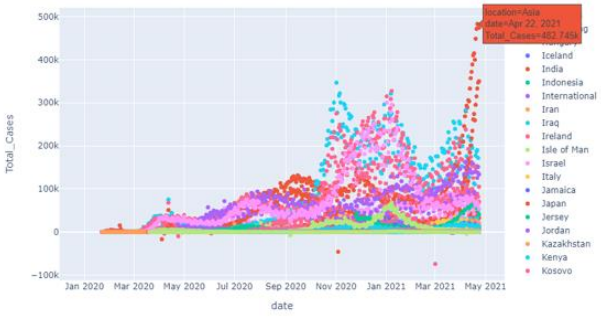

Fig. 3. Countries with covid cases

The above figure represents the total covid cases for Jan 2020 to May 2021. Asia has the highest cases, and it has an exponential increase. Followed by Europe which has the highest number of cases overall. At one stage India has very fewer cases compared to other countries but after the end of 2020, we can see a spike in the cases.

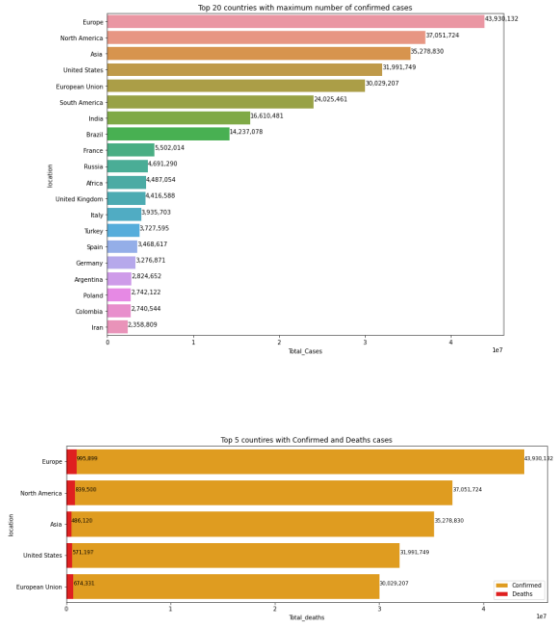

Fig. 4. Countries with a maximum no of confirmed and death cases

Europe is on top of the confirmed and death cases followed by North America and Asia. This shows the cruelty of the Covid in the death rate.

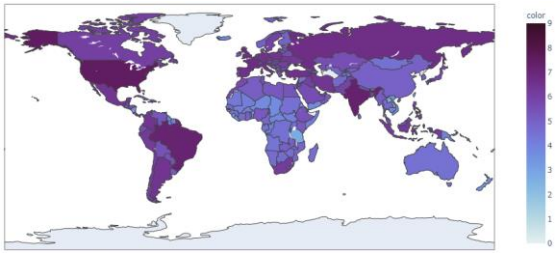

Fig. 5. Countries with a maximum no of confirmed cases

High-dense countries are with the highest number of cases. In the above map, most countries are affected, and it shows the seriousness of the pandemic. It alarms every person's health state.

B. Air Trafic Europe

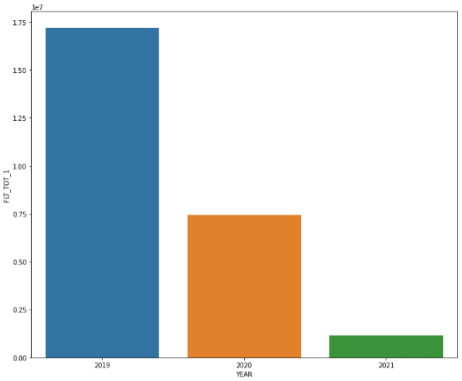

Fig. 6. Number of flights based on year

The above figure represents the total number of flights based upon the year, where it is clearly shown that the flight numbers have gradually decreased as covid-19 cases started to increase and 2019 was the year where there were more flights, followed by 2020 which was half of 2019 outcome and least was 2021

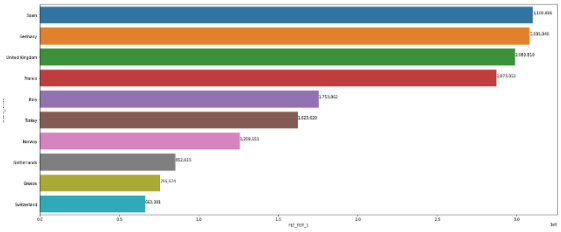

Fig. 7. Total number of flights arrived and departed in selected 10 countries

The above figure represents the total number of flights that arrived and departed in the top 10 selected countries namely Spain, Germany, United Kingdom, France, Italy, Turkey, Norway, Netherland, Greece, Switzerland where Spain has the more number of flights that arrived and departed when compared with other countries. Secondly, Germany and United Kingdom with a few variations in flight numbers, are to be the followed up countries to have more number of flights. However, Switzerland seems to be the only country to have a low number of flights when compared.

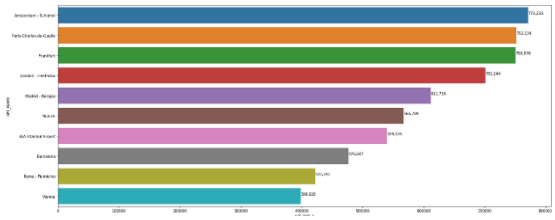

Fig 8. Number of flights based on airport

The above figure portrays the total number of flights based on airport names where Amsterdam seems to be the one to have a large number of flights and a bit busier even during the pandemic when compared with other airports. Followed by, Paris and Frankfurt with a slight difference in numbers and Vienna to be the last one with a low number of flights.

C. *Global Co2 Emission*

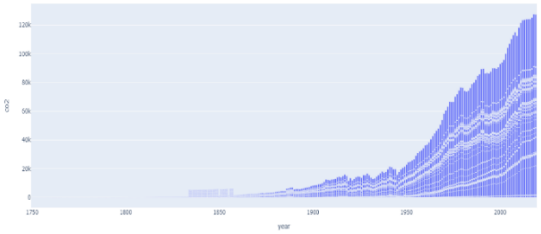

Fig. 9. Global Carbon dioxide emission rate

The above figure represents the global carbon dioxide emission since the 1800s. The plot clearly shows an exponential increase in the emission rate since industrialization (1950 and onwards).

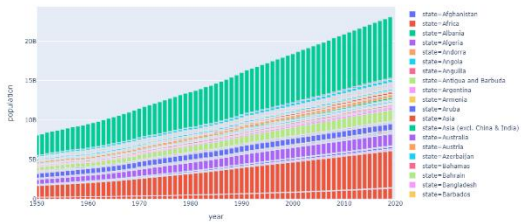

Fig. 10. World population Vs Year

One of the main reasons for the increase in CO2 emissions was industrialization. This was due to the sudden increase in population. In the plot above we can see the consistent growth in the world population.

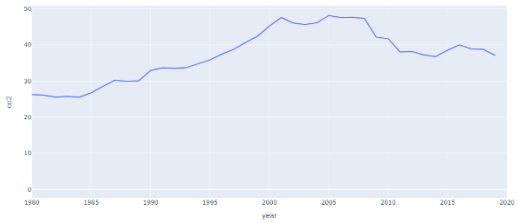

Fig. 11. CO2 emission rate in Europe since 1980

The Co2 emission rate in Ireland since 1980. Yet again there was an increase mid-way. And small changes throughout the period.

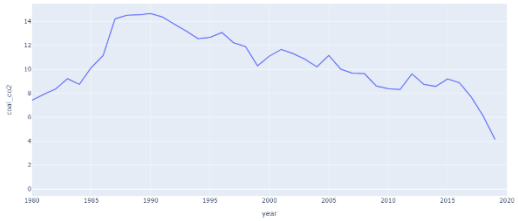

Fig. 12. Emission rate due to burning of coal

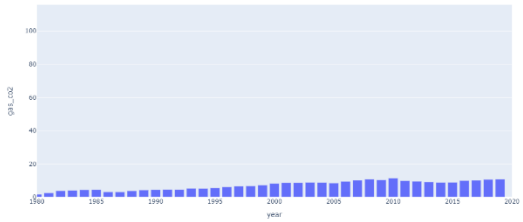

Fig. 13. Emission due to usage of gas as an energy source

Since the usage of coal has reduced since improvements in other energy sources, we can see a clear dip in the emission rates due to the burning of coal. As an alternative to coal, gas has been used as the main energy source in Ireland besides electricity.

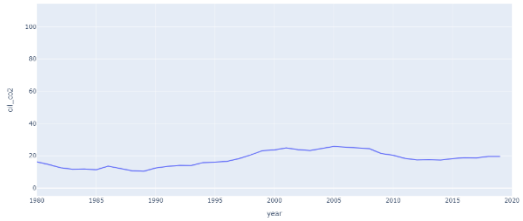

Fig. 14. Emission due to the burning of oil as an energy source

Lastly, the emission due to the burning of oil has been less since the start.

D. *Emission from Aviation Europe*

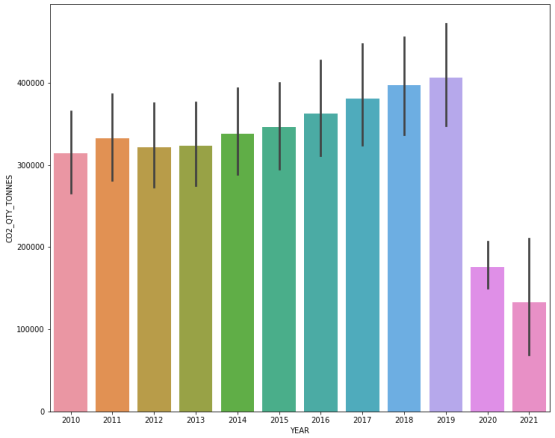

Fig. 15. World population Vs Year

The above plot describes the Co2 emission from air transportation in Ireland. The emission rate was coherently increasing till 2019. We can see a dip in emission rate in 2020, mainly due to the pandemic

VII. Combined Visualization

A. *Covid and Air Traffic*

The below graph is the sequence of comparison between the covid and air-traffic where we can see the huge decrease in the arrival and departure of the airports when the covid cases increases. Covid tests

are increased in 2021 as per the chart. We can see the marginal increase in the flight operations as they resume when there is a decrease in the covid cases.

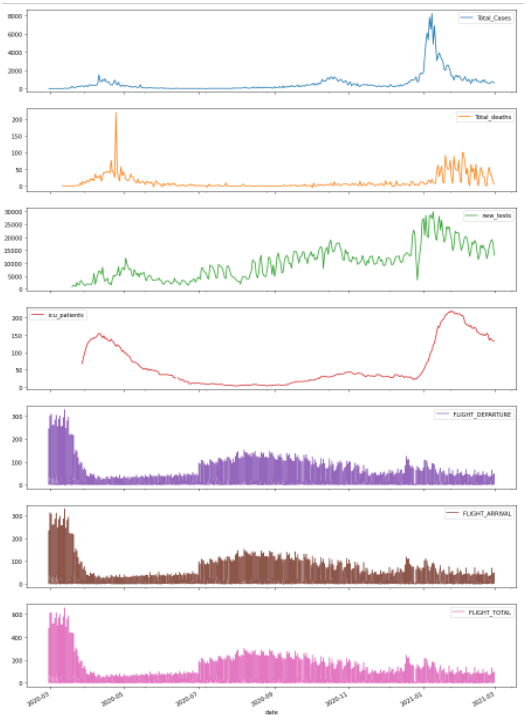

Fig. 16. Covid vs Airtraffic

For a comparative study of covid and air traffic, we have created an interactive plot. We can pick any airports/county from the dropdown and select columns to be compared to air traffic from the second dropdown. When changing or selecting multiple columns, the plot updates dynamically. In a single plot, instead of several continuous charts, we can obtain the complete comparative perspective.

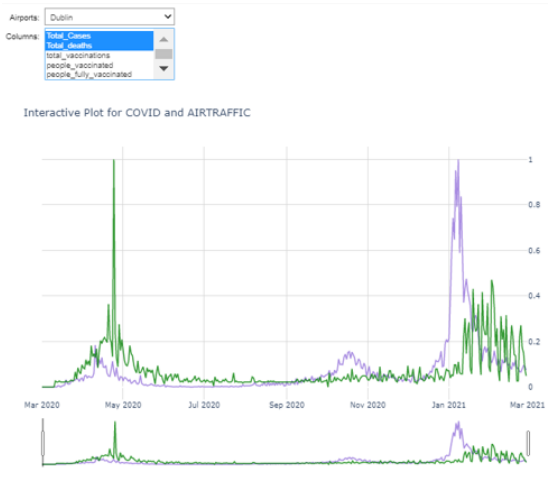

Fig. 17. Covid vs Airtraffic

If we hover over the plots, it shows us the column names and updates dynamically. We can see clearly that an increase in covid cases directly increases the death rate as well. Similarly, below is the comparison between covid total and flight total. In May 2020 there was high traffic in the airports, but it suspends all air transport due to the rise in the covid cases.

Fig. 18. Covid vs Airtraffic

We can find the correlation between two or more columns in a single plot. The below plot gives us insights on how the increase in covid impacts the covid tests as well airport traffic.

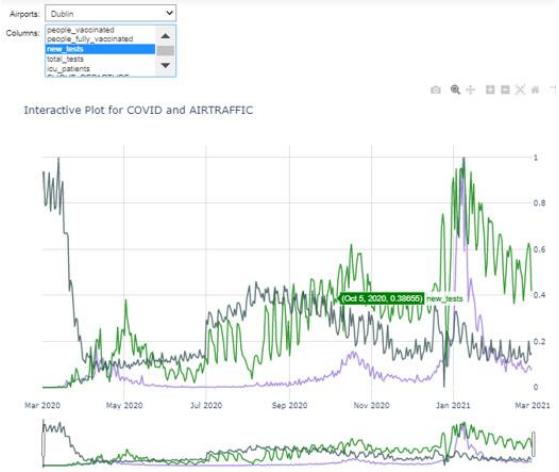

Fig.19. Covid vs Air traffic

B. Air Traffic and Co2 Emission Europe

The Air traffic dataset and Co2 emission in Europe dataset were left joined based on state name and year. The resulting rows of 59472 were then used for obtaining combined insights

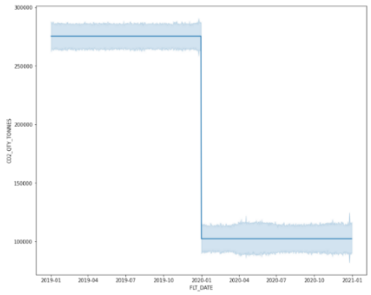

Fig. 20. Co2 _quantity Vs Date

The emission rates due to the aviation industry started declining rapidly during the pandemic as stated in the previous section. In the figure above, we can see a clear dip in the emission level between 2019 and 2020

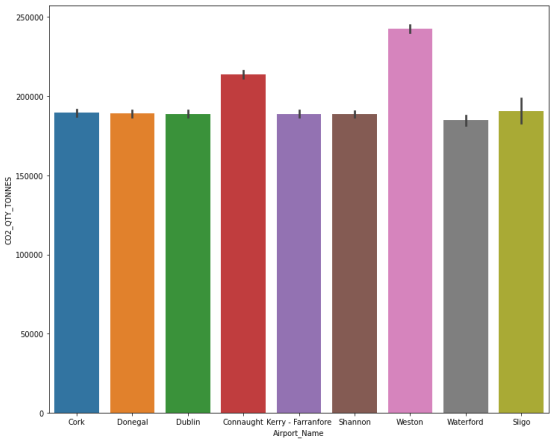

Fig. 21. States Vs Co2 Emission quantity

The clear segregation of emission levels in different counties of Ireland is presented in the above plot. And the emission rate month-wise throughout Ireland is presented in the plot below. Yet again we see a clear decline in the quantity of Co2 emission since the start of the year 2020 from 207331.81 tons to the lowest of 40032.25 tons during the complete confinement period

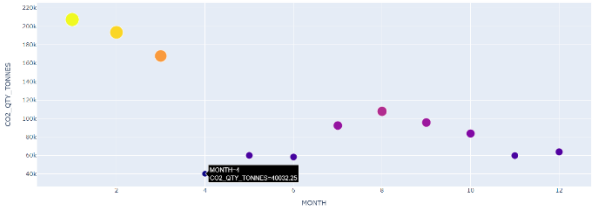

Fig. 22. The month-wise emission rate of Co2

VIII. CONCLUSION

The world is going through tough times and as per prediction, the second and third waves are much more intense and devastating. As shown in the visualizations, the number of cases in few countries, especially Asian countries are rising exponentially. As a result, many countries are imposing confinements and lockdowns to control the spread. As a result, the Aviation industry is starting to suffer again after a small break. As in the case of Ireland, the overall control measures seem to be working and the number of cases is seen to be contained. With the relaxation of the lockdown, the aviation industry is again starting to improve financially as the number of flight services is slowly increasing. And with this, the level of emission from the aviation industry is expected to increase by a smaller ratio. But the overall CO2 emission as of now has decreased to a greater extent than 2019 and if this can be well maintained and with new policies on environment and sustainability, this level of emission can be sustained in the future.

IX. FUTURE WORK

The work presented above is based on the before and after effects of covid on the aviation industry and the environment(Co2 emission). With the current scenario, it is unlikely that we would be free of covid-19 any sooner. In the future once enough data is available, the overall impact of covid-19 on various other sectors can be analyzed and the overall loss and gain aspects can be evaluated

ACKNOWLEDGMENT

All the works above have been done with the guidance and support of the National College of Ireland(NCI) and Prof. (Dr.) Athanasios Staikopoulos. We, the authors of this report are extremely for their help and this is one of many reports on the impact of Covid-19.

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