

# Bankruptcy By COVID-19: Top Five Airlines Affected

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**Abstract-** With quarantines and low flight activity across the world, airline companies struggled to make ends meet. The goal of this experiment was to examine which airline company would file for bankruptcy first. We developed a SIR model simulating COVID-19's interaction between the United States and five international countries using distinct airlines over six months. By performing a mutually exclusive tuple-pair simulation using the United States and the foreign countries asynchronously, the results conclude that no airline had undergone bankruptcy.

## I. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a respiratory illness that can spread from person to person. The virus that causes COVID-19 is a novel coronavirus that was first identified during an investigation into an outbreak in Wuhan, China. On January 30th, 2020, the WHO declared COVID-19 a Public Health Emergency of International Concern <sup>1</sup>. International airlines caused the virus to be present in more than 100 countries. The presence of the virus in a country indicates there is at least one confirmed infected individual in that country declared by the local hospital. With the number of cases increasing, individuals became fearful of catching the virus, prompting them to cancel or postpone their international trips. Shortly after, governing bodies around the world took the initiative to put forth quarantine protocols. These protocols ordered individuals to remain home and only leave in case of an emergency or to purchase essentials.

With more government regulations introduced, traveling outside of the country became difficult. Airlines must travel even with near-empty flights to retain valuable airport slots, as stated by EU laws and other significant aviation associations. These regulations cause airlines to fly ghost-like airplanes, causing financial stress. Revenue for the first quarter, and possible remaining quarters of the year, are expected to be lower than usual and could take years to recover. Maintaining a low level of income might be the most challenging task for large companies since they are expensive. We may start to wonder how long airline companies will last before they collapse, which leads us to the following question. Which airline is more likely to file for bankruptcy from COVID-19? Our metric focuses on the number of flights per day over six months. Our simulation examines this question by focusing on COVID's interaction between the United States and five countries from around the world with their most commonly used airline. Spain and Emirates, Egypt and Turkish Airlines, New Zealand and Air New Zealand, Qatar and Qatar Airways, and Singapore with Singapore Airlines.

## II. METHODOLOGY

We will be creating a SIR model between the United States and each country asynchronously, simulating airline flights for six months starting from March 8th, 2020. We chose March 8th because of each country containing at least one confirmed COVID-19 case, verified by the WHO <sup>2</sup>. We decided to make the simulation an asynchronous tuple interaction between a foreign country and the United States because of the disadvantage it would bring in combining individual airlines since it would raise the infection rate and alter the airlines' potential ability to fill airplane seats and make a profit. We chose five distinct airlines from five different countries around the world, Spain and Emirates, Egypt and Turkish Airlines, New Zealand and Air New Zealand, Qatar and Qatar Airways, and Singapore with Singapore Airlines. We chose these countries and airlines since we wanted to choose a country from each continent as well as the countries' most used airline. From the five chosen airlines, the biggest airline is Emirates. Emirates is also the biggest airline company in the

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<sup>1</sup> <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen>

<sup>2</sup> <https://www.worldometers.info/coronavirus/>

Middle East, operating over 3,600 flights per week in 80 different countries around the world <sup>3</sup>. The contact rate and recovery rate remained consistent for all countries with the contact rate staying at one infection per seven days, and one recovered individual per two weeks. We chose the beta value to be one infected individual per week since we assumed an individual would come in contact with another individual once every seven days to leave the house for essentials. We chose the gamma value as one recovered individual per two weeks since we assumed the worst-case scenario when trying to recover from the flu for an average healthy adult. For airline fuel expenses, we kept track of the number of flights per day and multiplied the number of flights by the fuel cost at \$4,000.00. We chose \$4,000.00 as the fuel cost per trip since we gave each country the benefit of the doubt that the duration of the trip was short. We then took that result and subtracted it from the total amount of money made that day from the number of tickets sold.

For each airline, we gathered data on the most common airplane used and kept track of the maximum seat capacity of the airplane model. Ticket prices remained the same for all airlines at \$356.51. We used \$356.51 since this was the average airline ticket price based amongst various airline websites and government air fares <sup>4</sup>. Sixty flights occurred per day for six months. We chose sixty flights since the computational power of our computers began to use much of its resources as we increased the number of flights past this capacity, taking a long time to calculate our simulation. The sixty flights occurred back and forth between the foreign country and the United States, giving thirty flights per country.

To begin our flight simulation, we assumed a random number of people boarded the airplane. We calculated the random number of people by taking the airplane seat capacity and multiplying it by a percentage out of one hundred. We determined the percentage out of one hundred by the total percent of people infected in both countries. Also, per flight, we assumed the airplane possibly contained an infected individual, or individuals, based off of the total percent infected from both countries. The total number of infected individuals gets calculated by adding the percent infected in a foreign country, plus the percent infected in the United States. When the total percent infected from both countries fall within a specific range, we randomly set a certain amount of individuals on that flight to be infected or fill up the airplane capacity. We used the total percent of individuals infected from both countries to dictate the number of people infected and seat capacity on the flight because this allowed for our simulation to grow over six months. Only using the percent infected from one country would make it difficult to establish a range since the percent would be tiny. Adding the percentages of both countries gave a better approximation.

As the percent of total infected individuals rises, the probability of the flight containing infected individuals also rises. We also assumed that as the total number of infected individuals rose, we decreased the number of flights per day due to fewer individuals wanting to use the airline. For each flight, those infected on the plane contributed to the destination countries' infected percentage, and those susceptible contributed to the destination countries' susceptible

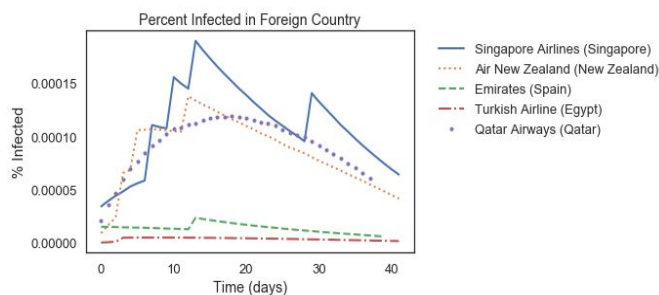
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<sup>3</sup> [https://en.wikipedia.org/wiki/Emirates\\_\(airline\)](https://en.wikipedia.org/wiki/Emirates_(airline))

<sup>4</sup> <https://www.bts.gov/air-fares>

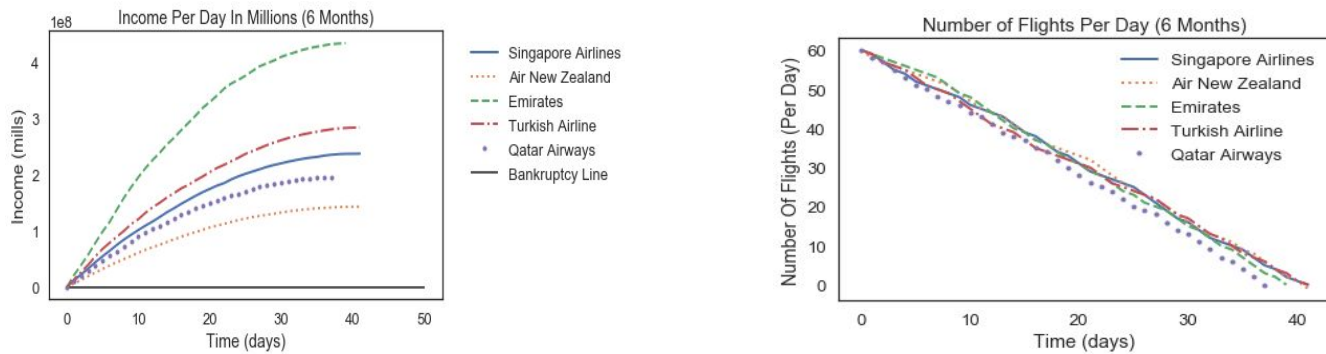
percentage. The recovered percentage was not modified because we assumed that an individual did not recover from the virus in a single flight. We did not simulate a typical flight duration from one country to another since simulating legitimate flight hours would involve a much more complex system. Per flight hour, the SIR model updated to keep track of the latest number of infected and susceptible individuals heading towards the country. After the number of flights flown per day, each countries' model updated to simulate the remainder of the day. If the number of flights reached zero, we ended the simulation between that foreign country and the United States since it is impossible to fly people without the airline having airplanes available. For the last part of our model, we swept our beta values at .14, one individual infected every seven days, and .80, one individual infected almost every day. Our gamma value remained at one individual recovered per two weeks. We chose .14 and .80 to be our beta values because we wanted to see if there was a noticeable difference in reducing the government's quarantine protocols with the spread of the virus. We chose our gamma to remain the same to act as our control variable in showing the differences in beta values. Sweeping the beta values allows us to change the number of interactions an individual might encounter with an infected individual. The different beta values are essential to sweep since various countries may have different quarantine protocols, changing the rate in which individuals get infected. Also, we only used two values for our beta and one value for our gamma because adding more than two values for our beta and more than one value for our gamma created a computational problem. Our computers were not capable of continuously running the simulation as we increased the beta and gamma values past this point. We predict that Spain, with Emirates airline, will be the first airline to go bankrupt since they have the highest starting infected percentage out of all other countries. We also predict that Emirates will be the first airline to stop flying. We also believe Emirates Airline will go bankrupt first because they have the most significant number of seats on their airplane. The higher number of seats will lead to the infected percentage to increase rapidly. Spain also has a more substantial amount of people infected in their country, which we believe will also assist in increasing the infected percentage.

### III. RESULTS

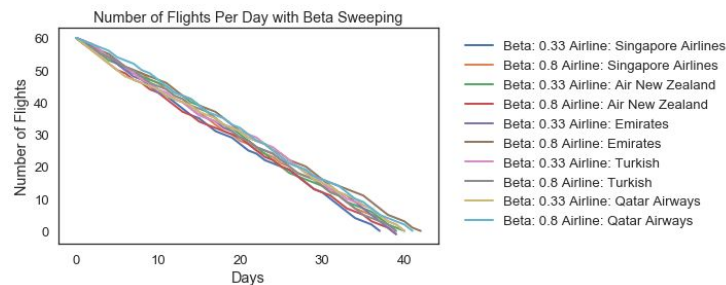


Shown in the figure above are the results after several simulations. Singapore airlines created the highest infected percentage, and Turkish Airlines had the lowest infected percentage. The percent of infected individuals over six months

was a small fraction of the susceptible population since all countries had a susceptible population in the millions with the infected population in the hundreds. An increase in the percent of individuals infected indicates a transfer of infected individuals from the United States to the Foreign Country. We also noticed that the flight simulation reached 40 days. What this tells us is that the number of flights had reached zero before the six months.



Although Singapore Airlines produced the highest percentage of infected individuals, they were not the first airline to stop flying. Qatar Airways was the first airline to end its flights after approximately thirty-eight days. Also, Qatar Airways was not the airline that produced the lowest profit. Air New Zealand made the lowest profit.



We swept the beta for each country between two values, 0.14 and 0.80. We only used two beta values since the graph became unreadable with more than two values. Shown above, the number of flights stayed relatively the same despite altering the beta values. Based on the various charts, we can form several observations. First, none of the airlines had gone bankrupt over six months. Second, although a country had a higher percentage of infected individuals, this did not directly correlate into the airline producing the fewest amount of flights and income.

#### IV. ANALYSIS

We predicted that Spain, with Emirates Airlines, would be the first airline to go bankrupt as well as the first airline to stop flying. Our predictions were incorrect. Emirates Airlines was not the first airline to go bankrupt or be the

first airline to stop flying. Emirates Airlines had produced the most amount of money out of all airlines. We believe this is because they had a larger airplane capacity than all of the other airlines. Although Spain contained a higher population of infected individuals, Spain also has one of the largest populations at approximately fifty million, making it one of the larger countries amongst all the countries in our model. The infected population over the susceptible population is a small percentage of infected individuals, which causes Spain to continue to allow more flights as opposed to Qatar, who ended the simulation first. Based on these observations, our model is slightly unpredictable and somewhat inaccurate for various reasons. First, the model depends on the probability of having infected individuals on a flight. Second, if the probability passes, there is a random chance for several individuals to be infected, which alters the number of flights for the following day. Although our model decrements the number of flights as the infected percentage increases, the percent infected has a chance to increase very slowly. Penultimately, the various beta and gamma values are not precisely correct since each country maintains a particular protocol to the pandemic. Lastly, various airline companies have different seating capacity, which affects the amount of profit made. Based on our model, generally, an airplane with more seats makes more money.

We believe our model to be descriptively realistic for the following reasons. Incorporating various airlines with different countries allows for extensive simulation since this is a global pandemic. We use factual data for all airlines and countries, which allows us to be in full control of our variables with fewer assumptions per variable used. Although COVID-19 is a relatively new virus, we assume close approximations for our beta and gamma values. Simulating the spread of disease through multiple countries with an interaction with the United States involves keeping track of many variables. We are limited to many of those variables because of public access and resources. We also believe our model is practical if only considering ticket prices as the source of income. Using ticket prices as the benchmark for income was the best choice since ticket price data was easier to find. Although we believe ticket prices to be a good indicator, we fail to incorporate more airline expenses, which significantly determines an airline's net profit. Our model relied on only going bankrupt by having fewer passengers fly over six months as well as fuel expenses, which depended on the total percent infected from both countries. We also fail to incorporate other countries that use the same airline. All airlines used in our model have multiple contracts with various countries around the world. If we took all of the countries that the airline is situated in, we would be able to get a more realistic simulation since these countries have their COVID-19 cases.

Although our model uses many precise values such as population, seat capacity, and COVID-19 data, our model is not entirely precise and robust. Our model contains many assumptions for determining a potentially infected individual, which leads to unpredictability. As an example, in the last graph with the sweeping beta values, some airlines are a few days apart. After numerous simulations, the number of days until the last flight sometimes may be closer together, although one beta value is high and the other value low. These results show inconsistency in using assumptions based on probability and randomness. Although the number of days until the last flight may be imprecise, particular graphs do show precision and robustness. Graph two, which contains the airline profit made over six months, was consistent when the simulation ran numerous times. This consistency is because of certain airlines having a higher capacity for passengers as

well as the country containing a high population with a low percentage of the population infected. Another consistency that showed precision was that countries with a smaller population experienced a more significant change than countries with larger populations. The smaller the population, the higher the impact the infected population had on converting susceptible individuals to infected individuals. The most noticeable changes came from countries that had less than ten million people, as shown in graph one. As each of those countries with lower populations interacted with the United States, they had a higher influx of individuals being affected. Another reason why precision and robustness displayed in our model is the consistent number of infected people per flight. Although we did say the probability was not entirely accurate, the model always increased the number of people infected on a flight as the number of total infected individuals increased.

Our model allows for a variety of countries to simulate against the United States. Given the susceptible, infected, and recovered population of a foreign country with specific airline data, it allows the model to run smoothly. We believe our model to be general because of the versatility in allowing different data sets, as well as the numerous conclusions drawn from simulating with different data sets. We believe it is imperative to keep our model versatile since this allows us to view our data from a different perspective that may help us solve our question. Although our model is general, we are limited to its scalability. Due to the limitation of flights per day capping out at sixty, increasing the number of flights per day presents a computational problem. For the most part, our models' skeleton presents more positives than negatives.

Although our airline bankruptcy model focuses on one aspect of airline profit, while neglecting expenses, we believe our model to be fruitful in multiple ways. The assumptions we made are relatively useful and relevant to today's global pandemic. Probability and randomness is a critical component in our model, but we support them with justifiable means. As an example, it is difficult to get an exact number of people departing on an airplane. It is also challenging to get an exact amount of how many people on that airplane are infected. The numbers we use are relative to the total percentage of people infected in both countries, which we believe to be a justifiable assumption.

Combining our earlier results, we believe that our model shows many limitations. Determining the number of airplane seats taken, susceptible, and infected passengers, heavily rely on assumed probability rather than factual probability. This assumed probability comes from combining the total infected population from the foreign country and the United States. The total infected population is not entirely accurate, which limits the models' ability to be trusted. We also believe our model shows limitations through insufficient accurate data. Due to our airline's only source of income being through ticket prices, and our model is set up only to accept tickets, this limits the model's ability to grow by implementing more sources of income. If we were to add more variables to produce income, we would not be able too. With our model only allowing one expense to be fuel cost, this also shows a limitation on adding more expense values. We also limit our model to only taking five countries. Each of these airlines inhabits many other countries around the world. Neglecting the addition of these airlines prevents the model from being accurate.



The conclusions we have made, based on the graphs and data we created, are useful to propel further research. Given enough resources and computational power, our model has the capability of scaling towards a more accurate model. The ideas used are also valuable since our model separates the interaction between foreign countries and the United States. This mutual exclusive tuple interaction allows for more excellent readability and understanding of an airline's position in the airline industry. Also, implicit results from the graph can help dictate what a country or airline should do during this pandemic to help prevent the spreading of COVID-19 from rapidly increasing.

## V. CONCLUSION

Despite many of the probabilistic assumptions made, we believe our model has the capacity for future research. The foundations of our model are not irrational. Our assumptions had stuck to close approximations to maintain a reasonable outcome. With airlines being such a significant industry in the world, many variables can be included in the model to expand the data. For future research, we may first begin by including legitimate COVID-19 beta and gamma values. The model alters to the rate of these values, which makes it necessary to gather them first. Secondly, including more airline expenditures would provide greater accuracy as to which airline would go bankrupt first, rather than relying on only customers flying per day and fuel cost. Overall, our model presents a good starting point to understand COVID-19's impact on the airline industry.

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