ORF 387 Project Progress Report

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Disclaimer: Python code was quite long and hard to fit into this report. However, if you would like to look through how we got the outputs we present in this progress report, please email either one of us!

Aim of the Project

The aim of this project is to study the effect COVID-19 has had on domestic flights in the United States and simulate how the virus might have spread around the country had stay-at-home orders not been issued.

Datasets used

- Data log of all domestic flights in the United States in 2019:
  - https://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=310&DB_Short_Name=Air%20Carriers
- Daily Total Confirmed Cases in Each US State:
  - https://github.com/nytimes/covid-19-data
- Stay-at-home order commencement date for each state:
  - https://www.nytimes.com/interactive/2020/us/coronavirus-stay-at-home-order.html
- Population of each US State (Census):
  - https://www.census.gov/data/tables/time-series/demo/popest/2010s-state-total.html#par_textimage

Part 1: Estimated Effect of Covid-19 on Domestic Flights

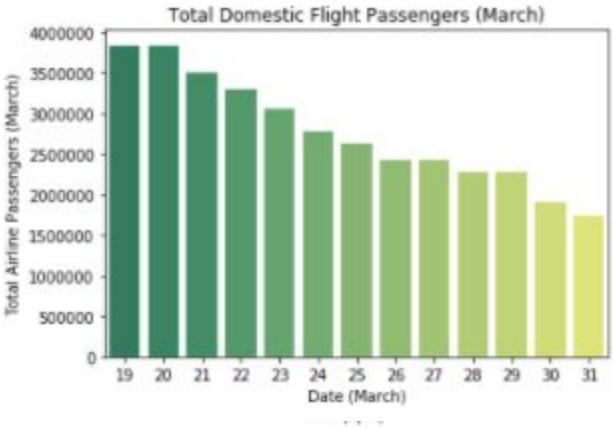
Using the data log of all domestic flights across the United States in 2019, we coded a program in Python to sift through the dataframe and calculate the following data:

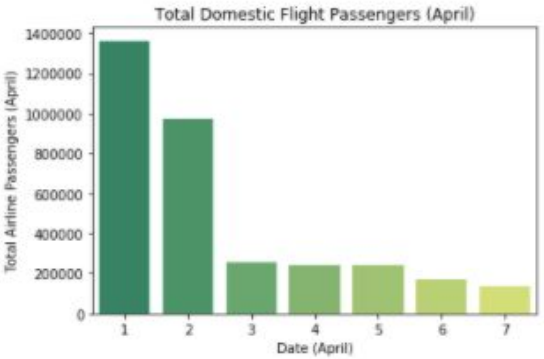
- Number of passengers leaving/entering each state each month (March and April 2019)
- Average daily number of passengers leaving/entering each state (March and April 2019)
- Total daily number of passengers during those two months.

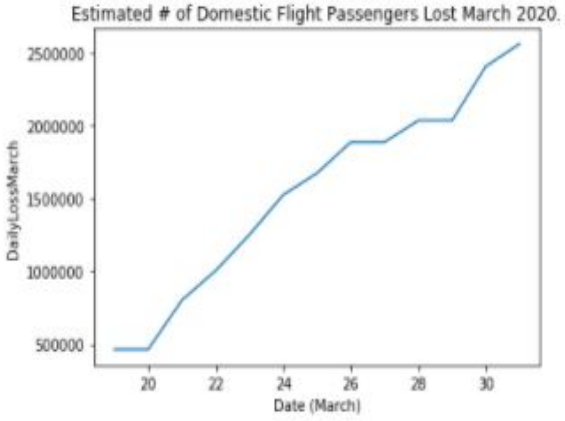
	PASSENGERS	DISTANCE	ORIGIN_CITY_NAME	ORIGIN_STATE_ABR	ORIGIN_STATE_NM	DEST_CITY_NAME	DEST_STATE_ABR	DEST_STATE_NM	MONTH
0	1	134	Birmingham, AL	AL	Alabama	Atlanta, GA	GA	Georgia	Mar
1	1	826	Birmingham, AL	AL	Alabama	Harlingen/San Benito, TX	TX	Texas	Mar
2	1	822	Birmingham, AL	AL	Alabama	Rochester, NY	NY	New York	Mar
3	2	906	Birmingham, AL	AL	Alabama	Midland/Odessa, TX	TX	Texas	Mar
4	2	744	Birmingham, AL	AL	Alabama	San Antonio, TX	TX	Texas	Mar

First Few Rows of the Data Log of Domestic US Flights

Using this information, we then used the dataset of stay-at-home commencement dates to estimate the daily loss of domestic airline passengers as each state went into lockdown (assuming that no one broke the stay-at-home orders and travelled domestically once a stay advised its citizens to stay at home). When a state went into lockdown, we removed the number of daily passengers entering/leaving that state from the total.







The two bar graphs above show the estimated change in total number of daily passengers on domestic flights in the months of March and April. The x-axis starts on March 19th as California was the first state to issue a stay-at-home order and ends on April 7th as South Carolina was the last state to issue a stay-at-home order on that day.

The two line plots illustrate the total number of domestic flight passengers lost as each state went into lockdown.

Part 2: Simulated the Spread of Covid-19 from March 19 to March 31st if States had not issued stay-at-home orders

Here, the first thing we did was use the domestic flight data log in order to create a more detailed data frame showing the daily passengers flying from one state to another. In the dataframe below, a row indicates the origin state whereas the columns indicate the destination state. For example, 2708 people travel from Alabama to Georgia each day on average in March.

Small Snapshot of DataFrame showcasing number of daily passengers flying between in each state in March 2019

Then we combined the dataset provided by the New York Times on daily Covid-19 cases in each state and the US Census, in order to get a better understanding of what percentage of the population was infected in each state on March 19th:

	Date	State	cases	Population	PercentInfected
0	3/19/20	AL	78	4903185	0.000016
1	3/19/20	AK	12	731545	0.000016
2	3/19/20	AZ	47	7278717	0.000006
3	3/19/20	AR	62	3017804	0.000021
4	3/19/20	CA	1067	39512223	0.000027

First few rows of DataFrame for cases in each state on March 19th

From there, we created a python program that estimated the change in the number of infections in each state as people travelled around the country. As in Part I, we have assumed that the same

number of domestic flights would have been scheduled in March 2020 as in March 2019. We also looked at the number of infected travelers on each day and where these people travelled. Importantly, we incorporated the fact that each person is likely to infect 2 to 2.5 people if stay at home order is not in place.[1] Below we have three data frames showcasing the number of infected citizens on March 19th, the estimated number of infected citizens on March 31st and the change in the number of infected citizens for each state.

[1] https://www.businessinsider.sg/coronavirus-vs-flu-social-distancing-infections-spread-explainer-video-2020-3?r=US&IR=T

	# of Infected Citizens March 19th
AL	78
AK	12
AZ	47
AR	62
CA	1067
CO	278
CT	159
DE	30
FL	434
GA	282
HI	26
ID	23
IL	420
IN	56
IA	44
KS	35
KY	47
LA	392
ME	52
MD	108
MA	328
MI	334
MN	89
MS	50
MO	35
MT	19
NE	47
NV	99
NH	44
NJ	735
NM	35
NY	4152
NC	104
ND	19
OH	120
OK	44
OR	87
PA	187
RI	44
SC	81
SD	14
TN	155
TX	248
UT	80
VT	22
VA	94
WA	1228
WV	5
WI	155
WY	18

	# of Infected Citizens March 31st
AL	1643029
AK	149433
AZ	599396
AR	1179380
CA	17325350
CO	3065314
CT	1859473
DE	457328
FL	7377318
GA	4627643
HI	416111
ID	471111
IL	6090074
IN	1327361
IA	963639
KS	806494
KY	1041442
LA	2500144
ME	676019
MD	2108325
MA	3633830
MI	4817503
MN	1744122
MS	1036303
MO	659285
MT	357439
NE	821443
NV	1461579
NH	651362
NJ	4779648
NM	719140
NY	10129431
NC	1992460
ND	543451
OH	2752003
OK	1027980
OR	1560770
PA	3931269
RI	546951
SC	1672450
SD	293936
TN	2779298
TX	5063848
UT	1334521
VT	302895
VA	1842413
WA	3971596
WV	141114
WI	2576260
WY	271463

In addition, we also have the number of infected travelers travelling between each state on March 19 and March 31. Not all states are shown as we still need to find a better way of screenshotting the outputs!

March 19

	AL	AK	AZ	AR	CA	CO	CT	DE	\
AL	0.000000	0.000000	0.000039	0.000021	0.000216	0.015206	0.000000	0.0	
AK	0.000000	0.104442	0.000633	0.000000	0.003916	0.006469	0.000000	0.0	
AZ	0.000080	0.001673	0.013437	0.001952	0.450918	0.227711	0.000000	0.0	
AR	0.000000	0.000000	0.000665	0.000000	0.002997	0.012165	0.000000	0.0	
CA	0.000032	0.002247	0.110185	0.002404	1.754712	0.615693	0.003033	0.0	
CO	0.005043	0.002165	0.031317	0.005794	0.357456	0.170602	0.011238	0.0	
CT	0.000000	0.000000	0.000006	0.000000	0.002052	0.011538	0.000000	0.0	
DE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	
FL	0.009799	0.000000	0.013805	0.003472	0.190812	0.284820	0.136510	0.0	
GA	0.042745	0.000000	0.013592	0.023298	0.195619	0.136520	0.038978	0.0	
HI	0.000000	0.004823	0.007936	0.000000	0.340605	0.036013	0.000000	0.0	
ID	0.000000	0.000000	0.003203	0.000000	0.037023	0.036930	0.000000	0.0	
IL	0.008002	0.000640	0.032195	0.010745	0.333368	0.219842	0.033135	0.0	
IN	0.000000	0.000000	0.004462	0.000000	0.019308	0.030896	0.000000	0.0	
IA	0.000000	0.000000	0.005050	0.000000	0.000027	0.029592	0.000000	0.0	
KS	0.000000	0.000000	0.001078	0.000000	0.000081	0.015400	0.000000	0.0	
KY	0.000000	0.000000	0.003513	0.000000	0.017094	0.040068	0.001561	0.0	

March 31

	AL	AK	AZ	AR	CA	CO	\
AL	0.000000	0.000000	0.201853	0.196304	1.887215	117.516761	
AK	0.000000	554.027495	3.296929	0.000000	34.205774	49.991257	
AZ	0.790058	8.875578	70.009284	18.648877	3939.089715	1759.766870	
AR	0.000000	0.000000	3.465140	0.000000	26.185109	94.013409	
CA	0.316023	11.921119	574.069400	22.967565	15328.668740	4758.123099	
CO	50.089691	11.486042	163.164357	55.357720	3122.633283	1318.426143	
CT	0.000000	0.000000	0.033642	0.000000	17.928543	89.163511	
DE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
FL	97.335172	0.000000	71.926886	33.175371	1666.882736	2201.107596	
GA	424.577285	0.000000	70.816695	222.608704	1708.873272	1055.039370	
HI	0.000000	25.582548	41.346184	0.000000	2975.430506	278.309537	
ID	0.000000	0.000000	16.686499	0.000000	323.421488	285.397849	
IL	79.479857	3.393603	167.739687	102.666977	2912.208800	1698.956609	
IN	0.000000	0.000000	23.246716	0.000000	168.669849	238.764214	
IA	0.000000	0.000000	26.308150	0.000000	0.235902	228.691349	
KS	0.000000	0.000000	5.618237	0.000000	0.707706	119.009038	
KY	0.000000	0.000000	18.301322	0.000000	149.325895	309.647340	

As is shown above, as the virus spreads, the number of infected travellers travelling between each state increases.

Next Steps

There are a few possible next steps we are considering.

Firstly, we want to try and create a visual illustration of the way in which the coronavirus would have spread across the country had stay-at-home measures not been implemented, especially in

regards to the number of infected travelers flying between each state. We think it would be much more informative if we could have red dots travelling between each state to depict the spread of the virus. We contacted the authors of a *New York Times* article exploring the drastic reduction in flight across china[2] and they informed us that they used the programs sveltejs and sveltegl to make their visualizations. We are hoping we could also use these programs but have not yet had the time to toy around with them yet.

[2] https://www.nytimes.com/interactive/2020/02/21/business/coronavirus-airline-travel.html