Visualization of the effects of Government Covid policies on Economic Indicators and major sectors around the world

Carleton University

COMP 4905 Final Report Draft

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Abstract

The objective of this Honours project was to conduct research on the effects that various world governments pandemic policies had on their economies. To do this I gathered data from many websites relating to government policy strictness and economic state of various countries, analysed the trends in the data and created Choropleth maps and Bubble plot visualizations to effectively display the results then finally that hosted everything on a react.js based website. Two of the Choropleth maps came out as expected and showed that between 2019 and 2020 economic indicators such as GDP growth became extremely low for many countries around the world. Contrastingly the bubble plots showed a mix of trends when looking at average stringency compared to percentage change is value of economic sector. Both export plots showed a negative correlation which links up with expectation while, tourism revenue gave a positive correlation. This was going against expectation and could be because the amount of data chosen for these visualizations was too small and not diverse enough. Future extensions to the project will have me adding more datasets to the Bubble plots and more categories to broaden the visualization and give better trends.

Acknowledgments

I would like to thank Professor Koon-Ho Alan Tsang for his guidance throughout the duration of this project, Okoh Ugochukwu kelvin for advice on the economic side of the project and I would like to give recognition to the people behind the Oxford COVID-19 Government Response Tracker as the Stringency Index that was used throughout the project was developed by them.

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1. Introduction

The primary objective of this honours project was first, to conduct research on the effects that the various world governments pandemic related policies had on their own economies, then gather data relating to the topic and analyse said data to find any interesting or hidden trends from comparing government strictness to the state of the economy pre covid-19 and during the pandemic.

The secondary objective was to adopt creative and effective visualization techniques that will translate the findings from the data into visual contexts to make identifying the patterns, trends and outliers in the data set easier.

1.1 Problem

The year 2020 will forever be remembered for the sudden outbreak of covid-19 virus and the simultaneous lockdowns of most developed and developing nations affected the societal norms and the economies in the countries. This came with a compounding effect of disrupting the global economy as the travel industry has been severely damaged with flight volumes being at only a fraction of what they were the year prior. Moreover, hospitality sector was hit hard with millions of jobs lost and many companies bankrupt. But not all industries were down due to government spending on covid-19 vaccines and treatment methods the values of pharmaceutical companies around the world increased significantly[Jones et al. 2021].

This project aims to visualize this economic crisis and show trends linking government covid policy to the state of the economy.

1.2 Goals

The goal of this project is to analyse and visualize data on the government covid-19 policies effect on the economy. To achieve this goal there were two subgoals , first the necessary data relating to the economy and government response needs to be collected and processed, then secondly the data will be visualized on a React based website.

1.2.1 Collect and analyse dataset

To achieve the first subgoal the necessary data to be collected relating to the economy will be, data on the 3 economic indicators GDP growth, Unemployment Rate and Consumer price index for all countries in the world. Then data that looks deeper into the effects on the different industries and sectors of the economy such as Oil exports, Manufacturing value added and Tourism revenue, as well as Gross Exports and Market capitalization. The data will be collected for 2019 and 2020 for the top countries in each category. Next the data relating to government policy responses implemented in 2020 will be collected from the Oxford covid-19 government response tracker[Thomas et al. 2021]. The data was then processed and stored in excel sheets.

1.2.2 Produce Visualizations and host on Website

For the second subgoal after storing the necessary datasets in excel tables they will be used to create three visualizations that will be hosted on a React.js based website with text that provides context and explanations for each.

1.3 Motivation

The motivation behind this project came from both my peak in interest in politics and covid related news during the 2020 lockdowns. Throughout most of the pandemic economic analysts would come on the news and preach about a drowning economy due to government responses to the pandemic leading to closing businesses and shifts in the market, so I decided to investigate this issue a bit deeper and create visualizations to see how and where economies were affected.

1.4 Objectives

The initial objectives were to get data related to government policy and the economic state of countries then to visualize this data. To achieve this data relating to government policy and economic state needs to be scraped from multiple websites put into excel tables to be processed and stored then used in creating visualization plots that will be hosted on a react.js based website.

2. Background

This section provides all the background knowledge needed to understand the various economic related terms mentioned in this paper and how they are associated with the main goal. Moreover, this section will also give background knowledge for the stringency index.

2.1 Stringency index

The stringency index came from the Oxford covid-19 government response tracker (OxCGRT). This project collects systematic information on policy measures that governments have taken to combat covid-19. The various policy responses that were adopted by governments were being tracked as early as January 1st, 2020, in more than 180 countries. These policies were then coded into a standardized series of twenty-three indicators to measure responses such as workplace closure, restrictions on international, income support, investment in covid vaccines and many more[Thomas et al. 2021]. The OxCGRT indicators are grouped into five categories, Containment and Closure which had indicators C1 – C8 , Economic response which has indicators E1 and E2, Health systems with indicators H1 – H8, Vaccine policies with indicators V1-V4 and Miscellaneous with indicator M1[Thomas et al. 2021].

The stringency index is one of the four policy indexes that are gotten from the OxCGRT, it uses policy indicators C1 - C8 and H1[Thomas et al. 2021]. I picked the stringency index over the others because I believed this to be a more inclusive measurement for government strictness for the purpose of this project not every country has the infrastructure of the budget to employ the various economic and health indicators that are in the tracker, but all countries were able to apply the containment and closure policies and the information campaign indicators so I thought it was a fairer judgment for government response for the purpose of this project because this way the index will be invariant to the size of the economy. Moreover, the figure below shows the global mean index values for all four policy indices for over 180 countries from January 1st, 2020,

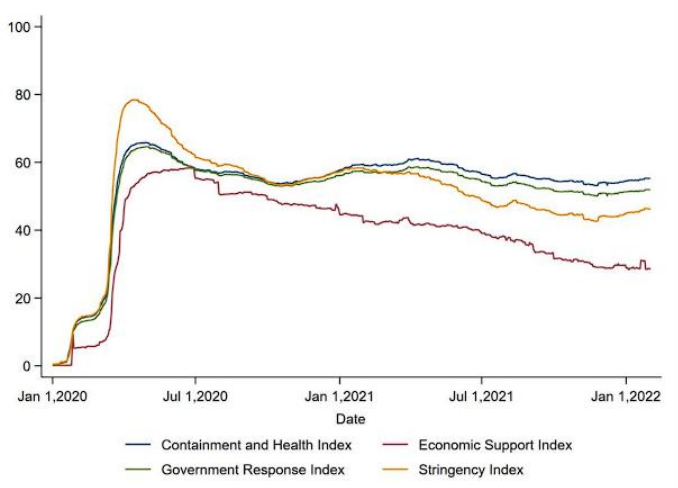

Figure 1 : Global mean index values for 180 countries[Thomas et al. 2021]

From the figure above we can see that stringency index was more reactive to the main lockdown periods in the 2020 time series, additionally we see that after the months of march period the averaged values start to match up with Government response index for the rest of 2020 which is the main index that takes into account all the twenty-three indicators, this was yet another point that led to me choosing the stringency index for the project over the other indices.

2.2 Economics

This subsection is for explaining a few to the economics mentioned in the paper and how they relate to measuring the state of the economy for the purposes of this project.

2.2.1 GDP growth

GDP growth rate or economic growth rate, measures the change in GDP of the country in comparison to an earlier period, for this project I used annual GDP growth rate which gets the percent amount change in GDP yearly. This is a determinant of a country's economic health and possible growth[Adithyan. 2022a]. I picked this indicator because it shows the change in economic activity of a country which is influenced by many factors such as government expenditure or exports and imports.

2.2.2 Unemployment rate

Unemployment rate is calculated as a percentage of jobless population in a country, it is not a predictive indicator rather its value varies due to changing economic conditions, when the economy is in poor shape the value can be expected to rise[Sujiaini. 2022]. I chose this indicator because workplace closures and downsizing were major incidents in the pandemic period which would surely have caused unemployment rate to increase.

2.2.3 Consumer price index

This Is a measure that examines the weighted average of prices of consumer goods and services, such as food, medical care, and transportation. It is calculated by taking price changes for each item and averaging them[Adithyan. 2022b]. I selected this CPI because its an indicator of retail inflation and I wanted to see if there were any trends in this type of inflation in relation to covid-19.

2.2.4 Oil exports

This is the amount of Crude oil shipments made by a country, this was used as a stand in for the primary sector of an economy for this project and the countries that exported the highest dollar value worth of crude oil during the period of 2019-2020 were selected.

2.2.5 Manufacturing value added

Manufacturing value of an economy is the total estimate of net output of all resident manufacturing activities, this was used to represent the secondary sector of an economy for this project and countries with the highest value during the period of 2019-2020 were selected.

2.2.6 Tourism Revenue

This is a measure of the economic impact of tourism and includes all tourism-related spending within a country by non-residents/visitors in categories such as transportation, food, recreation, etc. This was used to represent the tertiary sector of an economy for this project and countries with the highest revenues during the period 2019-2020 were selected.

2.2.7 Market Capitalization

Market cap of a country is the total value of all a company's shares of stock for all the companies in that country. This was used to represent the financial sector of an economy for this project and countries with the highest values during the 2019-2020 period were selected

3. Methodology

This section will cover the approach used for collecting the various datasets used in the project and processing the data to be used in the visualizations. It will also cover the process of coding the website and adding the visualizations. Moreover, it will cover attempts made along the way towards the finished results.

3.1 Data Scraping

There were many datasets that were considered in the early stages of data scraping, the focus was on collecting data that can show the state of the economy, this led to the collection of various datasets like economic indicators and data from different sectors of the economy.

3.1.1 Creating Tables

All the data for the Bubble plots was put into excel tables , the final layout for the plot was chosen to be Average stringency on the x-Axis as it is what we are measuring to be government policy strictness, Percent change in variable on y axis where the variable it the values we are measuring to show economic state, for the z axis(size of the bubble) proportion of GDP that the value in y axis makes up was used and finally for the colour axis was the 2020 GDP growth of the country. The GDP values for the countries that was used in all plots were gotten from data world bank[World Bank Group. 2022a], and the values for 2020 GDP growth that was used in all plots was gotten from knoema[Knoema. 2021].

3.1.2 Gross Exports

For Gross exports the data that was used in the bubble plot was gotten from data world bank website[World Bank Group. 2022b], the total value from exports in 2019 and 2020 for the countries with the highest value from exports were collected, then the percentage change from

2019 to 2020 value of exports was calculated. Then using the value from exports in 2019 and the GDP in 2019 the percentage share of GDP that Exports had in 2019 for the countries was calculated. Lastly the GDP growth for the selected countries was then included, this made up the table shown below

Country	value from exports (trillions) 2020	2020 billions	value from exports (2019)	percent change 2019 - 2020	GDP trillions 2019	% of GDP 2019	Gdp (trillions)(2020)	GDP growth 2020
China	2.7233	2723.3	2628.94	3.589279329	14.279	18.4112333	14.7227	2.35
USA	2.1234	2123.4	2519.72	-15.7287318	21.433	11.7562637	20.953	-3.4
Germany	1.67	1670	1812.9	-7.88239837	3.888	46.6280864	3.8464	-4.57
Japan	0.78537	785.37	644.98	21.76656641	5.1448	12.5365418	5.0578	-4.59
UK	0.77048	770.48	892.532	-13.6748038	2.878	31.0122307	2.76	-9.4
France	0.73317	733.17	862.106	-14.9559335	2.728	31.6021261	2.6303	-7.86
Netherlands	0.7115	711.5	751.25	-5.29118136	0.9102	82.5368051	0.91387	-3.8
Hong Kong	0.61257	612.57	644.98	-5.02496201	0.36302	177.670652	0.3466	-6.08
Singapore	0.59922	599.22	648.51	-7.60049961	0.3744	173.213141	0.34	-5.39
South Korea	0.59695	596.95	648.61	-7.96472456	1.651	39.2858873	1.6379	-0.85

Figure 2 : Excel table used for Gross export processing

3.1.3 Oil exports

For Oil exports the bubble plot data was gotten from world's top exports[Workman. 2020], from total value of crude oil exports in 2019 – 2020 the percentage change was calculated and using the 2019 value the % share of GDP that Oil exports had in 2019 for the different countries was calculated. Then GDP growth for 2020 included at the end to make the table shown below

Country	Value of exports (billion) 2020	Value of exports (billion) 2019	percent change	GDP billions 2019	% of GDP (2019)	Gdp (trillions) (2020)	GDP growth 2020
Saudi Arabia	113.7	168.5943	-32.56	792.97	21.26112	0.7001	-4.11
Russia	72.6	121.4047	-40.2	1687.45	7.1945647	1.4835	-2.95
Iraq	50.8	82.87113	-38.7	235.1	35.249309	0.1668	-15.67
USA	50.3	65.32468	-23	21433.22	0.3047824	20.953	-3.4
UAE	47.9	56.02339	-14.5	417.22	13.427782	0.3589	-6.13
Canada	47.6	68.09728	-30.1	1742.02	3.9090987	1.6454	-5.23
Kuwait	28.3	46.54605	-39.2	136.2	34.174782	0.106	-8.69
Nigeria	25.2	41.1093	-38.7	448.12	9.1737255	0.4323	-1.79
Kazakhstan	23.7	33.56941	-29.4	181.67	18.478233	0.1711	-2.5
Norway	22.7	28.88041	-21.4	404.94	7.1320213	0.3622	-0.72

Figure 3 : excel table used for oil export processing

3.1.4 Manufacturing Value added

For Manufacturing value added the data was scraped from the global economy site[TheGlobalEconomy.com. 2022a], the total values for 2019 and 2020 were used to calculate

percent change, then the percent share of GDP in 2019 that manufacturing value had been calculated for all the chosen countries then GDP growth for 2020 was added and this gives the table below,

Country	Value (billion) 2019	value (Billion) 2020	percent change 2019 -> 2020 (billions)	Gdp (trillions) (2019)	% of GDP (2019)	GDP growth 2020
China	3823.41	3852.81	0.76894709	14.279	26.77645	2.35
Germany	755.86	698.9	-7.53578705	3.888	19.44084	-4.57
South Korea	416.53	406.37	-2.43920006	1.651	25.22895	-0.85
india	383.56	348.37	-9.17457503	2.8705	13.36213	-7.25
italy	298.84	280.4	-6.17052603	2.0094	14.8721	-8.94
France	273.1	247.03	-9.54595386	2.728	10.011	-7.86
UK	255.62	239.68	-6.23581879	2.878	8.881862	-9.4
Indonesia	220.5	210.4	-4.58049887	1.1191	19.70333	-2.07
Brazil	190.43	141.15	-25.8782755	1.8778	10.14112	-4.06
Russia	219.22	196.65	-10.2955935	1.4835	14.77722	-2.95

Figure 4: excel table used for manufacturing value added data processing

3.1.5 Tourism revenue

For Tourism revenue the data was scraped from the global economy site [TheGlobalEconomy.com. 2022b], and put into the table below,

Country	Revenue from international tourism(Billion) 2020	Revenue from international tourism(Billion) 2019	percent change 2019 -> 2020 (billions)	Gdp (billions)(2019)	GDP growth 2020	% of GDP (2019)
USA	84.205	239.447	-64.83355398	21433.22	-3.4	1.11717698
France*	35.958	70.776	-49.19464225	2728.87	-7.86	2.59360101
Australia	26.234	47.953	-45.29226534	1391.95	0	3.44502317
Austria	15.365	25.924	-40.73059713	445.01	-6.73	5.82548707
Thailand	15.36	64.371	-76.13832316	544.26	-6.1	11.8272517
Japan	11.395	49.209	-76.84366681	5148.78	-4.59	0.95574097
Turkey	13.771	41.415	-66.74876253	761	1.79	5.44218134
UAE*	24.615	38.413	-35.92013121	417.22	-6.13	9.20689325
Italy*	20.459	51.91	-60.58755538	2009.38	-8.94	2.58338393
India*	13.413	31.661	-57.63557689	2870.5	-7.25	1.10297858
macao	9.442	41.166	-77.06359617	55.2	-54.01	74.576087

Figure 5: excel table used for oil export processing

the total values for 2019 and 2020 were used to calculate percent change, then the percent share of GDP in 2019 that tourism had was calculated for all the selected countries then GDP growth for 2020 was added.

3.1.6 Market Capitalization

For Market Cap the data was scraped from the global economy site [TheGlobalEconomy.com. 2022c], and placed into the table below,

Country	Stock market Cap 2019 (billions)	Stock market Cap 2020 (billions)	percent change 2019 -> 2020 ()	GDP growth 2020	% of GDP (2019)
USA	33890.83	40719.66	20.14949	-3.4	158.12
China	8515.5	12214.47	43.43808	2.35	59.63
Japan	6191.07	6718.22	8.514683	-4.59	120.24
Hong Kong	4899.23	6130.42	25.13028	-6.08	1349.59
Canada	2409.1	2641.45	9.644681	-5.23	138.29
India	2286.92	2595.45	13.49107	-7.25	79.67
Saudi Arabia	2406.82	2429.1	0.925703	-4.11	303.52
Germany	2098.17	2284.11	8.862008	-4.57	53.96
South korea	1484.84	2176.19	46.56057	-0.85	89.91
Australia	1487.6	1720.56	15.66012	0	106.87

Figure 6 : excel table used for Market cap data processing

the total values for 2019 and 2020 were used to calculate percent change, then the percent share of GDP in 2019 that Market cap had was calculated for all the countries then GDP growth for 2020 was added.

3.1.7 Average Stringency

The final dataset that was used in the Bubble plot was an Average for the stringency index for the year 2020, this data was gotten from Covid-19 government response tracker website[Thomas et al. 2021]. Below is a sample table showing how the Average stringency was calculated,

Country	Average stringency (2020)	stringency jan 2020	stringency feb 2020	stringency march 2020	stringency april 2020	stringency may 2020	stringency june 2020	stringency july 2020	stringency august 2020	stringency sept 2020	stringency oct 2020	stringency nov 2020	stringei dec 2020
China	72.99333	69.91	81.02	73.61	56.94	81.94	78.24	78.24	78.24	54.17	63.43	81.94	78.24
USA	58.2575	0	5.56	72.69	72.69	72.69	68.98	67.13	67.13	62.5	62.5	75.46	71.76
Germany	57.09917	5.56	25	76.85	76.85	59.72	63.43	57.87	59.72	49.54	60.65	67.59	82.41
Japan	33.48917	2.78	34.26	40.74	47.22	34.26	25.93	34.26	32.41	29.63	35.19	37.04	48.15
UK	61.65	8.33	11.11	79.63	79.63	69.44	71.3	64.35	66.2	67.59	75	67.59	79.63
France	58.71917	5.56	34.72	87.96	87.96	75	51.85	46.3	48.15	49.54	78.7	75	63.89
Netherlands	53.62667	0	5.56	78.7	78.7	71.3	59.26	39.81	50.93	62.04	62.04	56.48	78.7
Hong Kong	58.64333	49.07	52.78	63.89	66.67	52.78	41.67	66.67	66.67	51.85	51.85	68.52	71.3
Singapore	48.45833	25	30.56	36.11	76.85	73.15	50.93	50.93	50.93	50.93	45.37	45.37	45.37
South Korea	52.58583	2.78	55.56	75.93	43.52	55.09	53.24	53.24	53.24	60.19	51.39	57.87	68.98

Figure 7: excel table used for Stringency Index data processing

The stringency index for a country was calculated bi-weekly on the website, so I took the value at the end of the month for the entire year and averaged it.

Thus, a sample for the final table layout with all the necessary data needed to make the bubble plot is shown in the figure below,

Country	Average stringency (2020)	percent change 2019 - 2020	GDP growth 2020	% of GDP 2019
China	72.99333	3.58927933	2.35	18.4112333
USA	58.2575	-15.728732	-3.4	11.7562637
Germany	57.09917	-7.8823984	-4.57	46.6280864
Japan	33.48917	21.7665664	-4.59	12.5365418
UK	61.65	-13.674804	-9.4	31.0122307
France	58.71917	-14.955933	-7.86	31.6021261
Netherlands	53.62667	-5.2911814	-3.8	82.5368051
Hong Kong	58.64333	-5.024962	-6.08	177.670652
Singapore	48.45833	-7.6004996	-5.39	173.213141
South Korea	52.58583	-7.9647246	-0.85	39.2858873

Figure 8 : example final table for a dataset

3.1.8 Other Attempts at getting Datasets

There were other datasets collected in the journey to create the plot, one of those was sets was covid cases per 1000 capita shown below

Country	Covid cases per 1000 capita (2020)	population(2020)	Covid cases 2020
China	0.065110437	1,439,323,776	93,715
USA	61.54029262	331,002,651	20,370,000
Germany	20.76770272	83,783,942	1,740,000
Japan	1.889719226	126,476,461	239,005
UK	37.56296713	67,886,011	2,550,000
France	270.9697745	9,890,402	2,680,000
Netherlands	47.57683629	17,134,872	815,223
Hong Kong	1.185543888	7,496,981	8,888
Singapore	10.02146541	5,850,342	58,629
South Korea	1.220869807	51,269,185	62,593

Figure 9 : excel table showing alternate data that were scrapped

This data was created by collecting the value of total covid cases for the necessary countries in 2020 from the our world in data site[OurWorldInData. 2022] and the population data for those same countries from the worldometer site[Worldometer. 2022], I then divided covid cases in 2020 by population in 2020 and multiplied that value by 1000. This was chosen to be the Y axis value in an earlier stage of the project but through producing sample graphs and analysing the output and relevance to the topic it was dropped from the project.

Another data set collected was length of lockdown for the selected countries, this data was taken from Wikipedia[Wikipedia. 2021] in an earlier version of the project this was being used for the x axis in the bubble plot, but it did not provide sufficient logic, so it was dropped.

3.1.9 Summary Plot Creation

The final summary plot was then created in excel and it consists of lines of best fits for the x and y datasets for the five bubble plots, the table below shows the collection of x and y data used in the summary plot,

Exports x	Exports y		Oil x	Oil y		manfacture x	manfacture y		tourism x	tourism y		market cap x	market cap y
72.99333	3.589279		60.26333	-32.56		72.99333333	0.768947092		58.2575	-64.83355398		58.2575	20.14949177
58.2575	-15.7287		52.8175	-40.2		57.09916667	-7.535787051		58.719167	-49.19464225		72.99333333	43.43808349
57.09917	-7.8824		67.90167	-38.7		52.58583333	-2.439200058		57.561667	-45.29226534		33.48916667	8.514683245
33.48917	21.76657		58.2575	-23		70.21333333	-9.174575034		51.465	-40.73059713		58.64333333	25.13027557
61.65	-13.6748		53.31667	-14.5		69.71416667	-6.170526034		49.273333	-76.13832316		58.56666667	9.644680586
58.71917	-14.9559		58.56667	-30.1		58.71916667	-9.545953863		33.489167	-76.84366681		70.21333333	13.49107096
53.62667	-5.29118		67.70917	-39.2		61.65	-6.235818794		56.945	-66.74876253		60.26333333	0.925702795
58.64333	-5.02496		59.06667	-38.7		57.1375	-4.580498866		53.316667	-35.92013121		57.09916667	8.862008322
48.45833	-7.6005		67.7475	-29.4		59.8	-25.87827548		69.714167	-60.58755538		52.58583333	46.56057218
52.58583	-7.96472		44.59833	-21.4		52.8175	-10.29559347		70.213333	-57.63557689		57.56166667	15.66012369
									30.4025	-77.06359617			

Figure 10 : excel table showing x and y data from all datasets

Some of the data in a few of the tables was removed to give the line of best fit more defined, in tourism tables data for Macao Japan and Thailand was removed and in the market cap data for China and Japan were removed.

The purpose of this final graph is to have all the correlations on one plot to have a side-by-side comparison of the datasets for each economic state representatives.

3.2 Creating the website

This section goes over the creation of the website used to host the visualizations and the analysis from the results section of this paper. To create this website, I chose to use React.js as its focus on single paged applications with reusable components made it easier to display multiple sets of data using the same visualization component all on one page.

3.2.1 Initializing the react app

To begin coding the react app I needed to create a skeleton layout of a basic react app as a starting point so using Node.js, node package manager tool “npx” and the command “Npx create-react-app code” [Anon. 2022] I was able to create a simple development environment to build the project on. The react app comes with a lot of extra files that I did not need for this project do I removed those files such as service worker.js, setupTest.js and logo.

3.2.2 Creating API call and parsing data

All the necessary data for the bubble plot visualization had already been calculated and compiled in excel into just five tables, but the data for the Choropleth map visualization was to be collected from the world data bank through API calls to their economic Indicator API database[TheWorldBank. 2022]. To access the information, I wanted from their API I used a fetch request with specially constructed API calls to get data for GDP growth, unemployment rate and consumer price from 2015 – 2020, an example of one of these API calls is in the figure below,

```
//GDP growth
  const url = 'http://api.worldbank.org/v2/country/indicator/NY.GDP.MKTP.KD.ZG?date=2015:2020&format=json&per_page=2000'
  const response = await fetch(url);
  const data = await response.json();
  var plotdata = []
  for (let year = 0 ; year <= 5 ; year++){
  let buff = [['Country', 'GDP growth']]
  let mapdata = data[1].filter(item => item.date == year+2015 && item.value != null).map((item) => [item.country.id , item.value])
  var con = buff.concat(mapdata)
  plotdata[year] = con
  }
```

Figure 11: example API call and data parsing code

The const url is the API call and at the end the formatting was added to get from date 2015-2020 in JSON format with information per page set to two thousand to get all the data output instead of only one page worth of data.

As shown in figure 11 after the API call returns the data, I then start to process the JSON object so I can filter out the data year by year to be used by the Choropleth map. I create an array to hold the country ID and GDP value mapped from the JSON object for each of the filtered years. This process is then repeated for the other Economic indicators Unemployment rate and Consumer price index.

After this I also add into the App.js file the data from the five bubble plot data sets after converting them into multidimensional array so it can be compatible with the visualization functions the figure below shows the converted data for the Gross exports into a multidimensional array,

```
// Data for Bubbles
const dataExports = [["Percent change 2019-2020 of total exports vs Average stringecy"],[
  ["Country ", "Average stringency (2020)", "percent change 2019 - 2020", "GDP growth 2020", "% of GDP 2019"],
  ["China", 72.99333333, 3.589279329, 2.35, 18.41123328],
  ["USA", 58.2575, -15.72873176, -3.4, 11.75626371],
  ["Germany", 57.09916667, -7.882398367, -4.57, 46.62808642],
  ["Japan", 38.48, 21.76656641, -4.59, 12.53654175],
  ["UK", 61.65, -13.67480382, -9.4, 31.01223072],
  ["France", 58.71916667, -14.95593349, -7.86, 31.6021261],
  ["Netherlands", 53.62666667, -5.291181364, -3.8, 82.5368051],
  ["Hong Kong", 58.64333333, -5.024962014, -6.08, 177.6706518],
  ["Singapore", 48.45833333, -7.600499607, -5.39, 173.213141],
  ["South Korea", 52.58583333, -7.964724565, -0.85, 39.28588734]
]]
```

Figure 12: Total exports per country dataset converted from excel table into array

3.2.3 Loading visualizations

Both the Choropleth map and the Bubble plot used were gotten from google charts react library “react-google-charts” documentation for all the charts were gotten from google charts website[Google Devs. 2022]. I created a “components” folder to put both files Geoplot.js and Bubbleplot.js.

For the bubble plot the converted data sets will be passed into the component from the main App.js file as arrays, where each index contains the data for each of the 5 datasets. The figure below shows the configuration for using the imported google chart as a bubble plot,

```
    return (
      <div className="container mt-5">
        <Chart
          width={'1000px'}
          height={'500px'}
          chartType="BubbleChart"
          data={this.props.data[1]}
          options={
            {
              title: this.props.data[0][0],
              hAxis: {
                title: this.props.data[1][0][1]
              },
              vAxis: {
                title: this.props.data[1][0][2]
              },
              bubble: {
                textStyle: {
                  fontSize: 11
                }
              },
              sizeAxis : { maxSize : 40 , minSize : 10},
              colorAxis: {colors: ['#e31b23','#00853f'], minValue : '-9', maxValue : '1'},
              sizeAxis: {minValue : '1', maxValue : '35'}
            }
          }
        />
      </div>
    )
  }
}
export default BubblePlot
```

Figure 13: code for initializing a bubble plot using react-google-charts libraries

The data variable is the information that will be passed into this component from the main file App.js, then the options variable is used to set up the several aspects of the bubble plot like colour and min and max axis range. After exporting this component as BubblePlot

it can then be used in the main file as reusable bubble plot that can generate visualizations for different data sets by just passing them into the component.

For the Choropleth graph I used the google chart Geo plot alternative, the data collected from the three API calls will be passed into the component to display different Geo plots for the 6 years for each different economic indicator. The figure below shows the code for setting up the Geo plot in react,

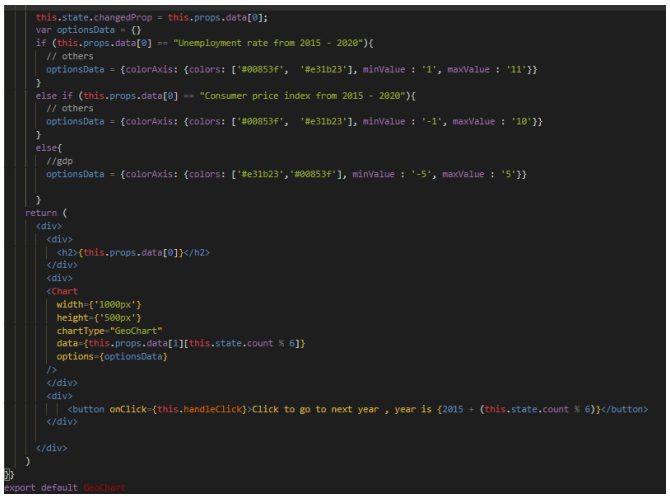

Figure 14: code for initializing a Geo map using react-google-charts libraries

The data that is passed in is an array with all 6 years for the specified indicator requested in the App.js file and a button is created to allow the users to swap through all 6 years. The option variable is made to change depending on the indicator that has been passed in because the minimum and maximum values needed to be displayed are different for each indicator.

3.2.4 Adding functionality to swap between datasets

The Main file App.js is where the final website render will be made, this is the file that will call the exported components from the components folder. The data for all visualizations was kept here and is made to be passed into the components depending on what information the user requests. The figure below shows the code used to add the GeoChart component to App.js file,

```
<div className='Map'>
  <div className ="button">
    <button onClick={this.mapChange1}> GDP growth</button>
    <button onClick={this.mapChange2}> Unemployment Rate</button>
    <button onClick={this.mapChange3}> Consumer price index</button>
  </div>
  <div className ="graph">
    <GeoChart data={mapItems[this.state.count]}/>
    <p className ="graphText">{textMaps[this.state.count]}</p>
  </div>
</div>
```

Figure 15: adding the Geo map to the main page with buttons to change maps

For the Map plots the user is given the choice to swap between the three maps by clicking buttons, these three buttons were assigned to three different functions that change the state of the App React component, thus causing the component to re-render with the new data. The data passed into the GeoChart component is then decided by the button clicks, this also changes the accompanying text that is for analysing the visualization. The figure below shows an example final output for the GeoChart of GDP growth,

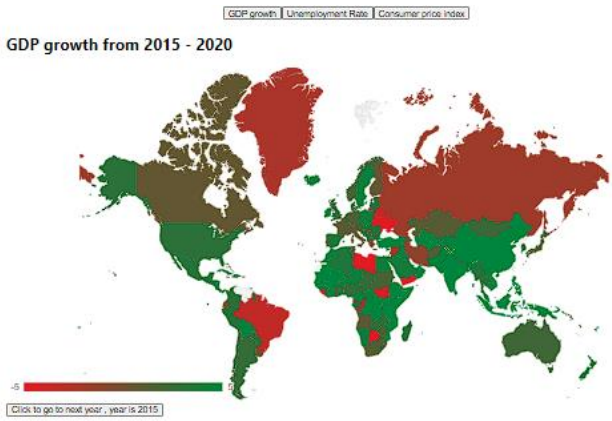

Figure 16: example output from website

From the figure we can see the three buttons to change the Graph, the button to change the year that also indicates the current year and the Graph title.

For the bubble plots the user has the option to swap between the five plots with five buttons that also swap the text that analyses each plot, this is done with the five buttons created, they link to functions that change the state of another constructor state variable thus causing the BubblePlot component to re-render. The figure below shows the code used to add the Bubble plot component to the App.js file,

```
<div className='Bubble'>
  <div className ="button">
    <button onClick={this.bubbleChange1}> Total Exports</button>
    <button onClick={this.bubbleChange2}> Oil exports</button>
    <button onClick={this.bubbleChange3}> Manufacturing Value added</button>
    <button onClick={this.bubbleChange4}> Tourism revenue</button>
    <button onClick={this.bubbleChange5}> Market capitalization</button>
  </div>
  <div className ="graph">
    <BubblePlot data={bubbleItems[this.state.count2]}/>
    <p className ="graphText">{textBubble[this.state.count2]}</p>
  </div>
</div>
```

Figure 17: adding the Bubble chart to the main page with buttons to change charts

The data passed in the Bubble plot component is from an array of bubbleItems that is a 2d array containing the converted excel table data and the Title for the graph. The figure below shows an example final output for the Bubble plot for Oil exports,

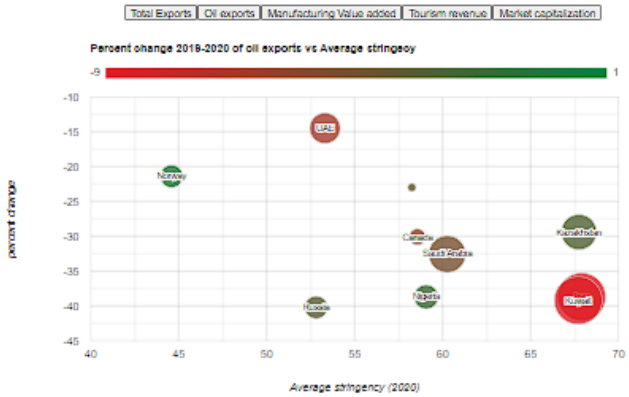

Figure 18: example output bubble plot from website

From the figure we can see the five buttons to change the plot and the specific plot title.

3.2.5 Styling and Text

For the styling and text some basic CSS was applied to add padding and margins to give the website more of a news article look, then descriptive and narrative text was added throughout the website to explain the plots and describe trends to the readers.

4. Results

This section will summarize the results gotten from the three visualizations made on the website and will go further to analyse the possible trends that could be gotten from them.

4.1 Map of GDP growth

The figure below shows the results from the GDP growth choropleth map,

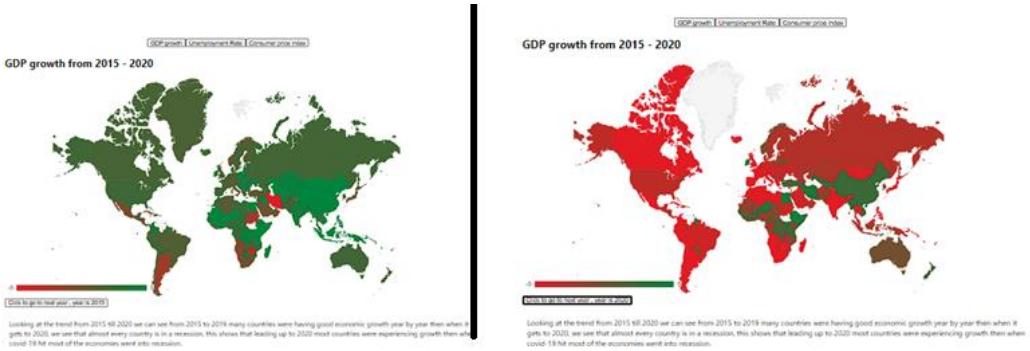

Figure 19: Results for GDP choropleth map for years 2019(left) and 2020 (right)

For the years leading up to 2019 the values for GDP growth show that many countries worldwide were having good economic growth year by year, then suddenly when it reaches 2020 and covid-19 pandemic hits, we can see that almost every country is in a recession. The outliers in this dataset are some African countries like Ethiopia and China, for the African countries the case could be that their economies are geared towards sectors that were not heavily affected by covid.

4.2 Map of Unemployment rate

The figure below shows the results from the Unemployment rate choropleth map,

Figure 20: results for unemployment rate choropleth map for years 2019 (left) and 2020 (right)

From the years leading up to 2020 there were fluctuations in the unemployment rates but in general most countries were at lower unemployment rates in 2019, especially the more developed nations. Then when we get to 2020 and the pandemic starts, most major economies are experiencing higher than average unemployment rates. Regionally we can see that North America and central Asia are two examples of higher-than-normal unemployment rate fluctuations in unemployment rate. These regions are places where

workplace closure also took place in efforts to combat the pandemic, and could be the contributor to the higher unemployment rates

4.3 Map of Consumer Price Index

The figure below shows the results from the consumer price index choropleth map,

Figure 21: results for CPI choropleth map for years 2019 (left) and 2020 (right)

The years leading up to 2020 showed on a global scale an average reduction year by year of the CPI, getting to 2020 unfortunately there was a lot of missing data for African countries so the trend cannot be studied further there, but regions such as North America and Asia show signs of the CPI reducing even further. This means covid-19 had no effect on inflation from the CPI index.

4.4 Bubble plot of Total exports vs Policy strictness

The figure below shows the results from the Total exports bubble plot,

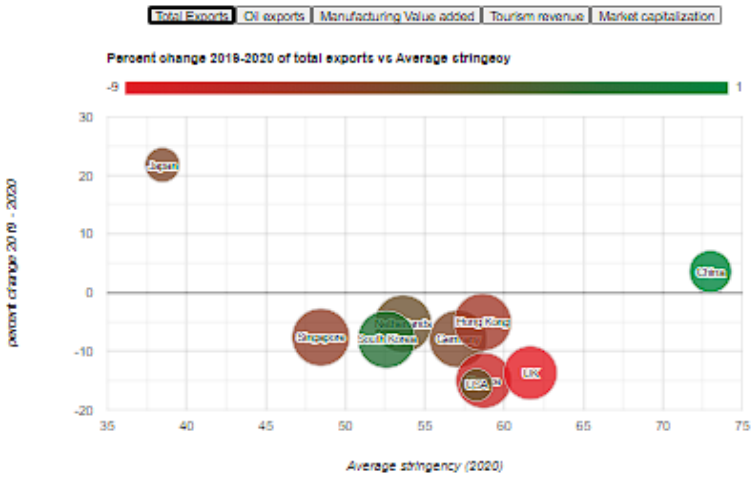

Figure 22: Plot of Total exports vs Average stringency

Firstly, looking at the x and y distribution of points we can see that there is a negative correlation which suggests that as the average stringency increases the percentage loss in total export revenue also increases. Next looking at the vertical colour spread there is not a strong correlation but there is some indication that with increase in percent loss in Export revenue correlates with more negative GDP growth. Lastly looking at the size of the bubbles we see that the bigger bubbles are grouped more at the bottom this shows that increase in % of GDP for total exports could mean an increase in percent loss.

4.5 Bubble plot of Oil exports vs Policy strictness

The figure blow shows the results from the Total crude oil exports bubble plot,

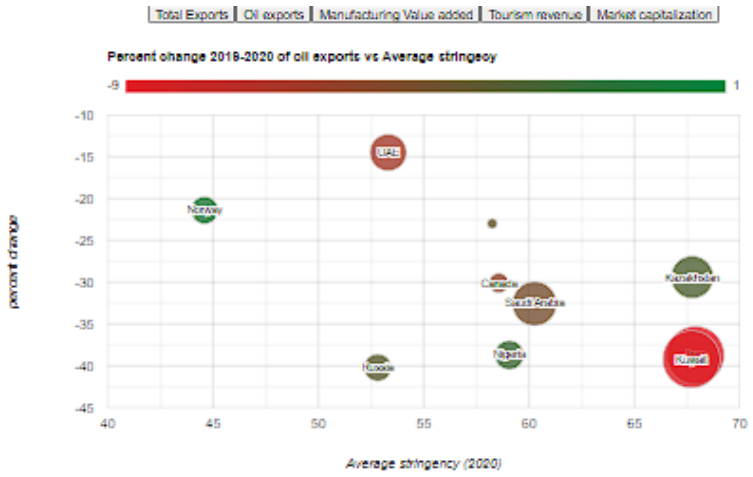

Figure 23: Plot of Total oil exports vs Average stringency

Firstly, looking at the x and y distribution of points we see a negative correlation, implying that as stringency increases the percent loss in total oil Export revenue increases. Next looking at the colour spread there is no discernible trend that can be seen. Lastly looking at the size of bubbles we see that the bigger bubble size follows the same strong negative correlation as the point distribution meaning that percent losses also increase with % share total GDP for Oil exports.

4.6 Bubble plot of Manufacturing value added vs Policy strictness

The figure below shows the result from the Manufacturing value added bubble plot,

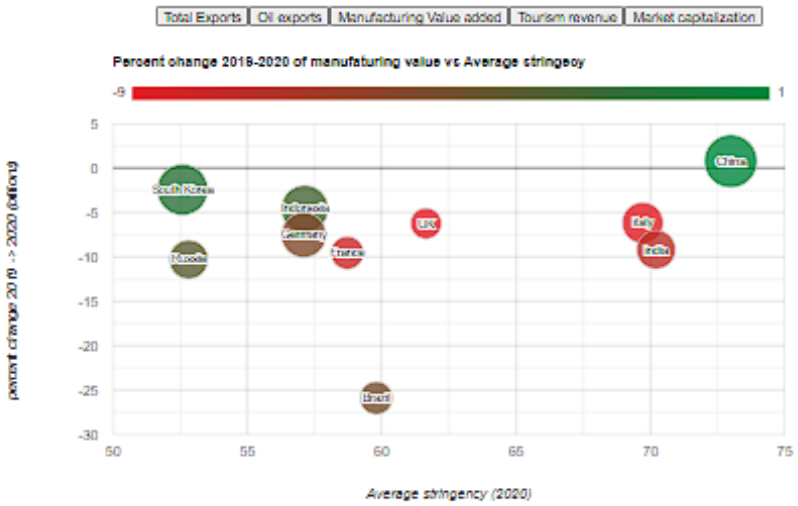

Figure 24: Plot of Manufacturing value added vs Average stringency

From the figure above we can see that there is no correlation between the distribution of points, but we can see some correlation with the horizontal colour spread, less stringency to more we see a negative correlation with 2020 GDP growth, as you go from left to right the GDP growth reduces.

4.7 Bubble plot of Tourism revenue vs Policy strictness

The figure below shows the results from total Tourism revenue bubble plot,

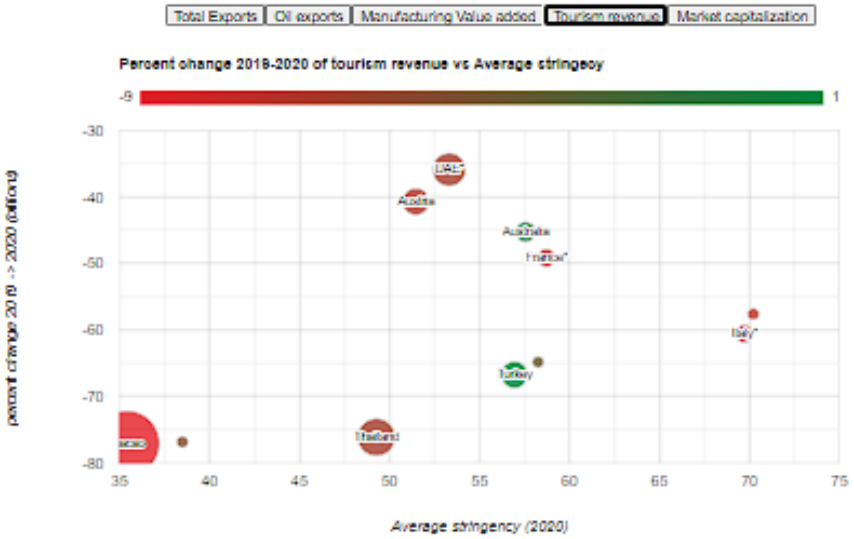

Figure 25: Plot of Tourism value added vs Average stringency

Firstly, looking at the distribution of points we see a positive correlation. This contradiction is brough about by Macao and Japan being so low on the graph with lower

values of stringency. Next looking at the colour spread there is not any noticeable correlation. Lastly looking at the size of the bubbles we see that going from left to right with an increase in stringency there is a reduction in %share of total GDP for tourism revenue. Going vertically, we can see hints that as percentage loss increases the percent share of GDP could be reducing but more data will be needed to be sure.

4.8 Bubble plot of Market Capitalization vs Policy strictness

The figure below shows the results from total Market Cap bubble plot,

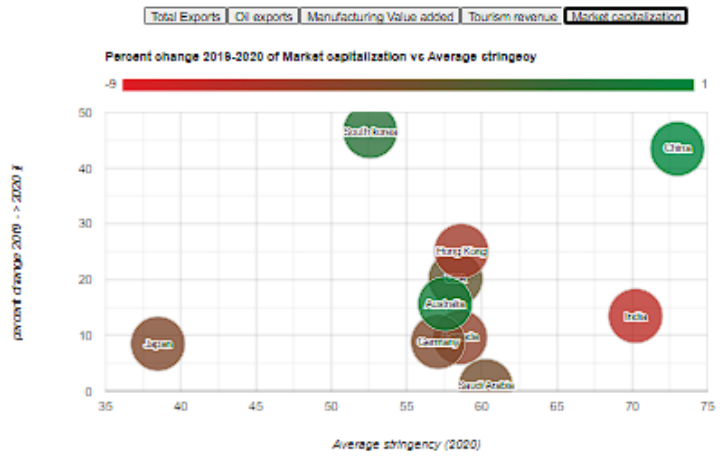

Figure 26: Plot of Market cap vs Average stringency

Firstly, from the data set chosen we see that our x and y distribution have a positive correlation this implies that with increase in stringency the total valuation of companies in a country increased. This shows that even though some businesses were closing and stock prices falling during lockdown, overall, the values of companies during 2020 were increasing. Moreover, looking at the horizontal colour shifts from left to right, it moves from green to red indicating that with higher stringencies the GDP growth of the countries reduces.

4.9 Summary line of best fit plot

The figure below shows the result from the final graph summary plot below,

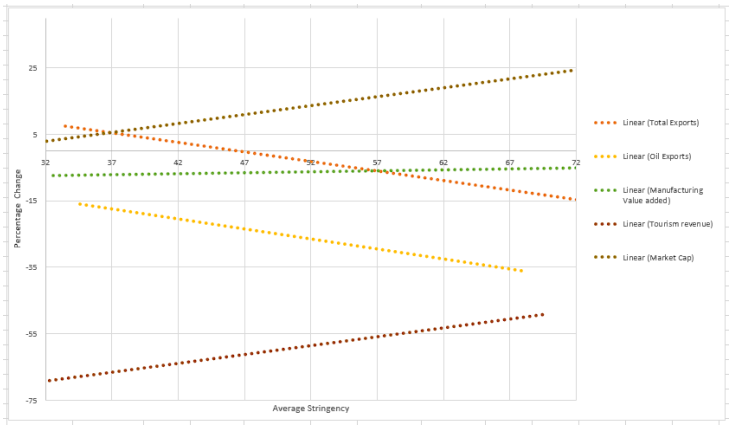

Figure 27: Plot of lines of best fit for all the bubble plots

From the figure above we can see that Total exports and Oil exports both had negative correlations, while Market cap and tourism revenue had positive correlations leaving Manufacturing value added as the only plot that did not show any correlation. We can also see that Market cap was the sector indicator with the highest percentage gain across 2019 and 2020, whilst Tourism revenue was the lowest.

5. Discussion

From the various results shown in the above section the map plot in general showed trends that I expected to see when examining the economic indicators, it was common knowledge that the economies of many countries were impacted by covid, although I expected CPI map to also follow suit and show a decline I assume the reason why it seems to be normal has to do with the way CPI is calculated, it is weighed on a basket on goods and services, thus if the preselected goods and services in said basket were more unaffected by covid-19 then this would make sense as to why many countries didn't experience inflation.

The bubble plots were the most surprising of the two visualizations, I expected the trends for all the data to be clear negative correlations fitting with my original narrative of government covid-19 policies directly affecting the economies of most countries. Two of the plots, Tourism revenue added, and Market capitalization gave positive correlations and Market value added gave no correlation. For market cap after further analysis, it seems that a lot of companies especially pharmaceutical companies and other companies that are not traditional brick and mortar stores were actually doing really well during 2020 and their stock values were able to rise or remain stable. This explains away Market cap but for Tourism value added this contradiction in result I believe comes from the fact that I did not have enough data sets, if I added more countries to the plot I believe we could have seen a

negative correlation , also Macao and other countries with strange economies would have to be excluded as they are not of the size of an average country.

Moving forward I think the next steps for this project would be to use larger datasets as said earlier, to avoid such impossible trends given due to small datasets. Moreover, the addition of more plots of different sectors would be good to increase the scope of the datasets.

One constant limitation that kept coming back during the project was the lack of datasets, for some categories entire countries will be missing and for every visualization I was not able to find information on 2021 indicators or industry data that I could use for the plots.

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