How should we assess the national performance and the health and economic consequences of COVID-19? Are conclusions robust to how these consequences are measured?

1. *Introduction*

Covid-19 is a pandemic that has affected health and economic outcomes worldwide. Different countries have responded to this pandemic in different ways. In this paper, we evaluate performance across countries through looking and comparing rankings across several indicators. Four indicators were used in our analysis: two for health consequences (excess deaths per 100k, total cases per million), and two for economic consequences (GDP per capita and unemployment rate). Robustness of each indicator was evaluated. Two economic models were used: a multivariate ordinary least squares regression (OLS) and a country-fixed effects model. Previous studies have used a variety of models to analyse cross-country performance of the Covid-19 pandemic, including using the merging of statistical, inference and artificial intelligence tools, simple numeric rankings, and cross-country OLS (Haug et al, 2020; Jamison et al, 2020; United Nations, 2021). In this paper, we evaluate our indicators of interest and appropriate models in more depth.

2. *Conceptualising the health and economic consequences of COVID-19*

Health and economic consequence indicators are evaluated based on five criteria: clarity, validity, measurability, consistency, and attribution. The evaluations of each indicator are displayed below.

	Health indicator 1: Excess deaths per 100k (OWID)
Clarity	Yes; Excess deaths measure the difference between how many people died during the pandemic, from any cause, and how many deaths would have been expected had there been no pandemic.
Validity	Valid in estimating the impact of COVID on death rate, as we are making a general comparison between typical deaths and specific deaths caused by the pandemic. However, certain health consequences (i.e. long term consequences) are not necessarily showcased in this indicator. Likewise, this indicator does not measure deaths due to covid specifically (only excess deaths); there might be other indirect consequences (ie changes in healthcare utilisation) that affect death but are not directly caused by covid. Despite certain limitations, this indicator seems to be a relatively valid measure when comparing the general differences in countries and how their approach to the pandemic affects excess death count.
Measurability	Measurable; feasible to count overall deaths and compare excess to expected. However, the method for which ‘excess deaths’ is measured might vary across countries.
Consistency	The process for which excess deaths are calculated is likely consistent within each country; therefore, there is consistency within each country and their week by week data. However, different countries might have

	different methods for measuring ‘excess deaths’ - i.e. - whether it be tabulating deaths due to covid specifically or excess deaths in general. Therefore, there might not be perfect consistency across countries.
Attribution	Given the time frame of our data and how this variable specifically compares expected deaths with excess deaths, this variable is highly attributed to the pandemic and how different countries performed in their response. However, given how expected deaths is an estimated variable, there might be some additional underlying factors unrelated to the pandemic that explain the ‘excess death’ indicator. Likewise, certain variables unrelated to the country’s response to the pandemic (i.e. initial health levels of citizens, etc) might be confounding variables. Therefore, while the results might be directly attributable, the specific magnitude might not be as much.

	Health indicator 2: Confirmed COVID-Cases per million (OWID)
Clarity	Definition is clear. As referenced in our data source, a confirmed case represents someone who has tested positive for COVID-19 through laboratory tests. The term ‘laboratory tests’ is a little ambiguous however, as we do not know if this entails all laboratory tests or just specific ones (i.e. PCR).
Validity	This indicator is valid, as it accurately represents individuals who have tested positive for COVID-19.
Measurability	Indicator is measurable; however, there might be differences in how laboratory tests are conducted and measured in different areas and across time. False positive tests are also a risk factor in our measurement. Laboratory tests might have become more accurate as the pandemic progressed and additional technology improvements occurred. Suspected cases were left out of data.
Consistency	There might be differences in frequency and access to testing across and within countries, which might skew results. More specifically, certain countries might advise that everyone receives frequent testing (regardless of if they are experiencing symptoms), whereas other countries might restrict testing to only those who are experiencing COVID-related symptoms. Access to tests might vary on a week by week basis as well, depending on supply of tests and how many people are interested in getting tested.
Attribution	Given the number of confirmed cases is directly related to the spread of the pandemic, this variable is highly attributable with the pandemic and how the government might have controlled the spread of the virus.

	Economic indicator 1: GDP per capita (World Bank)
Clarity	This indicator is clear in its definition; GDP per capita represents Gross Domestic Product for each country, and is normalised to per head, US

	$, current prices, current PPPs, and is seasonally adjusted
Validity	GDP per capita might not be perfectly valid, as it is challenging to gather the total population for each country and normalise by this value. However, when measured correctly, GDP is an accurate representation of the economic status of a country and can be useful in our analysis on cross-country performance.
Measurability	GDP per capita is measurable; however, different countries might have different methods for measuring their total population and GDP; creating potential variability in the measurements. However, given our GDP per capita data is collected from one source (OECD), measurement variability is unlikely.
Consistency	As mentioned in the measurability section, there might be differences in how each country measures GDP per capita. Likewise, shelter-in-place and additional pandemic restrictions in countries might have made it challenging to keep a tab on all of the elements that go into calculating GDP (i.e. country output, expenditure, and income). Therefore, while data might be consistent, there are still a couple of risks for inconsistency.
Attribution	Since GDP contains many elements pertaining to a country's economic performance over time, this variable can be highly attributed to the economic consequences of the pandemic.

	Economic indicator 2: Unemployment rate; % of total labour force (
Clarity	The definition of unemployment is generally clear in that it is the percent of the total labour force who are seeking employment yet are not employed. However, given cultural differences by country, the exact definition of unemployment might vary (specifically, on the differences between unemployment versus underemployment), thereby affecting the measurement and analysis of this indicator.
Validity	As shown on the OECD website, data collected for the total of labour force and unemployment rate seems to be thorough and complete. However, given the challenges with surveying every individual in each country, the data might not be entirely accurate. Therefore, there is uncertainty with whether this measure is valid.
Measurability	As mentioned in the clarity section, the exact definition of unemployment might vary- for example, specifically, on the differences between unemployment versus underemployment, thereby affecting the measurement and analysis of this indicator.
Consistency	Data is likely consistent within each country over time, given the data is collected by one source. However, given the definition of unemployment might differ by each country, there is a chance data might not be consistent across countries, affecting how comparable results are across countries.

Attribution	Since unemployment is a direct market of the labour market during a specific time period, it is an attributable measure for the economic status of a country. However, there are other factors that might offer more nuanced or additional insights into the economic status of a country, such as GDP or other indicators that contain more elements.

3. *Describing the dataset & econometric model*

Dataset

Longitudinal data was collected for our countries of interest for the time frame of January 1st, 2020-August 2021, cleaned and combined into a long form panel set up for our analysis. Excess deaths and COVID-19 cases data were collected from Our World in Data, and GDP per capita and unemployment rate data were collected from OECD. Weekly data was used for deaths per 100k, cases, and unemployment rate. Given the low availability of weekly data for GDP per capita, quarterly data was collected for this measure.

Exploratory Analysis

For exploratory analysis, our metrics were graphed for each country against time. Appendix Graphs 1-4 shows how excess deaths per 100k and new cases per million vary based on time; however, their totals increase over time. Unemployment rate and GDP per capita seem to vary by time and country (Appendix, Graphs 5-7). Japan seems to have more minimal data on trends over time, therefore, results for this country should be interpreted with caution.

Data cleaning

Data was filtered by our countries of interest. Our time frame of January 1st, 2020-August 2021 was chosen as this pertains to the period of the pandemic before the vaccine was approved. We omitted data after the vaccine release to focus solely on country performance before pharmaceutical intervention, as this introduction might have skewed performance measures for each country in a different way (WHO, 2022). Given the way OWID estimated missing values for our deaths per 100k variable, several cells contained a negative value for early in the pandemic. For simplicity for our model, these values are eliminated from data analysis. All other missing values were also omitted from the data.

The countries Japan, Israel, Costa Rica, United Kingdom, United States, and Italy were included in our cross-country analysis, as they represent a diverse set of countries from different income levels and continents and have thorough data readily available. Australia was included in the Fixed Effects model as our reference country.

Econometric models

For our health consequence measures of interest (deaths and cases), a poisson generalised linear model (GLM) was used, as these variables represent a count. For our economic consequence measures of interest (GDP per capita and unemployment rate), a gaussian GLM model was used, given the data is continuous. GLM was used given the distribution of our data is not necessarily normal and the link between explanatory and dependent variables is not necessarily linear (Raymond et al, 1997; Breslow, 1996). Country fixed effects were included in our fixed effects models to account for any unobserved differences between countries that are unrelated to our outcome variable. Time (number of days since January 1st, 2020) was also included as an explanatory variable. Australia was used as our reference country for the fixed effects model, and the output coefficients pertaining to each country were compared against each other for final rankings.

Multivariate ordinary least squares (OLS) regressions were also run on each indicator for each country. For health indicators, dependent variables including population density, gdp per capita, and diabetes prevalence were included to control for population, economic status of the country, and general health predictors as well. For economic indicators, dependent variables included population density, deaths per 100k, and diabetes prevalence were included.

We assume there is no multicollinearity among explanatory variables (Correlation Matrix, Appendix Table 3) and independence across observations. For the models that are not GLM-based, we assume there is a linear relationship between the explanatory variables and the expected value of the dependent variable. Violations of these assumptions suggest there might be a risk of bias in our results, and therefore our results should be interpreted with caution. In order to compare country outcomes against each other, we also assume that, at the start of the pandemic, countries are starting with comparable levels of exposure to COVID-19, such that the differences in health and economic outcomes are directly related to the individual performance of that country in handling challenges associated with the pandemic.

Metrics from each model (i.e. log-likelihood, R-squared, p-values etc) were pulled to analyse the strength of the results. The regression equation pertaining to each model is explained below.

Equations:

For poisson:

$\log(E(Y_i)) = \beta_0 + \beta_1$*num_days + β_2*CostaRica_dummy + β_3*Israel_dummy + β_4*Italy_dummy + β_5*Japan_dummy + β_6*UK_dummy + β_7*US_dummy + ε_i

- Dependent variables (Y_i) = count of deaths per 100k; COVID cases per million

For gaussian:

$E(Y_i) = \beta_0 + \beta_1$*num_days + β_2*CostaRica_dummy + β_3*Israel_dummy + β_4*Italy_dummy + β_5*Japan_dummy + β_6*UK_dummy + β_7*US_dummy + ε_i

- Dependent variables (Y_i) = GDP per capita; unemployment rate
- $E(Y_i)$: the expected value of our dependent variable (count of deaths per 100k, count of COVID cases per million, GDP per capita, unemployment rate) for country i, based on the number of days that have passed since January 1st, 2020. For our poisson distribution, $E(Y_i)$ is also equal to variance.

- Num_days: the number of days that have passed since January 1st, 2020
- Country_dummy: the dummy variable that indicates whether the data point being iterated pertains to that country
- β_0: the intercept of our regression. β_0 also represents the expected value of our dependent variable for our reference country (Australia) on January 1st, 2020.
- β_1-β_7: the output coefficients for our countries of interest. Each coefficient represents the difference between the expected value of our dependent variable $E(Y_i)$ for country i and our reference country (Australia), controlling for country fixed effects.
- ε_i: the error term, which represents the variation in our dependent variable that is unexplained through our explanatory variables.

For Multivariate OLS:

Y = β_0 + β_1*num_days + β_2*population_density + β_3*gdp_per_capita + β_4*diabetes_perbalence + ε

G = β_0 + β_1*num_days + β_2*population_density + β_3*deaths_per_100k + β_4*diabetes_perbalence + ε

- Y = unemployment_rate or gdp_per_capita
- G = deaths_per_100k or cases_per_million
- OLS is done for each country individually
- β_0 = value of Y when all features are equal to zero
- β_1-β_4 = coefficient displaying relationship between independent and dependent variables
- ε - error term

4. *Results of the analyses*

The rankings from each model are displayed below. Regression coefficients for deaths per 100k, cases per million, and unemployment rate are ranked in ascending order, whereas GDP per capita coefficients are ranked in descending order. “Better performing” countries are associated with having lower ranks.

In our fixed effects model, our coefficients for our indicator of interest represents the difference in the mean of that indicator between country i and the reference country (Australia), controlling for country fixed effects. In our multivariate OLS model, our coefficient represents how much we expect our indicator of interest to change as time passes.

Table 1: Rankings using multivariate OLS regression model:

Country	***deaths**	**cases**	**Unemployment rate**	***GDP per capita**	**Health consequences**	**Economic consequences**	**Overall weighted ranking**
Japan	1	1	2	5	1	3	1

Israel	2	5	3	3	2	2	2
Costa Rica	3	2	6	6	3	5	4
United Kingdom	4	4	1	1	4	1	2
United States	5	6	4	2	5	2	3
Italy	6	3	5	4	6	4	5

*represents "best fit models"

Table 2: Rankings using country fixed effects regression model:

Country	deaths	cases	Unemployment rate	GDP per capita	Health consequences	Economic consequences	Overall weighted ranking
Japan	1	1	1	6	1	3	1
Israel	2	3	3	5	2	4	2
Costa Rica	3	4	6	4	3	5	4
United Kingdom	4	6	4	3	5	3	4
United States	5	5	2	2	5	1	3
Italy	6	2	5	1	4	2	3

In comparing the death count rankings across both models, the rankings appear to be the same across counties, with Japan ranking the highest in their performance of minimising death count, and Italy ranking the lowest. Japan also ranks the highest in both models for performance of minimising cases. However, when comparing case count rankings across other countries, there are some subtle differences across the fixed effects versus multivariate OLS models: Israel has a difference in ranking of 3 versus 5, Costa Rica of 4 versus 2, and the United States of 6 versus 4. Rankings are a bit more similar for Italy (2 versus 3) and the United Kingdom (5 versus 6).

Likewise, there are some similarities in the ranking for unemployment rate performance across different countries: rankings are the same across both models for Israel (3), Costa Rica (6), and Italy (5), and similar for Japan (1 versus 2). Unemployment rate rankings are slightly different for the United States (4 versus 1) and the United Kingdom (2 versus 4).For GDP per capita rankings, similarities persist among the United Kingdom (2) and Japan (6 versus 5), yet rankings are more different for Israel (5 versus 3), Costa Rica (4 versus 6), the United States (3 versus 1), and Italy (1 versus 4).

Health consequence rankings are calculated by combining the ranks of deaths per 100k and cases per million, and weighting each ranking by 50%. We find the overall health consequence ranking to be very similar across both models, with the expectation of Italy (ranked 4th for multivariate OLS, and 6 for fixed effects model).

Economic consequence rankings are calculated by combining the ranks of GDP per capita and unemployment rate, and weighting each ranking by 50%. Many of the rankings are similar: 3 for Japan, 5 for Costa Rica, 2 versus 1 for the United Kingdom. However, there are some differences in the rankings for Israel (2 versus 4), the United States (1 versus 3), and Italy (4 versus 2).

Overall weighted rankings are calculated by combining the rankings of all four indicators and weight each at 25% value. The countries with the lowest ranking - i.e. the best performance at handling health and economic consequences of Covid-19 - remain consistent throughout both models: Japan is ranked the best (1), followed by Israel (2), the United Kingdom (3). Costa Rica was consistently ranked a bit lower (4). There are some discrepancies in the specific rankings of the other two lower-performing countries: Italy being ranked at either 3 or 5, and the United States being ranked at 2 or 4. Note that several of the rankings are tied given the way in which weighting was incorporated.

The full regression outputs are listed in the Appendix (Table 4-12), including the log likelihood, p-values, and r-squared outputs for each model.

5. *Critical discussion of the analytical result*

The strength of the models and indicators of interest are compared using log likelihood, p-values, and R squared values. High log likelihoods, high-in-magnitude R-squared values, and low p-values (< 0.05) are associated with better fit models (Breslow, 1996).

In comparing *deaths per 100*k indicator to *cases per million* indicator for measuring health consequences, we find that both models fit better to the *deaths per 100*k variable. In our fixed effects model, the log-likelihood value for our *deaths per 100*k indicator is -218 versus -22,409 for *cases per million* indicator. Given higher log likelihood values are associated with better models, *deaths per 100k* seems to be a more robust indicator for measuring health consequences across each country. Likewise, in our multivariate OLS model, coefficients associated with our *deaths per 100*k indicator has higher R-squared values (0.79-0.99) and consistently low p-values (< 0.05) in comparison to our *cases per million* indicator (R-squared ranging from 0.2-0.7, most p-values low (> 0.05) with exception of 0.58 for Japan). While *deaths per 100k* seems to be a more robust indicator across both models, the p-values associated with the *deaths per 100k* coefficients for our fixed effects model are high (> 0.05) for several countries: Costa Rica, Israel, and Japan. Therefore, when comparing the robustness of all models for health consequence, the multivariate OLS model for *deaths per 100k* seems to be the best fit.

In comparing our *unemployment rate* indicator to our *GDP per capita* indicator in our fixed effects model, we find that the model for *unemployment rate* coefficients has a lower log likelihood (-647 versus -931), yet p-values for several coefficients are high (< 0.05 for Israel and the United States). Meanwhile, *GDP per capita* has consistently low p-values; although

0.000 might be unreasonably low. In our multivariate OLS model, we find that *unemployment rate* coefficients have a mix of high and low r-squared values (i.e. 0.82 for Costa Rica, 1.00 for Japan, 0.13 for the United Kingdom and 0.22 for Italy), whereas *GDP per capita* coefficients have relatively high R-squared, with the exception of Japan (-0.61). However, this low-in-magnitude R-squared might be attributed to how there appears to be more limited data for the *GDP per capita* of Japan (Appendix Graphs 1-7). P-values are low (< 0.05) for both indicators. While there are some nuances in the goodness-of-fit metrics for economic outcome indicators, our multivariate OLS model for *GDP per capita* seems to be the best fit. An additional constraint in our analysis is how our rankings are based on a numeric scale, and are not weighted based on the magnitudes of particular coefficients. Weighting our rankings in a more complex way might give us more insights into the magnitudes of the difference in performance by country.

Overall, while not one model is a perfect fit for our data, various goodness-of-fit metrics give us clarity on which indicators and which models might be best for our analysis. However, there might be limitations to both of our models. If there is missing or skewed data for our reference country (Australia) in our fixed effects model, this might impact our rankings. Likewise, if we are missing any confounding variables in our multivariate OLS (i.e. how developed a country is, cultural effects, etc.), this might also skew the rankings.

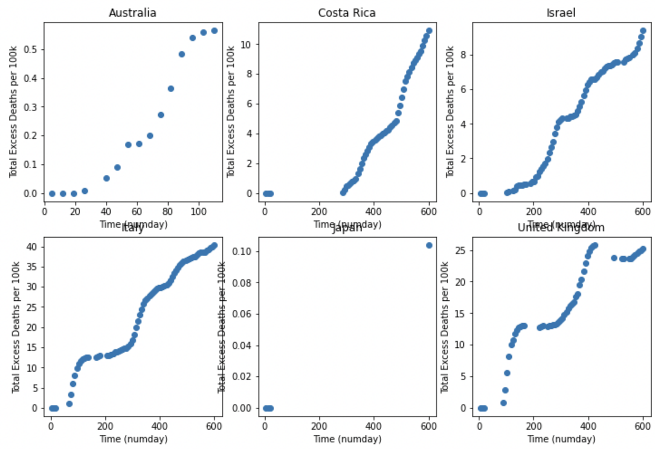
6. *Conclusion*

In our analysis on country performance during the peak of the Covid-19 pandemic (January 2020-August 2021), we find that our best fit model for health consequences of the Covid-19 pandemic is a multivariate OLS model for *deaths per 100k*, and the best fit model for economic consequences of the pandemic is a multivariate OLS for *GDP per capita*. Japan seems to perform very well across the board. In looking at the specific rankings of our best fit models, Japan appears to perform the best for handling health consequences (lowering *deaths per 100k*), whereas Italy performs the worst. The United Kingdom appears to perform the best for handling the economic consequences (i.e. in maintaining a higher GDP per capita or preventing any significant decrease of this metric), whereas Costa Rica performs the worst. However, given the slight nuances in cross-country rankings across different models, these results should be interpreted with caution. While our ranking results are often consistent, further analysis could be done with additional data and more complex models to test the robustness and compare rankings. Nonetheless, we find relatively consistent rankings in our analysis of cross-country performance.

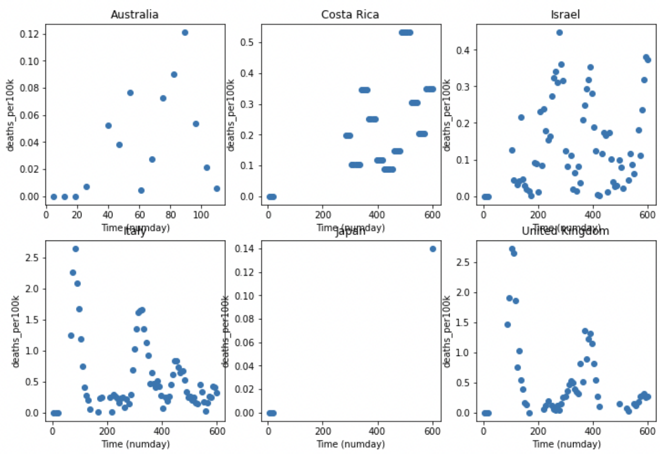
7. *Appendix*

Graphs 1-7: Descriptive data on indicator variables

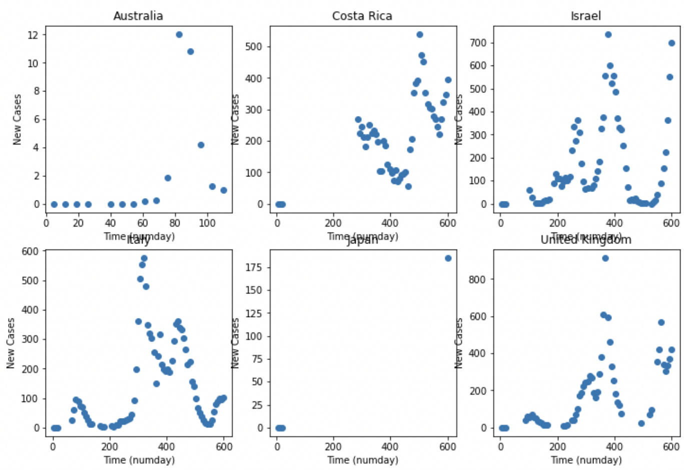
Graph 1: Total excess deaths per 100k



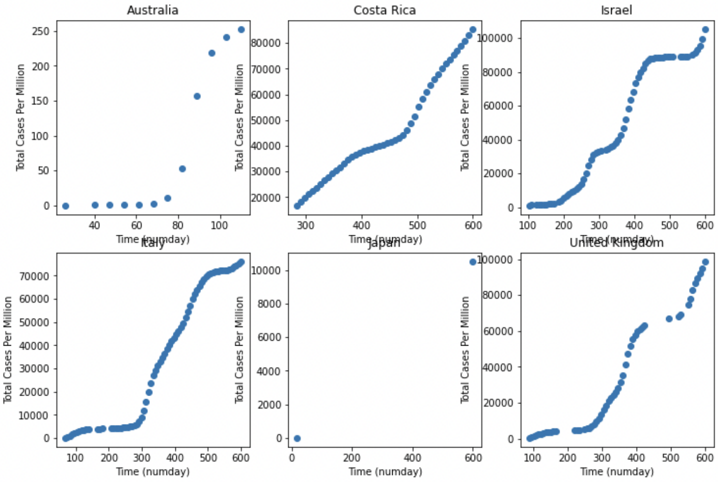
Graph 2: Excess deaths per 100k



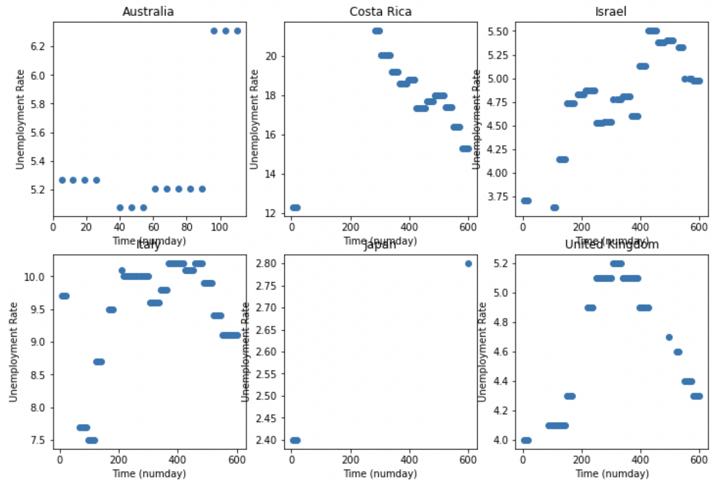
Graph 3: New Cases per Million



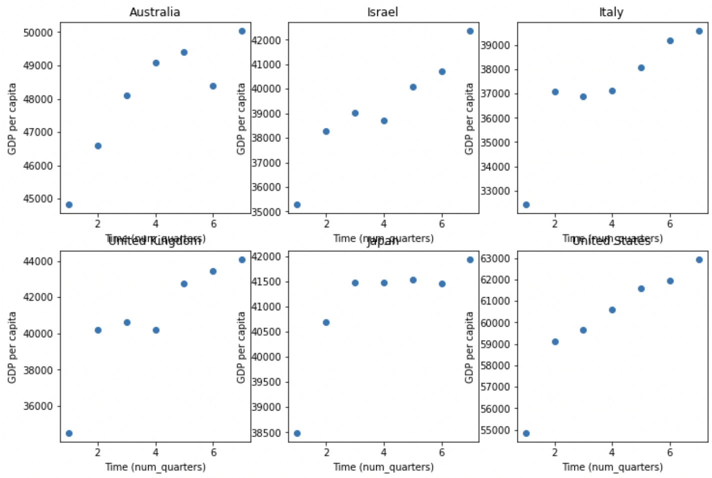
Graph 4: Total Cases per Million



Graph 5: Unemployment Rate



Graph 6: GDP per capita



Graph 7: GDP per capita, percent change

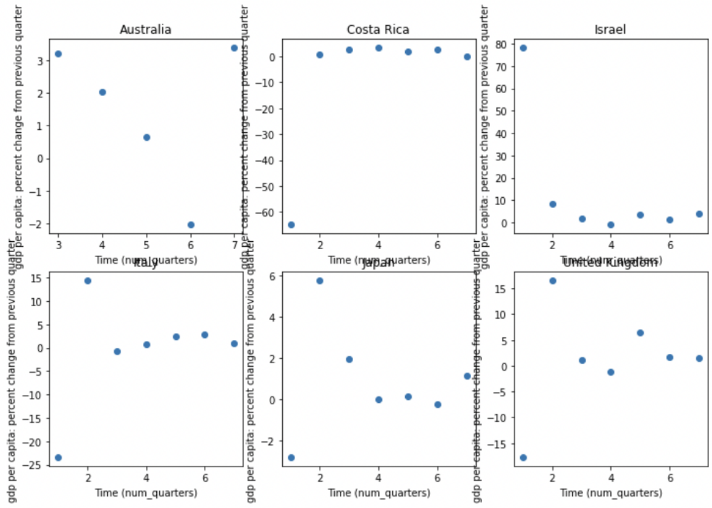


Table 3: Correlation matrix for dependent variables

correlation_matrix

GDP per capita	gdp_percent_change	total_deathsper100k	total_cases_per_million	unemploymentratetotaloflabourfor	numday	stringency_index	reproduction_rate	population_density	hospital_beds_per_thousand	gdp_per_capita	diabetes_prevalence
1.0	0.1686808224888090	0.2468698176560520	0.042240588085528300	-0.5750418473655960	-0.1642589928718400	0.05667170471132950	0.0007429339194478350	-0.29588441601487100	0.30270966227970200	0.9740458390500250	0.38824862540073900
0.1686808224888090	1.0	-0.05707806061074170	0.03679488368310870	-0.2685145055469760	-0.033436719885138900	-0.020920177562930300	-0.005386755548173320	0.20257404446679	0.10402303304005000	0.1606664962233290	0.032342984749426600
0.2468698176560520	-0.05707806061074170	1.0	0.5406904054102130	-0.11628308370767800	0.5938401863069620	0.11467578502303800	-0.1747734019373190	-0.17937683369303900	0.029752953383253100	0.31824236613502400	-0.13034076903424400
0.042240588085528300	0.03679488368310870	0.5406904054102130	1.0	-0.05887667223555510	0.9073048716166360	-0.3517133913635610	-0.1537064573871970	-0.012849557174783900	-0.1318622712344880	0.013041956409225100	0.2159432019238630
-0.5750418473655960	-0.2685145055469760	-0.11628308370767800	-0.05887667223555510	1.0	0.1735747875835920	-0.03442040810857190	-0.026883059543645500	-0.4634065325628600	-0.4882285412130750	-0.5942946575231610	0.2815077779941760
-0.1642589928718400	-0.033436719885138900	0.5938401863069620	0.9073048716166360	0.1735747875835920	1.0	-0.3470686947807000	-0.07462525119170710	0.007526110141550090	-0.221092286353816	-0.17773943988151600	0.10794556538827800
0.05667170471132950	-0.020920177562930300	0.11467578502303800	-0.3517133913635610	-0.03442040810857190	-0.3470686947807000	1.0	-0.21954907290649000	0.05450836591144140	0.05837112572474320	0.10047559852678000	-0.15663593726643800
0.0007429339194478350	-0.005386755548173320	-0.1747734019373190	-0.1537064573871970	-0.026883059543645500	-0.07462525119170710	-0.21954907290649000	1.0	-0.021938159271218000	0.006078265927954640	0.000982669786240566	0.0030731422286464200
-0.29588441601487100	0.20257404446679	-0.17937683369303900	-0.012849557174783900	-0.4634065325628600	0.007526110141550090	0.05450836591144140	-0.021938159271218000	1.0	0.23975620141391900	-0.30975156203845400	-0.6089012053247650
0.30270966227970200	0.10402303304005000	0.029752953383253100	-0.1318622712344880	-0.4882285412130750	-0.221092286353816	0.05837112572474320	0.006078265927954640	0.23975620141391900	1.0	0.32937068911294300	-0.23024687499377600
0.9740458390500250	0.1606664962233290	0.31824236613502400	0.013041956409225100	-0.5942946575231610	-0.17773943988151600	0.10047559852678000	0.000982669786240566	-0.30975156203845400	0.32937068911294300	1.0	0.2980787682468960
0.38824862540073900	0.032342984749426600	-0.13034076903424400	0.2159432019238630	0.2815077779941760	0.10794556538827800	-0.15663593726643800	0.0030731422286464200	-0.6089012053247650	-0.23024687499377600	0.2980787682468960	1.0

Table 4: GLM poisson with fixed effects (deaths per 100k), with country fixed effects

```
Model Family:                 Poisson   Df Model:                            7
Link Function:                    Log   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -218.71
Date:                Sun, 30 Apr 2023   Deviance:                       95.712
Time:                        00:00:18   Pearson chi2:                     102.
No. Iterations:                     6   Pseudo R-squ. (CS):             0.1028
Covariance Type:            nonrobust
==================================================================================
                     coef    std err          z      P>|z|      [0.025      0.975]
----------------------------------------------------------------------------------
const             -3.2144      1.323     -2.430      0.015      -5.807      -0.622
Costa Rica         2.0925      1.369      1.528      0.126      -0.591       4.776
Israel             1.5418      1.368      1.127      0.260      -1.140       4.223
Italy              2.9098      1.339      2.173      0.030       0.286       5.534
Japan             -0.0199      2.982     -0.007      0.995      -5.865       5.826
United Kingdom     2.8433      1.341      2.120      0.034       0.214       5.472
United States      2.6089      1.341      1.945      0.052      -0.020       5.237
num_days          -0.0009      0.001     -1.607      0.108      -0.002       0.000
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[ ]:  1
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Table 5: GLM poisson with fixed effects (new cases per million), with country fixed effects

Generalized Linear Model Regression Results

Dep. Variable:	new_cases_per_million	No. Observations:	344
Model:	GLM	Df Residuals:	336
Model Family:	Poisson	Df Model:	7
Link Function:	Log	Scale:	1.0000
Method:	IRLS	Log-Likelihood:	-22409.
Date:	Sun, 30 Apr 2023	Deviance:	42771.
Time:	00:16:30	Pearson chi2:	4.52e+04
No. Iterations:	8	Pseudo R-squ. (CS):	1.000
Covariance Type:	nonrobust		

	coef	std err	z	P>|z|	[0.025	0.975]
const	0.6040	0.178	3.395	0.001	0.255	0.953
Costa Rica	3.7631	0.179	21.081	0.000	3.413	4.113
Israel	3.6635	0.178	20.536	0.000	3.314	4.013
Italy	3.5039	0.178	19.638	0.000	3.154	3.854
Japan	2.6498	0.193	13.753	0.000	2.272	3.027
United Kingdom	3.8505	0.178	21.585	0.000	3.501	4.200
United States	3.8815	0.178	21.767	0.000	3.532	4.231
num_days	0.0023	2.78e-05	83.855	0.000	0.002	0.002

Table 6: Unemployment GLM (gaussian), with country fixed effects

Generalized Linear Model Regression Results

Dep. Variable:	unemploymentratetotaloflabourfor	No. Observations:	344
Model:	GLM	Df Residuals:	336
Model Family:	Gaussian	Df Model:	7
Link Function:	identity	Scale:	2.5747
Method:	IRLS	Log-Likelihood:	-646.74
Date:	Mon, 01 May 2023	Deviance:	865.11
Time:	20:34:18	Pearson chi2:	865.
No. Iterations:	3	Pseudo R-squ. (CS):	0.9993
Covariance Type:	nonrobust		

	coef	std err	z	P>|z|	[0.025	0.975]
const	5.4813	0.416	13.189	0.000	4.667	6.296
Costa Rica	12.7496	0.513	24.847	0.000	11.744	13.755
Israel	-0.2951	0.482	-0.612	0.540	-1.240	0.650
Italy	4.4045	0.479	9.192	0.000	3.465	5.344
Japan	-2.8079	0.905	-3.104	0.002	-4.581	-1.035
United Kingdom	-0.4625	0.488	-0.948	0.343	-1.419	0.494
United States	2.4165	0.476	5.073	0.000	1.483	3.350
num_days	-0.0011	0.001	-1.969	0.049	-0.002	-4.74e-06

Table 7: GDP per capita GLM, with country fixed effects

Generalized Linear Model Regression Results

Dep. Variable:	GDP per capita	No. Observations:	98
Model:	GLM	Df Residuals:	90
Model Family:	Gaussian	Df Model:	7
Link Function:	identity	Scale:	1.1467e+07
Method:	IRLS	Log-Likelihood:	-931.38
Date:	Mon, 01 May 2023	Deviance:	1.0320e+09
Time:	21:49:21	Pearson chi2:	1.03e+09
No. Iterations:	3	Pseudo R-squ. (CS):	1.000
Covariance Type:	nonrobust		

	coef	std err	z	P>|z|	[0.025	0.975]
const	4.781e+04	1134.488	42.140	0.000	4.56e+04	5e+04
Costa Rica	-3.172e+04	1279.875	-24.785	0.000	-3.42e+04	-2.92e+04
Israel	-1.14e+04	1279.875	-8.908	0.000	-1.39e+04	-8892.498
Italy	-1.103e+04	1279.875	-8.622	0.000	-1.35e+04	-8525.970
Japan	-1.047e+04	1279.875	-8.180	0.000	-1.3e+04	-7960.791
United Kingdom	-7911.6714	1279.875	-6.182	0.000	-1.04e+04	-5403.163
United States	1.147e+04	1279.875	8.963	0.000	8963.605	1.4e+04
num_quarters	1077.6276	171.030	6.301	0.000	742.414	1412.841

Table 8: Rankings from FE Model:

	Death count ranks	Case count ranks	GDP per capita rank \
Japan	1.0	1.0	6.0
Israel	2.0	3.0	5.0
Costa Rica	3.0	4.0	4.0
United States	4.0	6.0	3.0
United Kingdom	5.0	5.0	2.0
Italy	6.0	2.0	1.0

	Unemployment_rate rank	Health conseq rankings \
Japan	1.0	1.0
Israel	3.0	2.5
Costa Rica	6.0	3.5
United States	4.0	5.0
United Kingdom	2.0	5.0
Italy	5.0	4.0

	Econ conseq rankings	weighted_ranking
Japan	3.5	3.375
Israel	4.0	4.875
Costa Rica	5.0	6.375
United States	3.5	6.375
United Kingdom	2.0	5.250
Italy	3.0	5.250

Table 9: Multivariate OLS: Deaths per 100k
*Predictor variables: ['num_day', 'population_density', 'gdp_per_capita', 'diabetes_prevalence']

```
1 deaths_MV_OLS
```

	Country	MV_deaths_coef	R-squared	p-value	deaths_MV_OLS_ranks
0	Japan	0.000176	0.999622	1.889109e-04	1.0
1	Australia	0.006194	0.919293	1.767251e-08	2.0
2	Israel	0.018801	0.951920	6.973336e-46	3.0
3	Costa Rica	0.021038	0.755819	5.404698e-16	4.0
4	United Kingdom	0.040647	0.858223	3.865487e-24	5.0
5	United States	0.061161	0.967511	2.588929e-58	6.0
6	Italy	0.070989	0.962194	5.917729e-53	7.0

Table 10: Multivariate OLS: Cases per million

*Predictor variables: ['num_day', 'population_density', 'gdp_per_capita', 'diabetes_prevalence']

```
1 cases_MV_OLS
```

	Country	MV_cases_coef	R-squared	p-value	cases_MV_OLS_rank
0	Australia	-358.708631	0.515252	2.583603e-03	1.0
1	Japan	-29.629515	0.171660	5.856813e-01	2.0
2	Costa Rica	95.746185	0.480336	3.413189e-08	3.0
3	Italy	145.053952	0.728485	4.518531e-22	4.0
4	United Kingdom	155.220250	0.683692	7.407121e-15	5.0
5	Israel	201.808782	0.786325	3.841989e-24	6.0
6	United States	222.888782	0.868653	3.089274e-35	7.0

Table 11: Multivariate OLS: Unemployment rate, % of total labour force

*Predictor variables: ['num_quarters', 'population_density', 'diabetes_prevalence', 'total_deathsper100k']

```
1 unemp_MV_OLS
```

	Country	unemp_coef	R-squared	p-value	unemp_MV_OLS_rank
0	Australia	-1.422843e-02	0.638997	2.213432e-03	1.0
1	United Kingdom	-3.251832e-04	0.125297	3.078799e-02	2.0
2	Japan	1.388199e-14	1.000000	2.481176e-11	3.0
3	Israel	4.015516e-03	0.635619	3.398945e-15	4.0
4	United States	5.627893e-03	0.342338	1.496613e-07	5.0
5	Italy	7.444693e-03	0.222545	1.315111e-04	6.0
6	Costa Rica	2.455678e-02	0.817209	1.059155e-17	7.0

Table 12: Multivariate OLS: GDP per capita

*Predictor variables: ['num_quarters', 'population_density', 'diabetes_prevalence', 'total_deathsper100k']

```
1 gdp_MV_OLS
```

	Country	gdp_coef	R-squared	p-value	gdp_MV_OLS_rank
0	United Kingdom	1334.153571	0.803402	1.184430e-135	1.0
1	United States	1136.739286	0.848433	3.422246e-223	2.0
2	Israel	971.446429	0.895678	2.568985e-236	3.0
3	Italy	959.003571	0.774128	4.163455e-167	4.0
4	Japan	425.971429	0.614893	6.603483e-06	5.0
5	Costa Rica	414.010714	0.971283	7.642300e-263	6.0
6	Australia	316.700000	0.418584	3.322964e-09	7.0

Table 13: Multivariate OLS: GDP per capita, percent change

*Predictor variables: ['num_quarters', 'population_density', 'diabetes_prevalence', 'total_deathsper100k']

```
1 gdp_percentchange_MV_OLS
```

	Country	gdp_percentchange_coef	R-squared	p-value	gdp_perchange_MV_OLS_rank
0	Costa Rica	7.064519	0.365058	2.916282e-34	1.0
1	Italy	1.913802	0.132955	1.111023e-16	2.0
2	United Kingdom	1.180546	0.062467	4.461033e-06	3.0
3	Japan	-0.066332	0.003021	9.628917e-01	4.0
4	Australia	-0.371476	0.069120	7.588735e-02	5.0
5	United States	-2.935923	0.531101	4.989810e-90	6.0
6	Israel	-8.374926	0.402838	1.828686e-54	7.0

Table 14: Multivariate OLS ranking (excluding Australia)

	Country	deaths_MV_OLS_ranks	cases_MV_OLS_rank	unemp_MV_OLS_rank \
0	Japan	1.0	2.0	3.0
2	Israel	3.0	6.0	4.0
3	Costa Rica	4.0	3.0	7.0
4	United Kingdom	5.0	5.0	2.0
5	United States	6.0	7.0	5.0
6	Italy	7.0	4.0	6.0

	gdp_MV_OLS_rank	gdp_perchange_MV_OLS_rank	Health conseq rankings \
0	5.0	4.0	1.0
2	3.0	7.0	3.0
3	6.0	1.0	4.0
4	1.0	3.0	5.0
5	2.0	6.0	6.0
6	4.0	2.0	7.0

	Econ conseq rankings	weighted_ranking
0	4.0	1.250
2	3.5	1.625
3	6.5	2.625
4	1.5	1.625
5	3.5	2.375
6	5.0	3.000

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