LUND UNIVERSITY
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Restrictions and effects observed during the first pandemic year of Covid-19

A quantitative study on the economic implications and health outcomes of Covid-19 on OECD-members

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Abstract

Using the most recent data from various databases we have retrieved economic and health data from OECD member countries and analyzed it in regard to the Oxford COVID-19 Government Response Tracker, what we call Stringency index. We examine the effects on different economic variables such as GDP, exports, and unemployment, together with the health outcome variable excess mortality. In regard to our different countries' restriction strategies, that is their Stringency Index. The main method we employed is bivariate plots and regression analysis. The investigation and analysis are solely made for the first year of the pandemic, 2020. Our results reveal that all of our variables are significant in at least one regression. The adjusted R2 value shows that the dependent variables can be explained by our independent variables ranging from 27 to 75 percent. The variables we most often find significant are: Excess mortality per 100,000, GDP and Stringency index. A considerable effort was made when selecting, retrieving, and processing the data for our purposes and to make it comparable between the countries chosen. Other aspects that undeniably impact the outcomes are mentioned and discussed but due to the complexity we chose to limit this research to a few variables with complete and comparable data. Our results show how the different outcomes are significant for the measurements taken but also how the measurements impact the outcomes in a bilateral relationship. The insights derived are hopefully useful for economists, politicians, and the public in concerns to the management of the Pandemic during its first year.

Keywords: Covid-19, Stringency index, Excess mortality, Economic implications, Pandemic

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1. Introduction

The Covid-19 outbreak shook the world during the spring of 2020 and affected everyone and every country, striking up heated discussions on what precautionary measures would be the best and most effective. This intensive discussion and the media's undivided attention of Covid-19 coverage is the source to our fascination with the subject.

As of the 10th of December 2020, roughly 70 million people, worldwide, had been confirmed positive for Covid-19, and roughly 1,6 million people deceased (Johns Hopkins Coronavirus Resource Center, 2020). Many of those to come down with the virus needed healthcare and the load on many countries' healthcare systems have been immense. Other treatments unrelated to the Covid-19 virus have been postponed which has severely affected people suffering from other illnesses than Covid-19 (Griffin, S., 2020; The Lancet Rheumatology, 2021).

The spread of infection and the governmental actions to hamper the spread have been said to come hand in hand with large and negative consequences to national as well as global economic outlooks (O'Donnell, L. B., Kristen E. Broady, Wendy Edelberg, and Jimmy, 2020; World Bank, 2020a). These kinds of medial and governmental statements made us decide that we wanted to analyze the economic and health-effects of different countries' decisions in regard to restrictions. The insights we hope to find and the knowledge we seek to uncover will be of relevance when looking back and evaluating countries' different course of action in the fight against the Covid-19 pandemic. The insights we hope to discover will be retrieved from our analysis by assessing which methods have been most effective from an economical point of view but also from a health perspective. The analyses we conduct are the foundations of which our research is based upon.

A nation's economy is thought to be affected by the level of virus spread, the restrictions put in place to hamper the spread and the restrictions put in place in other countries which will reduce the demand of a country's goods and services, causing disturbance in supply chains (Barlow, P. *et al.* 2021; Eurostat, 2021; IMF, 2020a; UNCTAD, 2020). Therefore, we include GDP and export in the data we analyze, to see if we can ensure the effects, we suspect the pandemic and restrictions will cause. A high spread of infection will make households reduce their close-to-contact consumption to reduce the risks of being infected and infect others, which is thought to reduce production and hence employment because of the uncertainty of consumption and production (JpMorgan, 2020; McKinsey, 2021a). Therefore, we also include unemployment in the analysis.

Besides the economic variables we include in our analyses we also incorporate the most relevant health variable, countries excess mortality rates. Another health variable is people reported dead of Covid-19, however many argue that excess mortality is better when trying to capture the total impact of the pandemic on deaths for many reasons, such as some countries only report Covid-19 deaths from hospitals, some countries do not test all their dead which makes it impossible be sure who died of Covid (Aron, J. & Muellbauer, J. 2020; Institute for Health Metrics and Evaluation, 2021; OurWorldInData, 2021a). We decided to only include excess mortality because of the uncertainty in reported deaths and to give the research a deeper understanding in the interaction between economic consequences and raw numbers of deaths regarding different restriction measures put in place in different countries.

The final piece to our analysis is the so-called Stringency index. What we will further in this thesis call "Stringency index" is officially named COVID-19 Government Response Tracker, which is developed by a university collaboration between the University of Oxford and Blavatnik School of Government (Oxford COVID-19 Government Response Tracker, 2020). The Stringency index systematically collects information on several different common policy responses that governments have taken to act against the pandemic on 9 policy indicators, such as school closures and travel restrictions. The index has data from most of the world's countries.

We decided to use this index as our variable for restrictions because it is widely used by other studies (König, M. and Winkler, A. 2021; Wang, D. et al. 2021), and in media coverage (Douglas, J., 2020). We thought of creating our own restriction index for the countries we wanted to observe but quickly realized that this would be a huge undertaking, the Stringency index has a team with over one hundred Oxford scholars and staff contributing to the data collection, hence we decided to use the index that they provide at no cost. (Oxford COVID-19 Government Response Tracker, 2020)

Another relevant dimension when it comes to analyzing economic outcomes during the pandemic are the big policies with the intention to "get the economy on its feet again" that both the European Union and US are conducting. The European Union has decided on a €1.8 trillion stimulus package from 2021-2027 with a €750 billion temporary recovery instrument that intends to repair immediate economic and social damage in the European Union (European Commission, 2020). It’s the biggest stimulus package ever financed in Europe.

The US are not afraid of spending either, with President Biden passing a $1,9 trillion stimulus package in March 2021, Trump passed a $2,5 trillion package during 2020, and in December the American congress passed another $900 billion corona relief bill, this adds up to a total of 27% of the American GDP in different Covid-19 related stimulus packages (Washington Post, 2021).

Unfortunately, it was difficult to compile the stimulus related data for all of our countries, hence we will not include it in our data analyses. We will however incorporate it in our discussion as a variable that potentially could distort our result. Giving some background information about these huge relief packages is relevant for you readers to fully recognize how committed governments are, in the battle against Covid-19.

What we want to accomplish with our research is to discover and illustrate patterns concerning measures put in place to reduce the spread of infection and outcomes, both economical outcomes and health outcomes. This is a complex task since measures depend on outcomes as well as outcomes depend on measures. It is a bilateral connection with causality in both directions. To investigate the connection between measures and outcomes we will examine the variation in the data between our chosen OECD countries and over time. We split up our data into two time periods, half-year periods. These patterns will be of utmost interest when conducting further research and discussions on which measures are optimal when facing a pandemic such as Covid-19. After visualizing and plotting our data we found that the most suitable method for estimating these outcomes was by using the ordinary least squares (OLS) method through linear regressions.

2. Previous research

Undeniably there has been a great deal of research regarding the Covid-19 pandemic, research that analyzes and discusses almost every aspect of the pandemic that has affected us all. We have mainly focused on the research made regarding macroeconomic effects, health outcomes and governance since these are the topics we are also analyzing.

One relevant paper published by the European think tank Bruegel which specializes in economic subjects, has some similarities to our research (Bruegel, 2020). The goal with their paper is to analyze and observe why Covid-19 hit different European economies so differently. They include several factors that they believe influenced the degree of economic contraction of the EU countries they examine in their research. These factors are the severity of lockdown measures, the structure of national economies, public indebtedness, and the quality of governance in the countries they are examining.

Regarding the severity of lockdown measures factor that they include in their analyzes we notice they also use the Oxford Covid-19 Government response tracker, that is the Stringency index. Similar to us they compute an average of the index over the first semester of 2020, whilst we compute an average for each half-year of 2020.

Their second possible factor is the structure of national economies. Measures taken to combat the spread of the virus affect different economic activities differently. They have used the share of tourism in total GDP as a proxy for different countries' economic structure. Tourism is thought by Bruegel to be extremely negatively affected by sanitary measures implemented to fight the spread of the virus. 2019 tourism averaged 4.8 percent of GDP in the European Union.

The final factor they include in their analysis is the quality of governance. They constructed an indicator of governance by summing up for each country its scores for the six parts of the World Bank Worldwide Governance Indicator, resulting in a score for each country varying from -15 to 15. In 2018, the latest data available, the quality of governance in the European Union averaged 6. The research author expects that, for a given degree of severity of lockdown measures, a given structure of the economy and a given level of public debt, the degree of the Covid-19 economic shock will be lower in countries with a higher quality of private and public governance and institutions.

We can observe some differences in our research compared to Bruegel's: they have focused more narrowly on macroeconomic factors that they argue will explain differences in economic outcome when faced with a pandemic such as Covid-19. We on the other hand have relied more on the Stringency index as our explaining factor that we expected and assumed before conducting our study influenced both economic and health outcomes. It is also relevant to mention that our research is substantially broader, we examine three types of economic outcome, GDP, exports, and unemployment rates, as well as incorporating a health-outcome perspective in the analysis.

A central subject in the Bruegel paper is the record-breaking European stimulus package. It is evident that it is a big question they want to shed light on. They bring up the huge stimulus package in the very first sentences of their introduction and emphasize that the multi-billion fund will mostly benefit the countries that have been hardest hit by the pandemic. And thus, wanting to be able to explain why these countries got hit so hard, compared to other countries in Europe.

The Bruegel research arrived at some interesting results, generally they found that differences in GDP losses were between 30 and 50 percent down to lockdown strictness, between 35 and 45 percent to the quality of governance and between 15 and 25 percent down to tourism. The variation in results exists because of their way of analyzing the data, they compare pairs of countries and some country groupings to each other, hence the variation. One example of a comparison they made was Italy vs. Netherlands, where the lockdown strictness variable and governance variable each accounted for about half of the differential between the two countries, and the contribution of the tourism variable is negligible. We will compare these results to our own in the discussion section of the thesis.

Another research regarding the Covid-19 pandemic which is relevant for us was published by the National Bureau of Economic Research (Coibion, O., Gorodnichenko, Y. and Weber, M. 2020) which is a renowned economic research organization originating from the US. This paper is dedicated to conclude the costs of the Covid-19 pandemic and covers some similar topics to our research. They include lockdowns in their analysis, macroeconomic expectations of the crisis and tries to predict consumer spending. Worth noting is that the paper was released in May 2020 so there was not much reliable data to work with at that time.

Their research focuses solely on the US and they study how the differential timing of local lockdowns due to Covid-19 causally affects household spending and macroeconomic expectations at local level. Their research's course of action to obtain data was to use several waves of customized surveys with over 10,000 respondents who are a representative panel of households in the US. They found that roughly 50 percent of the survey participants reported both income and wealth loss due to Covid-19. Average loss of income was $5,293 and average wealth loss was $33,482. They also found that counties in the US that went into lockdown earlier than others have an expected unemployment rate that is 13 percent higher over the next twelve months.

The research illustrates the high levels of concern from American households regarding their financial situation facing the Covid-19 pandemic. As mentioned earlier, their study was published in May 2020, their findings are expected losses not realized losses and it is unfortunate that there has not been a follow-up study on the households that responded to these surveys which could give us better insights regarding how American households de facto were affected by the pandemic during 2020. Their results will be compared to our own in the discussion section.

3. Data and empirical material

3.1 Data description

We limited our research to only analyze data from the OECD countries. There are 37 members in the OECD (OECD, 2020). We chose to use the countries in OECD because they publish reliable and comprehensive data. The time period for retrieval of all data is limited to the calendar year 2020 with the exception of population data, because 2019 was the latest data published.

**Note some data variables are missing for some countries, specifications are included in the appendix.

3.1.1 Stringency index

The Stringency index, which we use to examine restrictions put in place by governments, is a composite measure with a simple additive score from nine different indicators on an ordinal scale and rescaled to vary from 0 to 100 where 0 is no imposed restrictions and 100 is the most severe restrictions. The Stringency index gives us a score from 0-100 every day for each country starting from 21/01-2020 until 31/12-2020. Using this index as a basis for our comparison we decided to split up the data for each country into two averages, one for the first half-year (21/01-2020 to 30/06-2020) and another for the second half of the year (01/07-2020 to 31/12-2020). The reasoning behind splitting the data up into half-year averages is to give a fair comparable value for all countries, since the actual spread and restrictions caused by Covid-19 differs between the countries. The half-year average was produced by calculating the sum of the index score for that half-year divided by the amount of days in that time period. We are using these averages as our restriction variable for each country, to compare and analyze with our economic and health variables.

More information about how the Stringency index is calculated and computed, together with calculations and sources from all other variables used in our data is explained in detail in the Appendix.

3.1.2 Health data

Excess mortality per 100,000:

Excess mortality per 100,000 shows how many more died during 2020 (divided into first and second half-year) compared to the yearly average deaths from 2015-2019.

Population (2019)

The country's population for the year 2019, latest data available.

3.1.3 Economic data

GDP

The percentage change in GDP with reference period Q4 2019. For the first half-year we used the GDP level for Q2 2020 and for the other half we used GDP level for Q4 2020.

Export

The percentage change in export with reference period Q4 2019. For the first half-year we used the export amount for Q2 2020 and for the other half we used the export amount for Q4 2020.

Unemployment

The unemployment level for the first half-year by directly retrieving the unemployment rates from OECD stats for Q2 2020, for the second half we did the same but for Q4 2020.

3.1.4 Other data

Population ages 65 and over (% of total population)

Population age 65 and above as a percentage of the total population.

Urban population (% of total population)

Urban population refers to people living in urban areas as defined by national statistical offices. Countries differ in the way they classify populations as "urban" or "rural". There is no consistent and universally accepted standard for distinguishing urban from rural areas, in part because of the wide variety of situations across countries (World bank, 2021b). Since we chose to limit our research to countries that are members of OECD, we assume that the difference between these countries is negligible.

3.2 Initial data analysis – visualizing our data

3.2.1 Stringency index distribution

Figure 1. Stringency half-year average 21 January 2020 to 30 June 2020

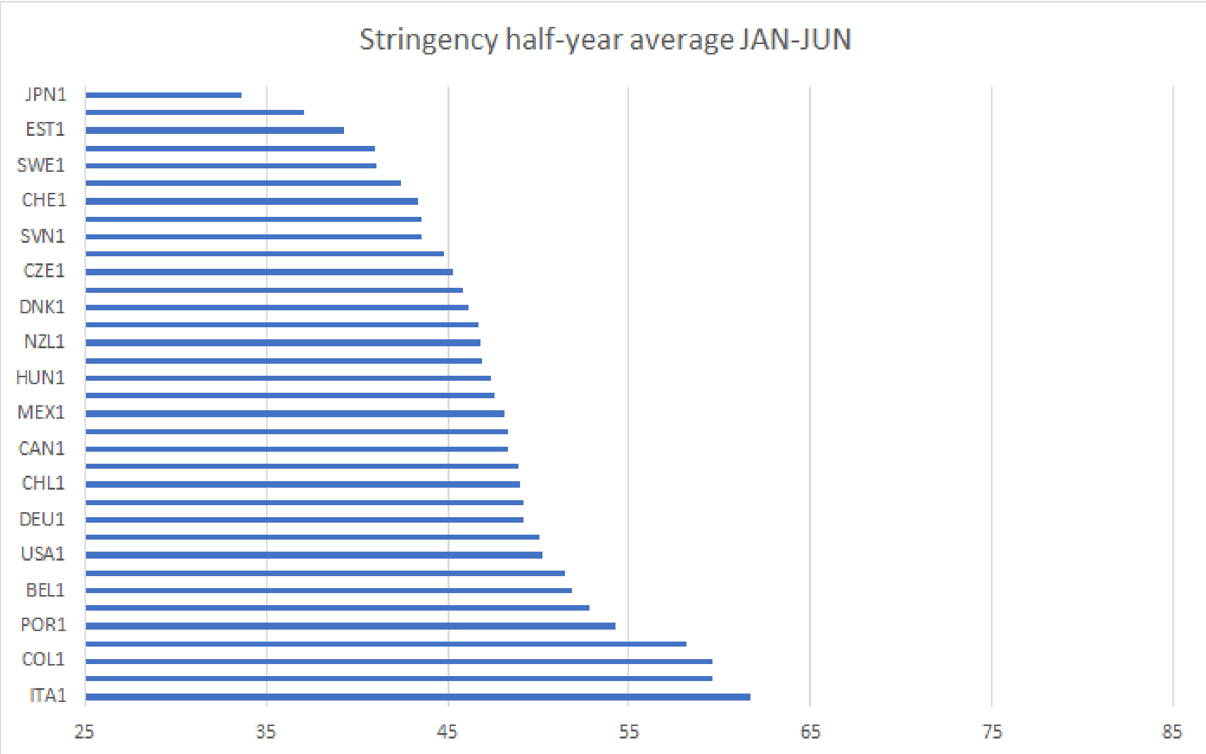
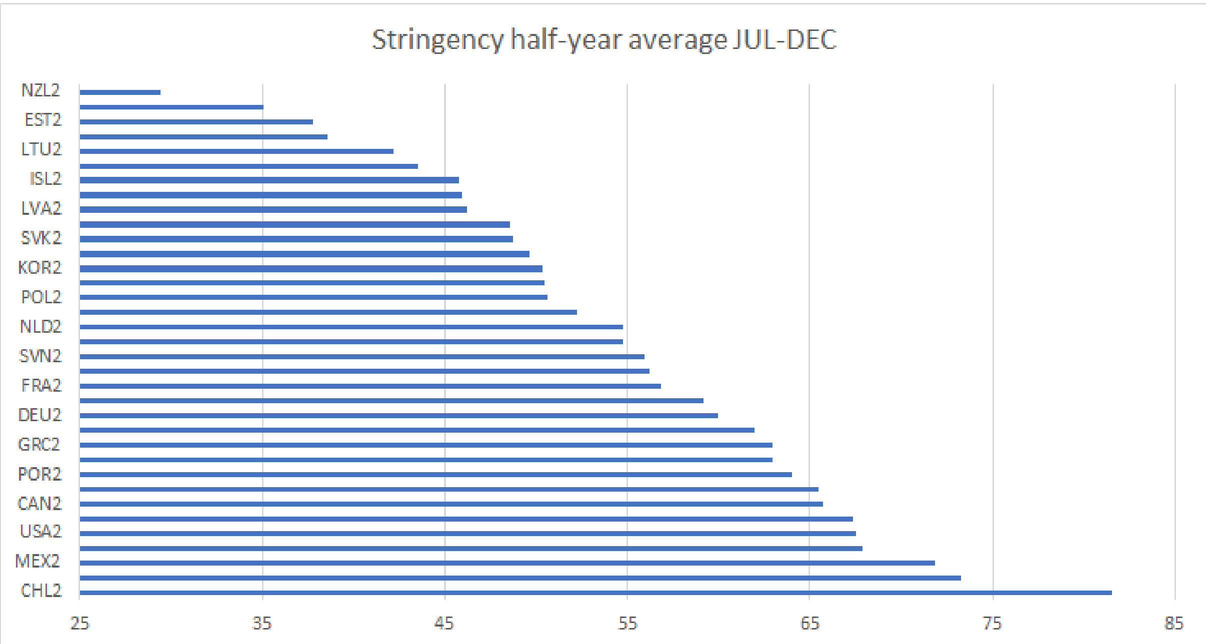


Figure 2. Stringency half-year average 21 January 2020 to 30 June 2020

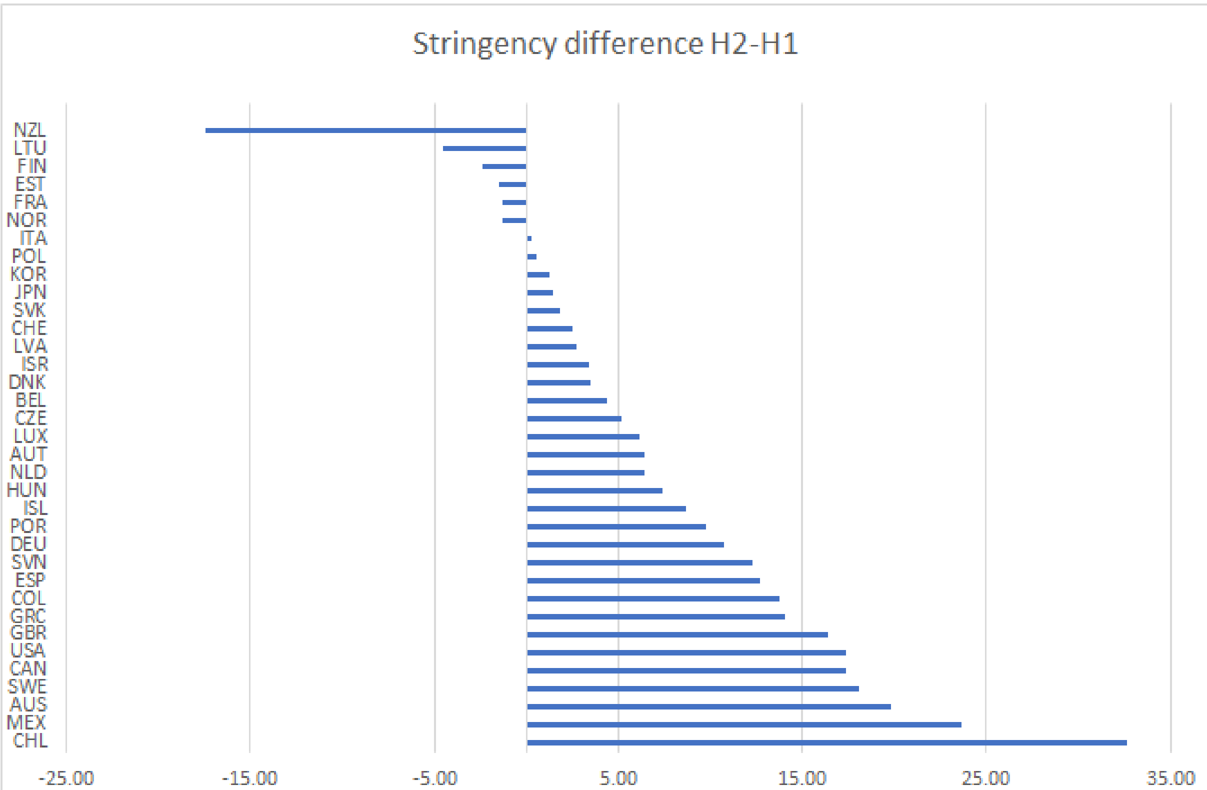


We explained that we decided to use the Stringency index as our variable for implemented restrictions, instead of making our own index which would be extremely time consuming. We begin our analysis with clarifying and illustrating three of our variables in order to convey a clear picture of the differences during the two time periods, for deeper understanding of the underlying variables when we progress into the linear regressions. As you can see in the first two figures, we begin our initial analysis with comparing the Stringency index for our included countries. Our first step was to calculate the half-year averages of the index.

To reach greater understanding we evaluate if countries that quickly implemented harsh restrictions, that is had a high Stringency index in the first half-year, lowered their restrictions in the second half or kept them harsh. The same goes for countries that had soft restrictions for the first half-year, did they increase dramatically for the second half? Since we include 37 countries in our analysis, we decided to not have the names of all countries written out in all of the charts, for aesthetic reasons.

In the second figure, the second half-year average of the Stringency index, it is easy to observe a big increase in implemented restrictions.

Figure 3. Stringency index difference between second and first half-year



We noticed that most countries imposed harder restrictions, with some countries as exceptions by lowering their restrictions. To illustrate the actual difference, we plot a chart with the difference by taking the second half-year average minus the first half-year average and display it on the x-axis. As we can observe in the figure there are some major increases in restrictions implemented, but also decreases.

For the first half-year we can note that Japan had the lowest average Stringency index with a value of 33.6 and they only increased it by 1.46 for the second half-year, giving them the 2nd lowest Stringency index at the end of 2020, with a value of 35. New Zealand can be observed in the first half-year with an average Stringency value of 46.7 which was quite average, putting them in the middle of the countries. We observe in the difference figure that New Zealand has by far the largest contraction of restrictions. They reduced their index with 17.4 resulting in them having the lowest Stringency value of all the countries we include in our analysis in the second half-year, a value of 29.3.

In the first half-year chart we note that Italy was the country with the highest restrictions imposed. Italy had an average value of 61.7 during the first half-year of 2020. We can then note in the difference chart that Italy was the country that had the smallest change of imposed restrictions, only increasing their Stringency index with 0.25 to an average value for the second half-year of 61.95.

As seen in the difference figure we observe that Chile is the country with the largest increase of imposed restrictions, an increase of 32.6. Resulting in Chile being the country with the undoubtedly largest Stringency index value for the second half of 2020, an average value of 81.5. Another observation from the second half-year chart, Latin America claims the three highest positions in the Stringency index. Chile with the largest value of 81.5 followed by Colombia with an average value of 73.2 and in third place we see Mexico with an average value of 71.8.

Since we are Swedish and study at a Swedish university we suffer from home-bias. We found it relevant noting Sweden had the 4th largest increase in imposed restrictions, an increase of 18.1. Resulting in an average value of 59.1 for the second half-year. This is interesting since Swedish media, the Public Health Agency of Sweden and the Swedish Government all communicated the "Swedish strategy" which was seen as very soft and inadequate by global news agencies, for example the Wall street journal (Pancevski, B. 2020). Being the 4th largest

Stringency index increase from the first to the second half-year, it is plausible to speculate if perhaps the Swedish government fell for global peer pressure.

3.2.2 Excess mortality distribution

Figure 4: Excess mortality per 100,000 1 January 2020 to 30 June 2020

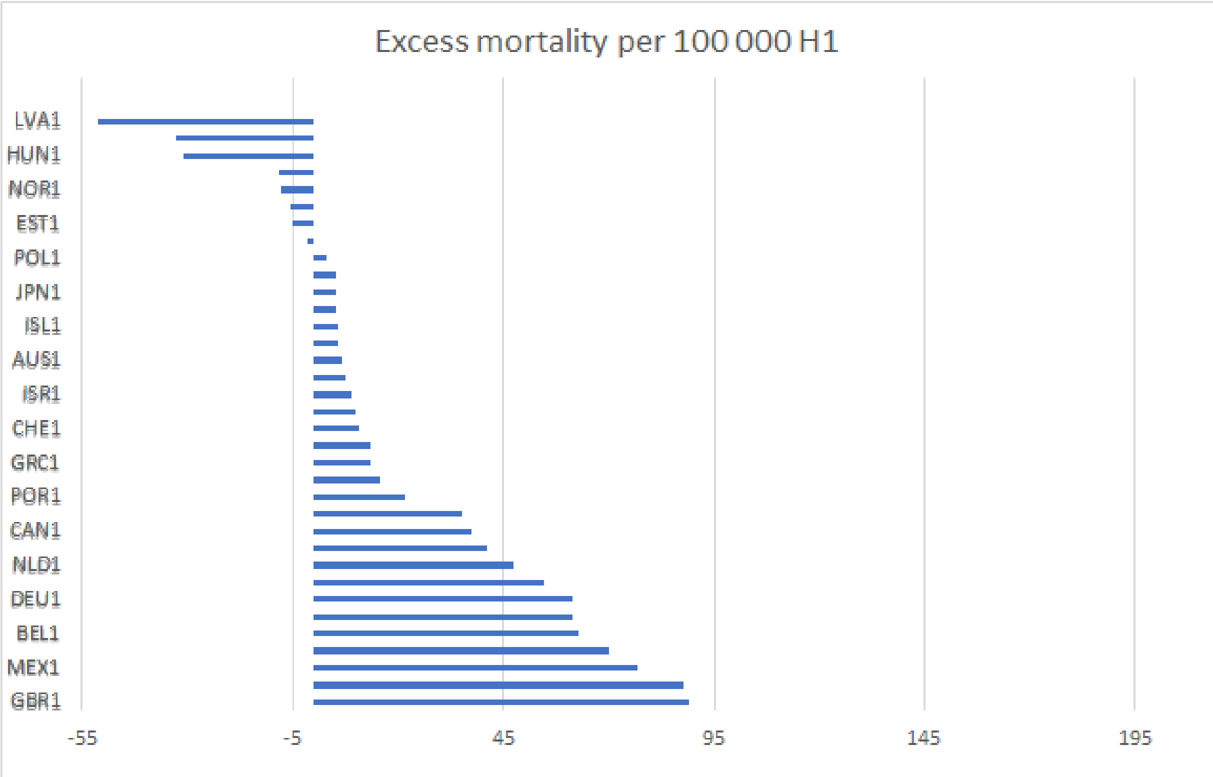
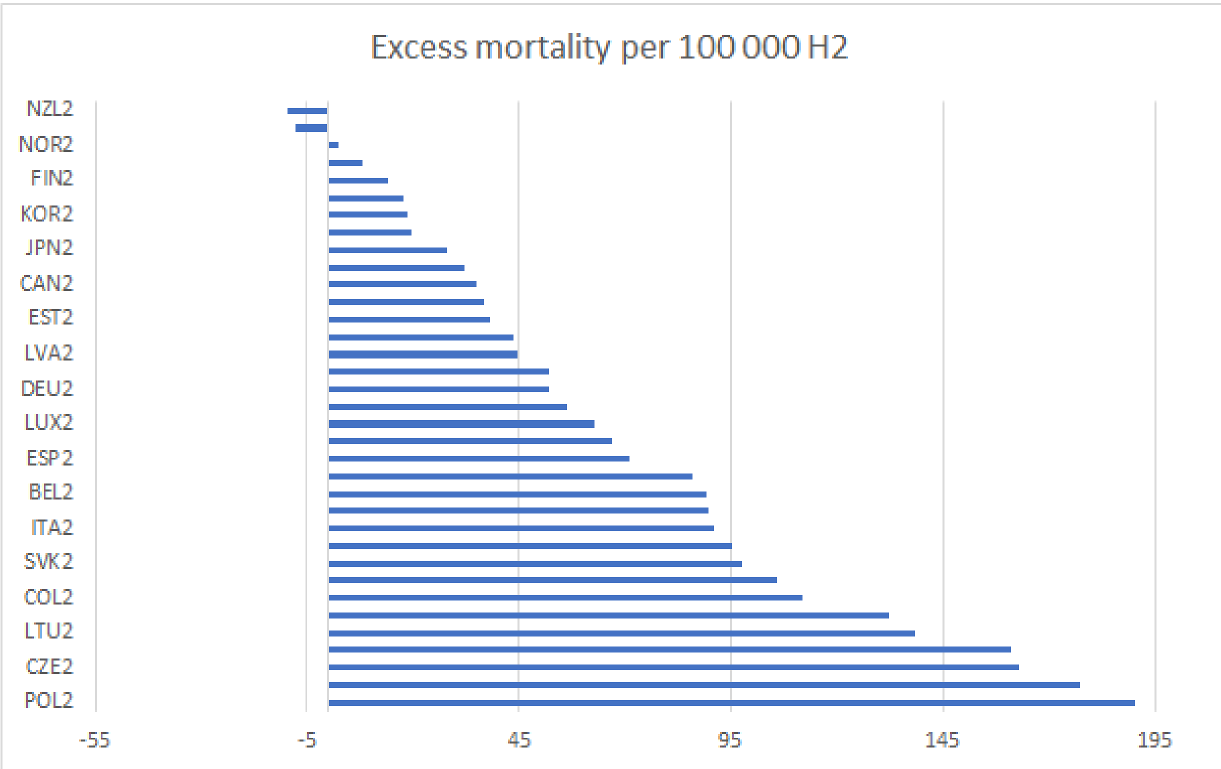


Figure 5: Excess mortality per 100,000 1 July 2020 to 31 December 2020



In the figures above we can observe excess mortality per 100,000 inhabitants during our both half-year periods of 2020. The way we calculated these rates was to retrieve data from Our World in Data which included deaths per week for 2020 and also an average death per week for 2015-2019 (OurWorldInData, 2021b). We then calculated two half-year averages for excess mortality, which is our consistent approach, to calculate our data into two half-year periods.

We observe in the first half-year that the United Kingdom is the country with the largest excess mortality, with a value of 88.9. This means that 88.9 individuals per 100,000 have died in addition to the average death toll from 2015-2019 for the first half-year of 2020.

Closely following is Spain, with an average excess mortality for the first half-year of 87.7.

On the other end of the first half-year figure we find three eastern European countries with negative excess mortality values, Latvia, Lithuania and Hungary.

Latvia is the country with the largest negative value, an average half-year value of 51.6. This means that 51.6 individuals per 100,000 fewer have died during the first half of 2020, compared to the half-year average deaths from 2015-2019. Followed by Lithuania with a negative half-year average value of 32.6. Not far behind we see Hungary with a negative value of 30.9.

After these three countries we can observe quite a large gap in the excess mortality. The 4th largest negative value comes from Slovakia, with a half-year negative average value of 8.1, a large gap from 30.9 as mentioned.

In the second half-year excess mortality figure we observe the major increase in excess mortality values, in the first half-year period we only had two countries above 85 per 100,000, now we have 14 countries with a value greater than 85.

In our first half-year chart we observe Poland with a very low value, actually the lowest value of countries that still had a positive excess mortality, with an average value of 2.8. In the second half-year we note them furthest down on the chart, with an average value of 190. A significant increase. If we compare Poland's excess mortality to their Stringency index during the first half-year, we can conclude that Poland was relatively strict compared to the other countries in our analysis, they had an average Stringency index of 50 during the first half-year, which makes them our 10th most strict country during the first half-year.

We note that Lithuania and Hungary, who were in the bottom three when looking at the first half-year excess mortality, dramatically increased their excess mortality rate. Lithuania, which had a negative value of 32.6 for the first half-year period, has a positive value of 138.4 during the second period, which is the 5th largest value observed for the second period. Hungary is once again closely following Lithuania, they increased their excess mortality from a negative value during the first period of 30.9 to a positive value during the second period of 132.3. Lithuania had a Stringency index value of 46.7 during the first half-year period and Hungary had a value of 47.3. Both these Stringency values are very average if we examine them in regard to the rest of our countries, yet their excess mortality increases are some of the largest observed. We note that both Lithuania and Hungary have a relatively large proportion of elderly, both countries are observed with roughly 20 percent of their population aged 65 or above, this proportion is greater than most of our other countries. This will be further looked into in later stages of the research with our regressions, where we will add urbanization and share of population aged 65 or above to our analysis, to see if these variables can illustrate deeper insights to the drastic increases in excess mortality.

In the first half-year period we observed eight countries with a negative excess mortality, in the second half-year of 2020 only two countries showed negative excess mortality values, those two countries were Australia and New Zealand. New Zealand was the country with the highest negative value, an average value of 9.6. Australia was not far behind with an average negative value of 7.6. Worth noting is that both New Zealand and Australia had low positive values during the first half-year, New Zealand had 5.9 and Australia 6.4. The actual differences are not very high when comparing the values from the two periods, roughly differentiating 15, whilst our big differences in countries such as Poland and Lithuania differentiate roughly 170.

3.2.3 GDP development

The last initial examination of the main variables we will include in our analysis is GDP. We include other variables in our more extensive examination of economic outcomes, but GDP is our prominent one, therefore we will shortly introduce it.

Similar to what we have done with the Stringency index and excess mortality, we decided to divide GDP into two half-year periods.

Figure 6: GDP percentage change Q2 2020 compared to Q4 2019

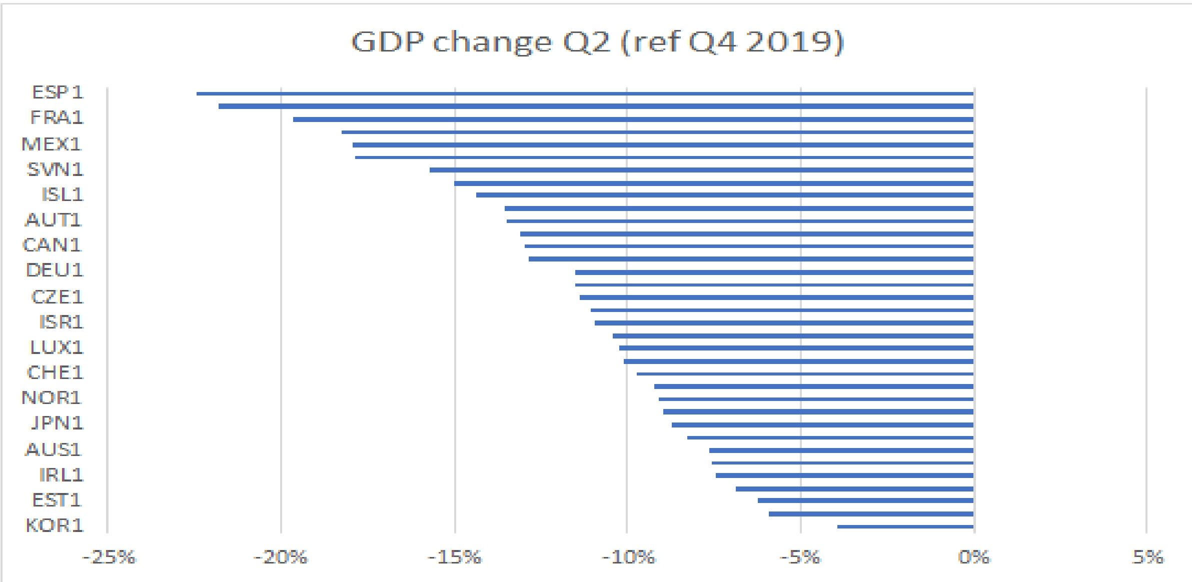
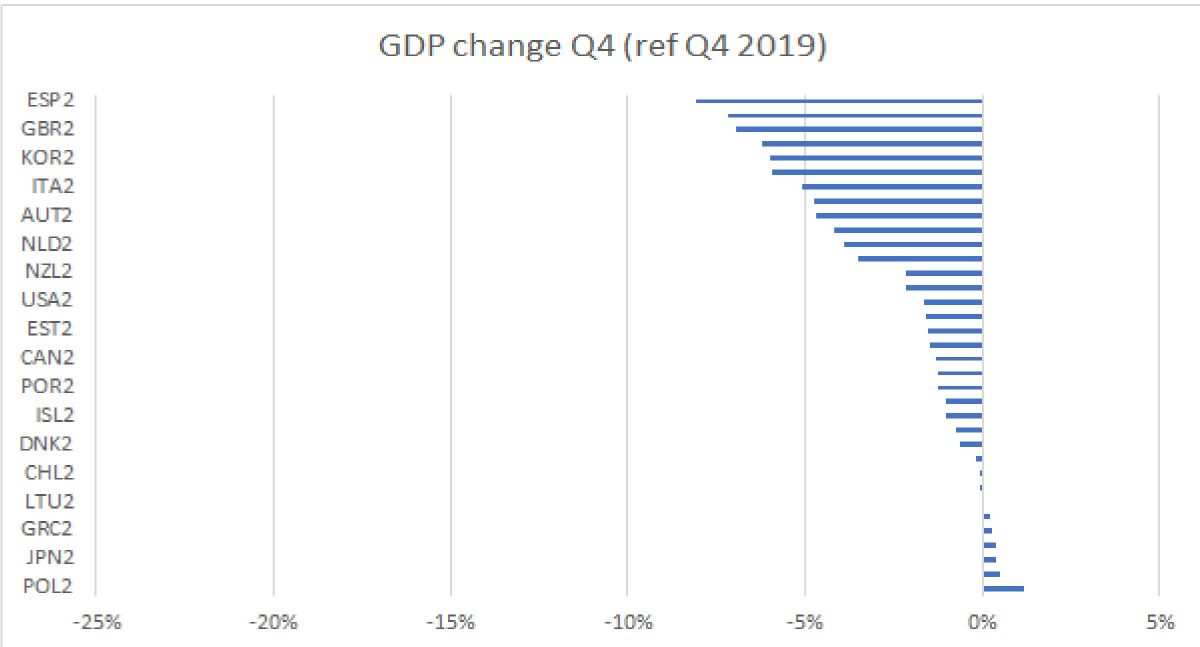


Figure 7: GDP percentage change Q4 2020 compared to Q4 2019



Above we see the charts illustrating the GDP change for our countries. We calculated the GDP change by simply taking the 2nd and 4th quarter GDP value of a country and subtracting it to the value of the 2019 4th quarter, then dividing the difference to the 4th quarter of 2019 to get a percentage change.

An observation in the first half-year chart, every single one of the countries we include in our analysis experienced a negative GDP development during the first half-year of 2020.

The largest decline of GDP we observe in Spain, with a decrease of 22.4 percent in GDP. Italy, which had the largest value in the Stringency index during the first half-year period, had the sixth largest GDP decline with a 17.8 percent decrease. This is something we expected to be clear, that countries with harsh restrictions, that is large Stringency index values, would see the largest declines in economic variables. We will examine and analyze these initial thoughts more profoundly as we continue forward with our research and conduct regressions.

Other factors we believe will influence how a certain country is economically affected by the Covid-19 pandemic is the structure of the certain country's economy. If the country is relying heavily on exports and tourism for example it is intuitive to expect that this certain country would be more economically affected by a pandemic. Exports are affected because of lower consumption hence lower and uncertain product demand, tourism because it is such a contact-intensive sector (World bank, 2020a).

The majority of our included countries experienced a GDP loss between 17 to 7 percent.

The least affected country in our first half-year chart was Korea. They were the only country to see a decline in GDP of less than 5 percent. Korea saw a decrease in their GDP of 3.9 percent. Japan, which is geographically close to Korea, saw a GDP decrease of 8.7 percent, more than double the loss of Korea.

Finland, who experienced the second lowest contraction in GDP, a decrease of 5.9 percent, which is much smaller than the contraction of neighboring countries such as Norway, who experienced a 9.1 percent decline in GDP.

Japan was the country with the lowest Stringency index for the first half-year, 33.5 and their neighbors Korea had a value of 49.1, but yet Japan’s drop in GDP was more than twice the size of Korea. Finland had a Stringency index value of 41 and Norway 44.8, small differences in the restrictions put in place but vastly larger differences in GDP for the first half-year period.

The largest decline of GDP in the second half-year figure we still observe to be Spain, however with a big improvement from the second quarter. In this chart we can interpret Spain's GDP contraction to 8.1 percent, compared to their 22.4 percent decline in the second quarter. Since the reference period is the same, we can state that they managed to recover most of the damage caused in the first half-year period.

Worth noting are the countries that managed to turn the ship around and experience positive GDP growth in the 4th quarter. Poland experienced the largest positive GDP growth with a value of 1.2 percent, followed by Latvia with 0.5 percent and the third largest GDP growth observation was Japan with 0.3 percent increase.

We note that Korea's and Japan's GDP development completely shifted when we evaluate the data from the 4th quarter. Korea, which we now can observe to have the 5th biggest decline in GDP with a negative value of 6 percent, compared to the second quarter when they were the least economically affected country of all our observations.

One potentially huge explaining factor for the big recovery that we can observe from the second to the fourth quarter, is execution of fiscal policy, especially the enormous stimulus and relief packages that governments all over the world have committed into.

3.3 Bivariate plots

The Stringency index tells us how severe restrictions different governments chose to implement. A greater value on the Stringency index implies that governments have implemented harsher restrictions, the values range from 0 to 100. All of our bivariate plots include the Stringency index, to see how the severeness of restrictions influence different health and economic outcomes.

3.3.1 The contemporaneous connection between Stringency and excess mortality

Excess mortality (per 100,000)

Figure 8: Stringency and excess mortality XY scatter plot for the first half-year of 2020

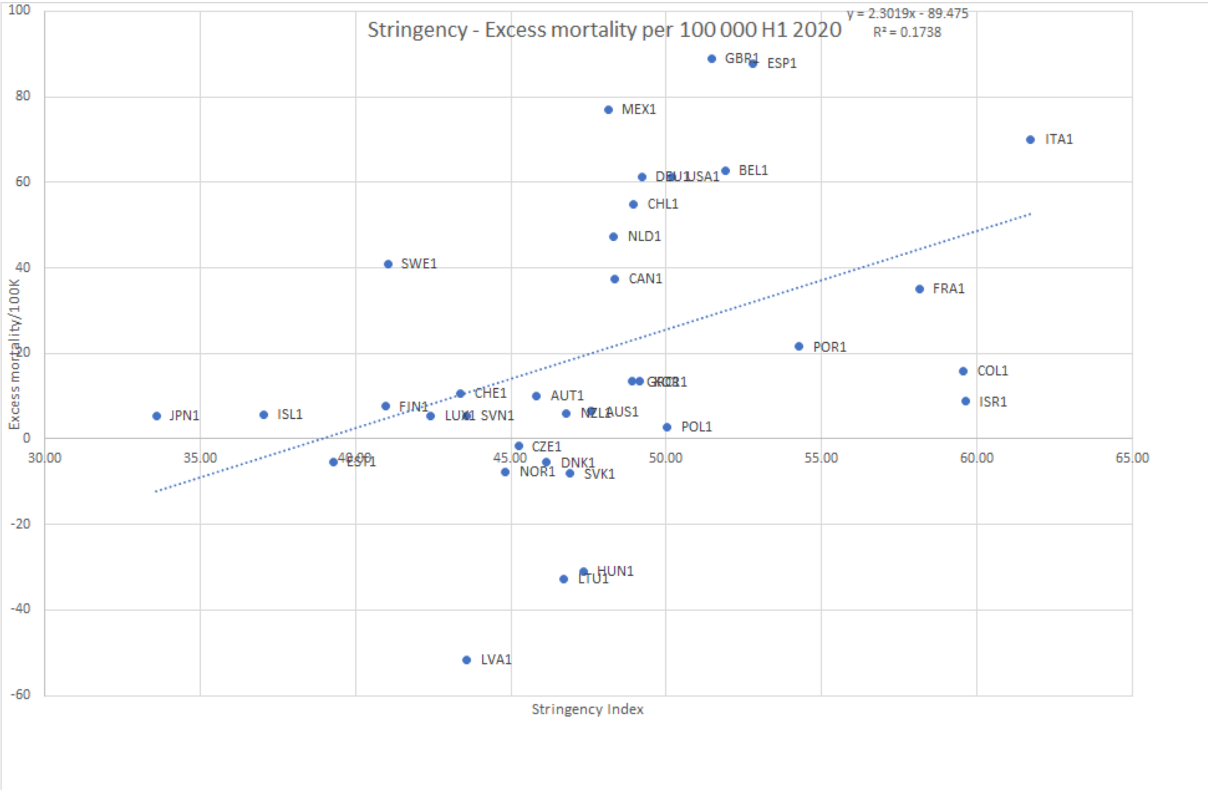


Figure 8 shows the Stringency index on the x-axis and excess mortality per 100,000 on the y-axis. We note Italy furthest to the right which means that they had the highest Stringency average of 61.7, they are also among the top four when looking at the y-axis. Italy had an excess mortality of 70.0 during the first half-year. The United Kingdom was the country with the highest excess mortality of our included countries with a value of 88.9 while their average stringency value was 51.5. Another observation is Latvia who had a stringency of 43.6, an observed difference of only 7.9 index points to the UK, but Latvia's excess mortality rate was the lowest of all countries with an observed negative value of 51.6. trendline

Figure: 9 Stringency and excess mortality XY scatter plot for the second half-year of 2020

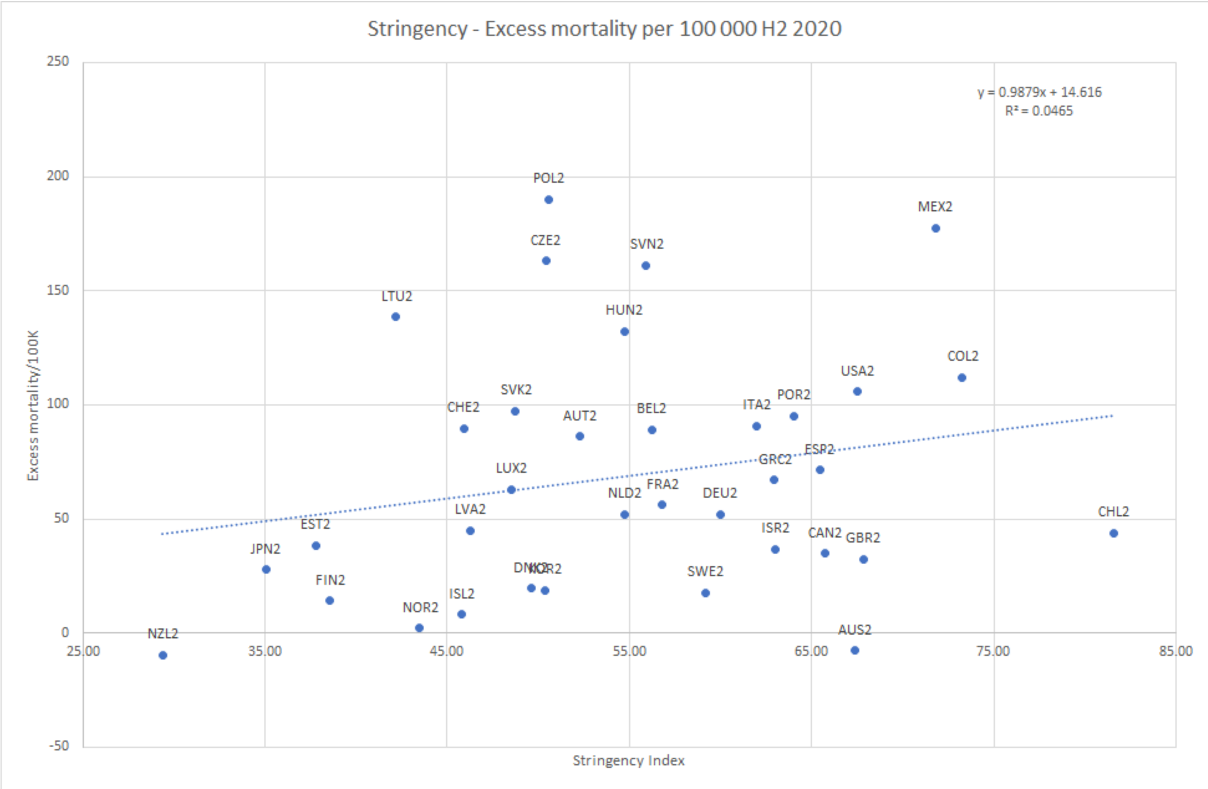


Figure 9 illustrates the same variables as figure 8 but for the second half-year of 2020. The countries with the biggest differences in regard to the Stringency index are Chile and New Zealand and we observe those at respective horizontal ends. Chile had the highest average of 81.6 and New Zealand at only 29.4. Both these countries have an excess mortality per 100,000 under 50. Poland had the highest excess mortality of 190.2 per 100,000. We note Sweden around the middle on the x-axis with a relatively low excess mortality of 17.6, observing only 5 countries with a lower value. During the second half of the year only two countries had a negative value for excess mortality, compared to eight countries in the first half. Observing the trendline we note a small correlation between larger Stringency values and larger excess mortality values, which is very contradicting to at least our initial expectations.

3.3.2 The contemporaneous connection between the economic outcome and stringency

GDP

Figure: 10 Stringency and GDP XY scatter plot for the second quarter of 2020

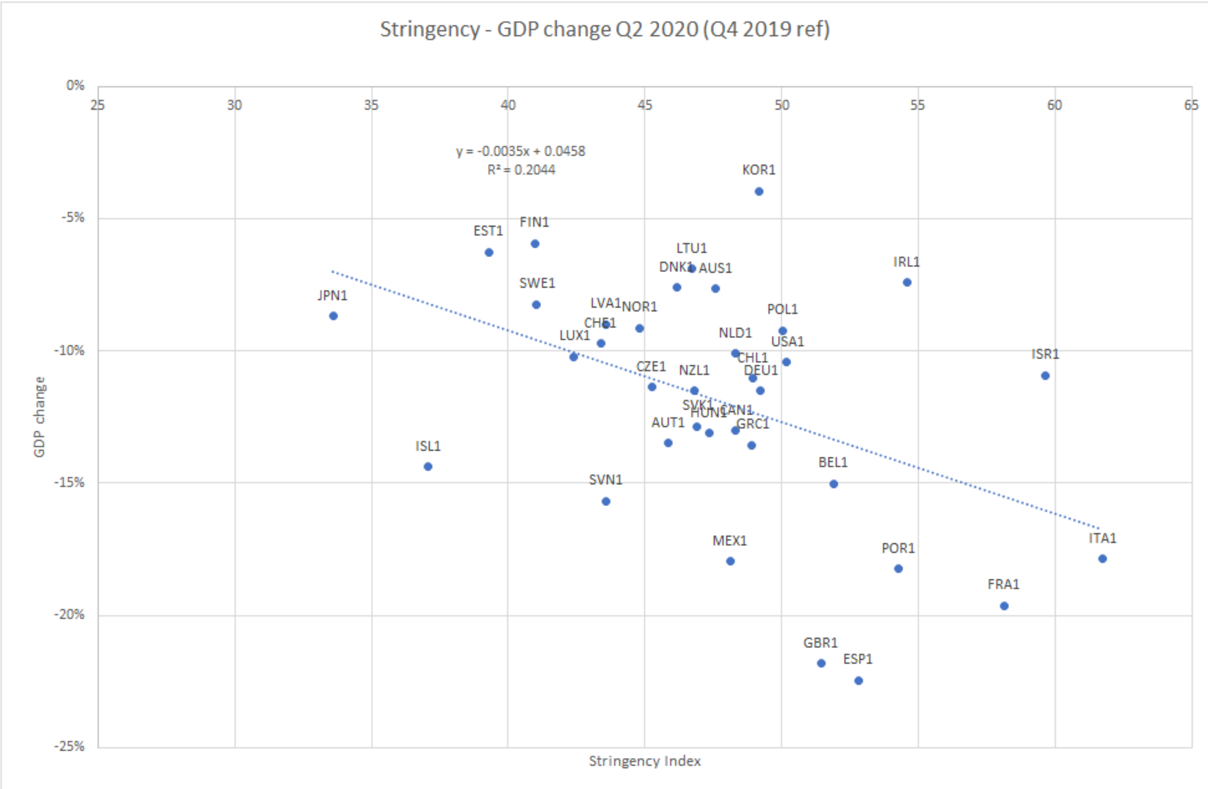


Figure 10 illustrates the Stringency index on the x-axis and the relative GDP change of Q2 2020 compared to Q4 2019 on the y-axis. As expected, we observe a downwards sloping trendline which means that a higher Stringency index correlates to a larger negative effect on GDP. The country that had the biggest contraction on their GDP was Spain with a GDP decrease of 22.4 percent and they had an average Stringency of 52.8. We observe that every single country we include decreased their GDP during the first half of 2020. South Korea was the country who had the smallest reduction of their GDP of 3.9 percent, while having an average stringency value of 49.2. Most of the countries with a Stringency average value between 40-50 have a GDP decrease between 17-7 percent.

Figure 11: Stringency and GDP XY scatter plot for the fourth quarter of 2020

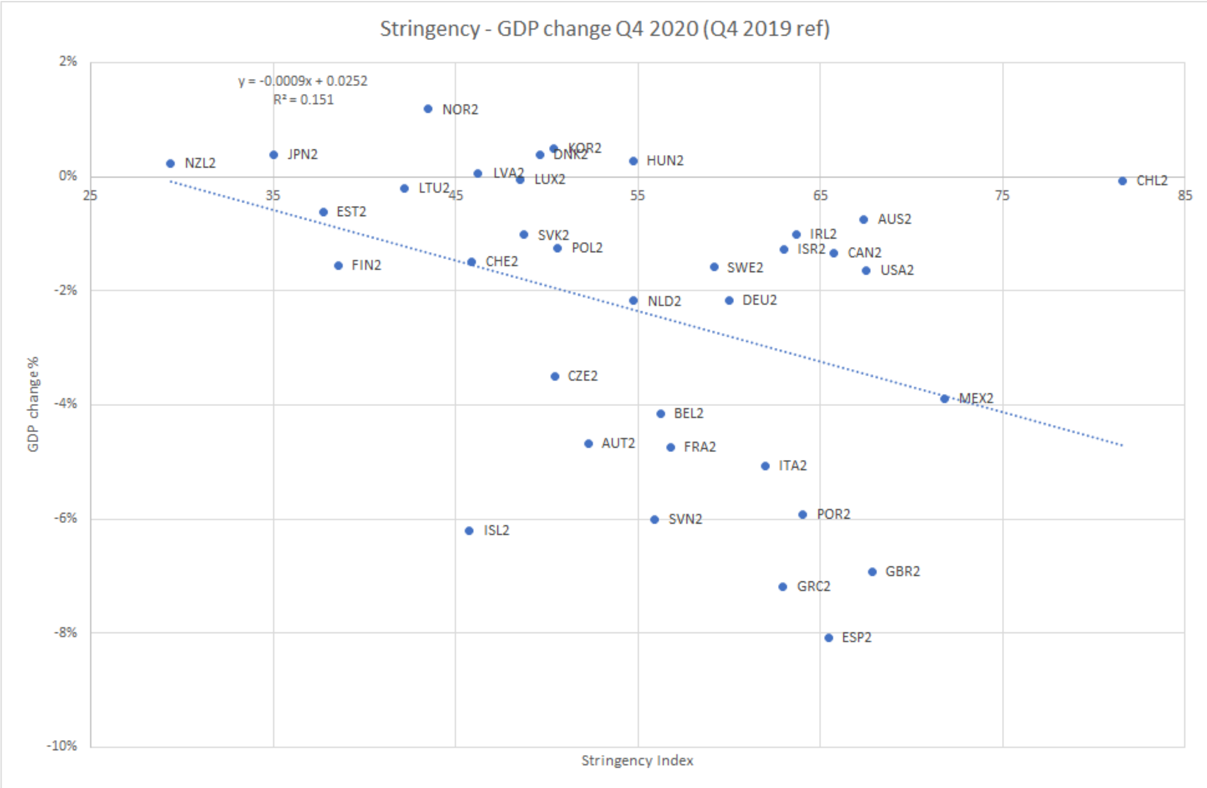


Figure 11 illustrates the Stringency index on the x-axis and the relative GDP change of Q4 2020 compared to Q4 2019 on the y-axis. Examining this second half-year chart in regard to the first half of 2020, we observe that GDP contraction is substantially lower overall. Spain still has the biggest GDP contraction but now only an 8.1 percent decrease compared to 22.4 percent during the first half-year. Some countries even saw an increase in their GDP levels and most of those are on the lower half in regard to the average Stringency value, countries such as New Zealand, Norway and Japan. We note that Chile had an average Stringency value of 81.6 but barely a 0.1 percent decrease in their GDP compared to one year earlier, which is a very small GDP decrease if we look at the other countries with high Stringency values. Why the GDP contraction for the second half-year period is lower than for the first period is fascinating since excess mortality is generally higher for the second period, as well as the Stringency index which is also generally higher during the second period. This is something we will include and discuss in the discussion section of our research. We will then also discuss different factors that we did not include in our analysis that could potentially counteract our variables and benefit GDP despite the larger stringency and excess mortality values.

Unemployment

Figure 12: Stringency and unemployment XY scatter plot for the second quarter of 2020

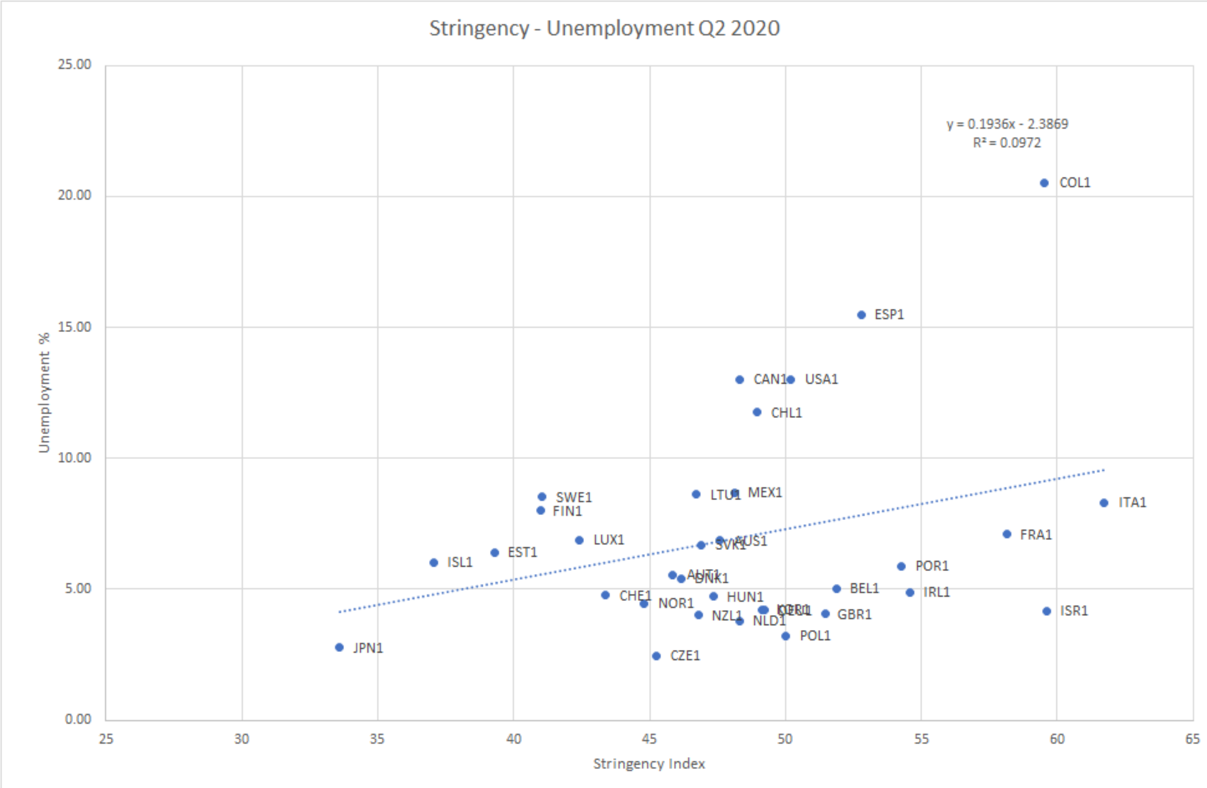


Figure 12 exhibits the Stringency index on the x-axis and unemployment rate during Q2 on the y-axis. Most countries are below 10 percent unemployment, and we see an upwards sloping trendline so there is some correlation between the amount of unemployed and how strict the Stringency index is in the countries observed. Colombia has by far the highest unemployment rate of 20.5 percent and are also in the top three observations of average Stringency values for the first half-year. Sweden has an unemployment rate of 8.5 percent which is the highest for the Nordic countries with Finland slightly below at 8 percent.

Figure 13: Stringency and unemployment XY scatter plot for the fourth quarter of 2020

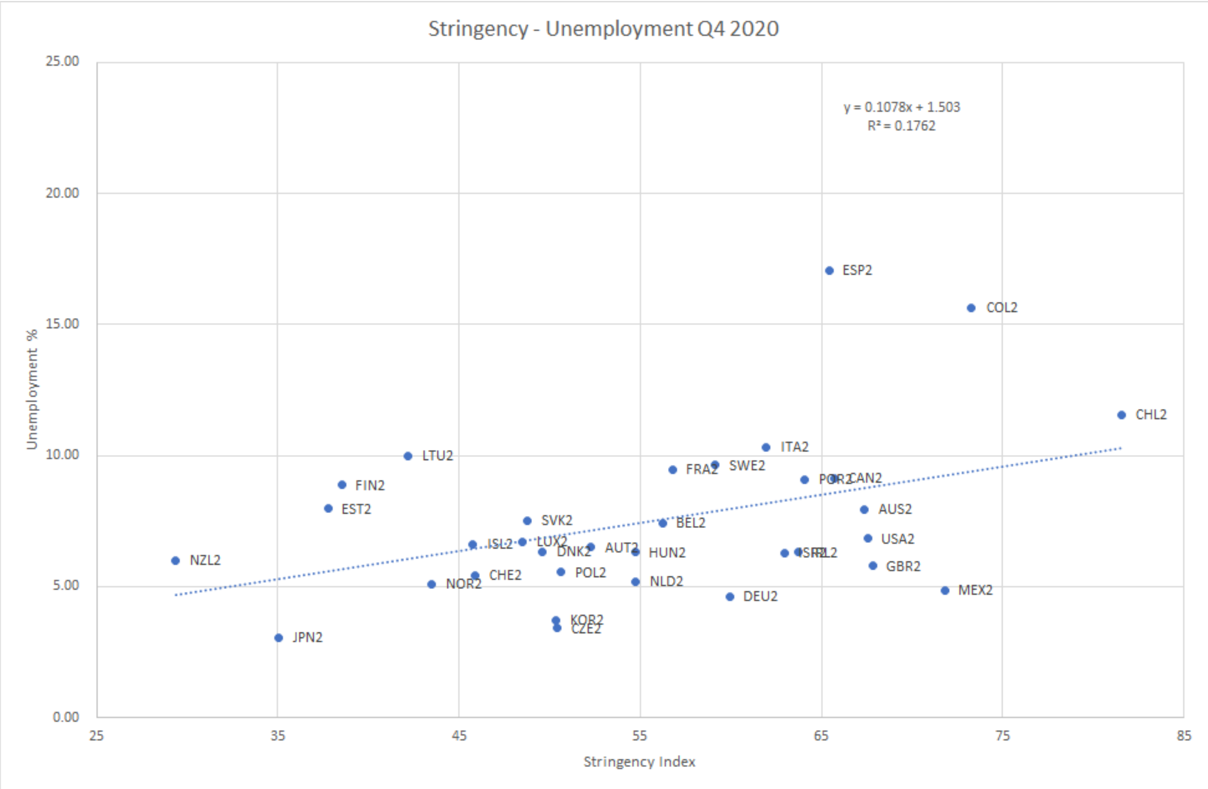


Figure 13 shows the Stringency index on the x-axis and the unemployment rate during Q4 on the y-axis. Compared to the first half-year, Colombia is no longer the country with the highest unemployment rate, it has contracted to 15.6 percent. We can now observe Spain at the top with an unemployment rate of 17.1 percent. The slope on the trendline is almost halved for the second half-year compared to the first half, which indicates that the correlation between the Stringency index and unemployment is almost halved. Sweden increased both their unemployment rate and Stringency index compared to the first half-year, from 8.5 to 9.6 percent and from 41.0 to 59.1.

Export

Figure 14: Stringency and export XY scatter plot for the second quarter of 2020

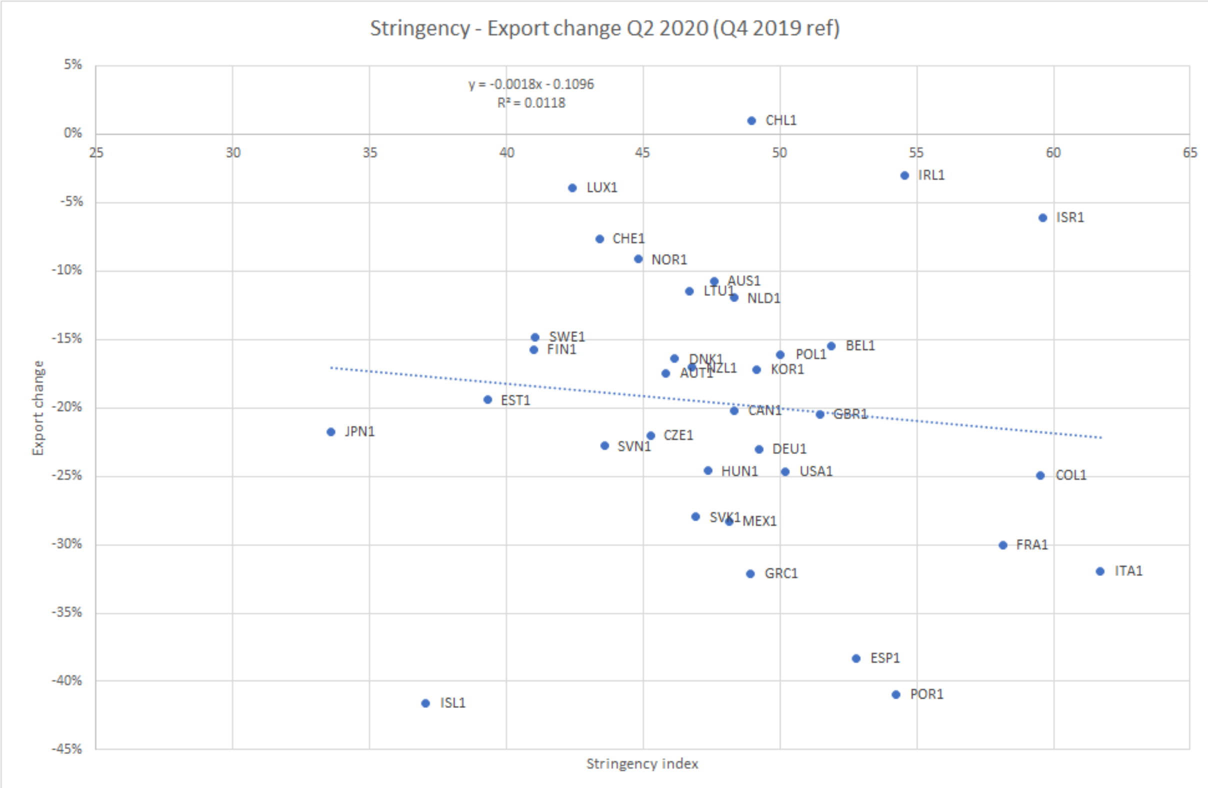


Figure 14 shows the Stringency index on the x-axis and the relative export change of Q2 2020 compared to Q4 2019 on the y-axis. A downwards sloping trendline implies that a stricter Stringency leads to a larger negative change in the export. Chile is the only country with a positive relative change in their export, with a 1 percent increase. We observe Sweden with a negative change of 14.9 percent in their exports, which is a quite average loss of exports when looking at all our observations. The country with the largest exports' contraction is Iceland with a 41.6 percent decrease, we observe that Iceland has the second lowest Stringency value.

Figure 15: Stringency and export XY scatter plot for the fourth quarter of 2020

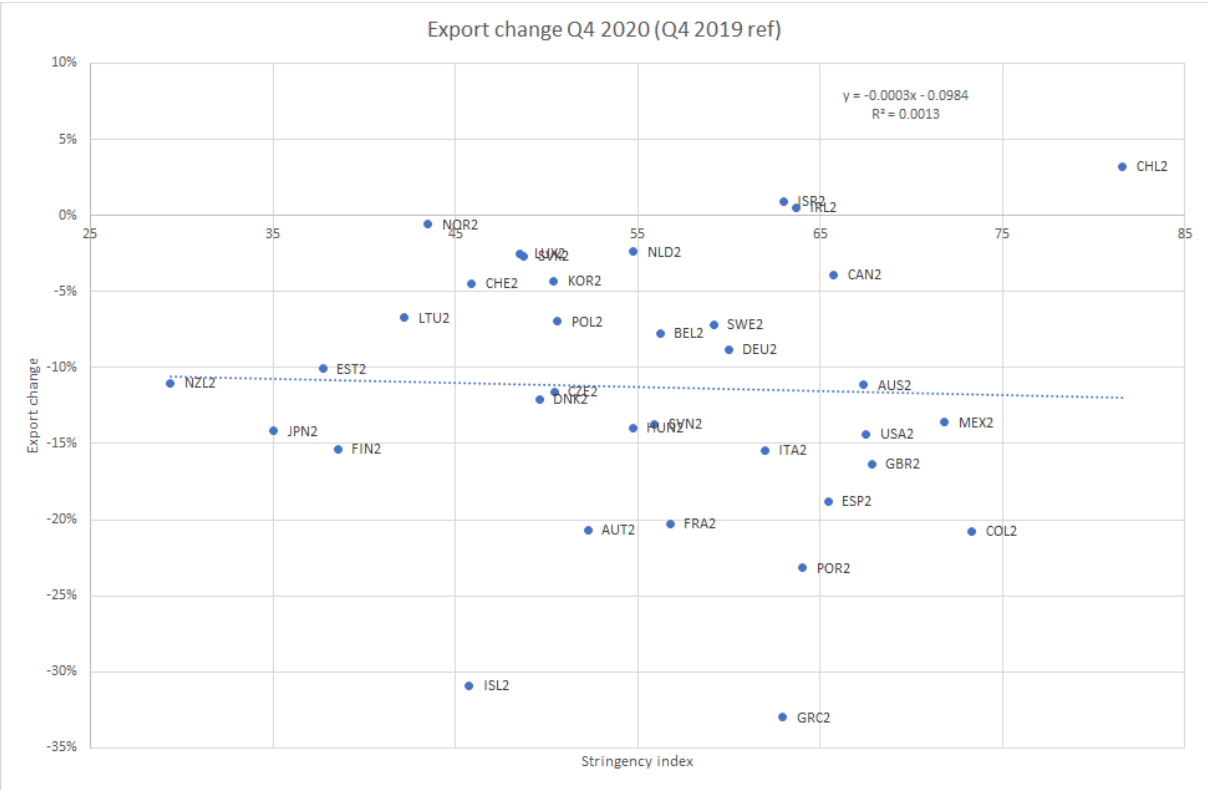


Figure 15 shows the Stringency index on the x-axis and the relative export change of Q4 2020 compared to Q4 2019 on the y-axis. Comparing this figure with the first half of 2020, figure 14, the overall average export change has improved from 19.7 percent to 11.3 percent. Now both Israel and Ireland accompany Chile in being countries with a total increase in their export. However the trendline is almost horizontal, the slope is -0.0003, and we see almost no correlation between the Stringency index and the relative export change. Sweden has recovered from a negative 14.9 percent change during the first half-year of 2020 to negative 7.2 percent during the second half.

3.3 Multiple Regression

When collecting all data necessary for our multiple regressions and importing it to our econometrics software, we noticed that the data for our variables was incomplete with some countries missing. To exclude this inconsistency, we chose to reduce the estimates by removing all the countries that did not have data for all variables. In total there are 37 countries that are OECD members, but our regression estimates only consist of 31 countries. The countries reduced are the following: Colombia, Greece, Ireland, Latvia, Slovenia, and Turkey

The estimation method used for these tables using the ordinary least squares (OLS) method. We include our explanatory variables which consists of health and economic outcomes. We run the regression four times and each time we omit the variable with the highest p-value before running the next regression. The regressions tables show 3 different types of dependent variables, government response measures (Stringency index), health outcomes (Excess mortality per 100,000) and economic outcomes (GDP change).

Table 1: Regression table with Stringency H1 as dependent variable

Dependent variable: Stringency H1	Model 1	Model 2	Model 3	Model 4
Constant	55.462***	54.765***	52.299***	47.668***
	(0.000)	(0.000)	(0.000)	(0.000)
Urban population 2019	−0.137	-0.135	-0.132	-0.091
	(0.185)	(0.180)	(0.180)	(0.316)
GDP change Q2	-0.655*	-0.663*	-0.689**	-0.919***
	(0.070)	(0.060)	(0.045)	(0.001)
Export change Q2	0.150	0.153	0.172	0.188
	(0.273)	(0.247)	(0.166)	(0.131)
Excess mortality per 100,000 H1	0.0474	0.044	0.045	
	(0.299)	(0.282)	(0.267)	
Population over 65 2019	−0.137	-0.126		
	(0.630)	(0.642)		
Unemployment Q2	-0.060			
	(0.866)			
R^2	0.379	0.379	0.373	0.342
Adjusted R^2	0.224	0.254	0.277	0.269

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

In table 1 we use Stringency H1 as our dependent variable and our explanatory variables are with data from the same time period (first half of 2020) except for urban population and population over 65 which are from 2019. Table 1 concludes that the coefficient of GDP change for Q2 is significant at the 10% level on model 1 and 2 but increases as we omit more variables. In model 4 we see a significance at the 1% level. The negative coefficient implies that a positive change of 1 percentage unit in GDP is explaining a negative change on the Stringency index with 0.919 units. A continuous increase in adjusted R2 with each regression indicates that the estimates are becoming more accurate.

Table 2: Regression table with Stringency H2 as dependent variable

Dependent variable: Stringency H2	Model 1	Model 2	Model 3	Model 4
Constant	37.387	36.301**	37.041**	38.623**
	(0.000)	(0.033)	(0.021)	(0.013)
Population over 65 (2019)	−0.888*	-0.884**	-0.869**	-0.917**
	(0.051)	(0.043)	(0.037)	(0.022)
Stringency H1	0.488	0.490	0.478	0.468
	(0.127)	(0.112)	(0.102)	(0.102)
Excess mortality per 100.000 H2	0.027	0.028	0.027	0.023
	(0.472)	(0.357)	(0.354)	(0.404)
Excess mortality per 100,000 H1	0.192**	0.190***	0.186***	0.169***
	(0.015)	(0.007)	(0.004)	(0.002)
Unemployment Q4	0.721	0.726	0.715	0.642
	(0.253)	(0.233)	(0.227)	(0.256)
GDP change Q4	0.592	0.585	0.427	
	(0.659)	(0.654)	(0.599)	
Export change Q4	-0.052	-0.052		
	(0.877)	(0.875)		
Urban population (2019)	-0.010			
	(0.958)			
R^2	0.649	0.649	0.649	0.645
Adjusted R^2	0.521	0.542	0.561	0.573

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

In table 2 we have Stringency H2 as our dependent variable and we are using the same explanatory variables except for Q4 GDP, unemployment and export. This time we also include Stringency H1 as well as the excess mortality for both time periods. Model 1 shows a significance in the coefficient for population over 65 at a 10% level and also excess mortality per 100,000 H1 at a 5% significance level. As we omit more variables, we see in model 4 that excess mortality for H1 has a coefficient of 0.169 at a significance level of 1%. This implies that for each unit increase in excess mortality the Stringency index increases with 0.169 units during the second half-year.

Table 3: Regression table with excess mortality per 100,000 H1 as dependent variable

Dependent variable: Excess mortality per 100,000 H1	Model 1	Model 2	Model 3	Model 4
Constant	165.680**	154.873***	163.570***	119.260***
	(0.015)	(0.009)	(0.003)	(0.002)
Urban population (2019)	0.957**	0.945**	0.995**	0.940**
	(0.033)	(0.031)	(0.016)	(0.022)
GDP change Q2	-3.858**	-3.794**	-3.442***	-4.110***
	(0.014)	(0.013)	(0.004)	(0.002)
Unemployment Q2	2.913*	2.977*	2.766*	2.862**
	(0.058)	(0.057)	(0.055)	(0.049)
Stringency H1	0.947	0.919	1.017	
	(0.299)	(0.302)	(0.226)	
Export change Q2	0.289	0.222		
	(0.639)	(0.701)		
Population over 65 (2019)	0.463			
	(0.716)			
R^2	0.587	0.586	0.582	0.558
Adjusted R^2	0.485	0.502	0.519	0.509

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

In table 3 we have excess mortality per 100,000 H1 as our dependent variable and using the same explanatory variables as in table 1, except that Stringency H1 is now an explanatory variable instead of dependent. Model 4 shows us that urban population, GDP change and unemployment are all significant on at least the 5% level. The positive coefficients on unemployment and urban population reveal that as these variables increase more people are dying. The negative coefficient in GDP change indicates that as GDP level decreases, we see a higher excess mortality. Together these three variables explain just over 50%, adjusted R2 is 0.509 in model 4, and with only 31 data points this gives a good indication.

Table 4: Regression table with excess mortality per 100,000 H1 as dependent variable

Dependent variable: Excess mortality per 100,000 H2	Model 1	Model 2	Model 3	Model 4
Constant	282.464* (0.065)	289.566** (0.024)	305.484*** (0.006)	276.603*** (0.001)
Urban population (2019)	−2.787*** (0.005)	-2.802*** (0.004)	-2.902*** (<0.001)	-2.868*** (<0.001)
GDP change Q4	-6.756 (0.380)	-6.927 (0.342)	-5.843 (0.309)	-5.765 (0.307)
Unemployment Q4	-4.633 (0.201)	-4.612 (0.192)	-4.552 (0.188)	-4.796 (0.154)
Export change Q4	1.044 (0.591)	1.089 (0.553)	0.928 (0.582)	1.058 (0.517)
Stringency H2	0.891 (0.472)	0.927 (0.418)	0.779 (0.417)	0.942 (0.281)
Population over 65 (2019)	-1.005 (0.713)	-0.993 (0.710)	-1.129 (0.660)	
Excess mortality per 100,000 H1	-0.119 (0.806)	-0.119 (0.801)		
Stringency H1	-0.172 (0.928)			
R^2	0.436	0.436	0.434	0.429
Adjusted R^2	0.231	0.264	0.292	0.315

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

In table 4 we use Excess mortality per 100,000 H2 as our dependent variable to check if we can observe any similarities with table 3. In this regression we use both our Stringency index for H1 and H2, we also use excess mortality from the previous time-period. The only variable in this table that has an acceptable significance level is the urban population. In comparison with the dependent variable from table 3 we can no longer see a significant explanation for GDP change and unemployment level.

For tables 5 and 6 regressions we attempted to lag the regression by using Stringency and excess mortality per 100,000 for H2, however the other variables are still from H1 to check whether the explanatory variables give us more clarifications for the outcomes than when using the first time period.

Table 5: Lagged regression table with Stringency H2 as dependent variable

Dependent variable: Stringency H2	Model 1	Model 2	Model 3	Model 4
Constant	38.946 (0.110)	39.071 (0.102)	30.074* (0.054)	30.683** (0.046)
Stringency H1	0.544* (0.081)	0.578** (0.045)	0.622** (0.022)	0.610** (0.022)
Excess mortality per 100,000 H1	0.151** (0.033)	0.161** (0.010)	0.148*** (0.008)	0.144*** (0.007)
Population over 65 (2019)	-0.713* (0.097)	-0.731* (0.080)	-0.711* (0.082)	0.772** (0.044)
Unemployment Q2	0.831 (0.120)	0.814 (0.119)	0.842* (0.099)	0.809 (0.104)
Export change Q2	0.134 (0.509)	0.096 (0.547)	0.070 (0.633)	
Urban population (2019)	0.074 (0.629)	-0.077 (0.609)		
GDP change Q2	-0.172 (0.754)			
R^2	0.664	0.662	0.659	0.656
Adjusted R^2	0.561	0.578	0.591	0.603

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01

In table 5 we observe that the coefficients for Stringency H1, excess mortality per 100,000 H1 and population over 65 are significant on at least the 5% level in model 4. However in model 3 we also note that unemployment Q2 is significant at the 10% level. The Stringency index explains how different governments respond to the pandemic and it is therefore reasonable to make decisions based on data from a previous time-period. This estimation shows a strong indication that this is the case since we observe an adjusted R2 value over 60%, 0.603.

Table 6: Lagged regression table with excess mortality per 100 000 H2 as dependent variable

Dependent variable: Excess mortality per 100 000 H2	Model 1	Model 2	Model 3	Model 4
Constant	322.208**	320.071**	333.729***	312.868***
	(0.035)	(0.031)	(0.002)	(0.001)
Population over 65 (2019)	-2.382	-2.457	-2.514	-2.509
	(0.355)	(0.307)	(0.279)	(0.272)
Urban population (2019)	-2.944***	-2.926***	-2.954***	-2.790***
	(0.004)	(0.003)	(0.002)	(0.001)
GDP change Q2	-1.717	-1.522	-1.626	-2.340
	(0.611)	(0.563)	(0.511)	(0.216)
Unemployment Q2	-1.446	-1.490	-1.520	-1.021
	(0.651)	(0.631)	(0.616)	(0.713)
Excess mortality per 100,000 H1	0.157	0.161	0.174	
	(0.705)	(0.690)	(0.651)	
Stringency H1	0.199	0.239		
	(0.914)	(0.982)		
Export change Q2	0.119			
	(0.651)			
R^2	0.390	0.390	0.390	0.385
Adjusted R^2	0.205	0.238	0.267	0.290

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01

In table 6 we use excess mortality per 100,000 H2 as our dependent variable to check if the outcomes from the first half-year can explain the outcome for excess mortality per 100,000 H2. In all models we see that urban population is the only variable that is significant at the 1% level. Similar to table 4 we cannot use the economic outcomes or the restriction measures implemented to explain our dependent variable using this estimation. The adjusted R2 value is below 30% which indicates that there are plenty of other factors that can explain this variable, which we have not included in our estimation.

Table 7: Regression table with GDP change Q2 as dependent variable

Dependent variable: GDP change Q2	Model 1	Model 2	Model 3	Model 4
Constant	-0.725 (0.935)	1.219 (0.832)	2.090 (0.670)	3.855 (0.389)
Stringency H1	−0.198* (0.071)	-0.207** (0.044)	-0.210** (0.038)	-0.217** (0.029)
Excess mortality per 100,000 H1	-0.058** (0.014)	-0.055*** (0.009)	-0.052*** (0.007)	-0.053*** (0.005)
Export change Q2	0.222*** (0.001)	0.228*** (<0.001)	0.224*** (<0.001)	0.213*** (<0.001)
Population over 65 (2019)	0.106 (0.496)	0.102 (0.503)	0.086 (0.558)	
Unemployment Q2	0.102 (0.600)	0.096 (0.614)		
Urban population (2019)	0.017 (0.773)			
R^2	0.680	0.679	0.677	0.672
Adjusted R^2	0.600	0.615	0.626	0.635

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

In table 7 we have GDP change Q2 as our dependent variable to observe how the economic outcome can be explained by the other variables. In model 4 we have the coefficient of three variables, stringency H1, excess mortality per 100,000 H1 and export change, that are significant on at least the 5% level. The negative coefficient on Stringency H1 and excess mortality per 100,000 H1 implies that a positive change of one unit in these variables would lead to a negative change in GDP by 0.217 respectively 0.053 units. The positive coefficient of export conveys a positive relationship, that is when export increases with 1 unit, GDP increases by 0.213 units. This table has an adjusted R2 value from 0.600 to 0.635 which implies that these three variables explain 60 to 63.5 percent of the dependent variable.

Table 8: Regression table with GDP change Q4 as dependent variable

Dependent variable: GDP change Q4	Model 1	Model 2	Model 3	Model 4
Constant	2.183 (0.621)	3.132 (0.399)	3.273 (0.366)	4.505** (0.033)
Excess mortality per 100,000 H2	−0.005 (0.380)	-0.005 (0.347)	-0.005 (0.360)	-0.006 (0.157)
Unemployment Q4	-0.112 (0.267)	-0.107 (0.277)	-0.101 (0.284)	-0.109 (0.233)
Export change Q4	0.194*** (<0.001)	0.190*** (<0.001)	0.192*** (<0.001)	0.194*** (<0.001)
Stringency H1	-0.059 (0.260)	-0.058 (0.256)	-0.053 (0.263)	-0.056 (0.223)
Excess mortality per 100,000 H1	-0.036*** (0.003)	-0.035*** (0.003)	-0.034*** (<0.001)	-0.032*** (<0.001)
Urban population (2019)	0.014 (0.656)	0.011 (0.670)	0.012 (0.675)	
Stringency H2	0.015 (0.659)	0.010 (0.759)		
Population over 65 (2019)	0.031 (0.679)			
R^2	0.794	0.793	0.792	0.790
Adjusted R^2	0.720	0.730	0.740	0.748

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

Table 8 illustrates the GDP change Q4 which has the same variables as table 7 but for the second half-year. Similar to the previous table we observe that excess mortality per 100,000 H1 and the export change Q4 are both significant at the 1% level. The coefficients for these variables are going in the same direction as before which indicates a robust result. All models have an adjusted R2 value > 0.7 ensuring us that the estimates are a good fit.

Table 9: Lagged regression table with GDP change Q4 as dependent variable

Dependent variable: GDP change Q4	Model 1	Model 2	Model 3	Model 4
Constant	1.444	2.392	3.262**	2.568***
	(0.724)	(0.369)	(0.047)	(0.005)
Excess mortality per 100,000 H1	-0.020*	-0.019*	-0.018*	-0.019*
	(0.088)	(0.076)	(0.076)	(0.070)
GDP change Q2	0.291***	0.292***	0.277***	0.269***
	(0.005)	(0.004)	(0.003)	(0.003)
Export change Q2	0.064*	0.067*	0.069**	0.075**
	(0.075)	(0.055)	(0.041)	(0.018)
Unemployment Q2	0.053	0.049	0.049	0.059
	(0.562)	(0.577)	(0.571)	(0.480)
Population over 65 (2019)	-0.031	-0.034	-0.036	
	(0.661)	(0.630)	(0.601)	
Stringency H1	0.025	0.020		
	(0.635)	(0.678)		
Urban population (2019)	0.008			
	(0.759)			
R^2	0.772	0.771	0.770	0.767
Adjusted R^2	0.703	0.714	0.724	0.731

Note: p-values in parentheses. significance levels: *p<0.1 **p<0.05 ***p<0.01.

Table 9 displays GDP change Q4 but with the lagged explanatory variables from H1 and Q2 to observe how the outcomes and measurement taken in the first half-year affects the GDP by the end of the year. Model 4 shows similar results from tables 7 and 8 which indicates that the signs and sizes of the significant coefficients are reliable. The GDP change as dependent variable has the overall highest adjusted R2 values which implies that this model fits the best estimations for the economic outcome. It is important to note that outcomes affect measurements taken and that those measurements affect the future outcomes which will in turn affect further measurements taken, hence we conclude a bilateral relationship.

4. Results

The multiple regressions are the core of our results to actually observe how the estimations give us results to interpret. The regression tables illustrate three different types of dependent variables, government response measures that is Stringency index, health outcomes that is excess mortality per 100,000 and economic outcomes that is GDP change. Note that the majority of our variables are in percentage units, but we also have variables in other units, for example excess mortality per 100,000 and population which is the actual number of people in a country. This is of great importance when interpreting and comparing the results.

4.1 Stringency index as dependent variable

First, we used the Stringency index as our dependent variable and ran the regressions for both half-year periods and a lagged regression with explanatory variables from the previous time period. The results seen from table 1 shows the coefficient of GDP change Q2, -0.919, to be significant at the 1% level which indicates a negative change in GDP of one percentage unit generates a positive change on the Stringency index with 0.919 units.

In both table 2 and 5 where Stringency H2 is the dependent variable we notice that the coefficient for excess mortality per 100,000 H1 is significant at the 1% level and the value ranges from 0.144 to 0.169. We also observe that the coefficient for the population over 65 is significant at the 5% level. In table 5 we also note how the coefficient for the Stringency index H1 is significant at the 5% level with a value of 0.610. These significant explanatory variables imply that the restrictions imposed in the first half-year in addition to how old the population is as well as the excess mortality rate during the first half-year, all together explains roughly 60% of the Stringency index value during the second half of 2020. The adjusted R2 values for both these models are between 0.573 to 0.603 which manifest the percentage variation by the independent variables that actually affect the dependent variable.

4.2 Excess mortality per 100,000 as dependent variable

Our health outcome variable excess mortality per 100,000 was the second dependent variable, displayed in tables 3, 4 and 6.

In table 3 we have the first half-year period H1. We note that three explanatory variables are significant on at least the 5% level with unemployment Q2 and urban population having positive coefficient values, 2.862 respectively 0.940, and on the 1% significance level the

GDP change exhibits a negative coefficient of -4.110. This implies that when GDP decreases with 1 percentage unit the Excess mortality per 100 000 rate increases with 4.110 units. The adjusted R2 value of 0.509 indicates that the significant explanatory variables explain our dependent variable excess mortality per 100,000 H1, by 50.9%.

Table 4 and 6 uses the excess mortality per 100,000 H2 as the dependent variable and in both these tables only the variable urban population is significant at the 1% level. The coefficient values range from -2.868 to -2.790 which means that when the urban population decreases with 1 percentage unit the excess mortality per 100,000 increases with roughly 2.8 units. The adjusted R2 value for these tables is 0.315 respectively 0.290 which is substantially lower than for table 3. This indicates that the explanatory variables for table 3 are a better fit in the estimation and explain the excess mortality per 100,000 to a higher degree for H1 than for H2.

4.3 GDP change as dependent variable

The economic outcome variable chosen for the regressions was the relative GDP change Q2 and Q4 with Q4 2019 as reference period.

Tables 7-9 displays both our time-periods and a lagged regression. Both excess mortality per 100,000 H1 and the export change was significant in all tables, where the first one had a negative coefficient and the ladder a positive coefficient.

When excess mortality increases it implies a decrease in GDP. The coefficient ranges from -0.05 to -0.02 and is interpreted as for each unit increase in excess mortality per 100,000 the relative GDP level decreases by two to five percentage units. As we expected, when there is an increase in exports, we also observe an increase in GDP.

In table 7 the Stringency H1 coefficient is significant at the 5% level with a negative coefficient of -0.217. This is interpreted as for each unit increase on the Stringency index the GDP level decreases by 0.217 percentage units.

The adjusted R2 value observed is highest for tables 7-9 which indicates that the estimations in the model are relatively best fitted for the economic outcome as dependent variable followed by the government response measure, Stringency index, and lastly health outcome excess mortality per 100,000.

Table 7 displays adjusted R2 values between 0.6 and 0.635, which can be interpreted as following: our significant explanatory variables in all four models displayed on table 7 at least explain our dependent variable, GDP change Q2, with 60%.

Our most explaining regression we conclude is Table 8. Here we can observe our largest determination coefficient between explanatory variables and the dependent variable, GDP change Q4. We observe adjusted R2 values ranging from 0.72 to 0.748 for all four models, that is the explanation for the dependent variable by the significant explanatory variables ranging from 72% to 74.8% which indicates a good fit and is our most distinguished result.

Comparison between the tables shows how the outcome variables affect the measurements taken and how the measurements taken affects the outcomes which illustrates how complex this topic is. This bilateral connection is displayed when looking at different tables with different dependent variables whilst noting the significant explanatory variables. For example, if we look at table 1, where Stringency for the first half-year is the dependent variable, we note GDP change for the first half-year to be significant, when observing table 7 we find GDP change for the first half-year as our dependent variable and note that Stringency for the first half-year now is a significant explanatory variable. This illustrates the causal link we try to point out. The connection can also be identified when comparing the tables of excess mortality and GDP as dependent variables.

Our model does not take all possible variables and explanations into account. The results can however give us a better understanding of how these variables affect each other and be helpful for reasoning and decision making when approached by similar situations resembling Covid-19 in the future. Since the data is limited to one year it was not suitable for a time-series or panel regression but should be considered for future research when more data is available.

5. Discussion

The results are presented in three perspectives which are government response measures, health and economic outcomes. Our expectations were that these variables in some ways affect each other's, for example regarding the Stringency index we first assumed and expected that when a country enforces stricter measures and increases their Stringency index following things would occur: GDP and export should decrease since more people are staying home and reducing their consumption, while focusing on supporting local business over international. We expected unemployment levels to rise as uncertainty in demand increases within several sectors. In addition to uncertainty in demand a lot of workplaces switched to working from home but since that option is not applicable in all work sectors, we expect an increase in unemployment because of the work structure changes. An increase of the Stringency index is a way to prevent spread of infection and we expected that excess mortality rates should decrease for countries with higher Stringency values, since it would hamper the spread of Covid-19 infection but also reduce other diseases because of the restrictions that keep people more at home. Another expectation we had was that countries with an older population, higher percentage rates of population age 65 and over, would reflect on the degree of implemented restrictions, that is their Stringency index values. In regard to increases in excess mortality our expected consequences were as stated above, larger Stringency index values but also that the increased Stringency would in turn cause GDP contraction.

The results illustrate that more accurate comparisons and conclusions should be drawn from the lagged regressions where the explanatory variables are from the previous time-period to see how the outcomes affected the government response decisions. This is reasonable since it takes time to collect data and detect patterns from the outcomes and use that information to direct both health and economic outcomes through response measures. Stringency H2 could be explained by how the Stringency looked during the first period, H1, which we observed to be significant. We also note that the amount of excess mortality reflects on how big the actual infection spread is in the country and not only based on data for confirmed cases and deaths related to Covid-19. Table 5 confirms this as the coefficient of excess mortality per 100,000 for H1 is significant at the 1% level for Stringency H2.

The results confirm our expectations that countries with an older population and a high excess mortality implement stricter measures, at least according to the results derived from our regressions with Stringency index as dependent variable. Our results cannot confirm our expectations regarding unemployment levels, we can only observe it being significant in one of our tables, table 3. In table 3 the coefficient of unemployment Q2 was 2.862 and is significant at the 5% level which tells us that one percentage unit increase in unemployment explains an increase in excess mortality per 100,000 H1 with 2.862 units. However, it is important to be careful when interpreting these results since we only observed significance for unemployment once, while our other variables show significance in several tables.

Similar to the results concluded from Bruegel we see how the lockdown measures and health outcomes plays a significant role in explaining economic outcomes from the pandemic, which in our report is reflected on the significance of Stringency and excess mortality with respect to GDP. In one of their regressions, they obtain roughly 60% explanation, adjusted R2 value, from their explanatory variables' lockdown, tourism, and governance to their dependent variable, "covid economic shock". From our table 7 we can observe slightly more robust results explaining our dependent variable, GDP change Q2 with 63.5% by our significant explanatory variables lockdown, health outcome and export change. For future research, when more Covid-19 related data is available, results and causation of outcomes could be very fascinating if both Bruegel's variables and ours were to be included in the analysis.

The National Bureau of Economic Research report we depicted in the previous research section, based their results from surveys and expectations from individuals how the lockdown affected their income and wealth. Their results stated that counties that implemented lockdowns earlier faced higher uncertainty which resulted in less spending that in turn affected the local GDP and unemployment negatively. Even though the method NBER uses with surveys differs from ours, the results can be interpreted in a comparable way and give consensus that stricter lockdown measures are more costly when assessing the economic dimension of Covid-19.

Since our results and analysis are derived from our data, it is highly relevant to discuss the reliability and accuracy of our used data.

Starting off with our restriction variable, we used the Stringency index provided by Our world in data, who retrieved the data from Oxford's COVID-19 Government Response Stringency Index, we found this data to be the best comparable variable for implemented restrictions available. It reports how different countries have responded to the pandemic with different restriction policy indicators. However, we are aware that this index has its distinct flaws and that it is far from a perfect measurement to reflect the whole picture of reality. Since it only consists of nine different policy indicators it does not convey a very broad look of the different types of restrictions. The scoring in the index is also quite problematic, and sometimes also very simplified which leads to unjust comparisons. The scoring problems are described very well in an article from AIER, American Institute for Economic Research (Book, J. 2020).

The author illustrates a perfect example with the variable for international travels “C8”. As stated in our appendix, C8 is a five-step ranking variable that reads: “0: No measures, 1: Screening, 2: Quarantine arrivals from high-risk regions, 3: Ban on high-risk regions, 4: Total border closure”. The ranking has rephrased its requirements since the article from AIER was written but the issues still remain.

When AIER published their article the third ranking was phrased “3: Ban arrivals from *some* regions”. Now however with “*high-risk* regions” the problem is still the same, countries can define high-risk in their own fashion.

The article continues illustrating the world of differences of “*some*” or “*high-risk*” that is not reflected in the index. The 25th of May 2020 Denmark admitted “*some*” people into its country while turning everyone else down, here they were downgraded to a 3 which was the same as Sweden. Sweden followed the European Union’s baseline policies which restricted non-EEA nationals which is the European Economic Area. Sweden kept their 3 throughout 2020. When they included certain non-European countries, made it easier for those with family connections to arrive, or allowed those with work permits to come, nothing got reflected in the ranking score, showing how static the variable is. Iceland had a 3 after the early stages of the pandemic as well. Iceland however barely let anyone in, then opened up for tourists in June against a test at the border, then in August they implemented a 5-day quarantine with a test before and after said quarantine, all at the travelers’ expense. Sweden’s attitude: No quarantine, no tests, minimal restrictions to far-off travelers.

Very different approaches from our Nordic countries, but the ‘3’ remained for all of them.

With over one hundred individuals from Oxford and Blavatnik School of Government involved in the Stringency Index it might still be difficult to keep track of all the minor changes in restriction policy in the world's many countries. The critique is in our opinion still warranted though when analyzing data the way we do, heavily relying on the Stringency index as a fair and equal index displaying differences in restrictions.

Another variable which is much like the previous one, very static, is C7. This variable describes Internal Movement, which is a 3-ranking variable. 0: No measures, 1: Recommend movement restrictions, 2: Restrict movement. Let us look at May again. Swedish Health Authorities had then offered recommendations not to travel if you were ill, and that people should consider if they really needed to travel. This warranted a ‘1’ according to the team at Oxford. Noting here that Danish authorities recommended working from home and avoiding public transport if possible, the team at Oxford ranked Denmark at ‘0’.

We also note that other relevant factors when looking at imposed restrictions are not included in the index, such as mask mandates, which is one of the biggest topics and widely debated about the Covid-19 pandemic and in our opinion quite a big deal in regard to freedom.

To summarize our thoughts and critique against the Stringency index, we feel that it is not nuanced or spaced enough to capture the true differences between countries or reflect what people actually mean by “lockdowns” or government policies.

When inspecting our other data variables there are things to comment on as well. For example, our urbanization variable. Here we see quite large differences in our chosen countries, for example Slovakia has an urban population of 53.7 percent and the Netherlands has 91.8 percent living in an urban area. This variable is problematic because there is no consistent and universally accepted standard of distinguishing urban from rural areas, that is countries decide the classification themselves.

Most countries use the urban classification related to the size or characteristics of settlements, while other countries define urban areas based on the presence of certain infrastructure and services, other countries designate urban areas based on administrative arrangements. Because of the differences between nations' classifications, comparisons should be made with caution. Our main analysis is conducted with respect to economic and health outcomes, but to give the research a deeper dimension we decided to also include urbanization and a variable with percent of population age 65 or above, since we thought these variables would be relevant to analyze in regard to a virus such as Covid-19. Regarding the critique towards urbanization, we decided it would still be relevant to include even though differences in classification for countries, since our main conclusions originate from the economic and health variables. If all data we collected had the same universal standard the estimates would give a more accurate result and lead to more clear conclusions. Since this is a lot easier said than done and the complexity behind all these variables, as the collection and compilation of certain data has to be realistic, we must take these inconsistencies into consideration when evaluating the results.

We have now mentioned and discussed potential problems with the data we used in our study, but there is even more to consider when it comes to dimensions and data we did not include in our research that could lead to biases, distorted results and errors. Examples of variables we did not include but could be of interest are: More comprehensive data of national economic structures such as tourism, social structures and economic gaps in countries, the short time span, Covid-19 relief packages.

As we have worked with our study, read more research papers and news articles concerning the Covid-19 topic, it has become clear to us that countries relying on tourism have been immensely more affected by Covid-19 than other countries, regardless of the spread of infection in these countries. Why countries heavily relying on tourism have been affected more is not difficult to comprehend. According to the IMF the travel and tourism sector has become one of the most important sectors in the world economy, accounting for 10 percent of global GDP and 320 million jobs, the sector being worth almost $9 trillion (IMF, 2020b; McKinsey,2020b). Covid-19 caused an unprecedented crisis in the tourism sector since countries did not allow international travelers to enter, furthermore people did not want to travel in the midst of a pandemic because they rely on their national health-care systems and do not feel comfortable travelling as they weigh the risk of falling ill. International tourist arrivals were projected to plunge by 60 to 80 percent during 2020, and tourism spending is not likely to return to pre-crisis levels until 2024, endangering up to 120 million jobs (McKinsey,2020b). With all of this in mind let us review the case of Spain.

Spain which was the country who we observed had the largest economic contraction in terms of GDP out of all our included countries. If we break down the economic structure of Spain it is easy to observe the importance of tourism for Spain’s economy. According to OECD in 2017 tourism accounted for 12.2 percent of the GDP and in 2018 it sustained 13.5 percent of all jobs, 2.6 million direct jobs (OECD iLibrary, 2020). With tourism being such a contributive sector, a cornerstone for the Spanish economy we believe that tourism is a strong contributive factor for economic contraction caused by Covid-19.

The country with the second largest economic contraction we saw during Q2 2020 was the UK. Tourism stands for roughly 10 percent of their GDP and sustains 11 percent of jobs, once again highlighting tourism as a strong contributive factor when analyzing Covid-19 economic contraction. Sweden's tourism accounted for 6.2 percent of their GDP and observe a decrease in Sweden’s GDP of only 8.2 percent compared to Spain’s decrease of 22.4 percent.

In hindsight, including tourism as a percentage of GDP variable probably would be a good idea but in the beginning of our study, we decided to limit the variables because of the vast amount of data and the time-consuming efforts made to retrieve and process it for our purposes. It is also now in the later stages of our work we reached the insights regarding tourism, re-doing our data analysis and regression tables felt redundant.

Social structures and economic gaps in different nations are most likely also relevant when analyzing economic contraction and health outcomes caused by Covid-19.

An article published by Brookings highlights this dimension of the pandemic. They emphasize that inequities in social determinants of health, income, health-care access, education and housing puts minority groups at increased risk of economic contraction and dying from Covid-19. According to Brookings, Black and Hispanic communities in the US are clustered in high-density urban locations, which were the locations most affected during the early stages of the pandemic (O’Donnell, L. B., Kristen E. Broady, Wendy Edelberg, and Jimmy, 2020). In addition, they also illustrate that Black and native American people disproportionately use public transit, which has been associated with higher Covid-19 contraction rates. Relatedly, these demographic groups entered the crisis with higher incidence of diseases such as hypertension, diabetes, and heart disease, which increase one’s risk of severe illness and dying from Covid-19.

Compared to white, non-Hispanic Americans, Black Americans were 4.7 times more likely to be hospitalized as a result of contracting the virus, and 2.1 times more likely to die from Covid-19 related health issues. Going deeper and analyzing Covid-19 consequences in regard to social structures will probably deliver interesting results, but it is a bit too specific for our research and would require a lot of time finding the relevant data for all of our countries. For our research we decided to focus on the larger macroeconomic effects but as the article illustrates, there are fascinating discoveries to be made regarding minorities and socially vulnerable society groups facing Covid-19.

One external factor that we consider to be perhaps the most relevant are the extensive and massive Covid-19 related relief packages which have been mentioned previously in the study. The absolute incomprehensive amount of money spent on stimulus and relief packages throughout the world are unique, according to McKinsey more resources was spent during the first 2 months of the Covid-19 crisis than in the whole financial crisis 2008-2009, and western Europe alone allocated resources to an amount almost 30 times larger than today's value of the Marshall plan (McKinsey, 2020).

Covid-19 stimulus packages is a central subject in the Bruegel paper, and it seems to be a big topic they want to shed light on. They bring up the record-breaking European Union stimulus package in the very first sentences of their introduction and emphasize that the multi-billion fund will mostly benefit the countries that have been hardest hit by the pandemic. And thus, wanting to be able to explain why these countries got hit so hard, compared to other countries in Europe.

We speculate that stimulus packages could be an explaining factor for the economic recovery of Japan which we saw in Q4 2020. Japan is one of the countries in the world that committed most resources in terms of percent of GDP in different relief packages, with the intention of boosting their economy (Kajimoto, L. K., Tetsushi 2020; McKinsey, 2020). According to Reuters they have allocated resources corresponding to roughly two thirds of their total GDP into different Covid-19 related relief packages. Japan's prime minister had this to say concerning the last stimulus package of 2020: "We have compiled the new measures to maintain employment, sustain business and restore the economy and open a way to achieve new growth in green and digital areas, so as to protect people's lives and livelihoods" (Kajimoto, L. K., Tetsushi, 2020)

Suga also said that this fresh stimulus package would boost Japan's GDP by roughly 3.6 percent, further giving us reason to believe the stimulus packages played a big part in all of the recoveries we saw from our Q4 2020 GDP analysis compared to Q2 (Kajimoto, L. K., Tetsushi, 2020). Initially when we began our research, we had no clue about the extensive stimulus packages that had been launched. It was first when stumbling upon the McKinsey article comparing Covid-19 stimulus to the 2008 financial crisis stimulus that we understood the magnitude of allocated resources by governments. We quickly thought this would be very relevant and interesting to include in our analysis, however it was difficult finding data for our chosen countries and hence we decided not to include it when we only found reliable data for a couple of countries.

The results derived from this research could give meaningful input in political discussions about future policies and also give insights of how the economic costs have been affected by the response measures which is of great importance when trying to determine best practice policy for future pandemics. Since the topic is inherently complex, with a bilateral relationship and causality in two directions, that is measurements affecting outcomes and vice versa, there are no simple answers. Even if there is no direct or short answer to the complex Covid-19 dilemma it is relevant to assess consequences and examine data to find patterns, flaws, or other errors in order to come closer to discussions that lead to solutions. We make an effort to highlight several other potentially relevant variables for further research that we detected during the work process which we hope can be of use to future scholars.

References

Aron, J. and Muellbauer, J. (2020) ‘The US excess mortality rate from COVID-19 is substantially worse than Europe’s’, *VoxEU.org*, 29 September. Available at: https://voxeu.org/article/us-excess-mortality-rate-covid-19-substantially-worse-europe-s [Accessed 18 April 2021]

Barlow, P. et al. (2021) ‘COVID-19 and the collapse of global trade: building an effective public health response’, *The Lancet Planetary Health*, 5(2), pp. e102–e107. Available at: https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(20)30291-6/fulltext [Accessed 19 April 2021]

Bruegel (2020). Why has COVID-19 hit different European Union economies so differently? Available at: https://www.bruegel.org/2020/09/why-has-covid-19-hit-different-european-union-economies-so-differently/ [Accessed 19 April 2021]

Book, J. (2020) Oxford's Stringency Index is Falling Apart – AIER. Available at: https://www.aier.org/article/oxfords-stringency-index-is-falling-apart/ [Accessed 8 May 2021]

Coibion, O., Gorodnichenko, Y. and Weber, M. (2020) The Cost of the Covid-19 Crisis: Lockdowns, Macroeconomic Expectations, and Consumer Spending. w27141. National Bureau of Economic Research. Available at: https://www.nber.org/papers/w27141 [Accessed 19 April 2021]

Douglas, J. (2020) ‘Measuring the Strictness of Your Lockdown: A University Boils It Down to One Number’, *Wall Street Journal*, 23 May. Available at: https://www.wsj.com/articles/measuring-the-strictness-of-your-lockdown-a-university-boils-it-down-to-one-number-11590246001 [Accessed 17 April 2021]

Eurostat (2021). Impact of COVID-19 on international trade by Member State (2021). Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Impact_of_COVID-19_on_international_trade_by_Member_State [Accessed 22 April 2021]

European Commission. Recovery plan for Europe (2020) European Commission Available at: https://ec.europa.eu/info/strategy/recovery-plan-europe_en [Accessed 3 May 2021]

GitHub (2021). covid-19-data/excess_mortality.csv at master · owid/covid-19-data · Available at: https://github.com/owid/covid-19-data/blob/master/public/data/excess_mortality/excess_mortality.csv [Accessed 18 April 2021]

Griffin, S. (2020) ‘Covid-19: Waiting times in England reach record highs’, *BMJ*, 370, p. m3557. Available at: https://www.bmj.com/content/370/bmj.m3557 [Accessed 8 May 2021]

IMF (2020a). World Economic Outlook, April 2020 : The Great Lockdown (2020) Available at: https://www.imf.org/en/Publications/WEO/Issues/2020/04/14/World-Economic-Outlook-April-2020-The-Great-Lockdown-49306 [Accessed 5 May 2021]

IMF (2020b). Impact of the Pandemic on Tourism (2020). Available at: https://www.imf.org/external/pubs/ft/fandd/2020/12/impact-of-the-pandemic-on-tourism-behsudi.htm [Accessed 7 May 2021]

Institute for Health Metrics and Evaluation (2021). Estimation of total mortality due to COVID-19 Available at: http://www.healthdata.org/special-analysis/estimation-excess-mortality-due-covid-19-and-scalars-reported-covid-19-deaths [Accessed 17 April 2021]

Johns Hopkins Coronavirus Resource Center. COVID-19 Map (2020) Available at: https://coronavirus.jhu.edu/map.html [Accessed 16 April 2021]

J.P. Morgan (2020). How COVID-19 Has Transformed Consumer Spending Habits. Available at: https://www.jpmorgan.com/solutions/cib/research/covid-spending-habits [Accessed 18 April 2021]

Kajimoto, L. K., Tetsushi (2020) 'Japan unveils $708 billion in fresh stimulus with eye on post-COVID growth', *Reuters*, 8 December. Available at: https://www.reuters.com/article/us-japan-economy-stimulus-idUSKBN28I02Y [Accessed 7 May 2021]

König, M. and Winkler, A. (2021) 'COVID-19: Lockdowns, Fatality Rates and GDP Growth', *Intereconomics*, 2021(1), pp. 32–39. Available at: https://www.intereconomics.eu/contents/year/2021/number/1/article/covid-19-lockdowns-fatality-rates-and-gdp-growth.html [Accessed 3 May 2021]

McKinsey (2021a). The consumer demand recovery and lasting effects of COVID-19 Available at: https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/the-consumer-demand-recovery-and-lasting-effects-of-covid-19 [Accessed 27 April 2021]

McKinsey (2020b). How government COVID-19 spending can deliver impact Available at: https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-10-trillion-dollar-rescue-how-governments-can-deliver-impact# [Accessed 10 April 2021]

O'Donnell, L. B., Kristen E. Broady, Wendy Edelberg, and Jimmy (2020) 'Ten facts about COVID-19 and the U.S. economy', *Brookings*, 17 September. Available at: https://www.brookings.edu/research/ten-facts-about-covid-19-and-the-u-s-economy/ [Accessed 2 May 2021]

OECD. Statistics (2020). Available at: https://stats.oecd.org/ [Accessed 16 April 2021]

OECD iLibrary (2020). Spain OECD Tourism Trends and Policies 2020. Available at: https://www.oecd-ilibrary.org/sites/8ed5145b-en/index.html?itemId=/content/component/8ed5145b-en [Accessed 7 May 2021]

Our World in Data (2021a). Coronavirus (COVID-19) Cases - Statistics and Research (2021) Available at: https://ourworldindata.org/covid-cases [Accessed 17 April 2021]

Our World in Data (2021b). Excess mortality during the Coronavirus pandemic (COVID-19) - Statistics and Research (2021) Available at: https://ourworldindata.org/excess-mortality-covid [Accessed 16 April 2021]

Oxford COVID-19 Government Response Tracker (2021). Available at: https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker [Accessed 16 April 2021]

Pancevski, B. (2020) 'Inside Sweden's Radically Different Approach to the Coronavirus', *Wall Street Journal*, 30 March. Available at: https://www.wsj.com/articles/inside-swedens-radically-different-approach-to-the-coronavirus-11585598175 [Accessed 20 April 2021]

The Lancet Rheumatology (2021) 'Too long to wait: the impact of COVID-19 on elective surgery' 3(2), p. e83. Available at: https://www.thelancet.com/journals/lanrhe/article/PIIS2665-9913(21)00001-1/fulltext [Accessed 1 May 2021]

UNCTAD (2020). *Covid-19 and tourism: Assessing the economic consequences* Available at: https://unctad.org/webflyer/covid-19-and-tourism-assessing-economic-consequences [Accessed 7 May 2021]

Wang, D. et al. (2021) 'Reply to: Observed impacts of the COVID-19 pandemic on global trade', *Nature Human Behaviour*, 5(3), pp. 308–309. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7306102/ [Accessed 20 April 2021]

Washington Post (2021) 'How the $1.9 trillion U.S. stimulus package compares with other countries' coronavirus spending'. Available at: https://www.washingtonpost.com/world/2021/03/10/coronavirus-stimulus-international-comparison/ [Accessed 10 May 2021]

World Bank (2020a). *COVID-19 to Plunge Global Economy into Worst Recession since World War II* Available at: https://www.worldbank.org/en/news/press-release/2020/06/08/covid-19-to-plunge-global-economy-into-worst-recession-since-world-war-ii [Accessed 2 May 2021]

World Bank (2021b). *World Development Indicators* Available at: https://databank.worldbank.org/source/world-development-indicators [Accessed 16 April 2021]

Appendix

In the appendix we go more into detail on how the Stringency index is constructed and calculated. Together with the other variables where we explain where the data is collected, how it has been used in calculations to create clean and comparable data.

Stringency index

The indicators are organized into different groups where C is containment and closure policies and H is health system policies. These specific policy and response categories are described as follows:

School closures (C1):

0 - No measures

1- Recommend closing

2 - Require closing (only some levels or categories, just high school or just public schools)

3 - Require closing all levels

Workplace closures (C2):

0 - No measure

1 - Recommend closing (or work from home)

2 - Require closing (or work from home) for some sectors or categories of workers

3 - Require closing (or work from home) all but essential workplaces (eg grocery stores, doctors)

Cancel public events (C3):

0 - No measures

1 - Recommend canceling

2 - Require canceling

Restrictions on gatherings (C4):

0 - No restrictions

1 - Restrictions on very large gatherings (the limit is above 1000 people)

2 - Restrictions on gatherings between 100-1000 people

3 - Restrictions on gatherings between 10-100 people

4 - Restrictions on gatherings of less than 10 people

Close public transport (C5):

0 - No measures

1 - Recommend closing (or significantly reduce volume/route/means of transport available)

2 - Require closing (or prohibiting most citizens from using it)

Public information campaign (H1):

0 - No COVID-19 public information campaign

1 - Public officials urging caution about COVID-19

2 - coordinated public information campaign (eg. across traditional and social media)

Stay at home (C6):

0 - No measures

1 - Recommend not leaving house

2 - Require not leaving house with exceptions for daily exercise, grocery shopping, and 'essential' trips

3 - Require not leaving house with minimal exceptions (e.g. allowed to leave only once every few days, or only one person can leave at a time, etc)

Restrictions on internal movement (C7):

0 - No measures

1 - Recommend movement restriction

2 - Restrict movement

International travel controls (C8):

0 - No measures

1 - Screening

2 - Quarantine arrivals from high-risk regions

3 - Ban on high-risk regions

4 - Total border closure

The calculation for the stringency index is described by Our world in data as follows:

"The stringency index is calculated using only the policy indicators C1 – C8 and H1. The value of the index on any given day is the average of nine sub-indices pertaining to the individual policy indicators, each taking a value between 0 and 100: $I = \frac{1}{9}\sum_{j=1}^{9} Ij$Indicators C1 to C7 and H1 have an additional flag corresponding to whether the policy has been applied locally, in specific areas/circumstances, or generally, nationwide. We define G_j to be 0 if the policy is targeted and 1 if general. Note that a policy can only be general if it has a non-zero value, since a zero value corresponds to no measures being taken. Because different indicators *j* have different maximum values N_j in their ordinal scales, we weight the additional contribution of a general policy by the average number of ordinal points across the eight indicators that have the targeted/general qualification. This ensures that general policies are not "over-contributing" to indicators with fewer ordinal points or "under-contributing" to indicators with more ordinal points. The additional weight for a policy of general scope is defined in relation to the number of ordinal points of the eight indicators that have the targeted/general flags, that is $w = \frac{1}{8}\sum_{j=1}^{8} \frac{1}{(Nj+1)}$, then we define, for these 8 indicators the sub-indices to be $Ij = 100(Cj \frac{1-w}{Nj} + w\, Gj)$ where C_j is the ordinal value of indicator Cj and its weighting here ensures that the subindex Ij varies between 0 and 100. Since C8 has no notion of general vs targeted, we just have I_9=$100(C9/N9)$. The sub-indices are thus linearly proportional to the ordinal value of that policy indicator, with a standardized 'bonus point' for a generally-applied policy. If fewer than six policy indicators have data on a given day, the index calculation is rejected and no value is returned.'' (Oxford COVID-19 Government Response Tracker, 2020)

<u>Health data</u>

<u>Excess mortality per 100,000:</u>

Excess mortality was calculated by taking total deaths in a country for each half-year of 2020 subtracted with the total average death for the years 2015-2019 (one data point for each half

year). To get excess mortality per 100,000 we took the absolute value of excess mortality divided by the country's population multiplied 100,000.
Formula: ((Total deaths half-year 2020 - average annuals deaths 2015-2019)) / (Population) * 100,000

Data imported from:
https://github.com/owid/covid-19-data/blob/master/public/data/excess_mortality/excess_mortality.csv
**Missing countries: Ireland, Turkey

Population (2019)

The country's population for the year 2019, latest data available.

Data imported from: https://ourworldindata.org/covid-cases

Economic data

GDP

With this variable we wanted to observe the percentage change in GDP with reference period Q4 2019. For the first half-year we used the GDP level for Q2 2020 and for the other half we used GDP level for Q4 2020.

Formula: ((GDP level Q2 2020) - (GDP level Q4 2019)) / (GDP level Q4 2019) first half
((GDP level Q4 2020) - (GDP level Q4 2019)) / (GDP level Q4 2019) second half

Data imported from: https://stats.oecd.org/

**Missing countries: Colombia, Turkey

Export

The percentage change in export with reference period Q4 2019. For the first half-year we used the export amount for Q2 2020 and for the other half we used export amount for Q4 2020.

Formula: ((Export Q2 2020) - (Export Q4 2019)) / (Export Q4 2019) first half
((Export Q4 2020) - (Export Q4 2019)) / (Export Q4 2019) second half

Data imported from: https://stats.oecd.org/

**Missing countries: Latvia, Turkey

Unemployment

For this variable we observe the unemployment level for the first half-year by directly retrieving the unemployment rates from OECD stats for Q2 2020, for the second half we did the same but for Q4 2020.

Data imported from: https://stats.oecd.org/

**Missing countries: Greece, Latvia, Slovenia and Turkey

Other data

Population ages 65 and over (% of total population)

Population age 65 and above as a percentage of the total population.

Data imported from: https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS?locations=OE

Urban population (% of total population)

Data imported from:
https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=OE