Has the fairness or the prosperity of a country led to better health and economic outcomes from the COVID-19 pandemic?

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Abstract

This work product explores the hypothesis *"It is the level of equality (fairness) in a country rather than its level of GDP per capita (prosperity) that has led to better health and economic outcomes from the COVID-19 pandemic.".* The hypothesis is explored by correlating income inequality and GDP per capita with health and economic outcomes. The results are somewhat counter-intuitive, more prosperous countries have experienced higher death rates and worse economic outcomes than their less prosperous counterparts. This is largely driven by continental differences, most notably in Africa where the impacts of the pandemic have been lower. There is nevertheless some evidence to support the hypothesis that fairer countries have seen better (albeit 'less bad') outcomes than prosperous countries.

Background Context: At the start of the pandemic, the Institute and Faculty of Actuaries (IFoA) called for volunteers from its member base to address issues arising which were relevant to the profession and areas where it could assist. The resultant IFoA COVID-19 Action Task Force (ICAT) comprised over 550 volunteers allocated to 93 workstreams.

This paper is a product of the ICAT group focused on incomes and inequalities. Any views expressed in this paper are those of the authors and not those of either their employers or the IFoA. For the avoidance of any doubt, they should not be construed as advice and no decisions should be taken as a result of them.

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1. Hypothesis

It is the level of equality (fairness) in a country rather than its level of GDP per capita (prosperity) that has led to better health and economic outcomes from the COVID-19 pandemic.

2. Introduction

This paper considers the relative 'performance' of countries in responding to the virus 'Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)' and the consequent 'Coronavirus Disease (COVID-19)'. We refer to the collective effect of these within the human population as 'the pandemic'.

Our hypothesis as outlined above is that countries with greater 'equality' amongst the population tend to have better outcomes in relation to the pandemic than 'richer' countries. Accepting that these labels are simplistic we are comparing respectively 'fairness' ('fair/fairer') with 'prosperity' '(prosperous/more prosperous').

The rationale behind our hypothesis was that fairer countries are more likely to act to protect the wider interests of the whole population and might seek to achieve a different balance between 'health' and 'economic' outcomes from those taken by 'prosperous' countries. The assumptions behind this rationale are that fairer countries are more likely to invest in healthcare systems to treat those carrying the virus, welfare systems that offer such benefits as sick pay and perhaps leadership that has followed scientific advice with regards to tackling the pandemic. We acknowledge that while this may be a pattern of behaviour exhibited by fairer countries, more prosperous countries have more to spend on such systems.

Our analysis draws conclusions based on outcomes at particular points of time. Outcomes will be different at different time points and consequently conclusions may also change. The analysis is performed with the latest data as of April 2021.

We have seen a number of detailed papers/analyses covering health outcomes for a large number of countries or (separately) economic outcomes for a large number of countries or finally both health and economic outcomes for a small number of countries. However we have not seen any papers addressing our subject of both health and economic outcomes for a large number of countries.

3. Progression of the pandemic and consideration of factors that may influence outcomes

In general 'prosperous' countries will have more resources to battle a pandemic. By way of contrast 'fairness' is likely to influence how and where available resources are allocated.

We discuss below the progression of the pandemic and identify factors which might influence outcomes. Almost all these factors potentially interact with the concepts of prosperity or fairness,

albeit sometimes in complex ways. We mention them now and will discuss them in more detail in the Results section.

Spread and geography: The pandemic is understood to have started in Wuhan, China and from there spread via South East Asia to Europe and worldwide. It appears to have followed patterns of international air travel arriving first in the largest cities where it could spread quickly and only later to less accessible areas including certain islands, hinterlands or geographical extremities.

Policy decisions: These include restrictions designed to control the pandemic's spread but also measures to mitigate consequent economic damage and crucially the balance between the two. The former include 'lockdowns', social distancing, curfews, mask-wearing and test and trace systems which will depend on population compliance. The latter include support to employers (for example through 'furloughing' - state payments towards salaries), direct payments to individuals, and emergency investment in healthcare.

Experience with similar outbreaks: The previous SARS outbreak in 2003 affected predominantly China and countries in South East Asia. These countries appear to have been able to respond more quickly and effectively to the current pandemic.[1] There is also evidence that African countries' experience with Ebola and outbreaks of malaria have given them some advantages.[2]

Health infrastructure: A strong infrastructure in terms of equipment, staff, training and organisation should be more effective in fighting the pandemic.

Social policy: A strong social security network will give some protection from the adverse economic outcomes of the pandemic. This protection is likely to benefit mostly those of lower socio-economic status and may also act against adverse health outcomes by, for example, enabling those infected and their contacts to afford to isolate and so avoid infecting others.

Age profile: In general the probability of death increases with age. Similarly the probability of death (once infected) increases with age, believed to be linked to the increase with age of comorbidities and weakening of immune systems. Analysis conducted over a variety of countries indicates between 85% and 90% of deaths occurred amongst those aged over 65.[3] Further analysis by David Spiegelhalter of Cambridge University has suggested that (very approximately in the UK) the probability of death (once infected) roughly corresponds to the prior probability (by age and sex) of death from all other causes in that year.[4] Equivalently infection doubles the probability of death in that year.

Prevelance of Obesity: Throughout the pandemic it has been observed that individuals who are either overweight or obese are more likely to become seriously ill with or die from COVID-19. Various research papers have attempted to quantify this impact. A World Obesity Federation report cited John Hopkins Coronavirus research centre work showing a correlation of 0.547 between the percentage of a population that is overweight and mortality rates from COVID-19, in a dataset of 164 countries.[5]

4. Methodology

In this section, we describe -

- The inputs (measures of ‘prosperity’ and ‘fairness’) and outputs (the health and economic outcomes) observed
- The statistical analysis conducted
- The data sources

4.1 Inputs - Measures for ‘prosperity’ and ‘fairness’ between countries

To test our hypothesis we needed objective measures for prosperity and fairness. Measures are needed for a sufficiently large number of countries to support a credible comparison. Availability of data has therefore been a significant driver in the measures chosen.

We do not consider prosperity and fairness as mutually exclusive - a particular country might for example be considered both ‘prosperous’ and ‘fair’. Rather we are seeking an indication as to whether ‘fairness’ is more likely than ‘prosperity’ to lead to favourable outcomes.

The measures we chose are from established and well-recognised sources and we have relied on them absolutely. While we have carried out some tests for reasonableness and consistency we are not in a position to, nor do we consider it practical or necessary to, verify them independently.

4.1.1 Prosperity measure

Intuitively it seems that ‘wealth’ rather than ‘income’ is a better measure of the resources available to manage a pandemic. However putting a consistent value on either state or private wealth is not easily done and data for wealth is not available for many countries. Wealth and income are positively correlated, but not strongly.[6]

We concluded that the most consistent and generally available data relates to GDP per capita. We found data for this for 198 countries at current USD rates and have used this as our measure of prosperity.

4.1.2 Fairness measure

The appropriate measure for fairness was a more challenging exercise. There are a myriad of excellent indices - Gini coefficient, population proportions living below certain daily income thresholds, income share held by a given segment of the population and many others - measuring the features of a virtuous or fairer society. Often these indices involve some subjectivity in their construction and measurement and are designed to achieve a particular purpose. We concluded that for the purpose of our study a fairness measure needed to be objective and broadly comparable to the measure we used for prosperity.

This required us to consider how income is shared amongst the population. We considered the gini coefficient, which is a measure of the income distribution across a population. While the measure had the advantage of being readily available, it is less intuitive and is also difficult to interpret (identical gini coefficients could arise from very different income distributions). Ultimately we elected to use a measure which showed the proportion of total income attributable to the top 10% of individuals. Two indices were considered -

- World Bank index based on income (salaries, pensions etc) with data over the last 5 years available for 67 countries; and
- World Inequality Database index which was based on all income including income from capital for 169 countries over last 5 years

We chose the latter index which had the advantage of including an element for wealth (significantly increasing the share of the top 10%) and availability for more countries.

We established that many of these measures moved very closely, suggesting that any measure chosen amongst them should yield similar conclusions. For instance, income share held by the top 10% population and income share held by the bottom 50% population were very strongly negatively correlated exhibiting a rank correlation of 0.97. Income share of the top 10% population also showed a statistically significant strong relationship with poverty headcount ratio (proportion of the population living under $3.20 a day) exhibiting a rank correlation of 0.71.

We had data for all of the 54 countries in Africa, the highest number by continent. Asia had data for 47 out of 48 countries and Europe had 39 only out of the 44 available. North America (including Central American and the Carribean) had 16 countries out of the possible 23. South America had 12 countries. Oceania had Australia, New Zealand and Papua New Guinea only out of the 14 countries.

4.2 Outputs - measures for health and economic outcomes between countries

To obtain a more holistic measure of the effect of the pandemic we decided to measure both health and economic outcomes.

4.2.1 Health measures

We considered a number of initial measures for the pandemic health outcomes as follows:

Number of pandemic cases: This depends crucially on the level of testing which varies widely between countries. We therefore rejected this as a measure.

Deaths per positive case: While this may give some indication of the success of treatment it also depends crucially on the number of tests carried out and was consequently rejected.

Excess deaths: This is arguably the ideal measure as by measuring the deaths over those normally experienced (averaged for example over the last five years) it might be expected to detect the additional effect of the pandemic. We rejected this measure on the grounds of availability of data. In addition, for Africa deaths from malaria may dwarf deaths from the pandemic.[7]

Actual deaths declared by each country as being from coronavirus: This item is widely available, published by a number of sources (WHO, John Hopkins) and generally considered sufficiently reliable for broad comparison purposes. Nevertheless there are some inconsistencies in the method of calculation (for example death certificates vs deaths following positive test, definite or possible pandemic attribution and the 'of' or 'with' question). In addition there are concerns some countries may have deliberately or inadvertently understated their figures. Regardless of these concerns, this seemed to be the most reliable measure available and we therefore elected to use the measure published by Our World in Data.

We considered different adjustments to this as follows:

Deaths per million population: We chose this as our core health measure because it enables comparisons between countries of different population sizes. It is widely used for national comparison purposes and obtained from 'Our World in Data'.

Age adjusted deaths per million: This is a subsidiary variation of the core health measure above. It reflects evidence (in a UK context) that fewer than 10% of pandemic deaths occur amongst those aged under 65.[8] It is obtained by dividing the core health measure by the proportion of the population aged over 65 (the latter also obtained from 'Our World in Data'). For example if two countries have respectively 10% and 20% of their population aged over 65 the latter country might, all else being equal, expect approximately twice the number of deaths. The age adjustment is intended to level out this potential effect between countries although is inevitably a 'blunt instrument'.

Obesity adjusted deaths per million: This is an adjustment made to the deaths per million population to adjust for the prevalence of obesity within populations. We analysed various sources of information that estimated the increased risk of death due to overweight and obesity. Kompaniyets et al. (2021) carried out a study on a very large dataset collected from 238 U.S. hospitals between March and December 2020.[9] They found that being overweight, defined as having a body mass index (BMI) between 25 and 30, does not increase the risk of death. They found that being obese, defined as having a BMI in excess of 30 increases the risk of hospitalisation and death. We deduced from their results that the increased risk of hospitalisation was 13.6%; and of those hospitalised, the increased risk of death was 20.1%. Cumulatively this results in an increased risk of death of 36.5% compared to those not having obesity. Our adjustment backs out this effect and leaves us with the mortality rate for the non-obese portion of the population, hence removing the effect of different countries having different proportions of their population obese.

4.2.2 Economic measures

We chose three economic outcome measures: GDP growth (more often contraction in 2020), Debt/GDP ratio and unemployment.

There is a plethora of economic data available published by various sources (OECD, IMF, World Bank) and the above choice was influenced by the importance, availability and common usage of the three measures. All the measures are inevitably published with time-lags. While for example figures for OECD countries generally become available by the subsequent quarter end, data for other countries only becomes readily available over longer periods.

We also needed to consider the period over which our measures should be assessed. Available data makes it difficult to do large scale international comparisons on anything less than a quarterly basis and even this would be challenging. The pandemic hit different countries at different times (China at the very end of 2019 and Italy for example at the end of February 2020). Nevertheless economic effects began to be felt in Q1 2020 due to supply chain problems originating in China. We therefore concluded that it is reasonable to measure economic outcomes over a period starting from 1 January 2020.

The next challenge was the end-point of any analysis. Time lags make it difficult to find recent information for a sufficiently large number of countries. The IMF produces figures for the whole year with the latest report published in early April 2021 . They will generally have assessed the effect of the pandemic over 2020 but not the subsequent effects of any ‘second waves’ (for example in India occurring predominantly in the second quarter of 2021).

We have used this data although would caution that any analysis between health and economic outcomes should be treated with care. The precise indices we have used are:

GDP growth: The arithmetic difference between the actual IMF percentage growth in 2020 as published in the IMF April 2021 report and the corresponding projection for 2020 published in October 2019. We made a comparison against the estimate for 2020 published in October 2019 rather than using the actual figure for 2019 on the basis that we believe the approach we adopted is more likely to identify differences caused by the pandemic rather than those anticipated from particular country circumstances.

To illustrate, if two countries A and B have a 2020 GDP contraction of 5%, but their estimates for 2020 as at October 2019 were nil growth and a growth of 5% respectively, then under our approach country B has ‘lost more’ than country A.

Debt/GDP: General government gross debt as a percentage of GDP in 2020 as published in the IMF April 2021 report. We considered the arithmetic difference between this ratio at the beginning and end of the year. A distinct measure, intended to remove the effect of GDP growth over the year, was assessed by rebasing the ratio at year end to that of the GDP level at the start of the year.

Unemployment: The arithmetic difference between the actual unemployment rate for 2020 as published in the April 2021 IMF report and the corresponding actual figure for 2019. Unemployment measures are complex in that some countries are very dependent on the informal/gig economy which can make comparisons difficult. Furloughing (state payments towards salaries) as seen in the UK and US is a means of avoiding unemployment.

4.3 Data Analysis

Once data had been collected for our input and output variables, suitable testing was required to determine if a relationship existed between them and furthermore which input variables had the strongest relationships with the output variable. We concluded that correlation testing was the most natural approach.

The two most common methods for correlation testing are Pearson and Spearman. The Pearson correlation method tests for a linear relationship between the variables. It tests whether an increase in one variable might correspond to a proportionate increase in the other. In the tests laid out in our analysis it could be used to conclude, as an example, every $X of additional GDP per capita results in the death rate in a country falling by Y deaths per million.[10]

An alternative option is the Spearman Rank correlation test. This tests for a monotonic relationship between the two variables, achieved by placing the two variables in rank order. If one variable is increasing as the other increases or decreases, it will yield a result, even if the underlying relationship is non-linear.[11]

The nature of our experiment is not to find an exact (or even approximate) relationship between one variable and another but rather to understand if a relationship (correlation) exists. There is no expectation that any relationship would be linear. For this reason we chose to proceed using the Spearman rank correlation method. All subsequent references to correlation in this paper are to the Spearman rank correlation.

A correlation takes a value between -1 and +1. For example if the ranking of an input and an output measure were identical over 100 countries (say) then the rank correlation would be +1 (‘perfectly positively correlated) or if they were completely opposite (so the lowest on one measure is the highest on the other and so on) the rank correlation would be -1 (perfectly negatively correlated). It is also helpful to have a description of the strength of any rank correlation. We have denoted a rank correlation (whether positive or negative) between 0.8 and 1.0 as ‘very strong’, 0.6 to 0.8 as ‘strong’, 0.4 to 0.6 as ‘moderate’, 0.2 to 0.4 as ‘weak’ and nil to 0.2 as ‘very weak’.[11]

It is important to establish whether any rank correlation observed is statistically significant or not. In this context, that is to determine, given the number of data points (countries) in the test, the probability that the observed result occurs. Where the probability of the particular result occurring randomly, due to size of the dataset, is below 5%, the result is significant. This

significance is determined using a t-test to find the critical value for the degrees of freedom associated with the size of the same.

4.4 Data Summary

The below table is a summary of the data that has been used in our study with links to the source and brief description.

Figure 1: Summary of data sources

Inputs	Source	Link
GDP per capita	World Bank	https://data.worldbank.org/indicator/NY.GDP.PCAP.CD
Income share of top 10%	World Inequality Database	https://wid.world/data/

Outputs	Source	Link
Deaths per million	Our World In Data	https://ourworldindata.org/covid-deaths
Percentage of population aged 65 or over	Our World In Data	https://ourworldindata.org/covid-deaths
Percentage of population obese	World Health Organization	https://apps.who.int/gho/data/node.main.BMI30C?lang=en
GDP 2020 growth	International Monetary Fund	https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD
2020 unemployment rate	International Monetary Fund	https://www.imf.org/external/datamapper/LUR@WEO/OEMDC/ADVEC/WEOWORLD
2020 Debt/GDP	International Monetary Fund	https://www.imf.org/external/datamapper/GGXWDG_NGDP@WEO/OEMDC/ADVEC/WEOWORLD

Comments on specific data fields:

GDP per capita - Latest GDP per capita figures as sourced from World Bank national accounts, data at current US $ rates

Income Inequality measure - The figures available at March 2021 for share of national income held by the top 10% of the population published by the World Inequality Database based on tax

data and national surveys. The % was taken based on the most recent available within the last five years.

Deaths per million - as reported by countries and updated daily. This data source is subject to differences in reporting methodology between countries (for example the UK reports a pandemic death if it occurs within 28 days of a positive test whereas other countries use different measures). The data used in this study is up to and including March 10th 2021.

Percentage of population aged 65 or over sourced from Our World in Data, the original data source is World Bank data as of 2017.

Percentage of population obese: Latest data from WHO as of 2017.

GDP 2020 growth - GDP growth over 2020 produced by the IMF as part of the World Economic Outlook report dated April 2021.

Debt/GDP : General government gross debt as a percentage of GDP at the end of 2020 produced by the IMF as part of the World Economic Outlook report dated April 2021.

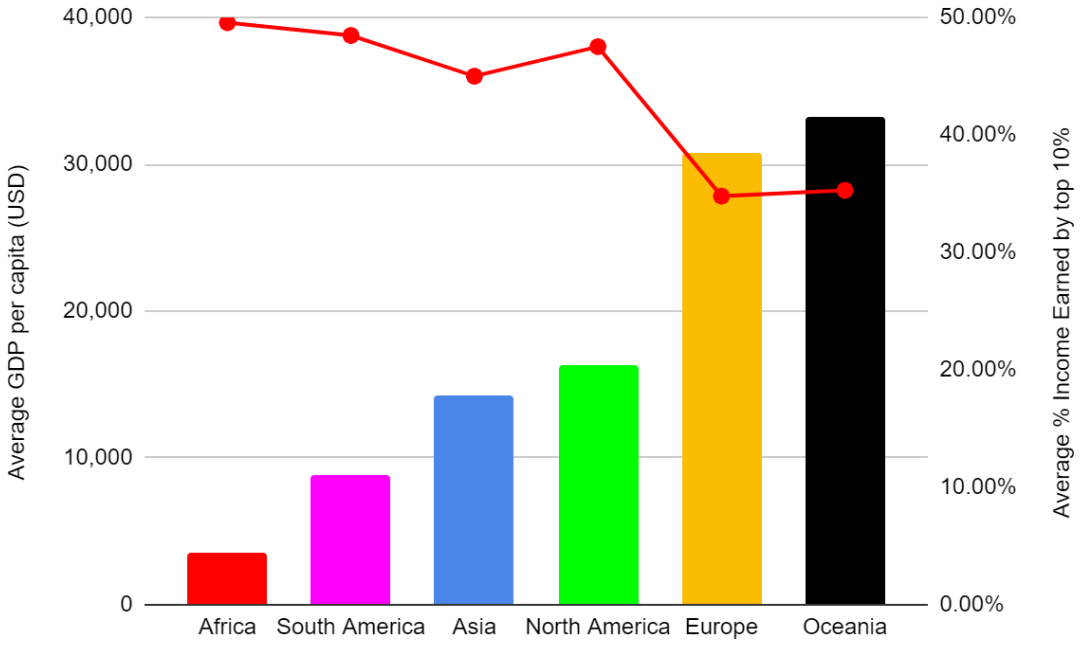
2020 Unemployment rate - Unemployment rate for 2020 produced by the IMF as part of the World Economic Outlook report dated April 2021.

5. Results

In this section we first consider the findings from the hypothesis testing in detail and then summarise key results.

Our results will consider outputs by continent and we therefore start by looking at continental averages for our prosperity and fairness measures. The graph below shows the average GDP per capita (bars) and the average income share of the top 10% (points) per continent.

Figure 2: GDP per capita and income share of top 10% by continent.



Our hypothesis is that fairer countries would tend to have better outcomes than prosperous countries. This hypothesis is challenging given the statistically significant, albeit moderate correlation of 0.42 between the prosperity and fairness measures themselves (indicating that prosperous countries tend also to be fairer).

Our original hypothesis had envisaged both fairer and prosperous countries outperforming their less fair and less prosperous counterparts with the specific hypothesis being that fairer countries would also outperform prosperous countries. Our early results however suggested that prosperous countries generally tended to have worse outcomes than less prosperous countries. As a consequence we adopted the convention that we will denote as a positive correlation any outcome where prosperous (or fairer) countries have an adverse outcome (so for example prosperous or fairer countries having more deaths or greater than expected fall in GDP).

In the detailed results that follow we discuss each of the output measures and also consider results by continent.

5.1 Health Outcomes

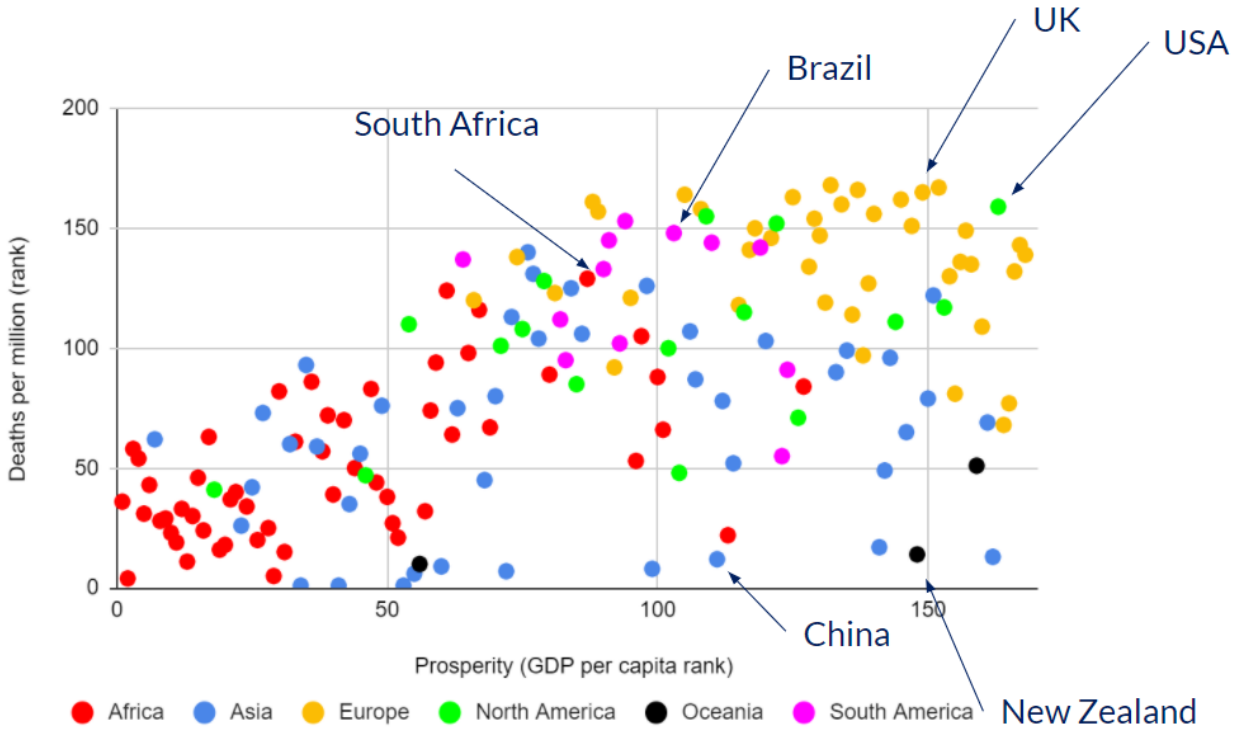
We compared both the prosperity and fairness measures against the deaths per million measure. The first step was to perform this analysis for prosperous countries where ranking data was also available for the fairness measure. The results are at first glance rather counter intuitive.

5.1.1 Prosperity v Deaths per million

The results show a moderate (tending to strong) correlation of 0.59 between prosperous countries and higher death rates. In other words, countries with higher GDP per capita have experienced higher death rates.

Upon further investigation the difference in continental results shows itself as the main driver of these results. What we see in the graph below is a more intuitive picture of how the ranking of deaths and GDP per capita varies, in particular between Europe and Africa.

Figure 3: GDP per capita vs deaths per million. Graph shows a moderate positive correlation of 0.59 between prosperity (GDP) and deaths per million. Key countries highlighted to ease interpretation. As we are testing a rank correlation these graphs have been constructed on a ranked basis. This means that they do not reflect the extent to which deaths per million or GDP per capita are different between countries.



European countries have experienced much higher death rates than African countries. This can be seen by their proximity to the upper half of the graph; they also have higher GDP per capita hence their proximity to the right hand side of the graph.
The countries with the highest GDP per capita are Luxembourg, Switzerland, Ireland, Norway & Iceland, which are all in Europe. At the opposite end of the scale, the five countries with the lowest GDP per capita are Somalia, Burundi, Malawi, Sudan & Central African Republic.

It can be seen that the cluster of European countries occupying the top right quadrant of the chart and the African countries residing most commonly in the bottom left quadrant is a significant contributor to the positive correlation observed between these two variables.

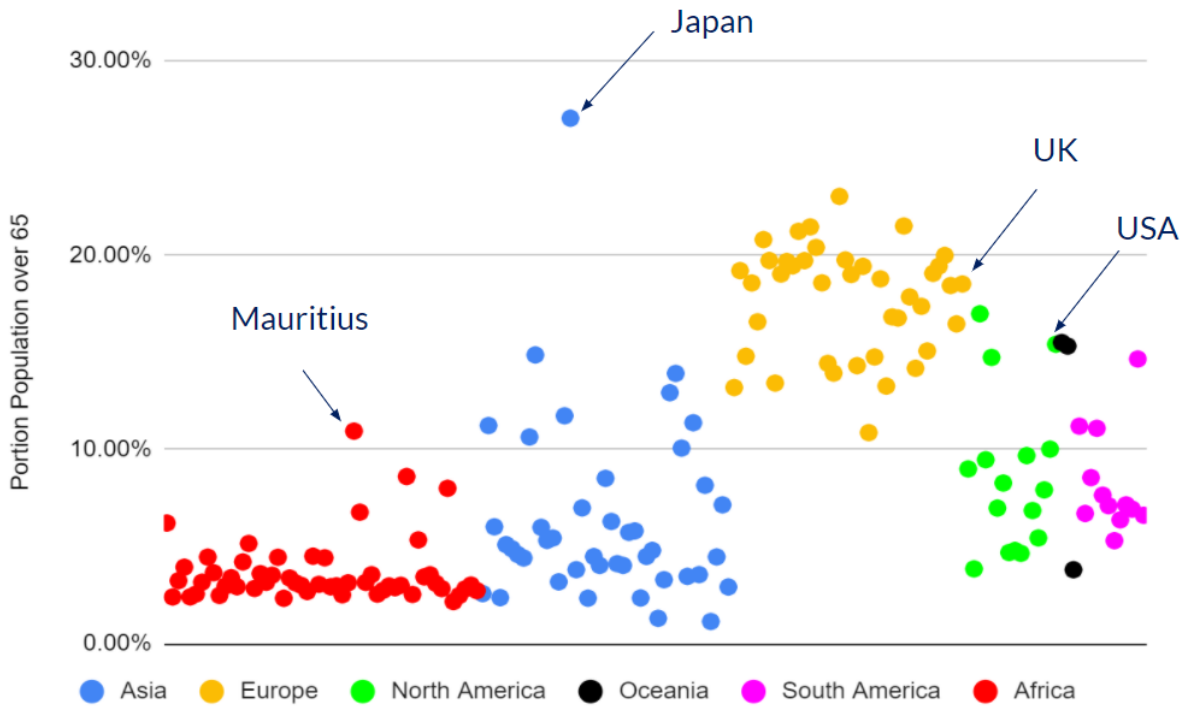
Oceania (in particular New Zealand and Australia) have lower death rates and are amongst the most prosperous while South American countries tend to have middling prosperity but higher death rates. Asian countries vary with the more eastern, often controlled but less prosperous countries having closed down their economies earlier and consequently having lower death rates whereas the more affluent Middle East has tended to have higher death rates. North American countries are spread throughout the data. The United States and Canada being the more prosperous nations and the deaths per million experience varying across the Central American and Carribean nations.

5.1.2 Prosperity v Age Adjusted Deaths per million

One of the reasons for the lower death rates in Africa is likely to be the lower average age of the population. A recent publication by The Economist Magazine reported that “Based on people’s age alone, you would expect the disease to be ten times more deadly in Italy than Uganda.”[12] The economist created its own metric, age-specific infection fatality rates which were used to explain, to a degree, the observed result in the chart above that older richer countries saw much higher death rates.

A key factor in our interest for understanding the age difference is observed in the below graph. The percentage of populations aged 65 or older varies significantly across the globe but again there are clear continental differences with Europe having, on average, an older age demographic.

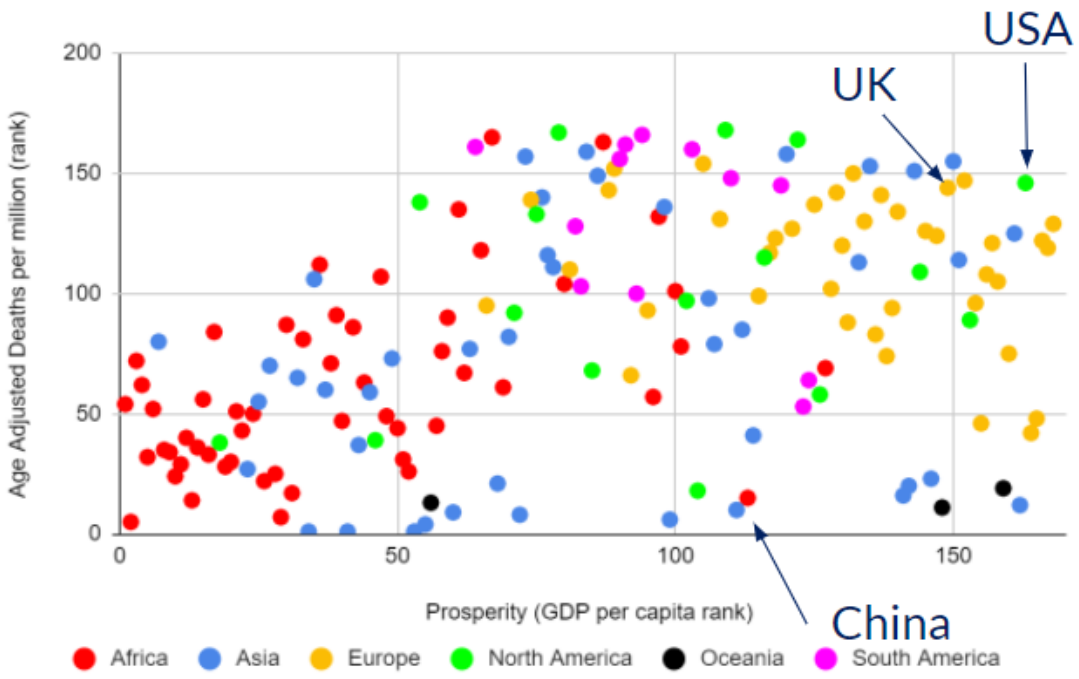
Figure 4: Percentage of population aged 65 or older. Results show clear differences by continent



In our analysis we looked at the proportion of a country's population aged 65 or older and made an adjustment to mortality rates as a result. This approach reflected observations previously referred to that over 90% of pandemic deaths occurred amongst those aged over 65 suggesting the proportion of population over aged 65 might be a better explanation of a country's health outcome. For explanation of the adjustment see the methodology section.

With this age adjustment the initial result is still observed with statistically significant rank correlation, that prosperous countries have seen higher death rates due to the pandemic, albeit the correlation is now 0.41 (moderate tending to weak) compared to 0.59 (moderate tending to strong) without the adjustment. This suggests age profile is a partial but not a full explanation of the adverse result for prosperous countries. We do acknowledge that the age adjustment itself does not fully reflect the difference in mortality at different ages nor the age distribution of populations.

Figure 5: GDP per capita vs deaths per million (age adjusted). The graph shows a moderate (0.41) positive correlation between prosperity and the age adjusted deaths per million.



Comparing the above graph with the unadjusted deaths per million graph (Figure 3), countries still sit at the same position on the x axis (their GDP per capita is unchanged) but move up or down according to the effect of the age adjustment.

We see the impact of the age adjustment immediately with many of the European countries moving down as their death per million count on an age adjusted basis is significantly lower. The more significant changes are seen, unsurprisingly, by countries with the largest portion of their population above 65. Italy, Portugal and Germany have the highest proportions and are three of six countries in our sample with more than 20% of their population over the age of 65. On the other end of the spectrum 26 countries have less than 2% of their population over the age of 65, the overwhelming majority of these being African countries.

5.1.3 Prosperity v Obesity Adjusted deaths per million

The second adjustment made was for the percentage of populations that are obese. As previously stated this was due to observed results across the world that obese individuals are more likely to contract and die from the virus. The effect of 'backing out' obesity levels between countries was to make very little difference to the results with the observed correlation of 0.59 (prosperity and deaths per million) falling only very slightly to 0.58 (prosperity v obesity adjusted deaths per million). We have therefore not shown our results in more detail.

The adjustment for obesity had a small impact due to the fact that even for countries with large proportions of obesity, their ranking did not change very much after allowing for the additional risk of death due to obesity in their populations.

To take the United States as an example - The United States has experienced 1,599 deaths per million and 37.3% of its population is classified as obese. We can say that 1,599 is the deaths per million for the entire population, but we assume that 37.3% of the population is 37% more likely to die than the rest of the population. This leaves us with deaths per million for those not obese of 1,410. When the adjusted deaths are ranked, the United States is the 12th highest, whereas it was the 10th highest on the unadjusted basis.

At the other end of the spectrum, Nepal has only 3.8% of its population classified as obese, ranking it 161st out of 167. The deaths per million are 103 which ranks it 96th, which is slightly in the better half. With the same adjustment as described above the deaths per million changes very little, as might be expected, to 102 and the rank only reduces to 95th.

Results like these at the extremes of the obesity scale show why the obesity adjustment had little effect on the results.

5.1.4 Fairness v Deaths per million

Our calculations showed that there is also a correlation (albeit weak at 0.33) between fairer countries and higher death rates. So fairer countries have experienced higher death rates than their less fair counterparts.

Nevertheless this is consistent with the hypothesis that fairer countries have outperformed prosperous countries (where the correlation with death rates was 0.59) albeit a better description might be that they have done ‘less badly’ rather than ‘better’.

Upon conducting analysis into income inequality we can see continental differences contributing to the counter-intuitive result that fairer countries have higher death rates. European countries, as already discussed have the highest death rates per million, in these results we see that they also have the more equal distribution of income.

By the measure chosen, top 10% share of income, the top five countries all reside within Europe. Czech Republic ranked highest with 28% of pre-tax national income being earned by the top 10% of earners. The remaining countries in the top five are; Iceland 28%, Slovenia 29%, Slovakia 30% and The Netherlands 30%. In the graph below they are given the highest rank of fairness.

At the other end of the scale the bottom five i.e. least fair, by this measure are; Sao Tome and Principe - 69%, South Africa - 65%, Central African Republic - 65%, Mozambique - 64% and Namibia 64%.

Figure 6: Rank of income share of top 10% vs rank of deaths per million. Graph shows a weak (0.33) positive correlation between the two variables. Gap in fairness rank data seen as a result of a number of Caribbean countries sharing the same income inequality metric. This does not have a material impact on the results.

5.1.5 Fairness v Age Adjusted Deaths per million

We notice for this test that the age adjusted result is not statistically significant. The effect of allowing for age profiles is to remove the correlation that existed between fairer countries and higher death rates suggesting that correlation was largely due to age profile.

Figure 7: Rank of fairness as measured by income share of the top 10% vs age adjusted deaths per million. No significant relationship found between the variables. Gap in fairness rank data seen as a result of a number of Caribbean countries sharing the same income inequality metric.

5.1.6 Fairness v Obesity Adjusted Deaths per million

As observed with the prosperity comparison the effect of an obesity adjustment on the correlation of fairness with deaths per million is minimal and the correlation remains 0.33 (weak).

5.2 Economic outcomes

We compared our various economic outcomes against our prosperity and fairness measures.

We did this for three core economic outcomes respectively GDP growth, change in Gross National Debt (as a proportion of GDP) and Unemployment. We consider these in turn.

5.2.1 Prosperity v Economic outcome - GDP growth

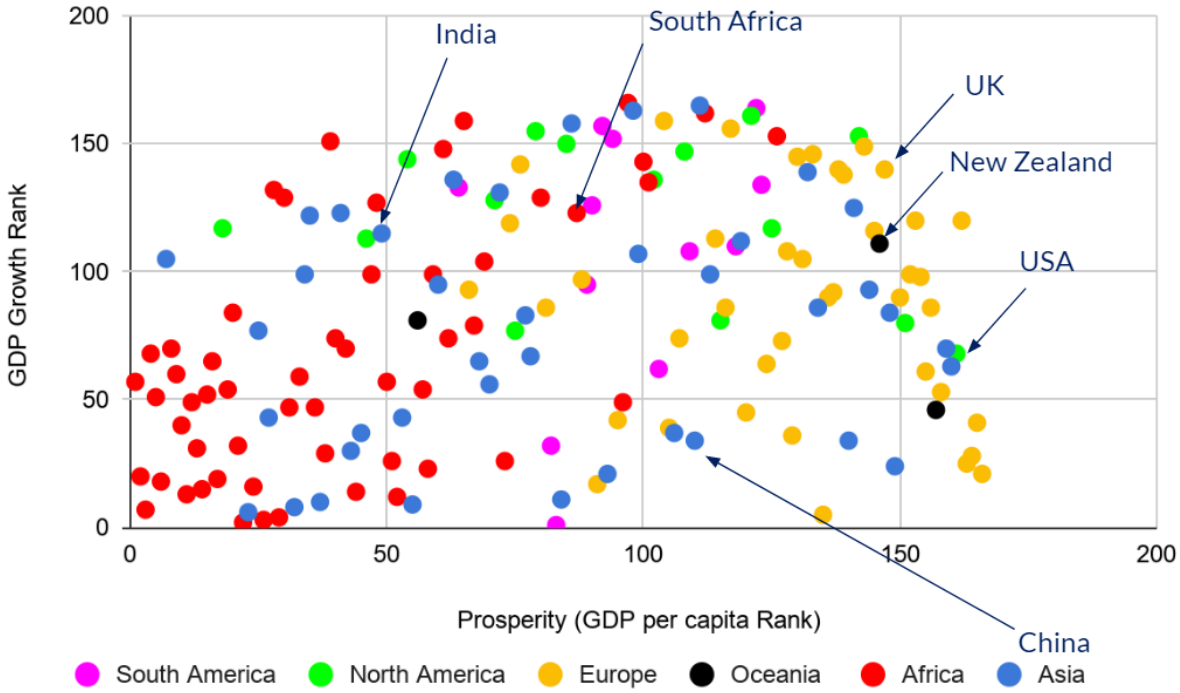
The first economic outcome we considered was the effect on GDP growth using the difference between IMF 2020 actual GDP growth rates and corresponding ‘pre-pandemic’ estimates as a leading measure of the economic impact. The first point to make is that these figures indicated that for 95% of the countries in the dataset GDP growth in 2020 was lower than the corresponding projections made in 2019. This doesn’t mean that there were necessarily contractions (although this was observed for 85% of the countries in the dataset) but rather that the original growth estimate had not been achieved.

It was no surprise that amongst the top 10 countries that experienced the highest erosion in their GDP growth were countries like Maldives, Mauritius and Bahamas etc. - countries heavily dependent on the tourism sector, which was one of the worst hit sectors during the course of the pandemic.

The result shows a statistically significant relationship albeit weak with correlation 0.30; the countries with the highest GDP per capita have experienced higher erosion in GDP growth. This means that more prosperous countries took a bigger hit to their GDP than their less prosperous counterparts. This may be because prosperous countries, having more in reserve, chose to absorb some loss of GDP growth in response to the pandemic.

Looking closely at the relationship between economic impact and prosperity, the difference in continental results shows itself as a key driver of these results. What we see in the graph below is a more granular story of how the ranking of economic impact and GDP per capita varies between continents.

Figure 8: GDP per capita vs GDP projection change. Graph shows a weak positive correlation of 0.30 between prosperity (GDP per capita) and impact on GDP. As we are testing a rank correlation these graphs have been constructed on a ranked basis and do not reflect the extent to which GDP per capita or change in GDP are higher between countries.



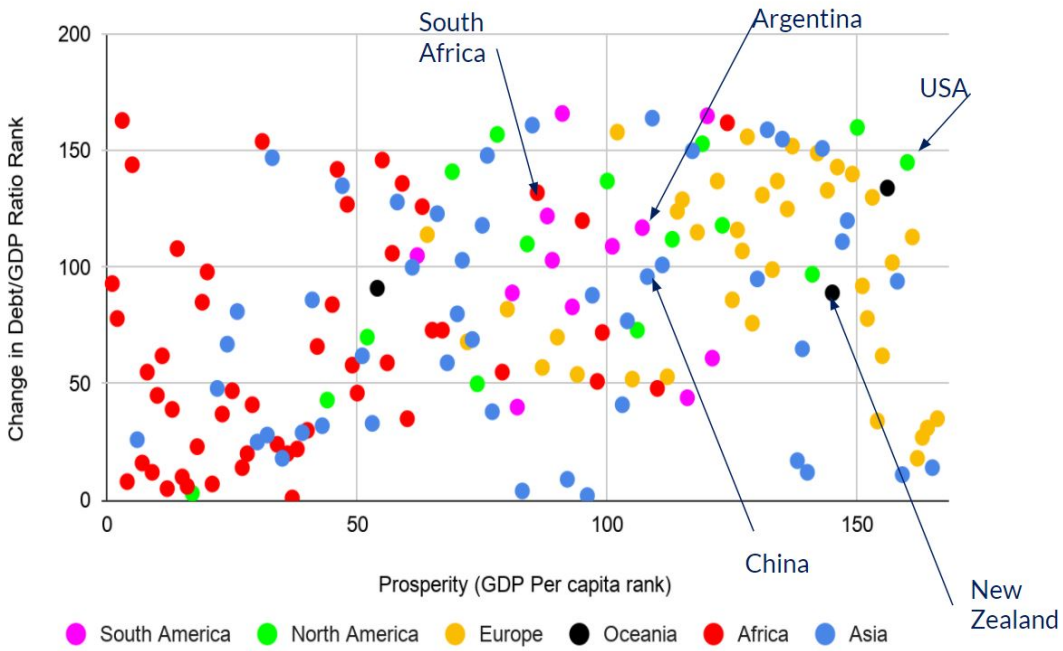
European countries, with higher GDP per capita, had a larger fall in their estimated GDP growth (seen by their representation in the top right half of the graph), while the fall for African countries, which lag behind on GDP per capita, was much lower. Asian countries exhibited a similar pattern with the more prosperous counterparts losing more on GDP growth than the less prosperous ones.

5.2.2 Prosperity v Economic outcome - Debt/GDP

The second economic variable considered is the Debt/GDP per country. Countries were expected to borrow more because of the unexpected pandemic expenses in health and economic sectors and for this the arithmetic difference between the Debt/GDP figure in 2020 and the Debt/GDP figure in 2019 was considered.

The results show a statistically significant relationship (albeit weak, correlation 0.33) between prosperity and Debt/GDP meaning that countries with the highest GDP per capita tended to borrow more for the year 2020. More prosperous countries have more capacity to borrow and their debt levels, even though high, are still at sustainable levels. The less prosperous countries have less capacity to borrow and even a small increase in their debt could push them to unsustainable levels.

Figure 9: GDP per capita vs change in Debt/GDP ratio. Graph shows a weak positive correlation of 0.33 between prosperity (GDP per capita) and change in Debt/GDP ratio.



One potential issue was that the increase in the Debt/GDP ratio might have arisen because of the decrease in the denominator (GDP) and not the increase in debt. To eliminate this effect we rebased the Debt/GDP ratios to 2019 GDP figures in order to remove the effect of the 2020 GDP contraction so that all that remains is the effect of the debt on the ratio.

The results still show a statistically significant relationship between prosperity and Debt/GDP (rebased to 2019 GDP levels) albeit slightly weaker at correlation 0.21. For most countries the increase in the ratio derives from the increase in debt and not the decrease in GDP. The countries that saw a big shift with the rebasing adjustment were the tourism-based countries which saw a large drop in their GDP for 2020.

An initiative by the World Bank and the IMF, the Heavily Indebted Poor Countries (HIPC), seeks to issue debt relief to less prosperous countries who meet certain criteria, commit to poverty reduction through policy changes and demonstrate a good track record over time. The goal is to reduce the debt to sustainable levels for these countries. The initiative began in 1996 and so far with the help of other multilateral, bilateral and commercial creditors, has benefited 37 countries, 31 of which are from Africa.[13]

5.2.3 Prosperity v Economic outcome - Unemployment

We also considered unemployment as a parameter to show the economic impact across the countries in our study. Unemployment is defined as persons above a specified age who are not employed or self employed and are actively looking for work during the specified period. For

this, we used the unemployment rates published by the IMF for 2020 in April 2021 against the actual unemployment rates posted by the same organisation for 2019.

Reliability of data on unemployment rates largely depends on how countries choose to record those people laid off temporarily or furloughed by their employers. For example, as per the "OECD unemployment rates news release: August 2020", the US and Canada recorded temporary laid off workers as unemployed which may explain their high unemployment rates, which then began to fall as the workers got back to work while in the Euro area, temporary laid off persons are not included in the unemployment statistics.[14] A report by the Brookings Institution, "The effects of COVID-19 on international labor markets", stated that at least 12 out of the 20 rich democracies that were included in its analysis have prevented large-scale unemployment by channeling reliefs through employers to their employees. These were mainly European countries.[15]

The disproportionate impact and uneven recovery could also have had an effect on unemployment rates. As per the "ILO Monitor: COVID-19 and the world of work. Seventh edition", the labour force survey data (up to the third quarter of 2020) contrasts massive job losses in hard-hit sectors such as accommodation and food services, arts and culture, retail, and construction and the positive job growth evident in a number of higher skilled services sectors such as information and communication, and financial and insurance activities.[16]

Unfortunately, availability of data was much lower for unemployment rates than for any of our other output measures, giving us a sample size of only 92. We tested both prosperity and fairness for correlation with the change in unemployment rates but neither showed statistically significant relationships. This implies that the degree to which a country is prosperous or fair has no bearing on the change in rates of unemployment caused by the pandemic.

The unemployment data only included 8 African countries, hence was dominated by the other continents. This is unlike the other tests where Africa contributed the largest number of countries and so may have contributed to our insignificant results. It is also possible that our analysis is premature and that testing unemployment would give more conclusive results in the coming months and years once the temporary unemployed have gone back to work and the furloughs cease.

5.2.4 Fairness v Economic outcomes

We compared our measure of fairness against all three of our economic outcomes. On none of these measures was there any statistically significant correlation. It follows that fairness, as we have measured it, appears not to be a differentiator on economic outcomes.

5.3 Summary of Results - Prosperity and Fairness against Health and Economic outputs

The following tables show the correlations obtained (as described above) between our inputs (prosperity and fairness) and outputs (health and economic).

Figure 10: Summary of correlation testing results

Health	Countries compared	Prosperity	Fairness
Deaths per million	167	0.59	0.33
Age adjusted deaths per million	167	0.41	Not significant
Obesity adjusted deaths per million	167	0.58	0.33

Economic	Countries compared	Prosperity	Fairness
GDP growth	166	0.30	Not significant
Debt/GDP	166	0.33	Not significant
GDP growth adjusted debt/GDP	166	0.21	Not significant
Unemployment	92	Not significant	Not significant

It can be seen that on every measure (with the exception of unemployment where no statistically significant relationship was observed) prosperous countries have a positive correlation with adverse outcomes. This correlation is moderate (tending to strong) on the unadjusted deaths measure but remains moderate (albeit tending to weak) when the age profile effect is stripped out. The economic outcome correlations may only be weak but are nevertheless counter-intuitive in that as with the health outcomes they indicate no obvious advantage deriving from prosperity.

The correlation of our outcomes against fairness is less convincing. While there is a correlation between fairness and the adverse outcome of higher deaths, this disappears when allowance for the age profile is made. Similarly on none of the economic measures is there any evidence of statistically significant outcomes (either favourable or adverse).

Taken in aggregate these results are surprising because they suggest that prosperous countries tended to have worse pandemic outcomes on our health and economic measures than less prosperous countries. Fairer countries have indeed, consistent with our hypothesis, done better (perhaps more correctly ‘less badly’) than prosperous countries but no better than their less fair counterparts.

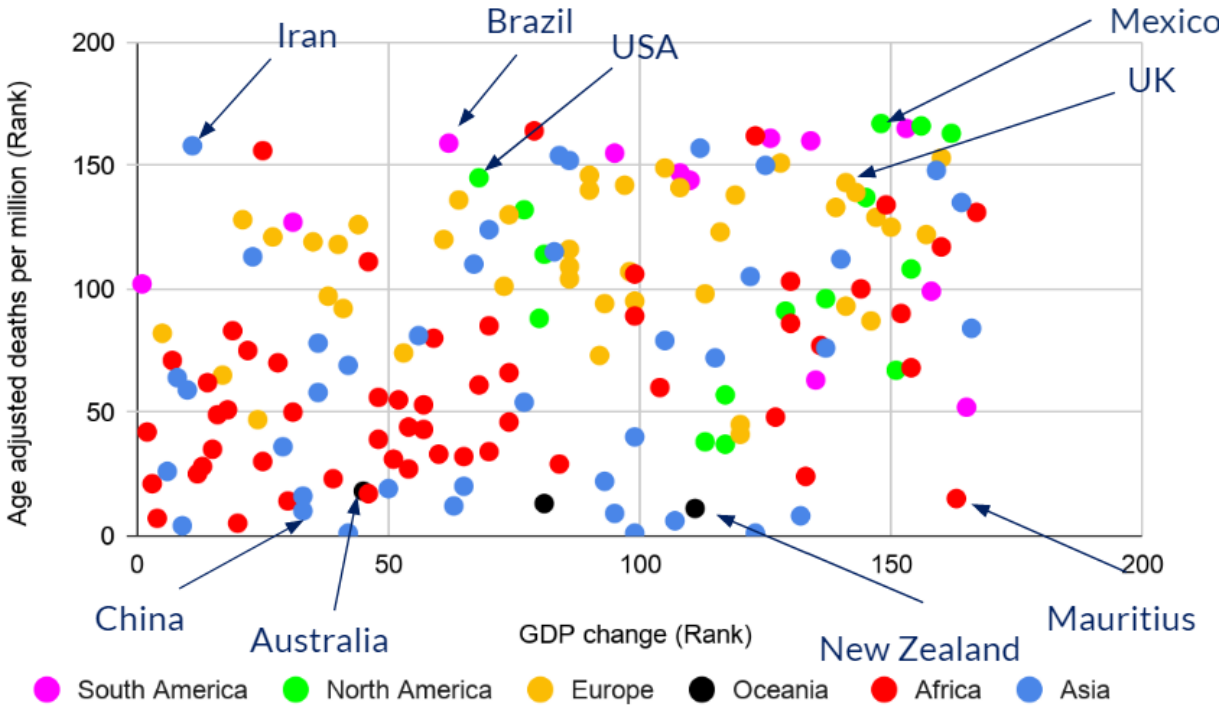
5.4 Interaction between outputs

The results we obtained indicated that prosperous countries had adverse outcomes on both mortality and GDP growth measures. On both measures this felt counter-intuitive against an expectation that more prosperous countries might be more resilient to the impact of the pandemic. The population age profile partially explains the result on mortality and it may be that

the GDP growth factor can be explained by the more complex (multi-linked and international) nature of more prosperous countries' economies.

A possible explanation could be that prosperous countries may have been better placed to choose to sacrifice economic output to protect the health output. We therefore looked at the relationship between the (age adjusted) mortality and GDP growth outputs. This, however, indicated a statistically significant positive relationship, albeit a weak one (0.35), between the two, i.e. worse economic impact and higher mortality tended to move together. This indicated that instead of there being a 'trade-off' between economy and deaths, there has been a compounding effect - bad news has followed on both economic and health fronts simultaneously. The following graph illustrates this correlation.

Figure 11: Age adjusted deaths per million vs GDP projection change



The result has been consistent with findings in other research pieces, which have concluded similarly that *"As well as saving lives, countries controlling the outbreak effectively may have adopted the best economic strategy too."* [17]

A closer look at some of the key territories highlights countries like China and Australia which have managed to keep both economic and health impacts contained and also countries like UK and Mexico that have suffered significantly on both. There remain countries that have not faced this 'dual worsening/ benefit' - notably Brazil and USA that have fared much worse on the health than the economic front and countries like New Zealand and Mauritius that have not had a heavy death toll but significant economic impact.These impacts are largely explained by policy

decisions. Brazil and USA, for example, have kept their economies largely open while New Zealand has imposed long and stringent lockdowns.

5.5 Africa in contrast to Europe

The difference in experience of the pandemic between Africa and Europe was a key driver behind the results that emerged from this study. We felt that it would be beneficial to include a qualitative commentary on this unforeseen outcome.

5.5.1 Health outcomes

African countries with lower GDP per capita and high income inequality have seen fewer deaths than their European counterparts. Some of this is due to their age profile. Africa is the youngest continent with 41% of its population being under 15 years of age and only 3% being above the age of 65. Europe, on the other hand, has more people above the age of 65 than under 15: 18% as compared to 16% who are below 15 years of age.[18] Age increases the risk of death in those who have contracted the virus. This is believed to be due to the higher likelihood of having underlying conditions and weakened immune systems. As a result, and as shown in the graphs above, deaths per capita in European states have been higher. Our age adjustment attempted to allow for this, but it does not fully explain the difference.

Another known risk factor for death from COVID-19 is overweight and obesity. Obesity prevalence is far higher in Europe, where 23.3% of the adult population are obese than in Africa where only 10.6% are obese[19]. Our obesity adjustment attempted to strip out the differences in death rates caused by differing levels of obesity by country, but this had little impact on the adjusted death rates.

Other than age and overweight/obesity, low population density and less international travel, a hot and humid climate which sees more outdoor living are all possible reasons for its relative success to date. There is also some speculation that experience with prior outbreaks, such as Ebola, together with pre-existing protective immune response from the BCG vaccination provided at birth in most African countries may contribute to the lower death rates.[20]

There will also be different approaches to testing levels and reporting of COVID-19 deaths, which could be contributing to lower death rates in Africa. It could be argued that the healthcare systems in Africa are not set up as well as those in Europe to test as widely or to report on COVID-19 deaths.

It must be noted that the pandemic is not over and the relative success to date in Africa may not continue. It is of paramount importance that African countries vaccinate their populations. To date they are lagging behind the rest of the world. As at mid-June, only 2.4% of the Africans had received at least one dose compared with 36.8% of Europeans and an average worldwide of 21.0%.[21]

5.5.2 Economic outcomes

The smaller contraction in African GDP may be a product of lower prosperity. Their economies are more often not sufficiently robust to make a conscious choice to close non-essential businesses and provide funds to people through stimulus packages or financial support to employers. This may explain the better (or strictly 'less bad') fall in GDP and smaller increase in unemployment rates compared to their more prosperous European counterparts. Indeed economies with lower GDP per capita, largely in Africa, may not have the buffer in their budgets or the capability to borrow in a way that allows them to close down their economies.

As noted in Section 5.2.2 the HIPC initiative is crucial to assist many indebted African countries escape from the burden of debt. It may also prove to be vital to the African nations in fighting this pandemic.

6. Conclusion

In conclusion, we have found some evidence to support our hypothesis that fairer countries had better outcomes than prosperous countries on both health and economic measures.

The conclusions are counter-intuitive, in that prosperous countries (in particular) tended to have worse outcomes than their less prosperous counterparts. Prosperous countries had higher death rates (observed with strong correlation). This remained the case (although the correlation was weaker) even after allowance was made for their older age profiles. Prosperous countries also had larger drops in GDP growth and increased debt.

Fairer countries also had higher death rates than their less fair counterparts although the correlation was weak. Once allowance was made for the higher age profiles of fairer countries there was no statistically significant evidence that fairer countries had higher death rates than their less fair counterparts. Similarly there was no statistically significant evidence of fairness impacting changes in expected GDP growth.

Neither prosperity nor fairness produced positive outcomes. Our conclusion, stated more precisely is, fairer countries performed ‘less badly’ than prosperous countries.

A large part of these differences arose because of continental differences. In particular Africa (generally less prosperous) had a lower death rate and less economic damage than Europe (generally more prosperous). Africa confounded expectations of potentially higher death rates; this is likely to be due to its age profile but there are other factors at play.

We also compared outcomes between countries. These tend to show a positive correlation between outcomes (age adjusted death rates and GDP loss) suggesting that countries cannot necessarily ‘choose’ between health and economic outcomes.

The effect of the pandemic has been profound and will leave significant scarring on medium term health and economic outcomes. Any conclusions we have made must be tentative and would require further research before definitive statements can be made. Each country has its own story and the aggregate effect is complex. At the time of writing in May 2021, the pandemic continues to evolve differently in different parts of the world, with vaccination programs at different rates and variants of concern emerging across the globe. It follows that future investigations with updated data could show different conclusions.

The scientific achievements leading to the development and production of vaccines give hope that over time the future damage caused by the pandemic will be mitigated if not eliminated. The vaccine may tip the advantage back towards prosperous countries although arguments for fairness and the view that each country’s safety depends on other countries’ safety suggest that fairness should be considered on a global rather than national level.

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