



Research Article

Examining the Effects of Social and Economic Freedoms on the COVID-19 Pandemic

Alexander Noviello^{*}, Sameer Menghani, Maksym Bondarenko, Bhushan Mohanraj, Oliver Solensky, Ian Lee, Jordyn Vermut, Deyaan Guha, Shaan Choudhri, William Sabat, Andrew Noviello

The Lawrenceville School, Lawrenceville, New Jersey USA

***Corresponding Author:** Alexander Noviello, The Lawrenceville School, Lawrenceville, New Jersey USA

Received: 11 November 2021; **Accepted:** 15 November 2021; **Published:** 24 November 2021

Citation: Alexander Noviello, Sameer Menghani, Maksym Bondarenko, Bhushan Mohanraj, Oliver Solensky, Ian Lee, Jordyn Vermut, Deyaan Guha, Shaan Choudhri, William Sabat, Andrew Noviello. Examining the Effects of Social and Economic Freedoms on the COVID-19 Pandemic. *Journal of Psychiatry and Psychiatric Disorders* 5 (2021): 172-188.

Abstract

Aim: The goal of this study was to examine how social and economic freedoms, as well as related variables, impacted the COVID-19 pandemic, including governmental pandemic response and cases, deaths, and tests throughout 2020.

Materials and Methods: To explore the effects of social and economic freedoms, gross domestic product (GDP), and other parameters on the COVID-19 pandemic, multiple datasets, including the

Economic Freedom Index and the Human Freedom Index were used, along with COVID-19 data, to examine both direct and indirect relationships. The K-Means clustering algorithm was used for many analyses.

Results: High economic and social freedoms were associated with increased numbers of COVID-19 cases and deaths throughout 2020. Countries within the highest category of economic freedoms reported their first COVID-19 case 44 days before and their

first virus death 91 days before low-economic-freedom nations, on average. Countries with the highest overall freedoms exhibited average COVID-19-stringency scores of 4.4, 12.85, and 4.49 points less than countries in the lowest freedom categories for the Spring, Summer, and Fall of 2020, respectively, representing less strict pandemic responses. Freedoms were also shown to correlate with other pandemic-influencing factors, including GDP, political systems, and population density.

Conclusion: High economic and social freedoms were associated with increased numbers of COVID-19 cases and deaths throughout 2020. Future analyses should address whether the enjoyment of freedoms can be balanced with the preservation of safety to improve responses to future pandemics.

Keywords: COVID-19; Economic freedoms; Social freedoms; Gross domestic product; K-Means analysis

Abbreviations

COVID-19: Coronavirus Disease 2019; GDP: Gross domestic product; USD: United States dollar

1. Introduction

On December 31, 2019, COVID-19 was first reported to the World Health Organization, and on March 11, 2020, COVID-19 was officially declared a global pandemic [1].

Since its late-2019 origination in China's Wuhan Province, the virus has infected well over 100 million people worldwide [2].

Despite the pandemic's foreseen long-lasting effects on global society, analysis of its spread is often focused on short-term individual government responses. Thus, the focus of this paper is to explore how pre-existing national social and economic freedoms and other related variables contributed to the virus' spread, widening the scope of inquiry. The Human Freedom Index, sponsored by the Cato Institute, one of the United States' most widely cited research organizations, the Economic Freedom Index, sponsored by the Wall Street Journal and the Heritage Organization, the world's most influential think tank, and datasets from OurWorldInData were used to examine the following hypotheses regarding the relationship between pre-existing national freedoms and the severity of the COVID-19 pandemic [3-9].

First, countries with greater economic freedoms were predicted to have higher and earlier COVID-19 case surges in the Spring of 2020, due to increased global exposure and dependency on trade, along with less willingness to impose economic shutdowns. Further expectations included that countries with significant social or human freedoms would be less likely to impose harsh restrictions on their populations due to higher freedom standards, and their populations would be less inclined to follow restrictions even when implemented, contributing to increased COVID-19 infection rates. Lastly, it was hypothesized that countries with higher GDPs, shown to be associated with higher economic freedoms, would be more likely to have the resources (monetary, scientific, etc.) to respond to the pandemic, namely treating infected individuals, minimizing the virus' fatality rate in their populations.

This report seeks to illuminate how oft-overlooked social and economic freedoms played a major role in dictating COVID-19 cases, deaths, and governmental pandemic responses, while speculating on how these same freedoms may affect future pandemics or other catastrophes.

2. Materials and Methods

To explore the effects of social and economic freedoms on the COVID-19 pandemic, datasets were used to examine both direct and indirect variable relationships. References to Spring 2020 indicate March 1 to May 31, 2020, Summer 2020 to June 1 to August 31, 2020, and Fall 2020 to September 1 to November 30, 2020, while all other dates were chosen based on data availability and situational specificity. For example, February 1, 2020 was deemed the starting date of the analysis on economic freedoms' relationship to the early pandemic, but that date does not represent the official beginning of "Spring 2020" due to a lack of data, namely in COVID-19-stringency scores.

2.1 Dataset descriptions

The Economic Freedom Index calculates economic freedom scores for each country in the world on an ascending 1-100 scale, with superscores calculated from over 30 wide-ranging features [5]. Economic freedom superscores were used, along with specific selected features chosen by relevance to the COVID-19 pandemic. The Human Freedom Index calculates human freedom scores for each nation on an ascending 1-10 scale, computing superscores from well over 100 features [3]. As with values from the

economic freedom index, certain variables within the index were selected for additional analyses due to their relevance in influencing the pandemic.

COVID-19 data consisted predominantly of confirmed and reported case counts, death counts, and testing information from the Global Data Change Lab in partnership with Oxford University [7-9]. Despite their inclusion in the Economic Freedom Index, countries' individual Gross Domestic Product (GDP) values, represented in billions of U.S. dollars, were utilized distinctly in relevant analyses [5].

COVID-19 governmental response data was obtained from the OurWorldInData COVID-19 Stringency Index, with stringency superscores calculated from a collection of smaller governmental restriction parameters on an ascending 1-100 scale [9]. Higher stringency scores represent stricter pandemic responses, including national mask mandates and mandatory workplace closures.

Lists of countries, containing both socialist/democratic-socialist and capitalist nations, were obtained from the World Population Review, with democracy scores, obtained from OurWorldInData, used to determine categorical statuses for dictatorship and democracy comparisons [7, 10-11].

Population density data, represented by people/mile², and vaccine distribution per capita as of February 10, 2021 (date was chosen to maximize data availability), were both used for each nation and sourced from OurWorldInData [9].

2.2 Research tools

The Python programming language and the Google Colaboratory IDE, were used for all data analyses. The Numpy, Pandas, SciKitLearn, and Keras libraries were used for data storage, data exploration, and machine learning algorithm implementation [12-15]. Matplotlib and Microsoft Excel were used for the creation of tables and figures [16].

2.3 Clustering and data analysis

After preliminary data collection and exploration, clustering (isolating groups with similar traits) and specific statistical calculations were used for analyses. Social and economic freedoms were clustered together and separately, primarily with the K-Means algorithm. For example, several different instances of the K-Means algorithm were used to obtain categories in Table 1, with placements based on either 1) a single K-Means model trained with both freedom indexes or 2) a K-Means model trained solely on economic or social freedom scores separately.

In clustering GDP values, uneven data distributions and lack of multiple features rendered K-Means ineffective and unnecessary in obtaining data for the first section of Table 2, “GDP vs. COVID-19 Impact”, as well as the GDP-focused section of Table 5. Instead of K-Means, countries were ranked by GDP and then divided equally into four categories. However, for the analysis included in the second half of Table 2 (“GDP and COVID-19 Fatality Rate”), K-Means was utilized to group countries based on actual GDP value, not simply rank, improving categorization accuracy. This was possible due to increased data availability. K-Means clustering was also used to

obtain classes of countries based on population density, while social system (democracy | dictatorship) and economic system (socialism | capitalism) categorizations were compiled directly from values in the applicable datasets. After clustering nations using the K-Means algorithm and/or the ranking system specified above, average values were computed for each class. Median and average case and death curves for freedom, social system, and economic system classes were also calculated.

2.4 World map plots for data visualization

Utilizing the Plotly Python Library, four world maps were constructed from each country’s social freedom superscore, economic freedom superscore, total COVID-19 cases, and total COVID-19 deaths as of 11/30/2020 [17]. Colors were applied with thresholds to ensure an even division of countries, with red categories denoting the highest values, yellow the middle values, and green the lowest values. To better separate data points and assess trends, the function x^2 was applied to each country’s social freedom score; scores under 37 were then colored in green, between 37 and 50 in yellow, and above 50 in red. The function $(x/10)^2$ was then applied to each country’s economic freedom score. The division by 10 allowed for similar scaling across all the maps, while the exponent was once again used for trend emphasis. Scores under 35 were colored in green, between 35 and 45 in yellow, and over 45 in red. Furthermore, the functions $|10\ln(x/100)|$ and $|10\ln(x+1)|$ were applied to total COVID-19 cases and deaths per country, respectively, with division by 100 used to standardize scale, and addition of 1 to eliminate domain errors.

The case counts under 50 were colored in green, between 50 and 80 in yellow, and over 80 in red. The death counts under 60 were colored in green, between 60 and 80 in yellow, and over 80 in red. Once again, functions were chosen for data-point separation and trend emphasis, while color thresholds were chosen to evenly divide countries into color-categories.

3. Results

3.1 Early pandemic analyses

Economic freedoms were strongly associated with early COVID-19 pandemic case trends, demonstrated

by countries within the highest category of economic freedoms reporting their first COVID-19 case 44 days before and their first virus death 91 days before the lowest economic freedom category nations, on average (Table 1). Similarly, the speed at which COVID-19 cases accumulated was fastest in countries with the highest economic freedom scores: these countries reported their first 1000 COVID-19 cases on average 43 days before and their first 100 COVID-19 deaths 90 days before countries in the lowest economic freedom category.

	Category 1	Category 2	Category 3	Category 4
Pandemic Start in Days from February 1, 2020 and Economic Freedom				
Countries, n	33	63	67	10
Economic freedom score, average	75.91	64.24	52.61	7.96
First COVID-19 case reported, average, days	19.91	32.59	41.00	64.00
First COVID-19 death reported, average, days	83.94	122.57	143.54	174.90
1000 COVID-19 cases first reported, average, days	65.97	72.38	81.18	108.80
100 COVID-19 deaths first reported, average, days	128.76	157.79	209.48	218.70
Direct Relationship between Economic and Social Freedoms and COVID-19 Impact				
Countries, n	28	52	58	4
Economic freedom score, average	76.46	64.59	53.52	6.48
Social freedom score, average	8.1	7.21	6.26	4.14
Spring 2020 cases of COVID-19, average, n	101877.71	29762.87	30673.62	2205.25
Spring 2020 deaths due to COVID-19, average, n	6472.64	2490.54	1113.28	60.50
Spring 2020 COVID-19 tests conducted, average, n	1220801.14	282307.58	337348.03	59563.50
Summer 2020 cases of COVID-19, average, n	284776.71	100338.98	204487.34	75887.00
Summer 2020 deaths due to COVID-19, average, n	9928.57	5137.9	5100.76	1968.00
Summer 2020 COVID-19 tests conducted, average, n	5100602	970477.9	1721957.22	406083.50
Fall 2020 cases of COVID-19, average, n	723196.36	317449.88	430406.64	187194.50
Fall 2020 deaths due to COVID-19, average, n	14726.57	9327.9	9403.55	3706.25

Fall 2020 COVID-19 tests conducted, average, n	4035726.39	1660542.35	4263220.86	878230.75
Overall Economic and Social Freedoms and COVID-19 Response by Period				
Countries, n	26	43	35	36
Economic freedom score, average	77.16	65.93	56.06	52.56
Social freedom score, average	8.26	7.35	6.23	6.12
GDP per country, average, millions USD**	1624.52	540.3	929.3	600.39
Spring 2020 COVID-19 stringency score, average	69.78	80.66	68.93	74.18
Summer 2020 COVID-19 stringency score, average	53	61.6	60.54	65.85
Fall 2020 COVID-19 stringency score, average	53.73	58.21	49.47	58.22
COVID-19 fatality rate 2020, average, %	2.03	2.98	2.33	2.08
Isolated Freedom Variables of Interest and COVID-19 Response				
Economic freedom score, average	76.93	64.72	53.61	6.48
Countries, n	29	49	58	4
Spring 2020 COVID-19 stringency score, average	70.37	80.04	69.97	86.17
Summer 2020 COVID-19 stringency score, average	52.11	63.21	61.59	83.89
Fall 2020 COVID-19 stringency score, average	52.88	57.72	53.20	69.29
Freedom of expression score, average***	9.09	7.65	6.03	3.65
Countries, n	63	46	29	6
Spring 2020 COVID-19 stringency score, average	70.28	74.89	76.28	68.30
Summer 2020 COVID-19 stringency score, average	57.05	61.93	63.41	56.64
Fall 2020 COVID-19 stringency score, average	49.39	58.14	54.69	50.77

*Category 1 represents greatest freedoms with descending freedoms to Category 4 representing the lowest level of freedoms.

**Gross Domestic Product in 2019.

***Freedom of expression reflects freedom of the press.

Note that the numbers of countries included in the analyses above reflect the available data.

Table 1: Economic and Social Freedoms and the COVID-19 Pandemic.*

Analyzing both economic and social freedoms together revealed that countries with the greatest overall freedoms sustained 101,878 COVID-19 cases and 6,473 deaths on average in Spring 2020, as opposed to the 29,763 cases and 2,491 deaths

sustained by countries in the second-highest freedoms category during the same time interval (Table 1).

This pattern of greater freedoms corresponding to higher COVID-19 cases and deaths can be seen across

every category for each season throughout 2020. Early in the pandemic COVID-19 testing was significantly higher in countries with the highest social and economic freedoms. However, this trend in testing based on overall freedoms was not seen as the pandemic continued in 2020. For instance, the third-freedom-category tested the most in the Fall of 2020, with 4.3 million tests/country on average, as opposed to 4.0 million in the first-freedom-category and 1.7 million in the second-freedom category.

This greater testing throughout 2020 may explain why third-freedom-category countries reported more cases on average during this time, but less deaths than second-freedom-category countries. Throughout the pandemic, average case and death curves for each freedom class show that the highest freedom category exhibited higher case and death counts on average than its lower category counterparts (Figure 1).

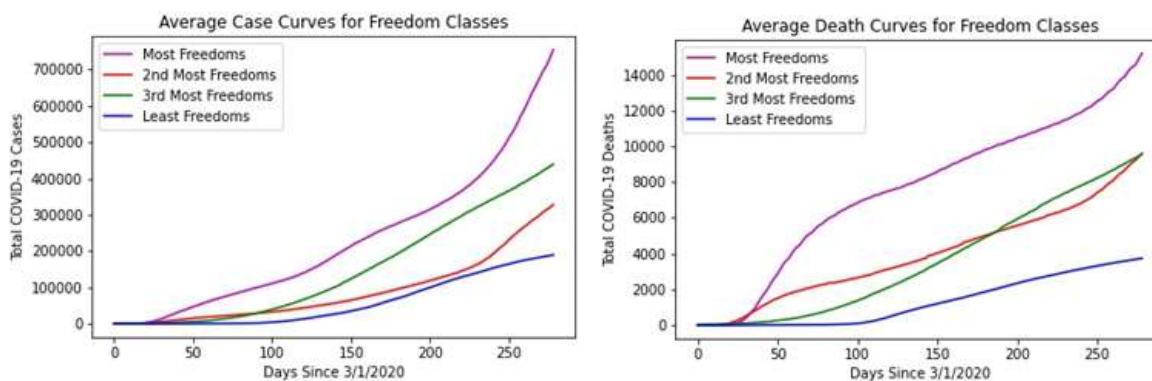


Figure 1: COVID-19 Case and Death Curves Based on Freedoms. The number of days after March 1, 2020, were plotted on the x-axis, and, per the overall social and economic freedom classes, average COVID-19 cases and deaths were plotted on the y-axis. The color purple denotes the highest overall social and economic freedom class, red the second-highest, green the second-lowest, and blue the lowest.

3.2 Additional effects of freedoms on COVID-19

Not only did long-standing freedoms directly affect the number of COVID-19 cases and deaths, but also contributed to determining governments’ responses to the pandemic, as reflected by COVID-19 stringency scores (Table 1). Countries with the highest overall freedoms exhibited average COVID-19 stringency scores of 4.4, 12.85, and 4.49 points less than countries in the lowest freedom categories for the

Spring, Summer, and Fall of 2020, respectively, indicating that higher freedoms were associated with less strict pandemic control measures. However, it should be noted that in Spring 2020 the second-highest freedom category exhibited the highest COVID-19-stringency scores, representing stricter controls. Despite this relationship between higher freedoms, decreased government response, and increased COVID-19 case counts, higher overall

freedoms were associated with a lower fatality rate, with countries in the highest-freedom category reporting an average fatality rate of 2.03%, as opposed to higher rates, up to 2.98%, in the lower categories (Table 1).

The direct relationship between economic freedoms specifically and government pandemic response shows that countries in the highest economic freedom category exhibited an average COVID-stringency score of 15.8 points lower than nations in the lowest freedom category in Spring 2020 (Table 1). Throughout the remainder of 2020, countries with the highest economic freedoms continued to exhibit the lowest COVID-19 stringency scores.

When examining the relationship between freedom of expression, or freedom of the press, specifically and COVID-19 governmental responses, countries in the highest-freedom of expression category exhibited COVID-19 stringency scores 4.61 and 6.0 points lower than countries in the next two categories, respectively, in the Spring of 2020. Interestingly, however, countries in the lowest freedom of expression category had similar COVID-19 stringency scores as the highest category throughout 2020, with the greatest stringency scores appearing in

the second and third freedom of expression categories.

3.3 GDP and COVID-19 analyses

A strong relationship between GDP and COVID-19 cases, deaths, and testing was also demonstrated. Countries in the highest GDP category reported an average of 1,485,807 COVID-19 cases and 35,390 COVID-19 deaths compared with the next lowest GDP category's 210,704 cases and 4,746 deaths and the lowest GDP category's 13,820 cases and 250 deaths, between March 1 and December 1, 2020, reflecting a downward trend (Table 2).

Despite the highest-GDP category nations administering 10,493,980 COVID-19 tests on average as opposed to the lowest GDP category nations administering a mere 62,326 COVID-19 tests on average over the given time period, the relationship between COVID-19 cases and deaths and GDP is still strong, likely a result of the connection between GDP and freedoms. A strong relationship between GDP and COVID-19 fatality rate is also demonstrated with the highest GDP category exhibiting an average total fatality rate of 2.00%, versus 4.26% for the lowest GDP category.

	Category 1	Category 2	Category 3	Category 4
GDP and COVID-19 Impact				
Countries, n	35	36	36	35
GDP per country, average, millions USD**	3061.9	307.11	65.88	18.01
Economic freedom score, average	60.31	64.71	59.57	58.42
Social freedom score, average	6.74	7.12	7	6.76
Cases of COVID-19, average, n	1485807.43	210704.42	66581.1	13820.46
Deaths due to COVID-19, average, n	35390.34	4745.78	1093.58	249.91
COVID-19 tests conducted, average, n	10493980.37	1775362.25	465123.17	62326.03
GDP and COVID-19 Fatality Rates				
Countries, n	99	29	11	7
GDP per country, average, millions USD**	728.94	440.76	234.82	233.33
COVID-19 fatality rate 2020, average, %***	2.30	1.71	2.33	3.94
Total COVID-19 fatality rate 2020, average, %***	2.00	2.14	2.32	4.26

*Category 1 represents greatest freedoms with descending freedoms to Category 4 representing the lowest level of freedom.

**Gross Domestic Product in 2019.

***Average COVID-19 fatality rate represents the sum of all of the fatality rates of the countries in a class divided by the number of countries in that class. Total fatality rate is defined as total COVID-19 deaths in all of the countries in a category divided by total COVID-19 cases in all of the countries in a category.

Table 2: Gross Domestic Product and the COVID-19 Pandemic.*

3.4 Societal and economic systems

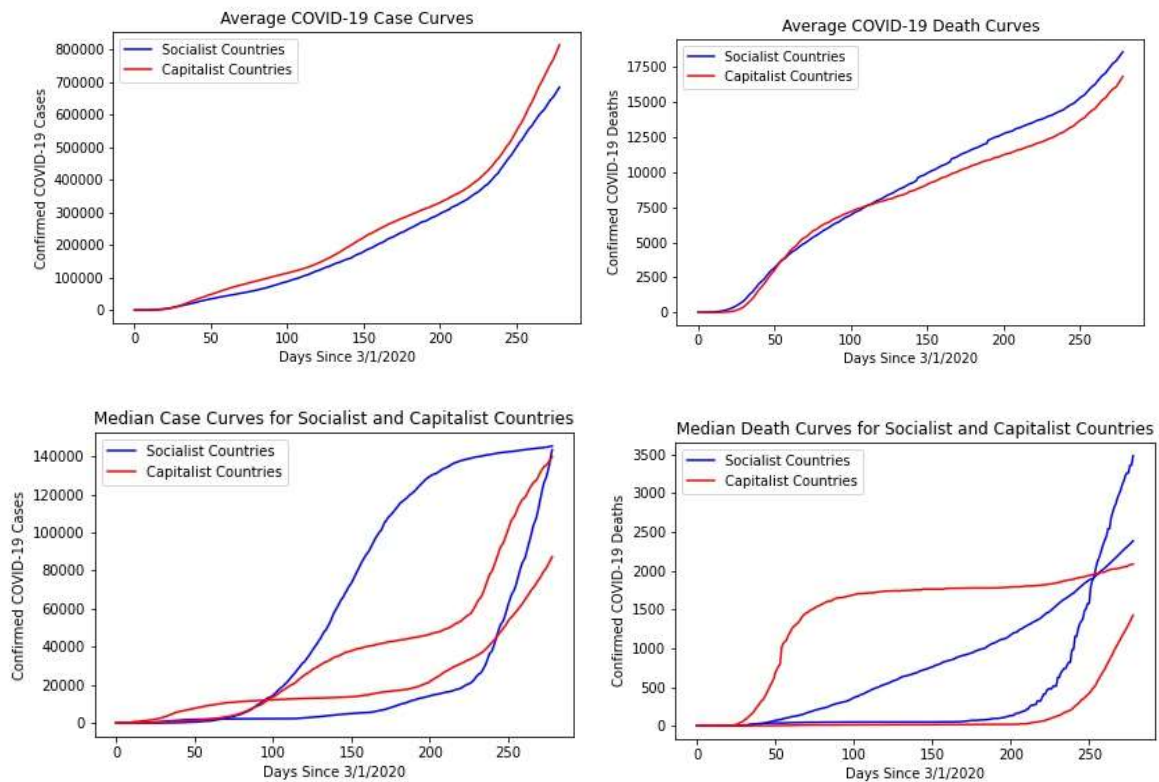
The relationships between societal and economic systems and the pandemic were also highly revealing with capitalist countries reporting an average of 134,348 more COVID-19 cases, but 1,731 less deaths than socialist countries during Spring, Summer and Fall 2020 (Table 3 and Figure 2). Despite these discrepancies in case and death counts, the two classes had generally similar average government response stringency scores with socialist nations having higher scores by 0.17, 2.95, and 2.91 for

Spring, Summer, and Fall 2020, respectively, indicating slightly stricter responses. Similarly, democracies and dictatorships exhibited different COVID-19 impact metrics (cases/deaths), with democratic nations reporting on average 5 times more COVID-19 cases than dictatorships (705,909 vs. 154,551) and 4 times more deaths (16,625 vs. 4,019) in 2020. Democracies had average COVID-19 stringency scores of 15.98, 7.14, and 10.14 higher than dictatorships for the Spring, Summer, and Fall of 2020, respectively.

	Socialist/Democratic-Socialist Nations	Capitalist Nations	Democracies	Dictatorships
Countries, n	26	26	83	26
Cases of COVID-19*, average, n	691208.65	825557.42	705908.81	154550.76
Deaths due to COVID-19*, average, n	18677.88	16946.81	16624.94	4018.62
Spring 2020 COVID-19 stringency score, average	73.73	73.56	64.39	48.41
Summer 2020 COVID-19 stringency score, average	55.63	52.68	50.18	43.04
Fall 2020 COVID-19 stringency score, average	55.65	52.74	47.44	36.99

*Represents total cases or deaths in Spring, Summer and Fall 2020.

Table 3: The COVID-19 Pandemic by Economic and Governmental Systems.



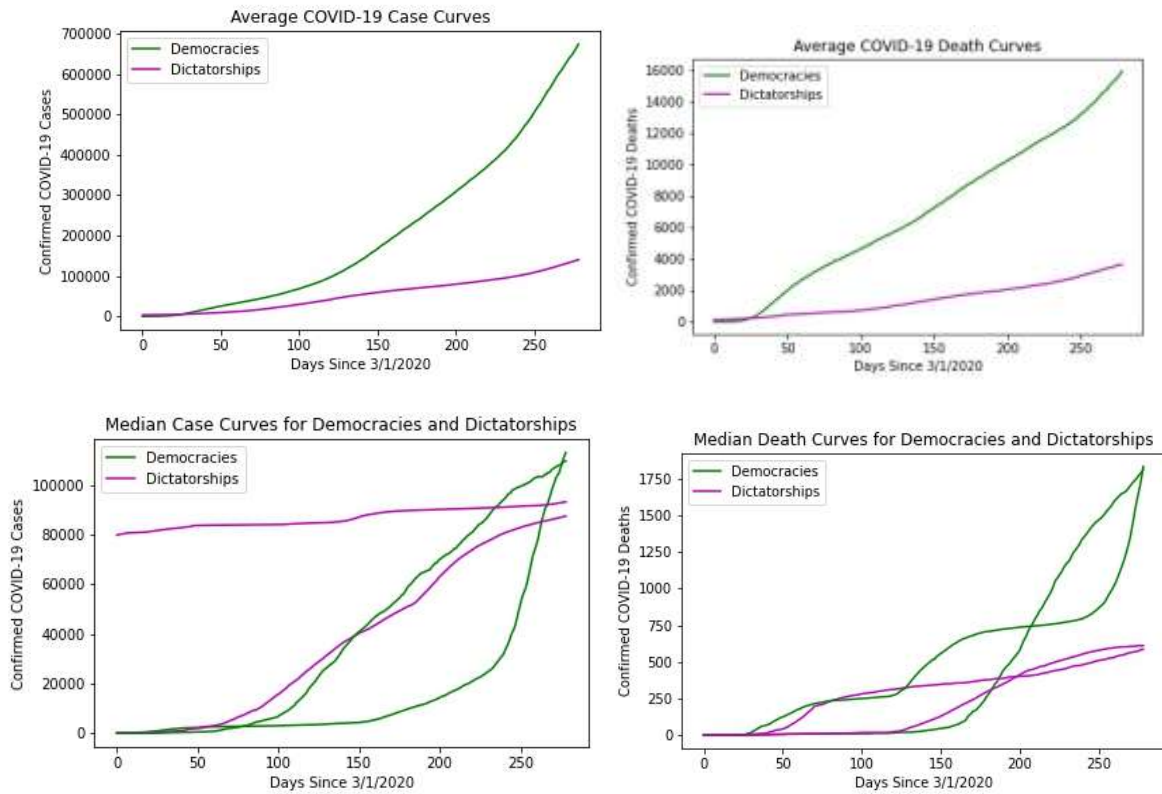


Figure 2: COVID-19 Case and Death Curves Based on Social and Economic Systems. Each graph portrays the number of days after March 1, 2020, plotted on the x-axis and COVID-19 cases or deaths, respectively, plotted on the y-axis. Countries’ economic systems were classified as either capitalist (denoted by red) or socialist (denoted by blue) and their social systems as either democracies (denoted by green) or dictatorships (denoted by purple).

3.5 Population density, freedoms, and COVID-19

A strong association between freedoms and population density was also discovered, with highest-freedom-category countries reporting an average

population density of 699 people/mile², as opposed to the average population density value of 158 people/mile² in lowest-freedom-category countries (Table 4).

Population Density by Overall Economic and Social Freedoms*					
	Category 1	Category 2	Category 3	Category 4	
Countries, n	26	44	36	36	
Population density, average, people/mile ²	698.68	167.73	109.33	158.24	
Population Density and COVID-19					
	Countries, n	Average Population Density, people/mile²	Average COVID-19 Cases, n	Average COVID-19 Deaths, n	Average Fatality Rate, %
Category 1 (Most Dense)	6	610.36	45086.83	416.67	1.70
Category 2	8	422.21	1394308.75	21297.50	1.45
Category 3	9	302.30	266189.78	8175.11	1.98
Category 4	19	205.10	244278.42	5503.63	1.81
Category 5	56	94.80	253815.63	7068.30	2.15
Category 6 (Least Dense)	64	25.99	1548823.73	35814.77	2.64

*Category 1 represents greatest freedoms with descending freedoms to Category 4 representing the lowest level of freedoms.

Table 4: Freedoms, Population Density, and COVID-19.

Population density itself in turn may have contributed to the spread of COVID-19 with countries in the second-highest population density category reporting on average 1,114,049 more confirmed COVID-19 cases and 14,230 more deaths than the second-lowest density category. Note that the highest and lowest density categories represented major departures from these trends, due to several outlying nations specifically many small, low-population European countries in the highest density category (Category 1) and the United States in the lowest density category

(Category 6). Fatality rates from COVID-19 increased with decreased population density, even in the highest and lowest density categories, with the lowest density category reporting an average fatality rate of 0.94% higher than the highest density category.

3.6 Vaccine distribution

No significant relationship was found between GDP and vaccine distribution and overall social and economic freedoms and vaccine distribution as of February 10, 2021. High-GDP countries scored 3.31

points lower than lowest-category GDP nations, with regard to vaccine distribution per capita (Table 5). Vaccine distribution per capita values in descending

overall freedom class order were 11.5, 3.67, 12.94, and 2.62, with no apparent trend.

GDP and Vaccine Distribution				
	Category 1	Category 2	Category 3	Category 4
Countries, n	13	13	13.00	13.00
GDP, average, millions USD**	4595.91	627.49	275.23	53.82
Vaccine Distribution Per Capita, average	4.94	6.6	8.63	8.25
Freedoms and Vaccine Distribution				
Countries, n	19	19	4	7
Economic freedom score, average	76.47	65.94	58.43	57.87
Social freedom score, average	8.30	7.62	6.60	6.38
Vaccine distribution per capita, average	11.50	3.67	12.94	2.62

*Category 1 represents highest GDP countries while Category 4 represents the lowest GDP countries.

**Gross Domestic Product in 2019.

Table 5: Economic and Social Freedoms, Gross Domestic Product, and Vaccine Distribution Per Capita.*

3.7 World map plot analysis

The four world map plots further expose a clear relationship between regions/nations with higher freedoms reporting more COVID-19 cases/deaths (Figure 3). Europe and North America had the highest concentrations of red dots, denoting highest value categories, throughout all four plots, while Africa and parts of Asia generally had the least freedoms, COVID-19 cases, and COVID-19 deaths, as denoted by the abundance of green dots in those respective regions. The Arabian Peninsula and Middle East regions both exhibited high case counts with somewhat lower death counts, indicators of moderate social freedoms and high economic freedoms. Conversely, Central America faced relatively low

case counts (due in part to small populations) compared to death totals, corresponding with high social freedoms but comparatively low economic freedoms.

The below maps and the subsequent dots depicted represent COVID-19 cases (top-right), COVID-19 deaths (top-left), Social Freedoms (bottom-left), and Economic Freedoms (bottom-right) per country. Red denotes the highest values, yellow the middle values and green the lowest values. Across all plots, there are similarly-located concentrations of similarly-colored dots, suggesting a strong relationship between social freedoms, economic freedoms, COVID-19 cases, and COVID-19 deaths.

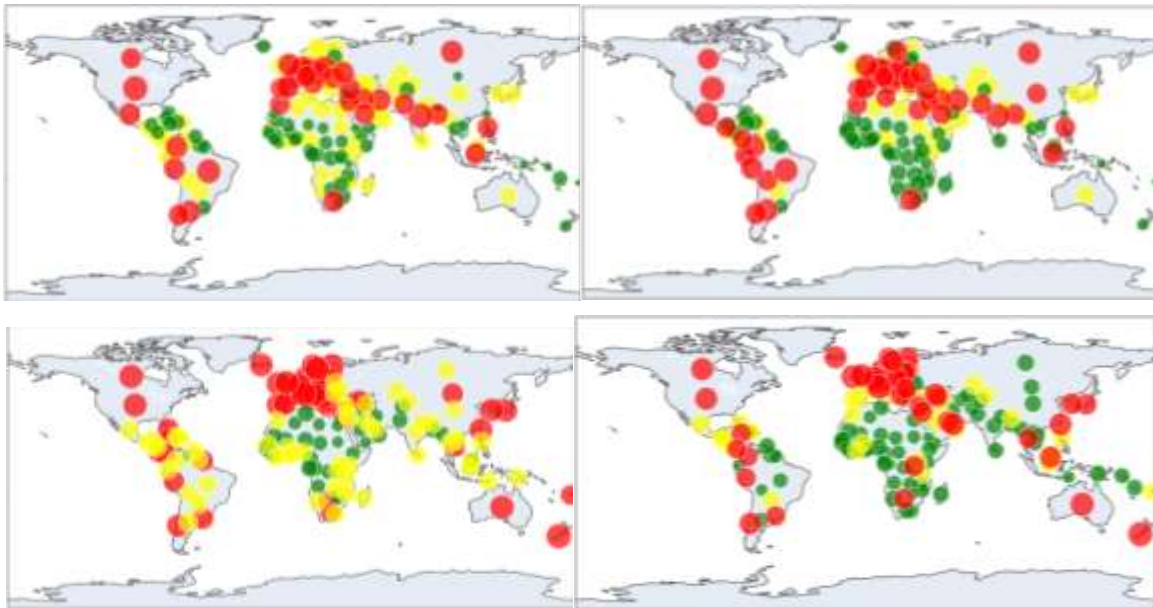


Figure 3: World Maps of COVID-19 Cases and Deaths, and Social and Economic Freedoms.

4. Discussion

Early in the pandemic, the spread of COVID-19 was faster to countries with higher economic freedoms likely due to greater activity in global trade. Similarly, these countries, due to their pre-existing economic freedoms, were less likely to suppress their internal economies and impose restrictions. Due to the frequent coexistence of high social freedoms and high economic freedoms, the populations of these same nations were less accustomed to and, as a result, less likely to follow governmental restrictions, when eventually implemented. Despite high-freedom countries' leniency in their COVID-19 responses, countries in the second-category of freedoms exhibited the most stringent responses to the pandemic, especially in Spring 2020, a discrepancy possibly explained by the direct relationship between freedoms and higher GDP. This relationship yields

second-freedom-category countries with the resources necessary to impose restrictions and the relative inclination to do so. In contrast, countries in the lowest economic and social freedom categories may have had the political means to impose restrictions but simply did not have the monetary, human, or scientific resources to do so in an effective way. Furthermore, GDP undoubtedly played a major role in testing, with wealthier nations able to test their populations disproportionately more than poorer countries. Partly as a result of that increased testing, countries with higher GDP were able to confirm far more COVID-19 cases and deaths than lower GDP nations. Despite these increased case counts as a result of testing, countries with higher GDPs exhibited lower COVID-19 fatality rates, possibly due to their ability to more effectively diagnose and treat

infected individuals and facilitate better access to healthcare.

Strong relationships were also present between types of social and economic systems and the pandemic. Capitalist countries had more COVID-19 cases than socialist nations, most likely due to their economic freedoms and decreased inclination to restrict businesses or their populations. Despite this, socialist countries reported more deaths on average than capitalist countries, most likely due to having less economic freedom and, by extension, less GDP and resources, thus decreasing their ability to treat infected individuals. On average, democracies also reported more COVID-19 cases and deaths than dictatorships, likely due to their greater social freedoms and less political and economic isolation. However, pandemic misinformation and false reporting within dictatorships may have also played a role.

Next, analyzing the relationship between economic and social freedoms and population density revealed that more freedoms often accompany higher population density. In turn, higher population density tended to lead to more COVID-19 cases and deaths, with a few exceptions. As explained earlier, these exceptions are potentially an effect of datapoint outliers, with high population density countries having lower net populations due to their smaller size (e.g. small European nations), and therefore less people to infect. On the other hand, large countries with urban centers leading to mass viral spread may have been classified as low density due to large swaths of sparsely populated land in other areas of the

country (such as in the United States). Thus, only by removing the highest and lowest density classes does the trend of greater population density increasing COVID-19 cases and deaths reveal itself. Fatality rate increasing as population density decreased could be a result of reduced access to healthcare in more rural areas.

Interestingly, high GDP category countries were shown to have the lowest average vaccine distribution scores, possibly as a result of greater populations and larger land-areas increasing logistical difficulties for distribution. Similarly, social and economic freedoms do not appear to be strong vaccination distribution success indicators other than lowest-freedom category nations having the worst distribution, most likely as a result of limited resources, as previously noted. However, as of the writing of this report, COVID-19 vaccines have not been available for a long enough period of time for appropriate assessments in many nations.

These analyses of the effects of social and economic freedoms on the COVID-19 pandemic have several limitations. First, it should be conceded that an innumerable number of factors certainly influenced the COVID-19 pandemic in each individual nation, many of which were not analyzed in this study, while other variables could have been better controlled in the analyses (e.g. population). Another major limitation was that this article focused exclusively on revealing trends in the data, not necessarily explaining the causal relationship in these trends beyond speculation. Obviously, an immense variety of other factors could have also influenced the relationships

found, including the susceptibility of certain populations to the virus, as well as access to healthcare, which clearly cannot be fully explained through the factors examined. Finally, it should also be noted that certain countries represented significant exceptions to the above trends, most notably China and the United States, possibly confounding some analyses.

Overall, it is clear that social and economic freedoms had both direct and indirect effects on the COVID-19 pandemic, with more pre-existing freedoms generally relating to a higher impact from COVID-19. Higher GDP and higher population density, both associated with more freedoms, were also seemingly associated with higher COVID-19 case counts and death counts, but comparatively low fatality rates. Capitalism and democracy, following the same freedom trends as above, also appeared to have been related to higher COVID-19 pandemic severity. Lastly, GDP and social and economic freedoms do not seem to be accelerating the vaccine distribution process, although it may be too early to tell.

5. Conclusions

In conclusion, countries with the highest economic and social freedoms were associated with increased numbers of COVID-19 cases and deaths throughout 2020. In addition, increased economic freedoms were associated with a more rapid speed of initial COVID-19 spread, and increased pre-existing social and economic freedoms were associated with less severe governmental restrictions due to the virus. With these relationships now determined, additional analyses

should address the underlying question of how the enjoyment of freedoms can be balanced with the preservation of the population's safety to improve responses to future global pandemics or other catastrophes.

Acknowledgements

The authors would like to thank Mr. David Wilcox and Ms. Amethyst King of The Lawrenceville School for their contributions in reviewing the manuscript. The authors would also like to thank Mr. George Negroponte of The Lawrenceville School for his mentorship.

Conflicts of Interest

Authors declare no conflict.

Financial Support

There was no external source of financial support.

Author Contributions

Alexander Noviello and Andrew Noviello designed and implemented the study, as well as drafted the manuscript. Each of the additional authors provided input on specific components of the study.

All authors reviewed and approved the final manuscript.

References

1. Gallegos A. WHO Declares Public Health Emergency for Novel Coronavirus. Medscape Medical News (2020).

2. Ramzy A, McNeil DG. W.H.O. Declares Global Emergency as Wuhan Coronavirus Spreads. *The New York Times* (2020).
3. Vasquez I, McMahon F. (n.d.). Human Freedom Index: 2020. *The Cato Institute* (2020).
4. Lichtblau E. Cato institute is caught in a rift over its direction. *The New York Times* (2012).
5. Miller T, Kim A, Roberts J. (n.d.). Index of Economic Freedom. *The Heritage Foundation* (2021).
6. Heritage ranked no. 1 globally for impact on public policy. (n.d.). *The Heritage Foundation* (2021).
7. Roser, Max. Democracy. *Our World in Data*. ourworldindata.org (2013).
8. Roser, Max, et al. World Population Growth. *Our World in Data*. ourworldindata.org (2013).
9. Roser, Max, et al. Coronavirus Pandemic (COVID-19). *Our World in Data*. ourworldindata.org (2020).
10. Capitalist Countries (2021).
11. Democratic Socialist Countries (2021).
12. Oliphant TE. A guide to NumPy. *Trelgol Publishing USA* 1 (2006).
13. McKinney , others. Data structures for statistical computing in python. In *Proceedings of the 9th Python in Science Conference* 445 (2010): 51-56.
14. Pedregosa F, Varoquaux Ga el, Gramfort A, et al. (2011). Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research* 12 (2011): 2825-2830.
15. Chollet F, others. Keras. *GitHub* (2015).
16. Hunter JD. Matplotlib: A 2D graphics environment. *Computing in Science and amp; Engineering* 9 (2007): 90-95.
17. Plotly Technologies Inc. Title: Collaborative data science Publisher: Plotly Technologies Inc. Place of publication: Montréal, QC Date of publication (2015).



This article is an open access article distributed under the terms and [Creative Commons Attribution \(CC-BY\) license 4.0](https://creativecommons.org/licenses/by/4.0/)