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Fighting COVID-19: patterns in international data

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This paper provides an empirical evaluation of countries' performance in fighting COVID-19, utilizing a performance index (which we call the Disaster Index) based on four health and economic indicators: deaths per population size, deaths per confirmed cases, and quarterly real gross domestic product (GDP) and monthly unemployment rate relative to pre-pandemic values. International data patterns are studied for these four indicators and the Disaster Index to analyze trends and basic empirical relationships. The approach is descriptive and primarily based on graphs, scatter diagrams, and correlation analysis. The ten best performers based on the Disaster Index for the first half of 2020 were (ranked 1st to 10th): Singapore, Taiwan, Belarus, Korea, New Zealand, Japan, Norway, Israel, Czechia, and Lithuania. The worst twelve performers were (bad to worst): Sweden, US, Canada, Philippines, France, Columbia, Spain, Belgium, United Kingdom, Ecuador, Italy, and Peru.

Thus, high-income Asian countries performed relatively better than low-income Asian countries, European, and American countries in the first half of 2020. Reasons for this geographical divide are very important and must be studied more carefully and closely, as successful methods in better performing countries will provide some lessons for other countries. It also would be interesting to see how this Disaster Index profile shifts in 2021 as vaccination and economic relief accelerate in countries like the United States. The pandemic exhibited the vulnerabilities in the world and reemphasized the vital significance of international coordination and cooperation in a globalized world. Recent trends show that most countries still have a long way to go to control the virus. Vaccination is a reassuring fresh hope, a potential game-changer, though requiring careful, painstaking, and timely implementation.

JEL classification: C00, E00, F00, I1, O57
Keywords: COVID-19, Disaster Index, data patterns, trends, correlations, cluster analysis

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1. Introduction[1]

The pandemic exhibited the vulnerabilities in the world and reemphasized the vital significance of international coordination and cooperation in a globalized world (Asian Development Bank [2020]; European Commission [2020]; European Central Bank [2020]; Federal Reserve Board of Governors [2020]; Global Health Security [2019]; International Monetary Fund [2020a, 2020b]; OECD [2020a, 2020b]; United Nations [2020]; World Bank [2020a, 2020b, 2021]; see Mariano & Ozmucur for additional references).

The world had 110 million cases and 2.5 million deaths by February 17, 2021. These numbers have been rising steadily. The deaths per hundred thousand are 31.23 (312 in a million) for the world and deaths per hundred confirmed cases are 2.21. No country is immune to this virus. There are data on 192 countries. The situation is fluid everywhere. A country may have a low number for a few weeks, but this may change suddenly. Vaccination is fresh hope, a potential game-changer, though requiring careful and painstaking implementation.

In our earlier study [Mariano & Ozmucur 2020] evaluating countries' performance in fighting a deadly virus, we introduced the Disaster Index (DI), based on four indicators: two for health—deaths per hundred thousand population and as a share of confirmed cases; and two for economic activity namely, quarterly real GDP relative to the fourth quarter of 2019 and unemployment rate relative to December 2019. In this paper, we take a closer look at the trends and basic empirical relationships that can be extracted from the observed data patterns. The approach is descriptive and primarily based on graphs, scatter diagrams, and correlation analysis. There is no argument of causality, except the fact that all data considered are for an earlier year (most of them are for 2019, and some are for 2018) than target variables, which are for 2020.

The paper is organized as follows. Section 2 is devoted to trends in indicators and the DI. Relationships and patterns in international data are discussed in Section 3. Some additional thoughts on the pandemic are given in Section 4 on related issues such as the trade-off between economic loss and health risk, the relevance of budget deficit and domestic debt, and modeling concerns for forecasting and policy analysis. A summary of findings and concluding remarks appears in the final section.

The ten best performers based on the DI for the first half of 2020 were (from #1 to #10): Singapore, Taiwan, Belarus, Korea, New Zealand, Japan, Norway, Israel, Czechia, and Lithuania. The worst twelve performers, with the highest DI, were (from bad to worst): Sweden, US, Canada, Philippines, France, Colombia, Spain, Belgium, United Kingdom, Ecuador, Italy, and Peru.

[1] The empirical analysis here, carried out in March 2021, utilizes available data up to February 2021 in view of the sustained upsurge of COVID-19. A complete set of tables and figures is included in the expanded working paper version which can be provided by the authors on request.

Thus, high-income Asian countries performed relatively better than low-income Asian countries, European, and American countries in 2020, first half. Reasons for this geographical divide are very important and must be studied more carefully and closely, as successful methods in better performing countries will provide some lessons for other countries. It also would be interesting to see how this DI profile shifts in 2021 as vaccination and economic relief accelerate in countries like the United States.

2. Trends in selected indicators and the Disaster Index

2.1. Deaths per hundred thousand and deaths from confirmed cases

Two common statistics used for international comparisons are the number of deaths in relation to population and the number of deaths in relation to confirmed cases (Table 1). Data are obtained from the Johns Hopkins University COVID Research Center. In addition to the two series, ranks of countries in ascending order and the clusters (based on K-means and using Stata software) are also given in the table (see Mariano & Ozmucur [2020] for details). A map for countries shows clusters for deaths per hundred thousand (Figure 1).

TABLE 1. Confirmed cases and deaths: country ranks and clusters as of February 17, 2021

	COUNTRY	CONFIRMED	DEATHS	DEATHS PER 100 THOUSAND	DEATHS PER 100 THOUSAND-CLUSTERS	DEATHS PER 100 THOUSAND-RANKS	CASE FATALITY	CASE FATALITY-CLUSTERS	CASE FATALITY-RANKS
1	Afghanistan	55,518	2,428	6.53	1	60	4.37	3	166
2	Albania	94,651	1,582	55.19	2	119	1.67	2	81
3	Algeria	111,069	2,945	6.97	1	63	2.65	2	135
4	Andorra	10,555	107	138.95	5	159	1.01	1	34
5	Angola	20,389	494	1.60	1	28	2.42	2	124
6	Antigua and Barbuda	443	9	9.35	1	69	2.03	2	105
7	Argentina	2,033,060	50,432	113.34	4	149	2.48	2	127
8	Armenia	169,391	3,150	106.72	4	145	1.86	2	93
9	Australia	28,911	909	3.64	1	47	3.14	3	146
10	Austria	436,139	8,260	93.36	3	139	1.89	2	96
11	Azerbaijan	232,337	3,185	32.03	2	105	1.37	1	62
12	Bahamas	8,383	179	46.42	2	115	2.14	2	112
13	Bahrain	114,361	410	26.12	2	99	0.36	1	7
14	Bangladesh	541,434	8,298	5.14	1	51	1.53	1	75
15	Barbados	2,331	25	8.72	1	66	1.07	1	39
16	Belarus	270,921	1,867	19.68	1	93	0.69	1	20
17	Belgium	741,205	21,750	190.42	5	173	2.93	3	141
18	Belize	12,188	313	81.71	3	132	2.57	2	132
19	Benin	5,039	62	0.54	1	11	1.23	1	51

	COUNTRY	CONFIRMED	DEATHS	DEATHS PER 100 THOUSAND	DEATHS PER 100 THOUSAND-CLUSTERS	DEATHS PER 100 THOUSAND-RANKS	CASE FATALITY	CASE FATALITY-CLUSTERS	CASE FATALITY-RANKS
20	Bolivia	237,706	11,274	99.30	4	140	4.74	3	167
21	Bosnia and Herzegovina	126,413	4,935	148.47	5	166	3.90	3	159
22	Botswana	25,802	226	10.03	1	73	0.88	1	26
23	Brazil	9,921,981	240,940	115.02	4	150	2.43	2	125
24	Brunei	184	3	0.70	1	13.5	1.63	2	79
25	Bulgaria	232,096	9,703	138.14	5	158	4.18	3	164
26	Burkina Faso	11,630	138	0.70	1	13.5	1.19	1	48
27	Myanmar	141,659	3,192	5.94	1	58	2.25	2	118
28	Cabo Verde	14,785	140	25.75	2	98	0.95	1	29
29	Cameroon	32,098	479	1.90	1	35	1.49	1	71
30	Canada	836,594	21,395	57.73	2	122	2.56	2	131
31	Central African Republic	4,996	63	1.35	1	27	1.26	1	54
32	Chad	3,689	131	0.85	1	20	3.55	3	152
33	Chile	782,039	19,644	104.88	4	144	2.51	2	128
34	China	100,639	4,831	0.35	1	8	4.80	3	168
35	Colombia	2,202,598	57,949	116.72	4	152	2.63	2	134
36	Comoros	3,393	133	15.98	1	88	3.92	3	160
37	Republic of the Congo	24,423	695	13.25	1	86	2.85	2	139
38	Democratic Republic of the Congo	8,419	123	0.15	1	7	1.46	1	68
39	Costa Rica	200,454	2,737	54.75	2	117	1.37	1	61
40	Côte d'Ivoire	31,365	179	0.71	1	15	0.57	1	15
41	Croatia	237,999	5,357	131.00	4	155	2.25	2	117
42	Cuba	39,941	274	2.42	1	40	0.69	1	18
43	Cyprus	32,707	225	18.92	1	91	0.69	1	19
44	Czechia	1,099,654	18,430	173.45	5	170	1.68	2	82
45	Denmark	205,871	2,309	39.83	2	110	1.12	1	44
46	Djibouti	5,981	63	6.57	1	61	1.05	1	36
47	Dominican Republic	231,095	2,975	27.99	2	101	1.29	1	57
48	Ecuador	268,073	15,392	90.09	3	137	5.74	4	169
49	Egypt	175,059	10,101	10.26	1	74	5.77	4	170
50	El Salvador	58,023	1,758	27.38	2	100	3.03	3	142
51	Equatorial Guinea	5,694	87	6.65	1	62	1.53	1	74
52	Estonia	53,444	508	38.46	2	109	0.95	1	30
53	Eswatini	16,606	634	55.80	2	120	3.82	3	157
54	Ethiopia	148,490	2,223	2.04	1	37	1.50	1	72
55	Finland	51,047	720	13.05	1	85	1.41	1	65
56	France	3,548,452	82,961	123.85	4	154	2.34	2	120
57	Gabon	12,865	75	3.54	1	46	0.58	1	16
58	Gambia	4,469	138	6.05	1	59	3.09	3	145

	COUNTRY	CONFIRMED	DEATHS	DEATHS PER 100 THOUSAND	DEATHS PER 100 THOUSAND-CLUSTERS	DEATHS PER 100 THOUSAND-RANKS	CASE FATALITY	CASE FATALITY-CLUSTERS	CASE FATALITY-RANKS
59	Georgia	266,462	3,377	90.51	3	138	1.27	1	55
60	Germany	2,352,766	65,829	79.38	3	131	2.80	2	138
61	Ghana	77,046	555	1.86	1	31	0.72	1	21
62	Greece	173,905	6,181	57.62	2	121	3.55	3	154
63	Guatemala	168,103	6,158	35.70	2	108	3.66	3	156
64	Guinea	15,020	85	0.68	1	12	0.57	1	14
65	Guinea-Bissau	2,950	46	2.45	1	41	1.56	2	76
66	Guyana	8,262	188	24.13	1	96	2.28	2	119
67	Haiti	12,192	247	2.22	1	39	2.03	2	103
68	Honduras	161,727	3,913	40.81	2	111	2.42	2	123
69	Hungary	389,622	13,837	141.65	5	163	3.55	3	153
70	Iceland	6,039	29	8.20	1	65	0.48	1	10
71	India	10,937,320	155,913	11.53	1	80	1.43	1	66
72	Indonesia	1,233,959	33,596	12.55	1	82	2.72	2	137
73	Iran	1,534,034	59,117	72.27	3	129	3.85	3	158
74	Iraq	649,982	13,192	34.32	2	107	2.03	2	104
75	Ireland	211,113	3,980	82.00	3	133	1.89	2	94
76	Israel	734,575	5,441	61.25	2	126	0.74	1	22
77	Italy	2,739,591	94,171	155.83	5	169	3.44	3	150
78	Jamaica	19,773	378	12.88	1	84	1.91	2	97
79	Japan	418,435	7,139	5.64	1	55	1.71	2	85
80	Jordan	352,219	4,491	45.11	2	114	1.28	1	56
81	Kazakhstan	252,821	3,144	17.20	1	90	1.24	1	52
82	Kenya	103,188	1,797	3.50	1	45	1.74	2	87
83	South Korea	84,946	1,538	2.98	1	43	1.81	2	92
84	Kosovo	64,868	1,548	83.89	3	135	2.39	2	121
85	Kuwait	179,488	1,014	24.51	1	97	0.56	1	13
86	Kyrgyzstan	85,564	1,444	22.86	1	94	1.69	2	83
87	Latvia	77,697	1,486	77.13	3	130	1.91	2	98
88	Lebanon	343,601	4,092	59.75	2	124	1.19	1	49
89	Lesotho	10,350	254	12.05	1	81	2.45	2	126
90	Liberia	1,985	85	1.76	1	29	4.28	3	165
91	Libya	128,036	2,051	30.71	2	103	1.60	2	77
92	Lithuania	191,264	3,095	110.95	4	147	1.62	2	78
93	Luxembourg	53,062	612	100.70	4	142	1.15	1	46
94	Madagascar	19,598	292	1.11	1	26	1.49	1	70
95	Malawi	29,421	968	5.34	1	52	3.29	3	148
96	Malaysia	269,165	983	3.12	1	44	0.37	1	8
97	Maldives	18,082	58	11.25	1	79	0.32	1	5
98	Mali	8,241	342	1.79	1	30	4.15	3	163
99	Malta	20,047	297	61.42	2	127	1.48	1	69
100	Mauritania	17,016	431	9.79	1	70.5	2.53	2	129

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101	Mauritius	603	10	0.79	1	19	1.66	2	80
102	Mexico	2,004,575	175,986	139.46	5	160	8.78	4	173
103	Moldova	171,514	3,678	103.73	4	143	2.14	2	113
104	Montenegro	69,770	910	146.22	5	165	1.30	1	58
105	Morocco	479,071	8,504	23.60	1	95	1.78	2	89
106	Mozambique	51,800	551	1.87	1	32	1.06	1	38
107	Namibia	36,366	392	16.01	1	89	1.08	1	40
108	Nepal	272,945	2,055	7.32	1	64	0.75	1	23
109	Netherlands	1,049,120	15,050	87.34	3	136	1.43	1	67
110	New Zealand	2,340	26	0.53	1	10	1.11	1	42
111	Nicaragua	6,398	172	2.66	1	42	2.69	2	136
112	Niger	4,706	169	0.75	1	17	3.59	3	155
113	Nigeria	148,296	1,777	0.91	1	21	1.20	1	50
114	North Macedonia	97,456	3,003	144.17	5	164	3.08	3	144
115	Norway	67,140	593	11.16	1	78	0.88	1	27
116	Oman	137,929	1,544	31.97	2	104	1.12	1	43
117	Pakistan	565,989	12,436	5.86	1	57	2.20	2	116
118	Panama	333,251	5,655	135.39	5	156	1.70	2	84
119	Papua New Guinea	955	10	0.12	1	5.5	1.05	1	35
120	Paraguay	146,216	2,971	42.71	2	113	2.03	2	106
121	Peru	1,238,501	43,880	137.17	5	157	3.54	3	151
122	Philippines	552,246	11,524	10.81	1	76.5	2.09	2	110
123	Poland	1,596,673	41,028	108.03	4	146	2.57	2	133
124	Portugal	788,561	15,522	150.97	5	168	1.97	2	101
125	Qatar	158,138	256	9.20	1	68	0.16	1	3
126	Romania	765,970	19,526	100.27	4	141	2.55	2	130
127	Russia	4,053,535	79,659	55.14	2	118	1.97	2	100
128	Rwanda	17,594	240	1.95	1	36	1.36	1	60
129	San Marino	3,352	72	213.11	5	174	2.15	2	114
130	Sao Tome and Principe	1,520	19	9.00	1	67	1.25	1	53
131	Saudi Arabia	373,368	6,441	19.11	1	92	1.73	2	86
132	Senegal	31,476	760	4.79	1	50	2.41	2	122
133	Serbia	424,020	4,261	61.03	2	125	1.00	1	33
134	Sierra Leone	3,825	79	1.03	1	23.5	2.07	2	107
135	Singapore	59,810	29	0.51	1	9	0.05	1	1
136	Slovakia	279,696	6,063	111.31	4	148	2.17	2	115
137	Slovenia	180,520	3,733	180.57	5	172	2.07	2	108
138	Somalia	5,373	163	1.09	1	25	3.03	3	143
139	South Africa	1,494,119	48,313	83.62	3	134	3.23	3	147
140	South Sudan	5,710	79	0.72	1	16	1.38	1	64
141	Spain	3,096,343	65,979	141.21	5	162	2.13	2	111

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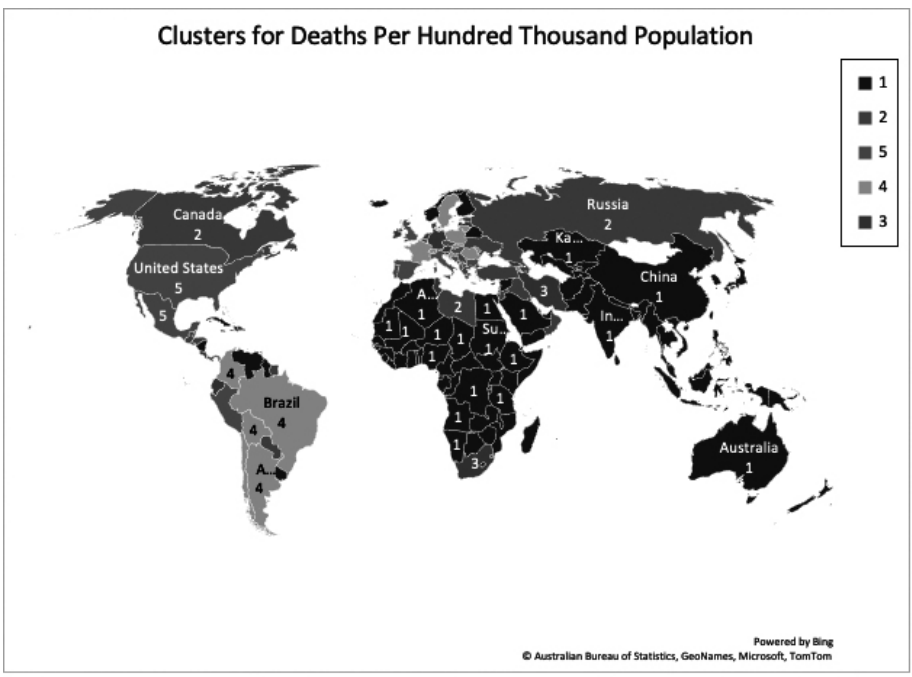
142	Sri Lanka	77,184	409	1.89	1	33.5	0.53	1	12
143	Sudan	30,052	1,863	4.46	1	48	6.20	4	171
144	Suriname	8,820	167	28.99	2	102	1.89	2	95
145	Sweden	617,869	12,487	122.62	4	153	2.02	2	102
146	Switzerland	544,282	9,817	115.27	4	151	1.80	2	91
147	Syria	14,951	984	5.82	1	56	6.58	4	172
148	Taiwan	937	9	0.04	1	3	0.96	1	31
149	Tajikistan	13,308	90	0.99	1	22	0.68	1	17
150	Tanzania	509	21	0.04	1	3	4.13	3	162
151	Thailand	24,786	82	0.12	1	5.5	0.33	1	6
152	Togo	5,953	81	1.03	1	23.5	1.36	1	59
153	Trinidad and Tobago	7,656	138	9.93	1	72	1.80	2	90
154	Tunisia	224,329	7,617	65.86	3	128	3.40	3	149
155	Turkey	2,602,034	27,652	33.59	2	106	1.06	1	37
156	United States	27,756,624	488,081	149.18	5	167	1.76	2	88
157	Uganda	40,063	331	0.77	1	18	0.83	1	25
158	Ukraine	1,322,406	25,862	57.96	2	123	1.96	2	99
159	United Arab Emirates	355,131	1,041	10.81	1	76.5	0.29	1	4
160	United Kingdom	4,070,332	118,421	178.11	5	171	2.91	3	140
161	Uruguay	49,725	546	15.83	1	87	1.10	1	41
162	Uzbekistan	79,461	622	1.89	1	33.5	0.78	1	24
163	Venezuela	133,927	1,292	4.48	1	49	0.96	1	32
164	Vietnam	2,311	35	0.04	1	3	1.51	1	73
165	West Bank and Gaza	169,487	1,942	42.50	2	112	1.15	1	45
166	Yemen	2,148	618	2.17	1	38	28.77	5	174
167	Zambia	70,823	974	5.61	1	54	1.38	1	63
168	Zimbabwe	35,315	1,414	9.79	1	70.5	4.00	3	161
169	Burundi	1,855	3	0.03	1	1	0.16	1	2
170	Liechtenstein	2,540	53	139.80	5	161	2.09	2	109
171	Monaco	1,787	21	54.29	2	116	1.18	1	47
172	Saint Lucia	2,549	23	12.65	1	83	0.90	1	28
173	Saint Vincent and the Grenadines	1,457	6	5.44	1	53	0.41	1	9
174	Seychelles	2,058	10	10.33	1	75	0.49	1	11
	World	109,502,318	2,418,776	31.23	2	104	2.21	2	117

Source: Data on confirmed, deaths, deaths per 100 thousand population, and case fatality are obtained from Johns Hopkins University Coronavirus Resource Center. Mortality Analyses - Johns Hopkins Coronavirus Resource Center (jhu.edu). Updated on Wednesday, February 17, 2021, at 06:50 EST. Access date: February 18, 2021.

Clusters and Ranks: Authors' calculations. Microsoft Excel is used for ranks and Stata is used for Cluster analysis. Note: Raw figures for the World are not included in calculations. Rank and cluster for the World is determined by closest country figures.

Cluster analysis is used to determine the natural groupings of observations. Stata has several algorithms for cluster analysis. In *k*-means, the number of groups (clusters), *k*, is determined in the beginning. Here, 5 clusters are chosen, analogous to letter grades in college. Each observation is assigned to the group whose mean is closest. The Euclidean distance measure is used among several distance measures available. Using that, new group means are determined. The procedure continues until no observation changes groups. There are many ways to determine initial group means. Here, initial group centers are determined by k unique random observations.

FIGURE 1. Clusters for deaths per hundred thousand population as of February 17, 2021



The Philippines had about 550 thousand confirmed cases and about 11 thousand deaths by February 17, 2021 (Table 1). Deaths per hundred thousand population were 10.81 (rank of 76.5 out of 174) which put the Philippines in the first cluster. On the other hand, deaths from confirmed cases were 2.09 percent (with rank=110 and cluster=2).

There were six countries with over a hundred thousand deaths by March 8, 2021. These countries were the United States, Brazil, India, United Kingdom, Mexico, and Italy. There were 36 countries with over ten thousand deaths.

Since daily numbers have large fluctuations mostly because of recording, moving averages may be used. The European Centers for Disease Control and Prevention no longer releases daily numbers, but weekly numbers.

Seven-day moving average at time t ($D(t\text{-}6)+D(t\text{-}5)+D(\text{t-}4)+D(t\text{-}3)+\text{D}(t\text{-}2)+D(t\text{-}1)+D(t)$)/7 or the average of the weekly change ($D(t)\text{-}D(t\text{-}7)$)/7 are two equivalent ways of obtaining a better measure. The former is used here. In addition to seven-day, 28-day (four weeks), 56-day (eight weeks), and 84-day (12 weeks) moving averages are calculated to see general tendencies. A comparison may show whether the number of deaths is decreasing or increasing. For example, in Brazil average daily rate was around 1600 for the week ending March 8th, compared with an average daily rate of about a thousand for the 84-week period ending March 8th. This is a very significant increase. On the other hand, India was able to reduce the number from 1200 to less than 200. Furthermore, India had a single peak in 2020. The United States had the highest daily death rates (over 3000) in 2020. The rate was reduced below 2000 in early March. The Philippines had not realized a steady decrease.

Most countries realized a second wave of deaths. After the initial surge in early 2020, countries took measures mostly in the form of lockdowns of schools, restaurants, and hotels. These measures helped to reduce the number of deaths, but they did not last very long. Some countries relaxed and some completely abandoned, which led to the second wave. Recently, smaller numbers for the United States and the United Kingdom may be due to vaccinations. More observations are needed for firm conclusions.

2.2. Percentage changes in real GDP from the fourth quarter of 2019

Real GDP at present is to be compared with real GDP at the end of 2019, before the widespread appearance of the coronavirus. Real GDP in 2020 may be compared with the real GDP average of 2019, or the fourth quarter of 2019. Here, the comparisons will be made with the fourth quarter of 2019. Data are obtained from the World Bank, Global Economic Monitor (GEM) database. All data are in 2010 US dollars and seasonally adjusted. Real GDP is calculated as the percentage change from the value in 2019 Q4 (the sum of these may be considered as the real GDP loss as in Mariano & Ozmucur [2020]).

The Philippines had very high percentage changes from the fourth quarter of 2019, both in 2018 and 2020 (Table 2). Figures for the Philippines for 2018 are very similar to China (they both realized high growth rates). In 2020, starting with the second quarter real GDP in China grew compared with contractions in the Philippines and many other countries. This may be since the virus was in China in 2019 and very serious lockdown measures were taken by China. The large shares of exports in GDP, significant tourism revenues, and remittances may help to explain the large declines in GDP in the Philippines due to COVID-19.

TABLE 2. GDP in 2010 US dollars: percentage change from the fourth quarter of 2019

	BRAZIL	CHINA	GERMANY	ITALY	JAPAN	KOREA	PHILIPPINES	UNITED KINGDOM	UNITED STATES	WORLD
2018Q1	-1.72	-9.44	-0.87	-0.22	1.20	-4.30	-10.57	-2.32	-3.76	-3.82
2018Q2	-1.83	-8.08	-0.40	-0.10	1.24	-3.71	-8.30	-1.94	-3.11	-3.16
2018Q3	-1.03	-7.29	-0.73	-0.15	0.57	-3.16	-7.54	-1.36	-2.61	-2.78
2018Q4	-1.52	-5.48	-0.39	-0.07	1.03	-2.32	-6.27	-1.20	-2.29	-2.23
2019Q1	-0.26	-3.59	0.22	0.12	1.61	-2.65	-5.01	-0.65	-1.58	-1.42
2019Q2	-0.06	-2.48	-0.29	0.32	1.69	-1.66	-3.58	-0.51	-1.21	-0.86
2019Q3	-0.22	-2.13	0.02	0.36	1.87	-1.29	-1.88	-0.02	-0.58	-0.46
2019Q4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020Q1	-1.55	-10.00	-1.99	-5.53	-0.56	-1.28	-5.60	-2.88	-1.26	-2.85
2020Q2	-11.00	0.66	-11.50	-17.85	-8.82	-4.40	-19.65	-21.37	-10.14	-10.40
2020Q3	-4.14	2.55	-3.97	-4.74	-4.03	-2.35	-13.21	-8.69	-3.42	-3.31
2020Q4		6.55	-3.88	-6.62	-1.11	-1.29	-8.38	-7.80	-2.46	-1.87

Source: Authors' calculations using the World Bank, World Economic Monitor (GEM) database. Global Economic Monitor (GEM) | Data Catalog (worldbank.org) Access date: February 24, 2021.

2.3. Change in the rate of unemployment from December 2019

The rate of unemployment is another very significant indicator to see the effects of a pandemic. Data are also available from the World Bank, Global Economic Monitor (GEM) database for most countries. These data are available monthly, but for some major countries (for example, India) they are not available. Here, comparisons with the unemployment rate in December 2019 are made.

There were significant increases in the rate of unemployment due to COVID-19 in all the countries, especially in the Philippines and the United States (Table 3). It should be noted that GEM gives monthly figures for the Philippines by using the same quarterly figure for the months of the quarter. This does not change the basic fact that the rate of unemployment increased by 0.4 percentage points in the first quarter of 2020 and 12.3 percentage points in the second quarter from the fourth quarter of 2019.

TABLE 3. The rate of unemployment: difference from December 2019

	BRAZIL	CHINA	GERMANY	ITALY	JAPAN	KOREA	PHILIPPINES	UNITED KINGDOM	UNITED STATES	WORLD
2019M01	0.69	0.05	0.10	0.69	0.20	0.60	0.30	0.00	0.40	0.19
2019M02	0.65	0.07	-0.28	1.05	0.17	0.10	0.30	-0.10	0.20	0.15
2019M03	0.50	0.05	0.17	0.43	0.23	0.10	0.30	-0.10	0.20	0.13
2019M04	0.41	0.02	-0.19	0.65	0.22	0.30	0.10	-0.10	0.10	0.07
2019M05	0.37	0.01	-0.20	0.55	0.12	0.10	0.10	0.00	0.10	0.05
2019M06	0.27	-0.01	-0.28	-0.10	0.08	0.20	0.10	-0.10	0.00	0.00
2019M07	0.15	-0.02	-0.14	0.27	0.07	0.20	0.40	0.00	0.00	0.02
2019M08	0.22	-0.03	-0.12	0.01	0.04	-0.50	0.40	-0.10	0.10	0.03
2019M09	0.32	-0.03	-0.16	0.11	0.14	-0.20	0.40	-0.10	-0.10	0.03
2019M10	0.34	-0.02	-0.17	-0.24	0.14	-0.20	0.00	-0.10	0.00	0.03
2019M11	0.12	-0.02	-0.06	-0.27	0.06	0.00	0.00	-0.10	0.00	0.02
2019M12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020M01	-0.13	0.04	0.00	-0.17	0.11	0.20	0.40	0.10	-0.10	0.05
2020M02	-0.14	0.06	-0.09	-0.08	0.18	-0.30	0.40	0.10	-0.10	0.06
2020M03	0.03	0.04	0.48	-2.54	0.33	0.10	0.40	0.10	0.80	0.21
2020M04	0.52	0.26	0.85	-3.33	0.41	0.10	12.30	0.20	11.20	2.06
2020M05	0.96	0.25	1.23	-1.41	0.61	0.60	12.30	0.20	9.70	2.14
2020M06	1.56	0.22	1.19	-0.09	0.58	0.50	12.30	0.40	7.50	1.95
2020M07	2.14	0.56	1.17	1.30	0.66	0.40	4.80	0.60	6.60	1.94
2020M08	2.82	0.55	1.15	1.44	0.73	-0.40	4.80	0.90	4.80	1.77
2020M09	3.13	0.55	1.27	0.49	0.73	0.30	4.80	1.00	4.20	1.65
2020M10	3.10	0.59	1.28	0.10	0.82	0.50	4.50	1.10	3.30	1.53
2020M11	3.14	0.60	1.30	-1.58	0.69	0.50	4.50		3.10	1.42
2020M12		0.62	1.37	-0.68	0.75	0.80	4.50		3.10	1.39

Source: Authors' calculations using the World Bank, World Economic Monitor (GEM) database. Global Economic Monitor (GEM) | Data Catalog (worldbank.org) Accessed February 24, 2021.

2.4. Disaster Index

Individual indicators are very useful, but each one may not capture the entire effect of a phenomenon. Since all four indicators will be used in DI calculations, 56 countries with data on all four indicators available were included (Table 4, see Mariano & Ozmucur [2020] for details). Since the numbers have different units, standardizing makes them more comparable. The mean and standard deviation of indicators for 56 countries were then used to calculate standardized variables and the Index with equal weights (EWI).

TABLE 4. Disaster Index for the first half of 2020

Order	Country	Disaster Index (DI)	Disaster Index (DI) (Rank)	Disaster Index (Cluster)
1	Argentina	0.6847	44	4
2	Australia	-0.6244	16	2
3	Austria	-0.1473	33	3
4	Belarus	-1.1960	3	1
5	Belgium	1.9508	52	5
6	Brazil	0.6442	43	4
7	Bulgaria	-0.2052	32	3
8	Canada	1.0011	47	4
9	Chile	0.4964	42	4
10	China	-0.3906	26	2
11	Colombia	1.4267	50	5
12	Croatia	-0.3212	28	3
13	Cyprus	-0.6458	12	2
14	Czechia	-0.7135	9	2
15	Denmark	-0.5712	23	2
16	Ecuador	2.2086	54	5
17	Egypt	-0.4361	25	2
18	Estonia	-0.6325	13	2
19	Finland	-0.6110	19	2
20	France	1.0737	49	4
21	Germany	-0.2634	30	3
22	Greece	-0.3642	27	3
23	Hungary	-0.2110	31	3
24	Iceland	-0.6268	15	2
25	Ireland	0.1767	40	3
26	Israel	-0.7440	8	2
27	Italy	2.2103	55	5
28	Japan	-0.9479	6	1
29	Korea, South	-1.1645	4	1
30	Latvia	-0.6223	17	2
31	Lithuania	-0.7045	10	2
32	Luxembourg	-0.5735	22	2
33	Malta	-0.3149	29	3

Order	Country	Disaster Index (DI)	Disaster Index (DI) (Rank)	Disaster Index (Cluster)
34	Morocco	0.0503	38	3
35	New Zealand	-0.9712	5	1
36	North Macedonia	0.3980	41	4
37	Norway	-0.8418	7	2
38	Peru	2.9267	56	5
39	Philippines	1.0590	48	4
40	Poland	-0.6311	14	2
41	Portugal	-0.0809	36	3
42	Romania	-0.1327	34	3
43	Russia	-0.6611	11	2
44	Singapore	-1.5380	1	1
45	Slovakia	-0.5994	21	2
46	Slovenia	-0.0447	37	3
47	South Africa	-0.6214	18	2
48	Spain	1.5865	51	5
49	Sweden	0.7849	45	4
50	Switzerland	-0.0978	35	3
51	Taiwan	-1.3779	2	1
52	Tunisia	0.0876	39	3
53	Turkey	-0.5608	24	2
54	United Kingdom	2.0765	53	5
55	Uruguay	-0.6072	20	2
56	United States	0.9551	46	4

Source: Mariano & Ozmucur [2020] Table 9.

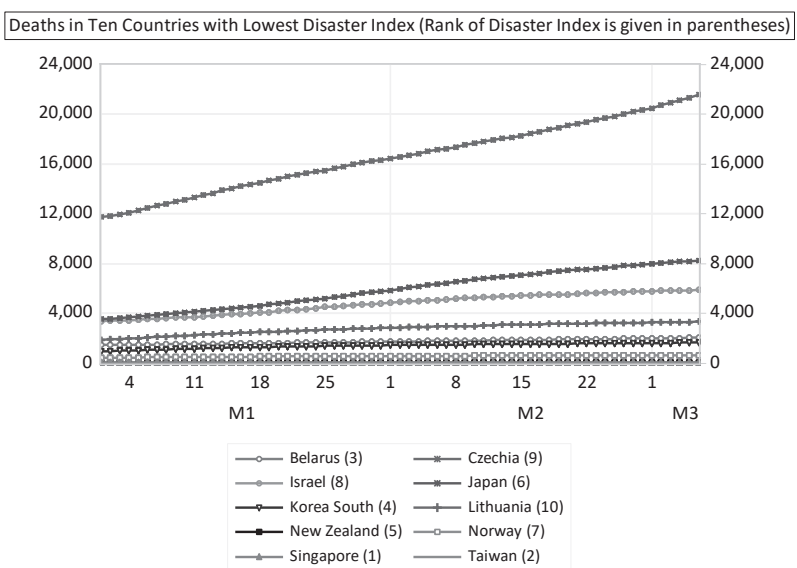
Principal components analysis for four indicators indicates that the first principal component explains 49 percent of the variance, and the second principal component explains 25.6 percent of the variance. The first two components explain close to three-quarters of the total variance. Loadings indicate that the first principal component has a correlation of 0.64 with the deaths per hundred thousand population. The second principal component has the highest correlation with the increase in the unemployment rate (0.83). The first principal component is to be used as the Index (PC1).

The DI is a weighted average of the Index with Equal Weights (EWI) and the first principal component (PC1) of the group of four indicators. The weights are the reciprocal of standard deviations of EWI and PC1.

It is important to look again at countries that we had calculated DIs for during the first half of 2020 [Mariano and Ozmucur 2020]. By studying recent trends, we can see if the country has improved performance or not since the end of the first half of 2020.

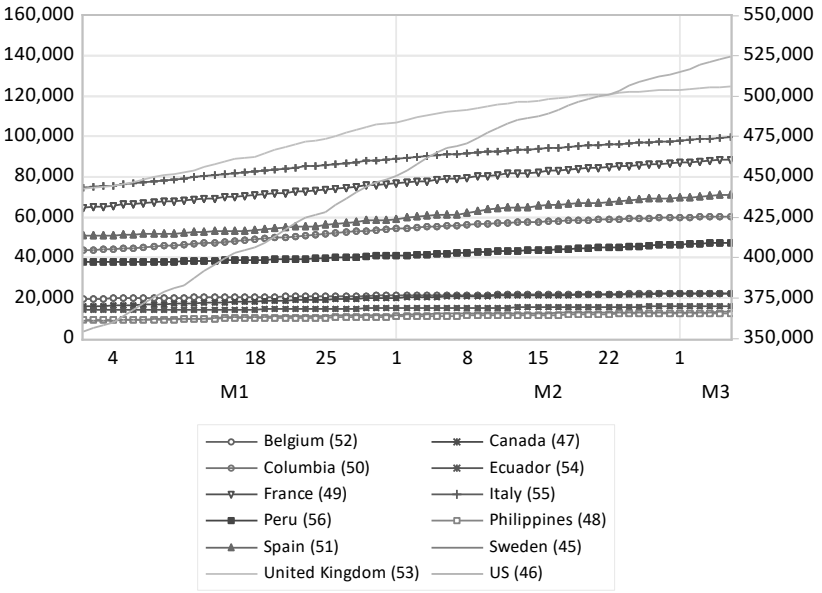
Figure 2 shows the 10 best performers based on the DI for the first half of 2020: Singapore (1), Taiwan (2), Belarus (3), Korea (4), New Zealand (5), Japan (6), Norway (7), Israel (8), Czechia (9), and Lithuania (10). Some countries were able to keep the level of performance. Some, on the other hand, could not. Most notably, Czechia had a very steep trend in the number of deaths during the first months of 2021. Japan and Israel also had positive trends in the number of deaths, but not at the same rate as Czechia (Figure 2).

FIGURE 2. Deaths in ten countries with lowest disaster index, 1/1/2021-3/6/2021



On the other end of the spectrum, countries with the 12 highest DI figures were: Sweden (45), US (46), Canada (47), Philippines (48), France (49), Colombia (50), Spain (51), Belgium (52), United Kingdom (53), Ecuador (54), Italy (55), Peru (56). Instead of 10, 12 were chosen so that Sweden and the US could be on the list (Figure 3). The United States continued its upward trend and reached 525 thousand deaths (right scale) by March 8th. The United Kingdom also continued its upward trend and reached 125 thousand deaths (left scale with other countries except for the US). Italy, Spain, France, and Colombia were the countries with positive trends, although not at the high rates of the United States and the United Kingdom.

FIGURE 3. Deaths in twelve countries with highest Disaster Index (US-right scale, other countries-left scale),1/1/2021-3/6/2021



Note: Rank of Disaster index is given in parentheses.

3. Relationships

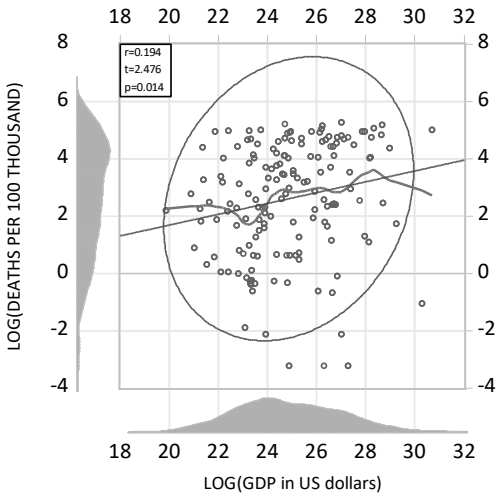
We look for the relationships between selected indicators and four variables that were used in the previous section. The list includes over a hundred indicators from the World Bank World Development Indicators. The comprehensive list includes variables related to GDP and its components, GDP per capita, surface area, population, health, environment, inequality and poverty, economic and social structure. Here we present only a few examples. It should be stressed that there is no argument made about causality, but only the correlation.

3.1. Size of the economy (GDP in US dollars)

Is there a relationship between the size of the economy and the health and economic activity indicators? This can be studied with the help of figures, which may have four components:

The kernel density for GDP in US dollars is given on the horizontal axis, and the kernel density for the deaths per 100 thousand is given on the vertical axis (Figure 4). Kernel densities help to see the distribution of individual variables. Both variables have large variances. Using logarithms reduced those variances significantly.

FIGURE 4. Size of the economy and deaths per hundred thousand



The scatter diagram has points for pairs of variables under consideration. The scatter diagram of 159 pairs of observations shows general tendencies, but in some cases may not be enough to see the degree and direction of the relationship.

The estimated regression line, nearest neighbor fit, and 95 percent confidence ellipse play supporting roles for the direction and to a certain extent degree of the relationship. The regression line shows the linear association between the two variables. It is possible to see that the estimated relationship has a positive slope. The nearest neighbor fit also indicates a positive fit, with some negative relationship at certain intervals of GDP. Outliers can easily be seen by points outside the 95 percent confidence ellipse.

The simple correlation coefficient, t-statistics, and p-value are given in a box. For example, the correlation between logarithms of GDP in US dollars and deaths per hundred thousand is 0.194. Although this may seem like a small figure, with 159 observations the correlation is significant at the five percent level. One can conclude at the 95 percent level of confidence that the correlation is statistically different from zero. In summary, the death rate is generally higher in larger economies.

3.2. Surface area

If the size of the economy is measured by its surface area, one finds a negative correlation. The correlation between logarithms of surface area and deaths per hundred thousand is negative 0.13. It is not statistically significant at the five percent level, but only at ten percent. If the surface area is larger, the death rate is generally lower. The effect is discernable at the 90 percent confidence level, but not at the 95 percent level.

3.3. Population

If the size of the economy is measured by its population, one finds a negative correlation as in the surface area. The correlation between logarithms of surface area and deaths per hundred thousand is negative 0.16. It is statistically significant at five percent (has a p-value of 0.038). If the population is larger, the death rate is generally lower. The relationship is statistically significant at the 95 percent level.

3.4. Share of the older population

A relatively high positive correlation is obtained between the share of the population aged 65 and above and the deaths per hundred thousand. The correlation is 0.555, which is significant at the one percent level (p-value is very close to zero). This is the reason that people ages 65 and above are considered among the highest risk groups.

3.5. Share of urban population

Another variable with a high positive correlation with deaths per hundred thousand is the share of the urban population. The correlation is 0.465, which is also significant at the one percent level (p-value is very close to zero).

3.6. Share of exports of goods and services in GDP

Because of its devastating effects on some sectors, we look for the relationship with those sectors also. The correlation between the share of exports of goods and services in GDP and deaths per hundred thousand is positive (0.172) and statistically significant at the ten percent level.

3.7. Tourism revenues

Another variable with a high positive correlation with deaths per hundred thousand is international tourism receipts in US dollars. The correlation is 0.270, which is significant at the one percent level (p-value is 0.001).

4. Some complementary thoughts on the pandemic

Some additional thoughts primarily based on Mariano & Ozmucur [2020] are presented in this section. Some of these points may seem trivial but events that have taken place warrant reiterating these precautionary observations.

4.1. The fallacy of "lives lost and activity loss tradeoff"

Is the economy a health alternative? The answer is "No". The "health or economy" choice put in front of the people is not the right one. Those are not competitive, but complementary. Public authorities should give guidance and

financial support, and not just let the public find a solution for themselves. It is the duty of the authorities to provide both health and economy to the public during a pandemic. Under normal times, that may not be required, and people, in general, may not demand those. But during a pandemic, authorities should provide those. Here are some of the reasons. A pandemic moves faster if healthcare is not provided to every single one in a society, in this case in the world. If a government asks a company to close its doors because of a pandemic, and not because of misbehavior of the company, is it fair for that company to bear the full burden of that closure? If the answer is no, which is what common sense tells us, then a government should cover some of the burdens to alleviate the pain. The government will cover the cost now, preferably by direct payments to citizens, and then collect taxes when the economy bounces back. This should not even be an issue for advanced economies, but it may be difficult for developing or emerging economies.

Preliminary findings show that health and the economy are not competitive (with a negative correlation). On the contrary, they are complementary as indicated by positive correlation coefficients. The correlation between deaths per hundred thousand population and real GDP loss is 0.42. On the other hand, the correlation between deaths as a percentage of confirmed cases and real GDP loss is 0.25. This is lower, but also statistically significantly different from zero at the five percent level. The correlations between health indicators and the increase in the unemployment rate are not statistically significantly different from zero, but estimated coefficients are not negative, that is suggesting no trade-off.

4.2. Pandemic and the relevance of budget deficit and domestic debt

The pandemic forced every government to take extra measures for the welfare of the people. High rates of unemployment forced governments to increase expenditures and exerted extra pressures on budgets. On the other hand, lower incomes reduced tax revenues for governments, leading to greater deficits. This situation is very common in recessions and downturns, and much amplified during a pandemic. Concepts like "the full employment budget deficit" were introduced for situations like these. Policymakers follow budget deficits closely, but adjustments must be made for the position of the economy in a cycle. It is important to keep in mind the level of the full employment budget deficit.

Government debt will increase with higher deficits. Governments will issue bonds to cover the increased deficit. In the United States, most of the buyers are citizens. The government is borrowing money from its citizens. This may not create a large problem because governments most likely will get those back with higher taxes in the future. What is needed are funds to ease the pain of the people, now. Tomorrow may be too late for the problem.

The deficit and debt can be taken care of later. For now, saving the patient is more important. Pay attention to the urgent problem now, and take care of the less urgent problem later. This simple logic should govern the minds and hearts of policymakers. But subsequent downstream problems must be anticipated and prepared for.

4.3. Pandemic and possible future outcomes

What is expected to happen in the "post-globalization" or "New World"?

There are probably two clear extremes and maybe many possibilities in between these two extremes. The first possibility, but maybe not the most likely, is a world with greater cooperation and coordination among countries. The second possibility, and maybe a more likely outcome, is moving towards a complete isolationist approach leading to countries aiming for self-sufficiency.

In any case, the most important requirement for worldwide recovery from this pandemic is a very close and complex international cooperation and coordination in every conceivable field. Whether this will be realized or not mostly depends on the existence of leaders with vision. Without sound leadership, the world population may have a very long struggle ahead of them.

During the pandemic of 2020, consumer expenditures dropped because of lack of income and rising unemployment, poverty, and uncertainty. Most businesses were closed because of mandatory lockdowns, lack of demand, and greater uncertainty. Since all countries are affected by the pandemic, there is a lack of demand from foreign countries. In terms of Keynesian categories, $GDP = C + I + G + X - M$;[2] C, I and $(X\text{-}M)$ are all lower since the beginning of the pandemic. To bring GDP back to its previous level, government expenditures (G) should increase.

Unfortunately, not all countries can respond adequately to this need for increased government expenditures because some countries were already in a vulnerable position even before the pandemic. Even more troubling is that some countries fail to see the need to expand government expenditures. Until this is realized, people cannot expect even temporary relief. There are also longer-term effects that international organizations are concerned about. If schools are closed for a long period of time, the proportion of well-educated people may decrease, which will have significant adverse effects on the growth prospects of all the countries. This lack of schooling will also perpetuate poverty and inequality.

None of the issues stated here can be solved by the private sector or by shrewd entrepreneurs in broken systems or markets with frictions. These problems can only be solved with capable leaders, sound public policies, and a solid foundation of national and international cooperation and coordination. Public authorities are expected to deliver these to be considered as true leaders.

[2] C- private consumption, I – private investment, G - government expenditures (current and investment), X-exports of goods and services, M-imports of goods and services.

Monetary authorities all over the world have been acting swiftly and surely during this crisis. Unfortunately, monetary policy cannot be effective without a firm and determined fiscal policy and income policy during a period of uncertainty and insufficient aggregate demand. Furthermore, the pandemic is also a human security issue. Treating it as if it were simply a military matter is too narrow. It is necessary to view the security issue more broadly in terms of protecting the people's general well-being, whether the threat comes from a visible enemy or an invisible virus. The world population seems to have a long way to go.

4.4. Incredible numbness or a different indifference

There are close to three million deaths globally (2,593,222 on March 8th, with about 117 million confirmed cases), according to Johns Hopkins University Coronavirus Resource Center [Coronavirus COVID-19 (2019-nCoV) (arcgis.com), Accessed March 8, 2021]. The reason for incredible numbness may be because people neither see patients fighting for their lives nor the dead being buried without their loved ones' presence. This may be part of a more general disturbing trend which may be described in a few sentences: "This is not on TV or social media. Therefore, it is not happening. Social media is the real world. The real world is somehow irrelevant until it hits the person." It does not mean it does not exist if one does not see it. This is true for all the viruses, bacteria, etc. that one can only see under a microscope.

The world needs to wage an all-out war against the virus. The remarkable efforts of some leaders, governors, public authorities, doctors, healthcare workers, first responders, and essential workers may not be enough for this fight.

4.5. The danger of transition from intelligent social beings to thoughtless individualists

Some people talk about freedom, but they do not seem to know much about freedom. One's freedom stops when it hurts the freedom of the next person. This is the case in a pandemic. Thus, freedom cannot be taken lightly as just a matter of choosing whether to wear a mask or not. One cannot behave as if there is no deadly virus. The virus may not hurt a person, but that person should behave as if the virus can hurt him/her because it can be transferred to another person with grave consequences.

The best examples of rules may be seen in traffic and games. There are universal rules in traffic set for the good of all road users. Those rules reduce the number of accidents and fatalities. One is free to drive anywhere provided traffic rules are obeyed. In general, people follow those rules. Same, if not more, is expected during a pandemic. If scientists suggest wearing masks, social distancing, and hygiene, it is best for all in the world if everyone follows those suggestions.

There are rules in every game, football, basketball, etc. One must follow those rules and stop making one's own rules. There is a simple reason for that. All those rules were made for the benefit of all the players after many years of experience. Players follow those rules even if they do not necessarily like them because it benefits a larger number of people than just a few. These are like rules during a pandemic. It helps everyone to follow those rules because people live in a society.

4.6. Modeling issues—structural analysis, policy formulation, forecasting

Modeling issues require answers to some questions. Is this virus a temporary phenomenon or a permanent one? If it is a permanent phenomenon, there is a need for a detailed sectoral breakdown of economic activity. Using real GDP as the only target variable may not be enough. Some sectors may not come back at all. Structural relationships such as the consumption function or investment function may be different from what they were before the pandemic. If it is a temporary phenomenon, what will be the duration of the pandemic? What will be the new relationships? Is it possible to use the old relationships after the end of the pandemic? Different answers to these questions will lead to different models. In the meantime, a historical average of the growth rate may be the best forecast for the average of the period over the next three or five years. Giving forecasts for individual periods may not be suggested until we have answers to all the questions posed here.

For the problem at hand, these suggest a sectoral model and not just a model for real GDP. A model that enables policy simulations may guide us for the appropriate policy to boost the activity if there are reasonably stable relationships.

Is there a need for a new modeling approach? The short answer is "yes", for the simple reason that the world in 2021 is very different from the one in 1980, and models are supposed to be just simple representations of the real world. How should the model be different? The model should probably address globalization and rising uncertainty. Building such a model may be a challenge that we would like to tackle with no guarantee of success. The problem is like the one in data mining. Most internet data are based on non-random samples. The models may be based on non-random samples.

Is it useful to have additional surveys? Under periods of uncertainty, business and consumer surveys may be useful sources of information. They are generally released earlier, and they may be more informative about the possible behavior of consumers and producers. Is it worthwhile to talk to policymakers and decision-makers in the private sector and labor? Is it necessary to add some questions to (online) business and consumer surveys? These subjective views or expectations may be very helpful during a period when accurate hard data may be difficult to get.

Another important question that researchers should ask is: Is the appearance of COVID-19 a random event, or an ignored or missed event, given earlier outbreaks: SARS, MERS, H1N1, Ebola, Swine flu? How many observations do we need to have some positive number in the empirical probabilities of such events? A regional

climate model with the appearance of a virus or bacteria may have predicted an outbreak or pandemic, maybe not the exact timing. Although we think we know a lot about the world, we probably ignored the degree of interrelatedness. Did we miss an event because of a lack of understanding of today's world? These questions have been asked. Hopefully, researchers will work on these and alleviate some of the pain in the future. The coordination of the international community appears to be the key in all aspects of the issues we deal with.

5. Concluding remarks

This paper has provided an empirical evaluation of countries' performance in fighting COVID-19, utilizing a performance index (which we call the Disaster Index) based on four health and economic indicators: deaths per population size, the share of deaths to confirmed cases, and quarterly real GDP and monthly unemployment rate relative to pre-pandemic values. International data patterns are studied for these four indicators and the DI to analyze trends and basic empirical relationships. The approach is descriptive and primarily based on graphs, scatter diagrams, and correlation analysis. The ten best performers based on the DI for the first half of 2020 were (best #1 to #10): Singapore, Taiwan, Belarus, Korea, New Zealand, Japan, Norway, Israel, Czechia, and Lithuania. The worst twelve performers, with the highest DI, were (from bad to worst): Sweden, US, Canada, Philippines, France, Columbia, Spain, Belgium, United Kingdom, Ecuador, Italy, and Peru.

These results support the proposition that high-income Asian countries performed relatively better than low-income Asian countries, European, and American countries. Reasons for this geographical divide are very important and must be studied more carefully and closely, as successful methods in better performing countries will provide some lessons for other countries. It also would be interesting to see how this DI profile shifts in 2021 as vaccination and economic relief accelerate in countries like the United States.

Unfortunately, in absolute terms, countries were not very successful in coping with the virus, with close to three million deaths in the world in about a year despite enormous medical and technological achievements over the years and altruistic and heroic efforts of doctors, healthcare workers, first responders, and other essential workers. Vaccination is fresh hope, a potential game-changer, though requiring careful and painstaking implementation.

The virus is a reminder that national security means the protection of citizens, whether it is from a visible military force or an invisible enemy such as a virus, a disease, or a cyber-attack. In this century, peoples from all nations observed that more emphasis was given to the visible enemy; and with national and international cooperation and coordination, some positive steps were taken with some success. A similar approach must be taken for all adversaries, not just visible, but also invisible ones such as viruses, bacteria, and cyber-attacks.

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