The Institutional and Cultural Context of Cross-National Variation in COVID-19 Outbreaks

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Background. The COVID-19 pandemic poses an unprecedented and cascading threat to the health and economic prosperity of the world's population.

Objectives. To understand whether the institutional and cultural context influences the COVID-19 outbreak.

Methods. At the ecological level, regression coefficients are examined to figure out contextual variables influencing the pandemic's exponential growth rate across 96 countries.

Results. While a strong institutional context is negatively associated with the outbreak (B = -0.55 … -0.64, $p < 0.001$), the pandemic's growth rate is steeper in countries with a quality education system (B = 0.33, $p < 0.001$). Countries with an older population are more affected (B = 0.46, $p < 0.001$). Societies with individualistic (rather than collectivistic) values experience a flatter rate of pathogen proliferation (B = -0.31, $p < 0.001$), similarly for higher levels of power distance (B = -0.32, $p < 0.001$). Hedonistic values, that is seeking indulgence and not enduring restraints, are positively related to the outbreak (B = 0.23, p = 0.001).

Conclusions. The results emphasize the need for public policy makers to pay close attention to the institutional and cultural context in their respective countries when instigating measures aimed at constricting the pandemic's growth.

Introduction

As of March 21, 2020, more than 271364 cases of coronavirus disease 2019 (COVID-19) were confirmed worldwide. Italy, then the second most impacted country with 47021 confirmed cases, recorded its first three cases only on January 31, 2020.[1] Efforts to completely contain the new virus largely failed. As a consequence of global mobility and trade, people carrying the virus arrive in countries without ongoing transmission. Governments are currently scrambling to put in unprecedented measures to flatten the curve, because the faster the infection curve rises, the quicker the national health care systems get overloaded beyond their capacity of treating people effectively. While ultimately the same number of people are likely to get infected, reducing the initial number of cases would make the outbreak easier to control overall.[2]

In this study, I examine cross-national variation in COVID-19 outbreaks in 96 countries to analyze the impact of global connectivity, national institutions, socio-demographic characteristics, and cultural values on the initial arc of the curve. While getting to know the epidemic through, inter alia, mathematical models is important for national and international countermeasures, experience from HIV shows that politics and ideology are often far more influential than evidence and best practice guidance.[3] It is well acknowledged that politics is central to policy-making in health generally, and that the institutional and cultural context plays a defining role in health policy outcomes. With the H1N1 2009 influenza pandemic, social determinants of health affected outcomes beyond clinically recognized risk factors.[4] Thus, getting to know the national context of the COVID-19 pandemic will be essential in informing the development of evidence-based measures.

Model and method

I implemented a linear regression model, in which the exponential growth rate of confirmed COVID-19 cases is regressed on institutional, socio-demographic, and cultural variables associated with testing and reporting cases, supporting the pathogen's path, and controlling the outbreak. As of March 21, 2020, there is sufficient COVID-19 outbreak data to estimate the model for 96 countries. All variables are detailed in Table 1. The aim of this ecological approach is to study health in an environmental context.[5]

Outbreak data

In this study, I use data from the European Center for Disease Control and Prevention (ECDC), which is an EU agency established in 2005 with the aim to strengthen Europe's defense against infectious diseases. The ECDC collects and harmonizes data from around the world, thus providing a global perspective on the evolving pandemic; the datafile is available via Our World in Data, an effort by the University of Oxford and Global Change Data Lab.[1] Note that the World Health Organization (WHO) changed their cutoff time on March 18, 2020, and, due to overlaps, their data is not suitable for understanding the pandemic's development over time beyond this date.[1] To have enough datapoints for estimating the relative growth rate (dependent variable GROWTH) in an exponential population model, I only include countries which have reported their first case on or before March 12, 2020, as per the ECDC dataset. With a change point analysis using the Fisher discriminant ratio as a kernel function, I confirm that the first reporting date is in fact the start of the outbreak.[6] Accordingly, there are no later significant change points in the outbreak.

Testing and reporting cases

During the current COVID-19 outbreak, practically all countries are struggling to test every person who should be tested from a medical standpoint. Under the guidelines of most countries, clinicians will test suspected patients only if they have travelled to an epidemic region.[7] The more tests a country performs, the more confirmed cases it tends to have. Because data on the number of tests performed is neither comparable across countries (it may refer to tests or individuals) nor updated regularly,[1] I introduce variables into the regression model, which could purportedly be associated with a country's capability and commitment to test and report. First, I use a perception indicator about the functioning of political institutions (independent variable POLINS; 0 = widespread irregularities to 4 = perfectly fair) from the 2016 edition of the International Profiles Database (IPD), which is a survey conducted by the French Directorate General of the Treasury.[8] Second, I calculate the time between Jan 01, 2020 (as a rather random starting point) and discovering the first case (independent variable DISCOV). This time lag helps a country to learn from others' experiences, and ramp up their own testing capabilities. As this is likely a non-linear effect, I logarithmically transform this measure in the regression model.

Interconnectivity between populations

Because international connectivity between countries increases the potential spread of a pathogen,[9] I introduce the independent variable IMPORT, which represents the value of all goods and other market services received by a country from the rest of the world (year 2017; in bn USD; based on data from the World Bank).[10] Additionally, with the logged variable DNSITY, I capture a country's population density, which is defined as all residents in a country divided by land area in square kilometers (year 2018; data from the World Bank).[11]

Institutional context

Because strong stakeholder processes can bring benefits to accepting decisions being made by the government,[12,13] I use an indicator on participation of the population in political institutions from the IPD database (independent variable PARPOP; 0 = very low to 4 = strong participation).[8]

Second, the society's openness can be described by the freedom of access to foreign information (independent variable FREEINF; 0 = no to 4 = total freedom; from IPD).[8] Third, the functioning of the public administration is, inter alia, mirrored in the level of corruption (independent variable CORRUP; 0 = high to 4 = very low level of corruption; from IPD).[8,14]

Socio-demographic mapping

Variable EDUCAT is a logged indicator of an education system's performance, calculated as the gross intake ratio to the last grade of primary education (average of years 2000 to 2018; data from the World Bank).[15] And as older people (especially in Italy) seem to get hit more frequently by COVID-19,[16] I introduce AGEMED as an independent variable for a country's median age (current data from the CIA World Factbook).[17]

Cultural variables

Given that culture determines the values and behaviors of societal members,[18] specific behavioral manifestations of culture can influence the transmission of pathogens.[19] Although country boundaries are not strictly synonymous with cultural boundaries, there is abundant evidence that geopolitical regions can serve as useful proxies for culture.[19] Thus, I use scores from Hofstede's dimensional framework of culture,[18] available for 73 countries included in my analysis. Individualism (independent variable INDLSM, score of 1 to 100) is defined as a preference for a loosely-knit social framework, whereas collectivism (low scores on the same variable) represents a preference for a tightly-knit framework, in which individuals expect members of a particular ingroup to look after each other in exchange for unquestioning loyalty. Previous studies have shown that the regional prevalence of pathogens is negatively associated with individualism.[19] Power distance (independent variable POWDIS, score of 1 to 100) expresses the degree to which the less powerful members of a society accept and expect that power is distributed unequally, with the fundamental issue being how societies handle inequalities among its members. Accordingly, the norm in countries with high values of POWDIS is the belief that everyone should have a defined place within the social order. The epidemiology of infections has been shown to be linked to power distance, but results are not conclusive.[20] In low power distance cultures, people are less willing to accept directions from superiors,[21] with potentially detrimental effects on controlling the outbreak of a pandemic. Conversely, in consumer research, country-level high power distance results in weaker perceptions of responsibility to aid others in a charitable way.[22] Lastly, the dimension of indulgence (independent variable INDULG, score of 1 to 100) reflects hedonistic societies that allow people to enjoy life and have fun, as compared to societies where restraint is emphasized. It can be assumed that countries scoring high on the indulgence dimension will have more difficulty constraining social activity, implementing social distancing measures, and thereby restricting its citizens' satisfying activities.

Statistical results

To test the association of the context variables on the growth rate of COVID-19, I use linear regression with pairwise exclusion of missing values. The results suggest that a significant proportion of the total variation of the outbreak can be explained by the context variables, $F(12,55) = 26.16$, $p < 0.001$. Multiple R^2 indicates that 85.09% of the variation in growth can be predicted by the context variables; estimated power to predict multiple R^2 is at the maximum of 1.000, as calculated with G*Power 3.1. Table 2 expounds the regression coefficients.

Multicollinearity in epidemiological studies can be a serious problem, being a result of unrepresentative samples or insufficient information in samples, that is not enough countries or omission of relevant variables.[23] I have conducted several diagnostics to eliminate multicollinearity issues in the regression analysis. First, the VIF never exceeds 4 (see Table 2), which is well below the recommended threshold of $\frac{1}{1-R^2} = 6.70$. Second, the highest correlation coefficient is 0.683 between variables DISCOV and IMPORT, which is below the typical cutoff of 0.8. Only another two correlation coefficients are above the 0.5 cutoff (EDUCAT and AGEMED: -0.56; POLINS and FEEINF: -0.58). Third, the variance-decomposition matrix does not show any groups of predictors with high values. In summary, a multicollinearity problem can be excluded.

Further, I conduct several tests to assess the robustness of the results by including other contextual variables. But because it is nearly impossible to establish a complete list of such confounding variables, I additionally quantify the potential impact of unobserved confounds (Table 2, column Impact threshold).[24] For instance, the necessary impact of such a confound for the variable DISCOV would be 0.80, that is, to invalidate the inference that the time lag has on the growth rate, a confounding variable would have to be correlated with both GROWTH and DISCOV at $\sqrt{0.80} = 0.89$, which is a strong correlation. Next, to alleviate concerns that the worldwide spread of the virus is not yet fully known and that this study might have been conducted too early in the pandemic, I ask how many countries would have to be replaced with unobserved cases for which the null hypothesis is true (i.e., the contextual variables have no influence on the growth rate) in order to invalidate the inference.[25] As Table 2 (column Confound threshold) shows, about 86% of the countries would have to be replaced with countries for which the effect is zero in order to invalidate the influence of DISCOV. In summary, it can be claimed that the influence of the identified contextual variables on the pandemic's growth rate is reasonably robust.

Discussion

As expected, countries with functioning political institutions (POLINS) report a higher relative growth rate of the outbreak, probably due to a better testing and reporting infrastructure. Likewise, for countries that have been hit by the outbreak at a later point of time (DISCOV). The scatterplot in Figure 1 graphically depicts the relationship between discovery of the first case and the rate of the outbreak. In this diagram every dot represents a country; Turkey shows up as an outlier having reported their first case only on March 12, 2020,[2] but showing a very rapid outbreak. International connectivity as measured by a country's import volume (IMPORT) elevates the growth rate (Figure 2). Contrary to expectations, population density (DNSITY) is negatively related to the outbreak. Maybe people in densely populated countries are more likely to adhere to precautionary measures because they realize the danger of physical closeness to pathogen transmission?[26] Or does this indicate that social distancing measures are more effective in crowded places? Yet, the DNSITY coefficient is not statistically significant in the regression model, and the confound threshold is rather low (p = 0.105, confound threshold 17.28%). A strong institutional context is negatively associated with the outbreak, as measured by participation in political institutions (PARPOP), access to foreign information (FREEINF), and absence of corruption (CORRUP). Rather surprisingly and contrary to the experience with HIV,[27] the quality of a country's education system is positively associated with the outbreak. Do people believe that the pathogen affects only poor countries, and therefore do not take precautionary measures seriously? Or do better educated people test more due to increased awareness? Providing a conclusive reasoning at this point in the COVID-19 outbreak is not possible, and I encourage further research in the months or years to come.

Whilst potentially controversial, an association between cultural characteristics and the outbreak of the pandemic should not be totally surprising, since implementing countermeasures is ultimately behavioral science.[28] The data shows that individualistic societies experience a lower outbreak growth rate, which is in line with previous studies about pathogen proliferation.[19] People in more collectivistic cultures apparently find it more difficult to engage in social distancing practices. And because the effectiveness of social distancing measures has rarely been assessed before,[26] this calls for a cross-cultural investigation in further research. Higher levels of power distance are associated with a lesser growth rate of the outbreak; it appears that individuals in low power distance cultures are less willing to blindly accept directions from the government on how to change their social behavior.[21] Instead, they prefer a say in decisions affecting their lifestyle. Even though managing individuals' obstinate behavior is quite a challenge in a pandemic, politicians in low-power distance countries need to work more towards achieving a buy-in of their electorate. Lastly, a country's hedonistic tendency towards indulgence and not accepting restraints is positively linked to the outbreak.

My study indicates that governments need to tailor their strategies for combating the COVID-19 pandemic to the institutional and cultural context in their respective countries. In addition to system change, culture change, that is, the establishment of new norms and behavior, is needed.[28] This change needs to be driven by leaders showing unequivocal and explicit support for outbreak control policies and their implementation, hopefully bringing the outbreak under control and reducing its overall magnitude. This is especially important because the unpredictable future of the pandemic will be exacerbated by public's misunderstanding of health messages,[29] causing not only worry but likely also mental health issues in the population.

Conflict of interest

The author declares that there is no conflict of interest.

Human participant protection

No humans participated in this study. The data used for the regression model in this study is available in its entirety in Table 1. The original data sources are referenced in the section Model and methods.

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290 **Table 1: Relative growth rate of COVID-19 and contextual variables**

Country	GROWTH	POLINS	DISCOV	IMPORT	DNSITY	PARPOP	FREEINF	CORRUP	EDUCAT	AGEMED	INDLSM	POWDIS	INDULG
Afghanistan	0.159	2.250	4.025	9.153	4.042	2.667	3.500	0.000	3.842	19.5			
Albania	0.260	2.500	4.234	6.070	4.650	2.000	4.000	1.000	4.560	34.3			
Algeria	0.202	2.250	4.043	55.604	2.875	2.333	3.500	0.500	4.464	28.9	20	77	78.000
Argentina	0.281	3.000	4.159	89.853	2.789	2.333	4.000	1.250	4.601	32.4	46	49	61.830
Armenia	0.294	2.750	4.111	5.706	4.641	1.000	3.000	0.750	4.560	36.6			
Australia	0.081	4.000	3.219	273.699	1.178	4.000	4.000	3.750		37.5	90	38	71.429
Austria	0.299	3.750	4.043	211.711	4.675	2.667	4.000	3.250	4.596	44.5	55	11	62.723
Azerbaijan	0.162	1.750	4.094	17.104	4.790	2.333	2.000	0.750	4.555	32.6			
Bahrain	0.150	2.750	4.007	23.876	7.610	1.667	3.000		4.573	32.9	38	80	34.000
Bangladesh	0.139	3.000	4.234	50.614	7.123	1.667	3.000		4.022	27.9	20	80	19.643
Belarus	0.199	1.000	4.078	36.436	3.844	1.000	2.500	2.000	4.612	40.9			
Belgium	0.191	4.000	3.555	407.020	5.933	3.000	4.000	4.000	4.297	41.6	75	65	56.696
Bosnia and Herzegovina	0.246	3.000	4.190	10.200	4.173	1.000	4.000	1.000		43.3			
Brazil	0.307	3.750	4.043	237.622	3.221	2.667	4.000	1.000	4.692	33.2	38	69	59.152
Brunei	0.366		4.248	4.318	4.399	0.333	1.000	2.500	4.643	31.1			
Bulgaria	0.336	3.250	4.220	37.120	4.170	3.000	4.000	0.750	4.581	43.7	30	70	15.848
Cambodia	0.047	1.250	3.332	14.219	4.522	1.667	4.000	0.500	4.336	26.4			
Cameroon	0.205	1.000	4.205	7.895	3.977	1.000	3.000	0.000	4.091	18.5			
Canada	0.099	4.000	3.258	554.657	1.405	4.000	4.000	3.500	4.567	41.8	80	39	68.304
Chile	0.334	4.000	4.159	75.394	3.226	2.667	4.000	2.500	4.576	35.5	23	63	68.000
China	0.116			2208.504	5.000	0.667	2.000	0.250	4.585	38.4	20	80	23.661
Colombia	0.405	2.750	4.205	62.882	3.801	2.333	4.000	1.500	4.529	31.2	13	67	83.036
Costa Rica	0.301	3.750	4.205	19.195	4.584	2.667	4.000	2.250	4.481	32.6	15	35	
Croatia	0.163	4.000	4.043	27.333	4.292	2.333	4.000	1.750	4.546	43.9	33	73	33.259
Cyprus	0.342	3.750	4.248	16.614	4.858	4.000	4.000	2.500	4.512	37.9			
Czech Republic	0.302	3.750	4.127	155.896	4.924	2.000	4.000	2.250	4.608	43.3	58	57	29.464
Denmark	0.356	4.000	4.060	158.589	4.928	3.333	4.000	4.000	4.597	42.0	74	18	69.643
Dominican Republic	0.194	2.750	4.127	21.234	5.394	1.000	4.000	0.500	4.472	27.9			
Ecuador	0.205	2.750	4.111	22.516	4.231	3.667	4.000	0.250	4.576	28.8		78	
Egypt	0.191	2.750	3.829	68.983	4.594	2.000	3.500	0.750	4.464	24.1	38	80	34.000
Estonia	0.307	4.000	4.078	19.253	3.414	2.333	4.000	3.500	4.583	43.7	60	40	16.295
Finland	0.127		3.401	95.590	2.899	4.000	4.000	3.250	4.602	42.8	63	33	57.366
France	0.151	4.000	3.219	824.460	4.807	3.333	4.000	3.500	4.594	41.7	71	68	47.768
Georgia	0.167	3.250	4.060	9.342	4.179	2.333	4.000	2.750	4.648	38.6			
Germany	0.153	4.000	3.332	1473.522	5.470	4.000	4.000	4.000	4.605	47.8	67	35	40.402
Greece	0.258	4.000	4.060	69.070	4.422	3.000	4.000	0.500	4.576	45.3	35	60	49.554
Hungary	0.240	3.750	4.174	113.002	4.681	2.333	4.000	1.000	4.561	43.6	80	46	31.473
Iceland	0.252	4.000	4.094	10.291	1.260	4.000	4.000	3.500	4.596	37.1			
India	0.094	4.000	3.401	583.124	6.120	3.333	3.500	1.250	4.428	28.7	48	77	26.116
Indonesia	0.314	3.500	4.127	194.699	4.996	2.667	3.500	0.750	4.536	31.1	14	78	37.723
Iran	0.278	2.750	3.932	108.230	3.916	2.333	2.500	1.000	4.530	31.7	41	58	40.402
Iraq	0.166	2.750	4.025	69.661	4.483	3.000	3.000	0.000	4.145	21.2			
Ireland	0.331	4.000	4.111	331.338	4.255	2.333	4.000	2.500	4.601	37.8	70	28	64.955
Israel	0.239	4.000	3.970	97.221	6.017	4.000	4.000	3.250	4.653	30.4	54	13	
Italy	0.245	3.750	3.434	545.247	5.325	2.333	4.000	1.500	4.615	46.5	76	50	29.688
Japan	0.113	4.000	2.708	818.383	5.850	3.000	4.000	2.750		48.6	46	54	41.741
Jordan	0.253	2.750	4.143	22.941	4.720	1.000	3.000	1.750	4.490	23.5	38	80	34.000
Kuwait	0.102	3.750	4.007	56.304	5.447	2.667	3.500	1.250	4.544	29.7			
Latvia	0.300	4.000	4.143	18.714	3.433	1.000	4.000	1.750	4.578	44.4	70	44	12.946
Lebanon	0.205	2.500	3.970	25.972	6.507	1.333	4.000	0.250		33.7	38	80	34.000
Lithuania	0.201	4.000	4.078	33.925	3.796	2.667	4.000	3.000	4.612	44.5	60	42	15.625
Luxembourg	0.339	4.000	4.111	116.816	5.522	2.667	4.000	4.000	4.406	39.5	60	40	56.027
Macedonia	0.200	1.750	4.060	7.802	4.414	3.000	4.000	1.000	4.540	39.0			
Malaysia	0.081	3.000	3.219	201.498	4.564	2.667	3.000	1.250	4.573	29.2	26	100	57.143
Malta	0.265	3.750	4.220	16.414	7.321	4.000	4.000	2.000	4.626	42.3	59	56	65.625
Mexico	0.206	2.750	4.094	457.356	4.173	2.333	4.000	0.000	4.570	29.3	30	81	97.321
Moldova	0.353	2.250	4.220	5.274	4.816	2.333	3.000	1.250	4.539	37.7			
Mongolia	0.183	3.500	4.248	6.562	0.713	2.000	4.000	1.250	4.520	29.8			
Morocco	0.272	2.500	4.143	51.304	4.391	2.000	3.500	1.000	4.186	29.1	46	70	25.446
Netherlands	0.330	4.000	4.078	604.197	6.237	3.667	4.000	3.500	4.569	42.8	80	38	68.304
New Zealand	0.162	4.000	4.078	54.053	2.921	3.000	4.000	4.000		37.2	79	22	74.554
Nigeria	0.094	2.750	4.078	49.508	5.371	2.667	4.000	0.000	4.374	18.6	20	77	78.000
Norway	0.291	4.000	4.060	130.798	2.678	4.000	4.000	4.000	4.598	39.5	69	31	55.134
Oman	0.098	2.750	4.025	34.960	2.748	1.333	1.500	3.000	4.358	26.2	38	80	34.000
Pakistan	0.235	3.000	4.060	53.590	5.618	1.667	3.500	0.250	4.132	22.0	14	55	0.000
Panama	0.375	3.000	4.248	28.219	4.029	2.333	4.000	0.250	4.495	30.1	11	95	
Paraguay	0.213	2.750	4.220	12.599	2.863	2.333	4.000	1.250	4.366	29.7			
Peru	0.382	3.750	4.205	48.096	3.219	1.667	4.000	1.000	4.551	29.1	16	64	46.205
Philippines	0.086	3.750	3.401	128.185	5.880	2.000	4.000	1.000	4.524	24.1	32	94	41.964
Poland	0.379	3.000	4.159	264.007	4.821	2.667	3.500	2.250	4.573	41.9	60	68	29.241
Portugal	0.333	4.000	4.143	92.111	4.721	3.000	4.000	2.500		44.6	27	63	33.259

Country	GROWTH	POLINS	DISCOV	IMPORT	DNSITY	PARPOP	FREEINF	CORRUP	EDUCAT	AGEMED	INDLSM	POWDIS	INDULG
Qatar	0.325		4.111	62.193	5.479	0.667	3.000	3.000	4.434	33.7	38	80	34.000
Romania	0.266	3.000	4.060	92.287	4.438	2.000	4.000	0.250	4.540	42.5	30	90	19.866
Russia	0.084	2.500	3.466	326.913	2.177	2.333	2.500	1.500	4.556	40.3	39	93	19.866
Saudi Arabia	0.331		4.143	202.046	2.752	1.333	3.000	2.000	4.632	30.8	38	80	34.000
Senegal	0.208	4.000	4.143	7.505	4.411	2.000	3.500	2.250	3.843	19.4	20	77	78.000
Serbia	0.405	2.500	4.205	25.207	4.380	2.000	4.000	0.750	4.604	43.4	25	86	28.125
Singapore	0.069	3.500	3.178	495.467	8.981	3.000	3.000	4.000	4.600	35.6	20	74	45.536
Slovakia	0.342	4.000	4.205	88.496	4.730	3.333	4.000	1.000	4.567	41.8			
Slovenia	0.329	4.000	4.174	35.996	4.631	2.667	4.000	2.500	4.575	44.9	27	71	47.545
South Africa	0.363	3.750	4.190	99.085	3.863	3.333	4.000	1.500	4.453	28.0	65	49	
South Korea	0.173	4.000	2.996	576.913	6.272	3.333	4.000	3.500	4.620	43.2	18	60	29.464
Spain	0.227	3.750	3.466	413.731	4.538	2.667	4.000	0.750	4.607	43.9	51	57	43.527
Sri Lanka	0.049	2.250	3.332	25.403	5.845	2.333	3.000	1.000	4.574	33.7			
Sweden	0.180	4.000	3.466	222.841	3.219	4.000	4.000	3.750	4.603	41.1	71	31	77.679
Switzerland	0.330	4.000	4.043	370.406	5.373	4.000	4.000	2.750	4.347	42.7	68	34	66.071
Taiwan	0.059	3.750	3.045			4.000	4.000	2.250		42.3	17	58	49.107
Thailand	0.063		2.565	247.430	4.912	2.333	4.000	1.500	4.459	39.0	20	64	45.089
Togo	0.055	2.000	4.205	2.103	4.977	1.667	4.000	1.000	4.063	20.0			
Tunisia	0.259	3.000	4.143	22.671	4.310	3.000	3.500	0.750	4.437	32.7	38	80	34.000
Turkey	0.790	2.500	4.277	249.702	4.672	1.667	2.500	1.250	4.572	32.2	37	66	49.107
Ukraine	0.210	2.500	4.159	62.494	4.344	3.333	3.000	1.250	4.599	41.2			
United Arab Emirates	0.076		3.296	290.783	4.910	0.333	3.000	2.500	4.449	38.4	38	80	34.000
United Kingdom	0.150	4.000	3.434	841.969	5.616	4.000	4.000	4.000	4.615	40.6	89	35	69.420
United States	0.138	3.750	3.045	2932.062	3.577	4.000	4.000	4.000	4.593	38.5	91	40	68.080
Vietnam	0.052	2.000	3.178	221.075	5.731	2.333	3.000	0.250	4.629	31.9	20	70	35.491

GROWTH: Outbreak's relative growth rate; POLINS: Functioning of political institutions (0 = widespread irregularities to 4 = perfectly fair); DISCOV: Time gap till discovery of first case, logged; IMPORT: Import volume (2017, in bn USD); DNSITY: Population density (2018), logged; PARPOP: Participation in political institutions (0 = very low to 4 = strong participation); FREEINF: Access to foreign information (0 = no to 4 = total freedom); CORRUP: Corruption (0 = high to 4 = very low level); EDUCAT: Performance of education system (average of years 2000 to 2018), logged; AGEMED: Median age; INDLSM: Individualism (0 = strongly collectivistic to 100 = strongly individualistic); POWDIS: Power distance (0 = low to 100 = high); INDULG: Indulgence (0 = typically restraint to 100 = typically indulgent).

Table 2: Regression results

	beta	Beta	Std. err.	*t*	*p*	VIF	Confound threshold	Impact threshold
Constant	-1.153583		0.132025	-8.738	5.57E-12			
POLINS	0.121066	1.098561	0.011473	10.552	7.86E-15	3.999	81.151	0.696
DISCOV	0.247635	1.167458	0.017465	14.179	5.15E-20	2.502	85.972	0.801
IMPORT	0.000166	0.528302	0.000025	6.510	2.39E-08	2.430	70.046	0.482
DNSITY	-0.007607	-0.095227	0.004624	-1.645	0.105634	1.236	17.288	0.030
PARPOP	-0.061203	-0.552946	0.009286	-6.591	1.76E-08	2.597	69.823	0.479
FREEINF	-0.070824	-0.569313	0.010113	-7.003	3.73E-09	2.438	71.600	0.508
CORRUP	-0.062390	-0.647649	0.009035	-6.905	5.39E-09	3.246	71.197	0.501
EDUCAT	0.110094	0.333678	0.025384	4.337	0.000062	2.184	54.141	0.279
AGEMED	0.005623	0.460424	0.001188	4.731	0.000016	3.495	57.978	0.318
INDLSM	-0.001668	-0.319459	0.000451	-3.696	0.000507	2.757	46.222	0.210
POWDIS	-0.001911	-0.326253	0.000472	-4.052	0.000161	2.392	50.874	0.248
INDULG	0.001203	0.230221	0.000349	3.450	0.001084	1.643	42.299	0.181

POLINS: Functioning of political institutions (0 = widespread irregularities to 4 = perfectly fair); DISCOV: Time gap till discovery of first case, logged; IMPORT: Import volume (2017, in bn USD); DNSITY: Population density (2018), logged; PARPOP: Participation in political institutions (0 = very low to 4 = strong participation); FREEINF: Access to foreign information (0 = no to 4 = total freedom); CORRUP: Corruption (0 = high to 4 = very low level); EDUCAT: Performance of education system (average of years 2000 to 2018), logged; AGEMED: Median age; INDLSM: Individualism (0 = strongly collectivistic to 100 = strongly individualistic); POWDIS: Power distance (0 = low to 100 = high); INDULG: Indulgence (0 = typically restraint to 100 = typically indulgent).

Figure 1: Association between time lag of COVID-19 outbreak and growth rate

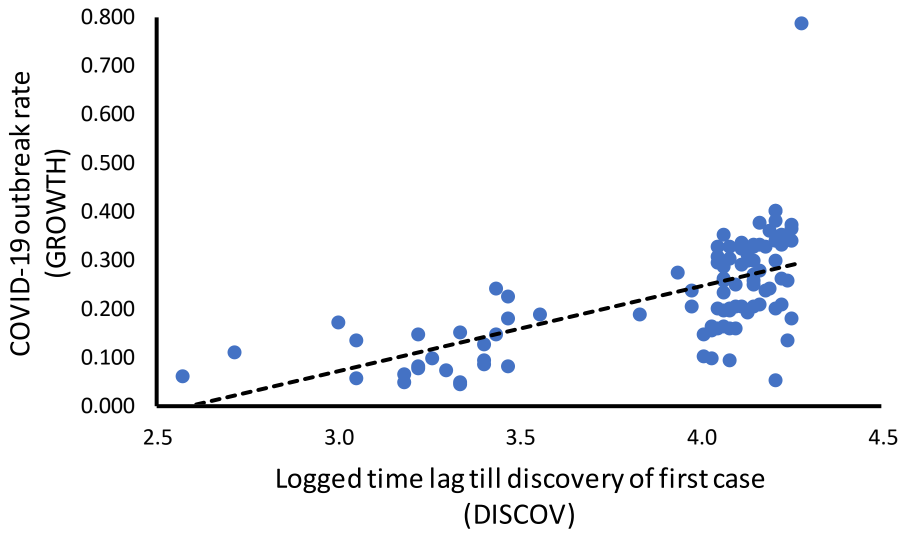

Figure 2: Association between import volume and time lag of COVID-19 outbreak