Supplementary materials for

"Stringent government policies are associated with a lower COVID-19 spread rate"

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***S1:* Table S1. Definitions and data sources of main variables used in the regression equation**

Notation	**Description**	**Data Source**
CASE_GROW	New case growth rate for a country *i* on a day *t*, calculated as follows: CASES_GROWit=(NEW_CASESit-NEW_CASESit-1)/ NEW_CASESit-1.	Our World in Data website
NEW_CASES	The count of confirmed COVID-19 case in a certain date	Our World in Data website
STRINGENCY_INDEX	Government Response Stringency Index: a composite measure based on eight response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest response).	Oxford COVID-19 Government Response Tracker, Blavatnik School of Government
STRINGENCY_TERCILE	A category variable, created by splitting the sample into three subsamples based on the original stringency index of a government and assign a measure of 1, 2, and 3 if its stringency index is in the bottom, medium, and top terciles of all sample countries on a certain day *t*, corresponding to three different strictness levels of a government's policy response to the COVID-19 spread: below average, average, and above average.	Oxford COVID-19 Government Response Tracker, Blavatnik School of Government
STRINGENCY_MEDIAN_ADJUSTED	a country's stringency index adjusted by all the country's median level of the index on a day *t*.	Oxford COVID-19 Government Response Tracker, Blavatnik School of Government
STRINGENCY_STD	A normalized index by considering both mean and standard deviation of the original stringency index on day *t*. Note that here the day *t* refers to the t^{th} day since a country reports its first case of COVID-19, not the calendar day.	Oxford COVID-19 Government Response Tracker, Blavatnik School of Government

LN_POPULATION	Natural logarithm of a country's population in 2020	United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2019 Revision
POPULATION_DENSITY	The number of people divided by land area, measured in square kilometers, most recent year available. We use the natural logarithm (LN_POPULATION_DENSITY) in the regression equations.	World Bank – World Development Indicators, sourced from the Food and Agriculture Organization and World Bank estimates
AGED_70_OLDER	Share of the population that is 70 years and older in 2015.	United Nations, Department of Economic and Social Affairs, Population Division (2017), World Population Prospects: The 2017 Revision
LN_MEDIAN_AGE	The median age of the population, UN projection for 2020	UN Population Division, World Population Prospects, 2017 Revision
LN_GDP_PER_CAPITA	Natural logarithm of a country's Gross domestic product at purchasing power parity (constant 2011 international dollars), most recent year available	World Bank – World Development Indicators, source from World Bank, International Comparison Program database
LN_CVD_DEATH_RATE	Natural logarithm of death rate from cardiovascular disease in 2017 (annual number of deaths per 100,000 people)	Global Burden of Disease Collaborative Network, Global Burden of Disease Study 2017 Results
DIABETES_PREVALENCE	Diabetes prevalence (% of population aged 20 to 79) in 2017	World Bank – World Development Indicators, sourced from International Diabetes Federation, Diabetes Atlas
MALE_SMOKERS	Percentage of men who smoke, most recent year available	World Bank – World Development Indicators, sourced from the World Health Organization, Global Health Observatory Data Repository
FEMALE_SMOKERS	Percentage of women who smoke, most recent year available	World Bank – World Development Indicators, sourced from the World Health Organization, Global Health Observatory Data Repository

HOSPITAL_BEDS_PER_100K	Hospital beds per 1,000 people, most recent year available since 2010	OECD, Eurostat, World Bank, national government records, and other sources

Source: *https://github.com/owid/covid-19-data/blob/master/public/data/owid-covid-data-codebook.md#codebook-for-the-complete-our-world-in-data-covid-19-dataset,* accessed on September 25, 2020.

S2: Descriptive statistics and Table S2

Table S2 reports the descriptive statistics of the main variables used in the study. All the continuous variables are winsorized at 1% and 99%. The average (median) spread rate of COVID-19 *(CASE_GROW)* is 22.41% (0%), with a standard deviation of 125.37%. The maximum growth rate on a particular day is as high as 788.24%. Government Response Stringency Index (*STRINGENCY_INDEX*) has a mean (median) value of 71.4082 (79.4900), with a standard deviation of 23.8832. The minimum and maximum values are zero and 100, suggesting that the governments in the sample implement dramatically different policies as a response to the development of COVID-19. The average for *STRINGENCY_TERCILE, STRINGENCY_MEDIAN_ADJUSTED*, and *STRINGENCY_STANDARDIZED* is 2.1142, -4.6471, and 0.0273, respectively. The median age of the population, based on the United Nations' projection for 2020, has an average value of 35.03 in our sample. The average (median) number of people over a land area in square kilometers or population density (*POPULATION_DENSITY*) in the sample is 286.1975 (97.9990), ranging from 3.0780 to 7915.7310 with a standard deviation of 983.7277. On average, approximately 7.4293% of the population in the sampling countries are 79 years older, as measured by *%AGED70_OLDER*. There are about 3.4920 hospital beds per 1,000 people in our sample, with a minimum and maximum of 0.3000 and 13.05 beds per 1,000 people. On average, there are 227.7598 deaths from cardiovascular disease in 2017 every year per 100,000 people, and about 7.7960% of the population aged 20 to 79 in 2017 suffers from Diabetes. Finally, as measured by *FEMALE_SMOKERS* and MALE_SMOKERS, about 11.8306% and 31.8709% of people in our sample are female and male smokers.

Table S2. Descriptive statistics

Variables	N	MEAN	SD	MIN	P25	P50	P75	MAX
CASES_GROW	6684	0.2241	1.2537	-1.0000	-0.3750	0.0000	0.3813	7.8824
NEW_CASES	6684	437.3359	1001.4436	0.0000	8.0000	50.0000	295.0000	4805.0000
STRINGENCY_INDEX	6684	71.4082	23.8832	0.0000	61.2400	79.4900	88.7500	100.0000
STRINGENCY_TERCILE	6684	2.1142	0.7937	1.0000	1.0000	2.0000	3.0000	3.0000
STRINGENCY_MEDIAN_ADJUSTED	6684	-4.6471	20.9930	-83.6000	-12.4400	0.3325	8.3300	67.6000
STRINGENCY_STD	6675	0.0273	0.9297	-4.3526	-0.3909	0.2835	0.6828	2.4794
LN_POPULATION	6684	16.6855	1.6737	11.4962	15.5129	16.6859	17.8121	21.0454
POPULATION_DENSITY	6684	286.1975	983.7277	3.0780	46.7540	97.9990	214.2430	7915.7310
AGED_70_OLDER	6684	7.3985	4.5071	0.6170	3.2620	6.9380	11.5800	16.2400
LN_MEDIAN_AGE	6684	3.5258	0.2578	2.7973	3.3776	3.5723	3.7377	3.8691
LN_GDP_PER_CAPITA	6684	9.8069	1.0346	6.6238	9.2669	10.0331	10.5904	11.4540
LN_CVD_DEATH_RATE	6684	5.2926	0.5085	4.4515	4.8542	5.2939	5.6289	6.3920
DIABETES_PREVALENCE	6684	7.7999	3.6503	1.9100	5.5000	7.1100	9.5900	22.0200
MALE_SMOKERS	6684	31.8790	12.6190	8.5000	21.4000	30.9000	40.8000	76.1000
FEMALE_SMOKERS	6684	11.8606	10.4430	0.2000	1.9000	7.8000	20.0000	35.3000
HOSPITAL_BEDS_PER_100K	6684	3.4920	2.6515	0.3000	1.6000	2.7700	4.5100	13.0500

***S3:* Test on government stringent responses and COVID-19 spread and Table S3**

We construct the following regression model to investigate the association between government responses and the spread of COVID-19 cases.

$$CASE\_GROW_{i,t} = \alpha + \beta_1 STRINGENCY\_INDEX_{i,t} + CONTROL\_VARIABLES \qquad (1)$$

In addition to the original government response stringency index or *STRINGENCY_INDEX*, we use $STRINGENCY\_TERCILE_{i,t}$, $STRINGENCY\_MEDIAN\_ADJUSTED_{i,t}$, and $STRINGENCY\_STANDARDIZED_{i,t}$ as independent variables in the regression analysis.

We first check the correlation coefficient among the main variables in the regression specification. Our untabulated result shows that *CASES_GROWTH* has a negative and significant correlation with all of the four government response stringency indexes[23]. It is positively correlated with *DIABETES_PREVALENCE* ($\rho = 0.0208, p<0.01$). We do not find severe issue of multicollinearity among the independent variables.

We conduct an ordinary least square (OLS) regression after controlling for country level and weekly fixed effect, whereas the standard errors are clustered at a country level. As reported in Table S3, all four measures of government stringency indexes have a negative and significant coefficient across four specifications, indicating that strict government response policies are associated with a slow spread rate of COVID-19 cases. In particular, the coefficient of *STRINGENCY_INDEX* in Column (1) is negative and significant (β = -0.0043, t = -3.22) after controlling for several factors, implying that for one standard deviation increase of stringency index (σ = 23.8832, as reported in Table 1), the COVID-19 growth rate decreases by 10.2702%. Given the average daily new case is about 437.3359 in our sample (reported in Table S2), this is equivalent to a reduction of 44.9134 new cases on a daily basis. Consistently, the coefficient of *STRINGENCY_TERCILE* is negative and coefficient (β = -0.0752, t = -3.50). The result indicates that for every one level increase of strictness of government response to COVID-19 cases (i.e., from a "below average" to "average" or an "average" to "above average"), the COVID-19 spread rate decreases approximately by 7.52%, equivalent to a reduction of 32.8877 new cases daily. Another two alternative measures, *STRINGENCY_MEDIAN_ADJUSTED* and *STRINGENCY_STANDARDIZED* both have a negative and significant coefficient, as shown in Columns (3) and (4).

Regarding the control variables in the regression results in Table S3, we note some interesting findings pertinent to the factors that are associated with the spread of COVID-19. Generally speaking, the COVID-19 cases spread quickly for countries or regions that have a higher population density, have more people older than 70 and have developed with Diabetes. To be specific, *POPULATION_DENSITY* has a positive and significant coefficient of 0.0065 at a 1% significance level across the four regression specifications. Its coefficient in Column (3) is 0.0095, implying that a one standard deviation increase of a nation's population density, or an increase of 983.7277 people for every square kilometer (as reported in Table S2), is associated with an increase of 9.3454% of COVID-19 cases. *AGED_70_OLDER* has a positive and significant coefficient, ranging from 0.5380 in Column (4) to 0.5725 in Column (2). To interpret, a one standard deviation increase of the percentage of the population older than 70 (σ =4.5071, as shown in Table S2) is related to an increase of 2.4248% - 2.5803% new cases of COVID-19 every day. The percentage of the population that have developed with Diabetes is another important factor influencing the COVID-19 spread, as indicated by a positive and significant coefficient of *DIABETES_PREVALENCE* across the four regression models. To be specific, a one standard deviation increase of the percentage of the population aged 20 to 79 who have Diabetes (σ =3.6503, as shown in Table S2) is related with an increase of 2.1471% - 2.4461% increase of new cases of COVID-19 on a daily basis. Wealthy countries, measured by *GDP_PER_CAPITA*, generally have lower spread rate of COVID-19 cases, as shown by the negative and significant coefficients of *GDP_PER_CAPITA*. A country populations' median age or *LN_MEDIAN_AGE*, the death rate from cardiovascular disease or *LN_CVD_DEATH_RATE*, and the percentage of women and men who smoke (*FEMALE_SMOKERS* and *MALE_SMOKERS*) are negatively and significantly related to the spread rate of COVID-19 cases. Somewhat surprisingly, *HOSPITAL_BEDS_PER_100K* has positive effect on the COVID-19 spread. The reason could be due to the increased hospital capacity to admit more COVID-19 cases. Overall, Table S3 shows that stringent government response policies are associated with a lower spread rate of COVID-19. In addition, COVID-19 cases spread more slowly in countries and regions with a younger population, lighter population density, fewer Diabetes people, and a higher national income.

Table S3. Regression analysis of the effect of government policy stringency index on COVID-19 spread (CASES_GROW)

Variables	(1)	(2)	(3)	(4)
STRINGENCY_INDEX	-0.0043***			
	(-3.22)			
STRINGENCY_TERCILE		-0.0752***		
		(-3.50)		
STRINGENCY_MEDIAN_ADJUSTED			-0.0052***	
			(-3.72)	
STRINGENCY_STANDARDIZED				-0.1166***
				(-3.93)
LN_POPULATION	-0.0192***	-0.0160***	-0.0216***	-0.0288***
	(-4.06)	(-3.26)	(-4.54)	(-4.73)
POPULATION_DENSITY	0.0097***	0.0114***	0.0095***	0.0097***
	(27.22)	(50.29)	(26.07)	(31.64)
AGED_70_OLDER	0.5510***	0.5725***	0.5497***	0.5380***
	(75.38)	(81.11)	(75.81)	(58.09)
LN_MEDIAN_AGE	-6.8121***	-7.5662***	-6.7360***	-6.6900***
	(-41.74)	(-66.63)	(-41.10)	(-39.80)
LN_GDP_PER_CAPITA	-1.1774***	-1.3147***	-1.1569***	-1.1710***
	(-27.26)	(-77.69)	(-26.02)	(-29.38)
LN_CVD_DEATH_RATE	-0.3711***	-0.4990***	-0.3360***	-0.3615***
	(-6.64)	(-30.72)	(-5.74)	(-7.26)
DIABETES_PREVALENCE	0.5974***	0.6701***	0.5882***	0.5912***
	(34.13)	(82.90)	(32.89)	(36.02)
MALE_SMOKERS	-0.0727***	-0.0795***	-0.0719***	-0.0722***
	(-41.98)	(-87.33)	(-40.32)	(-43.31)
FEMALE_SMOKERS	-0.0604***	-0.0458***	-0.0622***	-0.0572***
	(-16.28)	(-17.22)	(-16.42)	(-20.87)
HOSPITAL_BEDS_PER_100K	0.2110***	0.2481***	0.2069***	0.2129***
	(26.77)	(40.74)	(25.03)	(31.33)
CONS	30.3346***	33.9560***	29.6910***	29.8882***
	(29.74)	(78.37)	(27.39)	(29.92)
WEEK FIXED EFFECTS	YES	YES	YES	YES
COUNTRY FIXED EFFECTS	YES	YES	YES	YES
N	6684	6684	6684	6675
R^2	0.0309	0.0299	0.0318	0.0318

Note: ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively, for a two-tailed test. All reported t-values in parentheses are based on standard errors adjusted for country-level clustering.

***S4:* Discussions of economic significance of the effect of containment and closure policies on COVID-19 spread and Table S4.**

1. Regarding the governmental policies on workplace closing, for every one level increase of strictness in response to COVID-19 cases, that is, (i) from "no measures" to "recommend work from home", or (ii) from "recommend work from home" to "require work from home for some sectors or categories of workers", or (iii) from "require work from home for some sectors or categories of workers" to "require work from home for all-but-essential workplaces", the COVID-19 spread rate decreases approximately by 7.85% daily. Given an average daily new case is about 437.3359 in our sample (reported in Table S2), this is equivalent to a reduction of 34.3309 new cases on a daily basis. The effect would be even bigger if the policy is escalated to the highest level of "require work from home for all-but-essential workplaces" from the lowest level of "no measures" – 102.9927 new cases would have been reduced daily.
2. Regarding the governmental policies on restrictions on gatherings, for every one level increase of strictness in response to COVID-19 cases, the COVID-19 spread rate decreases approximately by 5% daily, equivalent to a reduction of 21.8668 new cases daily. The effect would be even bigger if the policy is escalated to the highest level of "restrictions on gatherings of 10 people or less" from the lowest level of "no restrictions" – 87.4672 new cases would have been reduced daily.
3. Regarding the governmental policies on close public transport, for every one level increase of strictness in response to COVID-19 cases, the COVID-19 spread rate decreases approximately by 15.21% daily, equivalent to a reduction of 66.5188 new cases daily. The effect would be even bigger if the policy is escalated to the highest level of "require closing (or prohibit most citizens from using it)" from the lowest level of "no restrictions" – 133.0376 new cases would have been reduced daily.
4. Regarding the governmental policies on stay home requirement, for every one level increase of strictness in response to COVID-19 cases, the COVID-19 spread rate decreases approximately by 11.02% daily, equivalent to a reduction of 48.1944 new cases daily. The effect would be even bigger

if the policy is escalated to the highest level of “require not leaving house with minimal exceptions (e.g. allowed to leave once a week, or only one person can leave at a time, etc.) from the lowest level of “no restrictions” – 144.5832 new cases would have been reduced daily.

5. Regarding the governmental policies on domestic travel, for every one level increase of strictness in response to COVID-19 cases, the COVID-19 spread rate decreases approximately by 9.75% daily, equivalent to a reduction of 42.6403 new cases daily. The effect would be even bigger if the policy is escalated to the highest level of “internal movement restrictions in place” from the lowest level of “no restrictions” – 85.2806 new cases would have been reduced daily.
6. Regarding the governmental policies on international travel, for every one level increase of strictness in response to COVID-19 cases, the COVID-19 spread rate decreases approximately by 8.13% daily, equivalent to a reduction of 35.5554 new cases daily. The effect would be even bigger if the policy is escalated to the highest level of “ban on all regions or total border closure” from the lowest level of “no restrictions” – 142.2216 new cases would have been reduced daily.

Table S4. Regression analysis of the effect of containment and closure policies on COVID-19 spread (CASES_GROW)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SCHOOLCLOSING	-0.0261								0.0196
	(-0.86)								(0.60)
WORKPLACECLOSING		-0.0785***							-0.0228
		(-3.45)							(-0.78)
CANCELPUBLICEVENTS			-0.0323						0.0831
			(-0.65)						(1.39)
RESTRICTIONSONGATHERINGS				-0.0500***					-0.0220
				(-2.64)					(-1.01)
CLOSEPUBLICTRANSPORT					-0.1521***				-0.0976**
					(-3.99)				(-2.51)
STAYATHOMEREQUIREMENTS						-0.1102***			-0.0509
						(-4.05)			(-1.55)
DOMESTICTRAVEL							-0.0975***		-0.0093
							(-2.87)		(-0.23)
INTERNATIONALTRAVEL								-0.0813***	-0.0644**
								(-2.95)	(-2.17)
LN_POPULATION	-0.0108*	0.0302**	-0.0101	0.0220	0.0212*	0.0098	-0.0115*	-0.0197***	0.0413*
	(-1.96)	(2.21)	(-1.61)	(1.54)	(1.80)	(1.32)	(-1.96)	(-3.13)	(1.68)
POPULATION_DENSITY	0.0108***	0.0094***	0.0106***	0.0102***	0.0098***	0.0098***	0.0104***	0.0100***	0.0089***
	(79.97)	(21.86)	(34.59)	(38.75)	(30.93)	(32.92)	(54.31)	(33.27)	(16.65)
AGED_70_OLDER	0.5620***	0.5804***	0.5515***	0.6081***	0.6218***	0.5951***	0.5605***	0.5286***	0.6348***
	(59.45)	(67.20)	(37.61)	(33.06)	(39.50)	(59.52)	(81.78)	(41.75)	(17.44)
LN_MEDIAN_AGE	-7.2584***	-7.0737***	-7.0568***	-7.9806***	-7.2911***	-7.3770***	-7.0144***	-6.5031***	-7.4625***
	(-83.15)	(-72.85)	(-22.53)	(-29.80)	(-97.57)	(-97.32)	(-57.75)	(-24.04)	(-11.78)
LN_GDP_PER_CAPITA	-1.2989***	-1.0633***	-1.2899***	-1.0221***	-1.0922***	-1.0983***	-1.3117***	-1.4881***	-1.0178***
	(-41.15)	(-15.59)	(-54.12)	(-9.97)	(-20.55)	(-22.54)	(-72.21)	(-21.07)	(-5.22)
LN_CVD_DEATH_RATE	-0.5560***	-0.2637***	-0.5378***	-0.2365**	-0.1501	-0.2394***	-0.5176***	-0.7659***	-0.1070
	(-26.79)	(-3.33)	(-51.34)	(-2.09)	(-1.56)	(-3.24)	(-42.08)	(-9.86)	(-0.49)
DIABETES_PREVALENCE	0.6505***	0.5839***	0.6395***	0.6096***	0.6067***	0.6040***	0.6389***	0.6655***	0.5929***
	(70.76)	(30.10)	(61.79)	(39.08)	(51.42)	(49.02)	(106.82)	(80.30)	(18.34)
MALE_SMOKERS	-0.0776***	-0.0701***	-0.0767***	-0.0684***	-0.0728***	-0.0715***	-0.0770***	-0.0802***	-0.0683***
	(-61.34)	(-31.35)	(-100.59)	(-19.66)	(-49.86)	(-44.06)	(-107.25)	(-67.05)	(-12.90)
FEMALE_SMOKERS	-0.0516***	-0.0727***	-0.0498***	-0.0680***	-0.0819***	-0.0664***	-0.0536***	-0.0532***	-0.0949***
	(-15.84)	(-10.39)	(-19.04)	(-9.49)	(-10.15)	(-15.04)	(-19.96)	(-22.04)	(-7.77)
HOSPITAL_BEDS_PER_100K	0.2336***	0.1789***	0.2258***	0.2070***	0.1795***	0.1687***	0.2222***	0.2541***	0.1706***
	(50.52)	(11.45)	(32.55)	(20.69)	(12.55)	(10.58)	(47.04)	(32.27)	(6.03)
CONS	33.2319***	28.6568***	32.4776***	30.7495***	28.9014***	29.9807***	32.4805***	34.0489***	28.3462***

	(54.11)	(21.05)	(45.59)	(31.03)	(24.47)	(34.18)	(75.34)	(68.80)	(12.94)
WEEK FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES	YES
COUNTRY FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	6411	6395	6390	6391	6369	6392	6368	6389	6316
R^2	0.0302	0.0310	0.0291	0.0303	0.0321	0.0316	0.0309	0.0315	0.0358

Note: ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively, for a two-tailed test. All reported t-values in parentheses are based on standard errors adjusted for country-level clustering.

S5: Table S5. Regression analysis of the effect of cultural tightness-looseness on the correlation between government responses and COVID-19 spread (CASES_GROW)

Variables	(1) LOOSE Culture	(2) TIGHT Culture	(3) LOOSE Culture	(4) TIGHT Culture	(5) LOOSE Culture	(6) TIGHT Culture	(7) LOOSE Culture	(8) TIGHT Culture
STRINGENCY_INDEX	-0.0038	-0.0105**						
	(-1.48)	(-2.95)						
STRINGENCY_TERCILE			-0.1089*	-0.1580***				
			(-2.04)	(-3.18)				
STRINGENCY_MED					-0.0046	-0.0107**		
					(-1.68)	(-3.03)		
STRINGENCY_STD							-0.1332**	-0.2135**
							(-2.31)	(-3.01)
LN_POPULATION	0.0772	0.0635***	0.1249***	0.1273***	0.0588	0.0621***	0.0416	0.0633***
	(1.18)	(7.27)	(4.68)	(6.04)	(0.84)	(7.22)	(0.70)	(7.17)
POPULATION_DENSITY	0.0005**	-0.0000***	0.0005**	-0.0000***	0.0005**	-0.0000***	0.0006***	-0.0000***
	(2.81)	(-3.31)	(2.92)	(-3.87)	(2.45)	(-3.37)	(4.02)	(-3.42)
AGED_70_OLDER	0.2777*	-0.0092	0.3325***	0.0106**	0.2444	-0.0099	0.2367*	-0.0203
	(2.13)	(-1.23)	(4.70)	(2.46)	(1.78)	(-1.30)	(2.17)	(-1.79)
LN_MEDIAN_AGE	-6.0024*	1.1522***	-7.0328***	1.1118***	-5.2884*	1.1615***	-4.9539*	1.5271***
	(-2.19)	(4.61)	(-4.64)	(5.14)	(-1.83)	(4.56)	(-2.11)	(4.20)
LN_GDP_PER_CAPITA	-0.2915**	-0.1471**	-0.3378***	0.1539***	-0.2691**	-0.1552**	-0.3201***	-0.1353**
	(-2.73)	(-2.29)	(-5.25)	(3.52)	(-2.40)	(-2.42)	(-4.51)	(-2.59)
LN_CVD_DEATH_RATE	0.4367*	-0.0993	0.4930***	0.0809	0.3765	-0.1053	0.3181	0.0698
	(2.02)	(-0.92)	(3.87)	(0.98)	(1.65)	(-1.00)	(1.60)	(1.02)
DIABETES_PREVALENCE	-0.0095	-0.0230***	-0.0203***	-0.0148***	-0.0043	-0.0234***	0.0062	-0.0175***
	(-0.60)	(-5.01)	(-3.26)	(-10.45)	(-0.25)	(-5.09)	(0.37)	(-6.47)
MALE_SMOKERS	-0.0219	0.0099**	-0.0276**	0.0047**	-0.0170	0.0101***	-0.0149	0.0051***
	(-1.18)	(3.01)	(-2.54)	(2.88)	(-0.86)	(3.13)	(-0.94)	(3.49)
FEMALE_SMOKERS	0.0223	-0.0011	0.0248**	-0.0188***	0.0182	-0.0007	0.0156	-0.0017
	(1.46)	(-0.29)	(2.53)	(-5.80)	(1.12)	(-0.18)	(1.16)	(-0.53)
HOSPITAL_BEDS_PER_100K	-0.0265***	-0.0772***	-0.0324***	-0.0601***	-0.0256***	-0.0779***	-0.0306***	-0.0677***
	(-4.36)	(-4.52)	(-7.05)	(-6.13)	(-4.20)	(-4.64)	(-6.47)	(-5.30)
CONS	19.0952**	-2.8299*	21.9749***	-7.7571***	16.9894*	-3.0455**	16.8463**	-5.3176***
	(2.39)	(-2.03)	(4.79)	(-4.47)	(2.00)	(-2.22)	(2.52)	(-3.69)
WEEK FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES
COUNTRY FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES
N	798	1009	798	1009	798	1009	798	1000
R^2	0.0398	0.0512	0.0397	0.0403	0.0409	0.0521	0.0424	0.0544

Note: ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively, for a two-tailed test. All reported t-values in parentheses are based on standard errors adjusted for country-level clustering.

S6: Population density, government responses, and COVID-19 spread

Previous findings in Table S3 shows a positive relation between *POPULATION_DENSITY* and COVID-19 spread rate, as more face-to-face interaction among people tend to take place in dense areas, which makes it easier in the populated areas for the rapid spread of cases[24]. Rubin, *et al.*[25] report that in the US, lower population density is associated with a decrease in the instantaneous reproduction number of SARS-CoV-2, the coronavirus strain responsible for COVID-19. Kadi and Khelfaoui[26] report a strong correlation between the population density and the number of COVID-19 infections in Algeria. Coşkun, Yıldırım and Gündüz[27] show that population density is one of the two major factors in explaining the variance in COVID-19 virus spread in Turkey cities. In this section, we investigate the effect of a country's population density on the negative association between government stringent policies and COVID-19 spread.

We use 20% and 80% quantile, corresponding to the number of people per square kilometers, 25.04 and 266.886, respectively as a cutoff to classify a country as highly- vs. low-populated. In particular, countries with population density equal to or less than 25.04 are classified as LOW group while countries with population density equal to or above 266.886 as HIGH group (28). We then conduct the original regression using these two subsamples, and report the results in Table S6. As Columns (1) and (2) show, the estimated coefficient of *STRINGENCY_INDEX* in the LOW subsample is -0.0016 (t = -0.49), and -0.0060 in the HIGH subsample (t = -3.09). We obtain similar and consistent results when using other alternative measures of government stringent policy indexes, as shown in Columns (3) – (8). The differences in the coefficient magnitude is sizable – the coefficients of government stringency indexes in the HIGH group are approximately 2 – 10 times those in the LOW group. The results show that when a country is highly populated, its governmental strict policies in response to the COVID-19 becomes more effective in slowing down the spread of COVID-19 than a less populated county.

Table S6. Regression analysis of the effect of population density on the correlation between government responses and COVID-19 spread (CASES_GROW)

Variables	(1) LOW	(2) HIGH	(3) LOW	(4) HIGH	(5) LOW	(6) HIGH	(7) LOW	(8) HIGH
STRINGENCY_INDEX	-0.0016	-0.0060***						
	(-0.49)	(-3.09)						
STRINGENCY_TERCILE			-0.0139	-0.1470*				
			(-0.24)	(-2.00)				
STRINGENCY_MED					-0.0034	-0.0060**		
					(-1.01)	(-2.92)		
STRINGENCY_STD							-0.0667	-0.1419***
							(-0.95)	(-3.62)
LN_POPULATION	-0.0174	-0.2599***	-0.0009	-0.0884	-0.0310	-0.2557***	-0.0284	-0.2634***
	(-0.59)	(-4.12)	(-0.05)	(-1.74)	(-1.09)	(-3.82)	(-0.99)	(-5.34)
POPULATION_DENSITY	0.1173***	-0.0000***	0.1117***	-0.0000***	0.1239***	-0.0000***	0.1227***	-0.0000***
	(10.80)	(-3.80)	(25.18)	(-3.14)	(10.47)	(-3.56)	(10.45)	(-4.78)
AGED_70_OLDER	-0.3395***	0.0537***	-0.3103***	0.1069***	-0.3782***	0.0534***	-0.3745***	0.0473**
	(-5.37)	(3.44)	(-14.57)	(8.91)	(-5.53)	(3.31)	(-5.37)	(2.85)
LN_MEDIAN_AGE	5.0990***	-1.1509	4.5374***	-3.9911***	5.7985***	-1.1634	5.7281***	-1.1650
	(4.48)	(-1.33)	(17.72)	(-5.85)	(4.78)	(-1.29)	(4.54)	(-1.58)
LN_GDP_PER_CAPITA	-0.8176***	0.1703	-0.7206***	-0.4406***	-0.9352***	0.1668	-0.9188***	0.1781
	(-4.17)	(0.94)	(-20.31)	(-3.03)	(-4.57)	(0.88)	(-4.33)	(1.17)
LN_CVD_DEATH_RATE	-1.2313***	0.6281	-1.0401***	-1.5960***	-1.4499***	0.6118	-1.4214***	0.6607
	(-3.24)	(1.00)	(-9.98)	(-3.27)	(-3.77)	(0.92)	(-3.42)	(1.26)
DIABETES_PREVALENCE	-0.0125***	-0.0251	-0.0126***	0.0553***	-0.0128***	-0.0239	-0.0144***	-0.0294
	(-3.63)	(-1.11)	(-3.75)	(3.00)	(-3.79)	(-0.99)	(-3.92)	(-1.63)
MALE_SMOKERS	0.0082***	-0.0048	0.0077***	-0.0007	0.0082***	-0.0048	0.0079***	-0.0071*
	(3.62)	(-1.42)	(3.62)	(-0.26)	(3.81)	(-1.45)	(3.77)	(-1.77)
FEMALE_SMOKERS	0.0412***	-0.0242***	0.0458***	-0.0146***	0.0381***	-0.0240***	0.0376**	-0.0240***
	(3.40)	(-5.61)	(3.55)	(-4.47)	(3.25)	(-5.30)	(2.76)	(-6.91)
HOSPITAL_BEDS_PER_100K	0.1875**	0.0289*	0.1454***	-0.0338**	0.2319**	0.0286*	0.2313**	0.0300**
	(2.28)	(1.91)	(3.34)	(-2.68)	(2.79)	(1.79)	(2.37)	(2.34)
CONS	-3.0251***	3.9827	-3.3817***	27.6118***	-2.8848***	3.8940	-2.9878***	3.8127
	(-2.87)	(0.56)	(-3.66)	(4.64)	(-3.04)	(0.52)	(-3.03)	(0.62)
WEEK FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES
COUNTRY FIXED EFFECTS	YES	YES	YES	YES	YES	YES	YES	YES
N	1286	1155	1286	1155	1286	1155	1286	1155
R^2	0.0348	0.0492	0.0346	0.0475	0.0358	0.0491	0.0353	0.0505

Note: ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively, for a two-tailed test. All reported t-values in parentheses are based on standard errors adjusted for country-level clustering.

S7: Endogeneity issue

A potential issue related to the previous results is endogeneity. In the early stage of the COVID-19 outbreak, the growth rate of confirmed cases in a country is high. At this time, the government is likely to adopt more stringent prevention and control measures to reduce the spread. We adopt an instrumental variable (IV) method to alleviate the reverse causality issue[29]. In particular, we use the Freedom in the World Index as an IV[30], and then conduct a two-stage least square regression. We expect a significant and negative associate between a country's Freedom in the World Index with the stringency of government response policies, as democratic countries are positioned to develop better policies to emerging issues and public health crisis than other authoritarian counterparts due to their enhanced information transparency and capabilities[31, 32]. Meantime, as an infectious respiratory disease first identified in December 2019 in Wuhan, China, COVID-19 has spread quickly across almost all the countries and regions in the world, regardless of democratic or authoritarian regimes. As Column (1) of Table S7 shows, the coefficient of the instrumental variable *FREEDOM_INDEX* is significant and negative at the 1% level (β = -16.5872, t = -75.13) and the Kleibergen-Paap rk Wald F-statistic is 143.838, higher than the 10% critical value of 16.38, indicating the instrument is a valid measure in the first stage of the regression. Consistent with our expectation, this result shows that democratic governments tend to implement less strict policies in response to the COVID-19 pandemic. When using the predicted stringency index (*STRINGENCY_INDEX_PREDICTED*) as the independent variable in Column (2), we find that it remains to have a negative and significant coefficient (β = -0.0353, t = -111.30), implying that a negative association between stringency of government policies and COVID-19 spread is robust after controlling for the potential reverse causality. Furthermore, we use the COVID-19 death growth rate (*DEATHS_GROW*) as a dependent variable to examine the effect of the strict government policies on the COVID-19 mortality rate after controlling for one- and two-week positive COVID-19 cases. The results shown in Column (3) and (4) indicate that strict policies are associated with a lower death rate.

Table S7. Endogeneity check by using country freedom index as an instrumental variable

Variables	(1) STRINGENCY_INDEX	(2) CASES_GROW	(3) DEATHS_GROW	(4) DEATHS_GROW
FREEDOM INDEX	-16.5872***			
	(-75.1304)			
STRINGENCY_INDEX_PREDICT		-0.0353***	-0.2085***	-0.2015***
		(-111.2981)	(-17.5571)	(-17.7246)
LN_L14CASE			0.0144	
			(1.1693)	
LN_L7CASE				0.0106
				(0.6587)
LN_POPULATION	-39.9735***	-0.1015***	0.4015***	0.3942***
	(-114.0754)	(-18.9480)	(12.4799)	(10.4755)
POPULATION_DENSITY	-0.6830***	0.0025***	-0.0021***	-0.0019***
	(-68.3462)	(46.4547)	(-12.2728)	(-10.8692)
AGED_70_OLDER	194.4369***	0.4856***	-2.9019***	-2.8468***
	(82.5026)	(78.9334)	(-17.7829)	(-17.9329)
LN_MEDIAN_AGE	-1905.1409***	-3.6214***	71.1504***	69.4278***
	(-79.4920)	(-64.8338)	(16.7995)	(16.8074)
LN_GDP_PER_CAPITA	165.9606***	-0.4306***	-14.5191***	-14.1718***
	(59.5568)	(-37.5322)	(-16.1248)	(-16.0763)
LN_CVD_DEATH_RATE	-303.1061***	0.8499***	-22.4620***	-21.9670***
	(-65.5361)	(51.9923)	(-15.6970)	(-15.6243)
DIABETES_PREVALENCE	29.9748***	0.2453***	0.3228***	0.3168***
	(99.0861)	(114.7384)	(12.1480)	(11.3797)
MALE_SMOKERS	2.9409***	-0.0424***	-0.1724***	-0.1676***
	(43.8874)	(-95.6032)	(-14.0933)	(-13.9848)
FEMALE_SMOKERS	-17.6555***	-0.1311***	-0.6035***	-0.5797***
	(-91.9176)	(-61.5783)	(-13.1097)	(-12.9004)
HOSPITAL_BEDS_PER_100K	16.1073***	0.0740***	2.1524***	2.1045***
	(77.8955)	(27.6377)	(16.0612)	(16.0358)
CONS	6894.5887***	11.6673***	45.1623***	40.4199***
	(84.8811)	(56.7092)	(13.2505)	(12.7132)
WEEK FIXED EFFECTS	YES	YES	YES	YES
COUNTRY FIXED EFFECTS	YES	YES	YES	YES
N	6684	6684	3672	3739
R^2	0.6727	0.0287	0.0908	0.0959

Note: ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively, for a two-tailed test. All reported t-values in parentheses are based on standard errors adjusted for country-level clustering.

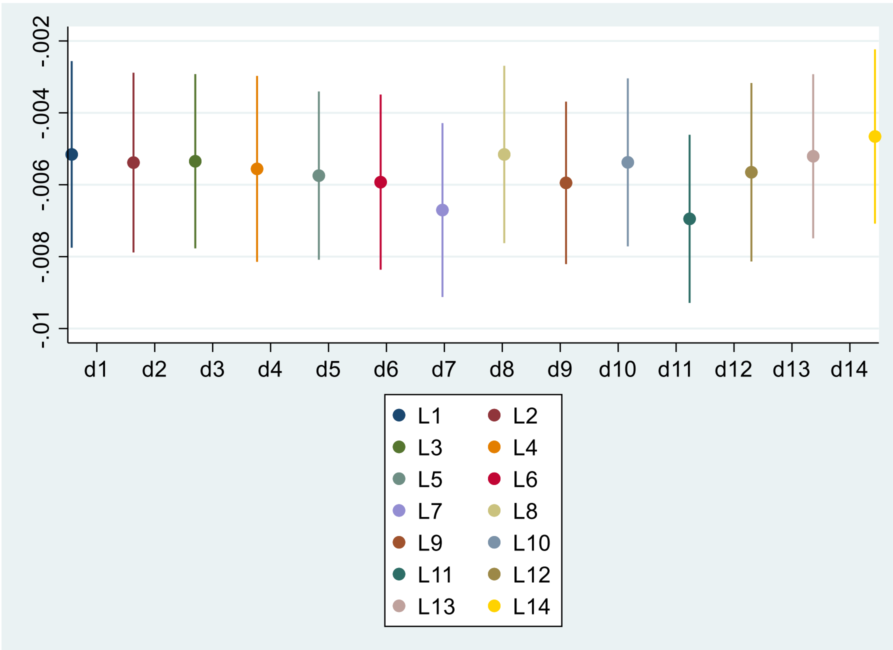
S8: Laggard effect of government responses on COVID-19 spread

There may be a time lag between the governments implementing policies as a response to COVID-19 spread and the growth rate of confirmed new cases. That is, when the government adopts strict prevention and control policies and actions, it may take some time before the spread of COVID-19 cases starts to decrease. Government policies generally takes 7-14 days to become effective, thus we lag *STRINGENCY_INDEX* by 1-14 days respectively to test the robustness of our previous findings. Using the laggard *STRINGENCY_INDEX* in the regression can also mitigate the potential endogeneity issue.

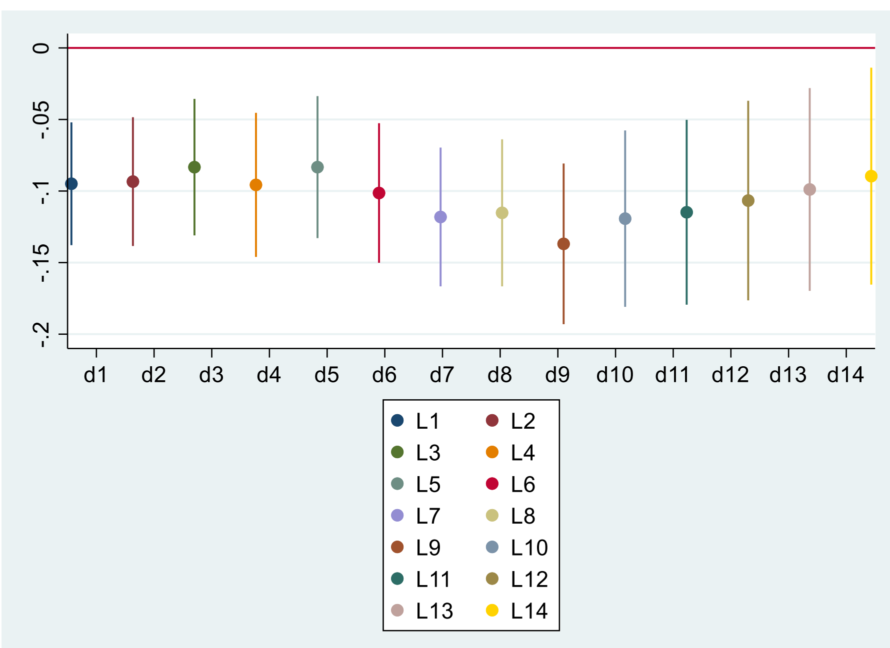
We continue to find that all the coefficients of laggard stringency index, from *LAG_1DAY_STRINGENCY_INDEX* to *LAG_14DAY_STRINGENCY_INDEX* are negative and significant, further confirming the important negative association between the strictness of a government response with the COVID-19 spread rate. That is, the more stringent government response policies, the lower COVID-19 spread rate. The results on the control variables are generally consistent with those reported in Table S3. We next plot the coefficients of these 14-laggard index in Panel A of Figure S1. Interestingly, we observe a downward trend of the magnitude of the coefficients from the first laggard week, with the smallest coefficient of laggard day 7 (β = -0.0067). The coefficient then starts to increase on laggard day 8, and then fall to the lowest on laggard day 11 (β = -0.0069). The pattern indicates that government response policies become the most effective in reducing the COVID-19 spread one week after these policies have been implemented. This finding is consistent with the SARS-CoV-2 transmission pattern overall time course for the disease. Once an individual person is exposed and becomes infected, the incubation period before the onset of symptoms is about five days, with the day 7 the worst. After day 11, most patients who survive are on their way to recover[33]. We next lag $STRINGENCY\_TERCILE_{i,t}$, $STRINGENCY\_MEDIAN\_ADJUSTED_{i,t}$, and $STRINGENCY\_STANDARDIZED_{i,t}$ by 1-14 days an conduct the regression analysis again, and show the coefficients in Panels B, C, and D, respectively. All the coefficients of government stringency indexes are negative and significant. Furthermore, an almost identical pattern remains to exist. Overall, we report robust and consistent results that strict government response policies are associated with a lower spread rate of COVID-19 cases.

Figure S1. Laggard effect of government responses on COVID-19 spread

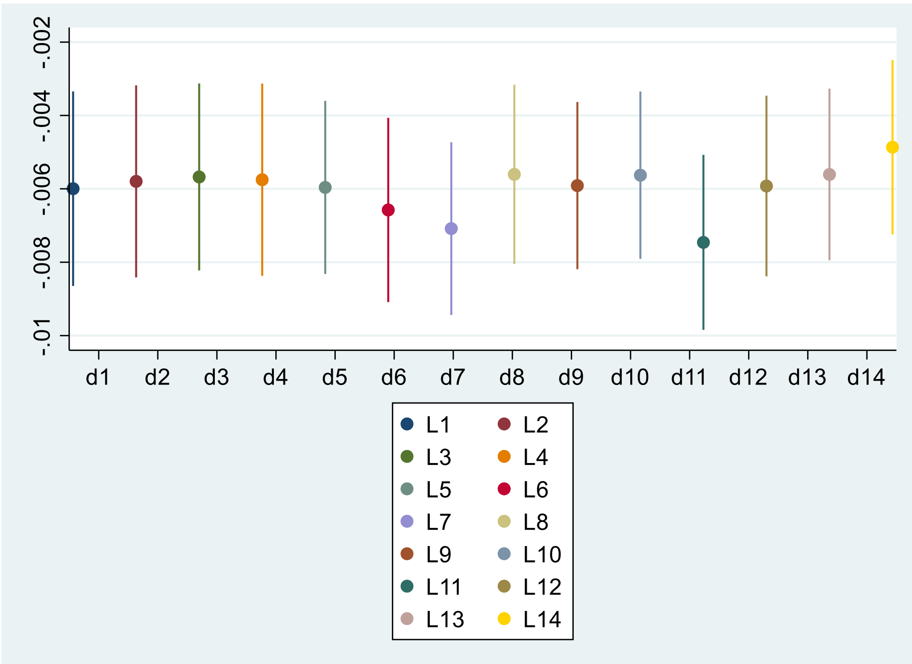
Panel A. Plot of coefficients of the original government stringency index (STRINGENCY_INDEX)



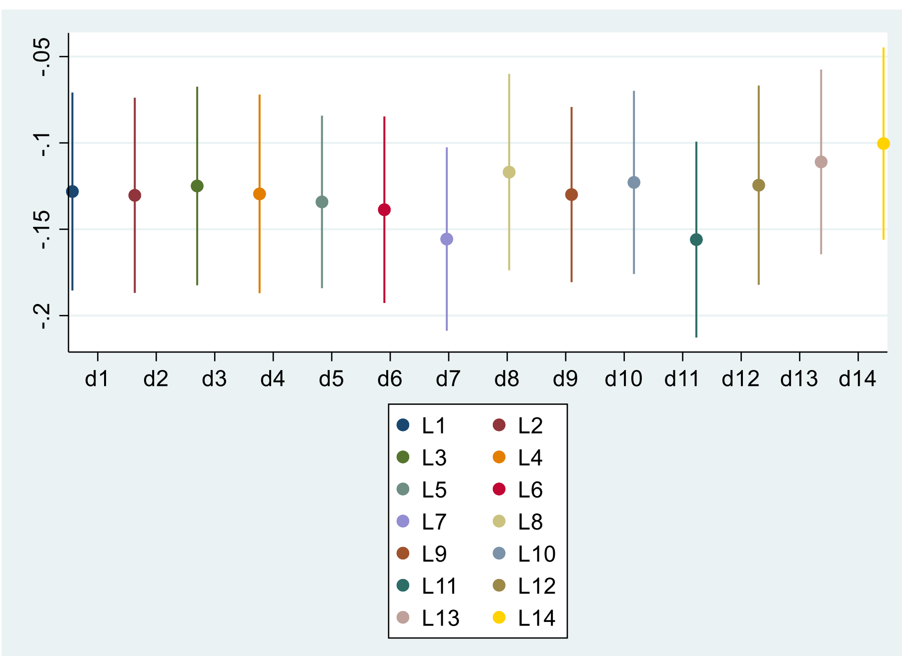
Panel B. Plot of coefficients of the government stringency index classified into bottom, medium, and top terciles (STRINGENCY_TERCILE)



Panel C. Plot of coefficients of the government stringency index adjusted by the median level (STRINGENCY_MEDIAN_ADJUSTED)



Panel D. Plot of coefficients of normalized government stringency index (STRINGENCY_STANDARDIZED)



1. We do not tabulate the correlation matrix to preserve the space. The table is available from the authors upon request.
2. S. Hamidi, S. Sabouri, R. Ewing, Does Density Aggravate the COVID-19 Pandemic? *Journal of the American Planning Association* 86, 495-509 (2020).
3. D. Rubin, *et al.*, Association of social distancing, population density, and temperature with the instantaneous reproduction number of SARS-CoV-2 in counties across the United States. *JAMA network open* 3, e2016099-e2016099 (2020).
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5. H. Coşkun, N. Yıldırım, S. Gündüz, The spread of COVID-19 virus through population density and wind in Turkey cities. *Science of The Total Environment* 751, 141663 (2021).
6. The LOW group includes Algeria, Argentina, Australia, Botswana, Brazil, Canada, Chile, Finland, Iceland, Kazakhstan, Mali, Mongolia, New Zealand, Niger, Norway, Oman, Paraguay, Russia, Saudi Arabia, Suriname, Sweden, Uruguay, and Zambia. The HIGH group includes Bahrain, Bangladesh, Barbados, Belgium, El Salvador, India, Israel, Japan, Lebanon, Mauritius, Netherlands, Philippines, Singapore, South Korea, Sri Lanka, United Kingdom, and Vietnam.
7. Another source of endogeneity is omitted unobservable variables that affect both dependent and independent variables. We use the country level fixed effect to control for this type of variables at the country level. In addition, we use laggard stringency index to mitigate the endogeneity issue in previous regressions.
8. Freedom in the World Index ranks political rights and civil liberties for most of the countries in the world. Please refer to the full methodology for more details: https://freedomhouse.org/reports/freedom-in-the-world/freedom-in-the-world-research-methodology.
9. K. N. Chan, S. Zhao, Punctuated Equilibrium and the Information Disadvantage of Authoritarianism: Evidence from the People's Republic of China. *Policy Studies Journal* 44, 134-155 (2016).
10. F. R. Baumgartner, *et al.*, Budgetary change in authoritarian and democratic regimes. *Journal of European Public Policy* 24, 792-808 (2017).
11. Q. Li, *et al.*, Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. *New England Journal of Medicine* 382, 1199-1207 (2020).