COVID-19 Regulations, Political Institutions, and the Environment

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Abstract

The COVID-19 pandemic was associated with short-term air quality improvements in many countries around the world. We study whether the degree of democracy and political institutions played a role. We provide novel empirical evidence from 119 countries. A given stringency of COVID-19 containment and closure policies had a stronger effect on air quality in more democratic countries, and in countries with majoritarian rather than proportional electoral rules. Our estimates suggest that the improvement in air quality was around 57% greater in majoritarian systems than in proportional systems. Confidence in government, trust in politicians, and social capital also affected outcomes.

Keywords COVID-19 · Infectious disease · Democracy · Electoral system · Institutions · Confidence in government · Trust · Social capital · Rally effect

JEL Classification Q53 · I18 · H11

1 Introduction

The COVID-19 outbreak was declared a global pandemic by the WHO on March 11, 2020. Government responses resulted in lockdowns and mobility restrictions, which led to short-term reductions in air pollution. In this paper, we study the role of democracy and electoral rules for the short-term improvements in air quality resulting from COVID-19 policies. To the best of our knowledge, this is a novel contribution to the literature.

The literature provides estimates of the changes in air quality resulting from the COVID-19 pandemic. Brodeur et al. (2021) find that particulate matter concentration levels declined by approximately 25% in the US and Europe. Sharma et al. (2020) report decreases of $PM_{2.5}$, PM_{10} , CO_2 , and NO_2 of between 10 to 43% in Indian cities, and Li

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et al. (2020) and Liu (2020) report similar declines in China. In contrast, Dang and Trinh (2021) report that across 164 countries, NO_2 and $\text{PM}_{2.5}$ levels fell by only 5 percent and 4 percent, respectively, and that mobility restrictions explain these findings. Meanwhile, the political science, psychology and medical literatures argue that a population's response to a crisis such as the pandemic depends on citizens' trust in government, political institutions, and science (Woelfert and Kunst 2020; Schraff 2021; Esaiasson et al. 2021; Groeniger et al. 2021). Consistent with this view, trust in institutions and government affected adherence to social distancing policies during the Ebola outbreak in Liberia, e.g. (Blair et al. 2017). We test the hypothesis that changes in air pollution resulting from government COVID-19 restrictions depended on the level of democracy and democracies' electoral system. In particular, we focus on proportional and majoritarian electoral systems. We thus help fine-tune our understanding of the short-term impacts on air pollution, a research focus emphasized by, e.g., Helm (2020) and Lee (2021).

If citizens' political trust is higher in democratic governments, compliance with regulations, changes in mobility patterns, and associated pollution reductions should be higher (Marien and Hooghe 2011; Eichengreen et al. 2021). However, the system for selection of government may matter in democracies. In proportional electoral systems, government leadership tends to be more fractionalized than in majoritarian electoral systems. The political and scientific views are likely to differ, resulting in more inconsistent messaging provided by coalition governments (Sagarzazu and Kluver 2017). Differentiated communication and political infighting among government parties are likely to reduce political trust in government in proportional systems. In majoritarian systems, messaging and management during a crisis may be expected to be more in unison and clear, resulting in greater political trust and compliance.¹ These differences may be particularly acute during a crisis such as a pandemic. A crisis may also give rise to "rally-around-the-flag" effects where the government is trusted to a greater degree (Dinesen and Jaeger 2013; Esaiasson et al. 2020; Schraff 2021; Groeniger et al. 2021). Flückiger et al. (2019) show that during the West African Ebola epidemic, trust in government increased with exposure to the epidemic. Using survey data from seven Western European countries, Bol et al. (2021) estimate that lockdowns increased satisfaction with democracy and trust in government by around 2.4–3.2%, and intentions to vote for the party of the head of government rose by 4.1–4.3% (with a total increase of 6% for all governing political parties). However, the 2008 global financial crisis reduced trust in governments according to Earle (2009). Similarly, Skali et al. (2021) find that when Switzerland (with a proportional electoral system) faced crisis during war time, trust in the government declined.

Our empirical work helps shed light on whether rally-around-the-flag effects differ across proportional and majoritarian systems, with consequent differential effects on environmental quality. We provide random effects estimates using panel data from a total of 119 countries. As a measure of air quality, we utilize daily values of satellite-based aerosol optical depth (AOD) from NASA (Platnick et al. 2015) for the period January 3–June 30, 2020. To estimate the change in AOD, the median value of AOD on the same day of the week (e.g., Monday) from January 3–February 6, 2020, is used as the baseline. The regulatory measure is the COVID-19 Stringency Policy Index by Hale et al. (2020) and Polity V is our main democracy measure (Marshall and Jaggers 2018).

¹ One exception is the US, where a high degree of partisanship contributed to reduced compliance with COVID-19 regulations (see, e.g., Clinton et al. 2021).

The estimations suggest that a given increase in the stringency of COVID-19 policies on average reduced daily AOD levels, but the decline was greater in more democratic countries. Within the group of democracies, the marginal AOD reductions were smaller in countries with proportional electoral rules compared to those with majoritarian systems. To help explain these findings, we show differential responses in community mobility. Mobility changes were measured at transit stations, groceries and pharmacies, and workplaces (data provided by Google 2020).

Next, we control for pre-COVID-19 (baseline) levels of confidence in government, trust in politicians, and social capital. Our results for democracies, proportional and majoritarian systems remain robust overall. COVID-19 policies reduced both AOD and mobility by more in countries with greater confidence in government and trust in politicians. Thus, there were rally-around-the-flag effects in countries with these characteristics. However, although social capital reinforced a decline in air pollution, this was not due to the mobility changes included in the analysis. The estimations suggest that the decline in mobility was slightly lower in countries with high social capital. One potential explanation may be that populations in countries with high social capital believed that others within their community would stay socially distant and wear masks, and they therefore would not need to comply and reduce their own mobility to the same degree. Moreover, Woelfert and Kunst (2020) report that social trust was related to a higher growth rate of infections in a study of 65 countries. It appears that in countries with high social capital the decline in air quality occurred to a higher degree via other channels such as declines in industrial production, construction, and long-range transportation (Li et al. 2020). However, the mobility changes help explain the overall impacts of COVID-19 regulations on air quality in democracies, and in proportional and majoritarian systems.

Our results are robust to controlling for risk exposure, the capacity of the health care sector, legal origins, colonial history, and institutional quality. While the literature has previously discussed the relationship between democracy, political institutions, and environmental quality and policy (e.g., Folke 2014; Kammerlander and Schulze 2020; Ang and Fredriksson 2021; Hu and Chen 2021), to our knowledge the questions addressed in the present paper are novel. We believe our findings broaden our understanding of the environmental (and health) effects of government policymaking, in particular during a crisis situation.

The paper is organized as follows. Section 2 discusses the empirical specification and data, and Sect. 3 reports the baseline results. Section 4 introduces measures of government confidence, trust and social capital into the baseline models. Section 5 shows how changes in mobility, conditional on democratic institutions, help explain the changes in pollution. Section 6 reports robustness analysis based on potential vulnerabilities, institutions, demography, instrumental variables, and excluding regions, respectively. Section 7 concludes.

2 Empirical Specification and Data

The following random-effects panel data model is estimated:

$$\begin{aligned} AOD_{i,t} = & \alpha + \beta Stringency_{i,t-1} + \gamma Stringency_{i,t-1} \times Electoralrules_i \\ & + \delta Stringency_{i,t-1} \times Democracy_i + cv'_i \eta + \theta_i + \sigma_t + \varepsilon_{i,t} \end{aligned} \quad (1)$$

AOD is an index of aerosol optical depth in country i on day t , $Stringency$ (lagged one day) is a measure of the rigor of government-imposed policies, $Electoral rules$ is a dummy

variable representing proportional or majoritarian electoral system, *Democracy* is a measure of the degree of democracy, and cv' is a set of control variables which are included both individually and also interacted with *Stringency*. θ_i captures the random disturbance of the i th country, which is constant over time and independent across countries. The specification also allows for time fixed effects, σ_t . $\varepsilon_{i,t}$ is the idiosyncratic error term.²

Daily values of satellite-based aerosol optical depth (AOD) from NASA (Platnick et al. 2015) measure air quality within the period January 3–June 30, 2020. AOD measures the degree to which the dispersion of the solar beam is hindered due to the presence of pollution particles (dust, haze) in the atmosphere (NOAA 2020). Data are drawn from the moderate resolution imaging spectroradiometer (MODIS) aboard NASA's Terra satellite. An AOD value of 0.01 indicates a clean and clear sky, 0.5 is hazy, and values of 1–3 or greater correspond to highly polluted air. For instance, on 11th February 2020, Norway had an average AOD value of 0.05, Bangladesh was at 0.6, while Ghana recorded an average AOD value of 2.5. We construct the AOD variable by measuring the change in AOD on a day relative to baseline days, where a baseline day is the median value of AOD on the same day of the week (e.g., Monday) from January 3–February 6, 2020. A negative AOD value indicates a decrease in pollution relative to the baseline period, while a positive value reflects an increase in pollution. The baseline period is selected such that few countries had taken strong action yet. The subsequent study period, February 7–June 30, 2020, is chosen mainly due to data availability, but has the advantage that major investments or changes in trade and demand patterns are less likely to strongly influence our results.

AOD provides an indirect but precise proxy of air quality. While PM 2.5, NO₂ and CO₂ are common measures of air pollution in the literature, we use AOD data due to its wide geographic and temporal coverage. Multiple previous studies have relied on AOD data as a measure of air quality, and also demonstrated a positive correlation between AOD, PM2.5 and PM10 (see, e.g., Hutchison 2003; Engel-Cox et al. 2004; Hu and Rao 2009; Gutierrez 2010; Khoshima et al. 2014; Kong et al. 2016). Using AOD data has advantages in comparison to the sparse coverage by other air quality measures. For example, AOD appears preferable to PM2.5, which is dependent upon the availability of ground-level air quality monitoring stations; their coverage differ across regions depending on geographic and economic factors (Shi et al. 2018). Furthermore, since aerosols are also known to disrupt atmospheric stability and hydrological cycles, it provides us with added information on air quality (Li et al. 2007; IPCC, 2013). Figure 1 shows the spatial distribution of AOD across countries.

We use the COVID-19 Stringency Policy Index by Hale et al. (2020), which measures regulations including school closings, workplace closings, cancellation of public events, restrictions on gatherings, closure of public transport, stay at home requirements, restrictions on internal movement, international travel controls, and provision of public information campaigns. For example, the raw sub-index for school closings ranges between 0 and 3:0 (no measures); 1 (recommended closing); 2 (required closing, but only for some school types or age groups, e.g., just high schools or just public

² We use standard errors for generalized least square estimates. Abadie et al. (2017) argue that the decision to use clustered standard errors depends on the sampling design. Clustered standard errors should be utilized if the analysis contains a small sample from a larger population and the sampling varies systematically with groups in the sample. In this paper, we use a global cross-country analysis. This ensures that all clusters in the population of interest are sufficiently represented in the sample. Thus, we do not use clustered standard errors.

Fig. 1 Distribution of the average change in AOD across countries *Notes:* The figure shows the spatial variation in the average change in AOD from the base period January 3–February 6, 2020, to February 7–June 30, 2020, for 119 countries

schools); 3 (required closing of all levels). The sub-index for closure of public transport may take three different values: 0 (no measures); 1 (recommended closing, or significantly reduce volume/route/means of transport available); 2 (required closing, or prohibit most citizens from using public transport). Moreover, the value for each measure is interacted with an indicator variable which takes a value of zero if the measure is targeted only locally, and unity if the policy applies generally. The daily variable is constructed by measuring the change in *Stringency* relative to the baseline day, the median value on the same day of the week January 3–February 6, 2020. The index is then rescaled from 0 to 1. A positive value of *Stringency* indicates an increase in the stringency of policies relative to the baseline period. Figure 2 shows the spatial distribution of *Stringency* across countries. The mean of *Stringency* is 0.44 and 0.45 in democracies and autocracies, respectively.

IDEA (2018) provides data on electoral systems; Marshall and Jaggers (2018) provide the Polity V democracy measure. We rescaled the original Polity V scale from -10 to 10, to 0 to 10, where a higher value reflects a stronger democracy. We define autocracies as countries with a score in the 0 to 2 range, and democracies as those with a score above 2. We have data on 49 proportional system democracies, 24 majoritarian system democracies, 6 proportional system autocracies, and 13 majoritarian system autocracies (IDEA 2018). We also have 20 democracies (e.g., Germany, Italy, Japan and South Korea) and 7 autocracies that are neither proportional nor majoritarian systems.

The control variables are the share of the manufacturing sector in GDP, vehicles/1000 inhabitants, climate change policy stringency, KOF globalization index, GDP/capita. These variables control for the level of pollution related to polluting production and consumption, transportation, environmental regulations, and trade patterns (Shapiro and Walker 2018; Wang 2021). The controls are entered individually and as *Stringency* interactions.

Fig. 2 Distribution of the average change in *Stringency* across countries *Notes:* The figure shows the spatial variation in the average change in *Stringency* from the base period January 3–February 6, 2020, to February 7–June 30, 2020, for 119 countries

Tables 9, 10, 11 in the Appendix provide definitions, sources, and summary statistics for all variables.

3 Baseline Results

Columns (1)–(3) in Table 1 provide baseline estimates of the effect of *Stringency* on *AOD*, including the interactions with *Democracy*, *Proportional*, and *Majoritarian*. The sample includes all autocracies. The marginal effect of *Stringency* is reported in each column. Column (1) suggests that *Stringency* has a negative effect on *AOD*, and the effect is stronger the higher the level of *Democracy*. Next, the effect of *Stringency* is smaller in proportional systems than in majoritarian systems. The estimate in column (2) suggests that (taking all interactions between control variables and *Stringency* into account) the estimated marginal effect of one standard deviation change in *Stringency* equals -0.111 in proportional systems, while column (3) indicates that this effect equals -0.174 in majoritarian systems (evaluated at the mean of all variables). Thus, the marginal change in *AOD* is 57% greater in majoritarian systems, where the negative effect equals 0.83 of a standard deviation. Columns (4)–(6) use an alternative *Democracy* measure, created by principal component analysis of four different democracy measures (Polity V; Vanhanen 2019; EIU 2018; Freedom House 2018). The results remain robust.³

³ The results remain robust when using these democracy indices individually (results available upon request). Note also that Vanhanen (2019) lacks data on Afghanistan and Ireland, reducing the number of observations in the principal component analysis.

Table 1 Democratic institutions: main results

<i>Dep. Var. = AOD</i>	(1) Democracy	(2) Proportional	(3) Majoritarian	(4) PCA Democracy	(5) Proportional PCA Democracy	(6) Majoritarian PCA Democracy
<i>Stringency</i>	−0.304*** (0.056)	−0.221*** (0.057)	−0.139** (0.058)	−0.401*** (0.058)	−0.345*** (0.058)	−0.251*** (0.059)
<i>Proportional</i>		−0.010 (0.016)			−0.008 (0.015)	
<i>Stringency × Proportional</i>		0.074*** (0.008)			0.084*** (0.009)	
<i>Majoritarian</i>			0.009 (0.017)			0.007 (0.016)
<i>Stringency × Majoritarian</i>			−0.098*** (0.009)			−0.102*** (0.010)
<i>Democracy</i>	−0.003 (0.003)	−0.003 (0.003)	−0.003 (0.003)	−0.009 (0.006)	−0.009 (0.006)	−0.009 (0.006)
<i>Stringency × Democracy</i>	−0.004*** (0.001)	−0.007*** (0.001)	−0.008*** (0.001)	−0.020*** (0.003)	−0.028*** (0.003)	−0.028*** (0.003)
<i>Manufacturing</i>	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	−0.000 (0.001)	−0.000 (0.001)	−0.000 (0.001)
<i>Stringency × Manufacturing</i>	0.003*** (0.001)	0.003*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
<i>Vehicles</i>	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<i>Stringency × Vehicles</i>	−0.000* (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
<i>CCPS</i>	0.050 (0.066)	0.049 (0.065)	0.049 (0.066)	0.063 (0.066)	0.063 (0.065)	0.063 (0.066)
<i>Stringency × CCPS</i>	−0.157*** (0.035)	−0.140*** (0.035)	−0.120*** (0.035)	−0.125*** (0.038)	−0.092** (0.038)	−0.075** (0.038)

Table 1 (continued)

Dep. Var. = AOD	(1)	(2)	(3)	(4)	(5)	(6)
	Democracy	Proportional	Majoritarian	PCA Democracy	Proportional PCA Democracy	Majoritarian PCA Democracy
<i>KOF</i>	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)
<i>Stringency</i> × <i>KOF</i>	0.005*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.006*** (0.001)	0.005*** (0.001)	0.005*** (0.001)
<i>GDP</i>	−0.005 (0.015)	−0.004 (0.015)	−0.004 (0.015)	−0.005 (0.015)	−0.004 (0.014)	−0.004 (0.015)
<i>Stringency</i> × <i>GDP</i>	0.005 (0.008)	−0.001 (0.008)	−0.003 (0.008)	0.004 (0.008)	−0.002 (0.008)	−0.003 (0.008)
Marginal effect	−0.147	−0.092	−0.111	−0.174	−0.120	−0.141
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
R – squared	0.041	0.046	0.048	0.048	0.056	0.057
Observations	21,355	21,355	21,355	20,826	20,826	20,826
No. of countries	119	119	119	117	117	117

This table reports random-effect estimates using data at the country-day level. The Hausman test is validated in all models. Standard errors in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively. Baseline control variables are included individually and in interactions with *Stringency*: share of manufacturing, vehicles per 1000 inhabitants, climate change stringency policy (CCPS), KOF globalization index, and GDP per capita

4 Confidence, Trust and Social Capital

Marien and Hooghe (2011) report that lower levels of political trust are associated with lower compliance with the law. The general population's response to the pandemic depends on their trust in government, political institutions, and science (Esaiaasson et al. 2021; Schraff, 2021; Woelfert and Kunst, 2020; Groeniger et al. 2021). However, the level of trust may change as a result of the pandemic (Bol et al. 2021; Skali et al. 2021). Here we study whether a given stringency of COVID-19 policies have differential effects on pollution, conditional on pre-pandemic levels of trust. We also study whether the effect of stringency depends on several forms of trust, yielding rally-around-the-flag effects.

Table 2 includes measures of the degree of confidence in government and the level of trust in politicians. *Government Confidence* (columns (1)–(3)) and *Trust in Politicians* (columns (4)–(6)) are the national averages of individual WVS (2015) and World Economic Forum (2017) survey responses, respectively. In columns (7)–(9), we utilize *Social Capital* from the World Economic Forum (2018), which measures trust among the general public and society overall. It may provide a partial or indirect measure of trust in government. These three baseline measures were created before the COVID-19 pandemic. Including these in the analysis helps us detect if rally-around-the-flag effects depended on pre-existing trust. Moreover, we are more likely to be able to discern differences in behavioral responses to changes in *Stringency* between proportional versus majoritarian systems, since the *Stringency* measure applies exclusively to the COVID-19 pandemic.

According to all columns in Table 2, the effect of *Stringency* on AOD is greater in democracies. Moreover, accounting for confidence in government and trust in politicians, the differential effect across proportional and majoritarian systems of *Stringency* remains. For example, according to column (2), at the mean values of *Confidence in Government* and *Democracy* (including the insignificant direct effect of *Stringency*), the estimated marginal effect of one standard deviation change in *Stringency* equals -0.127 in proportional systems. According to column (3), in majoritarian systems the marginal effect equals -0.141 (including the insignificant direct effect of *Stringency*). Thus, the marginal change is 11% greater in majoritarian systems.⁴ Moreover, *Stringency* has a more negative effect on AOD the greater the level of *Government Confidence*, *Trust in Politicians*, and *Social Capital*. This indicates rally-around-the-flag effects.

5 Mobility Changes

In this section, we study whether changes in mobility help explain the estimated effects. To measure the effect of *Stringency* on mobility, we use data on mobility trends from the Google Community Mobility Reports (Google 2020). Mobility reductions are measured at transit stations, groceries and pharmacies, and workplaces. The change in the daily movement in each of these areas is compared to the baseline day, defined as the median value of movement in an area on the same day of the week during the time period January 3–February 6, 2020.

⁴ To the best of our knowledge, the literature appears not to have addressed how to determine statistically significant differences in cases with multiple interaction terms and panel data.

Table 2 Democratic institutions, confidence in government, trust in politicians, social capital, and air pollution

<i>Dep. Var. = AOD</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Confidence in Government	Proportional	Majoritarian	Trust in Politicians	Proportional	Majoritarian	Social Capital	Proportional	Majoritarian
<i>Stringency</i>	-0.150 (0.094)	-0.071 (0.094)	-0.061 (0.096)	-0.228*** (0.063)	-0.135** (0.064)	-0.047 (0.066)	-0.181*** (0.068)	-0.127* (0.069)	-0.107 (0.069)
<i>Proportional</i>		-0.013 (0.020)			-0.013 (0.016)			-0.011 (0.016)	
<i>Stringency × Proportional</i>		0.078*** (0.010)			0.073*** (0.009)			0.066*** (0.009)	
<i>Majoritarian</i>			0.012 (0.027)			0.009 (0.018)			0.012 (0.019)
<i>Stringency × Majoritarian</i>			-0.066*** (0.014)			-0.099*** (0.010)			-0.092*** (0.011)
<i>Govt Confidence</i>	-0.027 (0.118)	-0.032 (0.116)	-0.043 (0.125)						
<i>Stringency × Govt Confidence</i>	-0.277*** (0.060)	-0.236*** (0.060)	-0.183*** (0.063)						
<i>Trust in Politicians</i>				-0.003 (0.007)	-0.004 (0.007)	-0.004 (0.007)			
<i>Stringency × Trust in Politicians</i>				-0.017*** (0.004)	-0.015*** (0.004)	-0.013*** (0.004)			
<i>Social Capital</i>							-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)
<i>Stringency × Social Capital</i>							-0.003*** (0.001)	-0.003*** (0.001)	-0.002* (0.001)
<i>Democracy</i>	-0.002 (0.004)	-0.002 (0.004)	-0.002 (0.004)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.002 (0.003)
<i>Stringency × Democracy</i>	-0.005** (0.002)	-0.007*** (0.002)	-0.006*** (0.002)	-0.009*** (0.002)	-0.011*** (0.002)	-0.012 (0.002)	-0.005*** (0.001)	-0.006*** (0.001)	-0.008*** (0.001)
<i>Marginal effect</i>	-0.189	-0.127	-0.141	-0.163	-0.100	-0.125	-0.090	-0.055	-0.088
<i>Baseline controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2 (continued)

<i>Dep. Var.</i> = AOD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Confidence in Government	Proportional	Majoritarian	Trust in Politicians	Proportional	Majoritarian	Social Capital	Proportional	Majoritarian
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R – squared	0.050	0.057	0.052	0.050	0.055	0.057	0.050	0.055	0.056
Observations	12,920	12,920	12,920	19,034	19,034	19,034	19,043	19,043	19,043

See Table 1

Table 3 Mobility reductions and electoral systems

Dep. Var. =	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Transit stations (percentage reduction from baseline)	Workplace mobility (percentage reduction from baseline)		Groceries and pharmacies (percentage reduction from baseline)		Average mobility index (percentage average reduction from baseline)		Majoritarian		Majoritarian		
	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian
<i>Stringency</i>	23.356 ^{***} (3.624)	23.253 ^{***} (3.620)	21.662 ^{***} (3.621)	57.971 ^{***} (3.878)	58.013 ^{***} (3.878)	56.409 ^{***} (3.877)	12.311 ^{***} (4.315)	12.300 ^{***} (4.315)	11.455 ^{***} (4.321)	31.242 ^{***} (3.463)	31.211 ^{***} (3.462)	29.868 ^{***} (3.463)
<i>Proportional</i>		-0.805 (1.308)			-1.443 (1.104)			-0.880 (1.300)			-1.051 (1.129)	
<i>Stringency × Proportional</i>		-3.183 ^{***} (0.468)			-1.040 ^{***} (0.501)			-1.427 ^{**} (0.558)			-1.885 ^{***} (0.447)	
<i>Majoritarian</i>			0.179 (1.438)			0.194 (1.214)			0.187 (1.435)			0.187 (1.245)
<i>Stringency × Majoritarian</i>			5.379 ^{***} (0.561)			4.978 ^{***} (0.601)			2.772 ^{***} (0.670)			4.377 ^{***} (0.537)
<i>Democracy</i>	0.100 (0.215)	0.132 (0.221)	0.107 (0.220)	0.082 (0.182)	0.135 (0.185)	0.090 (0.186)	0.120 (0.213)	0.152 (0.219)	0.126 (0.220)	0.100 (0.186)	0.140 (0.190)	0.108 (0.191)
<i>Stringency × Democracy</i>	-0.382 ^{***} (0.081)	-0.362 ^{***} (0.081)	-0.287 ^{***} (0.082)	-0.384 ^{***} (0.087)	-0.380 ^{***} (0.087)	-0.296 ^{***} (0.088)	-1.244 ^{***} (0.097)	-1.236 ^{***} (0.097)	-1.196 ^{***} (0.098)	-0.670 ^{***} (0.078)	-0.659 ^{***} (0.078)	-0.593 ^{***} (0.078)
Marginal effect	9.764	8.381	10.616	19.308	18.422	20.105	15.677	14.866	16.147	14.930	13.896	15.636
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.818	0.819	0.820	0.760	0.761	0.762	0.577	0.578	0.578	0.770	0.771	0.772
Observations	17,559	17,559	17,559	17,559	17,559	17,559	17,559	17,559	17,559	17,559	17,559	17,559

Notes: See Table 1

Columns (1)–(3) in Table 3 use the percentage reduction in mobility at transit stations as a dependent variable, columns (4)–(6) use the percentage reduction in workplace mobility, and columns (7)–(9) employ the percentage reduction in mobility in groceries and pharmacies. Columns (10)–(12) use an average of the mobility changes in columns (1)–(9). The marginal effects of *Stringency* are calculated taking all interactions into account (not all coefficients reported).

All columns in Table 3 suggest that the marginal effect of *Stringency* on mobility reductions is lower in more democratic countries. Thus, the greater effects of *Stringency* on air pollution in democracies found in Tables 1 and 2 are not due to mobility changes of the forms studied here. The greater civil liberties enjoyed in democracies may have resulted in a lower level of compliance with mobility restrictions. The stringency measures implemented in democracies may also have had a different focus or been enforced less strictly, therefore having a relatively smaller effect on mobility. Moreover, we may have incomplete data on mobility reductions. For example, emissions from international air travel and the manufacturing sector may have fallen more in democracies. Saha et al. (2017) find that the level of civil liberties was positively correlated with inbound tourism in 110 countries during 1995–2012. A sharper decline in tourism and international travel in democracies may help explain our findings. In addition, Acemoglu et al. (2019) find that democracy has a positive effect on per capita GDP and capital investments. The marginal effect of COVID-19 restriction on economic activity and pollution may therefore have been relatively larger. Note also that relative to the direct effect of *Stringency*, the effect of democracy is quite small, except perhaps in columns (7)–(9).

Next, the differential effects in proportional and majoritarian systems are consistent with the results for AOD in Tables 1 and 2. For example, according to the estimates in column (2), the marginal reduction in mobility of a one standard deviation increase in *Stringency* in proportional systems equals 8.381. This is 29.5% of a standard deviation of mobility at transit stations. Based on column (3), the corresponding effect in majoritarian systems equals 10.616, or 37.3%. The pattern is similar in columns (5)–(6), (8)–(9) and (11)–(12). Thus, the effects of more stringent COVID-19 regulations on mobility are relatively smaller in proportional systems than in majoritarian systems. This helps explain the differential effects on AOD.

Table 4 investigates the effect of stringency on mobility, taking institutions and culture into consideration. The average mobility index (from Table 3) is utilized in all columns. Columns (1)–(3) utilize our measure of confidence in government, columns (4)–(6) employ the measure of trust in politicians, and columns (7)–(9) include our measure of social capital. The impact of *Stringency* on mobility remains lower in democracies (except in columns (1)–(3) with insignificant *Democracy* interactions, perhaps due to a decline in observations) and proportional systems, but greater in majoritarian systems and where trust in government and government confidence are higher.⁵ This indicates that rally-around-the-flag effects occurred in such countries. Columns (7)–(9) suggest that the marginal effect of *Stringency* on mobility is relatively smaller where social capital is greater. The population in these countries potentially had a harder time giving up social activities. Alternatively, they may have believed that other citizens would practice social distancing, wear protective

⁵ Based on WVS (2015), the average level of confidence in government in proportional systems equals 0.34 and 0.44 in majoritarian systems. According to World Economic Forum (2018) the average level of trust in politicians in proportional systems equals 0.32, and 0.33 in majoritarian systems (higher values represent greater levels of trust).

Table 4 Democratic Institutions, Confidence in Government, Trust in Politicians, Social Capital, and Mobility

<i>Dep. Var. = Mobility reduction</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Confidence in Government		Trust in Politicians		Social Capital		Social Capital		
	Democracy	Proportional	Majoritarian	Democracy	Proportional	Majoritarian	Democracy	Proportional	Majoritarian
<i>Stringency</i>	-7.567 (6.152)	-7.889 (6.141)	-7.457 (6.155)	10.559*** (3.931)	9.316** (3.934)	7.051* (3.955)	35.834*** (3.944)	36.055*** (3.943)	35.432*** (3.939)
<i>Proportional</i>		-0.469 (1.347)			-0.789 (1.285)			-0.911 (1.238)	
<i>Stringency × Proportional</i>		-3.429*** (0.551)			-2.714*** (0.479)			-1.633*** (0.456)	
<i>Majoritarian</i>			-0.313 (1.856)			-0.007 (1.464)			0.192 (1.463)
<i>Stringency × Majoritarian</i>			-1.043 (0.775)			4.294*** (0.580)			3.869*** (0.573)
<i>Trust in Politicians</i>				-0.276 (0.585)	-0.286 (0.587)	-0.249 (0.588)			
<i>Stringency × Trust in Politicians</i>				1.751*** (0.215)	1.623*** (0.216)	1.497*** (0.218)			
<i>Confidence in Government</i>	1.459 (8.150)	1.411 (8.014)	1.859 (8.614)						
<i>Stringency × Confidence in Government</i>	14.842*** (4.250)	13.760*** (4.246)	16.423*** (4.408)						
<i>Social Capital</i>							0.050 (0.114)	0.044 (0.115)	0.045 (0.118)
<i>Stringency × Social Capital</i>							-0.631*** (0.044)	-0.641*** (0.044)	-0.690*** (0.045)
<i>Democracy</i>	0.077 (0.271)	0.098 (0.269)	0.065 (0.280)	0.072 (0.228)	0.094 (0.230)	0.076 (0.231)	0.089 (0.213)	0.116 (0.217)	0.096 (0.220)
<i>Stringency × Democracy</i>	-0.127 (0.114)	-0.136 (0.114)	-0.137 (0.114)	-0.323*** (0.089)	-0.328*** (0.089)	-0.286*** (0.089)	-0.429*** (0.080)	-0.418*** (0.080)	-0.336*** (0.081)
<i>Marginal effect</i>	5.777	4.004	5.657	6.296	4.182	6.648	19.918	19.238	21.002

Table 4 (continued)

<i>Dep. Var. = Mobility reduction</i>	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Confidence in Government		Trust in Politicians		Social Capital		Democracy		Majoritarian		Proportional		Democracy		Majoritarian		Proportional	
	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional	Democracy	Proportional
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.795	0.797	0.795	0.775	0.774	0.775	0.774	0.775	0.775	0.775	0.775	0.775	0.779	0.780	0.780	0.780	0.780	0.780
Observations	10,880	10,880	10,880	16,181	16,181	16,181	16,181	16,181	16,181	16,181	16,181	16,181	16,184	16,184	16,184	16,184	16,184	16,184

See Table 1

Table 5 Vulnerabilities

<i>Dep. Var. = AOD</i>	(1)	(2)	(3)	(4)	(5)	(6)
	PCA high exposure		Health system capacity specific to COVID – 19		General health system capacity	
	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian
<i>Stringency</i>	–0.221*** (0.057)	–0.139** (0.058)	–0.221*** (0.057)	–0.139** (0.058)	–0.221*** (0.057)	–0.139** (0.058)
<i>Proportional</i>	–0.010 (0.016)		–0.011 (0.016)		–0.009 (0.016)	
<i>Stringency × Proportional</i>	0.074*** (0.008)		0.073*** (0.008)		0.074*** (0.008)	
<i>PCA high exposure</i>	0.003 (0.008)	0.003 (0.008)				
<i>Majoritarian</i>		0.009 (0.017)		0.010 (0.017)		0.009 (0.017)
<i>Stringency × Majoritarian</i>		–0.098*** (0.009)		–0.098*** (0.009)		–0.098*** (0.009)
<i>Health capacity (Covid – 19)</i>			0.005 (0.005)	0.005 (0.005)		
<i>Health system capacity</i>					–0.001 (0.004)	0.000 (0.004)
<i>Democracy</i>	–0.003 (0.003)	–0.003 (0.003)	–0.003 (0.003)	–0.003 (0.003)	–0.003 (0.003)	–0.003 (0.003)
<i>Stringency × Democracy</i>	–0.007*** (0.001)	–0.008*** (0.001)	–0.007*** (0.001)	–0.008*** (0.001)	–0.007*** (0.001)	–0.008*** (0.001)
<i>Marginal effect</i>	–0.090	–0.110	–0.086	–0.105	–0.092	–0.112
<i>Baseline controls</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Time dummies</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>R-squared</i>	0.046	0.048	0.047	0.050	0.046	0.048
<i>Observations</i>	21,355	21,355	21,355	21,355	21,355	21,355

See Table 1

masks, and stay safe, and they therefore would not need to reduce their own mobility to the same extent.⁶ This appears consistent with Woelfert and Kunst (2020), who in a study of 65 countries find that social trust was related to a higher growth rate of infections. In these countries, the decline in air quality may to a higher degree have occurred via other channels such as declines in industrial production, construction, and long-range transportation (Li et al. 2020). However, the mobility changes do help explain the overall impacts of COVID-19 regulations on air quality in democracies, and in proportional and majoritarian systems.

⁶ This is similar to Guglielmi et al. (2021), who argue that Italians who had a favorable appraisal of regional institutions felt safer from the virus, reducing compliance with restrictions.

Table 6 Additional confounders

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Dep. Var.</i> = AOD	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian
<i>Stringency</i>	−0.239*** (0.057)	−0.143** (0.059)	−0.194*** (0.057)	−0.104* (0.058)	−0.216*** (0.057)	−0.135** (0.058)
<i>Proportional</i>	−0.023 (0.017)		−0.009 (0.016)		−0.003 (0.017)	
<i>Proportional</i> × <i>Stringency</i>	0.073*** (0.008)		0.079*** (0.009)		0.074*** (0.008)	
<i>Majoritarian</i>		0.029 (0.020)		0.011 (0.017)		0.013 (0.019)
<i>Majoritarian</i> × <i>Stringency</i>		−0.097*** (0.010)		−0.107*** (0.010)		−0.098*** (0.009)
<i>Democracy</i>	−0.001 (0.003)	−0.001 (0.003)	−0.002 (0.003)	−0.002 (0.003)	−0.003 (0.003)	−0.003 (0.003)
<i>Stringency</i> × <i>Democracy</i>	−0.007*** (0.001)	−0.008*** (0.001)	−0.007*** (0.001)	−0.008*** (0.001)	−0.007*** (0.001)	−0.008*** (0.001)
Marginal effect	−0.085	−0.088	−0.090	−0.109	−0.089	−0.109
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Legal Origins dum- mies	Yes	Yes	No	No	No	No
Institutions	No	No	Yes	Yes	No	No
Colony dummies	No	No	No	No	Yes	Yes
R-squared	0.056	0.056	0.049	0.051	0.067	0.067
Observations	21,180	21,180	20,815	20,815	21,177	21,177

See Table 1

6 Robustness Analysis

6.1 Vulnerabilities

In this section, we control for vulnerabilities that may affect behavior and thus the effect of regulations on pollution during the pandemic. Columns (1)–(2) in Table 5 control for risk exposure. This is the first principal component of three measures that reflect risk exposure: population density, net migration and urbanization (see, e.g., Noy et al. 2020). In columns (3)–(4) we control for the health system capacity specific to COVID-19 and in columns (5)–(6) for country-level health system capacity in general. In all cases, the results are consistent with our baseline findings.

6.2 Institutions

The efficacy of government interventions can vary greatly based on legal origin, institutional quality and colonial origin (Fredriksson and Wollscheid 2015; La Porta et al. 2018; Ang and Fredriksson 2021). We control for these factors in Table 6. The results remain robust. The marginal effect of *Stringency* on AOD is stronger the greater is *Democracy* and in majoritarian systems. The marginal effect is relatively weaker in proportional systems.

Table 7 Demography

<i>Dep. Var. = AOD</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Population density	Proportional	Majoritarian	Urbanization	Proportional	Majoritarian	Human Capital	Proportional	Majoritarian
<i>Stringency</i>	-0.291 ^{***} (0.056)	-0.213 ^{***} (0.057)	-0.137 ^{**} (0.058)	-0.375 ^{***} (0.059)	-0.304 ^{***} (0.059)	-0.221 ^{***} (0.061)	-0.238 ^{***} (0.058)	-0.139 ^{***} (0.059)	-0.063 (0.060)
<i>Proportional</i>		-0.010 (0.016)			-0.011 (0.016)			-0.010 (0.016)	
<i>Stringency × Proportional</i>		0.072 ^{***} (0.008)			0.077 ^{***} (0.008)			0.078 ^{***} (0.009)	
<i>Majoritarian</i>			0.009 (0.017)			0.010 (0.017)			0.010 (0.017)
<i>Stringency × Majoritarian</i>			-0.097 ^{***} (0.010)			-0.102 ^{***} (0.009)			-0.108 ^{***} (0.010)
<i>Population density</i>	0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)						
<i>Stringency × Population density</i>	-0.001 ^{***} (0.001)	-0.001 ^{**} (0.001)	-0.001 (0.001)						
<i>Urbanization</i>				0.001 (0.001)	0.001 (0.001)	0.001 (0.001)			
<i>Stringency × Urbanization</i>				-0.001 ^{***} (0.001)	-0.001 ^{***} (0.001)	-0.001 ^{***} (0.001)			
<i>Human Capital</i>							0.004 (0.138)	0.003 (0.138)	0.010 (0.137)
<i>Stringency × Human Capital</i>							0.314 ^{***} (0.073)	0.337 ^{***} (0.073)	0.275 ^{***} (0.073)
<i>Democracy</i>	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.003 (0.003)	-0.002 (0.003)	-0.002 (0.003)
<i>Stringency × Democracy</i>	-0.005 ^{***} (0.001)	-0.007 ^{***} (0.001)	-0.008 ^{***} (0.001)	-0.005 ^{***} (0.001)	-0.008 ^{***} (0.001)	-0.008 ^{***} (0.001)	-0.004 ^{***} (0.001)	-0.006 ^{***} (0.001)	-0.007 ^{***} (0.001)
<i>Marginal effect</i>	-0.140 Yes	-0.089 Yes	-0.110 Yes	-0.170 Yes	-0.117 Yes	-0.137 Yes	-0.037 Yes	0.029 Yes	-0.011 Yes
<i>Baseline controls</i>									

Table 7 (continued)

<i>Dep. Var.</i> = AOD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Population density	Proportional	Majoritarian	Urbanization	Proportional	Majoritarian	Human Capital	Proportional	Majoritarian
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.041	0.046	0.048	0.041	0.047	0.049	0.043	0.049	0.053
Observations	21,355	21,355	21,355	21,355	21,355	21,355	20,816	20,816	20,816

See Table 1

6.3 Demography

Next, we look at demographic variables that may affect stringency during the pandemic: population density, urbanization and human capital. Table 7 shows that in all cases the baseline results remain robust to the addition of the demographic confounders.

6.4 Instrumental Variable Estimates

In this section, we provide instrumental variable estimates to mitigate concerns about endogeneity. First, we use the daily cumulative number of COVID-19 cases as an instrument for *Stringency*. This is a suitable instrument as stringency regulations were progressively raised with increases in COVID-19 cases. However, the cumulative number of cases is also unlikely to directly lead to AOD changes, and this IV is therefore likely to satisfying the exclusion restriction. All control variables interacted with *Stringency* are also instrumented. The IV-2SLS results are reported in panel (a) in Table 8. Columns (1)–(2) use the cumulative number of COVID-19 cases lagged by one day, and columns (3)–(4) lag the instrument by five days. The lags account for the time it takes to implement and make social mobility restrictions effective. The results are largely consistent with the main findings.

Second, we utilize a measure of the potential increase in crop yield due to irrigation in agriculture (irrigation potential) as an instrument to exploit the exogenous variation of democracy. Bentzen et al. (2017) compile this measure of irrigation potential based on data from the Food and Agriculture Organization's (FAO) global Agro-Ecological Zones (GAEZ) 2002 database. Bentzen et al. (2017) find that countries with greater irrigation potential are less democratic in the present day. The IV-2SLS results reported in panel (b) of the Table 8 remain robust.

Using the critical values provided by Stock and Yogo (2005), the Cragg and Donald (1993) weak identification test rejects the null that the instruments are only weakly correlated with the endogenous regressors. The Anderson-Rubin (1949) and Stock-Wright (2000) tests reject the null hypothesis (at the 1% level) that the coefficients of the excluded instruments are jointly equal to zero. This indicates that the excluded instruments are statistically significant.

6.5 Excluding Regions

In Table 12 in the Appendix we study whether our main results are sensitive to excluding regions. Sequentially, we drop countries in Asia (columns (1)–(3)), Africa (columns (4)–(6)), the Americas (columns (7)–(9)), Europe (columns (10)–(12)), and Oceania (columns (13)–(15)). The main results remain consistent overall. However, while the interactions of interest remain significant with consistent signs when we exclude the African continent, the direct effect of *Stringency* is positive.⁷

⁷ This may be a topic for future research.

Table 8 Instrumental variable estimates

	(1)	(2)	(3)	(4)
Dep. Var. = AOD	IV = COVID – 19 cases ($t - 1$)		IV = COVID – 19 cases ($t - 5$)	
Panel (a)				
<i>Stringency</i>	– 0.066 (0.072)	0.097 (0.073)	– 0.028 (0.075)	0.140* (0.076)
<i>Proportional</i> × <i>Stringency</i>	0.072*** (0.009)		0.072*** (0.010)	
<i>Majoritarian</i> × <i>Stringency</i>		– 0.139*** (0.011)		– 0.142*** (0.011)
<i>Stringency</i> × <i>Democracy</i>	– 0.008*** (0.002)	– 0.010*** (0.002)	– 0.007*** (0.002)	– 0.009*** (0.002)
Baseline controls	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
R-squared	0.037	0.039	0.035	0.036
Observations	21,236	21,236	20,760	20,760
Diagnostic tests				
Cragg–Donald Wald F statistic	574.64 [5% c.v. = 20.25]	574.10 [5% c.v. = 20.25]	540.99 [5% c.v. = 20.25]	542.24 [5% c.v. = 20.25]
Anderson–Rubin Wald test	260.68 [$p = 0.000$]	382.75 [$p = 0.000$]	253.68 [$p = 0.000$]	370.65 [$p = 0.000$]
Stock–Wright LM S statistic	257.52 [$p = 0.000$]	375.98 [$p = 0.000$]	250.61 [$p = 0.000$]	364.15 [$p = 0.000$]
	(1)	(2)	(3)	
Dep. Var. = AOD	IV = Irrigation potential			
Panel (b)				
<i>Stringency</i>	– 0.268*** (0.058)	– 0.125** (0.061)	– 0.033 (0.063)	
<i>Proportional</i> × <i>Stringency</i>		0.099*** (0.010)		
<i>Majoritarian</i> × <i>Stringency</i>			– 0.126*** (0.011)	
<i>Stringency</i> × <i>Democracy</i>	– 0.016*** (0.003)	– 0.024*** (0.003)	– 0.022*** (0.003)	
Baseline controls	Yes	Yes	Yes	
Time dummies	Yes	Yes	Yes	
R-squared	0.036	0.037	0.042	
Observations	21,176	21,176	21,176	
Diagnostic tests				
Cragg–Donald Wald F statistic	4913.78 [5% c.v. = 20.25]	4296.18 [5% c.v. = 20.25]	4806.47 [5% c.v. = 20.25]	
Anderson–Rubin Wald test	41.97 [$p = 0.000$]	66.86 [$p = 0.000$]	52.71 [$p = 0.000$]	
Stock–Wright LM S statistic	41.88 [$p = 0.000$]	66.65 [$p = 0.000$]	52.58 [$p = 0.000$]	

See Table 1

7 Conclusion

In this paper, we test the hypothesis that the effect of COVID-19 regulations on air pollution is conditional on the level of democracy and on electoral rules. By controlling for the level of confidence in government, trust in politicians, and social capital, we seek to understand whether any rally-around-the-flag effects occurred. We find that a given COVID-19 policy stringency yielded improvements in air quality roughly 57% greater in majoritarian systems than in proportional systems. Mobility effects help explain this pattern.

During the crisis, majoritarian systems appear to have experienced rally-around-the-flag effects, encouraging adherence with COVID-19 regulations to a greater degree than in proportional systems. Confidence in government, trust in politicians and social capital also impact the regulatory effects on mobility and air quality.

Appendix

See Tables [9](#), [10](#), [11](#), [12](#).

Table 9 Data description

Variable	Description	Source
<i>A. Key measures</i>		
<i>AOD</i>	Aerosol Optical Depth (<i>AOD</i>) measures the level to which polluting particles in the air absorb the sunlight and reduce visibility. A higher concentration of aerosols in the atmosphere indicates poorer air quality. <i>AOD</i> is constructed by measuring the change in <i>AOD</i> on a day relative to baseline days, where a baseline day is the median value of <i>AOD</i> on the same day of the week (e.g., Monday) from January 3 – February 6, 2020. Aerosol particles include smoke from factories, from fires, dust from dust storms, volcanic ash and smog. The combined deep target and deep blue <i>AOD</i> for land and ocean at 0.55 microns wavelength are used (<i>MOD08_D3</i> v6.1). It has a daily temporal resolution and a spatial resolution of one degree. The data is monitored and recorded by the Moderate Resolution Imaging Spectroradiometer (<i>MODIS</i>) on NASA's <i>Terra</i> satellite	Platnick et al. (2015)
<i>Stringency</i>	A daily composite index measuring the rigor of government-imposed containment actions by focusing on nine related indicators: closure and containment of (i) schools, (ii) workplaces, (iii) public events, (iv) restriction on gathering size, (v) closure of public transport, (vi) stay-at-home and home quarantine orders, (vii) restriction on internal movements, (viii) restriction on international travel and (ix) implementation of public information campaign. The index is used for the period January 3–June 30, 2020. The daily variable is constructed by measuring the change in <i>Stringency</i> relative to the baseline day, the median value on the same day of the week January 3–February 6, 2020. The index is scaled from 0 to 1 where a higher value corresponds to greater increase in stringency	Hale et al. (2020)
<i>Electoral System</i>	Two binary variables for proportional and majoritarian electoral systems which classify a country's electoral system of the national legislation based on the most recent election	IDEA (2018)
<i>B. Baseline control variables</i>		
<i>GDP</i>	Logged GDP per capita for the year 2018 (in 2017 US dollars)	WDI (2020)
<i>Manufacturing</i>	Percentage share of manufacturing in the GDP in 2018	WDI (2020)
<i>Vehicles</i>	Road vehicles per 1000 inhabitants in 2014	Nationmaster (2020)
<i>CCPS</i>	Climate change policy stringency index	Sharma et al. (2021)

Table 9 (continued)

Variable	Description	Source
<i>KOF</i>	The KOF globalization index measures the economic, social and political dimensions of globalization	Gygli et al. (2019)
<i>Democracy</i>	The variable classifies countries on a 11-point scale ranging from zero to ten, where a greater value reflects a higher degree of institutionalized democracy in the year 2018	Marshall and Jaggers (2018)
<i>C. Alternative democracy measures</i>		
<i>Vanhanen</i>	Calculated by multiplying political competition and political participation scores for each country and then dividing the outcome by 100. Year: 2018	Vanhanen (2019)
<i>EIU</i>	Index by the Economist's Intelligence Unit is based on five categories: electoral process and pluralism; the functioning of government; political participation; political culture; and civil liberties. Countries are ranked on a scale of 0 to 10 with a higher value corresponding to a higher level of democracy	EIU (2018)
<i>Freedom House</i>	Indicates the quality of political rights and civil liberties in each country. Countries are ranked on a scale of 0 to 100 with a higher value corresponding to a higher level of democracy	Freedom House (2018)
<i>PCA</i>	Principal component analysis of the four democracy indices <i>Vanhanen</i> , <i>EIU</i> , <i>Freedom House</i> and <i>Democracy</i>	
<i>D. Other Variables</i>		
<i>Transit Stations mobility</i>	Mobility at transit stations is measured as the change in the movement in transit stations on a particular day as compared to the baseline day. A baseline day is the median value of movement in an area on the same day of the week between January 3, 2020 and February 6, 2020	Google (2020)
<i>Workplace mobility</i>	Mobility at workplace is measured as the change in the movement in workplaces on a particular as compared to the baseline day. A baseline day is the median value of movement in an area on the same day of the week between January 3, 2020 and February 6, 2020	Google (2020)
<i>Groceries and pharmacies mobility</i>	Mobility at groceries and pharmacies is measured as the change in the movement in groceries and pharmacies on a particular as compared to the baseline day. A baseline day is the median value of movement in an area on the same day of the week between January 3, 2020 and February 6, 2020	Google (2020)

Table 9 (continued)

Variable	Description	Source
<i>Govt Confidence</i>	Survey question asking respondents how much confidence do they have in their national government. The original variable takes values from 1 (very much) to 4 (not at all). This scale has been reverse-coded and standardized to a 0–1 variable. A higher score indicates a higher confidence in government	WVS (2015)
<i>Trust in Politicians</i>	Survey question to measure public trust in politicians. Respondents are asked how do they rate the ethical standards of the politicians in their country. A higher score indicates a higher value of trust in politicians. The original variable takes values from 0 to 7. This scale has been standardized to a 0–1 variable	World Economic Forum (2018)
<i>Social Capital</i>	This index measures a country's performance in three areas: social cohesion and engagement, community and family network, and political participation and institutional trust. A higher score indicates a higher value of social capital. The original variable takes values from 0 to 100. This scale has been standardized to a 0–1 variable	World Economic Forum (2018)
<i>PCA Risk Exposure</i>	The first principal component of population density, urbanization and net migration	WDI (2020) and authors' calculations
<i>Health system capacity specific to COVID-19</i>	An index evaluating country preparedness for COVID-19. The index is calculated using the average of 13 International Health Regulations core capacity scores and the operational readiness index of health systems. Both the indices are tabulated by the World Health Organization	Poljanšek et al. (2020)
<i>Health system capacity</i>	An index evaluating the health system's coping capacity in a country. The index is calculated using measures of health infrastructure such as physician density and number of hospital beds in a country	Poljanšek et al. (2020)
<i>Legal origin dummies</i>	A dummy variable that identifies the legal tradition of the company law or commercial code of each country as British, French, German or Scandinavian	La Porta et al. (2008)
<i>Institutions</i>	An index evaluating the institutional quality of a country. It is calculated by taking the average of the following measures: voice and accountability, political stability, rule of law, control for corruption, regulatory quality and government effectiveness (scaled to 0 and 1)	Kaufmann et al. (2010)
<i>Colony dummies</i>	Dummy variables that identifies the former colonial ruler of a country – British, Spanish, French, Portuguese or other European nations	Nunn and Puga (2012)
<i>Population density</i>	Population density per square kilometer of land area in 2018	WDI (2020)

Table 9 (continued)

Variable	Description	Source
<i>Urbanization</i>	Percentage of the population living in urban areas in 2018	WDI (2020)
<i>Human capital index</i>	Defined as “the amount of human capital that a child can be expected to attain by age 18, given the risks of poor health and poor education that prevail in the country where she lives”	World Bank (2020)
<i>Daily cumulative number of COVID-19 cases</i>	The daily cumulative number of confirmed COVID-19 cases for the period January 3–June 30, 2020, in each country. The variable is expressed in natural logs	Dong et al. (2020)
<i>Irrigation Potential</i>	Share of arable land where irrigation more than doubles agricultural yield	Bentzen et al. (2017)

Table 10 Summary statistics

Variable	Observations	Mean	Std. Deviation	Minimum	Maximum
<i>AOD</i>	21,355	0.049	0.209	− 0.828	3.998
<i>Stringency</i>	21,355	0.440	0.357	− 0.449	1
<i>Proportional</i>	21,355	0.453	0.499	0	1
<i>Majoritarian</i>	21,355	0.311	0.463	0	1
<i>Democracy</i>	21,355	6.311	3.569	0	10
<i>CCPS</i>	21,355	0.332	0.175	0.013	0.862
<i>Manufacturing</i>	21,355	12.894	6.281	1.748	38.201
<i>Vehicles</i>	21,355	213.288	221.669	3.000	797.000
<i>GDP</i>	21,355	9.373	1.149	6.766	11.332
<i>KOF</i>	21,355	66.550	13.873	38.162	91.277
<i>Govt Confidence</i>	12,920	0.364	0.104	0.194	0.691
<i>Trust in Politicians</i>	19,034	0.322	0.119	0.133	0.623
<i>Social Capital</i>	19,043	0.514	0.068	0.385	0.669
<i>Transit Stations</i>	17,559	− 25.529	28.445	− 95	31
<i>Workplace</i>	17,559	− 17.955	24.280	− 92	43
<i>Groceries & pharmacies</i>	17,559	− 10.857	20.666	− 97	76
<i>Average mobility</i>	17,559	− 18.114	23.077	− 93.333	36.667

Stringency declined in some locations compared to the baseline period, resulting in negative values

Table 11 Summary Statistics by Political Institution

Variable	Observations	Mean	Std. Deviation	Minimum	Maximum
<i>Proportional systems</i>					
<i>AOD</i>	9641	0.057	0.198	− 0.828	3.242
<i>Stringency</i>	9641	0.443	0.364	− 0.111	1
<i>Democracy</i>	9641	7.603	2.838	0	10
<i>Majoritarian systems</i>					
<i>AOD</i>	6627	0.031	0.246	− 0.824	3.998
<i>Stringency</i>	6627	0.420	0.344	− 0.111	1
<i>Democracy</i>	6627	4.696	3.670	0.000	10
<i>Autocracies</i>					
<i>AOD</i>	4630	0.072	0.243	− 0.718	2.337
<i>Stringency</i>	4630	0.449	0.372	− 0.449	1
<i>Democracy</i>	4630	0.386	0.625	0	2

Stringency declined in some locations compared to the baseline period, resulting in negative values

Table 12 Excluding regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Excluding Asia			Excluding Africa			Excluding the Americas			Excluding Europe			Excluding Oceania		
	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Proportional	Majoritarian	Majoritarian
<i>Stringency</i>	-0.303*** (0.059)	-0.154** (0.061)	-0.024 (0.063)	0.169* (0.087)	0.307** (0.088)	0.206** (0.088)	-0.183*** (0.064)	-0.178*** (0.064)	-0.100 (0.065)	-0.249*** (0.067)	-0.155** (0.068)	-0.054 (0.070)	-0.279*** (0.057)	-0.208*** (0.058)	-0.101* (0.059)
<i>Democracy</i>	-0.001 (0.004)	-0.001 (0.004)	-0.000 (0.004)	-0.004 (0.003)	-0.004 (0.003)	-0.005 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)
<i>Stringency x Democracy</i>	-0.002 (0.002)	-0.004** (0.002)	-0.006*** (0.002)	-0.003** (0.002)	-0.008*** (0.002)	-0.005*** (0.002)	-0.009*** (0.001)	-0.010*** (0.001)	-0.011*** (0.001)	-0.004** (0.002)	-0.006*** (0.002)	-0.008*** (0.002)	-0.005*** (0.001)	-0.007*** (0.001)	-0.008*** (0.001)
<i>Proportional</i>		-0.010 (0.018)			-0.013 (0.017)			-0.006 (0.017)			-0.008 (0.021)			-0.012 (0.016)	
<i>Stringency x Proportional</i>		0.092*** (0.009)			0.076*** (0.009)			0.035*** (0.010)			0.085*** (0.011)			0.070*** (0.009)	
<i>Majoritarian</i>			0.021 (0.021)			-0.003 (0.022)			0.006 (0.017)			0.009 (0.021)			0.011 (0.018)
<i>Stringency x Majoritarian</i>			-0.142*** (0.011)			-0.037*** (0.013)			-0.085*** (0.010)			-0.111*** (0.011)			-0.105*** (0.010)
<i>Marginal effect</i>	-0.143	-0.070	-0.082	-0.044	0.017	-0.055	-0.133	-0.128	-0.126	-0.184	-0.126	-0.161	-0.156	-0.117	-0.127
<i>Baseline controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Time dummies</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>R-squared</i>	0.055	0.064	0.067	0.065	0.073	0.067	0.051	0.052	0.058	0.047	0.053	0.057	0.041	0.045	0.049
<i>Observations</i>	15,988	15,988	15,988	14,708	14,708	14,708	17,572	17,572	17,572	15,791	15,791	15,791	20,637	20,637	20,637

See Table 1

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