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Lives versus Livelihoods during the COVID-19 Pandemic

How Testing Softens the Trade-off

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Abstract

The early COVID-19 pandemic literature focused on the conflict between lives and livelihoods. But cross-country evidence reveals that across countries high mortality rates were often associated with large gross domestic product contractions. This paper shows that the presumed trade-off was associated with lockdowns as the primary instrument of containment. Early transition from lockdowns to testing-tracing-isolation-based containment softened the trade-off within countries and explains the absence of a trade-off across countries. The analysis finds that testing had positive indirect effects on growth and perhaps even positive direct effects. By allowing countries to relax shutdowns without compromising on containment, testing could have indirectly contributed to about a 0.6 percentage point boost in growth. By infusing greater confidence in people to step out and engage in economic activity, testing could have added another 0.6 percentage point to growth. As the world struggles to scale up vaccination in the face of new waves and variants, continued emphasis on testing could help limit infection without recourse to costly lockdowns.

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Lives versus Livelihoods during the COVID-19 Pandemic: How Testing Softens the Trade-off

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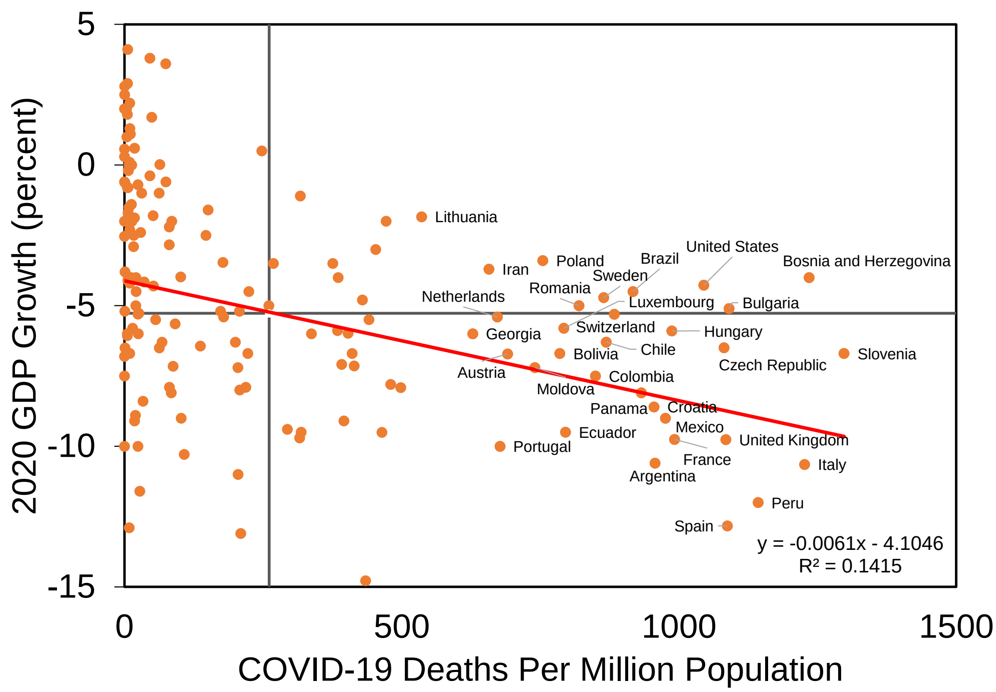
I. Introduction

The COVID-19 shock has destroyed lives and livelihoods across the world. In the early policy debate, countries were seen as facing a trade-off between "flattening the pandemic and recession curves" (Gourinchas, 2020). By this logic, heterogeneous health and economic outcomes across countries were in part the result of governments making different choices in the face of this trade-off. But the cross-country evidence reveals that many of the countries that suffered high mortality rates were often also the countries that saw the largest GDP contractions (Figure 1). Thus, saving lives was associated with saving rather than sacrificing livelihoods. Why the supposed trade-off did not materialize has been the subject of much casual observation but little empirical analysis.

Figure 1. Lives vs. Livelihoods: correlation of growth and mortality in 2020



Note: Data obtained from World Bank Economic Monitoring, Global Economic Prospect-January 2021, and Oxford Covid-19 Government Response Tracker 2020. GDP growth (y-axis) are annual 2020 forecast obtained from Global Economic Prospect and World Economic Outlook. Mortality rate (x-axis) is calculated as the number of Covid-19 related deaths reported per one million population in 2020. Quadrants are classified by the mean thresholds of global GDP growth (y-reference line) and mortality rate (x-reference line). Labelled dots represent countries suffering significant mortality (above 500 per million). Red curve (downward sloping) represents the linear fitted line of the distribution.

Anecdotal evidence suggests that the observed heterogeneity in outcomes across countries is related to whether a country was able to transition away early and safely from debilitating economy-wide shutdowns. The difference across countries in the speed of transition can in turn be related, first, to whether a country imposed early and effective domestic and international shutdowns to suppress infections. Countries such as China and Vietnam did so and emerged relatively unscathed from the pandemic in health and economic terms; Brazil and the United Kingdom did not and suffered significantly on both counts. The second reason for the difference in duration of shutdowns across countries relates to the capacity for "smart containment." Countries like the Republic of Korea and New Zealand were able to move quickly from economy-wide shutdowns because they were able to use testing, tracing and isolation, along with social distancing and masks, as instruments of containment; Indonesia and India were not.

Several studies have emphasized the role of smart containment, including targeted lockdowns, testing, tracing and other non-pharmaceutical interventions (NPIs), in fighting infections while lowering the economic costs of the pandemic (Acemoglu et al. 2021; Eichenbaum et al 2021; Glover et al. 2020; Brotherhood et al. 2020).[1] But all these studies rely on ex-ante simulations of the impact of alternative strategies. We have not so far seen an ex-post integrated assessment of the health and economic implications of smart containment.

Our argument is constructed in four steps. We begin by examining the determinants of COVID-19 infections in a panel for a sample of 174 countries. The focus is on policy actions that successfully lowered infections and deaths across countries. We find that both mobility restrictions and open COVID-19 testing policy helped to contain the spread of infections. We also find that restrictions were more effective when implemented early in the pandemic (as reflected in the level of infections at the time). These results are confirmed in an array of econometric specifications and using multiple indices of government's policy responses.

Second, we examine the factors that influenced reliance on shutdowns as a measure of containment. We find that reliance was significantly and negatively associated inter alia with

[1] Most papers rely on extensions and simulations of the Kermack and Mc Kendrick (1927) SIR-based macroeconomic model to study the impact of smart containment on health and economic outcomes.

levels of testing. This finding is consistent with the argument that greater capacity for containment through testing, tracing and isolation, allowed an earlier relaxation of stringent mobility restrictions.

Third, we assess how policy actions, as well as other country-specific factors, influenced economic growth during the COVID-19 shock in 2020. We identify four key correlates of growth performance: the severity of the COVID-19 impact; the measures taken to contain its spread; the exposure to the global economy; and the capacity of the government to provide fiscal support. As far as containment measures are concerned, growth was strongly negatively associated with shutdowns. In contrast, testing is positively (though less robustly) correlated with output growth across countries, even after controlling for the level of mortality rate and the stringency of lockdowns.

Finally, drawing the above elements together, we argue that the supposed trade-off between lives and livelihoods was associated with lockdowns as the primary instrument of containment. Testing softened the trade-off within countries and explains the absence of a trade-off across countries. Testing had positive indirect effects on growth and perhaps even positive direct effects. By allowing countries to relax shutdowns without compromising on containment, testing could have indirectly contributed to about a 0.6 percentage point boost in growth. It is possible that testing also infused greater confidence in people to step out and engage in economic activity, and thus could have added another 0.6 percentage point to growth.

This paper contributes to an emerging literature that studies the effectiveness of non-pharmaceutical interventions (NPI) that have been imposed by governments, which generally include lockdowns and mobility reduction, testing, and contact tracing. On lockdown measures, the existing literature suggests heterogeneous effects on disease containment.[2] Some evidence

[2] For instance, Askitas et al. (2020), Bonardi et al. (2020), and Weber (2020) argue that the closure of borders or travel restrictions had little effect. In contrast, studies on international air travel (Chinazzi et al. 2020, Keita 2020) find sizeable effects. Eckardt et al. (2020) find limited effectiveness of border controls during the first wave of COVID-19 in 18 Western European countries. Effective implementation of lockdown measures, especially in capacity-constrained economies, is likely to be challenged by unfavorable socio-economic factors, such as the existence of an extended informal sector, lack of comprehensive social protection, or government's limited fiscal space to provide financial support or to sustain stay-at-home restrictions (Loayza et al. 2020).

based on high frequency electricity data for a limited number of countries suggests that countries that implemented non-pharmaceutical interventions in the early stages of the pandemic appear to have lower cumulative mortality, compared with countries that imposed non-pharmaceutical interventions during the later stages of the pandemic (Demirguc-Kunt et al. 2020).[3] We add to this literature by providing an ex-post evaluation of the impact of early action along with other government interventions in reducing infections and deaths for a large set of countries.

We also contribute to the evidence that testing helped to lower infections. The importance of testing accompanied by rigorous contact tracing has been emphasized since the early stages of the pandemic (Rae and Friedman 2020, WEF 2020). Indeed, among various interventions including mask usage, school closures, and restrictions on gatherings, intensive testing has been found to have the greatest impact on controlling the spread of COVID-19 and is the common characteristic among countries that successfully controlled the disease (Ranan-Eliya et al. 2021; Chinazzi et al. 2020; and Andrabi et al. 2020). We confirm the role of testing in controlling infections, and also show that testing contributed to growth by allowing the earlier relaxation of restrictions.

This paper also contributes to the rapidly expanding literature on the economic effects of the COVID-19 shock. Most existing papers have pointed to the damage of lockdowns in terms of employment losses, decline in spending, and deterioration in local economic conditions in the United States (Baek et al., 2020; Baker et al., 2020; Béland et al., 2020; Chernozhukov et al., 2020; Coibion et al., 2020; Gupta et al., 2020) and across different countries (Carvalho et al., 2020, Chronopoulos et al., 2020; Deb et al., 2020; Demirgüç-Kunt et al., 2020; Kaplan et al. 2020; Fotiou and Lagerborg, 2021).[4] Several papers also study the impact of lifting lockdowns,

[3] In part, this is because the interventions have been less stringent. Moreover, there is evidence that COVID-19 mortality at the peak of the local outbreak has been lower in countries that acted earlier. In this sense, the results suggest that the sooner non-pharmaceutical interventions are implemented, the better are the health outcomes. Deb et al. (2020) and Fotiou and Lagerborg (2021) further show the importance of early implementation on the success of containment policies.

[4] Some papers use rich structural models of production to predict the damage of lockdowns, mostly finding very large effects on economic activities (Barrot et al., 2020; Baqaee and Farhi 2020; Bonadio et al., 2020; Cakmaklı et al., 2021a; Fadinger and Schymik, 2020; Inoue and Todo, 2020) and on firms' liquidity and solvency (Carletti et al., 2020; Gourinchas et al., 2020; Schivardi and Romano, 2020). Furthermore, some papers study how supply shocks may cause demand shortage (Guerrieri et al., 2020) and interact with nominal rigidities (Baqaee and Farhi, 2020).

showing that it led to only a limited rebound in mobility (Dave et al., 2020) and economic activity, and arguing that voluntary social distancing might have played a greater role than lockdowns (Allcott et al., 2020; Bartik et al., 2020; Kahn et al., 2020; Maloney and Taskin, 2020).[5] Our results suggest that the testing-induced shortening of lockdowns had a significant direct effect on economic activity and testing may also have boosted economic activity directly by helping relax private precautionary behavior.

The rest of the paper is organized as follows. Section II outlines a simple framework to analyze how containment policies--lockdowns and testing--influence health and economic outcomes. Section III discusses the data. Sections IV and V present the empirical strategies and results on the determinants of containment and economic growth, respectively. Section VI discusses the implications of our findings for the lives-versus-livelihoods debate. Finally, Section VII concludes.

II. Framework to analyze the effects of lockdowns and testing policies

We assume infections and economic output are functions of containment policies and other exogenous variables. Specifically,

$$I_i = I(L_i, T_i, Z_i^I) \qquad (1)$$

where I_i represents infection for any country i. Containment policies include lockdowns, L_i, and testing, T_i. Z_i^I represents other exogenous variables that may affect infections.

[5] The literature also documents that the early phases of the pandemic have had a harsher effect on more economically vulnerable individuals, both in the United States and other countries (Alstadsæter et al., 2020; Béland et al., 2020). These individuals include those with lower income and educational attainment (Cajner et al., 2020; Chetty et al., 2020), minorities (Fairlie et al., 2020), immigrants (Borjas and Cassidy, 2020), and women (Alon et al., 2020; Del Boca et al., 2020; Papanikolaou and Schmidt, 2020). One reason is that lower-paid workers are often unable to perform their jobs from home (Barrero et al., 2020; Dingel and Neiman, 2020; Gottlieb et al., 2020). This warns of a potential widening of inequality (Mongey et al., 2020; Palomino et al., 2020) and speaks to the importance of government economic support policies.

We are interested in change in infections, so taking the total differential yields:[6]

$$dI = I_L dL + I_T dT + I_{Z^I} dZ^I \qquad (2)$$

Where dI refers to a change in infections/deaths in country i, and dL and dT refer to a change in government-imposed mobility restrictions and testing, respectively, and dZ^I refers to changes in other exogenous variables that affect infections. The terms I_L and I_T represent the marginal impact on infections of restrictions and testing, respectively, and are expected to have a negative sign. Equation (2) can be used to evaluate $\left.\frac{dL}{dT}\right|_{dI=0}$, which is the rate of substitution of testing for lockdowns for which infections remain unchanged. Then,[7]

$$\left.\frac{dL}{dT}\right|_{dI=0} = -\frac{I_T}{I_L} \qquad (3)$$

Similarly, economic output is a function of lockdowns and other government measures, such as testing:

$$Y_i = Y(L_i, T_i, Z_i^Y) \qquad (4)$$

Where Y_i, L_i, T_i, and Z_i^Y represent GDP, lockdowns, testing and other exogenous variables that may affect output for any country i.

The change in output can be presented as:[8]

$$dY = Y_L dL + Y_T dT + Y_{Z^Y} dZ^Y \qquad (5)$$

The change in output with respect to testing is the sum of a direct effect and an indirect effect due to the induced relaxation in lockdowns:[9]

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[6] One can also consider the time dimension. In that case, one can take the derivative with respect to time t and equation (2) can be written as $\frac{d}{dt} I_{it} = \frac{\partial I_{it}}{\partial L}\frac{\partial L_{it}}{\partial t} + \frac{\partial I_{it}}{\partial T}\frac{\partial T_{it}}{\partial t} + \frac{\partial I_{it}}{\partial Z^I}\frac{\partial Z_{i,t}^I}{\partial t}$.

[7] To arrive at equation (3), we assume that $\frac{dZ^I}{dT} = 0$, which says that other exogenous policy variables are targeting infections and are independent of testing.

[8] The derivative with respect to time t can be written as $\frac{d}{dt} Y_{it} = \frac{\partial Y_{it}}{\partial L}\frac{\partial L_{it}}{\partial t} + \frac{\partial Y_{it}}{\partial T}\frac{\partial T_{it}}{\partial t} + \frac{\partial Y_{it}}{\partial Z^Y}\frac{\partial Z_{i,t}^Y}{\partial t}$.

[9] To arrive at equation (5), we assume that $\frac{dZ_i^Y}{dT} = 0$, which presumes that other exogenous policy variables are independent of testing.

$$\frac{dY}{dT} = Y_L \frac{dL}{dT} + Y_T \qquad (6)$$

For an unchanged level of infections ($\left.\frac{dL}{dT}\right|_{dI=0} = -\frac{I_T}{I_L}$), we obtain

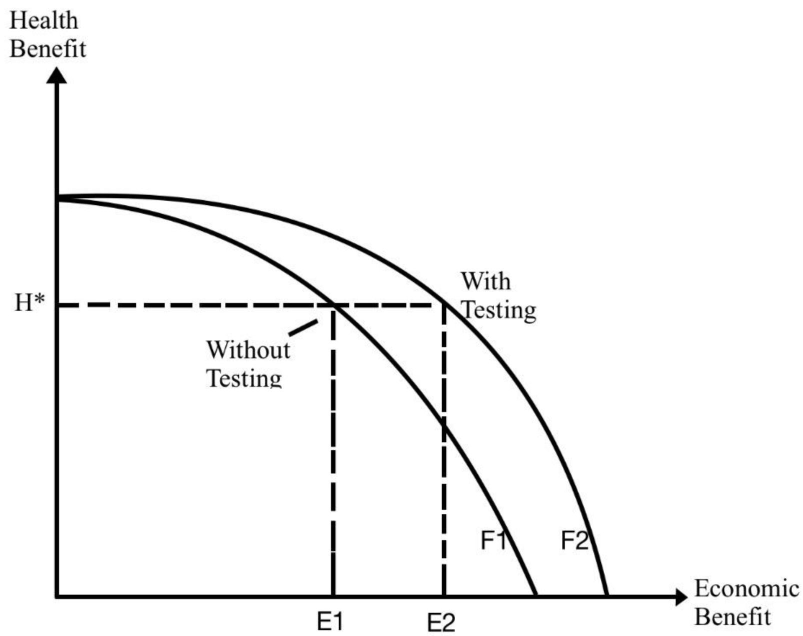
$$\frac{dY}{dT} = -\frac{I_T}{I_L} Y_L + Y_T \qquad (7)$$

where $\frac{I_T}{I_L}>0$.

Equation (7) shows the indirect and direct channels through which testing could affect growth. The first term captures the indirect channel and shows that higher testing can make it possible to ease lockdowns while maintaining the same level of infections. The second term captures the direct effects of testing on growth, as testing may help alleviate supply constraints by allowing more workers to go to work and boost demand by increasing consumer confidence.

Visually, this discussion can be illustrated in a simple diagram. Figure 2 demonstrates the trade-off between the health benefit (e.g., lower infections and/or mortality) and the economic benefit (e.g., lowering economic output) associated with a more stringent government lockdown measure. In the absence of testing, the socially optimal level of the lockdown lies somewhere on the health-economic frontier curve 1 (the "inner frontier" F_1). The potential benefit of testing in helping to soften the trade-off associated with lockdowns is represented in Figure 2 as the rightward shift of the health-economic frontier curve, from F_1 to F_2. Testing can help attain any desired containment level, H^*, at a lower economic cost– measured as the horizontal distance from E_1 to E_2. In subsequent sections, we discuss both the direct effects of lockdowns and testing, as well as the potential indirect economic effects of testing through enabling lockdown relaxation.

Figure 2. How testing can soften the health-economic trade-off associated with lockdowns



Source: Authors' illustration.

III. Data

We rely on two primary sources of high-frequency data. To examine the effect of policy actions in containing the spread of the virus, we use daily data on confirmed COVID-19 infections and deaths reported by the Oxford Covid-19 Government Response Tracker 2020 for the period of January 1–December 31, 2020. We also rely on several indices of government's policy responses from the same source.

The data suggest that the virus was rampant across most countries in the world during 2020 and that most countries witnessed waves of infections. We distinguish between three groups of countries: (i) the *mildly affected*, i.e., those suffered relatively few infections, defined as those countries for which the 15-day average of daily infection rate was always below the 10th percentile of highest infection rate for all countries in 2020;[10] (ii) the *under control*, i.e., those that experienced significant infection (above the 10 percentile threshold) but were able to successfully contain the spread; and (iii) the *ongoing*, i.e., those that suffered significant infection without successful containment in 2020.

Of 174 countries for which data is available, as of the end of 2020, only 17 were mildly affected, whereas 157 countries experienced significant infections (Table 1). The least affected group was predominantly in East Asia and Pacific (EAP) and Sub-Saharan Africa (SSA).[11] Less than a quarter of countries (36) managed to contain the disease after suffering significant infections. Over two-third of all countries were still facing high infections at the end of 2020. This group consisted of almost all countries in Europe and Central Asia (ECA) (48 of 49—with the exception being Greenland) and most countries in the other regions except for EAP and SSA.

Table 1. Summary statistics - widespread infection observed across most regions in 2020

Region	Number of Country	Not or mildly affected		Under control		Ongoing	
		Countries	Percent	Countries	Percent	Countries	Percent
East Asia and Pacific	20	7	35.00	5	25.00	8	40.00
Europe and Central Asia	49	1	2.04	0	0.00	48	97.96
Latin America and Caribbean	31	0	0.00	3	9.68	28	90.32
Middle East and North Africa	20	1	5.00	2	10.00	17	85.00
North America	3	0	0.00	0	0.00	3	100.00
South Asia	7	0	0.00	1	14.29	6	85.71
Sub-Saharan Africa	44	8	18.18	25	56.82	11	25.00
Total	174	17	0.00	36	0.00	121	0.00

Note: Authors' calculation based on daily data in 2020 from European CDC. Containment groups categorized based on infection data in 2020.

To assess the determinants of economic growth during the COVID-19 shock, we utilize quarterly GDP data for a large sample of 88 advanced economies and emerging markets and developing economies (EMDEs).[12] The shock to economic growth was severe and widespread (Table 2). On average, the year-on-year GDP growth decreased by over 11 percent in the second quarter of

[10] The 10th percentile of highest infection rate in 2020 was 2.7 cases per million.
[11] Mattoo and Rannan-Eliya (2021) argue that COVID-19 infections in Sub-Saharan Africa are significantly higher than shown from available official data.
[12] The sample is determined by availability of quarterly GDP data.

2020 relative to 2019Q2. The decline was approximately twice as large for advanced economies compared with EMDEs. During the third and fourth quarters, most countries witnessed less severe contractions; the growth contraction dropped to below 4 percent in advanced economies, and to about 1 percent in EMDEs.

Table 2. Summary statistics – economic activity dropped sharply during 2020

		Quarterly GDP growth (y-o-y) (*percent*)		
Year	Quarter	All countries	Advanced Economies	Emerging-Market and Developing Economies
2018	1	3.75	2.61	5.41
2018	2	3.55	2.55	5.03
2018	3	3.05	2.04	4.55
2018	4	2.74	1.69	4.16
2019	1	2.62	1.72	4.05
2019	2	2.65	1.54	3.97
2019	3	2.58	1.69	3.77
2019	4	2.17	1.39	3.73
2020	1	-0.19	-1.20	-1.89
2020	2	-11.11	-11.27	-6.76
2020	3	-4.03	-3.86	-1.03
2020	4	-2.68	-3.13	1.49

Note: Data from World Bank's Global Economic Monitoring. Statistics for 2018Q1-2020Q3 is computed based on quarterly GDP data from 87 countries. Statistics for 2020Q4 is computed based on available quarterly GDP data from 83 countries.

The largest economic contractions were observed in South Asia (SAR) (-24.27 percent; population-weighted average) and Latin America and the Caribbean (LAC) (-15.22percent) during the second quarter (Table A1). Output growth recovered after the second quarter, with EAP being the first region to report (barely) positive growth in the third quarter (1.51 percent), led by China and Vietnam.

IV. Correlates of COVID-19 infections

We assess the association between the COVID-19 fatality rate and the policy responses using panel data regressions. Fatality due to COVID-19 could be explained by measurable policy indicators, such as government policy to restrict human mobility, the availability of testing, and economic support provided during the pandemic. We test the following specification with daily data for 174 countries for the period January 01–December 31, 2020:

$$\Delta I_{it,t-L} = \alpha_0 + \alpha_1 I_{it-L} + \alpha_2 \{policies\}_{it-L} + \lambda_i + \sigma_t + \varepsilon_{it} \qquad (8)$$

where $\Delta I_{it,L}$ denotes the change in COVID-19-related fatality rate (deaths per thousand) for country *i* between dates *t-L* and *t*, with *L* denoting the lag in days. I_{it-L} refers to the number of deaths per thousand population at time *t-L*, when the policy was first implemented. $\{policies\}_{it-L}$ consists of the three policy indicators: (i) lockdown stringency (index score from Oxford Covid-19 Government Response Tracker 2020), (ii) the availability of open testing (binary indicator, constructed from the testing index from Oxford Covid-19 Government Response Tracker 2020), and (iii) economic support (index score from Oxford Covid-19 Government Response Tracker 2020). λ_i and σ_t represent country and day fixed effects, respectively. ε_{it} denotes robust standard errors.

To compare coefficients of policy indicators across different time lags, the growth outcome is standardized as a unit of standard deviation from the global mean growth rate. To control for possible endogeneity, we focus on changes in fatality rate at least 10 days after a policy is implemented, but also estimate specification (8) for various time lags. In essence, the association of policy responses and the containment of COVID-19, represented by α_2, is captured from within-country variations of the standardized infection growth rates across time.

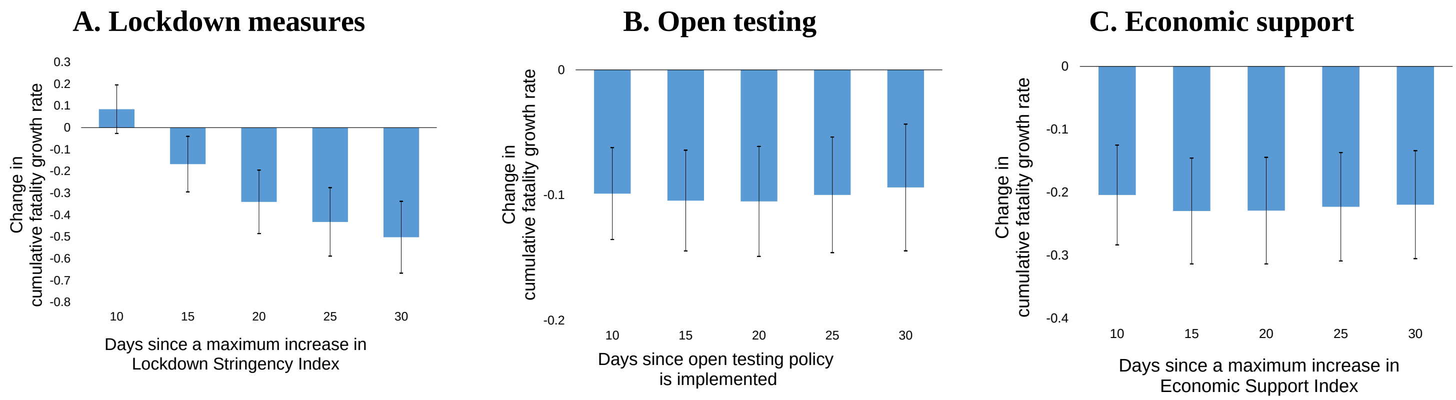
Table 3. Correlates of COVID-19 fatality across policy lags

	Dependent variable: fatality growth rate (percent; standardized)				
	(1)	(2)	(3)	(4)	(5)
Policy Lag Period (days)	10 days	15 days	20 days	25 days	30 days
Open testing policy (0/1)	-0.0988***	-0.104***	-0.105***	-0.0998***	-0.0938***
	(0.0223)	(0.0244)	(0.0266)	(0.0281)	(0.0307)
Stringency Index [0-1]	0.0842	-0.167**	-0.340***	-0.432***	-0.502***
	(0.0675)	(0.0773)	(0.0884)	(0.0953)	(0.100)
Economic Support Index [0-1]	-0.204***	-0.230***	-0.229***	-0.223***	-0.220***
	(0.0481)	(0.0511)	(0.0514)	(0.0523)	(0.0522)
Cases per thousand (cases/1000)	-0.00560***	-0.00522***	-0.00436***	-0.00416***	-0.00462***
	(0.000699)	(0.000725)	(0.000765)	(0.000843)	(0.000985)
Constant	0.160***	0.322***	0.420***	0.468***	0.508***
	(0.0584)	(0.0742)	(0.0896)	(0.0976)	(0.101)
Observations	42,724	41,941	41,151	40,357	39,567
R-squared	0.364	0.305	0.249	0.226	0.228
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Date Fixed Effects	Yes	Yes	Yes	Yes	Yes

Note: The table presents result from daily regressions of the growth rate in new COVID-related deaths, standardized as a unit of deviation from the global mean, on representative lags of open testing policy (constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise), lockdown stringency index (rescaled from [0-100] to [0-1] for chart representation), and economic-support index (rescaled from [0-100] to [0-1] for chart representation). Data collected from Oxford Covid-19 Government Response Tracker 2020 between January 01 and December 31, 2020. All regressions control for country and day fixed effects.

The measures taken to contain COVID-19 across the world, specifically restricting travel and mobility, testing (combined with tracing and isolating in some countries), and providing economic support, such as sick pay to encourage sick people to stay at home, are statistically significantly associated with a slower spread of COVID-19 infections (Figure 3; Table 3). The statistically significant negative correlations persist over time.

Figure 3. Correlates of COVID-19 fatality



Note: Authors' estimations, based on data from Oxford Covid-19 Government Response Tracker 2020 and Europe CDC, for January 1–December 31, 2020. This figure presents the point estimates from regressing cumulative growth rate in new deaths on lockdown index (Panel A), open testing policy (proxied indicator for public-health measure; Panel B) and availability of economic support (Panel C). We control for country-specific and day-specific fixed effects. Whiskers represent 95-percent confidence intervals of the estimates. The dependent variable (fatality growth rate) is standardized as a unit of deviation from the global mean. The testing policy index is constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise based on data on testing policy from Oxford Covid-19 Government Response Tracker 2020. The economic-support and lockdown-stringency indices are rescaled from [0-100] to [0-1].

A related question is whether there exists a benefit to an early introduction of containment policies. We interact each policy variable in the regression framework with the infection rate, defined as the number of total infected cases per thousand, when the policy was introduced:

$$\Delta I_{it,t-L} = \alpha'_0 + \alpha'_1 ifr_{it-L} + \alpha'_2 \{policies\}_{it-L} + \alpha'_3 \{policies * ifr\}_{it-L} + \lambda'_i + \sigma'_t + \varepsilon'_{it} \qquad (9)$$

where all else remains the same as in Eq. (8), and $\{policies * ifr\}_{it-L}$ represents the interaction between the policy indicators and infection rate at the time of the introduction of the policy. The coefficient α'_3 reflects the additional benefit of a timely policy response, measuring how the effectiveness of policy measures depends on the infection rate prevailing when they are introduced.

Table 4 shows that for several specifications, especially the ones pertaining to longer lags, the coefficient α'_3 is positive and statistically significantly different from zero, suggesting that the overall effect of lockdowns and testing on the fatality rate are stronger when they are introduced early, i.e., when the infection level is still low (Table 4).[13]

Table 4. Correlates of COVID-19 fatality: interaction effects

Dependent variable: fatality growth rate (standardized)					
	(1)	(2)	(3)	(4)	(5)
	10 days	15 days	20 days	25 days	30 days
Testing Policy (binary; 0/1)	0.125	-0.135***	-0.365***	-0.475***	-0.557***
	(0.0758)	(0.0211)	(0.0986)	(0.107)	(0.113)
Lockdown Stringency Index [0-1]	-0.121***	-0.125***	-0.125***	-0.119***	-0.111***
	(0.0251)	(0.0280)	(0.0310)	(0.0328)	(0.0355)
Economic Support Index [0-1]	-0.217***	-0.238***	-0.235***	-0.232***	-0.236***
	(0.0489)	(0.0507)	(0.0499)	(0.0503)	(0.0505)
Total cases per thousand (cases/1000)	-0.00947***	-0.0140***	-0.0174***	-0.0209***	-0.0248***
	(0.00290)	(0.00318)	(0.00373)	(0.00432)	(0.00504)
[Lockdown Index] X [cases/1000]	-0.0105***	-0.163*	0.00762*	0.0132***	0.0171***
	(0.00333)	(0.0863)	(0.00415)	(0.00465)	(0.00510)
[Testing Policy] X [cases/1000]	0.00969***	0.00916***	0.00885***	0.00838***	0.00770***
	(0.00184)	(0.00199)	(0.00224)	(0.00244)	(0.00253)
[Econ Support Index] X [cases/1000]	0.00141	0.000257	-0.000544	0.000287	0.00248
	(0.00189)	(0.00197)	(0.00208)	(0.00223)	(0.00236)
Constant	0.161**	0.341***	0.455***	0.515***	0.566***
	(0.0638)	(0.0803)	(0.0969)	(0.106)	(0.111)
Observations	42,724	41,941	41,151	40,357	39,567
R-squared	0.364	0.305	0.249	0.226	0.229
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Date Fixed Effects	Yes	Yes	Yes	Yes	Yes

Note: The table presents result from daily regressions of the growth in COVID-related deaths, standardized as a unit of deviation from the global mean, on representative lags of open testing policy (constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise), lockdown stringency index (rescaled from [0-100] to [0-1] for chart representation), and economic-support index (rescaled from [0-100] to [0-1] for chart representation), and the interactions of these policy determinants with the number of cases per thousand (same lag). Data collected from Oxford Covid-19 Government Response Tracker 2020 between January 01 and December 31, 2020. All regressions control for country and day fixed effects.

[13] We also test the correlation of government policies with the growth of infection rate (infected cases per thousand), and the results are similar: lockdowns, testing, and economic support are strongly correlated with a lower growth of infection rate (Tables A2 and A3).

V. Correlates of economic growth during the COVID-19 shock

We utilize a quarterly panel data estimation approach to assess the relevance of four country-specific factors that could have impacted economic growth during 2020, corresponding to the COVID-19 shock period: (i) the severity of COVID-19 virus in a particular country, measured by the number of COVID-19 deaths per million population (fatality rate); (ii) the policy response to contain the disease, which includes mobility restrictions and testing; (iii) exposure to the global recession, proxied by the country's dependence on tourism; and (iv) capacity to provide fiscal support, proxied by the country's gross debt position.

As far as the containment policies are concerned, for testing, we use indicators for both the extensive and intensive margins of testing, including the number of tests (in thousands) performed per confirmed infection case (intensive margin) and a dummy variable indicating the introduction of open public testing (extensive margin). For the lockdown, the intensity of the restrictions is captured by the quarterly average of the stringency index published by the University of Oxford.

Economic growth is affected by the extent of the disease, by measures to control the disease at home, and also by shocks emanating from abroad. We control for the exposure to the global recession by including the country's dependence on tourism (tourism revenues as a share of GDP). The tourism sector has been hit hard by cancellations of trips by non-residents (Gössling et al. 2020). Additionally, we control for the capacity of the governments to provide fiscal support by including the country's gross debt position (government gross debt as a share of GDP). Likewise, the ability to respond to the crisis is captured by the country's fiscal space reflected in the level of government indebtedness. Tourism revenues to GDP and government gross debt to GDP are obtained from the World Development Indicators and refer to pre-COVID-19 data.

Our panel data framework for the growth regression is as follows:

$$\Delta y_{i,t} = \alpha + \beta_1 \times COVID_{i,t} + \beta_2 \times R_{i,t} + \beta_3 \times E_{i,t} + \beta_4 \times G_{i,t} + \varepsilon_{i,t} \qquad (10)$$

where i refers to country and t refers to quarters. $y_{i,t}$ is the GDP growth rate of country i at time t. $COVID_{i,t}$ refers to the fatality rate (total deaths per million), $R_{i,t}$ refers to the government response (lockdown stringency index, tests per case, and open testing indicator), $E_{i,t}$ refers to exposure to the rest of the world (proxied by tourism as a share of GDP), and $G_{i,t}$ refers to the capacity of the government to support the economy (proxied by gross government debt as a share of GDP). Finally, we follow Lane and Milesi-Ferretti (2011) and König and Winkler (2020) and control for GDP per capita as well as the average GDP growth rate between 2014 and 2019.

Table 5. Quarterly panel regression (Ordinary Least Squares)

	Dependent variable: quarterly GDP growth (y-o-y)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total deaths per thousand	-0.0614***						-0.0362***	-0.0194**
	(0.00126)						(0.00114)	(0.000924)
Stringency index (daily mean)		-0.00109***					-0.000910***	-0.000624***
		(0.000182)					(0.000183)	(0.000230)
Tests per confirmed case (thousands)			0.00786***				0.00626***	0.00117
			(0.00267)				(0.00167)	(0.000914)
Open testing (0/1)				0.00336			0.00573	0.00936
				(0.00942)			(0.00861)	(0.00810)
Tourism (%GDP)					-0.00150**		-0.00165**	.
					(0.000649)		(0.000722)	.
Gross Debt Position (%GDP)						-0.000200**	-0.000156***	.
						(8.56e-05)	(5.54e-05)	.
Constant	-0.0630***	-0.0147	-0.0725***	-0.0739***	-0.0665***	-0.0570***	-0.00170	-0.0187
	(0.00687)	(0.0112)	(0.00709)	(0.00908)	(0.00738)	(0.0103)	(0.0135)	(0.0142)
Observations	311	311	294	311	303	296	280	279
R-squared	0.571	0.599	0.583	0.542	0.559	0.581	0.669	0.844
Number of quarters	4	4	4	4	4	4	4	4
quarter FE	Y	Y	Y	Y	Y	Y	Y	Y
country FE	N	N	N	N	N	N	N	Y

Note: The sample is a quarterly panel consisting of countries with available quarterly GDP data for the four quarters of 2020 as of April 20, 2021. Quarterly GDP obtained from Global Economic Monitoring (GEM). The dependent variable is year-on-year quarterly GDP growth. COVID-19 indicators (deaths per thousand, stringency index, and tests per case, and open testing indicator) collected from Oxford Covid-19 Government Response Tracker 2020. Tourism and gross debt position are pre-covid annual measures and obtained from World Development Indicators. All regressions control additionally for country's baseline (2019) annual GDP level and average quarterly GDP growth between Q1-2014 and Q4-2019. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1.

The results show that countries that experienced more severe contractions in 2020 had higher fatality rates, imposed more stringent mobility restrictions, were more dependent on earnings from tourism, and had more highly indebted governments (Table 5). Specifically, every 100 fewer deaths per million population is associated with three-fifth of a percentage point increase in annual output growth on average. While we observe no significant direct effect of open testing policy on growth, the quantitative measure of testing—i.e., number of tests per case—is positively correlated with economic growth, even after controlling for the fatality rate and the stringency of lockdowns. An increase in tests per case by 1000 is associated with an increase in growth by 0.6 percentage point. A higher intensity of testing may have contributed directly to growth by alleviating private precautionary behavior and hence infused greater confidence in people to step out and engage in productive activity.

We run several robustness exercises. First, the intensity of government's restrictions is likely to have been influenced by the progression of the disease (both infections and mortality), as well as the economic hardship imposed on the population. This could lead to an endogeneity between economic growth and the restrictions imposed. To check if this empirical concern would affect our main result, we utilize a two-stage least squares (2SLS) estimation framework. In the first stage, the monthly restrictions on mobility indicator is regressed on the one-month lags of monthly industrial production growth (a proxy for economic growth in the absence of data on monthly gross output), monthly mortality and infection rates, and country and month fixed effects. In the second-stage regression, we use a quarterly lockdown stringency measure constructed by aggregating the monthly predicted values obtained from the first stage.

The results from the first-stage estimation shows that the severity of lockdowns is statistically significantly and negatively associated with the previous month's industrial production, positively associated with the previous month's cases, and negatively correlated with higher tests per case (Table 6). The previous month's fatality rate is positively correlated with lockdowns but the correlation is not statistically significant when controlling for both infection rate and fatality rate. These results are in line with the framework introduced in Section II, which argued that higher testing was likely to be associated with less stringent lockdowns.

Table 6. Two-stage Least Square: first-stage regression

	Dep. var: Stringency Index (monthly aggregate)
Industrial Production (monthly growth, YoY, L1)	-4.406**
	(1.937)
Monthly deaths per million (L1)	0.241
	(0.300)
Monthly cases per million (L1)	0.0359***
	(0.00699)
Tests per case (L1)	-0.00135***
	(0.000259)
Constant	1,622***
	(16.87)
Observations	765
R-squared	0.805
spec	panel
months	3-12
month FE	Y
country FE	Y

Note: first-stage result from the 2SLS estimation framework discussed in the text. Monthly stringency index is regressed on the one-month lags of monthly industrial production growth (a proxy for economic growth in the absence of data on monthly gross output), monthly mortality and infection rates, and country and month fixed effects.

Table 7 shows the results of the second-stage estimation, where the constructed IV for government's lockdown response, namely "Lockdown IV", is the instrument for the original indicator, the stringency index. The findings are broadly consistent with the results in Table 5 as far as the policy variables are concerned.

Table 7. Quarterly panel regression (two-stage Least Square)

	Dependent variable: quarterly GDP growth (y-o-y)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total deaths per thousand	-0.0348***						8.82e-04	0.00458
	(0.000863)						(0.00244)	(0.00177)
Lockdown IV (daily mean)		-0.00366***					-0.00496***	-0.00346**
		(0.000855)					(0.00171)	(0.00137)
Tests per confirmed case (thousands)			0.00165				0.00548***	0.00198**
			(0.00182)				(0.00167)	(0.000837)
Open testing (0/1)				0.00799			0.000294	0.00153
				(0.00726)			(0.00978)	(0.00810)
Tourism (%GDP)					-0.00150**		-0.000655	.
					(0.000649)		(0.000879)	.
Gross Debt Position (%GDP)						-0.000200**	-0.000230***	.
						(8.56e-05)	(8.16e-05)	.
Constant	-0.0423***	0.143***	-0.0470***	-0.0509***	-0.0665***	-0.0570***	0.213**	0.131*
	(0.000965)	(0.0444)	(0.000258)	(0.00435)	(0.00738)	(0.0103)	(0.0859)	(0.0697)
Observations	311	243	292	311	303	296	219	217
R-squared	0.804	0.817	0.831	0.799	0.559	0.581	0.695	0.859
Number of quarters	4	4	4	4	4	4	4	4
quarter FE	Y	Y	Y	Y	Y	Y	Y	Y
country FE	Y	Y	Y	Y	N	N	N	Y

Note: The sample is a quarterly panel consisting of countries with available quarterly GDP data for the four quarters of 2020 as of April 20, 2021. Quarterly GDP obtained from Global Economic Monitoring (GEM). The dependent variable is year-on-year quarterly GDP growth. COVID-19 indicators (deaths per thousand, stringency index, and tests per case) collected from Oxford Covid-19 Government Response Tracker 2020. Lockdown stringency measure ("Lockdown IV") is constructed as a daily-mean of the quarterly aggregation of monthly predicted values obtained from a 2SLS first-stage regression of monthly stringency index on the one-month lags of monthly industrial production growth, monthly mortality and infection rates, and country-specific and month-specific fixed effects. Tourism and gross debt position are pre-covid annual measures and obtained from World Development Indicators. All regressions control additionally for country's baseline (2019) annual GDP level and average quarterly GDP growth between Q1-2014 and Q4-2019. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1.

We also consider the possibility that economic agents responded to the rising health risk posed by COVID-19 by voluntary social distancing, which in turn could affect economic activity. To capture this possibility, we use a de-facto mobility reduction in place of a de-jure lockdown stringency imposed by the government. The results are similar when we replace the stringency index score with a quarterly-average measure of daily mobility reduction obtained from Google Mobility Data (Table 8).[14]

We also utilize monthly Industrial Production (IP) data between March and December 2020 to capture higher frequency variations in output. The results are largely consistent with the previous findings (Table A4).

[14] We use the mobility indicator associated with "Retail and Recreation" destinations as categorized by Google. Our result is robust to other indicators that refer to mobility to other destination categories, such as "Workplace", or "Public Transit".

Table 8. Robustness: Quarterly panel regression (de-facto mobility reduction)

	Dependent variable: quarterly GDP growth (y-o-y)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total deaths per thousand	-0.0614***						-0.0152	5.24e-04
	(0.00126)						(0.00115)	(0.00105)
Mobility to retails (% change from baseline)		-0.00137***					-0.00131***	-0.00119***
		(0.000204)					(0.000216)	(0.000250)
Tests per confirmed case (thousands)			0.00786***				0.00662	0.00238
			(0.00267)				(0.00752)	(0.00484)
Open testing (0/1)				0.00336			0.00756	0.00789
				(0.00942)			(0.00873)	(0.00764)
Tourism (%GDP)					-0.00150**		-0.00127*	.
					(0.000649)		(0.000707)	.
Gross Debt Position (%GDP)						-0.000200**	-0.000169***	.
						(8.56e-05)	(5.32e-05)	.
Constant	-0.0630***	-0.0354***	-0.0725***	-0.0739***	-0.0665***	-0.0570***	-0.0221*	-0.0243***
	(0.00687)	(0.00901)	(0.00709)	(0.00908)	(0.00738)	(0.0103)	(0.0114)	(0.00761)
Observations	311	292	294	311	303	296	263	262
R-squared	0.571	0.663	0.583	0.542	0.559	0.581	0.712	0.860
Number of quarters	4	4	4	4	4	4	4	4
quarter FE	Y	Y	Y	Y	Y	Y	Y	Y
country FE	N	N	N	N	N	N	N	Y

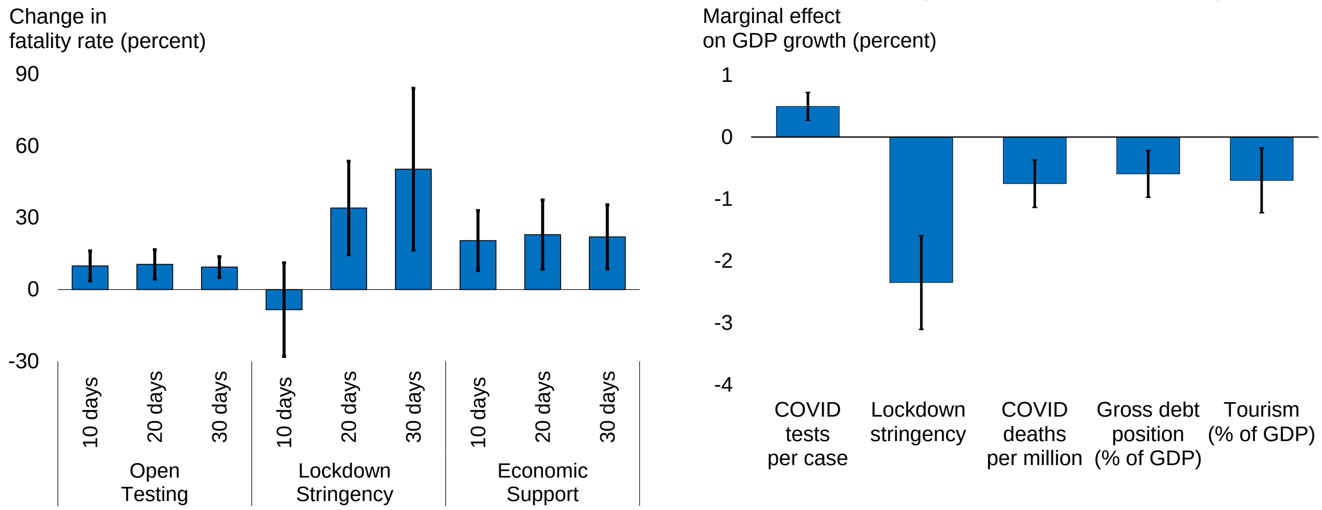
Note: The sample is a quarterly panel consisting of countries with available quarterly GDP data for the four quarters of 2020 as of April 20, 2021. Quarterly GDP obtained from Global Economic Monitoring (GEM). The dependent variable is year-on-year quarterly GDP growth. COVID-19 indicators (deaths per thousand and tests per case) obtained from Oxford Covid-19 Government Response Tracker 2020. Mobility reduction, measured as a percentage change from baseline, is obtained from Google Mobility Index. Tourism and gross debt position are pre-covid annual measures and obtained from World Development Indicators. All regressions control additionally for country's baseline (2019) annual GDP level and average quarterly GDP growth between Q1-2014 and Q4-2019. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1.

VI. Softening policy trade-offs

In order to better visualize the policy tradeoffs between saving lives (i.e., containing the disease at the cost of lowering economic activity) and saving livelihoods (i.e., resuming economic activity at the cost facing greater infection spread), we draw together the results presented in Sections IV and V.

Figure 4. Determinants of disease containment and growth

A. Correlates of COVID-19 infections **B. Correlates of growth outcomes during COVID-19**



Note: Authors' calculation, based on data from the World Development Indicators, Global Economic Monitoring, Europe CDC, and Oxford Covid-19 Government Response Tracker 2020. Panel A presents point estimates from a daily regression from January 01–December 31 2020, of change in fatality rates, standardized as a unit of deviation from the global mean, on open testing policy (constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise), lockdown stringency index (rescaled from [0-100] to [0-1]), and economic-support index (rescaled from [0-100] to [0-1]). The model controls for country and day fixed effects. Three separate point estimates presented for specifications with one-day, one-month, and two-month lags of policy responses. Whiskers represent 95-percent confidence intervals of the estimates. Panel B presents estimates from the sample of quarterly panel consisting of countries with available quarterly GDP data in 2020 (as of April 20, 2021). The dependent variable is year-on-year quarterly GDP growth. All quarterly explanatory indicators—tests per case, lockdown stringency, and deaths per million—are standardized and expressed in unit of standard deviation from global mean for each quarter. Gross debt position and tourism are annual measures at baseline (2019), also standardized and expressed in unit of standard deviation from global mean. Bar heights represent the sizes of the estimated coefficients. Whiskers represent 95-percent confidence intervals.

Figure 4 suggests that lockdowns are effective policy measures to contain the spread of the disease (Panel A) but entail a substantial cost to economic growth (Panel B). On average, reducing the average daily lockdown stringency by ten index points—a fifth of the world's median daily stringency score in 2020 (52)—would boost GDP growth by approximately one percentage point. In contrast, open and comprehensive testing policies are positively associated with both containment and growth outcomes, even after controlling for the level of mortality rate and the stringency of lockdowns. On average, every 1,000 additional tests per positive case is associated with a one percentage point increase in output growth. As noted above, more testing may have infused greater confidence in people to step out and engage in economic activity.

Thus, the lives-livelihoods trade-off is associated with lockdowns; testing saves both lives and livelihoods.

For magnitude interpretations, the estimated coefficients of the 30-day lag regression reported in Table 3 (column 5) suggest that the government's introduction of an open testing policy can help the country to relax the degree of lockdown stringency by about 19 percent while keeping its one-month fatality rate unchanged.[15]

Relying on the estimates obtained from the growth regression that controls for country and quarter fixed effects (Table 5; column 7) and the global average increase in daily lockdown stringency index between Q1 and Q2 2020 (+55.8 index points), the introduction of open testing policy could have *indirectly* reduced global output contraction in 2020 by 0.63 percentage point.[16] That is, introducing open testing could allow governments to relax the degree of lockdowns, thereby lowering the economic damage while maintaining socially desired levels of COVID-19 containment.

VII. Conclusion

This paper examined determinants of COVID-19 infections and economic growth outcomes. We find that countries that succeeded in containing the spread of the disease implemented early mobility restrictions, strong public health measures such as open COVID testing, and economic support packages. Countries that experienced greater growth contraction in 2020 had higher infection rates, imposed more stringent mobility restrictions, had more highly indebted

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[15] This trade-off is obtained by computing the $\left(-\frac{\alpha_3}{\alpha_2}\right)$ ratio in Equation 8 using estimates from the 30-day fatality regression reported in Table 3, column 5: $\left(-\frac{\alpha_3}{\alpha_2}\right) = \frac{0.0938}{0.502} = 18.7\%$. Equivalently, a regression with infection rate serving as the dependent variable (Appendix Table A2) yields the trade-off ratio of 12.7%.

[16] The indirect economic benefit of testing (through relaxing lockdown) is computed as $\left(-\frac{\alpha_3}{\alpha_2}\right) \text{ x } \beta_2 \text{ x } \sigma$, where $\left(-\frac{\alpha_3}{\alpha_2}\right)$ is the trade-off ratio obtained from Equation 8 (Table 3; column 5), β_2 is the coefficient associated with lockdown policy in Equation 10 (Table 5; column 8), and σ denotes the global average increase in daily lockdown stringency index between Q1-2020 and Q2-2020. The global average lockdown stringency index scores in Q1-2020 and Q2-2020 are 17.25 and 73.07 (out of 100), respectively.

governments, and were more externally exposed to global recession, as measured by the dependence on earnings from tourism.

Drawing these results together, it is evident that the presumed trade-off between lives and livelihoods was associated with lockdowns as the primary instrument of containment. Early transition from lockdowns to testing-tracing-isolation-based containment softened the trade-off within countries and explains the absence of a trade-off across countries. We find that testing had positive indirect effects on growth and perhaps even positive direct effects. By allowing countries to relax shutdowns without compromising on containment, testing could have indirectly contributed to about a 0.6 percentage point boost in growth. By infusing greater confidence in people to step out and engage in economic activity, testing could have added another 0.6 percentage point to growth.

As the world struggles to scale up vaccination in the face of new waves and variants, continued emphasis on testing could limit the spread of the disease and the need for costly lockdowns. Although vaccines can slow viral transmission, countries with substantial local incidence will still experience substantial transmission and deaths until very late in any vaccination deployment, which in many cases will take longer than a year. The extent of the human cost depends not only on vaccine efficacy, but also on how much interventions like testing reduce the effective reproductive number of the virus at the time a vaccine is deployed (Paltiel et al., 2021). The extent of the economic cost depends on how far outbreaks can be controlled without resorting to economically costly lockdowns.[17] The key implication is that countries will need to combine vaccines with continued emphasis on testing to bring the virus under control and save both lives and livelihoods.

[17] Delays in vaccinations in emerging markets and developing economies are estimates to lead to a significant global GDP loss through disruptions in trade (Çakmaklı et al. 2021b).

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Appendix

Table A1. GDP growth by region

Year	Quarter	Quarterly GDP growth (y-o-y)						
		EAP	**ECA**	**LAC**	**MENA**	**NAR**	**SAR**	**SSA**
2018	1	6.32	3.29	2.61	3.98	3.03	8.77	3.19
2018	2	6.22	3.04	1.89	3.84	3.22	7.59	2.65
2018	3	5.61	2.34	1.87	4.02	3.06	6.41	2.78
2018	4	5.60	1.73	0.96	4.25	2.46	6.32	2.68
2019	1	5.80	1.65	0.76	3.88	2.21	5.74	2.71
2019	2	5.39	1.73	1.31	3.63	1.98	5.33	3.09
2019	3	5.15	2.08	1.13	3.42	2.06	4.62	2.88
2019	4	4.93	2.24	0.86	3.32	2.27	3.30	2.54
2020	1	-3.77	-0.64	-1.54	2.20	0.25	2.87	2.56
2020	2	-0.74	-12.24	-15.22	-6.67	-9.41	-24.27	-7.05
2020	3	1.51	-3.47	-6.57	-2.44	-3.10	-7.18	-2.97
2020	4	3.30	-3.09	-2.68	-1.29	-2.47	0.46	-0.99

Note: Authors' computed population-weighted averages, using WDI 2019's population. Data from World Bank's Global Economic Monitoring. Statistics for 2018Q1-2020Q3 is computed based on available quarterly GDP data from 87 countries. Statistics for 2020Q4 is computed based on available quarterly GDP data from 83 countries.

Table A2. Correlates of COVID-19 infection across policy lags

	Dependent variable: change in infection rate (%; standardized)					
	(1)	(2)	(3)	(4)	(5)	(6)
Policy Lag Period (days)	10 days	20 days	30 days	40 days	50 days	60 days
Open testing policy (0/1)	0.0102	0.00837	-0.0357*	-0.0908***	-0.133***	-0.162***
	(0.0226)	(0.0247)	(0.0237)	(0.0211)	(0.0192)	(0.0179)
Stringency Index [0-1]	-0.243***	-0.228***	-0.281***	-0.357***	-0.449***	-0.548***
	(0.0310)	(0.0260)	(0.0280)	(0.0322)	(0.0355)	(0.0392)
Economic Support Index [0-1]	-0.149***	-0.166***	-0.194***	-0.218***	-0.234***	-0.217***
	(0.0359)	(0.0395)	(0.0383)	(0.0364)	(0.0353)	(0.0355)
Constant	0.217***	0.214***	0.289***	0.381***	0.473***	0.548***
	(0.0288)	(0.0268)	(0.0327)	(0.0378)	(0.0401)	(0.0416)
Observations	48,957	47,304	45,640	43,971	42,301	40,631
R-squared	0.142	0.088	0.116	0.165	0.214	0.244
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Date Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table presents result from daily regressions of the growth rate in new cases, standardized as a unit of deviation from the global mean, on representative lags of open testing policy (constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise), lockdown stringency index (rescaled from [0-100] to [0-1] for chart representation), and economic-support index (rescaled from [0-100] to [0-1] for chart representation). Data collected from Oxford Covid-19 Government Response Tracker 2020 between January 01 and December 31, 2020. All regressions control for country and day fixed effects.

Table A3. Correlates of COVID-19 infection: interaction effects

Dependent variable: change in infection rate (%; standardized)						
	(1)	(2)	(3)	(4)	(5)	(6)
Policy Lag Period (days)	10 days	20 days	30 days	40 days	50 days	60 days
Testing Policy (binary; 0/1)	0.0144***	0.0137***	-0.284***	-0.344***	0.0254***	0.0366***
	(0.00338)	(0.00224)	(0.0315)	(0.0328)	(0.00338)	(0.00423)
Lockdown Stringency Index [0-1]	0.0104	0.0104	-0.0363	-0.0941***	-0.135***	-0.158***
	(0.0252)	(0.0276)	(0.0263)	(0.0231)	(0.0207)	(0.0189)
Economic Support Index [0-1]	-0.140***	-0.162***	-0.191***	-0.214***	-0.235***	-0.230***
	(0.0354)	(0.0388)	(0.0368)	(0.0339)	(0.0318)	(0.0309)
Total cases per thousand (cases/1000)	-0.00962***	-0.00914***	-0.0147***	-0.0253***	-0.0405***	-0.0605***
	(0.00235)	(0.00219)	(0.00243)	(0.00293)	(0.00374)	(0.00484)
[Lockdown Index] X [cases/1000]	0.0144***	0.0136***	0.0135***	0.0169***	0.0254***	0.0366***
	(0.00215)	(0.00249)	(0.00243)	(0.00276)	(0.00312)	(0.00323)
[Testing Policy] X [cases/1000]	0.000764	-0.000211	0.00274	0.00671***	0.00867***	0.00851***
	(0.00173)	(0.00196)	(0.00197)	(0.00198)	(0.00216)	(0.00255)
[Econ Support Index] X [cases/1000]	-0.00284	-0.00153	-0.00147	-0.00128	0.00226	0.0120***
	(0.00200)	(0.00123)	(0.00173)	(0.00233)	(0.00327)	(0.00451)
Constant	0.234***	0.231***	0.305***	0.403***	0.512***	0.610***
	(0.0300)	(0.0277)	(0.0329)	(0.0383)	(0.0410)	(0.0429)
Observations	48,957	47,304	45,640	43,971	42,301	40,631
R-squared	0.143	0.088	0.116	0.166	0.216	0.248
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Date Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table presents result from daily regressions of the growth rate in new cases, standardized as a unit of deviation from the global mean, on representative lags of open testing policy (constructed as a binary indicator which equals 1 if testing is open and available to all, and 0 otherwise), lockdown stringency index (rescaled from [0-100] to [0-1] for chart representation), and economic-support index (rescaled from [0-100] to [0-1] for chart representation). Data collected from Oxford Covid-19 Government Response Tracker 2020 between January 01 and December 31, 2020. All regressions control for country and day fixed effects.

Table A4. Monthly panel regression with Industrial Production

	Dependent variable: monthly gorwth in Industrial Production (y-o-y)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total deaths per thousand	-1.260						-1.932	2.911
	(0.435)						(0.759)	(0.465)
Stringency index (daily mean)		-0.0983**					-0.132**	-0.111***
		(0.0380)					(0.0619)	(0.0417)
Tests per confirmed case (thousands)			-0.0172***				0.0427***	-0.0218***
			(0.00391)				(0.0145)	(0.00460)
Open testing (0/1)				-1.208			-1.148	-1.230
				(1.540)			(2.287)	(1.611)
Tourism (%GDP)					-0.156		-0.215	.
					(0.198)		(0.176)	.
Gross Debt Position (%GDP)						-0.0311*	-0.0251	.
						(0.0159)	(0.0184)	.
Constant	-6.767***	-0.729	-6.746***	-5.932***	-7.577***	-5.495**	4.702	1.277
	(0.214)	(2.359)	(0.00172)	(1.144)	(2.459)	(2.231)	(3.482)	(2.806)
Observations	676	676	668	676	646	666	636	636
R-squared	0.693	0.698	0.695	0.694	0.303	0.319	0.349	0.686
months	3-12	3-12	3-12	3-12	3-12	3-12	3-12	3-12
month FE	Y	Y	Y	Y	Y	Y	Y	Y
country FE	Y	Y	Y	Y	N	N	N	Y

Note: The sample is a quarterly panel consisting of countries with available monthly Industrial Production (IP) data for the months between March and December in 2020 (as of April 20, 2021). Monthly IP obtained from Global Economic Monitoring (GEM). COVID-19 indicators (deaths per thousand, stringency index, and tests per case) collected from Oxford Covid-19 Government Response Tracker 2020. Tourism and gross debt position are pre-covid annual measures and obtained from World Development Indicators. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1.