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Walking the Tightrope: Avoiding a Lockdown While Containing the Virus*

ABSTRACT

This paper finds that although containment policies can successfully reduce the spread of the virus, they can also have a substantial impact on reducing mobility and economic activity. It also shows that testing, combined with effective contact tracing, is crucial in reducing the spread of the virus, especially at relatively low levels of infection, and that mask-wearing and the protection of the elderly population in general and those in care homes in particular, might play an important role in combatting the virus while minimizing economic costs.

Since the onset of the pandemic, parameterized epidemiological SIR (susceptible, infected and recovered) models have been a popular tool for analyzing the disease dynamics (Anderson et al. 2020; Atkeson 2020; Stock 2020). These models can be used to shed light on the effectiveness of physical distancing and other public health measures in containing a second wave of infections (Ferguson et al. 2020; Matrajt and Leung 2020; Davies et al. 2020; Hornstein 2020). SIR models rely on several parameters (to quantify the impact of physical distancing on the basic reproduction or 'R' number, for instance), so their insights are only as good as these parameters are accurate. So far, however, most modelers have relied on past (mostly flu) epidemics to calibrate important parameters, while the current pandemic likely differs in important ways.

This study contributes to a burgeoning literature that seeks to quantify the impact of government interventions on disease progression and mobility by employing reduced-form econometric estimates of the Covid-19 pandemic itself. This literature has already shown that stricter lockdown policies go in tandem with a reduction in Covid-19-related deaths (Conyon et al. 2020). It has found strong evidence that banning mass gatherings is one of the most effective ways of taming the spread of the virus (Ahammer et al. 2020; Hunter et al. 2020; Weber 2020). Similarly, air travel restrictions are found to be effective, especially those imposed on international flights and at the early stages of the pandemic (Hubert 2020; Keita 2020, Leffler et al. 2020). Stay-at-home requirements and workplace closures can also curb the propagation of the disease (Deb et al. 2020; Hunter et al. 2020; Weber 2020), as can the use of face masks (Hatzius et al. 2020; Leffler et al. 2020; Mitze et al. 2020). Nevertheless, recent empirical literature has said little about the importance of testing and contact tracing policies (despite their prominence in SIR models) and the protection of the elderly population.

The rest of the paper is structured as follows. Section 2 presents the drivers of the reproduction rate, while Section 3 describes the determinants of mobility. Section 4 offers a scenario analysis and Section 5 provides some concluding remarks.

THE IMPACT OF POLICIES ON THE REPRODUCTION RATE

Confinement Policies

In estimation, the coefficients on five containment policies workplace closures, restrictions on gatherings, stay-at-home requirements, international travel controls and school closures[1] are found to have a statistically significant effect in reducing R

[1] Containment measures are drawn from the Oxford Blavatnik School of Government (Hale et al. 2020) and are variously scored 0 to 2, 0 to 3, or 0 to 4. In this paper, four different levels of stringency are included as distinct dummy variables (taking the value of zero or one) as there is no reason to expect a policy with a stringency value of 3 to have triple the effect of a policy with a value of 1). Data on mask wearing and protection of the elderly is constructed by the authors using textual extraction from various databases. The working paper version of this paper provides details on the data used for the estimations and some of the modelling choices: Égert et al. (2020).

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(Table 1).[2,3] The coefficient on school closures has the largest effect of any containment policies, but there is a degree of collinearity between school closures, stay-at-home requirements and workplace closures, which arises because such containment policies have often been imposed at the same time.

Further testing suggests that while the sum of the coefficients on these three containment variables is a robust indication of the effect of a combined package, the coefficient on any one of them is less reliable, as it is sensitive to the exclusion of other variables (for this reason, the combined effect of the three policies is given in Figure 5 under the heading of 'Typical lockdown', rather than showing each individually). Similarly, the absence in the equation of any role for the closure of public events is likely related to its overlap with restrictions on the size of gatherings, which is included. The combined effect of applying all containment polices suggests that from an initial R0 value of about 3, a complete package of containment measures would nearly halve the reproduction number.

An interesting finding is that the impact differs substantially across countries, in that workplace closures have a considerably larger negative effect on R in high-income countries as compared to other countries. One possible reason is that workplace closures can be enforced more effectively in high-income countries, where workers, more likely to be covered by social insurance, may be less tempted to circumvent them. This finding is mirrored in the mobility equation, according to which workplace closures have a larger impact in advanced economies. Conversely, while stay-at-home requirements are found to reduce R to a greater extent in advanced economies than in less developed countries, this is not the case for mobility. The lower effectiveness of stay-at-home requirements in less advanced economies may be attributable to larger household sizes and smaller living spaces.

An important feature of these results is that the full R reduction is often achieved well before the maximum level of stringency is reached; for example, a stringency score of 2 on the workplace closure variable reduces R, but no additional effect on R can be detected from a further increase in the degree of stringency. The combined effect of applying all containment polices suggests that from an initial R0 value of about 3, a complete package of containment measures would nearly halve the reproduction number (Figure 1).

Test and Trace Policies

Results suggest that test and trace policies can reduce the spread of the virus (Table 1). The most comprehensive form of test and trace policies[4] are more than 2½ times as effective in reducing R than more limited forms. Test and trace polices are most effective when the infection rate is not too high (which in estimation is taken to be less than 10 new daily cases per million population, a rate which was well exceeded by many countries in March and April 2020), a rather unsurprising finding given the difficulties of tracking down all contact persons in a timely manner when the system is overwhelmed with new cases.

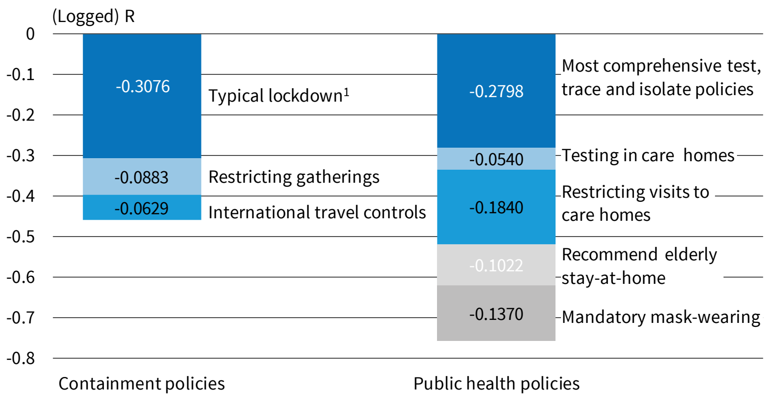
[2] The reproduction rate is estimated using the code developed by Systrom (2020), who extends the static Bayesian approach of Bettencourt and Ribeiro (2008).

[3] An important feature of the estimated equation explaining R is that the preferred functional form for the dependent variable is logarithmic; a formal test decisively rejects a linear form in favour of a logarithmic one. This implies that any policy intervention will have a larger effect when R is initially high than when it is low, and underlines the merit of early policy interventions.

[4] Most comprehensive testing is defined as open public testing (e.g., 'drive through' testing available to asymptomatic people). Most comprehensive tracing is defined as comprehensive contact tracing done for all identified cases.

Figure 1

Effect of Containment Policies and Public Health Policies on (Logged) R



Note: This chart decomposes the effect on (logged) R of the various containment policies (bars on left) and public health policies (bars on right) according to the regressions in Table 5.
[1] The effects of school closures (≥2), stay-at-home requirements (≥1) and workplace closures (≥2) have been combined into a single segment labelled 'Typical lockdown'. This is because such policies have often been imposed at the same time and, as discussed in the main text, because multi-collinearity means that the sum of the coefficients on these three containment variables is more reliable than any of the individual coefficients.
Source: Authors' calculations.

Overall, the impact of the most effective test and trace regime on reducing R in an environment of low daily infection is estimated to be greater than any other public health intervention and 2–3 times more effective than most individual containment measures (Figure 1). Variant regressions show that isolating the contacts of people who are sick or who tested positive with the virus has a non-trivial effect on R and substantially enhances the effectiveness of test and trace policies.

Protecting the Elderly

Empirical analysis provides strong evidence that policies can play an important role in shielding the elderly population. Stepping up the testing of residents and staff in long-term care facilities is found to correlate negatively with the transmission of the virus. Restricting visitor access to these establishments goes in tandem with lower reproduction rates. Furthermore, general stay-at-home recommendations for the elderly appears to be associated with fewer infections (Table 1). The combined effect of these polices on reducing R is estimated to exceed the effect of most individual containment measures (Figure 1).

Table 1

Drivers of the Reproduction Rate
Sample period: 1 January to 17 August 2020

Dependent variable: ln(R)	
Constant	1.0947**
Containment policies	
Stay-at-home requirement (≥1)	– 0.0536**
Workplace closures (=1)	– 0.0614**
Workplace closures (≥2)	– 0.0767**
School closures (≥2)	– 0.1773**
Restrictions on gatherings (=2)	– 0.0393**
Restrictions on gatherings (≥3)	– 0.0883**
International travel controls (≥1)	– 0.0629**
Test and Trace policies	
Test=1 or 2, Trace =1 or 2	– 0.1110**
Test=3, Trace=1	– 0.1364**
Test=3, Trace=2	– 0.2185**
All Test & Trace combinations when deaths < 10 per million	– 0.0613**
Policies protecting the elderly	
Testing in care homes (=2)	– 0.0540**
Restricting visits to care homes (≥1)	– 0.1840**
Recommending elderly to stay at home	– 0.1022**
Other non-containment policies	
Mandatory mask wearing indoors	– 0.1370**
Death rates (per million population)	
Daily national	– 0.0358**
Daily global	– 0.3637**
Total national	– 0.0007**
Adjusted R-squared	0.597
Daily observations	17,624
Countries covered	147
Country fixed effects	Yes

Note: For details of the construction of data on R see Annex A. The policy variables are based on the variables described in Tables 1 to 3 in the main text, but re-normalized to (0, 1) dummy variables as described in the main text. The notation in brackets (=n) given after a containment policy variable denotes that the dummy variable is assigned a 1 if the original score for that policy was equal to n, whereas the notation (≥n) denotes that the dummy variable is assigned a 1 if the original score for that policy was greater than or equal to n. ** denotes statistical significance at the 5% level, based on heteroscedasticity-robust standard errors.

Source: Authors' calculations.

Mask Wearing

Results show a sizeable and fairly robust negative effect on R from the introduction of mandatory mask wearing in all closed public spaces (Table 1), although other results (not reported) suggest that extending mask wearing obligations to the outdoors does not appear to add much to reducing the reproduction rate.

Awareness of the Virus and Towards Herd Immunity

Both the national and global daily death rates are included to proxy for general awareness of the virus prompting more cautious behavior, for example voluntary physical distancing and increased hand-washing. The importance of these variables is that they proxy for changes in behavior that are likely to be engendered regardless of governmentmandated restrictions. Total national deaths attributed to the virus expressed as a share of the population are also included separately as a proxy for the share of the population that has been infected, with the expectation of a negative coefficient; as the share of the population that has been infected rises (and presumably becomes immune), the speed with which the virus spreads will be reduced. Death rate variables are statistically significant with the expected negative sign, and their magnitudes imply that they can play an important role in the evolution of R.

THE IMPACT OF CONTAINMENT POLICIES ON MOBILITY

Putting in place containment and isolation policies hinders the free daily movement of people. Empirical results suggest that seven of the eight categories of containment policy published by Google have a negative effect on mobility, based on the movement of people with Android-based smartphones (Table 2).[5] Unlike in the equation for R, there is a clearer ranking in coefficients, so that a more stringent application of a particular policy tends to more greatly reduce mobility. For example, the most severe form of workplace closure (with a score of 3) has a nine times greater ef-

[5] The failure to detect any effect from restrictions on gatherings is likely related to its close correlation with the policy to cancel public events.

fect on mobility of the mildest form (with a score of 1). These findings suggest that moving to more stringent forms of workplace closure, stay-at-home requirements and school closure has larger negative effects on mobility and hence economic activity, although it is difficult to detect any corresponding benefit from further reductions in R.

For policies such as the cancellation of public events and travel restrictions, the most limited application of the policy has no significant effect on mobility. Applying all containment policies in their most severe forms would reduce mobility by more than half, relative to normal, with 50 percent of this reduction accounted for by workplace closures and stay-at-home requirements.

Alternative estimations explore the effect of mask-wearing on mobility. Positive coefficient estimates suggest that mandating mask wearing in public transport and shops increases mobility. Similarly, more extensive testing and the isolation of contact persons are found to encourage mobility (Table B.6 in Annex B), possibly by reducing concerns about infection.

The national daily death rate from the virus is again included to proxy general awareness of the virus and its effect in voluntarily reducing mobility due to an increase in natural caution. A national daily death rate running at around 15 per million – similar to the rate experienced by some major OECD countries going into the lockdown in March 2020 – would reduce mobility by 10 percent, independently of any government-mandated polices.

SCENARIO ANALYSIS

A number of stylized scenarios are constructed using the estimated equations for R and mobility (Figure 2, Table 3). For a typical country, at the first outbreak of the virus, the initial reproduction number R0 is estimated to be about 3, and mobility is normal before the impact of the virus on the economy is felt (represented by the red triangle at the top right-hand corner of Figure 2). Even before the implementation of government-mandated measures, awareness of the seriousness of the virus (represented by the daily death rate) is likely to reduce mobility and foster more cautious behavior, leading to a fall in R, although it remains well above 1.0 (indicated by the red triangle at *'Pre-lockdown + natural caution'* in Figure 2, which is calibrated on the daily death rates of a number of major OECD economies just prior to lockdown).

Once the number of daily infections is high (here proxied by the high national daily death rate), the implementation of a wide range of containment measures is essential to contain the spread of the virus. In the scenarios considered here, the implementation of full lockdown (FLD) measures, accompanied by a limited test-and-trace regime, reduces R to close to 1.0, but at the cost of a sharp fall in mobility (represented by the blue squares in Figure 2). The degree of stringency with which lockdown measures

Table 2

Drivers of Mobility
Sample period: 1 January to 17 August 2020

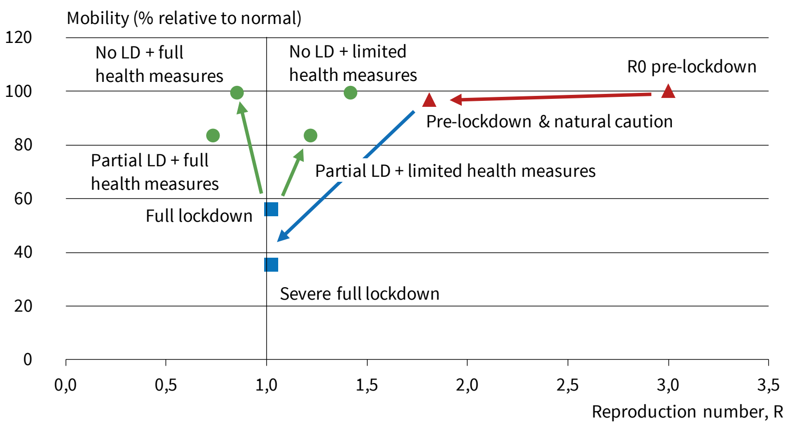
Dependent variable: Mobility	
Constant	1.0241**
Containment policies	
Stay-at-home requirement (=1)	– 0.0240**
Stay-at-home requirement (=2)	– 0.0668**
Stay-at-home requirement (=3)	– 0.1252**
Workplace closures (=1)	– 0.0216**
Workplace closures (=2)	– 0.0491**
Workplace closures (=3)	– 0.1980**
School closures (=2)	– 0.0237**
School closures (=3)	– 0.1098**
Canceling public events (=2)	– 0.0369**
Restrictions on internal movement (=2)	– 0.0220**
International travel controls (=4)	– 0.0554**
Close public transport (=1)	– 0.0439**
Close public transport (=2)	– 0.0650**
Death rate (per million population)	
Daily national	– 0.0066**
Adjusted R-squared	0.759
Daily observations	22,741
Countries covered	128
Country fixed effects	Yes

Note: Mobility data are made available by Google, based on the movement of people with 'location history' turned on in their smartphone settings. The index used here measures the change in mobility from a same-day-of-the-week average in January and early February, such that normality would suggest an index of 1.0. The containment policy variables are based on those given in Table 1, but re-normalized to (0, 1) dummy variables as described in the main text. The notation in brackets (=n) given after a containment policy variable denotes that the dummy variable is assigned a 1 if the original score for that policy was equal to n, whereas the notation (≥n) denotes that the dummy variable is assigned a 1 if the original score for that policy was greater than or equal to n. ** denotes statistical significance at the 5% level.

Source: Authors' calculations.

Figure 2

Stylized Scenarios: From the First Outbreak of the Virus, Through Lockdown (LD) and Exit



Note: The points represent scenarios, each of which are generated from consistent combinations of the equations for R and mobility, using assumptions for the explanatory variables that are presented in Table 3. Red triangles denote the situation at the start of the virus outbreak, blue squares indicate the situation following full lock-down policies, and green circles represent various exit scenarios.
Source: Authors' calculations.
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Table 3

Scenario Assumptions and Outcomes for R and Mobility

Scenario	Containment measures	Testing, tracing & isolation		Other public health policies				Daily national deaths	Daily global deaths	Total national deaths	R	Mobility index (1.00 = normal)
		Extensive	Limited	Mask-wearing	Testing in care homes	Elderly stay at home	Banning of care home visits	per million of population				
Pre-lockdown												
R0	None	-	-	-	-	-	-	0	0	0	3	1
Natural caution	None	-	-	-	-	-	-	5.0	0.8	50	1.81	0.967
Lockdown												
Full lockdown (FLD)	Comprehensive	-	√	-	-	-	-	5.0	0.8	50	1.02	0.562
Severe FLD	Comprehensive & severe	-	√	-	-	-	-	5.0	0.8	50	1.02	0.3547
Exit from lockdown												
Partial LD & full health measures	Banning of large public events, restrict gatherings, quarantine international travellers	√	-	√	√	√	√	1.0	0.7	300	0.73	0.8352
Partial LD & limited health measures	Banning of large public events, restrict gatherings, quarantine international travellers	-	√	√	-	-	-	1.0	0.7	300	1.22	0.8352
No LD & full health measures	None	√	-	√	√	√	√	1.0	0.7	300	0.85	0.9934
No LD & limited health measures	None	-	√	√	-	-	-	1.0	0.7	300	1.42	0.9934

Note: The assumptions here correspond to the scenarios illustrated in Figure 2.

Source: Authors' calculations.

are applied will determine the extent of the fall in mobility, with two scenarios considered here. The first assumes that containment policies are applied with a degree of stringency which is typical of that followed by countries in March/April 2020 (corresponding to the median country), while the second assumes that all containment policies are applied to their maximum possible degree of stringency. Mobility falls by more than 40 percent in the former case and by more than 60 percent in the latter; however, the estimation results suggest there is little additional benefit from maximizing the degree of stringency of containment policies in terms of lowering R (particularly with regard to workplace closures or stay-at-home requirements).

Even in the absence of further policy changes, the reproduction number will evolve during lockdown as the numbers of infections and deaths change. The fall in the daily death rate may tend to lower natural caution and so lead to some increase in R and mobility; on the other hand, as the total number of individuals who have already been infected and have acquired immunity rises, then this will tend to lower R. The estimation results and particular calibrations used in constructing these scenarios suggest these two effects roughly cancel each other out.

A number of strategies for avoiding a full lockdown are considered (represented by the green circles in Figure 2). The basic issue facing policymakers is how to prevent the need for a full set of containment policies while bringing or keeping R under control. The estimation results (Table 1) suggest that the implementation of a comprehensive test and trace policy along with a package of additional public health measures would more than compensate for the removal of lockdown policies, such that their successful implementation would see a return to near normality of mobility, with R remaining below 1 (as represented by the green circle labelled *'No LD + full health measures'* in Figure 2).

An even more decisive reduction in R below 1 might be achieved if comprehensive public health measures were accompanied by some containment policies being maintained (here assuming that restrictions on large public events, large public gatherings and international travel remain), although it would come at some cost to mobility (*'Partial LD + full health measures'* in Figure 2).

In practice, as the experience of several countries is showing, implementing a full range of public health policies and a comprehensive test and trace regime may be difficult, especially once the daily infection rate has begun to rise. Variant scenarios with *'limited health measures'* assume only a limited test-and-trace regime along with mandated mask-wearing in indoor public places, but no other public health policies targeted at the elderly or care homes. Such a combination of policies accompanied by a full relaxation of lockdown measures might see mobility initially return to just below normal levels (assuming the daily death rate has previously been reduced by lockdown), but R will likely increase well above 1.0 (represented by the scenario labelled *'No LD + limited health measures'* in Figure 6). However, this situation would not be a stable equilibrium, as with R above 1.0 there would be a subsequent pick-up in infections and deaths, which in turn would further reduce mobility, regardless of further government action.

A limited set of health measures accompanied by the same limited containment policies being maintained would come at a more immediate cost to mobility but bring R down further, although in the scenario considered here it would still remain above 1 (*'Partial LD + limited health measures'*), and so would not represent a sustainable situation.

CONCLUSION

This study investigated the impact of different government interventions on both the reproduction rate of the virus, R, and mobility, as a proxy for economic activity. The empirical results inform a number of scenarios, in which the epidemic/economic trade-off of different policy packages is assessed.

First, when the daily infection rate is high, a comprehensive combination of containment policies is needed to reduce the spread of the virus, although these are likely to severely reduce mobility and economic activity.

Second, once the daily infection rate has been lowered, test-and-trace policies represent a better alternative for controlling the virus, because they have no significant adverse impact on mobility or economic activity. Testing is found to be more effective in reducing R if accompanied by comprehensive contact tracing and is most effective in a low-infection environment, because contact tracing becomes increasingly difficult with higher levels of new daily infections (OECD 2020). Specific testing in care homes is also important to control the spread of the virus.

Third, other public health policies can also contribute to restraining the spread of the virus, including mandating mask-wearing in public indoor environments, restricting visits to care homes, and stay-at-home recommendations for the elderly population.[6]

Even with a comprehensive test-and-trace regime and supporting public health policies, there may be a need to resort to selective containment measures. These should prioritize restrictions on large gatherings and international travel. Where there are localized outbreaks of the virus, then targeted lockdown measures are appropriate.

Finally, vaccination is likely to become the most important policy with which to combat the spread of

[6] These findings are in line with and complement Acemoglu et al. (2020), who show in a multi-group SIR framework that the trade-off between mortality rates from the virus and economic damage can be attenuated if interventions are targeted on the most vulnerable individuals.

the virus in the coming year(s). There already seems to be clear evidence that the vaccination program in Israel is reducing the spread of the virus there (Rossman et al. 2021), but as yet it is difficult to identify evidence of vaccinations in multi-country estimations due to the lack of available data. However, any future work should have a special focus on the impact of vaccination programs.

REFERENCES

Acemoglu, D., V. Chernozhukov, I. Werning, and M. D. Whinston (2020), "Optimal Targeted Lockdowns in a Multigroup SIR Model", *NBER Working Paper* No. 27102.

Ahammer, A., M. Halla, and M. Lackner (2020), "Mass Gathering Contributed to Early COVID-19 Spread: Evidence from US Sports", CEPR *Covid Economics* 30.

Anderson, R.M., H. Heesterbeek, D. Klinkenberg and T.D. Hollingsworth (2020), "How Will Country-based Mitigation Measures Influence the Course of the COVID-19 Epidemic?", *The Lancet* 395(10228), 931–934.

Atkeson, A. (2020), "What Will be the Economic Impact of COVID-19 in the US? Estimate of Disease Scenario", *NBER Working Paper* No. 26867.

Bettencourt L.M.A. and R.M. Ribeiro (2008), "Real Time Bayesian Estimation of the Epidemic Potential of Emerging Infectious Diseases", *PLOS ONE* 3(5).

Conyon, M.J., L. He, and S. Thomsen (2020), "Lockdowns and Covid-19 Deaths in Scandinavia", CEPR *Covid Economics* 26.

Davies, N.G., A.J. Kucharski, R.M. Eggo, A. Gimma, and W.J. Edmunds (2020), "Effects of Non-pharmaceutical Interventions on Covid-19 Cases, Death and Demand for Hospital Services in the UK: A Modelling Study", *The Lancet Public Health* 5(7).

Deb, P., D. Furceri, J. D. Ostry, and N. Tawk (2020), "The Effect of Containment Measures on the Covid-19 Pandemic", CEPR *Covid Economics* 19.

Égert, B., Y. Guillemette, F. Murtin, and D. Turner (2020), "Walking the Tightrope: Avoiding a Lockdown While Containing the Virus", OECD Economics Department Working Paper No. 1633.

Ferguson et al. (2020), "Impact of Non-Pharmaceutical Interventions (NPIs) to Reduce COVID-19 Mortality and Healthcare Demand", Imperial College COVID-19 Response Team, London.

Hale, T. et al. (2020), "Oxford COVID-19 Government Response Tracker", Blavatnik School of Government, Oxford University.

Hatzius, J., D. Struyven, and I. Rosenberg (2020), "Face Masks and GDP", Goldman Sachs Global Economics Analyst, 29 June.

Hornstein, A. (2020), "Social Distancing, Quarantine, Contact Tracing and Testing: Implications of an Augmented SEIR Model", CEPR *Covid Economics* 18.

Hubert, O. (2020), "Spacial Distancing: Air Traffic, Covid-19 Propagation and the Cost of Efficiency of Air Travel Restrictions", CEPR *Covid Economics* 24.

Hunter, P.R., F.J. Colón-González, J. Brainard, and S. Rushton (2020), "Impact of Non-pharmaceutical Interventions Against COVID-19 in Europe: A Quasi-experimental Study", mimeo.

Keita, S. (2020), "Air Passenger Mobility, Travel Restrictions and the Transmission of the Covid-19 Pandemic between Countries", CEPR *Covid Economics* 9.

Leffler, G.T., E. Ing, J.D. Lykins, M.C. Hogan, C.A. McKeown, and A. Grzybowski (2020), "Association of Country-wide Coronavirus Mortality with Demographics, Testing, Lockdowns, and Public Wearing of Masks", mimeo.

Matrajt, L. and T. Leung (2020), "Evaluating the Effectiveness of Social Distancing Interventions to Delay or Flatten the Epidemic Curve of Coronavirus Disease", *Emerging Infectious Diseases* 26(8).

Mitze, T., R. Kosfeld, J. Rode, and K. Wälde (2020), "Face Masks Considerably Reduce Covid-19 Cases in Germany: A Synthetic Control Method Approach", CEPR *Covid Economics* 27.

OECD (2020), *Testing for COVID-19: A Way to Lift Confinement Restrictions*, https://www.oecd.org/coronavirus/policy-responses/testing-for-covid-19-a-way-to-lift-confinement-restrictions-89756248/.

Rossman, H. et al. (2021), "Patterns of COVID-19 Pandemic Dynamics Following Deployment of a Broad National Immunization Program", medRxiv.

Stock, J.H. (2020), "Data Gaps and the Policy Response to the Novel Coronavirus", *NBER Working Paper* No. 26902.

Systrom, K. (2020), *Estimating COVID-19's Rt in Real-Time*, IPython Notebook.

Weber, E. (2020), "Which Measures Flattened the Curve in Germany?", CEPR *Covid Economics* 24.