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Exiting from Lockdowns: Early Evidence from Reopenings in Europe

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Exiting from Lockdowns: Early Evidence from Reopenings in Europe [1]

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Abstract

European authorities introduced stringent lockdown measures in early 2020 to reduce the transmission of COVID-19. As the first wave of infection curves flattened and the outbreak appeared controlled, most countries started to reopen their economies albeit using diverse strategies. This paper introduces a novel daily database of sectoral reopening measures in Europe during the first-wave and documents that country plans differed significantly in terms of timing, pace, and sequencing of sectoral reopening measures. We then show that reopenings led to a recovery in mobility—a proxy for economic activity—but at the cost of somewhat higher infections. However, the experience with reopening reveals some original dimensions of this trade-off. First, the increase in COVID-19 infections after reopening appears less severe in fatality rates. Second, a given reopening step is associated with a worse reinfection outcome in countries that started reopening earlier on the infection curve or that opened all sectors at a fast pace in a relatively short time. Finally, while opening measures tend to have an amplification effect on subsequent cases when a large fraction of the economy is already open, this effect appears heterogenous across sectors.

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[1]

I. INTRODUCTION

Europe was among the regions most severely affected by corona virus (COVID-19) in the early months of 2020. The escalation of cases during the first wave of the pandemic led governments to introduce stringent lockdown measures in order to slow the spread of the virus and avoid overwhelming the health sector. As the first wave of infection curves flattened and the outbreak appeared controlled, most European countries started to reopen their economies to alleviate the unprecedented economic contraction generated by the lockdown. However, the strategies adopted to reopen the economy differed significantly across countries in terms of timing, pace, and sequencing of sectoral reopening measures. The cross-country differences in the evolution of infections following reopenings is also notable.

This paper analyses how the *de-jure* reopening measures translate into *de-facto* improvements in activity and how they influence the subsequent evolution of Covid-19 infections. It then explores whether some reopening strategies are associated with lower reinfection risks than others and, if so, whether it comes at the cost of subdued economic activity.

We start by constructing a daily database that captures the timing, intensity, and sector affected of reopening measures taken in a sample of 22 European countries, and documenting a significant heterogeneity in country strategies. In particular, reopening plans differed substantially in terms of the timing of the first reopening measures, with some countries waiting until the infection curve in the first wave had flattened, while others choosing to exit near to the peak of the infection curve. The pace of reopening plans also varied significantly, as some countries opened their economies gradually, spacing out sectoral reopenings over several weeks, while others chose to simultaneously open several sectors at once. Finally, there was also significant heterogeneity in terms of how sectors were sequenced to opened (for instance, some countries opened schools in the first phase while in others they were sequenced to open in the last stage of the plan).

We then explore the effect of reopening measures on mobility and subsequent infections. Relying primarily on local projection methods, we examine how the cumulative easing of aggregate and sectoral restrictions affects mobility and subsequent infections over a one month horizon. Our empirical strategy accounts for a rich set of controls, including country and time fixed effects, and a dummy that conditions on the first instance of reopening. Identification is also achieved by exploiting within-country sectoral differences in mobility and reopening, that allows to difference out time-varying country effects (e.g., endogenous policy reaction to infection dynamics).

We find that the adoption of opening measures is associated with a significant increase in the Google mobility indicator, a high-frequency proxy for economic activity. The results suggest that a one unit change in the reopening index (e.g, moving from fully closed to partially open in one sector) is associated, on average, with an initial increase in mobility of 1 to 1.5 percentage points. The effect declines gradually over time but remains statistically significant for almost two weeks. Our results suggest that about 30 percent of increased mobility is attributable to reopening measures, with proxies for the role of voluntary distancing accounting

for a smaller fraction (less than 10 percent). To put these results in perspective, opening all six sectors at once (from fully closed) is likely to increase of mobility by approximately 20 percent point over a week.

We also find that, on average, reopening policies lead to an increase in subsequent infections. As expected, the effect is only statistically significant after a certain lag of (about two weeks). A one-unit easing increases the weekly trend of new cases by 7 and 10 percent after two and three weeks, respectively. The effect on the weekly trend of new daily deaths is about 2 percent at a similar horizon. While the average effect of policy measures is statistically significant, only about 20 percent of the variation in subsequent infections can be attributable to reopening measures.

We then turn to assess if any early lessons can be drawn from the heterogeneous strategies pursued by European countries. We find that, indeed, the average effect of reopening measures on subsequent infections masks heterogeneous effects across countries' reopening strategies.

First, we find that a given reopening measure appears to have a larger effect on subsequent infections if the country starts opening early, when the circulation of virus is still pervasive and infection rates are growing; or if the reopening plan is implemented fast, with measures not sufficiently spaced over time. This likely reflects the very nonlinear nature of contagion. For instance, a given easing of restrictions is likely to lead to a larger increase in infections when many people are still infected (that is, when reopening happens early). Similarly, reopening twice as fast is likely to lead to a more-than-proportional increase in infections.

In contrast, the effect on mobility of a given reopening measure is not different between countries opening slow versus fast, or opening late versus early. In other words, easing containment restrictions by a unit delivers similar economic effects regardless of how and when a country exits, but has differential effects on infections, with a much smaller increase in cases if reopening is pursued in a late and slow manner. These results do not mean the effect on activity is inconsequential since postponing or slowing the reopening actions implies that full reopening is delayed. But the results suggest the economic cost of gradual strategies is not disproportionately larger, while the reinfection risk appears to be so.

Second, we also find that the marginal effect of opening individual sectors on subsequent infections depends on the sequencing of sectoral measures–that is, on how much of the economy is already open when the sectoral measure is adopted. For most sectors (with the notable exception of travel) the effect of reopening on infections is amplified when the individual action is taken at a relatively later stage of the reopening plan (in which a larger fraction of the economy is already open). However, the amplification effect on infections from sequencing a reopening at a later stage (in relative terms) differs across sectors, being higher, for instance, for retail and events.

Our paper contributes to the still nascent literature on reopening policies and its effect of economic activity and infections. While there is, by now, a large literature on how lockdown affects activity and infections (see Caselli and others, 2020, for a review), there is relatively

sparse evidence on the effects of reopening policies. Han and others (2020) qualitatively examine the approaches taken by nine high-income countries and regions that eased COVID-19 restrictions and find that countries have diverged in terms of the speed, scale, and intensity at which they have implemented easing. They note that significant differences can be observed between Asia and Europe in this regard[1] and assess that countries should not ease restrictions until they have robust systems in place to closely monitor the infection situation.

In a more quantitative contribution, Gupta, Simon, and Wing (2020) analyze reopening policies across states in the United States and find that mobility increases a few days after the policy change and that 31 percent of that increase is attributable to the reopening policies. However, they note that secular time trends explain the remaining bulk of the variation and that the effect of policy is somewhat smaller in the reopening phases than during the shutdown phase. Cheng and others (2020) examine regional reopenings in the United States and find that work-related mobility shows clear increases in levels and/or trends around reopening announcements[2]. Glaeser and others (2020) develop a model of learning by deregulation, which predicts that easing restrictions can signal that going out has become safer. In this sense, government actions can have both a direct effect (preventing people who want to go out from doing so) and an indirect effect (signaling to people when it is safe to go out again). Using restaurant activity data, they find that the implementation of stay-at-home orders in the United States initially had a limited impact, but that activity rose quickly after states' reopenings. The authors conclude that these results may explain why a sharp rise of COVID-19 cases followed reopening in some states.

To the best of our knowledge, our paper is among the first to compile data on sectoral reopening policies in Europe and construct metrics on the speed of reopening. In line with the model of Glaeser and others (2020) our results suggest that, on average, reopening policies explained the bulk of mobility activity post-reopening with a limited role played by voluntary social distancing and that cases increased following reopening. However, we show that these effects disproportionately affected countries that reopened fast and early. We also document how the effects vary by sector, and especially, the sequence in which they reopened.

The rest of the paper is organized as follows: the next section describes the construction of the reopening database and other data used (Section II), followed by descriptive statistics on mobility and infection trends in section III. Section IV lays out the methodology for the paper's empirical analysis with the results described in section V. Section VI concludes.

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[1]See also the blog by the International Monetary Fund which highlights differences between Asia and Europe: https://blogs.imf.org/2020/05/12/emerging-from-the-great-lockdown-in-asia-and-europe/

[2]The paper also finds that reopening policies generated asymmetrically large increases in reemployment of those out of work, compared to modest decreases in job loss among those employed.

II. DATA

Data employed in this paper comprises the reopening database we assembled based on Europeans countries' reopening policies and data from other sources capturing health dynamics and activity.
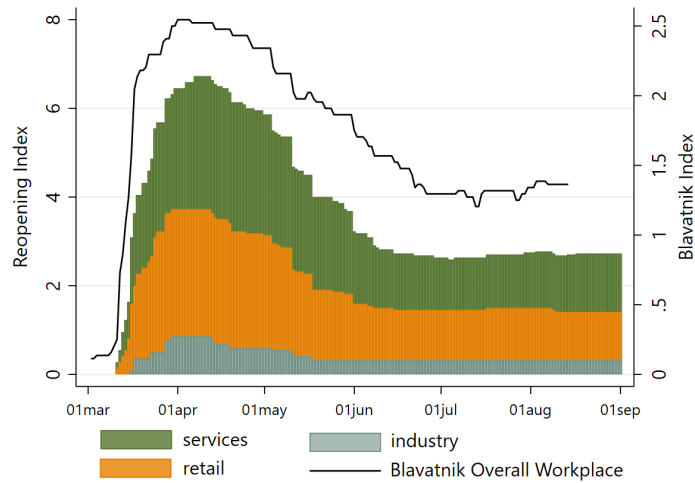
A. Reopening Database

Most European economies followed a phased approach, opening sectors differentially and in a gradual manner. We construct a database of the measures taken by the authorities of 22 European economies[3], to reopen the economy based on the (i) sector, (ii) timing, (iii) phase and (iv) intensity of reopening. For each country and date, we define the reopening measures as follows:

(i) Sector of reopening: Sectors are classified as schools, industry, retail, services (e.g., hotels, restaurants, hairdressers etc.), events/public-places, and international travel (including intra-European)[4].

(ii) Timing of reopening: The date and phase in which a country opened a specific sector.

(iii) Phase of reopening: The associated phase in which a sector was opened as part of the overall exit plan.

(iv) Intensity of reopening: Change in the opening status of a particular sector. Opening status is coded as 0 (open), 1 (open with restrictions/guidelines), 2 (partially open with only a subset of the sector allowed to function) and 3 (closed).

These indicators are constructed based on governments' reopening measures from official and other news sources. The chapter also uses supplemental information from the Oxford Covid-19 Government Response Tracker, the European Commission measures dashboard, and the ACAPS government measures dataset.

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[3]The countries in our database include: Austria, Belgium, Czech Republic, Germany, Denmark, Finland, France, Greece, Ireland, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Russia, Spain, Switzerland, Turkey, Ukraine and the United Kingdom. Sweden does not feature in our database as we were unable to comprehensively characterize its reopening given that it did not have a full lockdown.

[4]We do not make a distinction between essential and non-essential lines of work within each sectors, and mostly follows authorities' announcements of how the economy was planned to reopen. In principle, many countries left essential businesses to operate even under lockdown. Further it should be noted that despite the sectoral reopening announced by authorities, many workplaces encouraged (and continued to) telework both during lockdown and the reopening phases and our database does not collect information on its application.

Figure 1. Sectoral Reopening Indices vs. Oxford Blavatnik Overall Workplace Index

Note: The overall reopening index across the three sectors ranges from 0(open) to 9(closed); the Oxford Blavatnik overall work index ranges from 0 (open) to 3 (closed).

In comparison to other existing datasets that capture the level of government containment measures and their stringency, our data captures the sector-specific targeting of reopening measures. For instance, Figure 1 compares the Oxford Blavatnik's overall workplace stringency (see Hale and others, 2020) to disaggregated sectoral measures in our database. It can be seen that while the overall trend of the composite indices is similar across the two datasets, the sectoral disaggregation reveals some interesting patterns and variations.

B.   Other Data Sources

We use two other key data sources for measuring our two main outcome variables of interest, economic activity and infections. For the first outcome on economic activity we use a high-frequency proxy – mobility data provided by Google. The Google mobility measure captures movement trends by country across different categories of places. The data shows how visitors to (or time spent in) categorized places change compared to our baseline days. A baseline day represents a normal value for that day of the week. The baseline day is the median value from the five-week period 3 Jan – 6 Feb 2020. For our analysis we use the average mobility across three main mobility categories: retail and recreation, public transport and workplaces[5].

Figure 2 shows the relationship between retail (panel a) and workplace (panel b) mobility and quarterly GDP growth for a subset of European countries. As can be seen, the changes in mobility track the changes in GDP fairly well, with an estimated correlation coefficient of about 0.5 in 2020Q2 explaining over 80 percent of GDP variability

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[5]We omit other categories related to parks, supermarkets and residential as they are presumably less likely to reflect economic activity. They are also less affected by containment measures.

Figure 2. GDP growth and mobility change, 2020Q2

(a) Retail (Percent, q-on-q growth)　　　　　　　　(b) Workplace (Percent, q-on-q growth
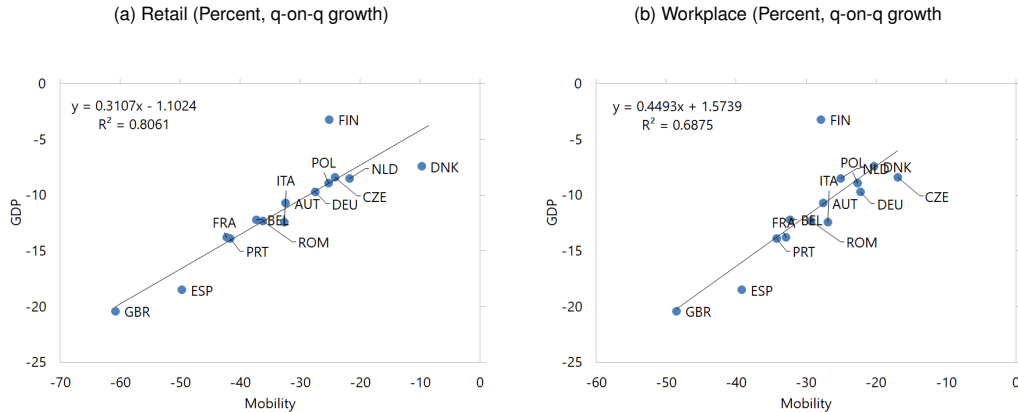
Note: The graph in the left (right) panel plots the quarter-on-quarter growth in 2020Q2 of retail (workplace) mobility against quarterly GDP growth.
Mobility changes are based on actual and projected deviation from baseline, where the baseline is proxied by normal activity in a period in early 2020.

On the second outcome variable of interest, we use data from the European Centre for Disease Prevention and Control (ECDC) and Our World in Data (OWID) on daily confirmed cases, deaths and tests conducted. We also supplement the health data by using survey data on people's responses to the coronavirus pandemic, conducted by Imperial College London in partnership with YouGov (Jones, 2020). The survey measures self-reported intensity of wearing masks and number of social contacts met among other things.

The analysis considers policy actions taken between April 1st and July 15th. The reintroduction of restrictions thereafter is not included as this would confound our measure of reopening which relies on easing of restrictions. For the mobility analysis we also restrict the period up to July 15th, excluding therefore the time around summer vacations so as to not confound the decline in mobility with changes in reopening policies or infections.

III.　Reopening Policies, Activity and Infection

A.　Characterization of Reopening Plans

Using our dataset of reopening we calculate two related metrics that help characterize the overall reopening plan for each country: the *speed* and *timing* of reopening plans.

- The *timing* of a country reopening strategy is calculated as the percentage change in daily deaths between the peak of the infection-death curve and the day the first reopening measure is introduced[6].

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[6]To characterize each country's exit timing, we use the infections curve related to deaths rather than cases as deaths is a more robust benchmark given cases could be under-detected, for instance depending on testing

- The *speed* at which countries reopened is computed as the ratio of effective to actual days since the first reopening measure is introduced. The *effective days open* is defined, at the sector level, by the cumulative extent of each sector's reopening each day. For instance if a country reopened schools for 4 days by 50% and subsequently by 100% for 1 day, the effective days reopened for schools is 3. The aggregate effective days open is the sum of the effective days open across all sectors.

A first clear difference relates to the timing of the first reopening measures in relation to the epidemiologic situation in the country (Figure 3a). Using the evolution of daily fatalities as an indication of the stage of the pandemic, the data reveals that some countries (e.g., Belgium, France) only started opening when the number of daily deaths had declined by about 80 percent with respect to the peak attained before; other countries, instead, opened around the time fatalities started to decline (e.g., Austria, Germany) or even when they were still on the rise (e.g., Poland, Russia).

Another key difference across country plans relates to the speed or pace of sectoral reopening actions once they started opening (Figure 3b). One way of capturing the difference in speed is to compute, at any given time, the ratio of effective days open (taking into account the extent of easing actions introduced at the individual sector level) to actual days open since the first reopening measure is introduced. As of mid-July, when reopening plans had plateaued, this metric ranged from around 30 percent (e.g., in Italy and Spain, that followed a gradual approach) to above 50 percent (e.g. in France, that opened at a fast pace once it started).

Figure 3. Overall Reopening Strategy and Characterization

(a) Time of Reopening   (b) Speed of Reopening
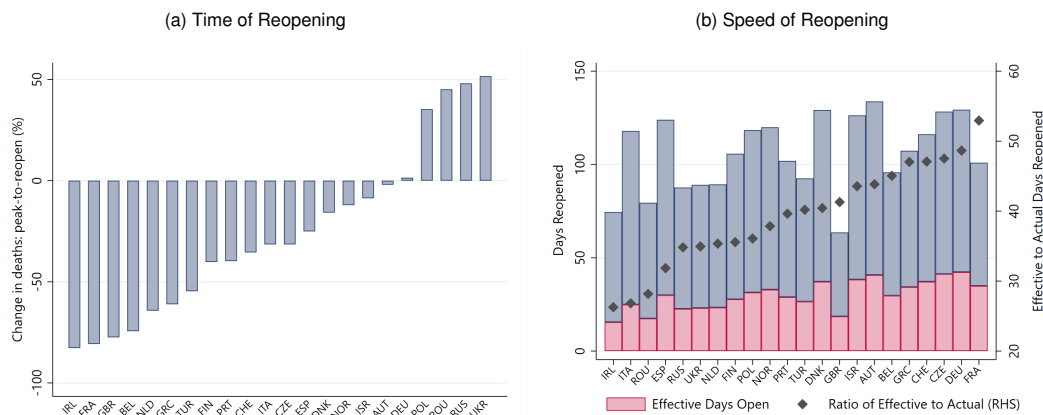
Note: The graph in the left panel plots the growth of daily deaths from peak to reopen. Note that the sign for the peak to reopen change in death is reversed for countries that open before the peak is reached. The graph in the right panel plots the number of days since reopening for all countries in the database. The shaded area shows the number of effective days open which is measured as the cumulative aggregate of the daily extent of reopening across sectors. The diamond markers show the ratio of effective to actual days open.

capacity. In addition, policy-makers were more likely to monitor deaths, at least in the first wave, as they are more closely linked to hospital capacity issues.

Our database also provides us with measures on the sequencing of sectors as they reopened. As countries announced their reopening plans, they typically did so in phases that featured the reopening of different sectors. Figure 4a shows, on average, industries were among the first to reopen, while retail and services were featured mostly in phase 2. Schools and international travel were often among the last to reopen, although in some countries schools did open in the first phase. Figure 4b shows the significant amount of variability across sectors and countries in easing actions. The figure plots the total extent of easing restrictions by sector on the left hand side axis and the average fraction of restrictions eased on the right hand side axis. By the end of June, countries had eased 33-66 percent of their lockdown restrictions by easing a range of restrictions across sectors.
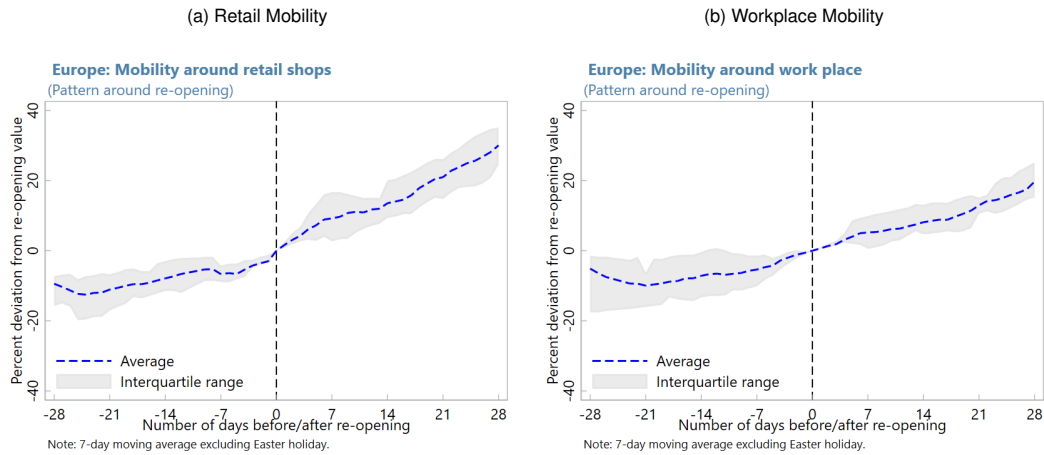
Figure 4. Sequence of Reopening Sectors and Easing Actions

(a) Sectoral Reopening Sequence

(b) Reopening Easing Actions
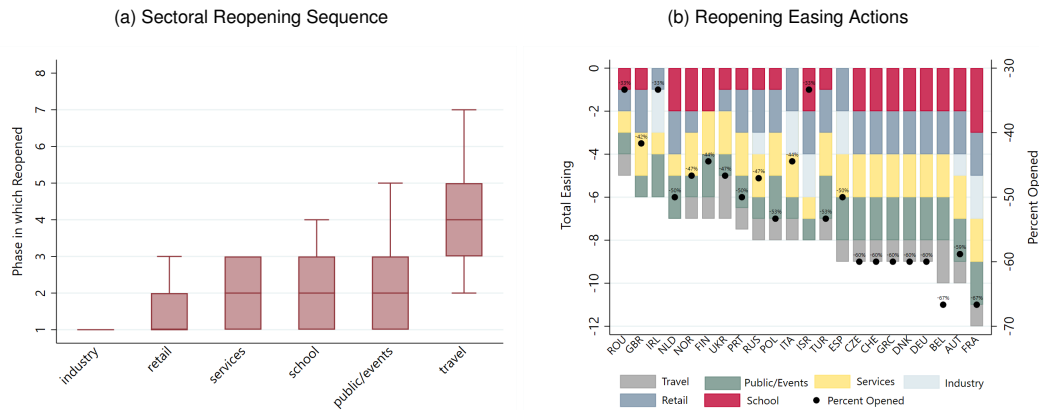
Note: The graph in the left is boxplot which shows the distribution, across countries, of the phase in which each sector opened. The graph in the right panel plots the cumulative change in the reopening index as of June 30, 2020. The index ranges from 0 to 18 based on the opening status of school, retail, services, industry, public-places/events and travel with 0 (open), 1 (open with restrictions), 2 (partially open), 3(closed); dots show the extent of restrictions removed (in percent).

B. Trends in Mobility and Infection

In this section we document broad patterns around the evolution of mobility and infection before and after reopening. Figure 5 plots the average and inter-quartile range for workplace and retail mobility, across countries in our sample. Both indicators are normalized to take the value zero at each country's reopening date. It can be seen that work-place mobility was below -5 percent prior to reopening and then gradually picked up on average, to reach 20 percent about a month after reopening. The pickup in retail mobility, in contrast, was relatively more quick, rebounding from the pre-reopening value of -10 percent to 20 percent, one month after reopening. For both indicators of mobility, the figure also shows a fairly narrow inter-quartile range suggesting that most countries experienced very similar mobility patterns upon reopening, with the average value broadly representative of each country's trend.

Figure 5. Trends around Reopening: Mobility

(a) Retail Mobility

(b) Workplace Mobility

Europe: Mobility around retail shops
(Pattern around re-opening)

Europe: Mobility around work place
(Pattern around re-opening)

Note: 7-day moving average excluding Easter holiday.

Note: 7-day moving average excluding Easter holiday.

Note: The graph in the left (right) panel shows the deviation in retail (workplace) mobility around the reopening date.

As reopening plans evolved and activity started to normalize, several countries experienced an uptick in their infection curves. Figure 6 and 7 plot the average and inter-quartile range for daily cases and deaths (seven day moving average) respectively, across countries. As before, all indicators are normalized to take the value zero at each country's reopening date. It can be seen that while both the case and death curves continued their downward trajectory on average (left panel), there was a gradual up-tick in cases by about two months after reopening. The inter-quartile range is fairly wide indicating that the evolution of infections that followed the reopening differed significantly across countries. The right panels of both figures 6 and 7, illustrate a few country cases that highlight the heterogeneity in infection evolution and show that some countries even surpassed their lockdown period peak in cases after reopening. The deaths curve, however, remained fairly stable and flat after reopening.

Figure 6. Trends around Reopening: Infection, Daily Cases

(a) Cross-country Distribution

(b) Selected Countries
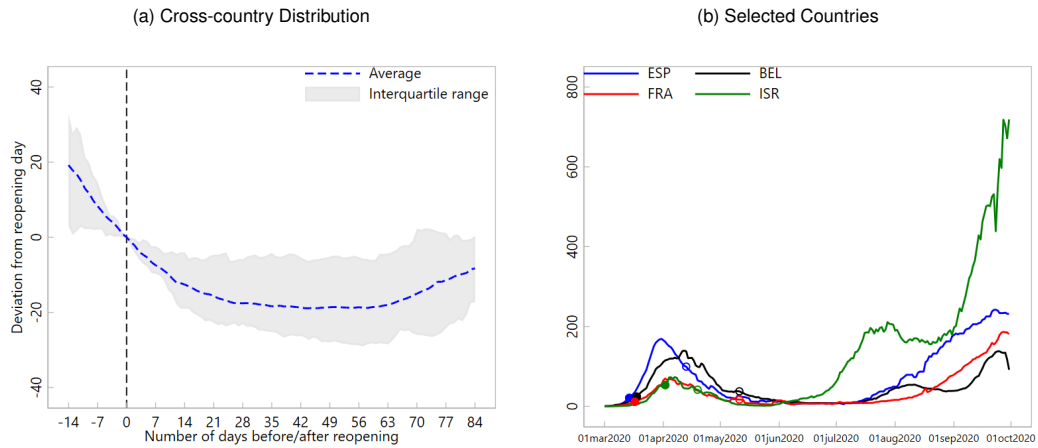
Note: The graph in the left panel shows the deviation in daily confirmed cases around the reopening date. Interpretation of reported values: 70 days after reopening, there were, on average, about 20 daily cases per million less than on the day the first reopening action was taken. The right panel shows the cases infection curve for selected European countries. Solid (hollow) markers denote lockdown start (end) dates.

Figure 7. Trends around Reopening: Infection, Daily Deaths

(a) Cross-country Distribution

(b) Selected Countries
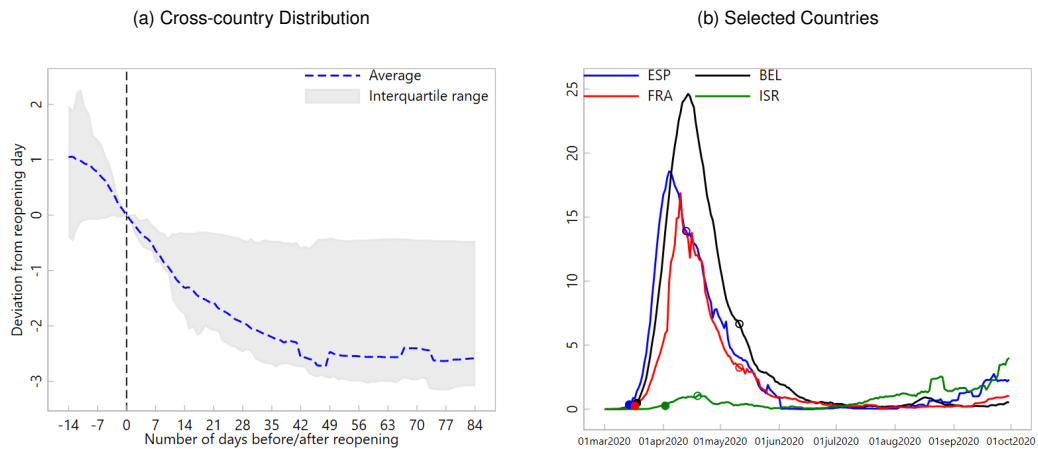
Note: The graph in the left panel shows the deviation in daily confirmed deaths around the reopening date. Interpretation of reported values: 70 days after reopening, there were, on average, about 2.5 daily deaths per million less than on the day the first reopening action was taken. The right panel shows the deaths infection curve for selected European countries. Solid (hollow) markers denote lockdown start (end) dates.

C. Health interventions and Health Behaviors

The reopening actions were accompanied in many countries by a set of additional health-related measures, like the recommendation (or mandate in some cases) to use face masks in public places (e.g. public transport), the launch of contact tracing applications, and an expansion of testing. Some survey-based evidence suggests that the population did follow these

directives. For example, Figure 8 shows, as expected, that the social contact circle widened after reopening, but this was accompanied by an increase in mask usage.

Figure 8. Health Policy and Behaviour around Reopening

(a) Health Interventions Accompanying Reopening

(b) Social Contacts

(c) Mask Wearing

Note: The graph in panel (a) shows the percent of countries adopting each health measure as announced by the authorities during reopening. Panel (b) and (c) plots the percent deviation of average responses on social contacts and masks per country around the day of reopening. The solid line shows the mean percent deviation across countries while the shaded area plots the inter-quartile range. For panel (b) on social contacts, respondents were asked how many social contacts they meet outside their households. For panel (c) on masks respondents were asked often they wore masks outside their home during the past 7 days ranging from 0 (never) to 4 (always).

IV. EMPIRICAL FRAMEWORK

We first estimate the effect of sectoral reopening measures on mobility using local projections methods (Jordà, 2005), which can easily accommodate nonlinearities in the lagged response of the dependent variable:

$$M_{it+h} = \alpha_i^h + \gamma_t^h + \beta^h R_{it} + \tau^h O_{it} + \omega^{\mathbf{h}} \mathbf{I_{it-1}} + \kappa^h ID_{it} + \eta^h M_{it-1} + \varepsilon_{it} \tag{1}$$

where M_{it+h} is the index of the mobility indicator[7] (relative to baseline of January) for country i and time t at horizon h, R_{it} is the cumulative easing (reopening) action summed across all sectors[8], O_{it} is a dummy taking the value one since first reopening, $\mathbf{I_{it-1}}$ is vector of lagged infection variables (7 day moving average of daily cases and deaths), ID_{it} is a country-specific infection trend variable (days since the first case) that approximates infection dynamics and α_i and γ_t are country and time fixed effects. Equation (1) is estimated by OLS for each $h = 1, ..., H$ using data from 22 countries at a daily frequency. Standard errors are robust to heteroskedasticity and serial correlation (using a bandwidth of 7 days).

Exploring the effect of containment policies is potentially subject to endogeneity concerns, and the estimates could be biased if time-varying unobservables affect both mobility and reopening plans. Including lagged infections in the baseline specification attenuates this concern but may not be sufficient. As a robustness exercise, we also exploit sectoral variation inherent in both the mobility and policy measures to difference out time-varying country unobservable factors[9]

In the second step we assess how reopening policies affect subsequent infection I_{it+h}^C at a given time horizon h (denoting, alternatively, the log of the seven day moving average of cases and deaths):

$$I_{it+h}^C = \hat{\alpha}_i^h + \hat{\gamma}_t^h + \hat{\beta}^h R_{it} + \hat{\tau}^h O_{it} + \hat{\omega}^{\mathbf{h}} \mathbf{I_{it-1}} + \hat{\kappa}^h ID_{it} + \hat{\eta}^h M_{it-1} + v_{it} \tag{2}$$

By estimating the reduced-form effect of reopening policies on infections in Equation (2), we are implicitly allowing reopening measures to have an impact on infections via the increased mobility associated with that policy but also though other sector-specific implications for social distancing. For instance, the extent of mobility associated with opening retail stores or schools could well be similar, but the contact-intensiveness of these two measures, both in terms of number of people an individual is exposed to and the time spent at a given location, could be very different, with different implications for potential infections. Lagged mobility and infections are included as controls, together with the dummy for the reopening period and country and time fixed effects. As before, standard errors are robust to heteroskedasticity and serial correlation (using a bandwidth of 7 days).

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[7]Our mobility index is the average of retail, workplace and transport mobility with the pre-COVID baseline equal to 100.

[8]This is, for instance, plotted on the LHS axis of Figure 4b.

[9]Containment measures were also typically accompanied by an introduction of other policies simultaneously (e.g, social-distance guidelines, unemployment schemes that encouraged workers to stay at home). Examining the period of reopening however allows us to isolate more clearly the reopening policy action from other policies as the announcement of emergency measures typically faded out during the reopening period.

V. Results

A. What is the Effect of Reopening Policies on Mobility?

We start by assessing the effects of aggregating reopening policies on overall mobility.[10] and estimate Equation (1) using local projection methods.

We find that conditional on the first reopening action, the marginal effect of a one unit of reopening (or easing restriction) is associated, on average, with an initial increase in mobility of 1 to 1.5 percent point (Figure 9, left panel). The effect declines gradually over time but remains statistically significant for almost two weeks. Detailed results for select horizon are reported in appendix table 3.

Figure 9. Effect of Reopening Measures and Voluntary Social Distancing on Mobility
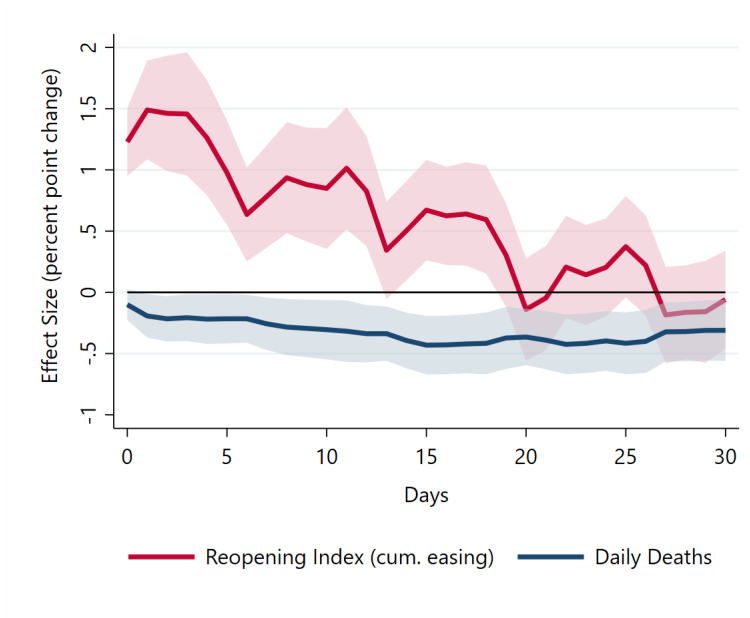
Note: The graph shows point estimates (solid line) of reopening measures and lagged daily deaths on mobility with 90 percent confidence intervals (shaded area) which are adjusted for heteroscedasticity and autocorrelation.

Changes in mobility can reflect the effect of policies but also the role of voluntary social distancing. Figure 9 (right panel) plots the effects of lagged infection (measured as the average number of daily deaths over the preceding week) on mobility, which can be roughly interpreted as the effects of voluntary reduction in mobility in response to infection spread.

We find that, conditional on the first reopening action, the marginal effect of a unit increase in per-capita daily deaths is associated with a decline in mobility of up to 0.5 percent point.

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[10]We measure overall mobility as an average of the mobility index for workplace, retail and transit

This effect increases across horizons and remains statistically significant. In terms of the relative magnitude of the two factors, the results suggest that policy actions explain a larger fraction of the increase in mobility than what can be attributed to voluntary social distancing. For instance, a one-standard deviation increase in reopening leads to an rise in mobility by 0.2 standard deviations, while a one-standard deviation decline in daily deaths per million is associated with an increase in mobility of only 0.05 standard deviations.

Another way to assess the relative importance of reopening policies versus lagged infections (or voluntary social distancing) in explaining changes in mobility is to compute the explained variation in the dependent variable that can be attributed to the different regressors. In order to do this, we follow the Shapley method[11] to decompose the relative contribution of each variable in our specification in explaining the overall variability in mobility (see for e.g., Henderson and others, 2018). The results are reported in Table 1. We find that, at a one-week horizon, the model explains about 67 percent of overall variability in mobility. The bulk of the explained variation (about 31 percent) is attributed to the reopening policies. Within reopening policies, the reopening of retail and services account for the largest share (around 6 percent each), followed by events (about 4 percent). Lagged infections or voluntary social distancing explain a much smaller fraction (16 percent of overall explained variation). The rest is explained roughly equally by lagged mobility and the country-specific infection trend variable.

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[11]We decompose the R2 (share of explained variance) of our model into contributions of (groups of) regressor variables with the help of Shapley values. The Shapley value adds the marginal contribution to the R2 from adding regressor x_k to the model, weighted by the number of permutations represented by this submodel.

Table 1. Explained Variation in Mobility (2 Week Horizon)

Variable	Percent variation explained
Lagged Mobility	**27.08**
Reopening	**30.68**
o/w:	
School	2.91
Retail	6.70
Industry	1.92
Services	6.49
Travel	1.67
Public/Events	4.21
Overall Reopen Period	6.75
Infections	**16.62**
o/w:	
Cases	6.91
Deaths	9.70
Time Trend	**25.61**
Overall Variation Explained	**67.3**

The result that voluntary social distancing matters less than reopening policies is in line with the model suggested by Glaeser and others (2020) that shows that easing restrictions can signal that going out has become safer. Government actions therefore have both a direct effect (preventing people who want to go out from doing so) and an indirect effect (signaling to people when it is safe to go out again).

Our estimates could be biased if time-varying unobservables affect both mobility and reopening plans. Including lagged infections in our baseline specification attenuates this concern but may not be sufficient. In a robustness exercise, we exploit the sectoral variation inherent in both the mobility and policy measures to ensure our results are not affected by time-varying unobservables relating to the effect of policies on mobility. We consider two sectors for analysis: retail and workplace. More precisely, we rewrite and disaggregate the outcome variable in Equation (1) by stacking mobility and reopening actions by sector:

$$M_{it+h,j} = \alpha_i^h + \gamma_t^h + \beta^h R_{it,j} + \tau^h O_{it} + \omega^{\mathbf{h}} \mathbf{I_{it-1}} + \kappa^h ID_{it} + \eta^h M_{it-1,j} + \varepsilon_{it} + u_{it,j} \qquad (3)$$

A sectoral differencing of Equation (3) eliminates time-varying unobservables (e.g, metrics of infections, testing expansion, or hospital capacity) yielding:

$$\Delta^j M_{it+h} = \beta^h \Delta^j R_{it} + \eta^h \Delta^j M_{it-1} + \Delta^j u_{it} \tag{4}$$

Our parameter of interest now measures the average effect of a sector's reopening on its mobility. We consider two sectors for analysis: retail and workplace. We measure workplace reopenings based on reopenings in services and industry. The results shown in the left panel of Figure 10 which indicate that a sectoral easing action of one unit leads to a statistical significant increase in sectoral mobility of about 2-4 percentage point. This suggests that the results in Figure 9 are robust to the presence of time-varying unobsevables.

An additional robustness exercise uses a sector-specific outcome variable, sectoral job postings,[12] to estimate Equation (4). The results shown in the right panel of Figure 10 which suggests that a sectoral easing action of one unit leads to a statistical significant increase in sectoral job postings index of about 0.15 percentage points after approximately four days. The effect on job postings is lower than the effects found for mobility suggesting some sluggishness in labor market indicators.

Figure 10. Effect of Reopening on Mobility - Identification using Sectoral Variation

(a) Effect of Reopening on Sectoral Mobility

(b) Effect of Reopening on Sectoral Job Postings

Note: Point estimate in red line with gray area showing 90 percent confidence intervals robust to heteroscedasticity and autocorrelation.

B. Are Reopenings Associated with an Increase in Subsequent Infections?

A key question to assess the success of reopening strategies is whether they carry a significant increase in reinfection risk. To answer this question we start by exploring the average effect of reopening measures on infections. Along this analysis we use both the log of daily confirmed cases and deaths as an outcome variable.

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[12]Job postings from indeed.com have been mapped to our six sectoral breakup of reopening measures.

Figure 11 shows the estimates of Equation (2) when using an aggregate reopening index (R_{it}). The red line shows the effects of a unit easing associated with reopening on daily cases over the subsequent two weeks, while the blue line shows the results for daily fatalities. The results suggest that a unit easing in the aggregate reopening index is associated, on average, with a significant increase of about 4 percent in daily cases after two weeks and close to 8 percent after one month. The effect for fatalities is also statistically significant but quantitatively smaller: daily deaths increase by about 2 percent one month after each unit of easing. Detailed results for select horizon are reported in appendix table 4 and 5.

Figure 11. Effect of Reopening Measures on Infections
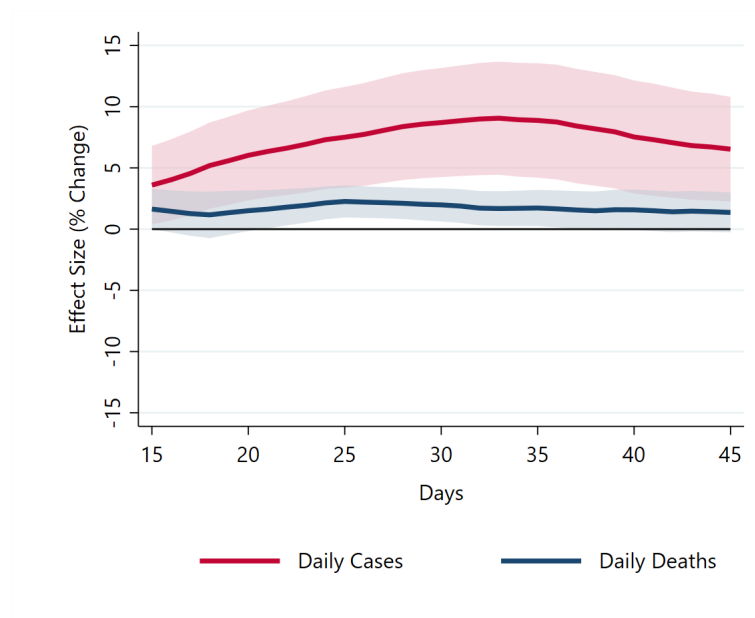
Note: The graph shows point estimates (solid line) of reopening measures on the (log) seven day moving average of cases and deaths with 90 percent confidence intervals (shaded area) which are adjusted for heteroscedasticity and autocorrelation.

In contrast to studies that focused on lockdown measures, we find a much lower magnitude for the effects of containment policies on deaths (see for e.g, Caselli and others, 2020; Jinjarak and others, 2020). The smaller response of fatalities during reopening, compared to that experienced during lockdowns, could reflect, among other factors, a shift in the demographics of the infected population towards a more younger age group, and the expansion of testing which led to an increased detection of cases.

To assess the relative importance of reopening policies versus the intrinsic dynamics of the epidemic, we decompose the relative contribution of each variable in explaining the overall variability in infections using the Shapley method. The results are reported in Table 2. We find that, at a three-week horizon, the model explains about 45 and 80 percent of overall variability in cases and deaths respectively. A sizable share of explained variation (about 20-24 percent) is attributable to the reopening measures. However, an even larger fraction of the

variability in subsequent infections (around 69-73 percent) is attributable to the dynamics of the epidemics itself, captured by lagged infections and the country-specific infection trend variable. Lagged mobility accounts for a small share (3-10 percent) and could pick up the effect of both lagged reopening policies (over and above what is explained by the current reopening policies) and voluntary movements.

Table 2. Explained Variation in Infection (3 Week Horizon)

Variable	Percent variation explained	
	Cases	Deaths
Lagged Mobility	**2.39**	**10.66**
Reopening	**24.50**	**20.27**
o/w:		
School	1.58	1.69
Retail	1.59	4.77
Industry	4.04	1.79
Services	0.97	2.45
Travel	2.01	1.01
Public/Events	3.36	3.11
Overall Reopen Period	10.93	5.42
Infections	**71.11**	**55.89**
o/w:		
Cases	59.63	22.74
Deaths	11.58	33.14
Time Trend	**1.86**	**13.16**
Overall Variation Explained	**45.05**	**80.69**

C. Are Some Reopening Strategies Riskier in Terms of Subsequent Infections?

We next explore whether the average positive effect of reopenings on subsequent infections can be attributed to certain reopening strategies (i.e., if they are driven by countries that adopted more ambitious reopening plans). In particular, we explore whether the effects of reopening on daily cases and deaths vary depend on the *speed* of countries' reopening strategies and on the *sequencing* of sectoral measures.

## 1. Do Faster and Earlier Reopening Strategies Carry More Risk?

To explore the role of the pace of reopening strategies, we classify countries into fast and slow re-openers based on the *speed* and *timing* metric described in section III (computed as the ratio of effective to actual days reopened and the change in deaths per capita from peak to reopen) and re-estimate Equation (2) for each group. We therefore estimate:

$$Y_{it+h} = \alpha_i^h + \gamma_t^h + \beta^h R_{it} + \lambda_F^h R_{it} \times Fast_i + \lambda_E^h R_{it} \times Early_i + [...] + \varepsilon_{it} \tag{5}$$

where Y_{it+h} represents the mobility or infections related outcome variable. The dummy variable $Fast_i$ indicates that a country opened fast when its effective-to-actual days open metric is above the sample median. The dummy variable $Early_i$ indicates that a country is an early opener when the reduction in daily deaths, relative to the peak attained, it had registered before taking the first reopening action is below the median across countries. For countries that registered more than one wave in daily deaths, the first wave is considered.

Figure 12 plots the differential effects of being a fast or early reopener on daily cases and mobility (λ_F^h, λ_E^h). The results suggest that in countries which pursued a fast reopening strategy, reopening actions had significantly higher daily cases per unit of easing (almost 10-15 percent higher), relative to counties classified as pursuing a slow reopening strategy. Similarly countries that opened later along the infection curve, also had 5-7 percent higher daily cases per unit of easing, relative to counties that opened earlier.

Interestingly, for every unit of easing, we do not find any statistically significant mobility differential between fast vs. slow or early vs. late reopeners. This seems to suggest that the effect of reopening on mobility does not vary across reopening strategies. However, in terms of calculating the tradeoff, we should note that fast and early reopeners would have experienced a longer period of increase in average mobility uptick relative to slow and late reopeners, despite seeing no difference in the rate at which mobility picked up at reopeneing.

Figure 12. Effect of Reopening by Speed and Timing of Reopening

(a) Effect on Infections

(b) Effect on Mobility
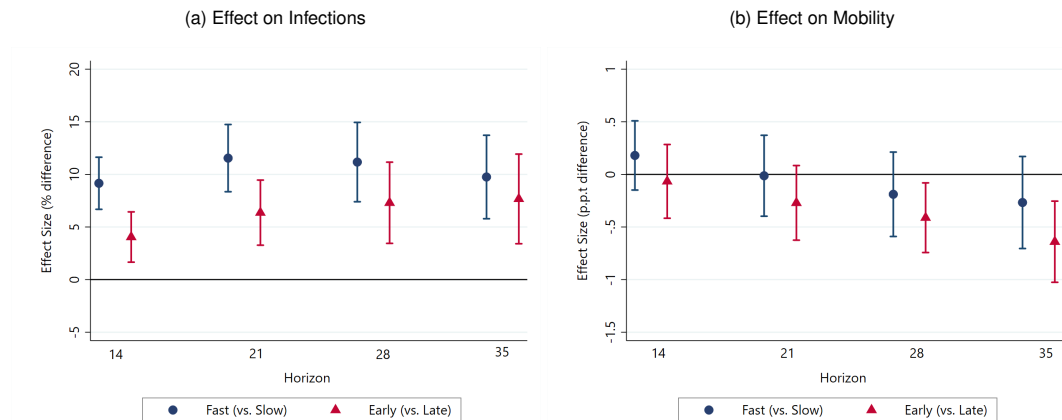
Note: The graph in the left panel shows the percentage difference in daily cases between fast vs. slow reopeners (blue dot with 90 percent confidence interval line) and early vs. late reopeners (red triangle with 90 percent confidence interval line). The right panel shows the same differential for mobility.

One way to illustrate the contrast in the results for mobility and infections is to compare the model predictions for these variables under different strategies. The results indicate that alternative reopening strategies produced marked differences in the trajectory of infections but only minor differences with respect to mobility pick-up (Figure13). In other words, easing containment restrictions by a unit delivers similar economic effects regardless of how and when a country exits, but has differential effects on infections, with a much smaller increase in cases if reopening is pursued in a late and slow manner.

These results do not mean the effect on activity is inconsequential since postponing or slow-ing the reopening actions implies that full reopening is delayed. But the results suggest the economic cost of gradual strategies is not disproportionately larger, while the reinfection risk appears to be so.

Figure 13. Alternative reopening strategies: Predicted Paths

(a) Predicted Mobility
(Mobility Index with pre-COVID baseline=100, 7-day moving average)

(b) Predicted Infections
(Per million, 7-day moving average)
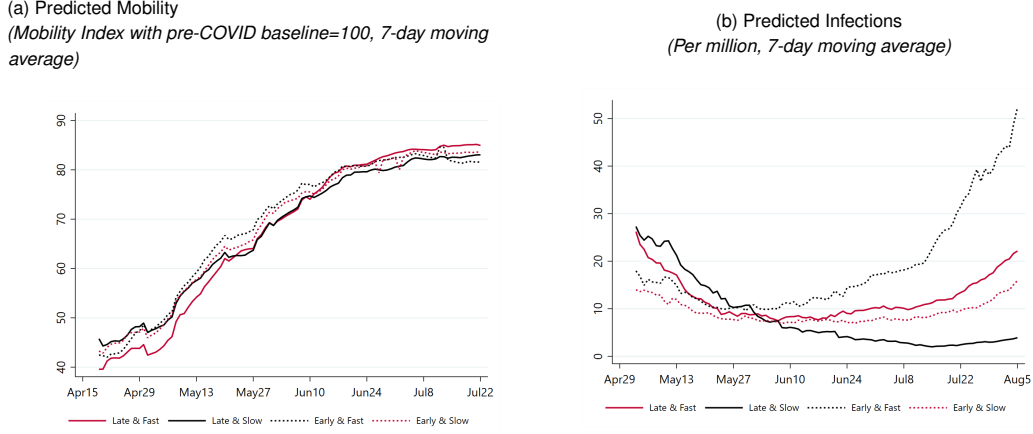
Note: The graph in the left panel shows the predicted path of daily cases based on equation (5) for each type of reopening classification. The right panel shows similar predicted paths for mobility.

2. Does the Sequencing of Sectoral Reopenings Influence Subsequent Infections?

As documented earlier, we found substantial heterogeneity in the effect of reopening on infection across different sectors. Further, the variance decomposition of infections based on the relative contribution of sectoral reopenings suggested that opening of public places and events played an important role (Table 2): they account for one of the largest share of explained variation attributable to policies (around 3 percent).

To assess how the effect of each sector-specific reopening on subsequent infections varies depending on its sequencing within the country-specific reopening plan (e.g., if it is among the first sectors to reopen), we undertake the following exercise. First, for each given sector j we calculate the re-openings of all other sectors ($\sum^{S \notin j} R^S_{it}$) and split this variable into sequencing terciles that represent how sector j opened: (i) early in the schedule when majority other sectors were not open (EO^j_{it}, or the bottom tercile of $\sum^{S \notin j} R^S_{it}$); (ii) middle in the schedule when some sectors had opened (MO^j_{it}, or the middle tercile of $\sum^{S \notin j} R^S_{it}$), and; (iii) late in the schedule when most sectors had opened (LO^j_{it}, or the upper tercile of $\sum^{S \notin j} R^S_{it}$).

We then re-estimate our specification, for each sector j by interacting the sector-specific reopening with its sequencing in the overall reopening:

$$
\begin{aligned}
I^C_{it+h} =\ & \alpha^j_i + \gamma^j_t + \phi^j_E EO^j_{it} + \phi^j_M MO^j_{it} + \phi^j_L LO^j_{it} + \\
& \zeta^j_E R^j_{it} \times EO^j_{it} + \zeta^j_M R^j_{it} \times MO^j_{it} + \zeta^j_L R^j_{it} \times LO^j_{it} + [...] + \eta^j M_{it-1} + \varepsilon^j_{it}
\end{aligned} \tag{6}
$$

The coefficients ζ^j_E, ζ^j_M and ζ^j_L measures the effect of each sector j's reopening depending on how it was sequenced to open (early, middle or late respectively).

Figure 14. Effects of Sectoral Reopenings on Infections by Sequence
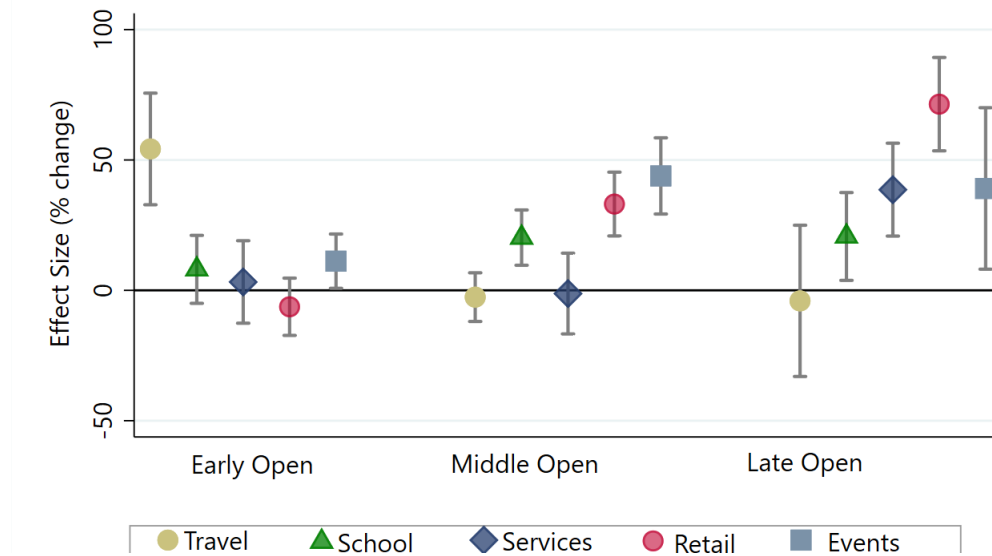
Note: The graph shows the total effect (in percentage change) on daily cases from a one unit easing of sectoral restrictions based on whether it was sequenced to open early (few other sectors opened), in the middle, or late (most other sectors opened). Industry is omitted as it was always sequenced early.

Two results from this exercise stand out (Figure 14). First, the effect of a given sectoral re-opening step is larger when it is sequenced toward the end of the overall reopening plan. For instance, a one-unit easing in services has little effect on infections if it happens at an early or intermediate stage (when social interaction is still limited) but the effect is positive and statistically significant if it takes place toward the end of the plan (when a large fraction of the economy is already open). The same is true for the other sectors (with the notable exception of international travel). This may be because community transmission, a factor identified as amplifying risks (Stage and others, 2020), is higher at later stages of reopening[13]. This may also reflect that a sector's reopening at a later stage involves social interaction synergies with other sectors already opened, which could intensify infection spread (e.g., visiting a shop alone in an early stage vs visiting a shop and the beach together at a late stage).

However, the amplification effect on infections from sequencing a reopening at a later stage (in relative terms) differs across sectors. As countries need to calibrate sectoral containment measures, this finding offers insights into sectoral strategies that could mitigate infection amplification risks. At later stages (that is, when the other sectors are mostly open), the re-opening of retail and events, for instance, is associated with a relatively larger increase in daily cases compared with opening other sectors, such as schools, at a similar stage. This suggests that sequencing retail to open early and schools later carries lower risk than the opposite strategy. The relatively low amplification effect found for schools is broadly in line with early evidence documenting that reopening schools has not resulted in a significant increase in the

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[13]The lower and insignificant effects on infections from opening international travel at a later rather than earlier stage (Figure14) may reflect that the potential importation of infections from other countries has a negligible effect when community transmission is already high (see also WHO, 2020).

growth rate of infections (Levinson, Cevik, and Lipsitch, 2020; Stage and others, 2020). The literature has attributed this result to, among other factors, stronger social-distancing practices and monitoring infrastructure in schools as well as the lower susceptibility and infectivity among younger children[14]. Still, these results should be interpreted cautiously because the implementation of school reopening policies varied across country and time (with some countries allowing voluntary attendance and with July and August subject to varied summer vacation closures).

The results on sectoral sequencing should however be viewed as preliminary evidence; a more comprehensive assessment would require additional granular data, such as on person-to-person infection transmission. More broadly, decisions on sectoral sequencing would also need to encompass other considerations, such as equity, which is beyond the scope of this chapter.

D. Additional Robustness for the Effect of Reopenings on Infections

One concern with the ramp-up of testing is that it could be jointly correlated with reopening policies and infection evolution, thereby biasing our results. In addition, it may be that the larger effect found for countries opening faster or earlier reported in Figure 12, may be reflecting increased testing capacity in those countries. To address these concerns, we run an additional specification controlling for daily tests per-capita (using a smaller sample given data limitations). Figure 15 shows results from this exercise and it can be seen that we obtain similar results for both the average and differential effects of reopenings, suggesting that our results are robust to developments in testing.

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[14]It should be noted however that the effect of closing schools has been found to reduce disease prevalence and contain virus spread (see Adda, 2016; Egert, Guillemette, and Turner, 2020). Our analysis is different from this strand of literature as it explores the order in which schools are reopened (relative to other sectoral openings) and its associated amplification effects.

Figure 15. Robustness to Testing
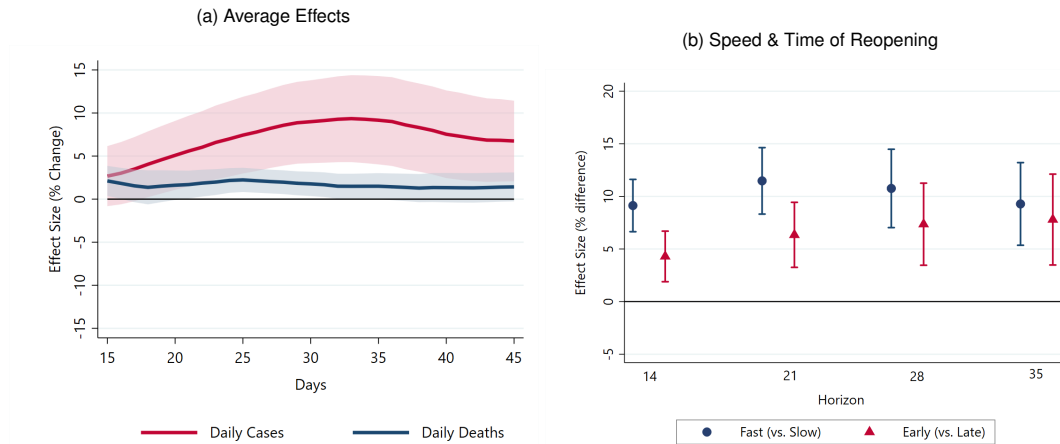
(a) Average Effects

(b) Speed & Time of Reopening

Note: The graph in the left panel plots the effect of reopening on the (log of) seven day moving average of cases and deaths, after controlling for daily testing rates in (2). The graph in the right panel plots the differential effect on cases for fast vs. slow and early vs. late reopeners, after controlling for testing rate in equation (5).

In Annex Figure 16 we also present another set of robustness results controlling further for self-reported mask usage and self-reported number of (non-household) social contacts. Both these variables capture the effect of other non-pharmaceutical interventions that could be correlated with reopening strategies and subsequent infections. It should be noted however that the results from this specification is based on a reduced sample of countries and time-period that were included in the Imperial College survey[15]. The results show that our baseline findings are robust to controlling for testing and the implementation of other non-pharmaceutical interventions.

VI. CONCLUSION

A continuous calibration of containment policies to keep Covid-19 at check will keep policymakers busy until a vaccine or an effective pharmaceutical treatment becomes widely available. This finetuning involves uncomfortable tradeoffs: the results in this chapter show that reopening measures led to a much-needed recovery in economic activity, but this came at the cost of some uptick in infections already under way at end-August.

While this result is consistent with findings on the effect of the introduction of lockdowns just a few months earlier, the findings in this chapter point to some novel dimensions of the tradeoff between economic activity and spread of the pandemic during the reopening phase.

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[15]These countries are Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain and United Kingdom.

First—and fortunately—the unwelcome increase in Covid-19 cases associated with reopening measures appears less severe in terms of fatalities than what the earlier findings for lock-downs would have suggested. This likely reflects a shift in the demographics of the infected population toward lower-risk groups but also that better medical care for severe cases may have been developed. Nonetheless, as the resurgence in infection has gained strength in several countries in recent weeks, authorities have had to reintroduce containment measures to avoid overwhelming the health system.

Second, the results suggest that the reinfection risk increases disproportionately under certain reopening strategies. In particular, a given reopening measure appears to have a larger effect on subsequent infections if the country starts opening when the circulation of virus is still pervasive. Similarly, an easing action appears to be associated with a disproportionately worse outcome in terms of subsequent infections if reopening measures are not sufficiently paced. While opening later or slower is associated with a delayed recovery in mobility —as a fully reopened stage gets postponed further— the incremental cost is not disproportionately larger. Taken together, these findings suggest some merit of gradual and prudent reopening strategies.

Finally, the findings suggest that the sequencing of sectoral reopenings matters. In general, reopening any sector at a later stage is associated with an amplification of infection risks—from its interactions with other sectors that are already opened—but these amplification effects are larger for some sectors (like retail and events) than others.

Certainly, the overall success in dealing with the pandemic as economies reopen will depend on not only the general principles regarding the timing, pace, and sequencing of measures outlined here but also, crucially, on the population's collective behavior. As activity continues to resume, making it more difficult to maintain social distancing, some evidence of more widespread use of face masks is encouraging, but it may not be sufficient to keep new large outbreaks in check. Further work is needed on examining whether a targeted approach to applying containment measures as activity keeps resuming can reduce the odds of new massive outbreaks at check.

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VII. APPENDIX

Figure 16. Robustness to Testing, Masks and Social Distancing
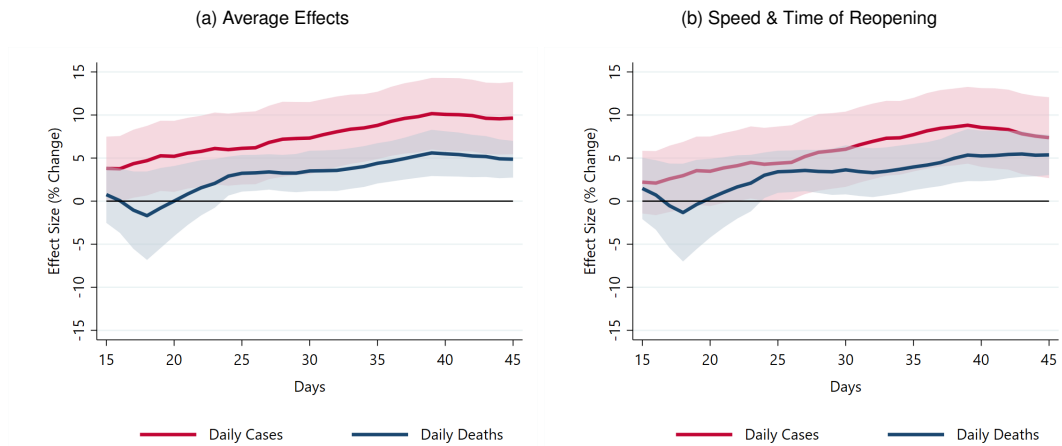
(a) Average Effects

(b) Speed & Time of Reopening

Note: The graph in the left panel plots the effect of reopening on the (log of) seven day moving average of cases and deaths as in (2). The graph in the right panel plots the effect of reopening on the (log of) seven day moving average of cases and deaths, after controlling for testing rate, self-reported masks usage and self-reported social interactions. Results in both figures are from a reduced (comparable) sample of countries for which survey responses on masks and social distancing are available.

Table 3. Baseline Effects of Reopening on Mobility (Index with 100 as normal)

	Horizon (Days)				
	0	7	14	21	28
Reopening	1.228***	0.784***	0.503**	-0.045	-0.163
	(0.168)	(0.254)	(0.246)	(0.259)	(0.233)
Cases (Lagged)	0.002	-0.005	-0.001	0.000	-0.017
	(0.009)	(0.017)	(0.017)	(0.016)	(0.017)
Deaths (Lagged)	-0.100	-0.257**	-0.393***	-0.391***	-0.320**
	(0.077)	(0.130)	(0.138)	(0.144)	(0.147)
Mobility (Lagged)	0.440***	0.280***	0.199***	0.125***	0.092***
	(0.031)	(0.044)	(0.038)	(0.038)	(0.035)
Reopen Period Dummy	0.554	0.114	2.757***	3.523***	2.260**
	(0.770)	(1.003)	(0.960)	(1.147)	(0.992)
Infection Time Trend	2.686	1.995	1.269	1.673	1.805
	(1.967)	(1.590)	(1.573)	(1.566)	(1.567)
Observations	2075	1921	1770	1618	1466
r2	0.863	0.809	0.782	0.718	0.657
Country F.E.	X	X	X	X	X
Time F.E.	X	X	X	X	X

The table reports the average effects of reopening and other covariates on the index of mobility (average of retail, work-place and transport movements recorded by Google) . All columns report results from a panel fixed effects specification with country and time fixed effects. Standard errors reported in parentheses are robust to arbitrary heteroscedasticity and time series auto-correlation. * indicates significance at 10%; ** at 5%; *** at 1%.

Table 4. Baseline Effects of Reopening on Daily Cases (log of 7 day m.a.)

	Horizon (Days)				
	14	21	28	35	42
Reopening	0.031*	0.063***	0.084***	0.089***	0.071***
	(0.019)	(0.023)	(0.026)	(0.028)	(0.027)
Cases (Lagged)	0.737***	0.573***	0.373***	0.200***	0.043
	(0.061)	(0.064)	(0.064)	(0.062)	(0.062)
Deaths (Lagged)	-0.058	-0.058	-0.032	-0.043	-0.058
	(0.077)	(0.090)	(0.095)	(0.098)	(0.100)
Mobility (Lagged)	0.008***	0.010***	0.011***	0.012***	0.013***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Reopen Period Dummy	-0.281***	-0.369***	-0.419***	-0.402***	-0.343***
	(0.090)	(0.118)	(0.127)	(0.120)	(0.101)
Infection Time Trend	0.016	0.049	0.009	0.026	-0.121*
	(0.051)	(0.062)	(0.071)	(0.065)	(0.069)
Observations	2068	2068	2068	2069	2002
r2	0.655	0.464	0.370	0.389	0.445
Country F.E.	X	X	X	X	X
Time F.E.	X	X	X	X	X

The table reports the average effects of reopening and other covariates on the log of the 7-day moving average of daily per capital deaths . All columns report results from a panel fixed effects specification with country and time fixed effects. Standard errors reported in parentheses are robust to arbitrary heteroscedasticity and time series auto-correlation. * indicates significance at 10%; ** at 5%; *** at 1%.

Table 5. Baseline Effects of Reopening on Daily Deaths (log of 7 day m.a)

	Horizon (Days)				
	14	21	28	35	42
Reopening	0.018*	0.016*	0.021***	0.017*	0.014
	(0.010)	(0.009)	(0.008)	(0.009)	(0.010)
Cases (Lagged)	0.141***	0.126***	0.095***	0.089***	0.076***
	(0.030)	(0.025)	(0.022)	(0.021)	(0.024)
Deaths (Lagged)	0.526***	0.453***	0.405***	0.305***	0.243***
	(0.055)	(0.045)	(0.038)	(0.039)	(0.042)
Mobility (Lagged)	0.000	0.000	0.001	0.001	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Reopen Period Dummy	-0.064**	-0.085**	-0.118***	-0.072*	-0.007
	(0.031)	(0.035)	(0.039)	(0.039)	(0.039)
Infection Time Trend	-0.004	0.005	-0.004	0.018	-0.028
	(0.012)	(0.014)	(0.019)	(0.022)	(0.028)
Observations	2068	2068	2068	2069	2002
r2	0.837	0.803	0.758	0.618	0.465
Country F.E.	X	X	X	X	X
Time F.E.	X	X	X	X	X

The table reports the average effects of reopening and other covariates on the log of the 7-day moving average of daily per capital deaths . All columns report results from a panel fixed effects specification with country and time fixed effects. Standard errors reported in parentheses are robust to arbitrary heteroscedasticity and time series auto-correlation. * indicates significance at 10%; ** at 5%; *** at 1%.