Online Supplement to “Social Distancing, Vaccination and Evolution of COVID-19 Transmission Rates in Europe”

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This online supplement is organized as follows. Section A outlines regions definitions. Section B provides plots of cases and baseline estimates of the transmission rates and $R$ numbers for (i) China and the rest of the world, (ii) major world regions, and (iii) selected large countries. Section C provides comparisons of the estimated $R$ numbers for alternative choices of the multiple factor (MF). Section D provides comparisons of the estimated effective transmission rates for alternative choices of MF. Section E provides details regarding the estimation of standard errors in the pooled regressions. Section F presents the summary statistics of the regressors used in the panel regressions of the transmission rates. Section G investigates Google mobility data as a potential co-variate for explaining the transmission rates.
A Regions and their definitions

Table S1: Regional Classifications

| Region                                | Countries                                                                 |
|---------------------------------------|---------------------------------------------------------------------------|
| **East Asia and Pacific**             | Australia, Brunei, Cambodia, China, South Korea, Fiji, Indonesia, Japan,  |
|                                       | Laos, Malaysia, Marshall Islands, Mongolia, Burma, New Zealand, Papua     |
|                                       | New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Taiwan,        |
|                                       | Thailand, Timor-Leste, Vanuatu, Vietnam                                   |
| **Eastern Europe and Central Asia**   | Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria,  |
|                                       | Croatia, Georgia, Kazakhstan, Kyrgyzstan, Montenegro, Moldova, Romania,   |
|                                       | Russia, Serbia, Tajikistan, North Macedonia, Turkey, Ukraine, Uzbekistan  |
| **Western Europe**                    | Andorra, Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland,    |
|                                       | France, Germany, Greece, Holy See, Hungary, Iceland, Ireland, Italy,      |
|                                       | Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands,  |
|                                       | Norway, Poland, Portugal, San Marino, Slovakia, Slovenia, Spain, Sweden,   |
|                                       | Switzerland, United Kingdom                                               |
| **North America**                     | United States, Canada                                                     |
| **Latin America and Caribbean**       | Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil,|
|                                       | Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador,  |
|                                       | El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico,  |
|                                       | Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia,    |
|                                       | Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay,  |
|                                       | Venezuela                                                                |
| **Middle East and North Africa**      | Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon,     |
|                                       | Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab   |
|                                       | Emirates, Yemen                                                          |
| **South Asia**                        | Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri    |
|                                       | Lanka                                                                    |
| **Sub-Saharan Africa**                | Eastern and Southern Africa and West and Central Africa                   |
| **Eastern and Southern Africa**       | Angola, Botswana, Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya,   |
|                                       | Lesotho, Madagascar, Malawi, Mozambique, Namibia, Rwanda, Seychelles,      |
|                                       | Somalia, South Africa, South Sudan, Sudan, Uganda, Tanzania, Zambia,      |
|                                       | Zimbabwe                                                                 |
| **West and Central Africa**           | Benin, Burkina Faso, Cabo Verde, Cameroon, Central African Republic, Chad,|
|                                       | Congo (Brazzaville), Congo (Kinshasa), Cote d’Ivoire, Croatia, Equatorial|
|                                       | Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali,        |
|                                       | Mauritania, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, |
|                                       | Togo                                                                     |
COVID-19: A global pandemic with heterogeneous time-varying transmission

In this section we report country-specific estimates of the effective reproduction number, $R_{et}$, which we simply refer to as the “$R$ number”. We plot these estimates alongside the estimates of the effective transmission rate, $\hat{\beta}_t/\gamma$ with $\gamma = 1/14$, to separately assess the influence of herding from social distancing (and other related mitigating factors), for a large sample of countries.

While we estimate the two parameters of interest for all jurisdictions for which JHU reports case statistics, in this section we report only the results for selected countries and regions. See Figures 1-8. The results for China and the rest of the world are given in Figure 1. Figures 2-4 show results by geographic regions (excluding China): the Northern and Southern Hemispheres (Figure 2) and all main regions of the world (Figures 3-4), including East Asia and Pacific, South Asia, Eastern Europe and Central Asia, Western Europe, North America, Latin America and Caribbean, Middle East and North Africa, and Sub-Saharan Africa. Figures 5-6 report results for selected large economies. Finally, Figures 7-8 present results for the selected European countries, also analyzed in Section 4 below. The estimates of transmission rates and $R$ numbers for the regions are based on aggregate region-specific case statistics rather than by averaging country specific estimates of the $R$ numbers.

Each panel reports two sets of charts. The charts on the left-hand-side of the figures report the seven-day moving average of the number of reported new infected cases per 100,000 population. The charts on the right-hand-side report two lines. The solid (red) line is the estimated $R$ number, $\hat{R}_{et} = (1 - c_t)\hat{\beta}_t/\gamma$. The dotted (blue) line is the effective transmission rate, $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$. This is the variable that we model in Section 4. Recalling that the effective transmission rate, $\hat{\beta}_t/\gamma$, coincides with $\hat{R}_{et}$ only when $c_t \approx 0$, but as the epidemic spreads more widely we have $c_t > 0$, herd immunity can eventually start to play a non-negligible role and manifests itself in later stages of the epidemic with an increasing gap between $\hat{R}_{et}$ and $\hat{\beta}_t/\gamma$, depending on the magnitude of $c_t$. Also, we expect $\hat{\beta}_t/\gamma$ to be in the range 0 to 3 (similarly to $\hat{R}_{et}$), and $\hat{R}_{et}$ to be smaller or equal to the effective transmission rate as the epidemic progresses. Thus the gap between the red and the

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28The full set of estimation results is available on the authors’ websites (sites.google.com/site/alexanderchudik/, pesaran.com, sites.google.com/site/alessandrorebucciphd/).
blue lines is a function of \( s_t = 1 - c_t \), the share of susceptible (not yet infected) population.

We start by estimating the effective transmission rate, \( \tilde{\beta}_t/\gamma \), and hence the \( R \) numbers, when the seven-day moving average of new cases exceeds a threshold of 50 cases to ensure a reasonably precise estimate of \( \beta_t/\gamma \). Note that at the early stages of the spread of the infection, when both \( c_t \) and \( i_t \) are close to zero, estimation of \( \beta_t/\gamma \) becomes problematic as can be seen directly from (6). In effect it involves computing the ratio of two very small numbers, each subject to sampling errors. Note also that, since some countries (in particular China) were able to virtually eradicate the virus in some sub-periods, there will be gaps in our charts reporting the \( R \) numbers. In addition, we start to report estimated \( R \) numbers at the beginning of the sample from the day in which \( \hat{R}_{ct} < 3 \) for the first time. This is to avoid showing widely varying estimated values in the initial days of the epidemic driven by unusually large growth rates of new confirmed cases, which could reflect delays in reporting the number of infected cases.

\[ \text{B.1 China and the rest of the world} \]

**China**  China experienced a large first wave followed by a few small and localized outbreaks (Figure 1). Two points are worth highlighting. First the \( R \) number comes down very fast, in less than a month during the first wave. This is consistent with disaggregate evidence in Fang, Wang, and Yang (2020) and also clinical evidence. Second, the effective reproduction number always coincides with the effective transmission rate in the case of China, given the fact that only a very small fraction of population has been infected. The number of infected cases in China is 90,000 \( \times \) \( MF \) out of a population of 1.4 billion. This is a very small share even if we set \( MF \) to 20, which is at the upper end of the estimates reported for \( MF \) across many countries and reviewed in the Introduction. This confirms herd immunity had no role in the reduction of the effective reproduction number in the case of China.\(^{29}\) When the epidemic resurfaces, the estimated effective transmission rate increases sharply, but the extremely small number of cases permitted

\(^{29}\)The effective reproduction number coincides with the effective transmission rate in most other Asian countries. Nonetheless, even in Asia, we observe a great deal of heterogeneity in terms of the shape of the epidemic curve. Japan and Indonesia fared better at the start of the pandemic, but did not avoid a large second wave. South Korea, in contrast, had two waves, one in March 2020 and a second toward the end of 2020, possibly reflecting its decision to avoid China-style mandatory social distancing, embracing a strategy revolving around testing and tracing with less restrictive limits on mobility and interactions (results not reported but available from the authors).
due to aggressive containment strategies prevented any new large-scale spread of the virus. But as it is widely acknowledged under mandatory lock-downs and social distancing the population never reaches herd immunity, unless there is a comprehensive vaccination policy in place.

**The Rest of the World excluding China**  The bottom panel of Figure 1 reports results for the rest of the world excluding China. As we noted earlier, these estimates are based on aggregate cases, as opposed to averages of country specific estimates. In the rest of the world, the COVID-19 epidemic started later than in China and the $R$ number comes down more slowly compared to China, never really falling below one until the end of 2020. The $R$ number increased from May to July 2020, and then again starting at the end of August 2020. As a result, the pandemic’s incidence was many, many times higher than in China in terms of cases. Indeed, our estimation results show that even an $R$ number slightly above one can be devastating once the epidemic has spread widely. Overall, the rest of the world as a whole never managed to eradicate the epidemic to an extent comparable to China. Not surprisingly, as restrictions ease during the summer of 2020, the epidemic resurfaces and worsens dramatically. Moreover, some of the decline in the $R$ number is due to herd immunity, which is extremely costly in terms of lives and, possibly, long term health consequences for the population.

**B.2 Major World Regions**

Comparing Northern and Southern Hemispheres reported in Figure 2, we see that climate has made a difference to both the initial spread, which was faster in the northern winter, and the shape of the epidemic curve, which was more persistent in the southern hemisphere. It does not, however, make a significant difference in terms of the epidemic peak; the number of daily new confirmed cases peaked about 10-12 per 100k population in the Northern Hemisphere, whereas the peak number of new cases (per 100k population) was about 10 the Southern Hemisphere in January of 2021. In the South, the $R$ number declined more slowly, but eventually dropped below one for several months in the middle of 2020. In both hemispheres, the estimates suggest that the COVID-19 transmission rate was falling in February 2021.
Figures 3-4 report the estimates at more regional levels of disaggregation.\textsuperscript{30} A stark difference emerges between the epidemic peaks reported in the left charts. North America reached a peak of 70 new cases per 100k population. Western Europe together with Eastern Europe and Central Asia experienced the second largest peaks at about 45-50 new cases per 100k population. Peaks in the daily new cases in Latin America and Caribbean region are also quite sizeable, but considerably smaller, staying below 20 new cases per 100k population. In contrast, the largest peak in the daily new cases is only about 7 in Middle East and North Africa, about 5 in South Asia, and even smaller peaks of less than 3 new cases per 100k population were achieved in East Asia and Pacific (excl. China) and Sub-Saharan Africa.

Large differences can be observed not only in terms of the magnitude of the peaks in new infections, but also in the trajectory of the epidemic more broadly. South Asia experienced a protracted single peak culminating in September 2021, which is reflected in the overall $\mathcal{R}$ number not falling below one from the start of the epidemic until early in September 2020. By contrast, Sub-Saharan Africa experienced two definite peaks (July 2020 and January 2021). North America and Western Europe experienced three major waves. The first wave occurred in March/April in both regions. After some significant community spread of the virus, containment policies were enacted which helped to bring the $\mathcal{R}$ number below one in a very short period of time. In North America, containment measures were relaxed quicker, and therefore the $\mathcal{R}$ number did not stay below one for long, resulting in the second wave in the summer of 2020. By contrast, the $\mathcal{R}$ number stayed below one for longer in Western Europe, until about mid-summer, when the virus began to spread exponentially again, resulting in the second (and largest) European wave in the Fall. After the new containment measures, $\mathcal{R}$ number declined again, but it did not stay below one for long, resulting in the third wave of infections in January 2021 in both regions.

Experience from the remaining regions is more atypical than one might expect from the epidemic models. New cases in the Middle East and North Africa and, to some extent East Asia and Pacific (excl China), exhibit a broad upward trend throughout 2020 with a number of local peaks; new cases data for Latin America and Caribbean appear to be subject to much more noise compared

\textsuperscript{30}Table A1 in the online Appendix lists countries included in each region.
with any other regions, and there is an unusual jump in the daily new cases in Eastern Europe and Central Asia, driven by the data for Turkey. $R$ numbers closely reflect the first derivative of the smoothed version of the new cases data in all regions; new cases subside when $R$ falls below one and increase when $R$ is above one.

The difference between the solid red lines ($R$ numbers) and the dotted blue lines (effective transmission rate) is virtually zero in the most successful regions in terms of the total number of cases, such as Sub-Saharan Africa and South Asia, suggesting that herd immunity played no role in these regions due to the relatively small number of overall infections. On the other hand, the gap between the two lines is largest in North America, followed by Western Europe, showing that herd immunity has started to contribute more meaningfully to mitigation of the epidemic in these regions starting in December 2020.

B.3 Selected Large Countries

Clearly the trajectory of the epidemics has been quite heterogeneous across regions. In addition, there are considerable differences across countries within each region, to which we now turn for selected large countries. We report estimates for the United States, Brazil, India and Russia in Figure 5, for South Africa, Australia, Iran and Turkey in Figure 6, and nine European countries in Figures 7-8—Belgium, France, Germany, Italy, Netherlands, Poland, Portugal, Spain, and UK. The selected countries include most of the G20 economies with the widest regional coverage globally.

In contrast to China’s and the rest of the world, the United States (reported in the top panel of Figure 5) stands out for the largest gap between the effective reproduction number and the effective transmission rate since the reopening of the economy in May 2020. The gap continues to widen throughout the subsequent period, peaking at the end of the sample in February 2021. Only a few other countries in the world, including the United Kingdom, Israel and some Latin American countries, display a comparable contribution of herd immunity to the decline in the $R$ number. The US case also stands out because of the three very distinct waves, with the second and the third re-emerging after a brief fall of the $R$ number below one. This led to a much higher number of infections per 100,000 people compared to the rest of the world.
Like the United States, Brazil’s estimates also show visible gaps between the $R$ number and the effective transmission rate starting in mid-2020. The case count in Brazil is more volatile compared to the United States and the remaining countries, possibly due to differences in the data quality other than under-reporting controlled for with the multiplication factor. Unlike the US case, Brazil brought down the $R$ number more gradually, falling below one for the first time only during the summer of 2020. This resulted in a protracted first wave that peaked in August. The $R$ number however did not remain below one for long, and in November a second large wave took off.

India also experienced a protracted first wave. Estimates of the $R$ number in India stayed above one until late September. Nevertheless, India did not experience a large number of cases per 100k population, compared with the remaining countries. As a result, herd immunity has not played a role in India. Russia, by contrast, experienced two large waves. Similarly to the western countries, Russia managed to bring the $R$ number down relatively fast, but not permanently, resulting in a larger second wave at the end of 2020.

A two-wave epidemic trajectory is also observed in the case of South Africa and Australia (in Figure 6), but with a different time profile. The first wave of the epidemic peaked in July 2020 in South Africa as authorities were unable to bring the $R$ number below one quickly enough. South Africa, as the richest country in the region, stands out with much higher infection rates compared to the rest of Africa. Australia, on the other hand, managed the virus very well. We can see two small peaks, one in March and the second in July-August 2020, each followed by a rapid decline in the $R$ number well below one, each time almost eradicating the virus without any discernible contribution from herd immunity.

For the two major neighboring countries, Iran and Turkey in the Middle East (the bottom two panels of Figure 6), the trajectories of the number of new cases differ markedly, with the outbreak of the virus starting much earlier in Iran due to the close trading relations with China. The initial spread in Iran began in late February 2020 and peaked in late March after the Iranian New Year ($20^{th}$ March) and then declined slightly before starting to move up to its second peak in November 2020. By contrast, new cases in Turkey were detected in March and remained low for quite a few months before rising dramatically to a peak of 165 per 100,000 in December 2020. The associated $R$
numbers for Iran and Turkey also show very different trajectories, with Turkey’s $R$ number hitting the maximum value of 3 during the December 2020 peak.

The estimation results for selected European countries are reported in Figures 7-8. We report the same sample of countries as the one used in the next section for panel estimation of the transmission rate determinants. The virus outbreak in continental Europe begins with Italy in early 2020, with the recorded number of infections accelerating rapidly from February 21, 2020 onward. A rapid rise in infections takes place about one week later in Spain, Germany and France, followed by Austria (not reported) at the end of February. As the rolling estimates show, the $R$ number fell below one in mid- to late-April in all these countries. As lock-downs were eased during the summer, however, the transmission rates started to rise again. By the end of the 2020, the $R$ numbers were much more dispersed, with some countries doing better than others. However, all large European countries reported in Figures 7-8 show a second wave much larger than the first one. The United Kingdom, Spain, Portugal and Netherlands exhibit distinct third waves, with larger case counts compared with their second-waves.

In summary, only China and a few other countries have been successful in containing the COVID-19 epidemic well. Contrary to common perception, however, not all countries accomplished this with the same draconian mandatory social distancing as in China. So we now turn to explaining the effective transmission rates to better understand the heterogeneity that we described, focusing on selected European countries reported in Figures 7-8, all experiencing quite similar starting dates and the initial wave of the epidemic, but quite differing subsequent trajectories.
Figure 1: New cases (left) and $R$ numbers (right) for China and the rest of the world

China

World Excl. China

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $R_{et}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_{et}/\gamma = \hat{\beta}_{et} \times 14$ (right charts, dotted blue line). $R_{et} = (1 - MF\hat{\gamma}) \hat{\beta}_{et}/\gamma$, where $\gamma = 1/14$, and MF declining linearly from 5 to 2 for each country. $\hat{\beta}_{et}$ is estimated using (12), where the number of active infections is computed using the data on confirmed cases minus imputed removed cases. The number of removed (recoveries + deaths) is imputed recursively using $R_t = (1 - \gamma) R_{t-1} + \gamma C_{t-1}$ for all countries.
Figure 2: New cases (left) and \( R \) numbers (right) for North and South Hemispheres (excl. China).

**North Hemisphere Excl. China**

**South Hemisphere**

**Notes:** The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the \( R \) number, \( R_{\text{eff}} \) (right charts, solid red line), and the effective transmission rate, \( \hat{\beta} / \gamma = \hat{\beta} \times 14 \) (right charts, dotted blue line). See notes to Figure 1.
Figure 3: New cases (left) and $R$ numbers (right) for selected geographic regions

North America

Western Europe

Eastern Europe and Central Asia

Latin America and Caribbean

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $\hat{R}_{et}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$ (right charts, dotted blue line). See notes to Figure 1.
Figure 4: New cases (left) and $R$ numbers (right) for selected geographic regions

Middle East and North Africa

South Asia

East Asia and Pacific (Excl. China)

Sub-Saharan Africa

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $R_{et}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$ (right charts, dotted blue line). See notes to Figure 1.
Figure 5: New cases (left) and $R$ numbers (right) for selected countries

**US**

**Brazil**

**India**

**Russia**

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $R_{ct}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$ (right charts, dotted blue line). See notes to Figure 1.
Figure 6: New cases (left) and $\mathcal{R}$ numbers (right) for selected countries

South Africa

Australia

Iran

Turkey

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $\mathcal{R}$ number, $\tilde{\mathcal{R}}_{\text{ct}}$ (right charts, solid red line), and the effective transmission rate, $\tilde{\beta}_t/\gamma = \tilde{\beta}_t \times 14$ (right charts, dotted blue line). See notes to Figure 1.
Figure 7: New cases (left) and $R$ numbers (right) for sample of European countries

Belgium

France

Germany

Italy

Netherlands

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $\hat{R}_{et}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$ (right charts, dotted blue line). See notes to Figure 1.
Figure 8: New cases (left) and $R$ numbers (right) for sample of European countries

Poland

Portugal

Spain

United Kingdom

Notes: The figure plots a seven-day moving average of the number of reported new cases per 100k population (left charts), the $R$ number, $R_{ct}$ (right charts, solid red line), and the effective transmission rate, $\hat{\beta}_e/\gamma = \hat{\beta}_e \times 14$ (right charts, dotted blue line). See notes to Figure 1.
C  Comparison of estimated $\mathcal{R}$ numbers for selected countries and regions for two choices of multiplication factors, MF declining from 5 to 2 and from 8 to 2.5

Figure 9: Comparisons of estimated $\mathcal{R}$ numbers for China and the rest of the world for two choices of multiplication factors, MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line)

Notes: The figure plots the $\mathcal{R}$ number, $\hat{\mathcal{R}}_{ct}$, using MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).

Figure 10: Comparisons of estimated $\mathcal{R}$ numbers for North and South Hemispheres (excl. China) for two choices of multiplication factors, MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line)

Notes: The figure plots the $\mathcal{R}$ number, $\hat{\mathcal{R}}_{ct}$, using MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).
Figure 11: Comparisons of estimated $\mathcal{R}$ numbers for main geographic regions (excl. China) for two choices of multiplication factors, MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).

Notes: The figure plots the $\mathcal{R}$ number, $\hat{\mathcal{R}}_{ct}$, using MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).
Figure 12: Comparisons of estimated $\mathcal{R}$ numbers for selected countries for two choices of multiplication factors, MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).

Notes: The figure plots the $\mathcal{R}$ number, $\hat{\mathcal{R}}_{ct}$, using MF=8 to 2.5 (solid red line) and MF=5 to 2 (dotted black line).
Figure 13: Comparisons of estimated $\mathcal{R}$ numbers for sample of European countries for two choices of multiplication factors, $\text{MF}=8$ to 2.5 (solid red line) and $\text{MF}=5$ to 2 (dotted black line).

Notes: The figure plots the $\mathcal{R}$ number, $\hat{\mathcal{R}}_{ct}$, using $\text{MF}=8$ to 2.5 (solid red line) and $\text{MF}=5$ to 2 (dotted black line).
D Comparison of estimated transmission rates for selected countries for two choices of multiplication factors, MF declining from 5 to 2 and from 8 to 2.5

Figure 14: Comparison of estimated transmission rates for China and the rest of the world for two choices of multiplication factors, MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line)

Notes: The figure plots the effective transmission rate $\hat{\beta}/\gamma = \hat{\beta} \times 14$ using multiplication factor MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line).

Figure 15: Comparison of estimated transmission rates for North and South Hemispheres (excl. China) for two choices of multiplication factors, MF=5 to 2 (solid blue line) and MF=5 to 2 (dotted black line)

Notes: The figure plots the effective transmission rate $\hat{\beta}/\gamma = \hat{\beta} \times 14$ using multiplication factor MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line).
Figure 16: Comparison of estimated transmission rates for main geographic regions (excl. China) for two choices of multiplication factors, MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line).

Notes: The figure plots the effective transmission rate $\hat{\beta}_t / \gamma = \hat{\beta}_t \times 14$ using multiplication factor MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line).
Figure 17: Comparison of estimated transmission rates for selected countries for two choices of multiplication factors, MF=8 to 2.5 (solid blue line) and MF=3 (dotted black line).

US

Brazil

India

Russia

South Africa

Australia

Iran

Turkey

Notes: The figure plots the effective transmission rate $\hat{\beta}_t/\gamma = \hat{\beta}_t \times 14$ using multiplication factor MF=8 to 2.5 (solid blue line) and MF=5 to 2 (dotted black line).
Figure 18: Comparison of estimated transmission rates for sample of European countries for two choices of multiplication factors, $MF=8$ to $2.5$ (solid blue line) and $MF=5$ to $2$ (dotted black line).

Notes: The figure plots the effective transmission rate $\hat{\beta} / \gamma = \hat{\beta} \times 14$ using multiplication factor $MF=8$ to $2.5$ (solid blue line) and $MF=5$ to $2$ (dotted black line).
E Conducting inference about the pooled panel results

Consider a linear panel data model, which, for convenience, can be written as

\[ y_{jt} = \theta' \zeta_{jt} + u_{jt}, \]

for \( j = 1, 2, ..., N \), where \( \zeta_{jt} \) is the vector of variables (inclusive of intercept). We allow for unbalanced panel by assuming \( t = 1, 2, ..., T_j \). Let \( \hat{\theta} \) be the pooled estimator. We have

\[ \hat{\theta} - \theta = \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}' \right)^{-1} \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} u_{jt}. \]

The variance of \( \hat{\theta} \) is given by

\[ Var(\hat{\theta}) = \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}' \right)^{-1} Var \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} u_{jt} \right) \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}' \right)^{-1}. \]

Assuming \( E(\zeta_{jt} u_{jt}) = 0 \), we obtain

\[ Var(\hat{\theta}) = \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}' \right)^{-1} \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \sum_{j'=1}^{N} \sum_{t'=1}^{T_{j'}} E(\zeta_{jt} \zeta_{jt'}' u_{jt} u_{jt'}) \right) \left( \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}' \right)^{-1}. \]

E.1 Inference robust to serial correlation of errors

Let

\[ Q_{nT} = \frac{1}{N} \sum_{j=1}^{N} \sum_{t=1}^{T_j} \zeta_{jt} \zeta_{jt}', \]

and

\[ S_{nT} = \sum_{j=1}^{N} \frac{T_j}{\sum_{j=1}^{N} T_j} \left[ \frac{1}{T_j} \sum_{t=1}^{T_j} \sum_{t'=1}^{T_j} E(\zeta_{jt} \zeta_{jt'}' u_{jt} u_{jt'}) \right], \]

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then
\[
\text{Var}(\hat{\theta}) = \frac{1}{\sum_{j=1}^{N} T_j} Q_{nT}^{-1} S_{nT} Q_{nT}^{-1}.
\]

We estimate \( S_{nT} \) by the Newey-West method, extended to our panel setup:
\[
\hat{S}_{nT} = \sum_{j=1}^{N} \frac{T_j}{\sum_{h=1}^{N} T_h} \hat{S}_j,
\]
where
\[
\hat{S}_j = \hat{\Omega}_{j,0} + \sum_{\ell=1}^{m_j} w(\ell, m_j) \left( \hat{\Omega}_{j,\ell} + \hat{\Omega}_{j,\ell}' \right),
\]
and
\[
\hat{\Omega}_{j,\ell} = \frac{1}{T_j} \sum_{t=\ell+1}^{T_j} \zeta_{jt} \zeta_{j,t-\ell} \hat{\epsilon}_{jt} \hat{\epsilon}_{j,t-\ell},
\]
in which \( \hat{\epsilon}_{jt} = y_{jt} - \hat{\theta}' \zeta_{jt} \). We set
\[
w(\ell, m_j) = 1 - \frac{\ell}{m_j + 1},
\]
and \( m_j = m_{j,nT} \) is chosen to be a suitable increasing function of the sample size. We set \( m_{j,nT} \) to be the integer part of \((T_j)^{1/3}\).

### E.2 Inference robust to serial and cross-sectional correlation of errors

Allowing for correlation of errors over time, as well as across units (countries) requires a different estimator of \( S_{nT} \). It is useful to re-write \( S_{nT} \) as
\[
S_{nT} = \sum_{t=1}^{T} \sum_{t'=1}^{T} h_{nt} h_{nt}',
\]
where
\[
h_{nt} = \sum_{j \in N_t} \zeta_{jt} u_{jt},
\]
in which we use $\mathcal{N}_t$ as the index set of cross-section units with available observations for a period $t$. Following Driscoll and Kraay (1998), $S_{nT}$ is estimated as

$$\hat{S}_{nT} = \hat{\Omega}_{t0} + \sum_{\ell=1}^{m} w(\ell, m) \left( \hat{\Omega}_{\ell, \ell} + \hat{\Omega}'_{\ell, \ell} \right),$$  \hspace{1cm} (E.2)$$

where

$$\hat{\Omega}_{\ell, \ell} = \frac{1}{T} \sum_{t=\ell+1}^{T} \hat{h}_{nt} \hat{h}_{nt-\ell}, \text{ for } \ell = 0, 1, \ldots, m,$$

and

$$h_{nt} = \sum_{j \in \mathcal{N}_t} \zeta_{jt} \hat{u}_{jt}.$$ 

$m = m_{nT}$ is chosen to be a suitable increasing function of the sample size. We set $m_{nT}$ to be the integer part of $T^{1/3}$.

**F Summary statistics**

This section reports sample maximums and minimums of the individual regressors in pooled regressions reported in Table 2.
Table S2: Sample minimum and maximum

| Pre-vaccination sample ending 31 January 2021 |
|-----------------------------------------------|
| Social Distancing | Economic Support | Vaccination | Delta Variant | Threshold |
| index            | index            | share       | share         | indicator |
| Belgium          | 0.11,0.81        | 0.00,1.00   | 0.00,0.00     | 0.00,1.00 |
| France           | 0.06,0.88        | 0.00,1.00   | 0.00,0.00     | 0.00,1.00 |
| Germany          | 0.11,0.85        | 0.00,0.63   | 0.00,0.00     | 0.00,1.00 |
| Italy            | 0.19,0.94        | 0.00,0.75   | 0.00,0.00     | 0.00,1.00 |
| Netherlands      | 0.00,0.79        | 0.00,0.88   | 0.00,0.00     | 0.00,0.01 |
| Poland           | 0.11,0.87        | 0.00,0.75   | 0.00,0.00     | 0.00,1.00 |
| Portugal         | 0.06,0.88        | 0.00,0.75   | 0.00,0.00     | 0.00,1.00 |
| Spain            | 0.11,0.85        | 0.00,0.88   | 0.00,0.00     | 0.00,1.00 |
| United Kingdom   | 0.11,0.88        | 0.00,1.00   | 0.00,0.01     | 0.00,1.00 |
| all 9 countries  | 0.00,0.94        | 0.00,1.00   | 0.00,0.01     | 0.00,1.00 |

| 1 February 2021 - 30 November 2021 sample |
|-------------------------------------------|
| Belgium        | 0.40,0.76        | 0.75,0.75   | 0.00,0.75     | 0.00,1.00 |
| France         | 0.44,0.75        | 0.25,0.50   | 0.00,0.69     | 0.00,1.00 |
| Germany        | 0.37,0.83        | 0.38,0.38   | 0.00,0.67     | 0.00,1.00 |
| Italy          | 0.47,0.83        | 0.75,0.75   | 0.00,0.73     | 0.00,1.00 |
| Netherlands    | 0.32,0.82        | 0.50,0.75   | 0.00,0.66     | 0.00,1.00 |
| Poland         | 0.39,0.76        | 0.75,1.00   | 0.00,0.54     | 0.00,1.00 |
| Portugal       | 0.41,0.88        | 0.75,0.75   | 0.00,0.88     | 0.00,1.00 |
| Spain          | 0.41,0.71        | 0.88,0.88   | 0.00,0.80     | 0.00,1.00 |
| United Kingdom | 0.41,0.88        | 0.25,1.00   | 0.01,0.68     | 0.00,1.00 |
| all 9 countries| 0.32,0.88        | 0.25,1.00   | 0.00,0.88     | 0.00,1.00 |

Notes: This table report sample maximums and minimums of the individual regressors in pooled regressions presented in Table 2. The top panel reports summary statistics for the pre-vaccination sample (ending January 31 2021), and the bottom panel reports summary statistics for the remainder of the full sample – 1 February 2021 to 30 November 2021.
G Controlling for mobility

This section explores Google Mobility data (https://www.google.com/covid19/mobility/) as an additional covariate potentially explaining the transmission rate of COVID-19. Mobility is likely correlated with social distancing and the other factors we considered in our analysis, but does not coincide with any of them. For example, it is possible to be socially distanced (by keeping distance from others, wearing masks etc.) but mobile, or to stay home and not being socially distanced. In other words, lower mobility is neither necessary nor sufficient to contain the spread of the virus as the many studies in the literature that evaluate the impact of COVID-19 containment measures employing mobility data show.

We construct an overall mobility index as a simple arithmetic average of ‘Retail and Recreation’, ‘Grocery and Pharmacy’, ‘Parks’, ‘Transit Stations’, and ‘Workplaces’ Google indices, divided by 100. Minimum and maximum observations for the mobility index in our sample of 9 European countries is -0.912 and 0.874, respectively.

We start by including the mobility index as the only covariate in our panel data model. A positive coefficient is expected, since an increase in mobility should to be associated with higher transmission rate. Tables S3-S5 report estimation results for the pre-vaccination subsample (ending January 2021), post-vaccination subsample (February 1, 2021 to November 30, 2021), and the full sample, respectively. We considered two options for multiplication factor, $MF = 2$ and 3. The estimated mobility coefficient is positive, in line with the prior above. However, the model fit is poor, about 6 to 7 percent in the pre-vaccination sample and only 2 to 4 percent in the post-vaccination subsample. Also, the estimated magnitude of the mobility coefficient is notably smaller in the post-vaccination subsample. This could be due increased vaccinations, which results in slower aggregate transmission of the virus and possibly contributed to increased mobility of individuals.

Next, we consider panel regressions that include the mobility index as well as the other regressors. The estimation results are summarized in Tables S6-S8 for the full sample and the three different threshold variables. Table S6 reports the results without threshold effects, Table S7 reports the results with a single 0/1 threshold indicator, and Table S8 shows the results with the
smooth threshold variable. The coefficient of the mobility index is now negative, suggesting reduced mobility could be associated with a higher rate of transmission! This perverse result is most likely due to the positive relationship that exists with mobility and mitigation measures and vaccination uptakes. It is reasonable to expect that vaccinated individuals and those that are taking precautionary mitigating measures are more likely to increase their mobility without the fear of contracting the virus. This also explains why we find reduced statistical significance of the vaccination variable once the mobility index is added to the regressors. Nevertheless, the threshold variables remain statistically highly significant regardless of the inclusion of the mobility index.
Table S3: Panel regressions of effective transmission rates using google mobility data alone

(Pre-vaccination subsample ending January 31)

| Multiplication Factor: | Pooled Estimates | Fixed Effects Estimates |
|------------------------|------------------|-------------------------|
|                        | $MF = 2$         | $MF = 3$                |
|                        | $MF = 2$         | $MF = 3$                |
| Mobility Index         | 1.13             | 1.12                    | 1.27                     | 1.26                     |
| standard s.e. (t-ratio)| 0.08 (13.5)      | 0.08 (13.3)             | 0.09 (14.6)              | 0.09 (14.4)              |
| robust1 s.e. (t-ratio)| 0.14 (7.9)       | 0.14 (7.8)              | 0.16 (7.8)               | 0.16 (7.8)               |
| robust2 s.e. (t-ratio)| 0.36 (3.1)       | 0.36 (3.1)              | 0.50 (2.5)               | 0.50 (2.5)               |

$R_0$ numbers (Constant Terms)

|                          | Pooled Estimates | Fixed Effects Estimates |
|--------------------------|------------------|-------------------------|
| common [robust2 s.e.]    | 1.55 (0.15)      | 1.57 (0.15)             |

specific [robust2 s.e.]:

| Country                 | $MF = 2$         | $MF = 3$                |
|-------------------------|------------------|-------------------------|
| Belgium                 | 1.54 (0.20)      | 1.56 (0.20)             |
| France                  | 1.62 (0.22)      | 1.63 (0.22)             |
| Germany                 | 1.45 (0.19)      | 1.46 (0.19)             |
| Italy                   | 1.60 (0.22)      | 1.61 (0.22)             |
| Netherlands             | 1.43 (0.16)      | 1.44 (0.16)             |
| Poland                  | 1.42 (0.15)      | 1.43 (0.15)             |
| Portugal                | 1.66 (0.22)      | 1.68 (0.22)             |
| Spain                   | 1.77 (0.28)      | 1.79 (0.28)             |
| United Kingdom          | 1.71 (0.24)      | 1.73 (0.24)             |

R-squared

|                | 0.06 | 0.06 | 0.07 | 0.07 |

Notes: Mobility index is arithmetic average of ‘Retail and Recreation’, ‘Grocery and Pharmacy’, ‘Parks’, ‘Transit Stations’, and ‘Workplaces’ google mobility indices, divided by 100. Lower value of mobility index implies less mobility.
Table S4: Panel regressions of effective transmission rates using google mobility data alone

(Post-vaccination subsample February 1 - November 30, 2021)

| Multiplication Factor: | Pooled Estimates | Fixed Effects Estimates |
|------------------------|-------------------|-------------------------|
|                        | $MF = 2$          | $MF = 3$                |
|                        | $MF = 2$          | $MF = 3$                |
| **Mobility Index**     | **0.52**          | **0.63**                |
| standard s.e. (t-ratio)| 0.07 (7.1)        | 0.08 (7.5)              |
| robust1 s.e. (t-ratio) | 0.12 (4.3)        | 0.13 (4.7)              |
| robust2 s.e. (t-ratio) | 0.16 (3.1)        | 0.19 (3.3)              |
| **R_0 numbers (Constant Terms)** |          |                        |
| common [robust2 s.e.]  | 1.22 (0.05)       | 1.37 (0.06)             |
| specific [robust2 s.e.]: |                  |                         |
| Belgium                | 1.38 (0.07)       | 1.58 (0.09)             |
| France                 | 1.21 (0.09)       | 1.36 (0.10)             |
| Germany                | 1.15 (0.07)       | 1.20 (0.08)             |
| Italy                  | 1.15 (0.07)       | 1.25 (0.07)             |
| Netherlands            | 1.32 (0.10)       | 1.52 (0.12)             |
| Poland                 | 1.18 (0.11)       | 1.27 (0.12)             |
| Portugal               | 1.17 (0.07)       | 1.33 (0.08)             |
| Spain                  | 1.16 (0.08)       | 1.31 (0.09)             |
| United Kingdom         | 1.29 (0.06)       | 1.46 (0.07)             |
| **R-squared**          | **0.02**          | **0.02**                |
|                        | **0.04**          | **0.03**                |

Notes: See notes to Table S3.
Table S5: Panel regressions of effective transmission rates using google mobility data alone

(Full sample ending November 30, 2021)

| Multiplication Factor: | Pooled Estimates | Fixed Effects Estimates |
|------------------------|------------------|-------------------------|
|                        | $MF = 2$         | $MF = 3$                |
| Mobility Index         | 0.67             | 0.80                    | 0.72                     | 0.86         |
| standard s.e. (t-ratio)| 0.05 (12.6)      | 0.06 (14.3)             | 0.06 (13.0)              | 0.06 (15.0)  |
| robust1 s.e. (t-ratio)| 0.09 (7.4)       | 0.10 (8.3)              | 0.10 (7.4)               | 0.10 (8.6)   |
| robust2 s.e. (t-ratio)| 0.20 (3.4)       | 0.20 (3.9)              | 0.24 (3.0)               | 0.24 (3.6)   |

$R_0$ numbers (Constant Terms)

|                        | $MF = 2$         | $MF = 3$                |
|------------------------|------------------|-------------------------|
| common [robust2 s.e.]  | 1.36 (0.08)      | 1.44 (0.08)             |
| specific [robust2 s.e.]: |                 |                         |
| Belgium                | 1.41 (0.10)      | 1.53 (0.11)             |
| France                 | 1.38 (0.12)      | 1.47 (0.12)             |
| Germany                | 1.29 (0.11)      | 1.32 (0.11)             |
| Italy                  | 1.33 (0.10)      | 1.40 (0.10)             |
| Netherlands            | 1.35 (0.10)      | 1.46 (0.10)             |
| Poland                 | 1.27 (0.09)      | 1.32 (0.09)             |
| Portugal               | 1.36 (0.10)      | 1.47 (0.10)             |
| Spain                  | 1.41 (0.14)      | 1.51 (0.14)             |
| United Kingdom         | 1.45 (0.12)      | 1.56 (0.11)             |

R-squared | 0.03 | 0.03 | 0.04 | 0.03 |

Notes: See notes to Table S3.
Table S6: Panel regressions of effective transmission rates featuring google mobility data and other regressors without threshold variable

(Full sample ending November 30, 2021)

| Multiplication Factor: | Pooled Estimates | Fixed Effects Estimates |
|------------------------|------------------|-------------------------|
|                        | $MF = 2$         | $MF = 3$                | $MF = 2$         | $MF = 3$                |
| **Stringency Index**   | -3.78            | -3.89                   | -3.69            | -3.75                   |
| standard s.e. (t-ratio)| 0.10 (-38.2)     | 0.10 (-37.4)            | 0.11 (-33.2)     | 0.12 (-32.0)            |
| robust1 s.e. (t-ratio)| 0.31 (-12.0)     | 0.31 (-12.4)            | 0.31 (-11.8)     | 0.32 (-11.8)            |
| robust2 s.e. (t-ratio)| 0.55 (-6.9)      | 0.53 (-7.3)             | 0.93 (-4.0)      | 0.92 (-4.1)             |
| **Economic Support**   | -0.86            | -0.85                   | -1.16            | -1.17                   |
| standard s.e. (t-ratio)| 0.05 (-18.2)     | 0.05 (-16.9)            | 0.06 (-19.0)     | 0.06 (-18.2)            |
| robust1 s.e. (t-ratio)| 0.13 (-6.9)      | 0.13 (-6.7)             | 0.17 (-6.7)      | 0.17 (-6.7)             |
| robust2 s.e. (t-ratio)| 0.24 (-3.7)      | 0.23 (-3.7)             | 0.34 (-3.4)      | 0.33 (-3.5)             |
| **Vaccinated Share**   | -0.32            | -0.02                   | -0.43            | -0.12                   |
| standard s.e. (t-ratio)| 0.05 (-6.5)      | 0.05 (-0.3)             | 0.05 (-6.6)      | 0.05 (-2.3)             |
| robust1 s.e. (t-ratio)| 0.11 (-2.9)      | 0.12 (-0.1)             | 0.11 (-3.8)      | 0.12 (-1.0)             |
| robust2 s.e. (t-ratio)| 0.18 (-1.8)      | 0.20 (-0.1)             | 0.23 (-1.9)      | 0.24 (-0.5)             |
| **Delta Variant Share**| -0.08            | -0.02                   | -0.09            | -0.03                   |
| standard s.e. (t-ratio)| 0.04 (-2.3)      | 0.04 (-0.5)             | 0.04 (-2.5)      | 0.04 (-0.8)             |
| robust1 s.e. (t-ratio)| 0.07 (-1.2)      | 0.07 (-0.2)             | 0.06 (-1.4)      | 0.07 (-0.4)             |
| robust2 s.e. (t-ratio)| 0.10 (-0.8)      | 0.11 (-0.2)             | 0.12 (-0.7)      | 0.13 (-0.2)             |
| **Mobility Index**     | -0.83            | -0.91                   | -0.62            | -0.68                   |
| standard s.e. (t-ratio)| 0.06 (-13.0)     | 0.07 (-13.5)            | 0.07 (-9.0)      | 0.07 (-9.4)             |
| robust1 s.e. (t-ratio)| 0.13 (-6.3)      | 0.13 (-6.8)             | 0.13 (-4.6)      | 0.14 (-4.9)             |
| robust2 s.e. (t-ratio)| 0.21 (-3.9)      | 0.21 (-4.2)             | 0.24 (-2.5)      | 0.24 (-2.8)             |

$R_0$ numbers (Constant Terms)

| common [robust2 s.e.] | 4.24 (8.4) | 4.30 (8.8) |
| specific [robust2 s.e.]: | | |
| Belgium                | 4.38 (5.6) | 4.46 (5.8) |
| France                 | 4.31 (5.5) | 4.37 (5.6) |
| Germany                | 4.16 (5.4) | 4.18 (5.5) |
| Italy                  | 4.67 (5.3) | 4.71 (5.4) |
| Netherlands            | 4.40 (5.5) | 4.49 (5.8) |
| Poland                 | 4.23 (5.5) | 4.28 (5.7) |
| Portugal               | 4.50 (5.4) | 4.55 (5.5) |
| Spain                  | 4.51 (5.3) | 4.56 (5.4) |
| United Kingdom         | 4.68 (5.4) | 4.74 (5.6) |

| R-squared              | 0.32 | 0.30 | 0.34 | 0.32 |

Notes: See notes to Table S3.
Table S7: Panel regressions of effective transmission rates featuring google mobility data and other regressors with a single 0/1 threshold variable

(Full sample ending November 30, 2021)

| Multiplication Factor: | Pooled Estimates | Fixed Effects Estimates |
|------------------------|------------------|------------------------|
|                        | $MF = 2$         | $MF = 3$               |
|                        | $MF = 2$         | $MF = 3$               |
| **Stringency Index**   |                  |                        |
| standard s.e. (t-ratio)| 0.11 (-21.7)    | 0.12 (-20.7)           |
| robust1 s.e. (t-ratio)| 0.23 (-10.1)    | 0.25 (-10.2)           |
| robust2 s.e. (t-ratio)| 0.39 (-6.0)     | 0.37 (-6.8)            |
| **Economic Support**   | -0.32            | -0.48                  |
| standard s.e. (t-ratio)| 0.05 (-6.7)     | 0.07 (-7.5)            |
| robust1 s.e. (t-ratio)| 0.10 (-3.1)     | 0.16 (-3.3)            |
| robust2 s.e. (t-ratio)| 0.17 (-1.9)     | 0.20 (-2.5)            |
| **Vaccinated Share**   | 0.03             | 0.19                   |
| standard s.e. (t-ratio)| 0.05 (-6.6)     | 0.05 (3.6)             |
| robust1 s.e. (t-ratio)| 0.09 (-3.3)     | 0.11 (1.8)             |
| robust2 s.e. (t-ratio)| 0.17 (-2.0)     | 0.20 (0.9)             |
| **Delta Variant Share**| -0.17            | -0.16                  |
| standard s.e. (t-ratio)| 0.03 (-4.9)     | 0.04 (-2.7)            |
| robust1 s.e. (t-ratio)| 0.06 (-2.7)     | 0.07 (-1.5)            |
| robust2 s.e. (t-ratio)| 0.10 (-1.7)     | 0.11 (-0.9)            |
| **Mobility Index**     | -0.36            | -0.38                  |
| standard s.e. (t-ratio)| 0.06 (-5.8)     | 0.07 (-5.3)            |
| robust1 s.e. (t-ratio)| 0.11 (-3.4)     | 0.12 (-3.2)            |
| robust2 s.e. (t-ratio)| 0.19 (-1.9)     | 0.16 (-2.3)            |
| **0/1 Threshold Variable** | -2.48            | -2.40                  |
| standard s.e. (t-ratio)| 0.09 (-28.4)    | 0.10 (-23.4)           |
| robust1 s.e. (t-ratio)| 0.26 (-9.5)     | 0.26 (-8.6)            |
| robust2 s.e. (t-ratio)| 0.46 (-5.4)     | 0.61 (-3.7)            |
| threshold value        | 0.20             | 0.20                   |
| $R_0$ numbers (Constant Terms) |              |                        |
| common [robust2 s.e.]: | 5.37 [0.22]     | 5.41 [0.22]            |
| specific [robust2 s.e.]: |              |                        |
| Belgium                 | 5.39 [0.55]     | 5.44 [0.56]            |
| France                  | 5.36 [0.57]     | 5.39 [0.58]            |
| Germany                 | 5.29 [0.58]     | 5.27 [0.59]            |
| Italy                   | 5.56 [0.57]     | 5.57 [0.58]            |
| Netherlands             | 5.40 [0.56]     | 5.46 [0.57]            |
| Poland                  | 5.26 [0.56]     | 5.28 [0.57]            |
| Portugal                | 5.44 [0.56]     | 5.47 [0.57]            |
| Spain                   | 5.43 [0.56]     | 5.45 [0.57]            |
| United Kingdom          | 5.52 [0.55]     | 5.55 [0.56]            |
| R-squared               | 0.40             | 0.41                   |
|                        | 0.38             | 0.38                   |
Notes: See notes to Table S3.
Table S8: Panel regressions of effective transmission rates featuring google mobility data and 
other regressors with a smooth threshold variable 
(Full sample ending November 30, 2021)

| Multiplication Factor | Pooled Estimates | Fixed Effects Estimates |
|-----------------------|------------------|-------------------------|
|                       | $MF = 2$         | $MF = 3$                | $MF = 2$                  | $MF = 3$                  |
| **Stringency Index**  | -2.20            | -2.37                   | -2.30                     | -2.41                     |
| standard s.e. (t-ratio) | 0.11 (-20.7)  | 0.11 (-20.9)            | 0.12 (-19.7)              | 0.12 (-19.4)              |
| robust1 s.e. (t-ratio) | 0.22 (-10.0)   | 0.23 (-10.2)            | 0.23 (-10.2)              | 0.24 (-10.0)              |
| robust2 s.e. (t-ratio) | 0.36 (-6.0)    | 0.36 (-6.5)             | 0.32 (-7.1)               | 0.33 (-7.4)               |
| **Economic Support**  | -0.32           | -0.32                   | -0.48                     | -0.51                     |
| standard s.e. (t-ratio) | 0.05 (-6.7)    | 0.05 (-6.2)             | 0.06 (-7.6)               | 0.07 (-7.6)               |
| robust1 s.e. (t-ratio) | 0.10 (-3.1)    | 0.11 (-3.0)             | 0.15 (-3.1)               | 0.15 (-3.3)               |
| robust2 s.e. (t-ratio) | 0.16 (-1.9)    | 0.16 (-2.0)             | 0.21 (-2.3)               | 0.20 (-2.6)               |
| **Vaccinated Share**  | -0.01           | 0.28                    | -0.09                     | 0.20                      |
| standard s.e. (t-ratio) | 0.05 (-0.3)    | 0.05 (5.5)              | 0.05 (-1.9)               | 0.05 (4.0)                |
| robust1 s.e. (t-ratio) | 0.09 (-0.1)    | 0.10 (2.8)              | 0.10 (-0.9)               | 0.10 (2.0)                |
| robust2 s.e. (t-ratio) | 0.17 (-0.1)    | 0.19 (1.4)              | 0.18 (-0.5)               | 0.20 (1.0)                |
| **Delta Variant Share** | -2.95           | -0.11                   | -0.17                     | -0.11                     |
| standard s.e. (t-ratio) | 0.10 (-29.4)   | 0.04 (-3.1)             | 0.03 (-5.1)               | 0.04 (-3.0)               |
| robust1 s.e. (t-ratio) | 0.27 (-10.8)   | 0.07 (-1.7)             | 0.06 (-2.8)               | 0.07 (-1.6)               |
| robust2 s.e. (t-ratio) | 0.37 (-7.9)    | 0.10 (-1.1)             | 0.09 (-1.8)               | 0.10 (-1.0)               |
| **Mobility Index**    | -0.35           | -0.45                   | -0.29                     | -0.37                     |
| standard s.e. (t-ratio) | 0.06 (-5.8)    | 0.07 (-6.8)             | 0.07 (4.4)                | 0.07 (-5.2)               |
| robust1 s.e. (t-ratio) | 0.11 (-3.3)    | 0.11 (-4.0)             | 0.11 (2.6)                | 0.12 (-3.1)               |
| robust2 s.e. (t-ratio) | 0.18 (-2.0)    | 0.18 (-2.4)             | 0.15 (-1.9)               | 0.16 (-2.3)               |
| **Smooth Threshold Variable** | -2.95  | -2.84                   | -2.77                     | -2.68                     |
| standard s.e. (t-ratio) | 0.10 (-29.4)   | 0.11 (-26.8)            | 0.10 (-26.7)              | 0.11 (-24.3)              |
| robust1 s.e. (t-ratio) | 0.27 (-10.8)   | 0.27 (-10.4)            | 0.28 (-10.0)              | 0.28 (-9.6)               |
| robust2 s.e. (t-ratio) | 0.37 (-7.9)    | 0.37 (-7.6)             | 0.57 (-4.9)               | 0.57 (-4.7)               |
| threshold value $\tau$ | 0.09           | 0.10                    | 0.09                      | 0.09                      |
| shape parameter $\delta$ | 17.3        | 19.6                    | 17.3                      | 18.2                      |

$R_0$ numbers (Constant Terms)

|                     | Pooled Estimates | Fixed Effects Estimates |
|---------------------|------------------|-------------------------|
| common [robust2 s.e.] | 5.78 [0.14]   | 5.78 [0.14]             |
| specific [robust2 s.e.]: |                 |                         |
| Belgium              | 5.77 [0.45]     | 5.82 [0.47]             |
| France               | 5.75 [0.47]     | 5.77 [0.48]             |
| Germany              | 5.67 [0.48]     | 5.65 [0.49]             |
| Italy                | 5.93 [0.46]     | 5.93 [0.47]             |
| Netherlands          | 5.79 [0.46]     | 5.84 [0.48]             |
| Poland               | 5.65 [0.46]     | 5.66 [0.48]             |
| Portugal             | 5.83 [0.46]     | 5.84 [0.47]             |
| Spain                | 5.81 [0.46]     | 5.82 [0.47]             |
| United Kingdom       | 5.90 [0.45]     | 5.92 [0.46]             |

R-squared | 0.41 | 0.38 | 0.41 | 0.39

Notes: See notes to Table S3.