Modern Pandemics: Recession and Recovery*

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Abstract

We examine the immediate and bounce-back effects from six modern health crises: 1968 Flu, SARS (2003), H1N1 (2009), MERS (2012), Ebola (2014), and Zika (2016). Time-series models for a large cross-section of countries indicate that real GDP growth falls by around two percentage points in affected countries relative to unaffected countries in the year of the outbreak. Bounce-back in GDP growth is rapid, but output is still below pre-shock level five years later. Unemployment for less educated workers is higher and exhibits more persistence, and there is significantly greater persistence in female unemployment than male. Moreover, the negative effects of pandemics are economically contagious — indirect effects on own-country GDP from affected trading partners are significant for both the initial GDP decline and the positive bounce back. However, the negative effects on GDP and unemployment are felt less in countries with larger first-year responses in government spending, especially on health care. Our estimates imply that the impact effect of the Covid-19 shock on world GDP growth is approximately four standard deviations worse than the average past pandemic.

Keywords: Health crises; Covid-19; Output loss; Unemployment; Trade network; Fiscal policy
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"We've never had a coronavirus pandemic infection like this. It may have happened centuries ago, but we didn't see it."

— Michael Osterholm, PhD, MPH, Director of the Center for Infectious Disease Research and Policy, University of Minnesota, 29 May 2020

1 Introduction

Epidemiologists, economists, and policymakers continue to devote considerable attention to understanding the human ravages and economic toll of the coronavirus Covid-19. As worldwide deaths attributed to the pandemic rise above two million, measures of economic activity have been equally funereal. Although economists have documented that many financial and political crises are associated with severe recessions (see Cerra and Saxena 2008, Reinhart and Rogoff 2009, and Jordà, Schularick, and Taylor 2013), little attention was paid to global health crises until recently, when a huge spate of papers analyzed the Covid crisis, its economic impact, and policy responses.

We now have emerging evidence on the impact effects of Covid. In Table 1, for example, we display simple estimates of the "Covid shock" to world GDP growth for the impact year 2020 and "bounce-back" year 2021. In the first row, we display "actual" world GDP growth (estimates) for 2020 according to data published in January 2021 by the IMF, World Bank, and Consensus Economics. These range from -3.5% to -4.3%. In the second row, we display the pre-Covid forecasts for 2020 made by these institutions in January 2020. The difference between actual and forecasted growth, listed in the third row, represents the "Covid shock" for 2020. For example, while as of January 2020, the IMF had been forecasting 2020 GDP growth of 3.3%, it now estimates that growth was -3.5%, implying a Covid shock of -6.8%. This is quite close to the implied Covid shock from the World Bank and Consensus. In the bottom half of Table 1, we compute the implied Covid "bounce-back shock" in 2021 as the difference between the January 2021 and January 2020 forecasts for 2021. This is approximately *positive* 2%, reflecting a projected bounce-back to growth following the pandemic-induced large recession.

In this paper, we make progress understanding Covid-19 — including for example how unusual the Table 1 shocks are — by systematically documenting the global impact of previous pandemics and epidemics in a large set of countries. We analyze six episodes

Table 1 The Covid Shock to World GDP Growth

	IMF	World Bank	Consensus
2020			
"Actual"[a]	-3.5	-4.3	-4.0
Pre-Covid forecast[b]	3.3	2.5	2.5
Shock[c]	-6.8	-6.8	-6.5
2021			
Current forecast[a]	5.5	4.0	4.9
Pre-Covid forecast[b]	3.4	2.6	2.6
Shock[c]	2.1	1.4	2.3

[a]"Actual" and "Current forecast" numbers, respectively, are the 2020 GDP growth (estimate) and 2021 GDP growth forecast taken from the January 2021 issues of World Economic Outlook (IMF), Global Economic Prospects (World Bank), and Consensus Forecasts (Consensus).

[b]Pre-Covid forecasts are taken from the January 2020 issues of these same sources.

[c]"Shock" = (Actual - Pre-Covid forecast) or (Current forecast - Pre-Covid forecast)

identified by global health experts in Jamison et al. (2017), beginning with the 1968 Flu up to Zika in 2016. We estimate the effects of past pandemic shocks in the onset year and the bounce-back dynamics over time, to gain insights into how quickly countries recover economically. There are four parts to the analysis. First, we estimate the effects on GDP growth and unemployment, including the distributional consequences. Second, we decompose the components of GDP growth using growth accounting, and investigate the channels through which pandemics affect the real economy. Third, we estimate the effects of pandemics on international trade and assess the extent to which trade propagates the macroeconomic effects of health crises. Finally, we document the extent to which fiscal policy aids recovery.

GDP growth and unemployment We first estimate the effect of past health crises on GDP growth and unemployment. We find that real GDP falls by around two percentage points and unemployment rises by nearly one percentage point, in affected countries relative to unaffected countries, in the year the outbreak is officially declared. Our estimates imply that the impact of the Covid-19 shock as computed in Table 1 is approximately *four* standard deviations worse than the average past pandemic. Moreover, we show that past pandemic shocks have very persistent effects. Although GDP growth rebounds quickly in one year, output remains below its pre-shock level five years later. For unemployment, it takes two years for the effect to vanish.[1] Furthermore, we show that there is a differential

[1]Our findings on the effect of health crises are consistent with previous analyses of financial crises, in

effect on workers based on education and gender: less educated workers experience larger unemployment than those with higher levels of education, and the persistence of female unemployment is significantly greater than of male unemployment.[2]

Transmission channels from growth accounting Second, we perform a growth accounting exercise that allows us to study the channel through which pandemics affect the real economy. We find that labor, physical capital and TFP growth display a similar pattern as GDP growth: they all fall in the onset year but start to recover one year later. We do not find any significant effect of pandemics on human capital indices.

International trade Third, in light of the global nature of pandemics, we document the effects of past health crises on international trade, and furthermore examine the role of trade networks. We find that trade plummets initially and that bounce-back is once again rapid but by an amount insufficient to restore the level implied by the pre-crisis trend. We further investigate spillover or network effects in trade, asking for example, how much is an individual country's economy affected by the fact that its trading partner suffered from the health crisis? This is relevant because a health-crisis induced decline in total spending could spill over to other countries, including countries unaffected by the pandemic, through a trade linkage channel. We find that these indirect effects on domestic GDP are not trivial, both in terms of magnifying the initial decline in GDP and in the positive bounce-back. Our estimate of the indirect channel working through international trade is around 20% of the total effect, consistent with structural model estimation in Bonadio, Huo, Levchenko, and Pandalai-Nayar (2020).

Fiscal policy Finally, we examine whether economic recovery is aided by fiscal policy. We group countries according to their average fiscal adjustment during the onset year across episodes. We estimate the impulse response functions separately on the high and low fiscal adjustment countries. We find that countries that respond in the onset year with higher government expenditures, especially on health care, enjoy more bounce-back in output growth compared to countries with less of a fiscal expenditures response. Given that health

particular with respect to the persistence of the shock's effects, as in Cerra and Saxena (2008), for example. As a basis for understanding the magnitude and persistence of our health crisis shocks, we show that they are similar to those from systemic banking crisis shocks, as identified by Laeven and Valencia (2013), in the online appendix.

[2] This might exaggerate existing income inequality during pandemics (see Furceri et al. (2020)).

crises have a persistent effect on output, according to our estimation, a quicker and larger bounce-back resulting from a stabilizing fiscal policy could have a permanent effect on economic activity, consistent with Dupraz, Nakamura, and Steinsson (2019). In contrast, we do not find that lowering taxes is effective in hastening recovery.

Estimation strategy

We primarily use local projections impulse responses as in Jordà (2005). This gives us a flexible and widely used technique to estimate the effect of a health crisis shock on GDP growth or unemployment of affected countries relative to unaffected countries, including the dynamic effects. Identification relies on the dates that health organizations officially declared a crisis. We also make use of panel regressions, which facilitate robustness checks of our baseline results. We address potential endogeneity in three ways in robustness exercises. First, we include consensus forecasts of growth in our regressions. Second, we employ a seemingly unrelated regressions framework that allows the feedback between health expenditure (proxy for the vulnerability to health crises), health crisis, and GDP growth. Third, we estimate the effects of pandemics using firm-level data. In all estimates, we allow for cross-sectional dependence by correcting standard errors using the method of Driscoll and Kraay (1998).[3]

Contributions to the Literature

We contribute to several strands of the literature. First, our paper belongs to the literature that investigates the effect of financial and political crises as in Cerra and Saxena (2008), Reinhart and Rogoff (2009), Jordà et al. (2013) and Laeven and Valencia (2013). Different from these papers, we investigate the effect of global health crises using several postwar pandemics and epidemics, similar in spirit to Jordà et al. (2011) who study financial crises using data from 14 developed countries over 140 years (1870–2008). Jordà et al. (2020) also examine low-frequency economic consequences of pandemics but focus on the real rates of return, while we examine GDP and unemployment. Using our health shocks dataset, Furceri et al. (2020) look at the effect of past pandemics on income inequality. Our

[3] Results from estimating an AR(4) as in Cerra and Saxena (2008) are similar to Jorda's local projections. Another approach would be to estimate impulse responses using panel vector autoregressions, an option we eschew in favor of the simplicity of local projections.

work is also related to papers that look at the effect of the 1918 Spanish flu (Barro et al. (2020) and Correia et al. (2020)) with implications for the Covid-19 pandemic.

Second, our paper contributes to the large volume of work on the economic impact and policy implications of Covid-19. Much of the work has been based on versions of the SIR model. For example, Atkeson (2020) analyzes disease scenarios that are designed to provide input into calculations of economic costs. How an epidemic plays out over time is determined by the transition rates between people in different states of the disease. Eichenbaum et al. (2020) emphasize that the severity of the recession will be exacerbated by people's decisions to cut back on economic activity in order to reduce the severity of the epidemic and save lives. As the authors emphasize, the optimal government containment policy saves thousands of lives but worsens the recession because infected people do not fully internalize the effect of their decisions on the spread of the virus. Berger et al. (2020) focus on testing and case-dependent quarantine during a period of asymptomatic infection, and find that testing can result in a pandemic with smaller economic losses while keeping the human cost constant. Glover et al. (2020) emphasize the distributional consequences of shutdown policies. Different from those papers, ours directly estimates the economic impact and policy effectiveness using historical events. Binder (2020) presents consumer survey evidence about awareness of the Fed's policy responses and macro expectations.

Third, our paper contributes to the literature that investigates the role of government policy in containing crises. For example, Gourinchas (2020) and Drechsel and Kalemli-Ozcan (2020) both propose a strong fiscal response to contain the impact of Covid-19. A large and growing literature studies different policy responses to contain the impact of Covid-19 such as Alvarez et al. (2020), Guerrieri et al. (2020), Fornaro and Wolf (2020) and Bethune and Korinek (2020). Our paper adds to this work by directly estimating the impact of different policy responses to past crises. In this sense, our paper is closely related to the work by Cerra et al. (2013), which looks at different international policy responses to spur recovery from recessions.

In the next section, we describe our data. Section 3 describes our econometric approach, including how we address concerns about endogeneity. Section 4 documents the effect of health crises on GDP and unemployment, while section 5 presents the effects on international trade and investigates propagation through trade linkages. Section 6 considers the effectiveness of fiscal policy responses. Section 7 concludes. Our online appendix contains additional information on data sources (online appendix section A), tables (online appendix section B), figures (online appendix section C), and additional analysis.

2 Data

We combine data from several sources. For the annual country-level analyses, we rely mainly on the World Development Indicators (WDI) from the World Bank as it provides the most comprehensive coverage for cross country variables. We supplement this with Penn World Tables data, which further allows us to study the channels through which pandemics affect real GDP. Forecasts of GDP growth are obtained from Consensus Economics Inc. and bilateral trade data from the World Integrated Trade Solution (WITS) database. We obtain firm-level data from Thomson Reuters Worldscope dataset. To identify the pandemic and epidemic events, we manually collect data from the WHO and other public resources. The detailed information on data source and summary statistics is provided in online appendix section A.

Epidemic and Pandemic Events

We focus on six postwar pandemic and epidemic events identified in Jamison et al. (2017)'s volume 9 of *Disease Control Priorities*, a book authored by well-known global health experts. The Disease Control Priorities Network (DCPN) was a multi-year project managed by the University of Washington's Department of Global Health and the Institute for Health Metrics and Evaluation.[4] As of this writing, the book has received more than 3,000 citations according to Google Scholar. Three editions have been published: DCP1 in 1993 (by the World Bank), DCP2 in 2006, and most recently DCP3 in 2017.[5] We rely mainly on the 9th volume of edition 3 which focuses on the economic impact of pandemics.

Using this volume as our guide, the six episodes we analyze are: the 1968 Flu (aka "Hong Kong flu"), SARS (2003), H1N1 (2009), MERS (2012), Ebola (2014), and Zika (2016). We determine the timing of the event from the dates that the World Health Organization (WHO) officially declares a Public Health Emergency of International Concern (PHEIC). In most cases, there are significant time lags between the initial appearance of an outbreak and official declaration.[6] Reporting lags and even discrepancies between the Cen-

[4] See `http://dcp-3.org/about-project` for details.

[5] Contributors include over 500 scholars, policymarkers and technical experts. The editors include well-known economists and CDC experts, such as Dean Jamison, Hellen Gelband, Susan Horton, Prabhat Jha, Ramanan Laxminarayan, Charles N. Mock and Rachel Nugent. The project was funded by the Bill & Melinda Gates Foundation, and the volume includes an introduction by Lawrence H. Summers.

[6] For example, Hoffman and Silverberg (2018) find that the H1N1 outbreak initially began on March 15, 2009, was detected by officials on March 18, 2009, but was declared a PHEIC only on April 25, 2009.

ters for Disease Control and Prevention (CDC) and the WHO do not affect our key identification variable — a dummy that equals one when WHO declares a pandemic/epidemic for an affected country and zero otherwise. In our matched sample, we have 313 country-year observations for the identified shocks.[7] Detailed information is in Table A1.

Having identified the epidemic/pandemic events and affected countries, we examine data on total cases and deaths from the official websites of the WHO, European Centre for Disease Prevention and Control (ECDC), CDC and from public news articles. Among the six events, the most widespread and deadly one is H1N1. It affected more than 200 countries, with more than 284,000 recognized deaths reported by the US CDC.[8] The ECDC is the only source containing detailed information for all affected countries around the world. Figure C1 depicts the global severity of those episodes, displaying the ECDC reported number of cases.[9] Although the Covid crisis stands out for its severity, other episodes were large. For example, it is estimated that 500,000 infections occurred in Hong Kong in the first two weeks of the 1968 Flu. Correspondingly, governments responded quickly to contain the negative effect of those health crises. We provide details of each historical episode in the online appendix Table A2.

Country-level Variables

We mainly use annual country-level data from the World Bank's World Development Indicators (WDI). This data set offers wide country coverage, containing the 210 countries (economies) listed in Table A3. The data set contains annual observations from 1960 to 2019. The WDI database is also useful in providing consistent coverage of many variables we use for cross sectional comparison. This includes key controls for our GDP growth and unemployment regressions such as trade to GDP, domestic credit to GDP, population,

Similarly, the West African Ebola outbreak began December 26, 2013, was detected on March 22, 2014, but was declared a PHEIC only on August 8, 2014. For Zika, the main concern was about identification between microcephaly and the true Zika virus infections. Some consider this outbreak to have begun on October 22, 2015, when the rise in microcephaly cases was first identified. Later, on November 28, 2015, there was strong evidence for a link between the virus and the microcephaly. Nevertheless, the Zika outbreak was declared a PHEIC only on February 1, 2016.

[7]Of the 313 country-year observations, only 291 have data for growth rates.

[8]This amount is much larger than the number reported by WHO. The discrepancy exemplifies the challenges in finding reliable and complete coverage of cases and fatalities, a subject we return to below. Detailed information is at http://www.cidrap.umn.edu/news-perspective/2012/06/cdc-estimate-global-h1n1-pandemic-deaths-284000.

[9]We also display a trade network intensity heat map for all countries across episodes in Figure C2, with details in section 5.

and GDP per capita. We also use the growth accounting components such as labor, human capital index, physical capital and TFP from the Penn World Table dataset. The systemic banking crises are identified by Laeven and Valencia (2013) (with an updated dataset in Laeven and Valencia (2020)) and a U.S. recession dummy is from the NBER. Forecasts of GDP growth are obtained from Consensus Economics Inc. The data are monthly, from a survey of analysts from large banks and financial firms. The data covers over 32 countries from January 1990 to February 2020. We take GDP growth expectations based the end of year $t-1$ on year t for each country-year. We also collect bilateral trade data from the World Integrated Trade Solution (WITS), which aggregates data from UN COMTRADE and UNCTAD TRAINS database. It provides bilateral trade exports and imports for more than 200 countries from 1988 to 2018. All continuous variables are trimmed at the top and bottom 1% to remove outliers. Variable construction and summary statistics are in Table A4 and A5 of our online appendix.

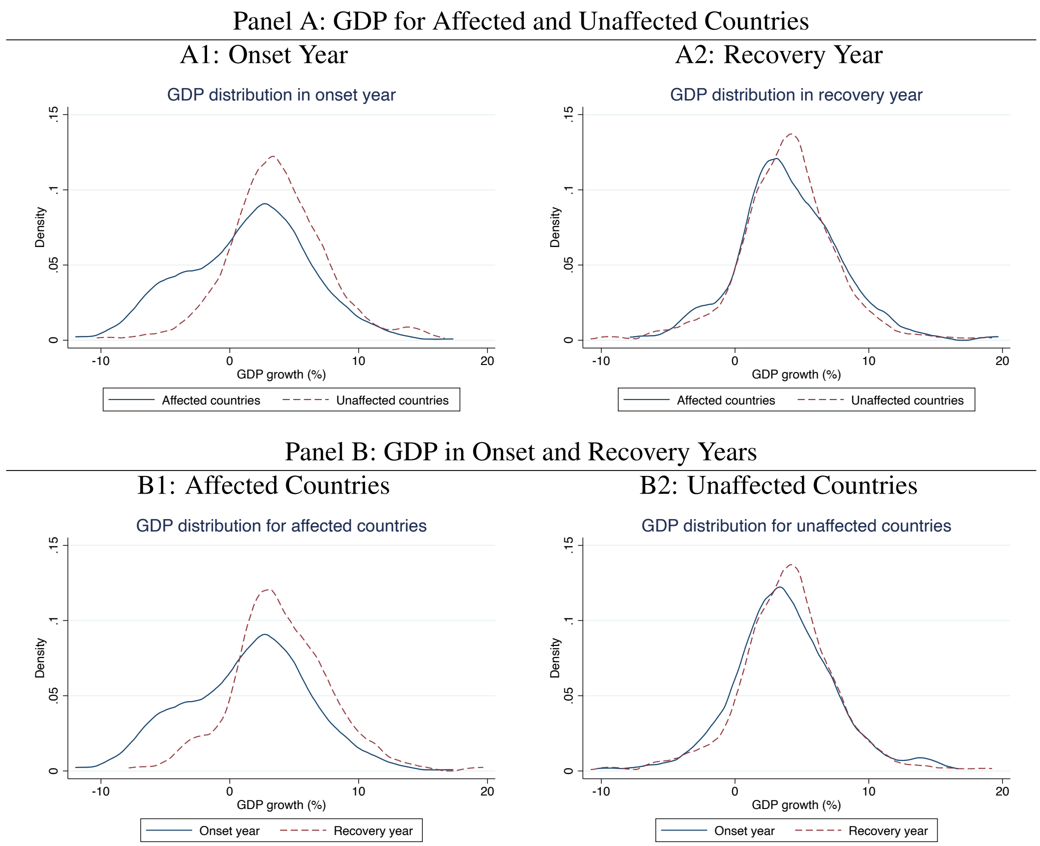
GDP growth around Health Crises

A summary look at the relationship between these health crises and annual real GDP growth is depicted in Figure 1. We plot the GDP growth distribution for affected and unaffected countries in the onset and recovery year for our six pandemics. Panel A1 compares the GDP growth rates for affected and unaffected countries in the onset year. Unconditionally, affected countries have a lower growth rate, compared to unaffected countries, 1.41% vs. 3.71%. However, as seen in panel A2, one year later, in the recovery year, there is no significant difference between affected and unaffected countries in terms of unconditional growth rate, 4.04% vs. 3.92%. Similarly, there is catch up for affected countries, as seen by comparing their growth rates in the onset and recovery year (panel B1). In contrast, there is no significant difference for the unaffected countries in the onset and recovery year (panel B2). Figure 1 thus displays sizable impact and bounce back effects during past pandemics.

3 Estimation Methodology

We use two approaches to study the effect of health crises on global macroeconomic outcomes such as GDP growth and unemployment. First is the local projections method of Jordà (2005), which we use to estimate impact effects and dynamic responses to the health

Figure 1 Real GDP Growth Distributions in Disease and Non-Disease Years



NOTE: The distribution of real GDP growth rate for affected countries and unaffected countries in onset (1968, 2003, 2009, 2012, 2014, 2016) and recovery years (1969, 2004, 2010, 2013, 2015, 2017). In Panel A1, the average growth rates for affected (unaffected) countries are 1.41 (3.71). In Panel A2, the average growth rates for affected (unaffected) countries are 4.04 (3.92). In Panel B1, the average growth rates for onset (recovery) years are 1.41 (4.04). In Panel B2, the average growth rates for onset (recovery) years are 3.71 (3.92).

crisis shock.[10] Second, we use panel regressions. These facilitate studying the robustness of our baseline results to various adjustments, including addressing endogeneity concerns. We use the Driscoll and Kraay (1998) correction for all confidence bands and regression standard errors.

Impulse Response Functions We begin with the local projections method of Jordà (2005) to estimate impulse response functions in the full panel of countries.

[10] Jordà et al. (2013) study the dynamic effects of financial crises using this technique.

$$y_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H y_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}, \text{with } H = 0, 1, \cdots, 5. \tag{1}$$

where y_{it} is alternatively real GDP growth or unemployment rate for country i in year t, D_{it} is a shock dummy variable indicating a pandemic/epidemic disease hitting country i in year t and X_{it} includes country-level controls for Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We include decade dummies and country fixed effects to control for unobserved cross section and cross time heterogeneity. To control for business cycles and financial crises, we also include a US recession dummy (from the NBER) and a systemic banking crisis dummy as in Laeven and Valencia (2013). We display impulse responses to an unexpected shock to D_{it} at time t, signifying the onset year of the crisis. Specifically, we plot the dynamics of $\{\delta_0^H\}_{H=0}^5$ for horizons up to five years after the shock, along with one standard error bands.

Panel Regressions Our panel OLS regression is similar to the local projection estimation equation in (1) and given as follows

$$y_{it} = \alpha_i + \beta D_{it} + \gamma X_{it} + \varepsilon_{it} \tag{2}$$

where here we restrict y_{it} to be real GDP growth rate for country i in year t, while D_{it} and X_{it} are the same as in equation (1).[11] In some specifications, we replace D_{it} with measures of crisis severity, such as individual countries' mortality rates or infection rates, as well as a relative severity dummy approach, as explained in detail later. We also replace the decade dummy by the year fixed effects or the world GDP as robustness tests. To estimate standard errors, we follow Driscoll and Kraay (1998), who note that traditional panel data techniques that fail to account for cross-sectional dependence will result in inconsistently estimated standard errors. This is especially a problem with relatively large cross sections but small time series samples. We implement their non-parametric covariance matrix estimation technique which they show yields standard error estimates that are robust to very general forms of cross-sectional and temporal dependence.

[11] To save space, we report regressions with GDP growth only; results for unemployment are consistent.

Exogeneity It is important to address concerns about endogeneity in our approach. The first concern is the assumption that the health crisis shock dummy D_{it} is exogenous to output growth and unemployment. Alternatively, one could conceive that output growth is exogenous, that recessions increase the probability of a health crisis, and that this reverse causality accounts for the associations that we document. Furthermore, it might be that third factors simultaneously affect GDP growth and the probability of a health crisis, including government expenditures on health care, the focus of section 6. Or it may be that (severity of) health crises and government expenditures are endogenous.

Similar concerns are voiced (and dexterously addressed) by Cerra and Saxena (2008), in the case of financial and political crises shocks. Health crisis shocks are arguably more exogenous to country-level growth and employment than are financial crisis shocks,[12] but nevertheless we investigate the empirical importance of the endogeneity concerns. First, we directly incorporate expectations. We test if consensus forecasts point to expected lower GDP growth simultaneously with the occurrence of a disease outbreak. Although this expectations channel is easier to see working through financial crises (investors foreseeing recession usher in a crisis), it is conceivable that expected weaker growth could sew the seeds for health crises via health preparedness channels. We show robustness of our baseline findings to controlling for consensus forecasts of GDP growth. We also test the pre-trend assumption for our panel regression, showing that lagged shocks are insignificant for GDP growth (see online appendix Table B1).

Second, we estimate a system of seemingly unrelated regressions that takes into account feedback between countries' health expenditure, the probability (or severity) of a health crisis shock, and real GDP growth.

$$g_{it} = \alpha_i^1 + \theta_1 D_{it} + \mu_1 D_{it-1} + \beta_1 g_{it-1} + \gamma_1 \text{Health Exp}_{it-1} + \delta_1 X_{it} + \varepsilon_{it}^1 \quad (3)$$

$$\text{Health Exp}_{it} = \alpha_i^2 + \theta_2 D_{it} + \mu_2 D_{it-1} + \beta_2 g_{it-1} + \gamma_2 \text{Health Exp}_{it-1} + \delta_2 X_{it} + \varepsilon_{it}^2 \quad (4)$$

$$D_{it} = \alpha_i^3 + \mu_3 D_{it-1} + \beta_3 g_{it-1} + \gamma_3 \text{Health Exp}_{it-1} + \delta_3 X_{it} + \varepsilon_{it}^3 \quad (5)$$

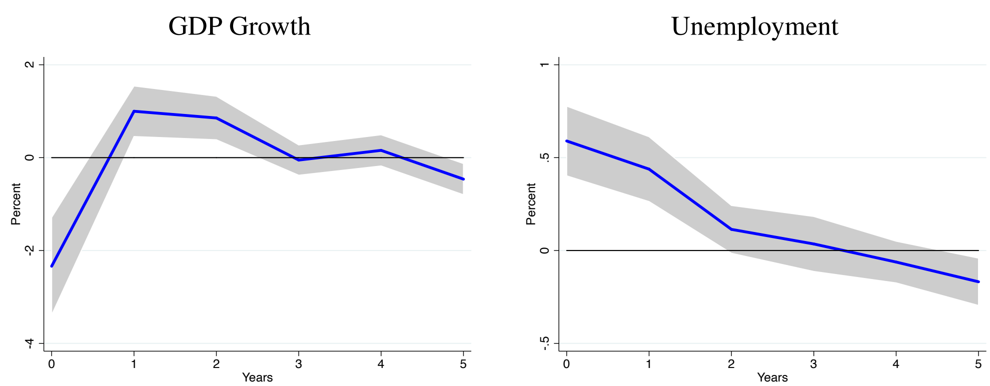
where g_{it} is annual real GDP growth for country i at year t, D_{it} is the shock dummy, Health Exp_{it} is current health expenditures (% GDP), and X_{it} includes the same country-level controls as in equation (1). All estimates include decade dummies, U.S. recession dummy, systemic banking crises dummy and country fixed effects as in the baseline panel

[12] "The virus respects no borders," Chinese President Xi Jinping, G20 Leaders' Summit on COVID-19, 27 Mar 2020. "The COVID-19 outbreak is the common enemy of the world."

OLS model. In the system of three equations, we allow for health crises to affect both real GDP growth and health expenditure contemporaneously, while assuming that growth and health expenditures affect health crises only with a lag. We alternatively estimate only the system of equations (3) and (5).[13]

Third, we document that there are significant effects of past pandemics on *firms* in affected countries relative to unaffected countries. As the pandemic shock is a country-level variable, the firm-level analysis is less vulnerable to endogeneity concerns. To this end, we collect all publicly listed firm data during 1990 to 2019 from the Thomson Reuters Worldscope database. We then exclude utilities (Standard Industrial Classification (SIC) codes 4900 -4999) and financial firms (SIC codes 6000-6999) since they are regulated. We further restrict the sample to firms located in countries with at least 10 publicly listed firms over the sample period.[14] Our final firm-level data set contains 47 countries.

Figure 2 Effect of Health Crises on GDP Growth and Unemployment



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $y_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H y_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where y_{it} is the annual real GDP growth rate (unemployment rate) for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown.

[13]We also examine replacing the shock dummy variable with the ex post mortality rate.

[14]We drop the United States because it has by far the most firms and furthermore is an affected country in all six episodes. We do not want our results driven by a single country. The final sample consists of 43,142 unique firms for a total of 466,073 firm-year observations. Table A4 provides detailed definition for the variables and Table A5 provides summary statistics for each variables.

4 Effects on GDP and Unemployment

4.1 Recession and Recovery

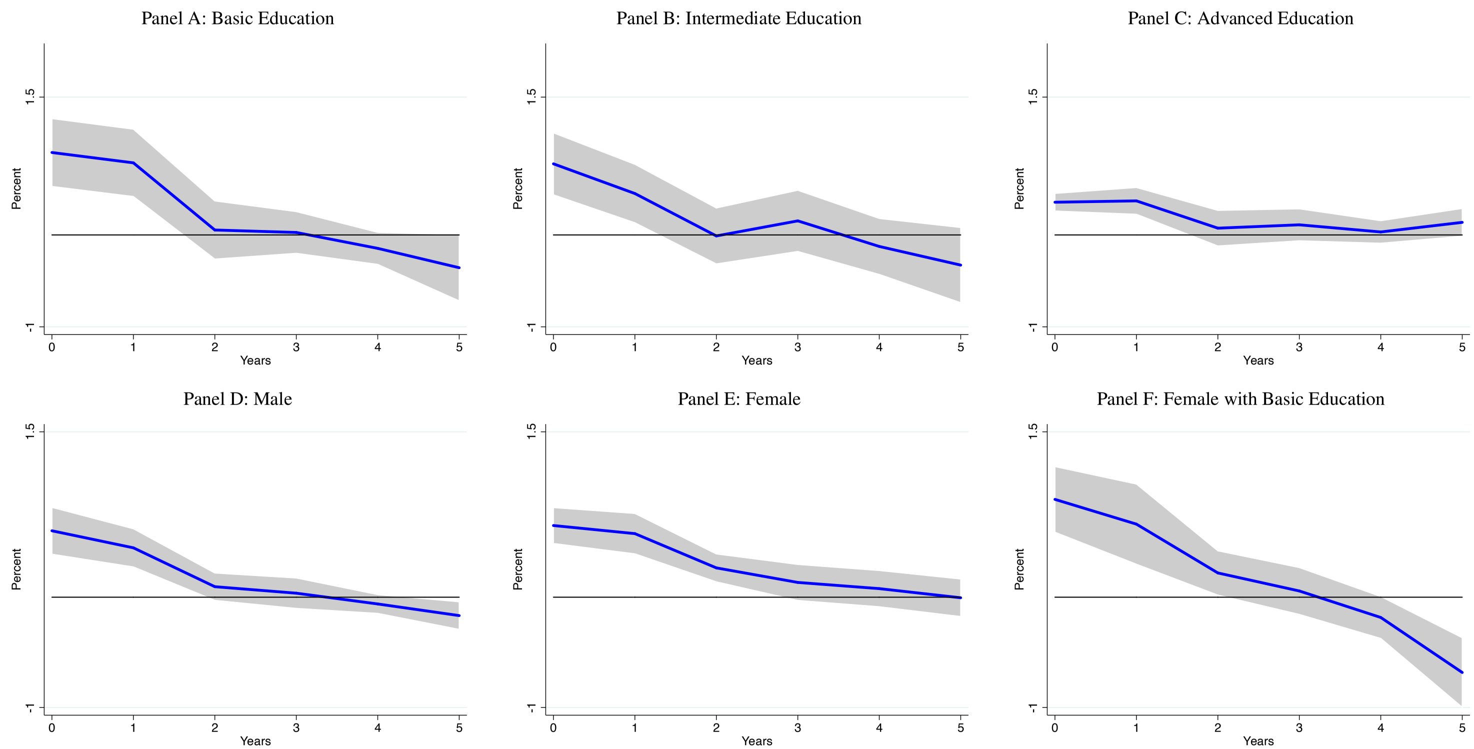
Figure 2 displays local projections estimates of real GDP growth and unemployment to the identified health crisis shock. The left panel represents the path of GDP growth in affected countries relative to unaffected countries, following the health crisis shock. We display estimates for the crisis onset year and subsequent five years. On average, GDP growth in affected countries is 2.3% below that of unaffected countries in the onset year. Furthermore, bounce-back from health crises shocks appears quickly according to our estimates, with affected countries enjoying nearly a one percentage point higher growth rate than unaffected countries in the year following the crisis. Resumption in growth in affected countries is not sufficient to overcome the initial decline, however, leaving the level of GDP persistently lower in affected countries compared to unaffected countries.[15] This points to a scarring effect of pandemic shocks on real GDP, like financial crises but with different dynamics.[16]

The right panel of Figure 2 indicates that in the onset year, unemployment is 0.7% higher in affected countries relative to unaffected countries. There is more persistence in unemployment than GDP growth, as unemployment remains 0.5% higher in affected countries in the year after onset. Disruptions to the labor market take longer to overcome than those to output. Moreover, different workers are affected differently. In Figure 3 and appendix Figure C3, we display unemployment impulse responses by gender, education level, and sector. Not surprisingly, the effect of the crisis is felt less strongly on those with a higher education level. However, industrial workers (and output) are hit harder than workers in the service and agricultural sectors, as displayed in Figure C3. In addition, although the impact effect on unemployment is felt approximately equally between males and females, there is significantly greater persistence in female unemployment. Hardest hit of all are female workers with a basic education, as seen in Panel F of Figure 3. These findings suggest that pandemics generate distributional effects that further deteriorates existing inequality (see Furceri et al. (2020)).

[15] Like the financial crises, there is a heterogeneous effect along multiple dimensions such as sectors, episodes, income level, economic development and geographic regions. We analyze this in detail in online appendix section D with impulse response figures in online Figure C3 and C4.

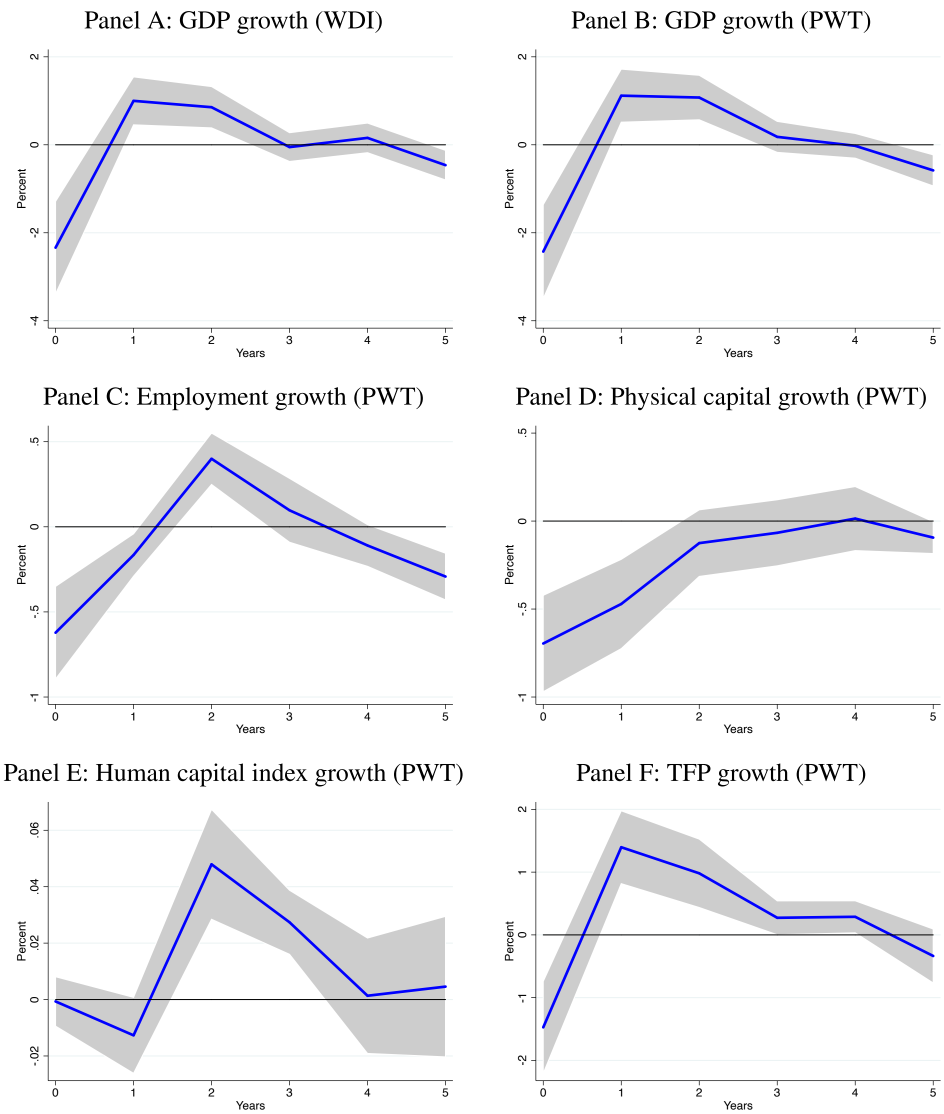
[16] In appendix section E, we compare the difference between pandemics and a typical financial crisis (the systemic banking crisis identified by Laeven and Valencia (2013)). Both types of crises have noteworthy similarities, including magnitudes, with the one key difference being that there is no quick bounce-back after banking crises. See online Figure C5 for details.

Figure 3 Effect on Unemployment (%): Education and Gender Breakdown



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $y_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H y_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where y_{it} is the annual unemployment rate for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown. Panels A, B and C present IRFs of unemployment for workers with basic education, intermediate education, and advanced education, respectively. Panels D and E present IRFs of unemployment for male and female workers, respectively. Panel F presents unemployment for female workers with basic education.

Figure 4 Channels of Pandemics



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $g_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H g_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s}^{\mathrm{H}} + \sum_{s=0}^{4} \gamma_s^H D_{it-s}^{\mathrm{M}} + \sum_{s=0}^{4} \mu_s^H D_{it-s}^{\mathrm{L}} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual growth rate of real GDP (WDI data in panel A), real GDP (PWT data in panel B), employment growth (panel C), physical capital (panel D), human capital index (panel E) and TFP (panel F) for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown.

4.2 Channels

To understand the channels through which past pandemics affect GDP growth, we decompose output according to growth accounting by labor input, human capital index, physical capital and TFP from the Penn World Tables dataset. We then estimate the impulse response functions of different factors to the same pandemic shock as in equation (1). Figure 4 presents the impulse response functions for the growth rates of different factors. As the growth accounting components are from Penn World Table (PWT) instead of the World Development Indicators (WDI), we first check whether our main results on GDP growth stay the same. Reassuringly, our results for GDP growth are robust to different datasets, as seen in panels A and B. Panel C presents the impact of pandemics on employment growth, i.e. the growth rate of labor input. On impact, employment growth falls by 0.6%. In the recovery year, the decline is only 0.2%. This pattern is consistent with the dynamics of the unemployment rate in Figure 2. Although the pandemic hurts the quantity of labor employed, it does not change the quality of labor as measured by the human capital index (panel E). Instead, the health crisis lowers physical capital investment and total factor productivity (panels D and F). Physical capital growth is lower by 0.7% in the onset year and slowly adjusts back to normal. For TFP growth, there is a negative impact in the onset year and bounce-back is immediate. All of these dynamics suggest a robust negative impact of pandemics on all inputs in the production function, which ultimately contributes to a lower GDP growth rate. However, in the recovery phase, the damage of pandemics is mitigated in all inputs, with TFP reverting back more than normal.

4.3 Extensions and Robustness

Estimating crisis-specific effects and controlling for expectations We display results for several robustness exercises in the panel regressions for GDP growth of Table 2.[17] Here we devote special attention to the H1N1 crisis, given its simultaneous occurrence with the 2009 Global Financial Crisis. First, we examine robustness to excluding the episode. Second, we allow different crises to have different effects, by using separate crisis dummy variables. Those dummy variables should absorb the contemporaneous effect from the global financial crisis on GDP and unemployment. Even though the global financial crisis affected most countries in 2009, the cross country heterogeneity in H1N1 exposure is arguably ex-

[17] All of our annual results are robust to a higher frequency quarterly data. See online appendix Section F for details.

ogenous to the financial crisis.[18] In addition, we examine specifications which control for expectations. These account for much of the effects of the economic control measures.

Column (1) of Table 2 displays results for the full sample period 1960-2019, while the remaining columns are for 1990-2019 due to our use of consensus forecasts, which are available for 32 countries beginning in 1990.[19] The coefficients in Table 2 on the shock dummy range from -1.2% to -3.3%, statistically significant and economically large. In appendix Table B2, with separate crisis event shock dummies, H1N1 has the largest effect, consistent with H1N1 having the largest number of deaths and cases. But still, the effect of the other disease episodes is not negligible.

Factoring in differences in crisis severity We also examine specifications that weight crises by their severity.[20] There are two caveats about this. First, there might be non-negligible measurement error for individual country reports of deaths and infection cases.[21] For example, the reporting discrepancy between the CDC and WHO could be systematically biased and incomplete. This consideration does not affect identification of the shock itself, but might contaminate interpretation of the severity panel regression estimates. Second, weighting the shock dummy by the individual country cases or deaths measure (however mis-estimated) assumes that, e.g., a 2% death rate in Ebola creates the same economic impact as a 2% death rate in H1N1. It is more reasonable to compare death rates and thus (cross-sectional) severity within the same health crisis.

To this end, and to be consistent with the *only* form in which severity data are available for the 1968 Flu ("isolated", "regional", and "widespread"), we form three dummy variables that capture the relative severity for affected countries in each episode.[22] We label affected countries as high, medium or low severity, using their ex-post mortality or case rate for each episode.[23] With this, our severity analysis groups countries into four categories: unaffected countries, low affected countries, medium affected countries and high

[18] We also remind that we include in our impulse response function estimation equation and panel regressions a recession dummy for the U.S. economy and a systemic banking crisis dummy.

[19] We also conduct robustness check using a smaller set of countries, i.e. IMF member countries. The results are available upon request.

[20] See Online Table B3 for details.

[21] In our matched 313 country-year sample for the health crises dummy, we have information on cases for 265 of them and on deaths for 259 of them. We do not have exact cases and deaths for the 1968 Flu.

[22] We still use the individual country's data for either mortality or case rates to form our new dummy variables. Although there might be measurement error for an individual country's data, the relative measure we construct should contain less of it.

[23] The threshold is percentiles 30 and 70. The results remain unchanged if we use the 1/3 and 2/3 cutoff.

Table 2 The Effect of Health Crises on GDP Growth

	GDP growth rate %							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample Period:	1960-2019	1990-2019						
	All Events	All Events				Without H1N1		
Shock	-2.33**	-2.36**	-3.28***	-1.75***	-1.68***	-1.24***	-1.21***	-1.65***
	(1.09)	(1.09)	(0.94)	(0.23)	(0.33)	(0.29)	(0.25)	(0.37)
Consensus Forecast			0.49***	0.36**	0.48***	0.62***	0.54***	0.61***
			(0.13)	(0.13)	(0.15)	(0.14)	(0.14)	(0.16)
Trade/GDP	2.44***	2.25***	3.37***	3.10***	3.30***	2.73***	2.74***	3.16***
	(0.31)	(0.49)	(0.88)	(0.91)	(0.95)	(0.70)	(0.72)	(0.81)
Domestic Credit/GDP	-3.48***	-5.37***	-3.33**	-3.24**	-3.69**	-2.36	-2.45*	-3.28**
	(0.58)	(0.71)	(1.56)	(1.44)	(1.46)	(1.43)	(1.41)	(1.48)
Log(Population)	-0.23	0.05	2.09	2.55*	2.49	2.97*	2.93*	2.56
	(0.62)	(1.12)	(1.59)	(1.47)	(2.05)	(1.54)	(1.51)	(2.01)
Log(GDP per capita)	0.75*	2.63***	-0.87	-0.44	-1.00	-0.61	-0.47	-1.18
	(0.39)	(0.92)	(1.49)	(1.47)	(1.56)	(1.53)	(1.50)	(1.52)
Recession	-0.39*	-0.52*	-0.23			0.29		
	(0.20)	(0.28)	(0.35)			(0.22)		
Banking Crisis	-1.11***	-0.98**	0.29	0.40	0.06	-0.23	0.04	-0.09
	(0.42)	(0.41)	(0.63)	(0.44)	(0.43)	(0.46)	(0.45)	(0.48)
World GDP growth				0.53***			0.22**	
				(0.09)			(0.09)	
Constant	1.32	-17.87	-24.69	-37.59	0.00	-42.16	-43.20	-32.90
	(11.55)	(23.55)	(34.96)	(32.89)	(.)	(34.21)	(33.79)	(42.44)
Observations	6300	4177	511	511	511	484	484	484
Within R^2	0.06	0.08	0.25	0.28	0.33	0.21	0.21	0.26
Decade FE	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Year FE	No	No	No	No	Yes	No	No	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real annual GDP growth. The sample period for column (1) is 1960-2019 while the sample period for columns (2)-(8) is 1990-2019. The shock dummy equals one for country i hit by a health crisis in onset year t, and zero otherwise. In columns (1)-(5), we include six health crises while columns (6)-(8) exclude H1N1. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

affected countries.[24] We expect that all affected country severity dummy variables in the GDP growth regressions will be negative and have an average magnitude that is approximately equal to the coefficient on the shock dummy in Table 2. Furthermore, we expect that the coefficient on higher severity dummies should be larger than for lower severity dummies.

Table 3 reports our panel regression with the severity dummy variables. The coefficients on all dummies are negative, consistent with our main regression in Table 2. The economic magnitude is much larger for high and medium severity countries than for low severity countries. The coefficients are highly significant and vary between -2.7% and -4.3% for the high and medium severity dummies, while they vary from -0.8% to -1.8%, sometimes

[24] See online appendix Table A6 in the data source section for country-episode category assignments.

Table 3 The Effect of Health Crises on Real GDP Growth, by Severity

	GDP growth rate %					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1960-2019	1990-2019		1960-2019	1990-2019	
High Mortality Rate	-3.45***	-3.60***	-4.25***			
	(0.97)	(0.98)	(1.06)			
Medium Mortality Rate	-3.08***	-3.10***	-4.15***			
	(0.81)	(0.88)	(0.47)			
Low Mortality Rate	-0.95	-0.95	-1.16**			
	(0.95)	(0.87)	(0.49)			
High Cases/Pop				-2.73**	-2.83**	-4.21***
				(1.17)	(1.25)	(1.21)
Medium Cases/Pop				-3.21**	-3.12**	-3.79***
				(1.51)	(1.47)	(0.70)
Low Cases/Pop				-0.77	-0.87	-1.83*
				(0.56)	(0.53)	(0.91)
Consensus Forecast			0.48***			0.49***
			(0.12)			(0.12)
Trade/GDP	2.46***	2.27***	3.51***	2.44***	2.26***	3.35***
	(0.30)	(0.49)	(0.95)	(0.31)	(0.50)	(0.99)
Domestic Credit/GDP	-3.46***	-5.34***	-3.11*	-3.46***	-5.36***	-3.17**
	(0.58)	(0.71)	(1.57)	(0.57)	(0.71)	(1.50)
Log(Population)	-0.18	0.13	2.43	-0.28	0.01	2.14
	(0.61)	(1.11)	(1.61)	(0.61)	(1.11)	(1.62)
Log(GDP per capita)	0.76*	2.66***	-0.91	0.73*	2.60***	-0.88
	(0.38)	(0.91)	(1.45)	(0.38)	(0.90)	(1.44)
Recession	-0.37*	-0.49*	-0.12	-0.40*	-0.55*	-0.29
	(0.19)	(0.26)	(0.32)	(0.20)	(0.28)	(0.36)
Banking Crisis	-1.10**	-0.98**	0.15	-1.11***	-0.99**	0.32
	(0.42)	(0.41)	(0.59)	(0.41)	(0.40)	(0.61)
Constant	0.52	-19.35	-30.32	2.26	-16.92	-25.48
	(11.34)	(23.28)	(34.98)	(11.35)	(23.16)	(34.84)
Observations	6300	4177	511	6300	4177	511
Within R^2	0.07	0.09	0.26	0.07	0.09	0.25
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real annual GDP growth. The sample period for columns (1) and (4) is 1960-2019 while the sample period for columns (2)-(3) and (5)-(6) is 1990-2019. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

insignificantly, for the low severity dummies. Interestingly, the high and medium severity dummies, both large and highly statistically significantly negative, are not significantly different from each other. This indicates that the relationship between health crisis severity and economic loss is non-monotonic. For comparison, we also estimate local projection impulse response functions for real GDP growth using these three new dummy variables and display them in Figure C6 of the online appendix.

Placebo regressions Finally, we do a placebo test by randomly picking a country-year observation as our shock dummy and re-estimating the panel regression. The results are in appendix Table B4. The coefficient on this randomly constructed variable is statistically insignificant, suggesting that our shock dummy indeed captures the effect of health crises on real GDP growth.

Table 4 Seemingly Unrelated Regressions:
Growth, Health Crises, and Health Expenditure

System 1	Shock_t	Shock_{t-1}	GDP growth_{t-1}	Health Expenditure_{t-1}	Obs	R^2
GDP growth	-2.19***	1.00***	0.22***	0.18***	2615	0.40
	(0.21)	(0.21)	(0.02)	(0.07)		
Health Expentidure	0.25***	-0.02	0.00	0.78***	2615	0.96
	(0.04)	(0.04)	(0.00)	(0.01)		
Shock		-0.07***	-0.00**	0.01	2615	0.14
		(0.02)	(0.00)	(0.01)		
System 2						
GDP growth	-2.20***	1.16***	0.24***	0.16**	2749	0.40
	(0.21)	(0.21)	(0.02)	(0.07)		
Shock		-0.07***	-0.00**	0.01	2,749	0.14
		(0.02)	(0.00)	(0.01)		

NOTE: System 1 reports estimates from the joint estimation of system of equations (3), (4) and (5). System 2 reports estimates from the joint estimation of system of equations (3) and (5). *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Feedback among growth, health crises, and health expenditures As discussed in Section 3, our baseline estimation assumes that the health crisis shock is exogenous to contemporaneous GDP growth. Although this is arguably reasonable, one may wonder whether lower past economic growth reduces health-related expenditures, making the country more vulnerable to a health crisis. Here we allow GDP growth, health expenditures, and the health crisis to be jointly determined in a system of equations (3), (4) and (5). We estimate this using seemingly unrelated regressions (SUR), modeling the determination of the shock dummy linearly, and report results in Table 4. Our key messages from the baseline regression are robust to alternative specifications of the system: GDP falls by 2.2% in the onset year, according to the SUR estimates, and bounces back by 1.0% in the following year. On the other hand, the probability of health shock does not depend on the magnitude of health expenditure in a statistically significant way.

4.4 Firm-level Results

An alternative way to show the negative effects of pandemics is to examine firms. As these health shocks occur at the country level, it is unlikely that firm-level outcomes will cause a health crisis. We estimate the effects of pandemics on the corporate sector using the following panel regression.

$$y_{ijt+h} = \alpha_i + \beta D_{jt} + \gamma X_{it-1} + \mu Z_{jt-1} + \varepsilon_{ijt}, \text{ for } h = 0, 1 \tag{6}$$

where y_{ijt+h} are alternative firm-level outcomes such as sales growth, wage, investment, profitability, leverage and employment for firm i at country j, year $t+h$, with $h = 0$ (onset year) and 1 (recovery year). D_{jt} is our health crisis dummy, X_{it-1} and Z_{jt-1} are the control variables at firm- and country-levels. All controls are lagged one year. We also include both firm and year fixed effects to control for unobserved firm and time variation.

Table 5 presents the results, with panel A depicting the onset year and panel B the recovery year. We find that the health crisis reduces firm sales growth, an effect that is large: firms located in affected countries experience -13.3% sales growth compared with firms in unaffected countries.[25] Moreover, investment and profitability also fall. This is consistent with our cross country analysis where GDP growth is lower in the onset year and physical capital declines. Similarly, firms cut their employment as wages increase, consistent with the rise in unemployment in our aggregate impulse response functions. The negative effect of pandemics also likely eats into firms' equity value and forces firms to raise more external financing, resulting in the higher leverage ratio shown in the table.

Finally, we document that the negative effects on firms are more persistent than what is found at the country level. In particular, both sales growth and profit continue to fall in the (aggregate) recovery year, although by a smaller magnitude. Investment starts to recover but is statistically insignificant. Interestingly, the wage starts to fall in the recovery year, which helps firms reduce their wage bills. Firms continue to cut employment, consistent with the greater persistence in aggregate unemployment found earlier.

5 International Trade and Cross-Country Propagation

The economic effects of a pandemic can transmit across borders through trade networks. Affected countries suffer a significant decline in GDP, consumption, and investment in the onset year of pandemics.[26] Furthermore, as seen in Panel A of Figure 5, the volume of in-

[25] This is calculated as -2.53%/18.98= -13.3%, where the average sales growth is 18.98%.

[26] Online Appendix Section G documents a significant negative effect on private consumption and fixed investment in the onset year (-1.8% and -6.6% respectively). See online appendix Figure C7 for the impulse

Table 5 Effects of Pandemics on Firm Outcomes

	Panel A: Onset Year						Panel B: Recovery Year					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
	Sales Growth	Wage	Investment	Profit	Leverage	Employment	Sales Growth	Wage	Investment	Profit	Leverage	Employment
Shock	-2.53***	0.24***	-0.22**	-0.55***	0.33***	-0.02***	-2.09***	-0.34***	0.12	-0.48**	-0.00	-0.02***
	(0.61)	(0.03)	(0.09)	(0.17)	(0.09)	(0.01)	(0.62)	(0.03)	(0.08)	(0.20)	(0.09)	(0.01)
Log(Assets)	-10.76***	0.01	-2.22***	-2.28***	-0.39***	0.60***	-19.65***	-0.02*	-0.24***	-0.58***	-0.55***	0.49***
	(0.43)	(0.01)	(0.05)	(0.13)	(0.03)	(0.01)	(0.44)	(0.01)	(0.05)	(0.13)	(0.03)	(0.01)
Cash Flow	-23.22***	0.02	-2.69***	-95.66***	2.55***	0.42***	-14.22***	0.10*	-2.17***	-18.48***	3.37***	0.54***
	(2.37)	(0.05)	(0.31)	(0.82)	(0.21)	(0.02)	(2.20)	(0.06)	(0.25)	(0.81)	(0.22)	(0.02)
TobinQ	3.82***	-0.01**	0.23***	0.74***	0.05***	0.02***	0.92***	-0.01**	-0.47***	-0.48***	0.10***	0.03***
	(0.27)	(0.00)	(0.03)	(0.10)	(0.02)	(0.00)	(0.24)	(0.00)	(0.03)	(0.11)	(0.02)	(0.00)
Cash	29.35***	0.01	-5.53***	0.65	0.27***	-0.17***	8.46***	-0.00	-0.87***	-0.23	0.18**	-0.11***
	(1.38)	(0.02)	(0.21)	(0.57)	(0.09)	(0.01)	(1.15)	(0.02)	(0.14)	(0.33)	(0.09)	(0.01)
GDP growth	0.06	-0.00	-0.05***	0.17***	0.01	0.01***	-0.23***	0.02***	0.01	0.02	0.02*	0.01***
	(0.07)	(0.00)	(0.01)	(0.02)	(0.01)	(0.00)	(0.07)	(0.00)	(0.01)	(0.02)	(0.01)	(0.00)
Log(Population)	-3.70***	-0.02***	0.21	-1.18***	-0.08	-0.11***	-1.03	0.01	0.07	-0.17	-0.10	-0.11***
	(0.72)	(0.01)	(0.13)	(0.20)	(0.10)	(0.02)	(0.73)	(0.00)	(0.12)	(0.14)	(0.11)	(0.02)
Log(GDP per capita)	5.63***	-0.07**	1.94***	0.98***	0.34***	-0.53***	14.81***	-0.19***	0.48***	0.42**	0.43***	-0.39***
	(1.11)	(0.04)	(0.14)	(0.23)	(0.09)	(0.03)	(1.14)	(0.04)	(0.13)	(0.18)	(0.09)	(0.03)
Recession	-5.22***	-0.29***	-2.56***	-0.69***	0.14	-0.09***	4.26***	0.27***	-0.47***	2.26***	-0.29**	-0.13***
	(0.92)	(0.03)	(0.13)	(0.25)	(0.12)	(0.01)	(0.93)	(0.03)	(0.11)	(0.28)	(0.12)	(0.01)
Banking Crisis	-0.30	-0.08***	0.40***	-1.25***	0.19	-0.14***	0.10	0.02	-0.19	-0.47*	-0.24**	-0.15***
	(0.79)	(0.02)	(0.13)	(0.23)	(0.12)	(0.01)	(0.79)	(0.02)	(0.12)	(0.25)	(0.12)	(0.01)
Constant	222.25***	1.03**	21.27***	59.96***	5.15**	2.77***	263.59***	2.29***	-0.38	11.75***	7.82***	3.36***
	(16.38)	(0.44)	(2.66)	(4.29)	(2.08)	(0.40)	(16.73)	(0.41)	(2.47)	(3.17)	(2.22)	(0.44)
Observations	299606	136593	289291	299592	297419	231356	270618	125776	262337	268986	268500	209123
Adjusted R^2	0.040	0.004	0.047	0.316	0.003	0.308	0.043	0.005	0.012	0.019	0.005	0.223
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: This table estimates the effects of health shocks on firm-level outcomes. See Appendix Table A4 for a detailed definition for all the variables. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

ternational trade — the sum of a country's multilateral exports plus imports — of affected countries plummets in the onset year. The drop of around 19.0% is on par with the U.S. trade collapse in 2008-09 (see Levchenko et al. (2010) and Novy and Taylor (2014)). Affected country trade rebounds quickly, however, growing relative to the trade of unaffected countries by 7.2% one year later.

Being involved in trade networks is of course a mixed blessing for a country during a pandemic. On the one hand, the negative effect of health crises on the trading partner spills over to the domestic economy through trade, making health crises economically more contagious. Trade suffers because crises can lower trade through both an extensive and intensive margin, as noted by Fernandes and Tang (2020) who look at the effect of SARS on Chinese trade. In addition, declining aggregate demand due to the pandemic can affect trading partners even if they are not directly affected by it. On the other hand, the bounce-back effect from a health crisis for the affected trading partner also benefits the domestic country. Moreover, being more integrated into global value chains can help firms diversify risks when the country itself is hit by the health crisis (see Huang (2017)).

To investigate such dynamics in our historical episodes, we begin by constructing a measure of "trade network infections" for each country and health crisis. The measure is constructed as,

$$\text{Trade Network Infection}_i^k = \sum_j \omega_{ij}^k \text{Case}_j^k$$

where ω_{ij}^k is the share of bilateral trade for country j in country i's total trade one year before health shock episode k and Case_j^k is the ex-post cases number for country j in health shock k.

This measure takes the number of infection cases from each of that country's trading partners and weights these case numbers by the bilateral trade share of that country with the domestic country. In other words, for each country the trade network infections measure reflects how much we trade with particular countries and how badly those trading partners were affected by the crisis. Figure C2 displays a heat map that depicts the trade network infection numbers for each crisis episode. As seen in the figure, this varies from episode to episode and varies across countries during any given episode. Clearly, the trade network effect is potentially much more severe during Covid-19 than the other episodes.[27]

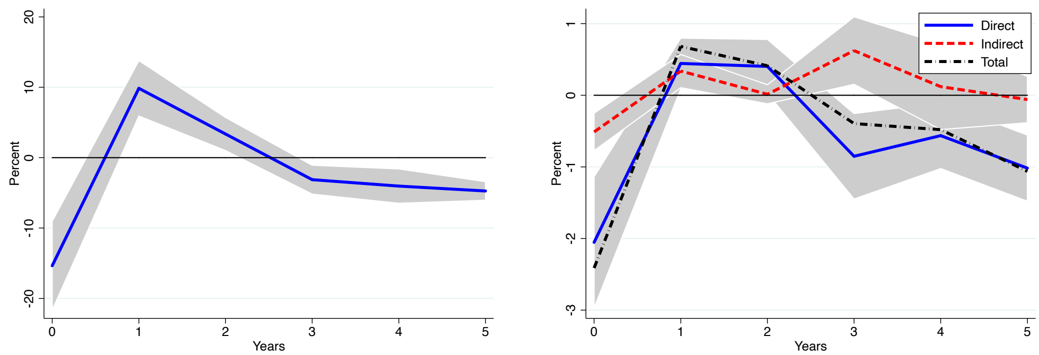
We decompose the total effect of health crises on domestic GDP growth into a direct

response functions.

[27] Recall that the trade data is available only from 1988-2018, hence no heat map for the 1968 Flu.

Figure 5 Health Crises and International Trade

Panel A: Effect on Trade growth (exports+imports) Panel B: Effect on GDP growth: the trade channel



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $g_{it+H} = \alpha_i^H + \sum_{s=1}^{4} \beta_s^H g_{it-s} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual real growth rate of total trade (export+import) in Panel A and is GDP growth in Panel B for country i at year t, D_{it} is a dummy variable indicating a health crisis hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, U.S. recession dummy, a banking crisis dummy and country fixed effects. In panel B, we also include an indirect effect measure D_{it}^I in the regression, where $D_{it}^I = 1$ if one of country i's trading partner has been hit by the health crisis at year t. The blue solid line is the direct effect (coefficient on D_{it}) while the red dashed dashed line is the indirect effect (coefficient on D_{it}^I). The black dash dotted line represents the total effect, i.e. the coefficient on D_{it} for the estimation on GDP growth in the baseline equation (1). Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown.

channel and an indirect channel, with the latter capturing the effect of pandemics on affected countries through their trading partners. The direct effect of the health crisis is captured by our shock dummy (D_{it} for country i at year t), while the indirect effect is captured by an indicator function that flags whether the trading partner is affected by the health crisis. To implement this, we augment our baseline estimation equation (1) with a dummy variable that indicates whether any of one's trading partners has been hit by the health crisis in the same year, i.e. $D_{it}^I = 1$ if one of the country i's trading partner country j is hit by the crisis. This is a parsimonious way of estimating the indirect channel. It captures the average effects of affected trading partners on the domestic economy and treats all of them equally.[28]

As seen in Panel B of Figure 5, indirect effects are not trivial, contributing approximately -0.5% to GDP growth in the onset year (versus direct effects of -2.1%) and +0.3% in the bounce-back year, or more than half the magnitude of the recovery's direct effect. For comparison, we also depict the total effect on GDP growth estimated separately from

[28]We find results that are robust constructing a measure that weights the trading partners by the trade weights, as in the heat maps. We display the impulse response functions using the dummy variables approach due to simplicity.

equation (1). The dynamics of pandemics through the indirect trade channel are the same as those of the direct channel, suggesting that the international trade network indeed amplifies the effect of pandemics. Our simple estimate of the indirect trade channel is very similar to the structural estimation by Bonadio et al. (2020), who find that one third of the average real GDP downturn due to the Covid-19 shock is through global supply chains.

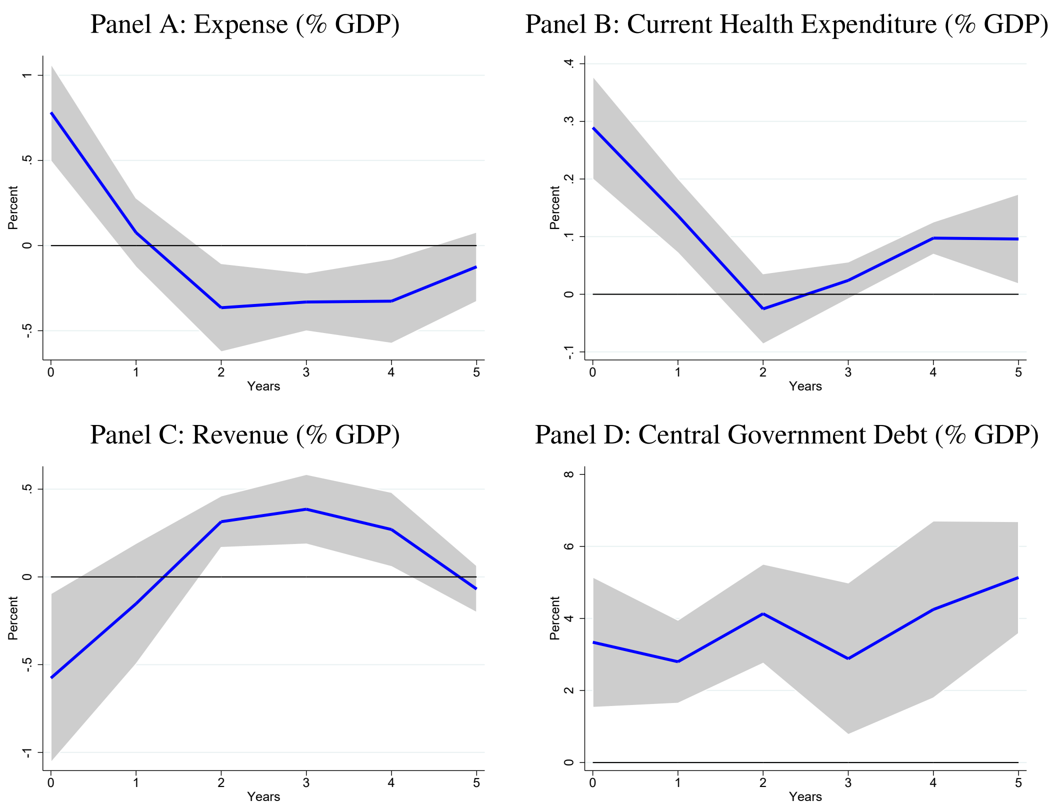
Finally, we use panel regressions to test the robustness of the trade linkages channel to alternative ways of constructing the proxy. As seen in column (1) of Table B5, we use a dummy capturing whether the trading partner was affected, as in the IRF of Figure 5. In column (2), we add a continuous variable, labelled "trade weighted by indirect shock", which multiplies the shock dummy (to a country's trading partner) by the bilateral trade between these two countries, as a share of the country's total trade. Columns (3) and (4) use the ex-post high, medium and low mortality rate dummies to replace the direct shock dummy, while columns (5) and (6) use the equivalent case rate dummies, and so is akin to column (1) and column (2). The estimates indicate that the indirect effect of health crises through trade linkages is large and significant. According to column (1), the impact through trade is around one fourth of the direct effect. When taking into account the importance (weights) of different trading partners, the effect becomes larger, especially for countries with high severity. We conclude that the effects of health crises on domestic GDP growth are significantly magnified by trade linkages.[29]

6 Fiscal Policy

In response to Covid-19, finance ministries have undertaken a variety of spending and tax-related policies designed to support households and businesses, and soften the impact on economic activity. According to standard Keynesian logic, fiscal stimulus in a time of crisis, either by increasing government spending or cutting taxes, can speed up economic recovery (see Gourinchas (2020)). More generally, fiscal policy has been proposed as an effective way to address crises, such as during the zero-lower bound period and in times of secular stagnation (see Eggertsson (2011), Eggertsson and Krugman (2012), Eggertsson et al. (2016), Benigno and Fornaro (2018), Fatás and Summers (2018), Fornaro and Wolf (2020)). Furthermore, Dupraz et al. (2019) find a permanent effect from stabilization policy

[29] As robustness, online appendix table B6 uses individual countries mortality or case rates to construct the indirect trade measure, weighting trading partners' mortality or case rates by the trading shares. The messages are similar.

Figure 6 Effect on Government Budget



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $y_{it+H} = \alpha_i^H + \sum_{s=1}^{4} \beta_s^H y_{it-s} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where y_{it} is the annual expense (% GDP), current health expenditure (% GDP), revenue (% GDP) or central government debt (% GDP) for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, U.S. recession dummy, a banking crisis dummy, and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown.

in dampening economic fluctuations and raising the average level of activity.

Figure 6 presents impulse response functions for the effect of health crises on the different components in government budget.[30] Following the shock, government expenditures increase by 0.8% of GDP. This may be due to increased transfer payments or fiscal stimulus packages to combat the crisis. Importantly, current health expenditures, defined by the World Bank as "including healthcare goods and services consumed but not including capital health expenditures such as buildings, machinery, IT and stocks of vaccines for emergency or outbreaks", increases by 0.3% of GDP following the pandemic shock. Meanwhile, government revenue falls by 0.6%, partially due to the automatic stabilizer role of

[30] Due to data availability, our sample size for this is cut to around 1,000 observations.

the tax system. Overall, the pandemic creates extra pressure on the government budget, decreasing the government surplus by around 1.4%, while central government debt increases by around 3.4% of GDP and stays there even in the recovery year.

Does an active fiscal policy aid recovery? To address this, we examine the average fiscal adjustment across episodes for affected countries. By averaging in this way, we eliminate the idiosyncratic response of affected countries in each episode. Our key indicator is a measure of countries' fiscal adjustment in the onset year: the change in government spending or revenues divided by the previous year's GDP. We separate countries into "high adjustment", defined as the 75th percentile and above, and "low adjustment", defined as the 25th percentile and below. The grouping includes both affected countries and unaffected countries. The average difference between high and low spending response countries is 0.8% of GDP. We then re-estimate the model on the separate groups and compare the impulse response functions.

Figure 7 shows the impulse response functions for real GDP growth and unemployment for high and low adjustment countries. We focus on health expenditures, which are more relevant for this investigation (Chang et al. (2019)), but results are similar for general government spending.[31] As seen in the top row of the figure, both groups experience equally large impact declines in GDP growth. However, high expenditure countries bounce back more robustly (Panel A1) than low adjustment countries (Panel A2). Those differential effects also appear in unemployment. As seen in Panel B1, the effect on unemployment in high health expenditure adjustment countries is relatively small on impact, less than 1%, and not persistent. In contrast, Panel B2 indicates that unemployment in low-adjustment countries is persistently elevated after the shock.[32]

The results above could be spurious if, for example, high adjustment countries also happen to be low severity countries, but that appears not to be the case. We calculate the correlation between a country's severity measure and its health spending adjustment, by episode, and report results in appendix Panel B of Table A6 and scatter plot of Figure C9. The underlying data are displayed in Panel A of Table A6. As can be seen, there is a slight negative correlation, insignificantly different from zero.

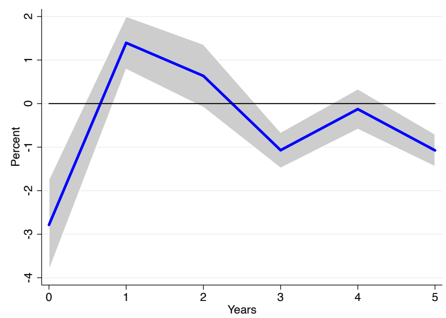
[31] Performing the same exercise based on high versus low tax revenue collection countries does not indicate significant differences. See Figure C8 in the online appendix.

[32] We are agnostic about why some countries respond more in health spending than others. Yet, a comparison in summary statistics between high and low adjustment countries suggests that high group countries have lower debt to GDP (41% vs. 60%), suggesting the possibility that greater fiscal space is a reason.

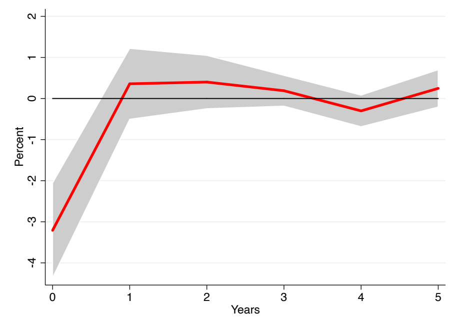
Figure 7 Effect on GDP Growth and Unemployment
Conditional on Immediate Health Spending Response

Panel A: GDP growth

A1: High Health Expenditure Response

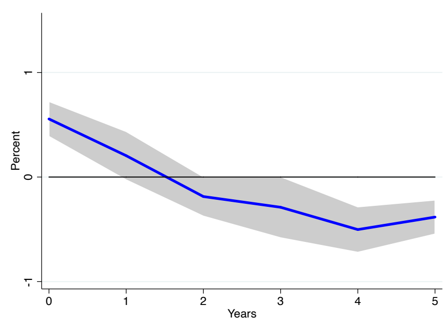


Panel A2: Low Health Expenditure Response

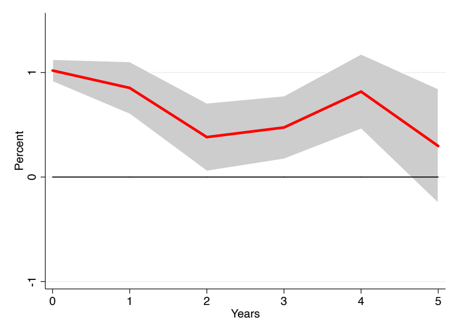


Panel B: Unemployment

Panel B1: High Health Expenditure Response



Panel B2: Low Health Expenditure Response



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $y_{it+H} = \alpha_i^H + \sum_{s=1}^{4} \beta_s^H y_{it-s} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where y_{it} is the annual real GDP growth rate or unemployment rate for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, U.S. recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown. Each row divides countries based on the average of $\frac{Z_{it}-Z_{it-1}}{\mathrm{GDP}_{it-1}}$ across all six health episodes where t is the onset year of each episode. Z refers to health expenditure. High refers to countries in the 75 percentile and above while low refers to countries in the 25 percentile and below.

7 Conclusion

We study various aspects of the economic effects of modern pandemics and epidemics, pre-Covid. We estimate that the typical health crisis lowers GDP growth in affected countries by around two percentage points in the onset year and that this effect persists for at least five years. Unemployment rises persistently too, with larger effects on females and the less educated. Furthermore, international trade plummets, and this significantly affects other countries (negatively) through trade linkages. Nevertheless, trading networks also benefit countries when there is bounce-back one year after the onset of a health crisis. We also show that fiscal policy helps to mitigate the effect of health crises. Increasing government spending, in particular on health care, significantly speeds up GDP growth recovery and reduces unemployment after the crisis.

Our paper thus forms a solid basis for evaluating Covid-19. Our GDP growth estimates imply that Covid-19 is approximately *four* standard deviations worse than the average past pandemic. Covid-19 is more widespread than the average crisis in our sample, and has a higher kill rate. Travel bans, social distancing, and economic lock downs are without parallel. In the Covid-19 world with more substantial trade linkages, the indirect trade network channel is more important than what we find for the historical episodes. The fact that today's global value chains are more prevalent suggests that countries went down, and will perhaps rebound, more sharply from Covid-19. Nevertheless, massive interventions by central banks and fiscal policymakers, of the type we find helps to speed up recovery, are now being undertaken worldwide. Restoration of robust international trade linkages remains an open question, however. Ominous signs of prolonged backlash against China appear from policymakers and in the media. The sentiment for countries not to be so reliant on imports, especially in sensitive sectors like medical supplies, may well prove an intractable foe of trade.

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Online Appendix to

‘Modern Pandemics: Recession and Recovery’

by C. Ma, and J. Rogers, and S. Zhou

March 2021

A Data Sources

Table A1 List of Global Pandemic and Epidemic Events

Announcement Time	Event Name	Affected Countries (Economies)	# of Affected Countries (in matched sample)	Total Deaths	Total Cases	Average Mortality Rate
1968/07	Hongkong Flu	ARG, AUS, CHL, DNK, FIN, FRA, GBR, GRC, HKG, ITA, JAM, JPN, NLD, NOR, PRT, SWE, USA, ZAF	18	N.A.	N.A.	N.A.
2003/02	SARS	AUS, CAN, CHE, CHN, DEU, ESP, FRA, GBR, HKG, IDN, IND, IRL, ITA, KOR, KWT, MAC, MNG, MYS, NZL, PHL, ROU, RUS, SGP, SWE, THA, USA, VNM, ZAF	28	737	7750	9.51%
2009/04	H1N1	AGO, ALB, AND, ARE, ARG, ASM, AUS, AUT, AZE, BDI, BEL, BGD, BGR, BHR, BHS, BIH, BLR, BLZ, BMU, BOL, BRA, BRB, BRN, BTN, BWA, CAN, CHE, CHL, CHN, CIV, CMR, COD, COG, COL, CPV, CRI, CUB, CYM, CYP, CZE, DEU, DMA, DNK, DOM, DZA, ECU, EGY, ESP, ETH, FIN, FJI, FRA, FSM, GAB, GBR, GEO, GHA, GRC, GRD, GTM, GUM, GUY, HND, HRV, HTI, HUN, IDN, IND, IRL, IRN, IRQ, ISL, ISR, ITA, JAM, JOR, JPN, KAZ, KEN, KHM, KIR, KNA, KOR, KWT, LAO, LBN, LBY, LCA, LIE, LKA, LSO, LUX, MAR, MDA, MDG, MDV, MEX, MHL, MKD, MLI, MLT, MMR, MNE, MNG, MOZ, MUS, MWI, MYS, NAM, NGA, NIC, NLD, NOR, NPL, NRU, NZL, OMN, PAK, PAN, PER, PHL, PLW, PNG, POL, PRI, PRT, PRY, PSE, QAT, ROU, RUS, RWA, SAU, SDN, SGP, SLB, SLV, SRB, STP, SUR, SVK, SVN, SWE, SWZ, SYC, TCD, THA, TJK, TLS, TON, TTO, TUN, TUR, TUV, TZA, UGA, URY, USA, VCT, VEN, VNM, VUT, WSM, YEM, ZAF, ZMB, ZWE	167	14390[a]	526353	2.73%
2012/03	MERS	ARE, AUT, CHN, DEU, DZA, EGY, FRA, GBR, GRC, IRN, ITA, JOR, KOR, KWT, LBN, MYS, NLD, OMN, PHL, QAT, SAU, THA, TUN, TUR, USA, YEM	26	498	1289	38.63%
2014/08[b]	Ebola	ESP, GBR, GIN, ITA, LBR, MLI, NGA, SEN, SLE, USA	10	11323	28646	39.53%
2016/02[c]	Zika	ABW, ARG, ATG, BHS, BLZ, BOL, BRA, BRB, CAN, CHL, COL, CRI, CUB, CYM, DMA, DOM, ECU, GRD, GTM, GUY, HND, HTI, JAM, KNA, LCA, NIC, PAN, PER, PRI, PRY, SLV, SUR, TCA, TTO, URY, USA, VCT, VIR	38	20	197689	0.01%

[a] This estimates are from European Center for Disease Prevention and Controls (ECDC). We use their estimates since they provide detailed coverage and mortality rate for each country. Detailed information can be found here: https://en.wikipedia.org/wiki/2009_flu_pandemic_by_country. However, the estimate from US Centers for Disease Control and Prevention (CDC) for global death troll is 284,000, about 15 times more than the number of laboratory-confirmed cases. See details in http://www.cidrap.umn.edu/news-perspective/2012/06/cdc-estimate-global-h1n1-pandemic-deaths-284000.

[b] The West African Ebola outbreak began December 26, 2013 and was declared a PHEIC August 8, 2014.

[c] The Zika virus outbreak occurred at October, 2015 but was declared a PHEIC February 1, 2016

Table A2 Details of Six Pandemic and Epidemic Events

Episodes	Vaccine/Cure	Government Response
1968 Flu	"Split vaccine" developed in 1968	The 1968 Flu spread widely as a result of international air travel, but the effects surfaced differently in different regions — the US and Canada experienced a severe initial wave with less a severe subsequent wave, while the reverse held true for Europe and Asia. In North America, where the burden of the flu was relatively small in comparison to in Europe and Asia, government relied on vaccination, hospitalization, and antibiotics to treat secondary pneumonia. Quarantines, closures, and other non-pharmaceutical means of intervention were not quite necessary to curb the disease.
SARS	No cure	Efforts to suppress SARS included isolation of symptomatic patients and rigid hospital infection control practices. The latter proved to be particularly effective in the 2003 SARS pandemic in hospitals in Hong Kong SAR, China, in which none of the health care workers wearing proper PPE ever contracted SARS. Governments mainly utilized containment measures which mirrored those used to rid of bubonic plagues — case tracking, quarantining those infected, bans on large gatherings, examination of travelers, improved PPE and barrier protection. These measures, working in tandem with travel restrictions, successfully curbed SARS likely because SARS is characterized by an insignificant asymptomatic carrier state and relatively shorter incubation periods.
H1N1	Vaccine released in October of 2009	In response to the outbreak of the Swine Flu, several countries' governments focused on restricting travel amongst infected regions. Additionally, private and public sector workers were advised to implement preventative measures, and schools were closed in areas of outbreak. China reverted to using the same measures it used to fight SARS, notably quarantining any and all persons who were possibly infected by H1N1. Moreover, many countries placed embargos on imports of pork from Mexico and the US. Airport screening was also implemented during this time. However, it has been shown that travel restrictions with regards to curbing influenza are only effective in delaying the spread and peak of the disease. Extensive travel restrictions are required to have significant impact on curbing influenza.
MERS	No available vaccine or specific treatment	The CDC collaborated with the World Health Organization, and began responding to the MERS crisis before it reached the US. Key areas of focus included epidemiology, laboratory science, travelers' health, and infection control. Another was collaboration within countries and between countries. The CDC brought about data-sharing agreements between countries and promoted global sharing of specimens and reagents to deliver an effective response to the disease.
Ebola	No known vaccine/treatment	The hardest-hit countries imposed certain measures to curb the devastation of Ebola. In general, health agencies and hospitals relied on isolation of symptomatic patients, quarantining, and bolstering of hospital infection control practices to combat Ebola. Some countries were better equipped than others to execute disease prevention —– Nigeria had experience running an emergency operations center and utilizing global positioning systems for contact tracing during previous polio eradication efforts. Ultimately, putting an end to Ebola required a multinational effort, with the World Bank's Pandemic Emergency Financing Facility (PEF) contributing US$3.8 billion to help with the costs of Ebola, and the World Bank Group pooling US$1.6 billion from the International Development Association and the International Finance Corporation to put towards economic recovery in Guinea, Liberia, and Sierra Leone.
Zika	No vaccine/specific treatment	In response to the outbreak, governments including those of the US and the UK declared travel precautions, advising pregnant women, in particular, to avoid travelling to countries affected by Zika. Control measures such as insect bite precautions and removal of possible breeding grounds for mosquitos were implemented, as well as regulatory reporting on recommendations regarding Zika and pharmaceutical intervention.

NOTE: The note relies on information mainly from Jamison et al. (2017), Mateus et al. (2014), Chang et al. (2016), Williams et al. (2015), Saunders-Hastings and Krewski (2016) and online information from https://graduateinstitute.ch/communications/news/brief-international-history-pandemics.

Table A3 Distribution of Countries and Firms

Panel A: List of Countries (ISO) from WDI (Total:210)[a]

ABW	BOL	DMA	GRD	KIR	MLT	PNG	**SVK**	VEN
AFG	**BRA**	**DNK**	GRL	KNA	MMR	**POL**	**SVN**	VGB
AGO	BRB	DOM	GTM	**KOR**	MNE	PRI	**SWE**	VIR
ALB	BRN	DZA	GUM	KWT	MNG	PRK	SWZ	VNM
AND	BTN	ECU	GUY	LAO	MOZ	**PRT**	SYC	VUT
ARE	BWA	EGY	HKG	LBN	MRT	PRY	SYR	WSM
ARG	CAF	ERI	HND	LBR	MUS	PSE	TCA	YEM
ARM	**CAN**	**ESP**	HRV	LBY	MWI	PYF	TCD	**ZAF**
ASM	**CHE**	**EST**	HTI	LCA	MYS	QAT	TGO	ZMB
ATG	**CHL**	ETH	**HUN**	LIE	NAM	**ROU**	THA	ZWE
AUS	**CHN**	**FIN**	**IDN**	LKA	NCL	**RUS**	TJK	
AUT	CIV	FJI	**IND**	LSO	NER	RWA	TKM	
AZE	CMR	**FRA**	**IRL**	**LTU**	NGA	**SAU**	TLS	
BDI	COD	FRO	IRN	**LUX**	NIC	SDN	TON	
BEL	COG	FSM	IRQ	**LVA**	**NLD**	SEN	TTO	
BEN	**COL**	GAB	**ISL**	MAC	**NOR**	SGP	TUN	
BFA	COM	**GBR**	**ISR**	MAR	NPL	SLB	**TUR**	
BGD	CPV	GEO	**ITA**	MCO	NRU	SLE	TUV	
BGR	CRI	GHA	JAM	MDA	**NZL**	SLV	TZA	
BHR	CUB	GIB	JOR	MDG	OMN	SMR	UGA	
BHS	CYM	GIN	**JPN**	MDV	PAK	SOM	UKR	
BIH	CYP	GMB	KAZ	**MEX**	PAN	SRB	URY	
BLR	**CZE**	GNB	KEN	MHL	PER	SSD	**USA**	
BLZ	**DEU**	GNQ	KGZ	MKD	PHL	STP	UZB	
BMU	DJI	**GRC**	KHM	MLI	PLW	SUR	VCT	

Panel B: Firm-level Statistics by Country

Country	# Firms	# Obs	Country	# Firms	# Obs
ARG	113	1,457	ISL	23	183
AUS	2,761	27,805	ISR	553	5,413
AUT	156	1,492	ITA	467	5,181
BEL	215	2,629	JPN	5,022	77,519
BRA	504	5,255	KOR	2,508	27,278
CAN	4,606	41,605	LUX	63	630
CHE	330	4,591	MAR	58	704
CHL	212	2,451	MEX	214	2,327
CHN	4,380	46,005	MYS	1,206	16,785
CZE	65	377	NLD	345	3,492
DEU	1,294	15,658	NOR	472	4,239
DNK	264	3,444	NZL	213	1,421
EGY	171	1,663	PHL	207	3,086
ESP	268	2,147	POL	619	5,822
FIN	242	3,265	PRT	120	1,201
FRA	1,532	16,895	RUS	916	8,730
GBR	3,800	36,462	SVK	40	251
GRC	381	5,272	SVN	47	462
HKG	1,794	14,282	SWE	973	8,948
HRV	108	1,070	THA	699	8,623
HUN	50	403	TUR	361	4,357
IDN	531	5,033	UKR	97	853
IND	3,298	33,389	ZAF	699	4,620
IRL	145	1,298			
Total	**43,142**	**466,073**			

Panel C: Firm-level Statistics by Industry

Industry (FF12)	# Obs	% Obs
Consumer NonDurables	50,477	10.83
Consumer Durables	19,080	4.09
Manufacturing	79,853	17.14
Energy	20,400	4.38
Chemicals and Allied Products	21,272	4.57
Business Equipment	63,875	13.71
Telecom	9,872	2.12
Shops	52,265	11.22
Healthcare	23,027	4.94
Other	125,952	27.02
Total	**466,073**	

[a]The countries in italics and bold have quarterly GDP data (Total:47).

Table A4 Main Variable Construction

Variable	Description	Source
Pandemics related Measures		
Health Shock	An indicator equals to one if a country is affected by six pandemics at health crisis year t and zero otherwise.	Hand Collected
Mortality Rate	The ratio of total deaths to total affected cases (in percent) for each affected countries at health crisis year t and zero for those unaffected countries.	Hand Collected
Cases/Pop	The ratio of total affected cases to national population (10 thousand) for each affected countries at health crisis year t and zero for unaffected countries.	Hand Collected
Country Level Measures		
GDP Growth Rate (WDI)	Annual percentage growth rate of GDP based on constant local currency.	WDI
Unemployment Rate	The share of the labor force that is without work but available for and seeking employment (International Labour Organization Estimate).	WDI
Tax Revenue (% GDP)	Ratio of tax revenue divided by GDP. Tax revenue refers to compulsory transfers to the central government for public purposes. Certain compulsory transfers such as fines, penalties, and most social security contributions are excluded.	WDI
Expense (% GDP)	Ratio of expense divided by GDP. Expense is cash payments for operating activities of the government in providing goods and services. It includes compensation of employees (such as wages and salaries), interest and subsidies, grants, social benefits, and other expenses such as rent and dividends.	WDI
Current Health Expenditure (% GDP)	Ratio of current health expenditure divided by GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year. This indicator does not include capital health expenditures such as buildings, machinery, IT and shocks of vaccines for emergency or outbreaks.	WDI
Central Government Debt (% GDP)	Ratio of debt divided by GDP. Debt is the entire stock of direct government fixed-term contractual obligations to other outstanding on particular date. It includes domestic and foreign liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government.	WDI
GDP Consensus Forecast	Consensus forecasts of percentage growth rate of GDP at year t based on the end of year t-1.	Consensus Economics Inc.
Trade/GDP	The sum of exports and imports of goods and services measured as a share of GDP at year t.	WDI
Domestic Credit/GDP	Domestic credit to private sector by banks measured a share of GDP at year t.	WDI
Log(Population)	The natural logarithm of total population based on the de facto definition of population at year t.	WDI
Log(GDP per capita)	The natural logarithm of GDP per capita (measured as GDP divided by midyear population) in constant 2010 U.S. dollar at year t.	WDI
Recession Dummy	An indicator equals to one if year t is within the contractions of U.S. business cycle and zero for the expansions.	NBER
Banking Crisis Dummy	An indicator equals to one if a country at year t is identified as systematic banking crisis and zero otherwise.	Laeven and Valencia (2013)
Quarterly GDP Growth Rate	Quarterly percentage gorwth rate of GDP (seasonal adjusted) based on same quarter at year t-1 (YoY change).	OECD National Accounts Statistics
GDP Growth Rate (PWT)	Change of Log Real GDP at constant 2017 national prices (in mil. 2017US$).	PWT10.0
Physical Capital Growth Rate	Change of Log Capital stock at constant 2017 national prices (in mil. 2017US$).	PWT10.0
Human Capital Growth Rate	Change of Log Human capital index, based on years of schooling and returns to education.	PWT10.0
TFP Growth Rate	Change of Log TFP at constant national prices (2017=1).	PWT10.0
Firm Level Measures		
Sales Growth	The Sales Growth in thousands of dollars (Worldscope item 01001).	Worldscope
Wage	Change of average staff costs in thousands of dollars (Worldscope item 01084) divided by the number of employees (Worldscope item 07011).	Worldscope
Investment	Change of capital expenditures (Worldscope item 04601) divided by assets (Worldscope item 02999).	Worldscope
Profitibility	Change of Earnigs before Interest and Taxes (EBIT, Worldscope item 18191) divided by assets (Worldscope item 02999).	
Leverage	Change of Long-term debt (Worldscope item 03251) divided by assets (Worldscope item 02999).	Worldscope
Log(Labor)	The natural logarithm of the number of empolyee (Worldscope item 07011).	Worldscope
Size	Logarithmic value of total assets in dollar (Worldscope item 02999).	Worldscope
Cash Flow	EBIT plus Interest and Taxes (EBITDA, Worldscope item 18198) minus interest expense (Worldscope item 01251) and income taxes (Worldscope item 01451) divided by book value of assets at beginning year (Worldscope item 02999).	Worldscope
Tobin's Q	Assets (Worldscope item 02999) plus market value of equity (Worldscope item 08001) minus book value of equity (Worldscope item 03501) divided by total assets.	Worldscope
Cash	Cash holdings (Worldscope item 02001) divided by assets (Worldscope item 02999).	Worldscope

Table A5 Summary Statistics

Panel A: Country-level Summary Statistics						
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Obs	Mean	Median	Std	P25	P75
GDP Growth Rate (WDI)	9,211	3.79	3.84	4.40	1.44	6.25
Unemployment Rate	5,208	8.19	6.65	6.32	11.16	3.59
Tax Revenue (% GDP)	2,780	23.11	22.23	9.28	15.93	28.99
Expense (% GDP)	2,941	22.47	21.93	9.27	15.68	27.35
Current Health Expenditure (% GDP)	3,470	6.18	5.78	2.50	4.30	7.90
Central Government Debt (% GDP)	1,254	53.09	47.87	32.34	29.44	68.75
GDP Consensus Forecast	644	2.53	2.40	2.08	1.51	3.36
Trade/GDP	8,208	75.89	67.46	43.28	44.83	97.49
Domestic Credit/GDP	7,673	33.78	23.78	30.25	12.44	46.02
Log(Population)	12,279	14.87	15.29	2.27	13.34	16.42
Log(GDP per capita)	9,211	8.33	8.23	1.47	7.19	9.55
Recession Dummy	12,600	0.27	0.00	0.44	0.00	1.00
Banking Crisis Dummy	12,600	0.01	0.00	0.11	0.00	0.00
Quarterly GDP Growth Rate	7,876	3.33	3.24	3.51	1.49	5.22
GDP Growth Rate (PWT)	8,784	3.77	3.92	4.66	1.55	6.34
Physical Capital Growth Rate	7,307	0.92	0.83	0.60	0.53	1.24
Human Capital Growth Rate	8,785	4.25	3.77	3.20	1.97	6.04
TFP Growth Rate	5,414	0.25	0.48	3.70	-1.36	2.19

Panel B: Firm-level Summary Statistics						
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Obs	Mean	Median	Std	P25	P75
Dependent Variables						
Sales Growth (%)	400,139	18.98	5.95	80.46	-4.92	20.75
Wage	167,370	0.15	0.00	1.55	0.00	0.01
Investment (%)	395,068	-0.76	-0.06	10.54	-1.80	1.20
Profitibility (%)	402,011	-0.38	-0.19	27.53	-4.32	3.19
Leverage (%)	407,728	-0.02	0.00	7.46	-1.82	1.03
Log(Labor)	323,538	6.64	6.67	2.00	5.44	7.91
Firm-level Controls						
Size	465,796	18.57	18.64	2.30	17.25	19.98
Cash Flow	360,402	0.07	0.07	0.14	0.03	0.12
Tobin's Q	424,376	1.94	1.20	2.55	0.92	1.88
Cash	464,967	0.24	0.12	0.41	0.04	0.26

Table A6 Disease Severity and Health Expenditure Response Dummy

Panel A: Disease Severity and Health Expenditure Response Dummy

		1968Flu			SARS			H1N1			MERS			Ebola			Zika		
Country Name	Country Code	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure
Aruba	ABW	0	0	N.A.	0	0	N.A.	1	3	N.A.	0	0	N.A.	0	0	N.A.	1	2	N.A.
Afghanistan	AFG	0	0	N.A.	0	0	2	2	2	2	0	0	2	0	0	2	0	0	2
Angola	AGO	0	0	N.A.	0	0	2	1	1	1	0	0	1	0	0	1	0	0	2
Albania	ALB	0	0	N.A.	0	0	2	3	1	1	0	0	1	0	0	2	0	0	1
Andorra	AND	0	0	N.A.	0	0	2	0	1	1	0	0	1	0	0	1	0	0	2
United Arab	ARE	0	0	N.A.	0	0	1	3	1	1	2	3	1	0	0	1	0	0	1
Argentina	ARG	1	1	N.A.	0	0	2	3	3	2	0	0	2	0	0	2	1	1	2
Armenia	ARM	0	0	N.A.	0	0	2	0	0	1	0	0	2	0	0	2	0	0	1
American Sam	ASM	0	0	N.A.	0	0	N.A.	1	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Antigua and	ATG	0	0	N.A.	0	0	1	1	2	1	0	0	1	0	0	2	1	2	1
Australia	AUS	3	3	N.A.	1	2	1	2	3	2	0	0	2	0	0	2	0	0	1
Austria	AUT	0	0	N.A.	0	0	1	1	2	1	1	2	2	0	0	1	0	0	2
Azerbaijan	AZE	0	0	N.A.	0	0	2	3	1	2	0	0	2	0	0	2	0	0	2
Burundi	BDI	0	0	N.A.	0	0	1	1	1	2	0	0	1	0	0	1	0	0	2
Belgium	BEL	0	0	N.A.	0	0	2	1	1	2	0	0	1	0	0	1	0	0	1
Benin	BEN	0	0	N.A.	0	0	1	0	0	1	0	0	2	0	0	1	0	0	1
Burkina Faso	BFA	0	0	N.A.	0	0	1	0	0	2	0	0	1	0	0	1	0	0	2
Bangladesh	BGD	0	0	N.A.	0	0	1	2	1	1	0	0	1	0	0	1	0	0	1
Bulgaria	BGR	0	0	N.A.	0	0	2	3	1	1	0	0	2	0	0	2	0	0	2
Bahrain	BHR	0	0	N.A.	0	0	2	2	3	1	0	0	2	0	0	1	0	0	1
Bahamas, The	BHS	0	0	N.A.	0	0	1	3	2	1	0	0	1	0	0	1	1	2	2
Bosnia and H	BIH	0	0	N.A.	0	0	2	3	2	1	0	0	1	0	0	1	0	0	1
Belarus	BLR	0	0	N.A.	0	0	2	0	0	1	0	0	2	0	0	2	0	0	2
Belize	BLZ	0	0	N.A.	0	0	2	1	2	2	0	0	1	0	0	1	1	2	2
Bermuda	BMU	0	0	N.A.	0	0	N.A.	3	2	N.A.	0	0	N.A.	0	0	N.A.	1	2	N.A.
Bolivia	BOL	0	0	N.A.	0	0	2	2	3	2	0	0	2	0	0	2	1	1	2
Brazil	BRA	0	0	N.A.	0	0	2	3	2	2	0	0	2	0	0	2	3	3	2
Barbados	BRB	0	0	N.A.	0	0	2	2	3	1	0	0	2	0	0	1	1	2	1
Brunei Darus	BRN	0	0	N.A.	0	0	1	2	3	1	0	0	1	0	0	1	0	0	1
Bhutan	BTN	0	0	N.A.	0	0	1	1	1	2	0	0	2	0	0	1	0	0	1
Botswana	BWA	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	2
Central Afri	CAF	0	0	N.A.	0	0	1	0	0	2	0	0	2	0	0	2	0	0	1
Canada	CAN	0	0	N.A.	3	3	2	3	3	2	0	0	1	0	0	1	1	1	1
Switzerland	CHE	3	3	N.A.	1	2	1	2	2	1	0	0	1	0	0	1	0	0	2
Chile	CHL	3	3	N.A.	0	0	2	2	3	2	0	0	2	0	0	2	1	1	2
China	CHN	0	0	N.A.	2	3	2	2	2	2	1	1	2	0	0	2	0	0	2
Cote d'Ivoir	CIV	0	0	N.A.	0	0	1	1	1	1	0	0	2	0	0	2	0	0	1
Cameroon	CMR	0	0	N.A.	0	0	1	1	1	1	0	0	2	0	0	2	0	0	1
Congo, Dem.	COD	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	1
Congo, Rep.	COG	0	0	N.A.	0	0	1	1	1	1	0	0	2	0	0	1	0	0	2
Colombia	COL	0	0	N.A.	0	0	2	3	2	2	0	0	1	0	0	1	1	2	1
Comoros	COM	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1
Cabo Verde	CPV	0	0	N.A.	0	0	1	1	2	1	0	0	2	0	0	1	0	0	1
Costa Rica	CRI	0	0	N.A.	0	0	2	2	3	2	0	0	1	0	0	2	1	2	1
Cuba	CUB	0	0	N.A.	0	0	1	3	2	2	0	0	1	0	0	2	1	1	1
Cayman Islan	CYM	0	0	N.A.	0	0	N.A.	2	3	N.A.	0	0	N.A.	0	0	N.A.	1	3	N.A.
Cyprus	CYP	0	0	N.A.	0	0	1	1	3	1	0	0	1	0	0	1	0	0	2
Czech Republ	CZE	0	0	N.A.	0	0	2	3	2	2	0	0	1	0	0	1	0	0	1
Germany	DEU	3	3	N.A.	1	2	1	2	3	2	2	2	1	0	0	2	0	0	2
Djibouti	DJI	0	0	N.A.	0	0	N.A.	1	1	N.A.	0	0	N.A.	0	0	1	0	0	1
Dominica	DMA	0	0	N.A.	0	0	1	1	3	2	0	0	1	0	0	1	1	3	1
Denmark	DNK	3	3	N.A.	0	0	1	1	2	2	0	0	1	0	0	1	0	0	2
Dominican Re	DOM	0	0	N.A.	0	0	2	3	2	2	0	0	2	0	0	2	1	1	2

Disease Severity and Health Expenditure Response Dummy (Cont.)

Country Name	Country Code	1968Flu			SARS			H1N1			MERS			Ebola			Zika		
		Mortality Rate	Case/Pop	Health Expendi- ture	Mortality Rate	Case/Pop	Health Expendi- ture	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure	Mortality Rate	Case/Pop	Health Expenditure
Algeria	DZA	0	0	N.A.	0	0	1	3	1	2	2	2	2	0	0	2	0	0	1
Ecuador	ECU	0	0	N.A.	0	0	2	3	2	2	0	0	2	0	0	2	1	2	1
Egypt, Arab	EGY	0	0	N.A.	0	0	1	2	2	2	1	1	2	0	0	2	0	0	2
Eritrea	ERI	0	0	N.A.	0	0	2	0	0	2	0	0	N.A.	0	0	N.A.	0	0	N.A.
Spain	ESP	0	0	N.A.	1	1	2	2	2	1	0	0	1	1	2	1	0	0	1
Estonia	EST	0	0	N.A.	0	0	2	3	2	1	0	0	1	0	0	2	0	0	2
Ethiopia	ETH	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	2
Finland	FIN	1	1	N.A.	0	0	1	1	2	1	0	0	2	0	0	1	0	0	1
Fiji	FJI	0	0	N.A.	0	0	1	1	3	1	0	0	1	0	0	2	0	0	1
France	FRA	2	2	N.A.	3	2	1	3	1	1	2	1	1	0	0	1	0	0	1
Faroe Island	FRO	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Micronesia,	FSM	0	0	N.A.	0	0	2	1	3	2	0	0	1	0	0	1	0	0	2
Gabon	GAB	0	0	N.A.	0	0	1	1	1	1	0	0	1	0	0	1	0	0	2
United Kingd	GBR	3	3	N.A.	1	1	2	2	3	2	3	2	1	1	1	1	0	0	1
Georgia	GEO	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
Ghana	GHA	0	0	N.A.	0	0	2	2	1	2	0	0	2	0	0	2	0	0	1
Gibraltar	GIB	0	0	N.A.	0	0	N.A.	1	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Guinea	GIN	0	0	N.A.	0	0	1	0	0	1	0	0	1	3	3	2	0	0	2
Gambia, The	GMB	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	1	0	0	1
Guinea-Bissa	GNB	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	2	0	0	1
Equatorial G	GNQ	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1
Greece	GRC	2	2	N.A.	0	0	2	3	2	1	3	2	1	0	0	1	0	0	1
Grenada	GRD	0	0	N.A.	0	0	1	1	2	1	0	0	1	0	0	1	1	3	2
Greenland	GRL	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Guatemala	GTM	0	0	N.A.	0	0	2	2	2	1	0	0	1	0	0	2	1	2	2
Guam	GUM	0	0	N.A.	0	0	N.A.	2	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Guyana	GUY	0	0	N.A.	0	0	1	1	2	2	0	0	2	0	0	1	1	2	1
Hong Kong SA	HKG	1	1	N.A.	3	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Honduras	HND	0	0	N.A.	0	0	2	2	2	2	0	0	2	0	0	2	1	1	2
Croatia	HRV	0	0	N.A.	0	0	2	2	3	1	0	0	1	0	0	1	0	0	1
Haiti	HTI	0	0	N.A.	0	0	2	1	1	2	0	0	1	0	0	2	1	1	2
Hungary	HUN	3	3	N.A.	0	0	2	3	2	1	0	0	1	0	0	1	0	0	2
Indonesia	IDN	0	0	N.A.	1	1	1	2	1	1	0	0	1	0	0	2	0	0	1
India	IND	0	0	N.A.	1	1	1	3	2	2	0	0	2	0	0	1	0	0	2
Ireland	IRL	0	0	N.A.	1	2	2	2	3	1	0	0	1	0	0	1	0	0	1
Iran, Islami	IRN	0	0	N.A.	0	0	2	2	2	2	2	2	2	0	0	N.A.	0	0	N.A.
Iraq	IRQ	0	0	N.A.	0	0	N.A.	2	2	1	0	0	1	0	0	1	0	0	1
Iceland	ISL	0	0	N.A.	0	0	2	2	3	2	0	0	1	0	0	2	0	0	2
Israel	ISR	0	0	N.A.	0	0	1	3	3	1	0	0	2	0	0	2	0	0	1
Italy	ITA	2	2	N.A.	1	1	1	2	2	1	1	1	1	1	1	1	0	0	1
Jamaica	JAM	1	1	N.A.	0	0	1	3	2	1	0	0	1	0	0	1	1	2	2
Jordan	JOR	0	0	N.A.	0	0	1	2	3	2	2	3	1	0	0	2	0	0	1
Japan	JPN	3	3	N.A.	0	0	1	2	2	1	0	0	1	0	0	1	0	0	1
Kazakhstan	KAZ	0	0	N.A.	0	0	2	0	1	2	0	0	2	0	0	1	0	0	2
Kenya	KEN	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	1
Kyrgyz Repub	KGZ	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	2	0	0	1
Cambodia	KHM	0	0	N.A.	0	0	1	3	1	2	0	0	1	0	0	1	0	0	2
Kiribati	KIR	0	0	N.A.	0	0	1	1	2	1	0	0	1	0	0	2	0	0	2
St. Kitts an	KNA	0	0	N.A.	0	0	1	3	2	1	0	0	1	0	0	2	1	3	2
Korea, Rep.	KOR	0	0	N.A.	1	1	2	3	2	2	2	3	1	0	0	2	0	0	2
Kuwait	KWT	0	0	N.A.	1	2	1	2	3	2	2	3	1	0	0	2	0	0	1
Lao PDR	LAO	0	0	N.A.	0	0	2	2	2	2	0	0	2	0	0	1	0	0	1
Lebanon	LBN	0	0	N.A.	0	0	1	2	3	2	1	2	2	0	0	2	0	0	2

Disease Severity and Health Expenditure Response Dummy (Cont.)

Country Name	Country Code	1968Flu Mortality Rate	1968Flu Case/Pop	1968Flu Health Expendi-ture	SARS Mortality Rate	SARS Case/Pop	SARS Health Expendi-ture	H1N1 Mortality Rate	H1N1 Case/Pop	H1N1 Health Expenditure	MERS Mortality Rate	MERS Case/Pop	MERS Health Expenditure	Ebola Mortality Rate	Ebola Case/Pop	Ebola Health Expenditure	Zika Mortality Rate	Zika Case/Pop	Zika Health Expenditure
Liberia	LBR	0	0	N.A.	0	0	1	0	0	2	0	0	2	3	3	2	0	0	1
Libya	LBY	0	0	N.A.	0	0	1	2	2	2	0	0	N.A.	0	0	N.A.	0	0	N.A.
St. Lucia	LCA	0	0	N.A.	0	0	1	2	3	1	0	0	1	0	0	1	1	2	1
Liechtenstei	LIE	0	0	N.A.	0	0	N.A.	0	2	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Sri Lanka	LKA	0	0	N.A.	0	0	1	3	2	2	0	0	1	0	0	1	0	0	2
Lesotho	LSO	0	0	N.A.	0	0	1	1	2	2	0	0	2	0	0	2	0	0	1
Lithuania	LTU	0	0	N.A.	0	0	2	3	1	1	0	0	1	0	0	1	0	0	2
Luxembourg	LUX	0	0	N.A.	0	0	1	2	3	2	0	0	2	0	0	1	0	0	1
Latvia	LVA	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	1	0	0	2
Macao SAR, C	MAC	0	0	N.A.	1	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Morocco	MAR	0	0	N.A.	0	0	1	2	2	2	0	0	1	0	0	1	0	0	2
Monaco	MCO	0	0	N.A.	0	0	1	0	2	1	0	0	1	0	0	1	0	0	1
Moldova	MDA	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	2	0	0	1
Madagascar	MDG	0	0	N.A.	0	0	1	2	2	1	0	0	1	0	0	2	0	0	2
Maldives	MDV	0	0	N.A.	0	0	1	2	2	1	0	0	2	0	0	2	0	0	2
Mexico	MEX	0	0	N.A.	0	0	2	2	3	1	0	0	2	0	0	1	0	0	1
Marshall Isl	MHL	0	0	N.A.	0	0	1	2	3	1	0	0	2	0	0	1	0	0	2
North Macedo	MKD	0	0	N.A.	0	0	1	3	1	1	0	0	1	0	0	1	0	0	2
Mali	MLI	0	0	N.A.	0	0	1	1	1	1	0	0	2	3	2	1	0	0	1
Malta	MLT	0	0	N.A.	0	0	1	2	3	1	0	0	2	0	0	2	0	0	2
Myanmar	MMR	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	2
Montenegro	MNE	0	0	N.A.	0	0	N.A.	3	2	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Mongolia	MNG	0	0	N.A.	1	3	1	2	3	1	0	0	2	0	0	2	0	0	1
Mozambique	MOZ	0	0	N.A.	0	0	2	2	1	2	0	0	2	0	0	2	0	0	2
Mauritania	MRT	0	0	N.A.	0	0	2	0	0	1	0	0	1	0	0	2	0	0	1
Mauritius	MUS	0	0	N.A.	0	0	1	3	2	1	0	0	1	0	0	2	0	0	1
Malawi	MWI	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	2	0	0	2
Malaysia	MYS	0	0	N.A.	3	2	1	3	2	1	3	2	1	0	0	2	0	0	1
Namibia	NAM	0	0	N.A.	0	0	2	2	2	1	0	0	2	0	0	2	0	0	1
New Caledoni	NCL	0	0	N.A.	0	0	N.A.	2	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Niger	NER	0	0	N.A.	0	0	1	0	0	2	0	0	1	0	0	1	0	0	1
Nigeria	NGA	0	0	N.A.	0	0	2	3	1	1	0	0	2	2	2	1	0	0	1
Nicaragua	NIC	0	0	N.A.	0	0	1	2	3	2	0	0	2	0	0	2	1	2	2
Netherlands	NLD	3	3	N.A.	0	0	2	3	2	1	1	2	1	0	0	1	0	0	1
Norway	NOR	3	3	N.A.	0	0	2	2	3	2	0	0	2	0	0	2	0	0	1
Nepal	NPL	0	0	N.A.	0	0	1	2	1	2	0	0	2	0	0	2	0	0	2
Nauru	NRU	0	0	N.A.	0	0	N.A.	1	3	1	0	0	2	0	0	2	0	0	2
New Zealand	NZL	0	0	N.A.	1	2	1	2	3	2	0	0	1	0	0	2	0	0	2
Oman	OMN	0	0	N.A.	0	0	1	2	3	1	2	3	1	0	0	2	0	0	1
Pakistan	PAK	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	2	0	0	1
Panama	PAN	0	0	N.A.	0	0	1	2	2	2	0	0	2	0	0	2	1	2	2
Peru	PER	0	0	N.A.	0	0	1	2	3	2	0	0	2	0	0	1	1	1	2
Philippines	PHL	0	0	N.A.	3	2	2	2	2	2	1	1	2	0	0	1	0	0	2
Palau	PLW	0	0	N.A.	0	0	1	1	3	1	0	0	2	0	0	2	0	0	2
Papua New Gu	PNG	0	0	N.A.	0	0	1	1	1	1	0	0	2	0	0	2	0	0	1
Poland	POL	0	0	N.A.	0	0	1	3	1	2	0	0	1	0	0	1	0	0	2
Puerto Rico	PRI	0	0	N.A.	0	0	N.A.	0	1	N.A.	0	0	N.A.	0	0	N.A.	3	3	N.A.
Korea, Dem.	PRK	0	0	N.A.	0	0	N.A.	1	1	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Portugal	PRT	2	2	N.A.	0	0	1	1	3	1	0	0	1	0	0	1	0	0	2
Paraguay	PRY	0	0	N.A.	0	0	2	3	2	2	0	0	2	0	0	2	1	1	2
West Bank an	PSE	0	0	N.A.	0	0	N.A.	2	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
French Polyn	PYF	0	0	N.A.	0	0	N.A.	2	3	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Qatar	QAT	0	0	N.A.	0	0	2	3	1	1	2	3	1	0	0	2	0	0	1

Disease Severity and Health Expenditure Response Dummy (Cont.)

Country Name	Country Code	1968Flu Mortality Rate	1968Flu Case/Pop	1968Flu Health Expenditure	SARS Mortality Rate	SARS Case/Pop	SARS Health Expenditure	H1N1 Mortality Rate	H1N1 Case/Pop	H1N1 Health Expenditure	MERS Mortality Rate	MERS Case/Pop	MERS Health Expenditure	Ebola Mortality Rate	Ebola Case/Pop	Ebola Health Expenditure	Zika Mortality Rate	Zika Case/Pop	Zika Health Expenditure
Romania	ROU	1	1	N.A.	1	1	2	2	2	1	0	0	1	0	0	1	0	0	2
Russian Fede	RUS	0	0	N.A.	1	1	2	2	1	1	0	0	2	0	0	2	0	0	1
Rwanda	RWA	0	0	N.A.	0	0	2	1	2	2	0	0	2	0	0	1	0	0	2
Saudi Arabia	SAU	0	0	N.A.	0	0	1	2	3	2	2	3	2	0	0	2	0	0	1
Sudan	SDN	0	0	N.A.	0	0	2	3	1	2	0	0	2	0	0	2	0	0	1
Senegal	SEN	0	0	N.A.	0	0	2	0	0	1	0	0	2	1	2	1	0	0	1
Singapore	SGP	0	0	N.A.	3	3	1	2	3	1	0	0	1	0	0	1	0	0	2
Solomon Isla	SLB	0	0	N.A.	0	0	2	3	1	1	0	0	1	0	0	2	0	0	1
Sierra Leone	SLE	0	0	N.A.	0	0	2	0	0	2	0	0	1	2	3	2	0	0	1
El Salvador	SLV	0	0	N.A.	0	0	1	3	2	1	0	0	1	0	0	1	1	1	1
San Marino	SMR	0	0	N.A.	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1
Somalia	SOM	0	0	N.A.	0	0	N.A.	1	1	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Serbia	SRB	2	2	N.A.	0	0	2	3	2	1	0	0	2	0	0	1	0	0	1
South Sudan	SSD	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Sao Tome and	STP	0	0	N.A.	0	0	2	3	3	2	0	0	2	0	0	1	0	0	2
Suriname	SUR	0	0	N.A.	0	0	2	2	2	2	0	0	2	0	0	1	3	3	2
Slovak Repub	SVK	0	0	N.A.	0	0	1	3	2	1	0	0	2	0	0	1	0	0	1
Slovenia	SVN	0	0	N.A.	0	0	2	3	2	1	0	0	1	0	0	1	0	0	1
Sweden	SWE	1	1	N.A.	1	3	1	2	2	1	0	0	1	0	0	2	0	0	1
Eswatini	SWZ	0	0	N.A.	0	0	2	1	1	2	0	0	1	0	0	2	0	0	2
Seychelles	SYC	0	0	N.A.	0	0	1	1	3	2	0	0	2	0	0	1	0	0	2
Syrian Arab	SYR	0	0	N.A.	0	0	2	3	2	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.
Turks and Ca	TCA	0	0	N.A.	0	0	N.A.	0	3	N.A.	0	0	N.A.	0	0	N.A.	1	3	N.A.
Chad	TCD	0	0	N.A.	0	0	1	1	1	1	0	0	1	0	0	1	0	0	1
Togo	TGO	0	0	N.A.	0	0	1	0	0	2	0	0	2	0	0	2	0	0	2
Thailand	THA	0	0	N.A.	3	2	1	2	3	1	1	1	1	0	0	1	0	0	1
Tajikistan	TJK	0	0	N.A.	0	0	2	0	1	2	0	0	2	0	0	2	0	0	2
Turkmenistan	TKM	0	0	N.A.	0	0	2	0	0	1	0	0	2	0	0	2	0	0	2
Timor-Leste	TLS	0	0	N.A.	0	0	1	0	1	1	0	0	1	0	0	1	0	0	1
Tonga	TON	0	0	N.A.	0	0	1	3	2	1	0	0	2	0	0	2	0	0	2
Trinidad and	TTO	0	0	N.A.	0	0	2	2	2	1	0	0	1	0	0	1	1	3	1
Tunisia	TUN	0	0	N.A.	0	0	1	2	2	2	2	2	2	0	0	2	0	0	1
Turkey	TUR	0	0	N.A.	0	0	2	3	1	1	3	1	1	0	0	2	0	0	2
Tuvalu	TUV	0	0	N.A.	0	0	2	1	3	2	0	0	1	0	0	2	0	0	2
Tanzania	TZA	0	0	N.A.	0	0	2	2	1	1	0	0	2	0	0	1	0	0	2
Uganda	UGA	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	1	0	0	1
Ukraine	UKR	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	1	0	0	2
Uruguay	URY	0	0	N.A.	0	0	2	3	2	2	0	0	2	0	0	2	1	1	2
United State	USA	3	3	N.A.	1	2	2	3	2	2	1	1	2	2	1	2	1	1	2
Uzbekistan	UZB	0	0	N.A.	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
St. Vincent	VCT	0	0	N.A.	0	0	1	1	2	1	0	0	1	0	0	1	1	3	1
Venezuela, R	VEN	0	0	N.A.	0	0	2	3	2	2	0	0	1	0	0	2	1	2	2
British Virg	VGB	0	0	N.A.	0	0	N.A.	1	2	N.A.	0	0	N.A.	0	0	N.A.	1	3	N.A.
Virgin Islan	VIR	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	0	0	N.A.	1	3	N.A.
Vietnam	VNM	0	0	N.A.	2	3	2	3	1	2	0	0	2	0	0	1	0	0	2
Vanuatu	VUT	0	0	N.A.	0	0	1	1	1	1	0	0	1	0	0	1	0	0	1
Samoa	WSM	0	0	N.A.	0	0	1	2	3	2	0	0	1	0	0	1	0	0	2
Yemen, Rep.	YEM	0	0	N.A.	0	0	2	2	2	1	3	2	2	0	0	1	0	0	N.A.
South Africa	ZAF	3	3	N.A.	3	1	2	2	3	2	0	0	2	0	0	2	0	0	2
Zambia	ZMB	0	0	N.A.	0	0	2	1	1	2	0	0	2	0	0	1	0	0	2
Zimbabwe	ZWE	0	0	N.A.	0	0	N.A.	1	1	N.A.	0	0	1	0	0	2	0	0	2

Panel B: Correlation between Disease Severity and Health Expenditure Adjustment

	1968Flu Mortality Rate	1968Flu Case/Pop	SARS Mortality Rate	SARS Case/Pop	H1N1 Mortality Rate	H1N1 Case/Pop	MERS Mortality Rate	MERS Case/Pop	Ebola Mortality Rate	Ebola Case/Pop	Zika Mortality Rate	Zika Case/Pop
Health Spending Adjustment	N.A.	N.A.	-0.0003	-0.1219	-0.0893	-0.0502	-0.119	-0.0282	0.1036	0.6779	-0.0128	-0.1313
Significance	N.A.	N.A.	0.9986	0.5529	0.2706	0.5297	0.5626	0.8911	0.7757	0.0312	0.9425	0.459
Obs	N.A.	N.A.	26	26	154	159	26	26	10	10	34	34

NOTE: Panel A depicts the severity dummy and health expenditures adjustment dummy, by country and within each disease episode. For the former, we use either mortality rate or case-to-population rate. 0 means unaffected. For the 1968 Flu, 1, 2 and 3 means isolated, regional and widespread. For the health expenditures adjustment dummy, we divide countries into three groups based on the change in health expenditure in the crisis onset year, normalized by the previous year's GDP. Panel B reports the cross-country correlation between health spending adjustment and the severity measure (mortality rate or cases rate) for each episode in affected countries.

B Tables

B1 Regression Tables for Annual GDP Growth

Table B1 Pre-trend Analysis

	GDP growth rate %		
	(1)	(2)	(3)
Sample Period:	1960-2019	1960-2019	1960-2019
Shock (-1)	-0.05	-0.04	-0.11
	(0.35)	(0.39)	(0.45)
Shock	-2.30**	-2.35*	-2.40**
	(1.14)	(1.15)	(1.12)
Shock (+1)	0.62***	0.73**	0.75**
	(0.23)	(0.30)	(0.32)
Shock (+2)	0.47***	0.58***	0.52**
	(0.12)	(0.17)	(0.22)
Health Expenditure (Lagged)			0.17
			(0.11)
Trade/GDP	2.45***	2.27***	3.52***
	(0.31)	(0.52)	(0.44)
Domestic Credit/GDP	-3.50***	-5.53***	-7.11***
	(0.59)	(0.73)	(1.45)
Log(Population)	-0.14	0.46	1.28
	(0.67)	(1.20)	(2.10)
Log(GDP per capita)	0.82**	2.96***	3.94***
	(0.40)	(0.99)	(1.19)
Recession	-0.38*	-0.50	-0.85*
	(0.22)	(0.31)	(0.41)
Banking Crisis	-1.09**	-0.96**	-1.41
	(0.42)	(0.41)	(1.13)
Constant	-0.66	-26.99	-49.57
	(12.29)	(25.16)	(39.13)
Observations	6130	4049	2639
Within R^2	0.07	0.09	0.16
Decade FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

NOTE: This table estimates a panel regression with four dummy variables that flags one year before the health crises, the onset year, one year after and two years after the health crises. We also add a lagged health expenditure (% GDP) as a control in column (3). *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B2 The Effect of Health Crises on GDP Growth, by Crisis

	GDP growth rate %			
	(1)	(2)	(3)	(4)
Sample Period:	1960-2019	1990-2019		
	All Events	All Events		Without H1N1
EBOLA	0.97***	0.59	-0.27	-0.32
	(0.33)	(0.38)	(0.39)	(0.40)
H1N1	-3.92***	-3.93***	-5.11***	
	(0.50)	(0.50)	(0.33)	
MERS	-1.25***	-0.88**	-1.40***	-1.30***
	(0.28)	(0.34)	(0.38)	(0.38)
SARS	0.11	0.11	-0.85**	-0.88**
	(0.48)	(0.41)	(0.32)	(0.32)
Zika	-0.21	-0.23	-1.98***	-2.00***
	(0.25)	(0.30)	(0.33)	(0.32)
Hkflu	0.41			
	(0.41)			
Consensus Forecast			0.51***	0.61***
			(0.13)	(0.14)
Trade/GDP	2.40***	2.23***	2.90***	2.70***
	(0.31)	(0.48)	(0.87)	(0.72)
Domestic Credit/GDP	-3.36***	-5.17***	-2.73*	-2.34
	(0.56)	(0.66)	(1.49)	(1.44)
Log(Population)	-0.02	0.42	2.94*	3.01*
	(0.63)	(1.11)	(1.64)	(1.57)
Log(GDP per capita)	0.82**	2.82***	-0.49	-0.59
	(0.38)	(0.92)	(1.55)	(1.54)
Recession	-0.22	-0.25	0.23	0.29
	(0.19)	(0.21)	(0.22)	(0.22)
Banking Crisis	-1.13***	-1.05**	-0.17	-0.23
	(0.41)	(0.40)	(0.47)	(0.46)
Constant	-2.58	-25.40	-42.52	-43.08
	(11.57)	(23.44)	(36.12)	(34.88)
Observations	6300	4177	511	484
Within R^2	0.07	0.10	0.29	0.21
Decade FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real annual GDP growth. The sample period for column (1) is 1960-2019 while the sample period for columns (2)-(4) is 1990-2019. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B3 The Effect of Health Crises on Real GDP Growth: Weighted by Disease Severity

	GDP growth rate %					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1960-2019	1990-2019		1960-2019	1990-2019	
Mortality Rate	-3.11*	-2.99*	-5.61***			
	(1.57)	(1.56)	(1.47)			
Cases/Pop				-2.94***	-2.89***	-4.62***
				(0.96)	(0.89)	(0.86)
Consensus Forecast			0.49***			0.54***
			(0.14)			(0.14)
Trade/GDP	2.47***	2.31***	4.33***	2.48***	2.34***	4.21**
	(0.33)	(0.54)	(1.57)	(0.34)	(0.56)	(1.53)
Domestic Credit/GDP	-3.61***	-5.51***	-3.85**	-3.56***	-5.46***	-3.64**
	(0.65)	(0.82)	(1.73)	(0.61)	(0.78)	(1.71)
Log(Population)	-0.48	-0.39	1.43	-0.45	-0.30	1.72
	(0.63)	(1.14)	(1.79)	(0.62)	(1.13)	(1.83)
Log(GDP per capita)	0.67*	2.51**	-0.88	0.67*	2.54**	-0.66
	(0.40)	(0.95)	(1.54)	(0.39)	(0.93)	(1.56)
Recession	-0.52**	-0.77**	-0.56	-0.49**	-0.72**	-0.38
	(0.25)	(0.37)	(0.52)	(0.23)	(0.34)	(0.46)
Banking Crisis	-1.05**	-0.87*	0.98	-1.06**	-0.89*	0.88
	(0.46)	(0.51)	(0.92)	(0.45)	(0.49)	(0.89)
Constant	5.91	-10.10	-14.40	5.36	-11.79	-21.49
	(11.68)	(23.73)	(37.24)	(11.56)	(23.53)	(38.01)
Observations	6286	4170	510	6289	4173	510
Within R^2	0.05	0.07	0.17	0.06	0.07	0.18
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real annual GDP growth rate. The sample period for columns (1) and (4) is 1960-2019 while the sample period for columns (2)-(3) and (5)-(6) is 1990-2019. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B4 Placebo Test

	GDP growth rate %					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1960-2019	1990-2019				
	All Events	All Events			Without H1N1	
Shock	-0.31	-0.21	0.03	0.72	-0.21	0.53
	(0.26)	(0.23)	(0.77)	(0.63)	(0.71)	(0.59)
Consensus Forecast			0.53***	0.49***	0.64***	0.63***
			(0.15)	(0.16)	(0.14)	(0.16)
Trade/GDP	2.52***	2.38***	4.43**	3.37***	2.78***	3.16***
	(0.35)	(0.58)	(1.72)	(0.97)	(0.73)	(0.81)
Domestic Credit/GDP	-3.65***	-5.57***	-4.06**	-3.62**	-2.30	-3.16**
	(0.67)	(0.87)	(1.78)	(1.45)	(1.38)	(1.44)
Log(Population)	-0.52	-0.46	1.44	2.67	3.10*	2.72
	(0.64)	(1.15)	(1.85)	(2.09)	(1.52)	(2.02)
Log(GDP per capita)	0.65	2.46**	-0.89	-0.91	-0.51	-1.05
	(0.39)	(0.94)	(1.48)	(1.59)	(1.50)	(1.55)
Recession	-0.56**	-0.83**	-0.68	-34.23	0.36*	2.29***
	(0.27)	(0.40)	(0.59)	(43.48)	(0.20)	(0.48)
Banking Crisis	-1.03**	-0.84	1.18	0.07	-0.23	-0.10
	(0.47)	(0.53)	(1.00)	(0.42)	(0.45)	(0.45)
Constant	6.70	-8.65	-14.50	0.00	-45.60	-36.26
	(11.77)	(23.80)	(37.84)	(.)	(33.33)	(42.03)
Observations	6300	4177	511	511	484	484
Within R^2	0.05	0.07	0.15	0.32	0.20	0.25
Decade FE	Yes	Yes	Yes	No	Yes	No
Year FE	No	No	No	Yes	No	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The sample period for column (1) is 1960-2019 while the sample period for columns (2)-(6) is 1990-2019. The shock variable is randomly generated. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B5 The Effect of Health Crises on GDP Growth: Trade Linkages

	GDP growth rate %					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:			1988-2018			
Shock	-2.22**	-1.98**				
	(1.03)	(0.97)				
High Mortality Rate			-3.28***	-3.02***		
			(0.86)	(0.83)		
Medium Mortality Rate			-3.13***	-2.87***		
			(0.88)	(0.86)		
Low Mortality Rate			-0.55	-0.40		
			(0.61)	(0.56)		
High Cases/Pop					-2.62**	-2.36**
					(1.21)	(1.15)
Medium Cases/Pop					-2.71**	-2.45**
					(1.20)	(1.11)
Low Cases/Pop					-0.92	-0.71
					(0.55)	(0.49)
Shock to Trade Partner	-0.52**		-0.55*		-0.56**	
	(0.23)		(0.27)		(0.26)	
Trade Weighted by Indirect Shock		-1.00**		-0.99**		-1.07**
		(0.38)		(0.48)		(0.44)
Trade/GDP	0.19	0.17	0.21	0.19	0.20	0.18
	(0.33)	(0.33)	(0.34)	(0.34)	(0.34)	(0.33)
Domestic Credit/GDP	-0.73	-0.73	-0.72	-0.72	-0.73	-0.73
	(0.46)	(0.46)	(0.45)	(0.45)	(0.45)	(0.45)
Log(Population)	0.12**	0.11**	0.12**	0.12**	0.11**	0.11**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Log(GDP per capita)	-0.20**	-0.21**	-0.20**	-0.22**	-0.19**	-0.21**
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Recession	-0.56	-0.57	-0.52	-0.52	-0.58	-0.59
	(0.38)	(0.38)	(0.36)	(0.36)	(0.38)	(0.38)
Banking Crisis	-1.54***	-1.54***	-1.54***	-1.54***	-1.55***	-1.55***
	(0.37)	(0.36)	(0.37)	(0.37)	(0.36)	(0.36)
Constant	4.76***	4.99***	4.75***	4.97***	4.76***	5.01***
	(0.46)	(0.51)	(0.45)	(0.52)	(0.45)	(0.51)
Observations	4502	4502	4502	4502	4502	4502
Within R^2	0.065	0.066	0.070	0.070	0.066	0.067
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable is annual real GDP growth. Shock dummy equals one for country i in the onset year t, and zero otherwise. Shock to trade partner equals 1 if one of the country's trading partners is hit by a health crisis, and 0 otherwise. The weighted trade network measure in columns (2), (4), and (6) is constructed by multiplying the shock to a country's trading partner dummy by the share of bilateral trade between these two countries in the country's total trade (Trade weighted by indirect shock). Standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B6 The Effect of Health Crises on GDP Growth:
Trade Linkages (Severity of Crises)

	GDP growth rate %					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:			1988-2018			
Shock	-2.22**	-1.98**				
	(1.03)	(0.97)				
Mortality Rate			-2.07**	-2.40*		
			(0.86)	(1.22)		
Cases/Pop					-2.50***	-1.54***
					(0.62)	(0.55)
Shock to Trade Partner	-0.52**		-1.11		-1.04	
	(0.23)		(0.71)		(0.65)	
Trade Weighted by Indirect Shock		-1.00**				
		(0.38)				
Trade Weighted by Mortality Rates				-0.10		
				(0.07)		
Trade Weighted by Cases/Pop						-0.14***
						(0.02)
Trade/GDP	0.19	0.17	0.24	0.32	0.23	0.21
	(0.33)	(0.33)	(0.35)	(0.38)	(0.35)	(0.34)
Domestic Credit/GDP	-0.73	-0.73	-0.76	-0.76	-0.76	-0.73
	(0.46)	(0.46)	(0.49)	(0.49)	(0.48)	(0.46)
Log(Population)	0.12**	0.11**	0.11**	0.12**	0.11**	0.12**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Log(GDP per capita)	-0.20**	-0.21**	-0.23**	-0.22**	-0.22**	-0.19*
	(0.09)	(0.09)	(0.10)	(0.10)	(0.09)	(0.10)
Recession	-0.56	-0.57	-0.85*	-0.83*	-0.79*	-0.47
	(0.38)	(0.38)	(0.42)	(0.44)	(0.39)	(0.32)
Banking Crisis	-1.54***	-1.54***	-1.45***	-1.44***	-1.46***	-1.52***
	(0.37)	(0.36)	(0.41)	(0.43)	(0.40)	(0.40)
Constant	4.76***	4.99***	5.08***	4.64***	5.02***	4.51***
	(0.46)	(0.51)	(0.59)	(0.50)	(0.56)	(0.45)
Observations	4502	4502	4502	4502	4502	4502
Within R^2	0.065	0.066	0.051	0.045	0.055	0.061
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable is the real annual GDP growth rate. Shock dummy equals one for country i at onset year t, and zero otherwise. Shock to trade partner equals to 1 if one of the country's trading partner is hit by a health crisis, and 0 otherwise. The weight trade network in column (2) is constructed by multiplying the shock to a country's trading partner dummy by the share of bilateral trade between these two countries in the country's total trade (Trade weighted by indirect shock). The weight trade network in column column (4) and (6) is constructed by multiplying the trading partner's ex post mortality rate or cases number per population by the trade share (trade weighted by morality rate and cases to population). Standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

B2 Regression Table on Quarterly GDP

Table B7 The Effect of Health Crises on Real Quarterly GDP Growth

	Quarterly GDP growth rate (YoY)%			
	(1)	(2)	(3)	(4)
Sample Period:	1960-2018	1990-2018		
	All Events	All Events	All Events	Without H1N1
Shock (Q)	-3.73***	-3.80***	-2.32***	-0.98***
	(1.23)	(1.16)	(0.52)	(0.23)
Consensus Forecast (Q)			1.37***	1.35***
			(0.22)	(0.21)
Trade/GDP	0.03	-0.03	0.57	0.48
	(0.79)	(0.80)	(1.21)	(1.16)
Domestic Credit/GDP	-1.81***	-1.94***	-1.20	-1.20
	(0.56)	(0.68)	(1.35)	(1.33)
Log(Population)	-0.25***	-0.31*	-0.00	-0.01
	(0.09)	(0.17)	(0.08)	(0.08)
Log(GDP per capita)	0.59***	0.71*	0.08	0.10
	(0.18)	(0.37)	(0.23)	(0.22)
Recession	-1.48**	-1.85*	-1.36**	-1.29**
	(0.70)	(1.06)	(0.61)	(0.63)
Banking Crisis (Q)	0.29	0.52	-0.16	-0.26
	(1.14)	(1.25)	(0.90)	(0.90)
Constant	3.38***	3.48***	-1.59	-1.48
	(0.81)	(1.05)	(1.67)	(1.63)
Observations	5218	3959	1240	1222
Adjusted R^2	0.126	0.108	0.378	0.346
Decade FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real quarterly GDP growth rate, annualized. The sample period for column (1) is 1960-2018 while the sample period for column (2)-(4) is 1990-2018. The shock dummy equals one for country i hit by a health crisis at onset year t, and zero otherwise. In columns (1)-(3), we include all six health crises while column (4) excludes H1N1 and the 1968 Flu. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B8 The Effect of Health Crisis on Real Quarterly GDP Growth, by Crisis

	Quarterly GDP growth rate (YoY)%			
	(1)	(2)	(3)	(4)
Sample Period:	1960-2018	1990-2018		
	All Events	All Events	All Events	Without H1N1
EBOLA	0.40	0.30	-0.21	-0.21
	(0.35)	(0.35)	(0.26)	(0.27)
H1N1	-6.39***	-6.18***	-3.59***	
	(1.01)	(1.24)	(0.86)	
MERS	-0.86***	-0.79***	-0.87***	-0.85***
	(0.27)	(0.27)	(0.24)	(0.23)
SARS	-1.34***	-1.55***	-1.45***	-1.46***
	(0.39)	(0.36)	(0.28)	(0.27)
Zika	-2.62***	-2.62***	-0.93***	-0.94***
	(0.41)	(0.40)	(0.27)	(0.27)
Hkflu	-0.77*			
	(0.44)			
Consensus Forecast (Q)			1.34***	1.35***
			(0.22)	(0.22)
Trade/GDP	0.01	-0.06	0.53	0.48
	(0.78)	(0.79)	(1.20)	(1.16)
Domestic Credit/GDP	-1.76***	-1.90***	-1.22	-1.20
	(0.56)	(0.68)	(1.34)	(1.33)
Log(Population)	-0.25***	-0.32*	-0.01	-0.01
	(0.09)	(0.17)	(0.08)	(0.08)
Log(GDP per capita)	0.60***	0.72*	0.09	0.10
	(0.18)	(0.37)	(0.23)	(0.22)
Recession	-1.36**	-1.69	-1.29**	-1.31**
	(0.68)	(1.06)	(0.61)	(0.63)
Banking Crisis (Q)	0.21	0.42	-0.23	-0.26
	(1.13)	(1.25)	(0.90)	(0.90)
Constant	3.36***	3.42***	-1.47	-1.46
	(0.83)	(1.08)	(1.67)	(1.63)
Observations	5218	3959	1240	1222
Adjusted R^2	0.136	0.120	0.384	0.347
Decade FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

NOTE: The dependent variable is real quarterly GDP growth rate, annualized. The sample period for column (1) is 1960-2018 while the sample period for columns (2)-(4) is 1990-2018. Country and decade fixed effects are included. All standard errors are corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B9 The Effect of Health Crises on Real Quarterly GDP Growth, by Severity

	Quarterly GDP growth rate (YoY)%					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1960-2018	1990-2018		1960-2018	1990-2018	
High Mortality Rate	-4.77***	-5.09***	-2.72***			
	(1.36)	(1.25)	(0.75)			
Medium Mortality Rate	-5.17***	-4.93***	-3.66***			
	(1.27)	(1.31)	(1.06)			
Low Mortality Rate	-2.45***	-2.60***	-1.24***			
	(0.88)	(0.83)	(0.27)			
High Cases/Pop				-3.65***	-3.82***	-2.56***
				(1.20)	(1.23)	(0.90)
Medium Cases/Pop				-4.43***	-4.40***	-2.57***
				(1.28)	(1.19)	(0.47)
Low Cases/Pop				-3.02**	-3.09***	-1.72***
				(1.23)	(1.11)	(0.40)
Consensus Forecast (Q)			1.36***			1.37***
			(0.22)			(0.22)
Trade/GDP	0.05	-0.02	0.56	0.03	-0.03	0.57
	(0.80)	(0.81)	(1.21)	(0.79)	(0.80)	(1.22)
Domestic Credit/GDP	-1.80***	-1.93***	-1.23	-1.81***	-1.93***	-1.19
	(0.57)	(0.68)	(1.35)	(0.56)	(0.68)	(1.35)
Log(Population)	-0.25***	-0.31*	-0.00	-0.25***	-0.31*	-0.00
	(0.09)	(0.17)	(0.08)	(0.09)	(0.17)	(0.08)
Log(GDP per capita)	0.59***	0.71*	0.09	0.60***	0.72*	0.08
	(0.18)	(0.37)	(0.23)	(0.18)	(0.37)	(0.23)
Recession	-1.45**	-1.81*	-1.33**	-1.47**	-1.85*	-1.36**
	(0.69)	(1.06)	(0.60)	(0.69)	(1.06)	(0.61)
Banking Crisis (Q)	0.28	0.50	-0.18	0.29	0.52	-0.16
	(1.13)	(1.25)	(0.89)	(1.14)	(1.25)	(0.90)
Constant	3.36***	3.46***	-1.57	3.37***	3.48***	-1.59
	(0.81)	(1.06)	(1.67)	(0.81)	(1.05)	(1.68)
Observations	5218	3959	1240	5218	3959	1240
Adjusted R^2	0.128	0.111	0.382	0.126	0.109	0.378
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable in column (1)-(6) is real quarterly GDP growth rate, annualized. The sample period for columns (1) and (4) is 1960-2018 while the sample period for columns (2)-(3) and (5)-(6) is 1990-2018. Country and decade fixed effects are included. All standard errors are clustered corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B10 The Effect of Health Crises on Real Quarterly GDP Growth: Weighted by Severity of Crises

	Quarterly GDP growth rate (YoY)%					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1960-2018	1990-2018		1960-2018	1990-2018	
Mortality Rate	-4.67*	-4.65*	-4.33**			
	(2.68)	(2.46)	(1.66)			
Cases/Pop				-8.36***	-8.18***	-2.29**
				(1.67)	(2.01)	(1.07)
Consensus Forecast (Q)			1.41***			1.40***
			(0.24)			(0.24)
Trade/GDP	0.09	0.06	0.70	0.07	0.03	0.69
	(0.83)	(0.85)	(1.30)	(0.82)	(0.84)	(1.31)
Domestic Credit/GDP	-1.84***	-1.98***	-1.13	-1.81***	-1.95***	-1.15
	(0.59)	(0.71)	(1.36)	(0.58)	(0.70)	(1.36)
Log(Population)	-0.26***	-0.32*	-0.01	-0.26***	-0.32*	-0.01
	(0.09)	(0.18)	(0.08)	(0.09)	(0.17)	(0.08)
Log(GDP per capita)	0.60***	0.71*	0.08	0.60***	0.72*	0.09
	(0.18)	(0.37)	(0.23)	(0.18)	(0.37)	(0.23)
Recession	-1.55**	-1.98	-1.43**	-1.50*	-1.90	-1.40**
	(0.78)	(1.20)	(0.67)	(0.77)	(1.18)	(0.67)
Banking Crisis (Q)	0.42	0.67	-0.04	0.38	0.62	-0.06
	(1.18)	(1.32)	(0.96)	(1.18)	(1.31)	(0.96)
Constant	3.32***	3.46***	-1.86	3.31***	3.43***	-1.82
	(0.83)	(1.09)	(1.80)	(0.84)	(1.10)	(1.79)
Observations	5214	3959	1240	5214	3959	1240
Adjusted R^2	0.11	0.08	0.36	0.11	0.09	0.36
Decade FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

NOTE: The dependent variable in column (1)-(6) is real quarterly GDP growth rate, annualized. The sample period for columns (1) and (4) is 1960-2018 while the sample period for columns (2)-(3) and (5)-(6) is 1990-2018. Country and decade fixed effects are included. All standard errors are clustered corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B11 The Effect of Health Crises on Real Quarterly GDP Growth: Placebo Test

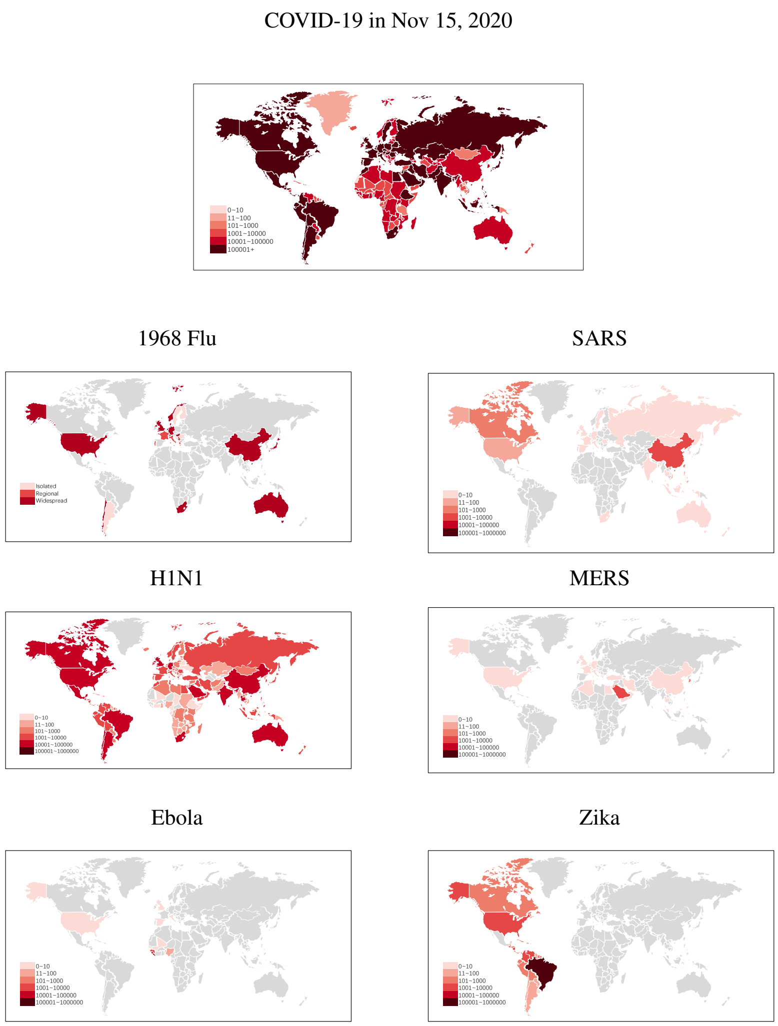
	Quarterly GDP growth rate (YoY)%			
	(1)	(2)	(3)	(4)
Sample Period:	1960-2018	1990-2018		
	All Events	All Events	All Events	Without H1N1
Shock (Q)	-0.27	-0.64	0.02	-0.07
	(0.46)	(0.53)	(0.35)	(0.32)
Consensus Forecast (Q)			1.42***	1.35***
			(0.24)	(0.21)
Trade/GDP	0.10	0.06	0.69	0.49
	(0.83)	(0.86)	(1.30)	(1.16)
Domestic Credit/GDP	-1.85***	-1.99***	-1.15	-1.20
	(0.60)	(0.71)	(1.37)	(1.33)
Log(Population)	-0.26***	-0.32*	-0.01	-0.01
	(0.09)	(0.18)	(0.08)	(0.08)
Log(GDP per capita)	0.60***	0.72*	0.09	0.10
	(0.18)	(0.37)	(0.24)	(0.23)
Recession	-1.57*	-2.00	-1.44**	-1.28**
	(0.80)	(1.22)	(0.68)	(0.64)
Banking Crisis (Q)	0.45	0.71	-0.03	-0.26
	(1.19)	(1.33)	(0.97)	(0.90)
Constant	3.33***	3.47***	-1.87	-1.50
	(0.84)	(1.10)	(1.81)	(1.64)
Observations	5218	3959	1240	1222
Adjusted R^2	0.105	0.082	0.358	0.344
Decade FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

NOTE: The dependent variable in column (1)-(4) is real quarterly GDP growth rate, annualized. The sample period for column (1) is 1960-2018 while the sample period for columns (2)-(4) is 1990-2018. The shock variable is randomly generated. Country and decade fixed effects are included. All standard errors are clustered corrected using Driscoll and Kraay (1998) and reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

C Figures

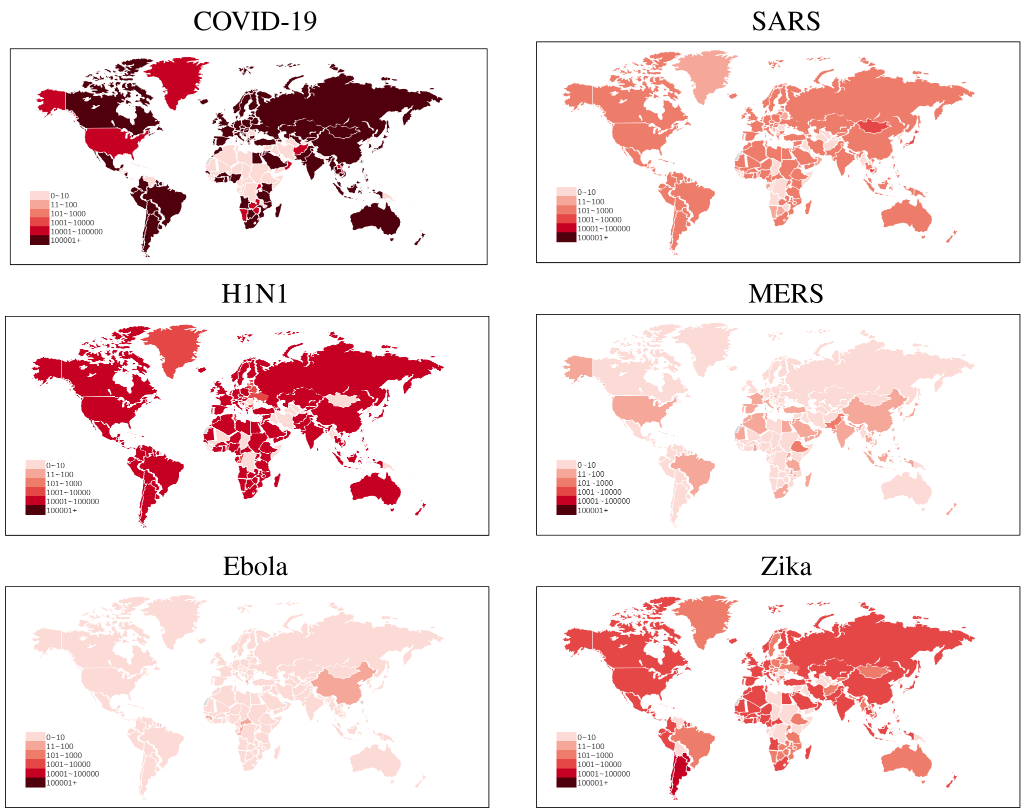
C1 Cross Episodes Figures

Figure C1 Severity of Six Modern Health Crises and COVID-19: Total Affected Cases



NOTE: This figure depicts the severity of health crisis episodes in our sample period and COVID-19. We classify economies into six groups based on the reported cases. The data for 1968 Flu is available only by severity groupings: isolated, regional and widespread.

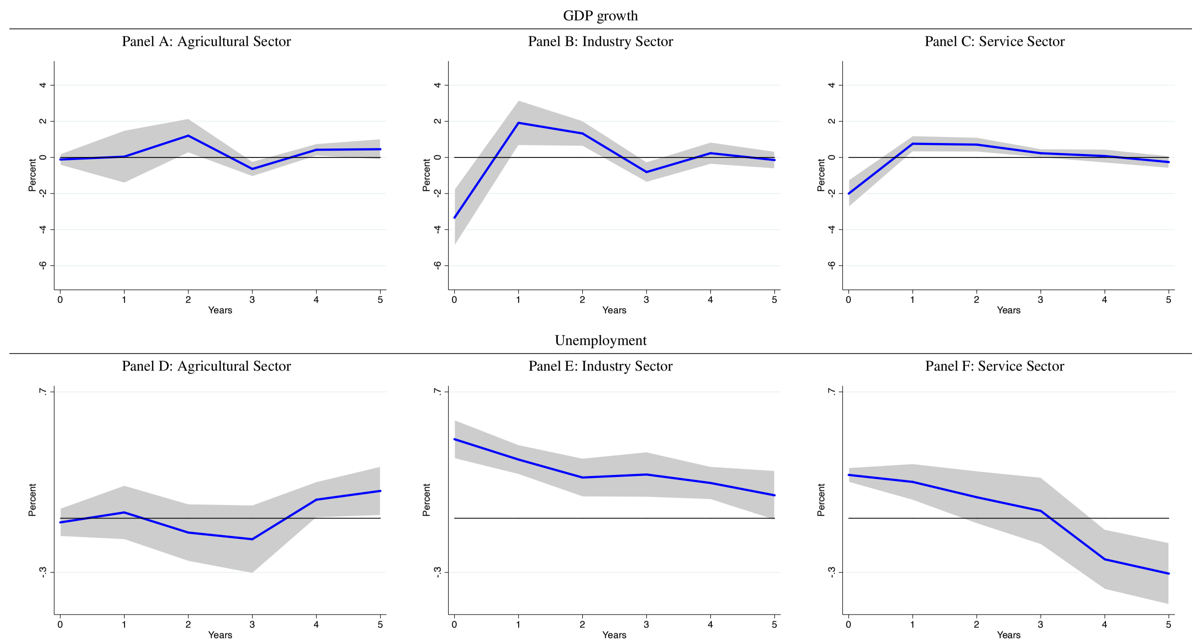
Figure C2 Trade Network Intensity in Health Crisis Years



NOTE: This figure depicts the trade network intensity measure using both ex-post cases and bilateral trade data. For each country's severity, we weight its trading partners' case number using the bilateral trade share. Due to data limitation, we use the trade data in 2018 and the reported number of cases for COVID-19 as of June 1, 2020 to construct the COVID panel.

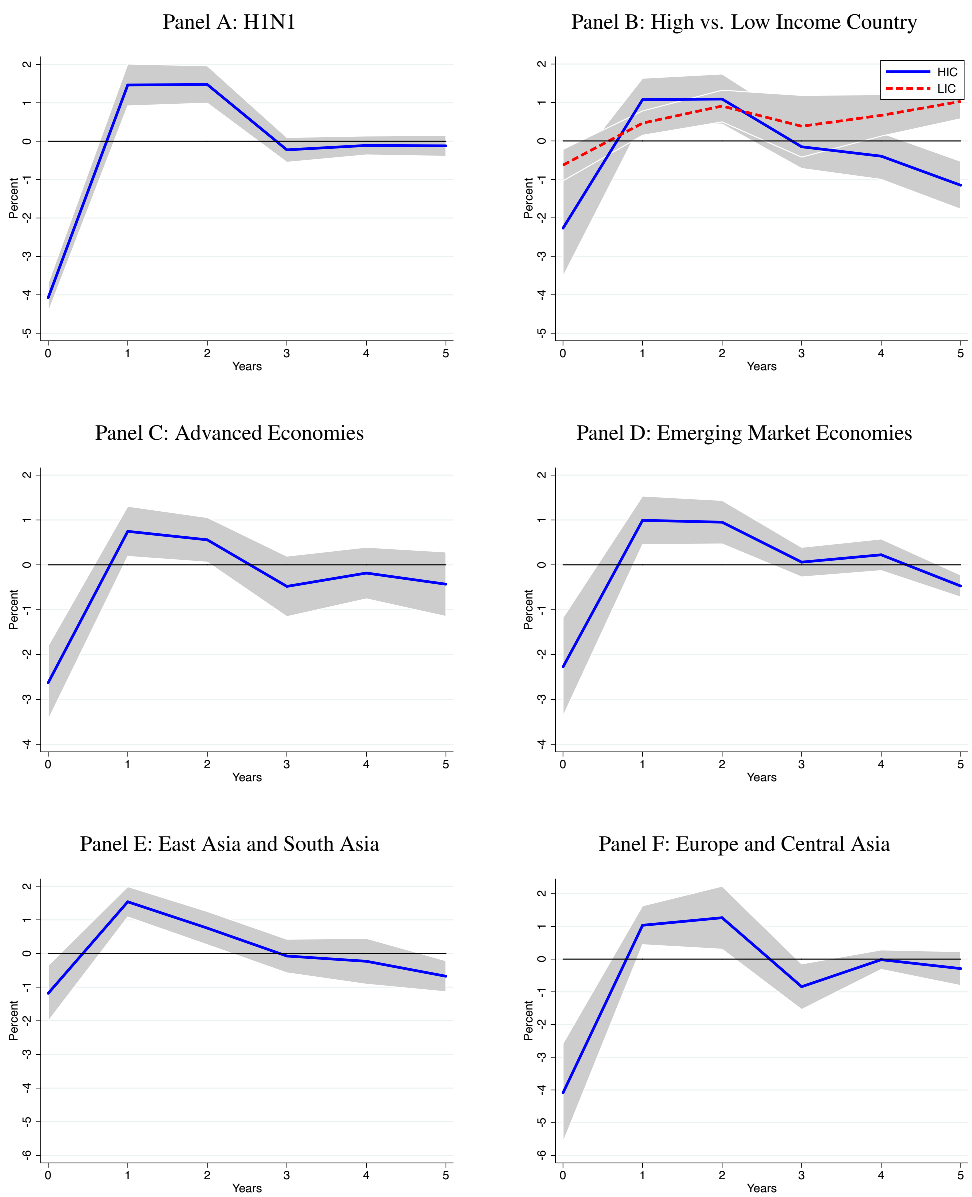
C2 Additional Impulse Response Function Figures

Figure C3 Effect on GDP growth and Unemployment (%): Sector Breakdown



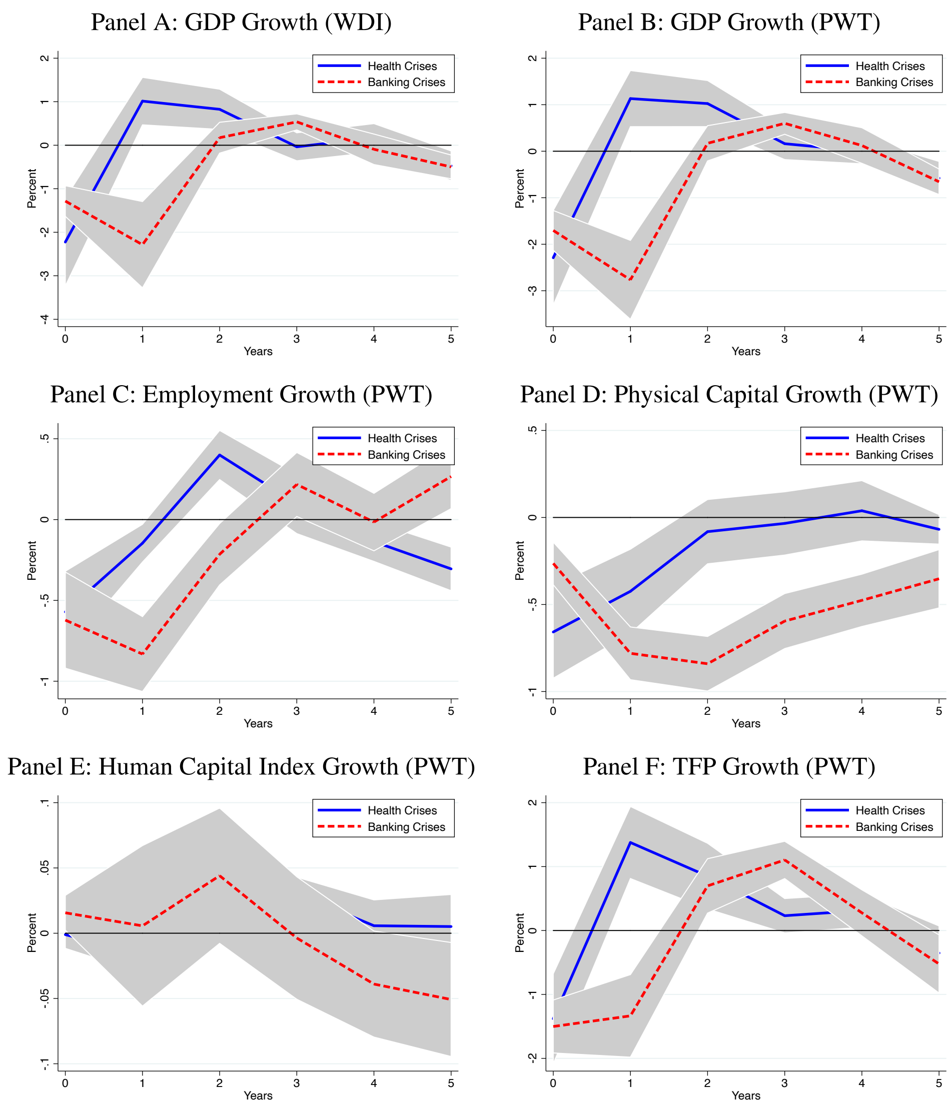
NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $y_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H y_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where y_{it} is the real GDP growth rate or annual unemployment rate for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown. Panel A (D), B (E) and C (F) present IRFs for real GDP growth (unemployment) rate at agricultural, industry and service sectors.

Figure C4 Effect on GDP: Episode and Geographic Breakdowns



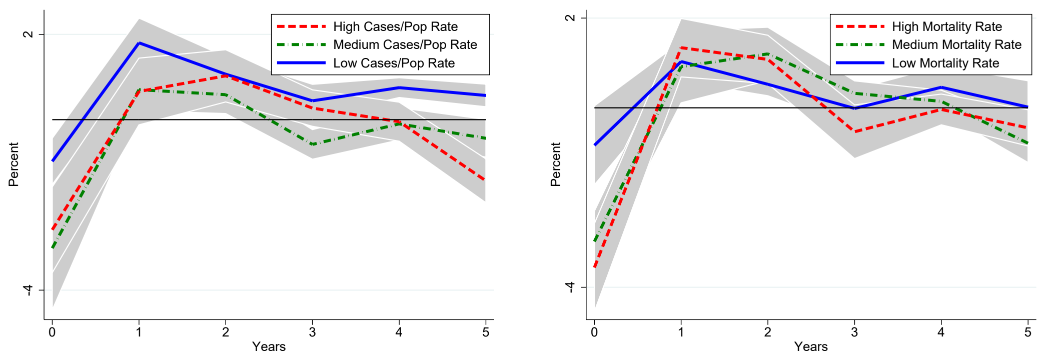
NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $g_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H g_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual real GDP growth rate for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown. Panel A re-defines the dummy D_{it} to flag the H1N1 shock only. Panel B presents IRFs for the sample of "High Income Country" and "Low Income Country" according to World Bank Classification. Panel C (D) presents IRFs for the sample of advanced economies (emerging market economies). Panel E (F) is for East Asia and South Asia (Europe and Central Asia).

Figure C5 Comparing Pandemics with Financial Crises



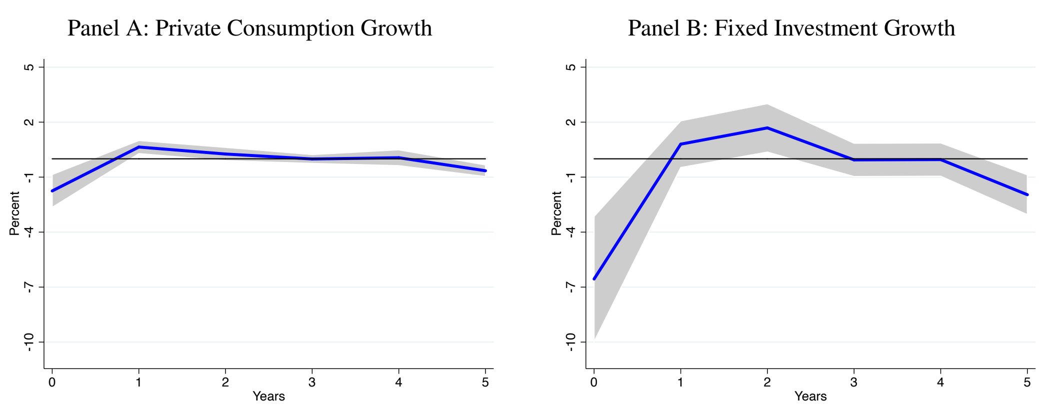
NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $g_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H g_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s}^{\text{Health Crises}} + \sum_{s=0}^{4} \gamma_s^H D_{it-s}^{\text{Banking Crises}} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual growth rate of real GDP (panel A in WDI data), real GDP (panel B in PTW data), employment (panel C), physical capital (panel D), human capital index (panel E) and TFP (panel F) for country i at year t, $D_{it}^{\text{Health Crises}}$ $\left(D_{it}^{\text{Banking Crises}}\right)$ is a dummy variable indicating a disease event (banking crisis) hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). The blue solid line represents the effect from health crises and the red dashed line represents the effects from banking crises. One standard error bands are shown.

Figure C6 Effects of Health Crises on GDP by Severity



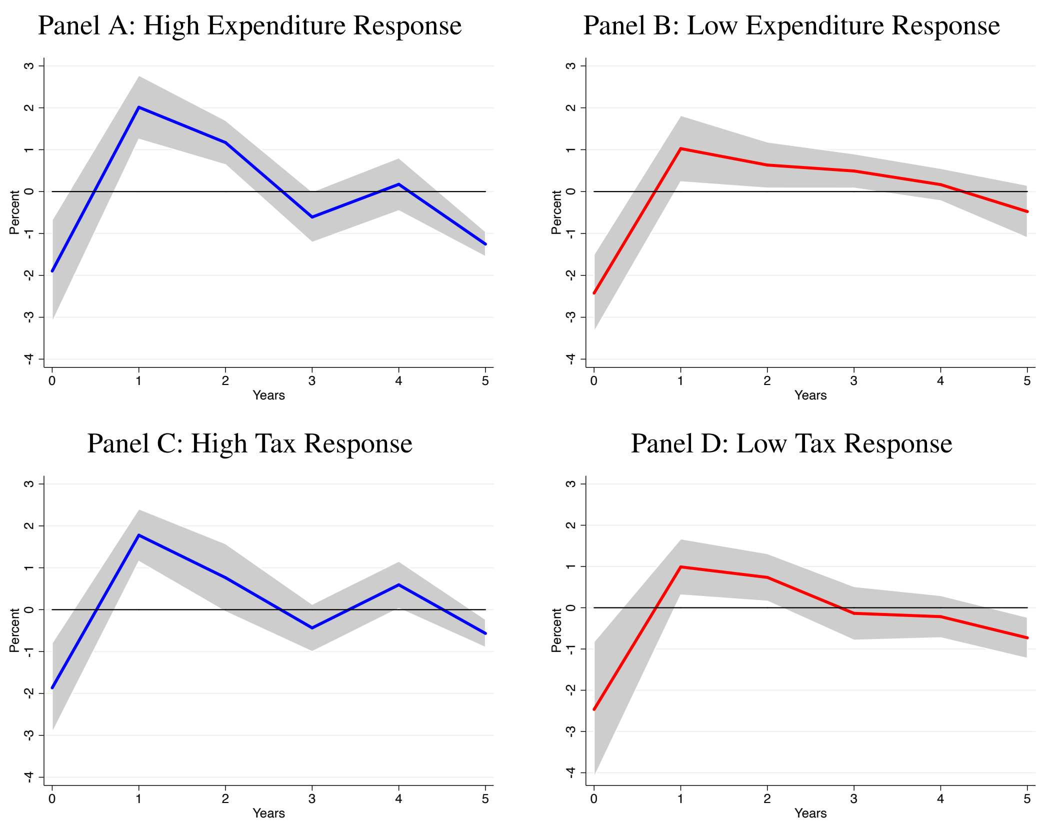
NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005) $g_{it+H} = \alpha_i^H + \sum_{j=1}^{4} \beta_j^H g_{it-j} + \sum_{s=0}^{4} \delta_s^H D_{it-s}^{\mathrm{H}} + \sum_{s=0}^{4} \gamma_s^H D_{it-s}^{\mathrm{M}} + \sum_{s=0}^{4} \mu_s^H D_{it-s}^{\mathrm{L}} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual real GDP growth rate for country i at year t, D_{it}^H $\left(D_{it}^M, D_{it}^L\right)$ is a dummy variable indicating a high (medium, low) mortality rate or cases per population rate for an affected country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). The blue solid line represents low, the green dash-dotted line represents medium and the red dashed line represents high. One standard error bands are shown.

Figure C7 The Effect of Health Crises on Consumption and Investment



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $g_{it+H} = \alpha_i^H + \sum_{s=1}^{4} \beta_s^H g_{it-s} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual real growth rate of private consumption in Panel A and fixed investment in Panel B for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, US recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown.

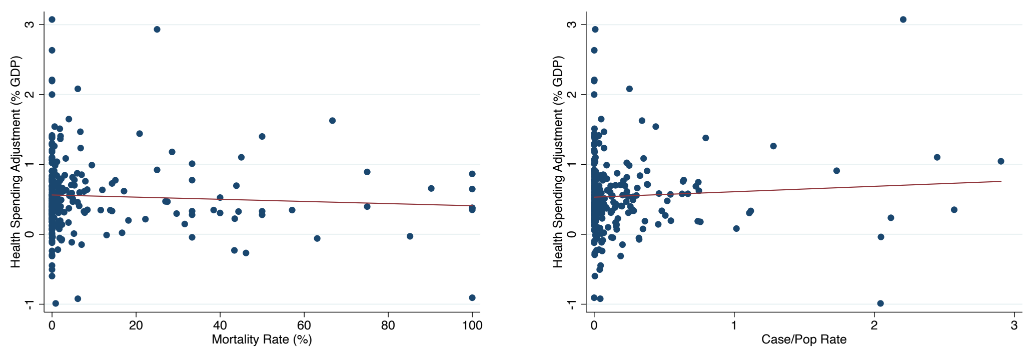
Figure C8 Effect on GDP Growth Conditional on Immediate Fiscal Response:
Results for General Expenditures and Tax Revenues



NOTE: Impulse response functions (IRF) are estimated based on the local projection method as in Jordà (2005): $g_{it+H} = \alpha_i^H + \sum_{s=1}^{4} \beta_s^H g_{it-s} + \sum_{s=0}^{4} \delta_s^H D_{it-s} + \gamma^H X_{it} + \varepsilon_{it}$, with $H = 0, 1, \cdots, 5$, where g_{it} is the annual real GDP growth rate for country i at year t, D_{it} is a dummy variable indicating a disease event hitting country i in year t, with X_{it} including country-level controls such as Trade/GDP, Domestic Credit/GDP, population and log GDP per capita. We also include a decade dummy, U.S. recession dummy, a banking crisis dummy and country fixed effects. Standard errors are corrected using Driscoll and Kraay (1998). One standard error bands are shown. Each row divides countries based on the average of $\frac{Z_{it} - Z_{it-1}}{\mathrm{GDP}_{it-1}}$ across all six health episodes where t is the onset year of each episode. Z refers to fiscal spending in Panel A and B, and tax revenue in Panel C and D. High refers to countries in the 75 percentile and above while low refers to countries in the 25 percentile and below.

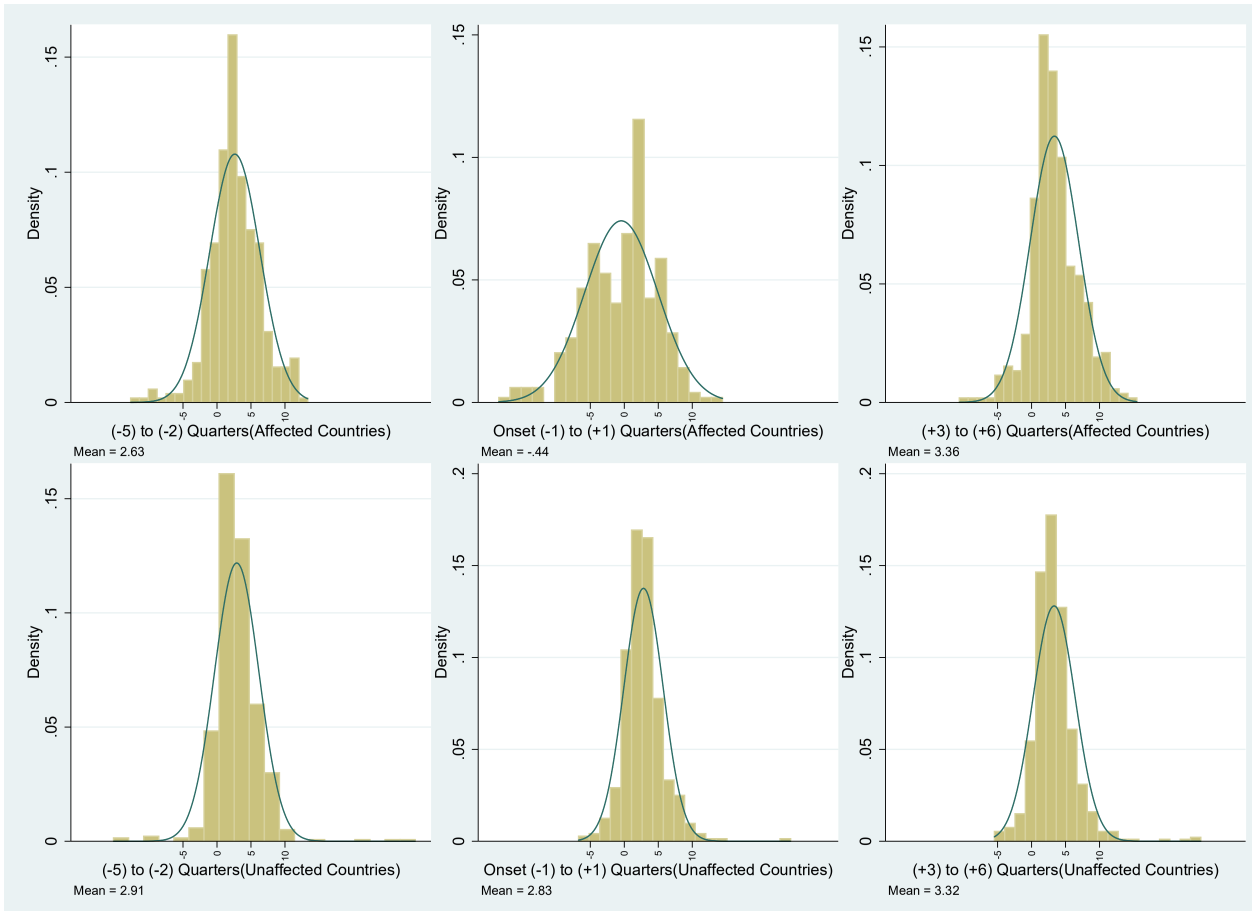
Figure C9 Health Spending and Crisis Severity

Panel A: Health Spending Adjustment and Mortality Rate Panel B: Health Spending Adjustment and Case Rate



NOTE: Panel A plots the relationship between health spending adjustment (defined as the change of health spending in the onset year normalized by the previous year's GDP) and the mortality rate, for all episodes in affected countries. The regression line has a slope of -0.002 with t-stat at -0.94. Panel B plots the relationship between health spending adjustment and the case rate for all the episodes in affected countries. The regression line has a slope of 0.078 with t-stat at 0.58.

Figure C10 Quarterly GDP Growth Distribution



NOTE: The real quarterly year-over-year seasonally adjusted GDP growth rate distribution for the affected and unaffected country groups. 0 represents the quarter when WHO declares a health crisis hits a country.

D Distributional Effects of Pandemics

We explore the distributional/heterogeneous effects of health shocks along multiple additional dimensions such as episodes, income level, economic development and geographic regions.[1] First, we investigate the impact of H1N1 crisis alone given it is the most severe health crisis before COVID. Panel A in Figure C4 displays the estimates for impulse response functions. Indeed, the effect of H1N1 is larger than our full sample estimates. In the onset year, the growth rate for affected countries is 4.1% lower than for unaffected ones. There is still bounce-back one year later — the growth rate for affected countries is 1.5% higher than that for unaffected ones. Nevertheless, our results are not driven by H1N1 only. In the robustness section, we show that other pandemics are also quantitatively important.

Panel B in Figure C4 considers High-income countries (in solid blue) and Low-income countries (in dashed red), as classified by the World Bank.[2] High income countries affected by the crisis have a GDP growth rate in the onset year that is 2.3% less than the GDP growth for high income countries unaffected by the crises. Bounce-back for these affected high-income countries is quick, however, as seen by the fact that growth is 1.1% higher in affected countries in the year after the crisis was declared. According to the red line in the figure, affected low-income countries have GDP growth rates are 0.6% lower than unaffected ones in the onset year with a recovery growth rate in the second year at 0.5% higher. Note that these are within-group comparisons, and hence do not speak to the issue of whether high income or low income countries are more affected by health crises.[3] Nevertheless, high income countries seem to fare worse once hit by the pandemics. One potential reason for a larger effect of health crises on high income groups is due to the economic structure. As noted above, in Figure C3, we divide GDP into three sectors and find that industry and service sectors are affected more by health crises, while agricultural output is not significantly different in affected and unaffected countries.

Panel C and Panel D show the effects on advanced and emerging market economies according to the IMF classification. In the onset year, the growth rate among advanced

[1] To save space, we display impulse response functions only for real GDP growth. Those for unemployment, which are available upon request, are consistent with the GDP growth in the sense of Okun's law.

[2] The World Bank groups countries into four categories based on 2018 GNI per capita — High-income, Upper-middle-income, Lower-middle-income and Lower-income economies. We estimate the impulse response functions for High-income and Lower-income country groups separately.

[3] The IMF growth forecasts for Low Income Developing countries is -1% in 2020, down from 5.2% in 2019. This compares to a forecast of -8.1% in 2020 for Advanced Economies. The IMF projects a rebound to 5.2% for the low income countries in 2021.

economies falls by 2.6% in affected compared to unaffected countries. One year later, there is a bounce back to 0.7% for the advanced country group. For emerging market economies, the growth rate falls by 2.3% for affected countries compared to unaffected ones, with a bounce back at 1.0% one year after the shock. However, the difference between advanced and emerging market economies seems not to be statistically significant.

Panel E and Panel F consider geographic regions. The decline in growth for affected East and South Asia countries relative to the unaffected ones is 1.2% in the onset year, with a 1.5% bounce-back one year later. For the Europe and Central Asia group, affected countries have a 4.1% decrease in GDP growth compared to unaffected countries in the onset year, with a 1.0% bounce-back one year later. One potential explanation may be due to the role of fiscal policy, as explored in Section 6.

E Comparing Pandemics with Financial Crises

In this section, we compare the effect of pandemics with financial crises. In particular, we focus on one typical crises, the systemic banking crisis identified by Laeven and Valencia (2013). For perspective, we jointly estimate the effect on GDP growth of pandemics and banking crises by augmenting our baseline estimation equation (1) with a dummy for the systemic banking crises and its four lags. We do it using our baseline sample using WDI. To understand the difference, we also conduct similar analysis for different components in the growth accounting, i.e. employment, human capital index, physical capital and TFP, using Penn World Table data.

Panel A and B in Figure C5 present the effects on GDP growth of pandemics (in blue) are of the same magnitude as banking crises (in red), although the dynamics are different. The results are robust to WDI or PWT data sample. In the onset year, there is a fall in real GDP, by 2.2% for health crisis and 1.3% for banking crises. However, one year later, GDP growth bounces back after a health crisis to 0.7% but continues to fall after a banking crisis. Although the magnitude from a health crisis in the onset year is comparable to that of a banking crisis, it features faster bounce-back of growth than banking crises. In contrast, the negative effect of banking crises is more persistent.

Moreover, we decompose the channels by investigating the dynamics of growth accounting components. Consistently, we find that banking crises causes a much larger impact on employment, physical capital and TFP. The prolonged negative impact on those factors explains why the banking crises can slow down the GDP growth rate for such a long period. Moreover, we do not find any significant difference in both crises to affect the growth rate of human capital indexes.

F Recovery in GDP growth: A Higher-frequency Look

Our analysis using annual data and a large sample of countries suggests that bounce-back occurs in the year after the health shock. It is interesting to investigate by how much and how quickly bounce-back occurs using higher frequency data. We have available quarterly GDP data from OECD, though only for 47 countries. See Table A3 for details. Figure C10 displays the quarterly GDP growth distribution of affected and unaffected countries side by side. We plot these distributions over three different intervals of three consecutive quarters: (1) from five quarters before to two quarters before onset, (2) centered in the onset quarter, and (3) from three quarters to six quarters after the onset quarter. We choose a three quarter window because the official declaration of a health crisis by WHO tends to be conservative (slow). This consideration does not affect identification in our annual sample nearly as much as it could affect the quarterly identification.[4]

The average, annualized growth rate in the three quarter window centered on the health crisis onset is -0.4% for affected countries and 2.8% for unaffected countries. This is in line with our estimates using annual data above. In quarters 2 to 5 before the health crisis, the average growth rate in affected countries is not much different than in unaffected countries, nor is it in quarters 3 to 6 after the health shock. This suggests that the bounce-back of GDP growth is quick. Examining the magnitudes of these comparative responses, however, we see that bounce-back is not sufficient to restore the *level* of GDP within this time interval, consistent with the results from the annual sample.

We also estimate panel regressions using quarterly GDP growth data. Table B7 confirms that our main results hold in the quarterly data. Health crises shocks lower GDP growth in affected countries compared to unaffected countries, with an impact magnitude that is slightly larger than in the annual data. Furthermore, each individual health crisis contributes to this negative effect, with the exception of Ebola (see Table B8). We also use the high, medium or low severity dummy to replace the shock dummy in Table B9 or directly weight the health shock by the severity of each health crisis in Table B10. We find that a more

[4]In addition, note that all countries in the quarterly sample were affected by H1N1, also unlike the annual sample. This weakens identification.

severe health crisis is associated with larger declines in GDP growth. Our last exercise is a placebo test of randomly picking a country-quarter to replace our quarterly shock dummy, as seen in Table B11. The insignificant coefficient on the artificially constructed variable suggests that our identification is valid.

G Consumption and Investment

We first estimate how the consumption and investment components of GDP were affected by past health crises. There are many reasons why a health crisis might lower consumption and investment.[5] For example, with an increase in uncertainty in the economy (see Baker et al. (2020)), people might increase precautionary savings and thus reduce consumption and investment plans. These effects will be even stronger if people expect a negative impact of health crises on future income. The decline in spending could further strengthen the negative impact of crises on the production side and slow down the recovery phase.

Figure C7 reports the impulse response functions for the growth rates of private consumption expenditure and fixed investment. Private consumption growth in affected countries is 1.8% less than for unaffected countries in the onset year, with a 0.6% bounce-back one year later. Perhaps not surprisingly, the drop in fixed investment growth is much larger: 6.6% relative decline in affected countries in the onset year and a 0.8% bounce-back one year later. The sharp drop in investment is consistent with the observed greater volatility in investment, in this case likely due to the heightened uncertainty accompanying the health shock and recession (Baker et al. (2016)).

The dynamics of consumption and investment behavior during the health crises help us understand the output dynamics. When the outbreak occurs, the negative shock elicits cuts in both consumption and investment expenditures. The effect on consumption is relatively milder. But for investment, the bounce-back is not sufficient to offset the negative impact the health crisis causes. As a result, the health crisis can have a persistent effect on output.

[5] Malmendier and Shen (2018) show that personal experiences from negative economic shocks "scar" consumer behavior in the long run. The authors do not directly address health crises *per se*, but instead show that households who have lived through times of high unemployment spend significantly less on food and total consumption, after controlling for income, wealth, employment, demographics, and the current unemployment rate. Their model of experience-based learning is suggestive of a channel through which a shock like COVID could have persistent effects. Carroll et al. (2020) also study the negative impact of COVID on consumption spending.