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THE CORONAVIRUS AND THE GREAT INFLUENZA PANDEMIC: LESSONS FROM THE "SPANISH FLU" FOR THE CORONAVIRUS'S POTENTIAL EFFECTS ON MORTALITY AND ECONOMIC ACTIVITY

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The Coronavirus and the Great Influenza Pandemic: Lessons from the “Spanish Flu” for the Coronavirus’s Potential Effects on Mortality and Economic Activity
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ABSTRACT

Mortality and economic contraction during the 1918-1920 Great Influenza Pandemic provide plausible upper bounds for outcomes under the coronavirus (COVID-19). Data for 43 countries imply flu-related deaths in 1918-1920 of 39 million, 2.0 percent of world population, implying 150 million deaths when applied to current population. Regressions with annual information on flu deaths 1918-1920 and war deaths during WWI imply flu-generated economic declines for GDP and consumption in the typical country of 6 and 8 percent, respectively. There is also some evidence that higher flu death rates decreased realized real returns on stocks and, especially, on short-term government bills.

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The spread of the new coronavirus (COVID-19) in early 2020 led worldwide to declines in stock prices, increases in stock-price volatility, decreases in nominal interest rates, and likely to contractions of real economic activity, as reflected in real GDP. A great deal of uncertainty attaches to the eventual scale of the pandemic, gauged by the number of persons ultimately infected and killed. Also uncertain are the full global economic implications of the pandemic and associated policy responses

The Great Influenza Pandemic

A reasonable upper bound for the coronavirus's mortality and economic effects can be derived from the world's experience with the Great Influenza Pandemic (popularly and unfairly known as the Spanish Flu[1]), which began and peaked in 1918 and persisted through 1920. Our estimate, based on data discussed later on flu-related death rates for 43 individual countries, is that this pandemic killed around 39 million people worldwide, corresponding to 2.0 percent of the world's population at the time. These numbers are likely the peak of worldwide mortality from a "natural disaster" in modern times, though the impact of the plague during the black death in the 14th century was much greater as a share of the population.[2]

The Great Influenza Pandemic arose in three main waves, the first in spring 1918, the second and most deadly from September 1918 to January 1919, and the third from February 1919 to June 1920. This airborne infection was based on the Influenza A virus subtype H1N1.

[1]Spain was not special in terms of the severity or date of onset of the disease but, because of its neutral status in World War I, did have a freer press than most other countries. The greater attention in news reports likely explains why the flu was called "Spanish." In terms of mortality rates and total persons killed, it would be more appropriate to label the pandemic as the Indian Flu. There is controversy about the origin point of the pandemic, with candidates including France, Kansas, and China.

[2] Other influenza outbreaks with global reach are estimated to have had lower mortality rates as a share of the global population, including by first place of registry: Siberia (1889-90) at 0.08%, East Asia (1957-58) at 0.07%, and Hong Kong (1968-69) at 0.03%.

The coincidence of the two initial waves with the final year of World War I (1918) encouraged the spread of the infection, due to crowding of troops in transport, including large-scale movements across countries. An unusual feature was the high mortality among young adults without pre-existing medical conditions. This pattern implies greater economic effects than for a disease with comparable mortality that applied mostly to the old and very young.

The pandemic killed a number of famous people, including the sociologist Max Weber, the artists Gustav Klimt and Egon Schiele, the child saints Francisco and Jacinta Marto, and Frederick Trump, the grandfather of the current U.S. President. Many more famous people were survivors, including Franz Kafka, Friedrich Hayek, General Pershing, Walt Disney, the Spanish King Alfonso XIII, Mary Pickford, and the leaders of France and the United Kingdom at the end of World War I, Georges Clemenceau and David Lloyd George. Of particular note, the disease severely impacted U.S. President Woodrow Wilson, whose impairment likely had a major negative impact on the negotiations of the Versailles Treaty in 1919. Thus, if the harsh terms imposed on Germany by this treaty led eventually to World War II, then the Great Influenza Pandemic may have indirectly caused World War II.

Table 1 shows our estimates of excess mortality rates from the Great Influenza Pandemic. These rates are expressed relative to the total population for 43 countries for each year from 1918 to 1920.[3] These data come from an array of sources, detailed in Ursúa (2009) and Weng (2016). Important references are Johnson and Mueller (2002), Murray, et al. (2006), Mitchell (2007), and the Human Mortality Database. Notably, the Murray, et al. (2006) study used all vital registration data available worldwide from 1915 to 1923. For countries with annual statistics on death tolls from the flu and flu-related deaths such as pneumonia, these direct numbers are used

[3] For all countries in our sample, the rate declined to zero by 1921, except for Chile where it was positive that year.

to measure excess mortality rates for 1918-1920. For some other countries, we followed their methodology to calculate the annual all-cause excess mortality rate for 1918-1920, measuring deaths that were above the average mortality rate from three years before and after the 1918-1920 period. Comparisons of direct yearly estimates of death rates from influenza/pneumonia with all-cause excess mortality rates for countries with both types of data indicate a close correspondence for the two methods. For the few countries for which there is little or no detail on the annual flu breakdown, we used the time distribution of deaths in neighboring countries as an approximation. The 43 countries covered (42 of which have GDP data for the relevant timeframe) constitute 89 percent of estimated world population in 1918.[4] These 43 countries would represent a much larger share of world GDP at the time.

The numbers in Table 1, combined with information on country population, correspond to total flu deaths for the 43 countries of 23.5 million in 1918, 8.4 million in 1919, and 2.8 million in 1920, for a total of 34.6 million. When inflated to the world's population (assuming comparable flu death rates in the uncovered places), the numbers are 26.4 million in 1918, 9.4 million in 1919, and 3.1 million in 1920, for a world total of flu deaths of 39.0 million cumulated over 1918-1920. The estimated aggregate flu death rates for the 43 countries were 1.38 percent for 1918, 0.49 percent for 1919, and 0.16 percent for 1920; the sum of these death rates is 2.0 percent.

Table 1 shows that the flu mortality rate varied greatly across countries and years. Some observations are zero; for example, because of a swift quarantine response, Australia avoided the

[4]Our main source of long-term population data is McEvedy and Jones (1978), who provide estimates for most countries for 1900 and 1925. The population estimates for each country between these benchmark dates are interpolations. Therefore, the annual numbers do not pick up sharp changes, such as those due to World War I or the Great Influenza Pandemic. However, these errors in annual population sizes would not materially affect the subsequent regression analysis. The total population for the 43 countries that we consider falls short of the estimated world population of 1.9 billion in 1918 by around 200 million, of which more than half is in Africa.

pandemic during 1918. Of particular interest for mitigation policies being followed in the current coronavirus pandemic, Australia did not suffer unusually high death rates when the flu finally arrived in 1919; instead, Australia's overall death rate of 0.3 percent is comparatively low. The highest rate by far is for India, with 4.1 percent in 1918 and a cumulative value of 5.2 percent.[5] Because of its high population (around 320 million), India accounted in 1918-1920 for 16.7 million flu deaths out of the world total of 39.0 million; that is, 43 percent of the total. The next highest death rates were for South Africa (cumulative value of 3.4 percent) and Indonesia (3.0 percent). China's death rate was not nearly as high, but because of its large population (about 570 million), its 8.1 million deaths (21 percent of the world total) were second highest across the countries. Spain is not special, with a cumulative death rate of 1.4 percent and a corresponding number of deaths of 300 thousand. The United States had a cumulative death rate of 0.5 percent, with an associated number of deaths of 550 thousand.

The mortality rates shown in Table 1 apply to total populations. The underlying data here are numbers of deaths and sizes of total populations. Mortality rates based on numbers infected are much less reliable because they depend on counts of infections, which are less accurately measured than deaths. A commonly quoted figure is that roughly one-third of the world's population was infected by the H1N1 virus during the Great Influenza Pandemic. If this number were accurate, a mortality rate of 2 percent for the overall population would translate into a mortality rate of 6 percent for the infected population.

[5]Among territories outside our sample, the island of Samoa is estimated to have suffered an even higher death rate, at nearly 22% of the local population, according to Tomkins (1992).

The one-third number for the world infection rate seems to come from Taubenberger and Morens (2006, p. 15),[6] who cite Frost (1920) and Burnet and Clark (1942).[7] Frost's (1920) evidence for the United States derives from surveys of 130,000 people in 11 U.S. cities and rural areas carried out in 1919 by the U.S. Public Health Service. Excluding Louisville, which had a truncated survey, the morbidity rates ranged from 18.5 percent for New London to 53.5 percent for San Antonio, with an overall infection rate of 29.3 percent (computed from the numbers given in Frost [1920, table on p. 588 and map on p. 585]). Frost (pp. 584-586) notes that the underlying canvases were carried out intelligently and on reasonable size samples. But he also observes (p. 597) that the numbers on morbidity are unreliable even for the whole of the United States: "As to the value of the statistics … they represent so few localities and such a small number of observations … that … they contribute little towards giving a picture of the epidemic in the country at large." Results from Mills, et al. (2004), based on an epidemiological model fit to the time profile of observed excess deaths, imply results for the United States consistent with a roughly one-third infection rate. However, this conclusion comes from the model, not from actual data on morbidity. For other countries, there seems to be no reliable information on numbers of infections during the Great Influenza Pandemic. Therefore, the estimated infection rate of one-third and the resulting infected mortality rate of 6 percent have to be regarded as highly speculative. On much firmer ground is the estimated mortality rate of 2 percent out of the total population. The regressions implemented below use the estimated mortality rates out of the total population in each country, as shown in Table 1.

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[6]This study appears in a journal, *Emerging Infectious Diseases*, that is published by the Centers for Disease Control and Prevention (CDC).

[7]However, Burnet and Clark (1942) rely mainly on Frost (1920). The only addition concerning morbidity is an undocumented comment that "A similar age distribution of attacks by the second wave was found in England (Leicester and Manchester) and in Copenhagen and this wave can be considered equivalent to the main American epidemic from which Frost's figures were derived." (Burnet and Clark [1942, p. 81].)

The present analysis focuses on the impact of a country's flu death rate on its economic outcomes, not on possible reverse effects of economic conditions on the death rate. However, it is worth noting that the flu death rate for 1918-1920 has an overall correlation of -0.25 with a country's real per capita GDP in the prior year 1910. This negative association likely reflects the impact of better health services and better organization more broadly on the probability of death from the disease (reflecting partly risk of infection and partly the mortality rate given infection). An offsetting force, however, is that more advanced economies are likely to have greater mobility and interactions, which foster spread of contagious disease.

Applying the flu death rates from the Great Influenza Pandemic to current population levels (about 7.5 billion worldwide in 2020) generates staggering mortality numbers. A death rate of 2.0 percent corresponds in 2020 to 150 million worldwide deaths and 6.5 million U.S. deaths. However, these numbers likely represent the worst-case scenario today, particularly because public-health care and screening/quarantine procedures are more advanced than they were in 1918-1920. Other factors, such as greater international travel, work in the opposite direction. In addition, those worst-case scenarios do not account of differences in the demographic profiles of the Great Influenza Pandemic compared to the ongoing COVID-19.

Macroeconomic Effects of the Great Influenza Pandemic and World War I

Our major objective is to estimate the macroeconomic impact of the Great Influenza Pandemic. Barro and Ursúa (2008) found that this impact might have been substantial. That research focused on rare macroeconomic disasters, using a definition of a disaster as a cumulative decline over one or more years by 10 percent or more in real per capita GDP or real per capita consumption (based on data on real personal consumer expenditure). Based on that definition, the three most important adverse global events since 1870 were World War II,[8] the Great Depression of the early 1930s, and World War I. The results further suggested that the Great Influenza Pandemic of 1918-1920 might have been the next most important negative macroeconomic shock for the world. Specifically, 12 countries were found (in Barro and Ursúa [2008, Table C2]) to have macro disasters based on GDP with trough years between 1919 and 1921, and 8 were found (in Table C1 for a smaller sample of countries with data) to have these disasters based on consumption. A complicating factor in this analysis was the difficulty in distinguishing effects of World War I from those of the Great Influenza Pandemic. Therefore, it is important that the present analysis allows us to separate these two forces.

The long-term annual national-accounts information described in Barro and Ursúa (2008) was subsequently expanded to 42 countries and covers the period of World War I and the Great Influenza Pandemic.[9] We use these data in our study of the determinants of growth rates of GDP and private consumption, notably to disentangle effects from the Great Influenza Pandemic. This analysis exploits variations in flu intensity from 1918 to 1920 across countries and over time.

To hold fixed the effects of World War I, we gauge the war intensity for each country that participated in the war by the ratio of military combat deaths to total population. The data by country on combat deaths, including missing in action, come mainly from Urlanis (2003, part II). In terms of annual death rates during the war, we found estimates for seven countries (France, Germany, Italy, United Kingdom, United States, China, and Taiwan). For the

[8]The high U.S. economic growth during World War II is an outlier. Germany did well economically during much of the war but then experienced a fall in per capita GDP from 1944 to 1946 by a staggering 74 percent (the largest macroeconomic disaster in the whole sample). For many other countries, World War II was also an economic disaster.

[9]See Ursúa (2011). The information is in the Barro-Ursua data set, available under Data Sets at scholar.harvard.edu/barro.

remaining countries involved in World War I, we use the annual distribution of deaths from countries that either fought alongside or against the given country. For example, British Commonwealth countries and colonies are assigned the time distribution of the United Kingdom, while Austria, Japan, Russia, and Greece follow that of Germany. The resulting data are in Table 2.

Our sample has a total of 6.2 million combat-related military deaths from 1914 to 1918. This number substantially understates the commonly cited total death toll for World War I of around 20 million, but this larger figure includes deaths of soldiers due to illness and while prisoners of war as well as civilian excess deaths from a variety of causes. The main point is that the deaths of soldiers in combat are measured most accurately and are likely to be a satisfactory proxy for the intensity of the war across countries and over time.[10]

An important point is that the data contained in Tables 1 and 2 encompass a lot of independent movements in flu and war death rates in 1918, the peak year of the Great Influenza Pandemic and the final year of World War I. Notably, many countries that experienced the flu were not involved in the war.

Table 3 uses regression analysis to assess effects of the Great Influenza Pandemic and World War I on economic growth, gauged by growth rates of real per capita GDP and real per capita consumption (personal consumer expenditure). The sample periods for annual growth rates are 1901 to 1929. The start year is somewhat arbitrary, and results are similar if we go back to 1870. The ending of the sample in 1929 simplifies the analysis by excluding the Great Depression. The cross-section corresponds to the 42 countries for which we have data on real

[10]Deaths in battle are positively and significantly correlated with the number of people mobilized by combatant countries, another proxy of war intensity that is reliably measured in military records.

per capita GDP.[11] (The sample for consumption is smaller because of missing data.) The explanatory variables are the flu and war death rates, as shown in Tables 1 and 2. Values for the flu death rate outside of 1918-1920 are set to zero,[12] and similarly for the war death rate outside of 1914-1918. The regressions include no other explanatory variables aside from constant terms. That is, our focus is on the two disaster shocks—flu and war—which we treat as (mostly) exogenous variables. We also view the associated events—World War I and the Great Influenza Pandemic—as unanticipated and contemporaneously perceived as having some persistence but ultimately being temporary. The results for GDP growth are in the first three columns and those for consumption growth are in the next three columns. Estimation is by panel least squares, with standard errors of estimated coefficients computed by allowing for clustering of the error terms by year.[13]

The regression for GDP growth in column 1 includes only the contemporaneous values of the flu and war death rates. The two estimated coefficients are significantly negative at least at the 5 percent level—indicating that flu and war are both bad for economic growth.[14] The coefficient of -3.0 on the flu death rate means that, at the cumulated aggregate death rate of 0.020 for 1918-1921 (Table 1), the Great Influenza Pandemic is estimated to have reduced real per capita GDP by 6.0 percent in the typical country. Given the cross-country range of experience

[11]This sample excludes Hungary, for which we have data on the flu death rate. (Hungary and Austria were part of Austria-Hungary until the end of World War I in 1918.)
[12]Except for the non-zero value for Chile in 1921.
[13]The R-squared values are low in these regressions because the two explanatory variables considered—flu and war death rates—operate at non-zero values only between 1914 and 1921. More important for our purposes are the statistical significance of the estimated coefficients on these two variables.
[14]The results shown in Table 3, column 1 (and other columns) change negligibly if country fixed effects are added. Inclusion of year fixed effects has a moderate impact; for example, the estimated coefficients in the column 1 specification become -2.60 (s.e.=1.25) on the flu death rate and -13.7 (2.9) on the war death rate. The changes in the results likely arise because the year effects absorb part of the relationship between economic growth and the two death rates, which are large for many countries at the same points in time. It is unclear that one would want to filter out this connection of global economic growth to aggregate death rates; that is, to the presence of the worldwide Great Influenza Pandemic and World War I.

with flu intensity, this result accords with the observation from before that the pandemic could have caused a substantial number of rare macroeconomic disasters in the sense of declines in real per capita GDP by 10 percent or more.

The coefficient of -17.9 on the war death rate means that, at the cumulated mean death rate of 0.0047 for 1914-1918, World War I is estimated to have reduced real per capita GDP in the typical country by 8.4 percent. This result accords with the large number of macroeconomic disasters associated with World War I, as reported in Barro and Ursúa (2008, Table C2).

The form of the regression in column 1 of Table 3 implies that the negative effects of temporary flu and war on growth rates are temporary and, hence, that the adverse effects on levels of real per capita GDP are permanent. Column 2 tests for these implications by including lags of flu and war death rates in the specification.. If the depressing effects of temporarily high flu and war death rates on the level of per capita GDP were only temporary, then lagged values of these death rates should, eventually, have positive coefficients—that is, negative growth-rate effects would be offset in the long run by recovery in the form of positive growth-rate effects.

Column 2 adds as regressors the average of the flu and war death rates for annual lags 1 through 4 and for annual lags 5 through 8. For flu death rates, the estimated coefficient on these two lagged variables are each positive but insignificantly different from zero at the 5 percent level. The two lags are also jointly insignificantly different from zero (p-value=0.25). However, we also cannot reject the hypothesis that the sum of the coefficients on the contemporaneous and lagged flu variables add to zero (p-value=0.48). Therefore, the results cannot rule out effects of the flu pandemic on the level of real per capita GDP that are fully permanent (corresponding to a coefficient of zero on the lagged variables) or fully temporary (where the coefficients on the contemporaneous and lagged variables sum to zero) or somewhere in between.

For war death rates, the first lag variable is significantly negative, indicating that the adverse effect of war on GDP growth tends to build up for a while. Then the second lag variable is significantly positive, indicating a systematic tendency for recovery of per capita GDP following a prior war. In this case, the sum of the three coefficients related to the war death rate is significantly negative (p-value=0.012). This results implies that the recovery from wartime economic decline is only partial; that is, part of the negative effect on the level of per capita GDP—roughly half—is permanent. This finding accords with broader results about rare macroeconomic disasters reported in Nakamura, Steinsson, Barro, and Ursúa (2013) and Barro and Jin (2019). Those studies found for a broad panel of countries that about half of disaster-related declines in consumption were permanent.

Columns 3 and 4 repeat the analysis for consumption growth rates. The sample size is smaller than that for GDP mostly because only 30 of the countries have full annual data on consumption going back at least to 1914. The main results are analogous to those for GDP growth rates, although the estimated effects on consumption growth are larger in magnitude. This result is not surprising for wartime effects, because the expansion of government outlays for the war would depress consumption beyond the effect from lower GDP. However, this pattern is surprising for flu effects.

We noted before the substantial number of rare macroeconomic disasters with troughs between 1919 and 1921. One of these events is the sharp U.S. economic decline from 1918 to 1921 (12 percent for GDP, 16 percent for consumption). In the U.S. history since 1870, this event comes just after the Great Depression in terms of the extent of proportionate declines in

GDP and consumption.[15] However, although it likely played a role, the Great Influenza Pandemic is probably not the main source of the large contraction. First, the U.S. cumulated flu death rate of 0.52 percent corresponds to estimated decreases by only 1.5 percent for GDP and 2.1 percent for consumption (using the respective regressions coefficients on the influenza death rate from columns 1 and 3 of Table 3). Second, part of the timing is off—although there were substantial declines in GDP and consumption in 1919 and 1920, the largest decreases were in 1921 (6 percent for GDP and 7 percent for consumption), well after the peak of the U.S. flu death rate in 1918.

In contrast to the United States, both the magnitude of expected declines and their timing fit better for other cases in our sample. As an example for GDP, our regression results (column 1 in Table 3) imply an expected contraction in India by 15.6 percent driven by both death rates. This amount is close to the observed contraction by 14.6 percent in India between 1916 and 1918, troughing precisely in the year when it was most affected by the pandemic. As an example for consumption, our results (column 3 in Table 3) imply an expected contraction in Canada by 16.5 percent. The actual figure for 1918-1921 was 19.6 percent, but a large part of that contraction happened between 1918 and 1919 (by 12.3 percent), which at least in part can be attributed to the negative impact of the pandemic in combination with war deaths.

Rates of Return and Inflation Rates

We now turn to exploring the effects of the pandemic- and war-related death rates on asset prices. Table 4 shows regression results for effects of flu and war death rates on realized real rates of return and inflation rates. As noted before, in interpreting the results, we view the

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[15]We are not counting here the sharp contraction in real GDP, but not consumption,, associated with the demobilization after World War II in 1946-1947. The GDP decline in this period is not customarily classified as a recession.

associated events—World War I and the Great Influenza Pandemic—as being unanticipated and contemporaneously perceived as having some persistence but ultimately being temporary. We consider returns on two types of assets: stocks (based on broad market indexes) and short-term government bills (analogous to U.S. Treasury Bills). In carrying out this analysis, we excluded observations with the most extreme inflation rates, which included hyperinflationary outcomes for Austria and Germany after World War I—the peak inflation rate was 1.8×10^{10} percent per year in Germany in 1923. These observations are sensitive to measurement error for inflation and, therefore, for real assets returns, which are computed from data on nominal returns and inflation rates. The simple linear relationships that we use would also not work for these extreme cases.

Columns 1 and 2 of Table 4 apply to realized real returns on stocks. The contemporaneous effect of the flu death rate is negative but statistically insignificantly different from zero. However, the point estimate, -13.1 (with a p-value of 0.13), is large. At a flu death rate of 2.0 percent (aggregate value from Table 1), this coefficient implies that the real stock return would be lower by 26 percentage points. At the U.S. death rate of 0.5 percent, the impact would be only 7 percentage points. Lagged effects are unimportant; that is, there is no prediction that the short-term negative effect will be reversed.

For the war death rate, the estimated contemporaneous effect is significantly negative. The coefficient, -40.0, implies that, at the mean war death rate of 0.0047 (from Table 2), the real stock return would be depressed by 19 percentage points. In this case, lagged effects are important, particularly the positive coefficient on the second lag. (The p-value for joint significance of the two lagged variables is 0.050.) A test that the coefficients of the contemporaneous and two lagged terms add to zero is accepted with a p-value of 0.27.

Therefore, the results predict an eventual recovery from the short-term stock-market decline, and the overall impact of war on real stock-market value might be zero.

Columns 3 and 4 of Table 4 cover realized real returns on government bills. The estimated coefficient on the contemporaneous flu death rate is significantly negative. The coefficient of -7.0 implies that the real return is depressed by 14 percentage points at a flu death rate of 2 percent (or by 3.5 percentage points at a flu death rate of 0.5 percent). This large effect can be interpreted partly as a decline in the "safe" expected real interest rate and partly as an effect of higher inflation (considered next) on the real returns on nominal claims (to the extent that bills have non-negligible maturity or that nominal rates paid on bills have some form of rigidity). The estimated coefficients on the lagged variables are individually and jointly insignificantly different from zero.

For the war death rate, the estimated coefficient on the contemporaneous variable is significantly negative. The coefficient of -27.2 means that, at the mean war death rate of 0.0047, the real return would be depressed by 13 percentage points. Lagged effects are unimportant here.

Columns 5 and 6 of Table 4 apply to the inflation rate. The data refer to reported price levels, which would have been influenced by price controls pursued during World War I in the United States and other countries, including Germany and the United Kingdom. The estimated effect of the Great Influenza Pandemic is significantly positive—the contemporaneous coefficient of 10.1 means that the inflation rate would have been higher by 20 percentage points at a flu death rate of 2 percent (or by 5 percentage points at a flu death rate of 0.5 percent). However, the estimated first lag coefficient is significantly negative and about the same magnitude, thereby indicating that the eventual effect on the price level could have been negligible (p-value =0.9 for the hypothesis that the coefficients of the contemporaneous and two lagged values add to zero).

For the war death rate, the contemporaneous coefficient is significantly positive, and the first lag coefficient is also significantly positive. In this case, the results reject the hypothesis (p-value=0.000) that the ultimate effect on the price level is nil.

The results on inflation confirm that the Great Influenza Pandemic and, especially, World War I increased inflation rates at least temporarily. These responses are important in interpreting the effects of these events on realized real rates of return, especially the effects on real T-bill returns that we considered before.

Implications for the Coronavirus Pandemic

The Great Influenza Pandemic of 1918-1920 represents a plausible worst-case scenario for disease outbreaks with global reach like COVID-19. Our findings show that, keeping everything else constant, the flu death rate of 2.0 percent out of the total population in 1918-1920 would translate into 150 million deaths worldwide when applied to the world's population of around 7.5 billion in 2020. Further, this death rate corresponds in our regression analysis to declines in the typical country by 6 percent for GDP and 8 percent for private consumption. These economic declines are comparable to those last seen during the global Great Recession of 2008-2009. Thus, the possibility exists not only for unprecedented numbers of deaths but also for a major global economic contraction. The results also show that the 1918-20 pandemic was accompanied by substantial short-term declines in real returns on stocks and short-term government bonds, driven by declines in economic activity and also higher inflation.

At this point, the probability that COVID-19 reaches anything close to the Great Influenza Pandemic seems remote, given advances in public-health care and measures that are being taken to mitigate propagation. In any event, the large potential losses in lives and economic activity justify substantial expenditure of resources to attempt to limit the damage. In effect, countries have been pursuing a policy of lowering real GDP—particularly as it relates to travel and commerce—as a way of curbing the spread of the disease. There is clearly a difficult tradeoff here concerning lives versus material goods, with very little discussion about how this tradeoff should be assessed and acted upon.

References

Barro, Robert J. and Tao Jin (2019). "Rare Events and Long-Run Risks." Unpublished, Harvard University, December.

Barro, Robert J. and Jose F. Ursúa (2008). "Macroeconomic Crises since 1870." *Brookings Papers on Economic Activity*, 39 (Spring): 255-350.

Burnet, Frank M. and Ellen Clark (1942). *Influenza, A Survey of the last 50 Years in the Light of Modern Work on the Virus of Epidemic Influenza*. Melbourne, Macmillan.

Frost, Wade H. (1920). "Statistics of Influenza Morbidity: with Special Reference to Certain Factors in Case Incidence and Case Fatality." *Public Health Reports*, 35 (11) (March 12): 584-597.

Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org

Johnson, Niall P.A.S. and Juergen Mueller (2002). "Updating the Accounts: Global Mortality of the 1918-1920 'Spanish' Influenza Pandemic." *Bulletin of the History of Medicine* 76 (1): 105-115.

McEvedy, Colin and Richard Jones (1978). *Atlas of World Population History*. New York, Penguin.

Mills, Christina E., James M. Robins, and Marc Lipsitch (2004). "Transmissibility of 1918 pandemic influenza." *Nature*, 432: 904-906.

Mitchell, Brian R. (2007). *International Historical Statistics.* New York, Palgrave.

Murray, Christopher, Alan D. Lopez, Brian Chin, Dennis Feehan, and Kenneth H. Hill (2007). "Estimation of Potential Global Pandemic Influenza Mortality on the Basis of Vital Registry Data from the 1918–20 Pandemic: A Quantitative Analysis." *The Lancet* 368, no. 9554: 2211–2218.

Nakamura, Emi, Jon Steinsson, Robert J. Barro, and José F. Ursúa (2013). "Crises and Recoveries in an Empirical Model of Consumption Disasters." *American Economic Journal: Macroeconomics*, 5: 35–74.

Taubenberger, Jeffery K., and David M. Morens (2006). "1918 Influenza: The Mother of All Pandemics." *Emerging Infectious Diseases* 12 (1): 15–22.

Tomkins, Sandra M. (1992). "The influenza epidemic of 1918-19 in Western Samoa." *The Journal of Pacific History*, v. 26-27: 181-197

Urlanis, Boris (2003). *Wars and Population*. Forest Grove, Oregon, University Press of the Pacific.

Ursúa, José F. (2009). "Flu, War, and Economic Recessions." Unpublished, Harvard University, November.

Ursúa, José F. (2011). “Macroeconomic Archaeology: Unearthing Risk, Disasters, and Trends.”, PhD Dissertation, Harvard University, Chapter 1.

Weng, Joanna (2016). *Blue from the Flu? A Cross-Country Panel Analysis of the 1918-1920 Great Influenza on Macroeconomic Growth*. Unpublished senior thesis, Harvard University, March.

Table 1

Flu Death Rates during the Great Influenza Pandemic, 1918-1920

	1918	1919	1920	Sum
Argentina	.0016	.0017	0	.0033
Australia	0	.0024	.0004	.0028
Austria	.0076	.0021	0	.0097
Belgium	.0071	.0011	.0001	.0083
Brazil	.0048	.0021	0	.0069
Canada	.0040	.0015	.0007	.0062
Chile	.0006	.0053	.0003	.0086*
China	.0056	.0065	.0022	.0143
Colombia	.0044	0	.0002	.0046
Denmark	.0017	.0008	.0006	.0031
Egypt	.0079	.0018	.0010	.0107
Finland	.0054	.0015	.0002	.0071
France	.0052	.0022	0	.0074
Germany	.0065	.0002	.0010	.0078
Greece	.0043	.0002	0	.0045
Hungary	.0091	.0026	.0010	.0127
Iceland	.0044	.0021	.0015	.0080
India	.0410	.0086	.0026	.0522
Indonesia	.0228	.0076	0	.0304
Italy	.0117	.0006	0	.0123
Japan	.0040	.0018	.0037	.0096
Korea	.0077	.0024	.0037	.0138
Malaysia	.0123	.0006	0	.0129
Mexico	.0155	0	.0052	.0206
Netherlands	.0055	.0014	.0002	.0071
New Zealand	.0057	.0003	.0009	.0069
Norway	.0045	.0011	.0001	.0057
Peru	.0010	.0010	.0019	.0039
Philippines	.0107	.0082	0	.0188
Portugal	.0172	.0009	0	.0181
Russia	.0142	.0039	.0006	.0187
Singapore	.0099	.0014	.0016	.0129
South Africa	.0211	.0124	0	.0336
Spain	.0105	.0014	.0017	.0136
Sri Lanka	.0057	.0100	.0017	.0174
Sweden	.0047	.0014	.0002	.0063
Switzerland	.0053	.0011	.0012	.0076
Taiwan	.0053	.0002	.0052	.0107
Turkey	.0103	.0005	0	.0108
United Kingdom	.0034	.0012	0	.0046

United States	.0039	.0007	.0005	.0052
Uruguay	.0013	.0005	.0004	.0022
Venezuela	.0099	.0026	0	.0125
Means	.0080	.0025	.0009	.0115
Aggregate death rate	.0138	.0049	.0016	.0200

*Chile's flu death rate in 1921 is .0023. All other flu death rates are zero in all years outside of 1918-1920.

Note: Sums are the additions of the death rates from 1918, 1919, 1920, and 1921. Means are unweighted averages of the flu death rates across the 43 countries. The aggregate death rate is the ratio of total flu deaths for the 43 countries to the total population of these countries. This value exceeds the mean of the death rates because of the positive correlation between a country's death rate and its population (driven especially by India).

Table 2

War Death Rates for Military in Combat during World War I, 1914-1918

Country	Estimated War Death Rate (fraction of total population)					
	1914	1915	1916	1917	1918	Sum
Argentina	0	0	0	0	0	0
Australia	.0003	.0012	.0029	.0038	.0028	.0110
Austria	.0020	.0071	.0050	.0047	.0054	.0242
Belgium	.0046	0	0	0	0	.0046
Brazil	0	0	0	0	0	0
Canada	.0002	.0007	.0017	.0022	.0017	.0066
Chile	0	0	0	0	0	0
China	0	0	.00002	.00003	.00003	.00008
Colombia	0	0	0	0	0	0
Denmark	0	0	0	0	0	0
Egypt	0	0	0	0	0	0
Finland*	--	--	--	--	--	--
France	.0030	.0034	.0025	.0016	.0023	.0128
Germany	.0023	.0079	.0055	.0050	.0057	.0265
Greece	0	0	0	.0010	.0012	.0022
Hungary	.0020	.0071	.0050	.0047	.0054	.0242
Iceland	0	0	0	0	0	0
India	.000003	.000010	.000022	.000029	.000021	.00008
Indonesia	0	0	0	0	0	0
Italy	0	.0021	.0038	.0049	.0013	.0121
Japan	.00003	.00011	.00008	.00007	.00008	.00037
Korea	0	0	0	0	0	0
Malaysia	0	0	0	0	0	0
Mexico	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0
New Zealand	.0004	.0014	.0033	.0043	.0032	.0127
Norway	0	0	0	0	0	0
Peru	0	0	0	0	0	0
Philippines	0	0	0	0	0	0
Portugal	0	0	.0003	.0004	.0003	.0010
Russia	.0008	.0026	.0018	.0016	.0019	.0087
Singapore	0	0	0	0	0	0
South Africa	.00002	.00009	.00021	.00027	.00020	.00079
Spain	0	0	0	0	0	0
Sri Lanka	0	0	0	0	0	0
Sweden	0	0	0	0	0	0
Switzerland	0	0	0	0	0	0
Taiwan	0	0	.00002	.00003	.00003	.00008
Turkey	.0004	.0017	.0038	.0050	.0038	.0147

United Kingdom	.0004	.0015	.0035	.0046	.0035	.0135
United States	0	0	0	.00001	.00051	.00053
Uruguay	0	0	0	0	0	0
Venezuela	0	0	0	0	0	0
Means	.00043	.00103	.00104	.00114	.00104	.00468

*In the available data, Finland's combat deaths through 1917 are included with Russia's.

Note: War death rates equal zero for all years outside 1914-1918. Russia's war deaths in 1918 apply to the revolution and civil war.

Table 3
Regressions for Economic Growth

Dependent variable	GDP growth rate		Consumption growth rate	
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**
Constant	0.0202*** (0.0034)	0.0169*** (0.0035)	0.0179*** (0.0033)	0.0150*** (0.0034)
Flu death rate	-2.98** (1.27)	-2.67** (1.18)	-4.06** (1.92)	-4.18** (1.82)
Lag of flu death rate	--	2.68 (2.10)	--	0.96 (2.06)
2nd lag of flu death rate	--	2.22 (2.10)	--	1.38 (1.93)
War death rate	-17.9*** (3.0)	-13.3*** (3.1)	-21.2*** (3.8)	-21.2*** (4.1)
Lag of war death rate	--	-10.2*** (3.8)	--	2.0 (4.9)
2nd lag of war death rate	--	12.5*** (3.3)	--	8.8** (4.2)
p-value, lags of flu death rate=0	--	0.25	--	0.70
p-value, lags of war death rate=0	--	0.000	--	0.081
p-value, coeffs of flu add to zero	--	0.48	--	0.051
p-value, coeffs of war add to zero	--	0.012	--	0.085
R-squared	0.041	0.043	0.057	0.058
s.e. of regression	0.070	0.070	0.077	0.077
Number of observations	1183	1175	875	867

Note: GDP growth rate refers to the annual growth rate of real per capita GDP. Consumption growth rate refers to the annual growth rate of real per capita personal consumer expenditure. Sample is from 1901 to 1929. The sample for GDP growth covers 42 countries. That for consumption growth has 30 countries, some of which are missing data for earlier parts of the sample but in all cases cover the whole war period. Lags of flu and war death rates are averages of annual lags 1 to 4. 2nd lags are averages of annual lags 5 to 8. Estimation is by panel least squares. The standard errors of coefficient estimates, shown in parentheses, allow for clustering of the error terms by year.

***Significant at 1 percent level.

**Significant at 5 percent level.

*Significant at 10 percent level.

Table 4
Regressions for Stock and Bill Returns and Inflation Rate

Dependent variable	Real stock return		Real T-bill return		Inflation rate	
Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Constant	0.063*** (0.017)	0.050*** (0.017)	0.026*** (0.008)	0.024*** (0.008)	0.024*** (0.009)	0.026*** (0.009)
Flu death rate	-13.1 (8.5)	-10.8 (8.2)	-7.0*** (2.2)	-6.8*** (2.1)	10.1*** (3.0)	10.0*** (2.8)
Lag of flu death rate	--	-2.3 (8.0)	--	4.5 (3.8)	--	-10.2** (4.8)
2nd lag of flu death rate	--	1.6 (6.2)	--	3.0 (3.8)	--	-0.8 (4.7)
War death rate	-40.0*** (14.3)	-30.9* (17.9)	-29.9*** (4.3)	-27.2*** (5.5)	28.6*** (4.3)	19.8*** (5.3)
Lag of war death rate	--	-15.4 (23.8)	--	-5.9 (9.3)	--	23.3*** (8.2)
2nd lag of war death rate	--	89.1** (36.4)	--	0.0 (6.2)	--	4.5 (5.6)
p-value, lags of flu death rate=0	--	0.93	--	0.33	--	0.102
p-value, lags of war death rate=0	--	0.050	--	0.59	--	0.012
p-value, coeffs of flu add to zero	--	0.35	--	0.89	--	0.89
p-value, coeffs of war add to zero	--	0.27	--	0.001	--	0.000
R-squared	0.028	0.082	0.106	0.113	0.089	0.113
s.e. of regression	0.209	0.204	0.091	0.090	0.098	0.096
Number of observations	533	529	520	512	893	885

Note: Real stock return is arithmetic annual realized rate of return on broad equity indexes, computed from total nominal returns (which include price appreciation and dividends) expressed relative to consumer price indexes. Real T-bill returns are analogous, computed for short-term government bills or analogous claims. Inflation rate, computed arithmetically, refers to consumer price indexes. Data are mostly from *Global Financial Data, and initially assembled as described in Barro and Ursúa (2008)*. Sample is from 1901 to 1929. Samples cover 27 countries for stock returns, 21 for bill returns, and 35 for inflation rates. The samples for the regressions were truncated to exclude inflation rates that exceeded 0.50. This exclusion applies to 22 observations for the inflation rate, 10 of which are for the post-WWI hyperinflations in Austria and Germany. Lags of flu and war death rates are averages of annual lags 1 to 4. 2nd lags are averages of annual lags 5 to 8. Estimation is by panel least squares. The standard errors of coefficient estimates, shown in parentheses, allow for clustering of the error terms by year.

***Significant at 1 percent level.
**Significant at 5 percent level.
*Significant at 10 percent level.