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WORKING PAPER NO. 568

Pandemics and Local Economic Growth: Evidence from the Great Influenza in Italy

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June 2020

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ISSN 2240-9696

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Pandemics and Local Economic Growth: Evidence from the Great Influenza in Italy

Mario F. Carillo[*] and Tullio Jappelli[**]

Abstract
We investigate the link between the 1918 Great Influenza and regional economic growth in Italy, a country in which the measures implemented by public authorities to contain the contagion were limited or ineffective. The pandemic caused about 600,000 deaths in Italy, a death rate of about 1.2%. We find evidence of a strong and significant adverse effect of the pandemic on regional growth. In particular, going from regions with the lowest mortality to those with the highest mortality is associated to a decline in per capita GDP growth of about 6.5%, which dissipated within three years. In line with this finding, we also estimate a small and transitory negative effect of the influenza on industrialization. Our estimates provide an upper bound of the adverse effect of pandemics on local economic growth in the absence of non-pharmaceutical public-health interventions.

Keywords: Great Influenza; regional growth; mortality and growth

Acknowledgements: We thank Paolo Malanima and Luigi Pistaferri for very helpful discussion and insights, Luigi Guiso, Franco Peracchi and seminar participants at Bocconi and CSEF for comments, and MIUR for financial support (PRIN Grant N. 2017RHFXK4).

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1 Introduction

The COVID-19 pandemic induced policymakers to take rapid decisions about urgent policy interventions to contain the contagion and its consequences. These decisions were based on weighting the effects of the pandemic and those of the interventions. However, the short and long-term economic consequences of a pandemic are not fully understood, mostly because historically they typically have been attenuated by government interventions.

We investigate this aspect by studying the effects of the 1918 Great Influenza Epidemic on local economic activity and exploring the different regional exposure to the pandemic in Italy. The limited or ineffective public health interventions undertaken to contain the pandemic combined with heterogeneous exposure across regions provide a unique opportunity to estimate the potentially adverse effect of a pandemic on local economic growth.

The 1918 influenza outbreak caused about 600,000 deaths in Italy which occurred mostly between end September and early November 1918. Mortality varied substantially across regions ranging from 0.7% in Veneto to 1.7% in Apulia and 1.9% in Campania. We use this variability across regions to investigate the effect of the health shock on subsequent GDP growth. To assess the impact on GDP of the influenza we follow an approach similar to that adopted by Barro et al. (2020), and regress regional GDP growth on flu mortality for various sample periods between 1900 and 1930, and controlling for other potential covariates such as war mortality, initial GDP, proxies for human capital, and regional fixed effects.

We find that the influenza contributed substantially to the different performance of the Italian regions during the 1919-21 recession. Regions with the highest mortality rates experienced a roughly 6.5% excess decline in GDP relative to regions that experienced the highest mortality rates. Using a distributed lag specification, we find that the impact of the influenza was highest immediately after the pandemic, and that the effect vanished after three years. In the long run (10 years and over), the statistical analysis reveals a small, negative and transitory effect of the influenza on the share of manufacturing employment. These findings are qualitatively consistent with recent cross-country evidence in Barro et al. (2020), and country evidence for the U.S. (Correia et al., 2020) and Denmark (Moller Dahl et al., 2020).

From an economic point of view, our results are consistent with a standard Solow growth model where a reduction in the labor force leads to a transitory reduction in economic growth. Historical accounts of the influenza pandemic reveal that the response of the health care system was essentially inadequate in all regions, and that

lockdown measures were mild and ineffective. These results allow a better understanding of the potential impact of an epidemic in a developing country with a poor health infrastructure and limited ability to impose and enforce lockdown measures.

The paper is organized as follows. In Section 2 we describe the development of the 1918 influenza in Italy and the recession of 1919-21. Section 3 reviews the possible economic mechanisms linking pandemics and economic growth, and the empirical literature on the economic effects of the 1918 influenza. Section 4 describes our data, and Section 5 provides descriptive evidence on the recessionary impact of the pandemic. Section 6 presents the regressions results linking GDP growth and influenza mortality for various sub-periods, taking into account initial regional differences in economic development. Section 7 explores the potential long-run consequences of the influenza, and Section 8 summarizes our main findings.

2 The 1918 Influenza in Italy

The 1918 influenza killed at least 40 million people worldwide (possibly many more), corresponding to 2.0 percent of the world's population at the time. Italy was one the most severely affected countries. Current estimates suggest that about 0.6 million out of 36 million people died similar to the number of military deaths in WWI, at an estimated mortality rate of 1.2%, below the world average but substantially above the mortality rates of other developed countries (Barro et al., 2020). For instance, in Germany, the estimated mortality rate was 0.8%, in the U.S. and the U.K. it was 0.5%, and in France it was 0.7%. So, the combined effect of influenza and war mortality reduced a population of 36 million by about 1.2 million between 1915 and 1918.

There were two waves of the influenza between May 1918 and early 1919. The first wave in Spring 1918 was relatively mild but the second wave was severe. The first infections were reported in late August and by mid-September the influenza had spread to all parts of Italy, reaching a peak in early to mid-October and ending mostly in November but with some cases still being registered in January and early February 1919. The influenza hit all parts of Italy very quickly. Tognotti (2015) provides a thorough investigation of the pandemic, and reports that deaths peaked in mid-October with only around a couple of weeks lag between it spread to the different regions of the country.[1]

Several factors contributed to the spread of the disease and the high mortality rate. First, the spread of the influence coincided with the end of WWI, the last Italian attack

[1] Daily deaths peaked on October 7 in Naples (256 cases), October 16 in Milan (127), October 18-19 in Turin (119 deaths), and October 19 in Rome (226 deaths).

against the Austro-Hungarians in late October, and the final victory on November 4, 1918. The movements of troops, sick soldiers and refugees in both Southern and Northern Italy most likely contributed to the rapid spread of the disease. While in many countries, social distancing and quarantine measures were implemented, in Italy the lack of coordination and poor organization meant that these measures were implemented too late to stop the pandemic and were largely ineffective.

The material conditions of the Italian population were another aggravating factor. Cohabitation of entire families in the same room, overcrowding, and lack of running water, electricity, toilets and sewers were the rule rather than the exception in many parts of Italy, with most people living in precarious conditions. Although we have no systematic accounts of social distancing measures which can be exploited in the empirical analysis of the economic impact of the pandemics, Tognotti (2015) reports that these measures were introduced only when the pandemic was out of control, and in practice were futile or unfeasible.[2]

Healthcare also was problematic since most doctors and medical personnel had been diverted to support the military, and hospitals existed only in large cities not smaller towns and rural areas. Finally, the information provided by the press was limited due to the initial censorship in place to ensure that the enemy did not receive news about the real proportion of the epidemic.

As in other countries, mortality was highest among the young (20 to 40 year olds) but the Italian case is peculiar for its excess mortality of young women. Pinnelli and Mancini (1998) proposed the explanation that since contagion depends on frequency of contact, girls were more likely to succumb because of their higher exposure to the flu based on their care of the elderly and sick. Mortality also varied considerable across regions, exceeding 1.5% in regions such as Campania and Apulia whereas in others such as Veneto it was substantially less than 1% (see Figure 1 and Table B.1 in Appendix B.). To some extent, these differences likely reflect resources, human capital and infrastructure gaps between the North and South of the country. Therefore, when assessing the economic consequences of epidemics it is important to take account pre-existing differences in initial conditions.

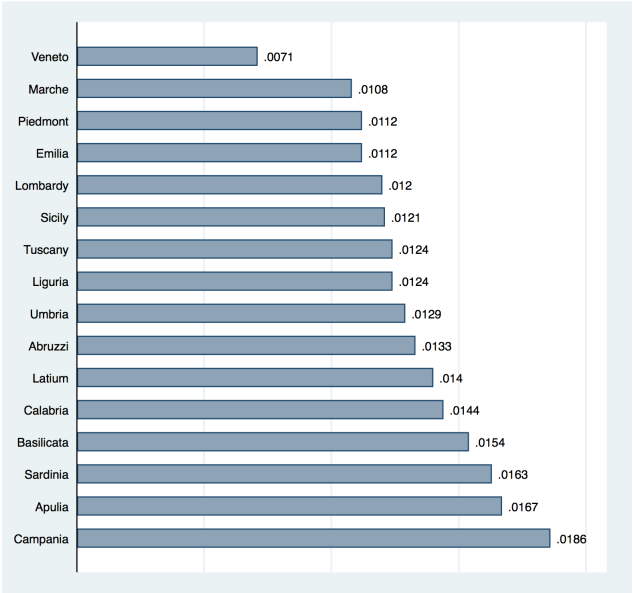
We base our analysis on recorded influenza mortality statistics. As Johnson and Mueller (2002) note, these data have potential limitations, given non-registration, missing records, misdiagnosis, and non-medical certification, and also may vary between locations. Indeed, Johnson and Mueller (2002) report national 1918 influenza mortality statistics showing that in many countries reported mortality rates are well below

[2] There are also reports showing that even at end September and early October 1918 when the epidemics was near its peak, large gatherings continued for religious or political reasons.

the rates recalculated after revisiting official records and calculating "excess" deaths recorded as due to influenza, respiratory causes or all causes. While we cannot exclude that reported mortality rates exhibit some variability at the regional level, in Italy the reported mortality rate (1.1%) is quite close to the recalculated death rate (1.07%) (Johnson and Mueller, 2002, p.113, Table 4), which is reassuring for our empirical analysis. In Appendix B we analyze in more detail the reliability of the statistics on mortality rate statistics used in the paper.

It should be noted also, that ideally, to assess the overall effect of the exposure to the influenza pandemic both contagion and mortality should be considered. Nevertheless, to the extent that contagion is proportional to mortality, our estimates include the overall effect of exposure to the disease.

Figure 1: Flu Mortality by Region



The pandemic hit the Italian economy in the last year of WWI, a period of significant economic expansion particularly of firms involved in war production stimulated by large government expenditures. The war was followed by a recession in 1919-21, which saw a large fall in per capita GDP in 1919 (-19%) and a cumulative decline of approximately 30% over the three years. In assessing the economic history of Italy, Malanima and Zamagni (2010) write that "public spending rose dramatically and was mostly financed with debt; particularly foreign debt. Social relations after the war became violently conflicting, and political stability was lost, with the rise of new movements and parties that destabilized the formation of long lasting-governments. Italian democracy was incapable of meeting these challenges and, in October 1922, Benito Mussolini became prime minister. At the end of 1925 he turned his government into a dictatorship." A feature of the fascist period is that it dramatically increased

the North-South divide. In the 50 years between 1861 and 1911 the South:North per capita GDP ratio declined by 13 points (from 93% to 80%), and during the fascist period (1922-1943) it declined by a further 21 points (to 59%).

The economic differences across regions before 1918 and the significant macroeconomic and political shocks that characterized the immediate post-WWI period of study induces some concern that areas more exposed to the pandemic may simultaneously be more exposed to other adverse economic shocks, given their low levels of health and education. Although we take account of initial conditions, the lack of regional convergence in economic growth between Northern and Southern regions suggests that our estimates should be interpreted with caution since they might plausibly indicate the upper bound of the potential adverse effect of the pandemic on regional growth trajectories.

3 The Economic Impact of Pandemics

In reviewing the literature on the economic consequences of the 1918 pandemic, it is useful to distinguish between short-run effects, long-run effects due to reduced productivity and human capital, and very long-run effects.[3] To evaluate the impact of the pandemic, a standard Solow growth model in which the pandemic destroys part of the labor force is useful. Suppose additionally that there is limited or no labor mobility across regions and countries. After the pandemic, the labor force (particularly the working-age group) shrinks, and the ratio of capital and land to labor increases. The scarcity of labor induces an increase in the wage rate and a reduction in the returns to capital and land, slowing investment and capital accumulation. The demand for investment falls, and the economy enters a recession with negative income per capita growth. In the medium and long runs, the capital-labor ratio recovers, wages fall, and the economy converges to the initial steady state.

The recessionary effect might be reinforced if the pandemic also affects the saving rate through an income effect due to the income loss from those exposed to the pandemic. Furthermore, as we can see today, individual and social measures to reduce the spread of the disease, loss of confidence and increased uncertainty seriously disrupt economic activity, reducing output and income in the short run.

The recession could have long run consequences because human capital (in the form of both health and education) falls during and after a pandemic, reducing labor productivity especially in higher human capital-intensive sectors (manufacturing). Human

[3] See Weil (2014) for an overview of the literature on health and economic growth.

capital externalities might affect the productivity of other workers, and of the economy at large. Thus, the reduction in savings might be exacerbated by lower investment in human capital, for instance in children's education and the health infrastructure.

While most economic arguments lead to the presumption that pandemics have recessionary effects, empirical analyses provide different estimates for size and duration of the effect. The typical empirical approach is to study variations in flu mortality rates across countries, regions or cities, and to trace the effect of the pandemic on various outcomes (GDP or GDP components, wages, poverty rates and human capital levels) in the years (or decades in some studies) after 1918.

In assessing the literature on the economic effects of the 1918 pandemic in the U.S., Garrett (2008) concludes that most of the evidence indicates that the effects were short-lived, hitting firms and households differentially. According to Garrett (2009), the most noticeable effect of the pandemic was to decrease the manufacturing labor supply and increase wages growth in U.S. states and cities by 2 to 3 percentage points for a 10 percent change in per capita mortality.

Brainerd and Siegler (2003) found that the 1918 epidemic was positively correlated to subsequent economic growth in the U.S. In particular, one additional death per thousand resulted in an average annual increase of 0.15% per year in the rate of growth of real per capita income over the following ten years. The authors argue that after the pandemic states with higher flu mortality rates showed a higher increase in capital per worker, and thus also income per worker.

More recently, Correia et al. (2020) used geographic variation in mortality during the 1918 influenza outbreak in the U.S., and found that more exposed areas experienced a sharp and persistent decline in economic activity. In particular, they found that the influenza epidemic led to an 18% reduction in state manufacturing output for states at the mean level of exposure. They use variation in the degree and intensity of non-pharmaceutical interventions (lockdown) and found that cities that intervened earlier and more aggressively performed no worse, and if anything, grew faster after the epidemic.[4]

The Swedish and Danish cases are interesting, because neither country was involved in WWI which reduces the risk of the pandemic's effects being confounded by disturbances related to the war. However, both countries suffered the indirect effects of the

[4] Not all economic historians agree with the fact that the 1918 flu epidemic had a large impact on the economy. According to Barry Eichengreen (interviewed by John Cassidy for the New Yorker on March 18, 2020), the economic impact of the 1918 pandemic in the U.S. was relatively mild: "The f had a big negative impact on retail sales, but, according to the available statistics, the over-all economy didn't fall into a recession. There was eventually a slump, in 1920-21, but Eichengreen and other economic historians have typically attributed it to the Federal Reserve raising interest rates to head off inflation".

war on international trade Karlsson et al. (2014) show that in Sweden the pandemic had a strong negative impact on capital income: the highest quartile (with respect to influenza mortality) experienced a drop of 5% during the pandemic and an additional 6% afterwards. The pandemic also increased the poverty rate (defined as the share of the population living in public poorhouses) but had no effect on earnings. Moller Dahl et al. (2020)find that more severely affected Danish municipalities experienced short-run declines in income (5% between 1917 and 1918), suggesting that the epidemic led to a V-shaped recession with relatively moderate, negative effects in the short-run and a full recovery after 2-3 years. They also report that unemployment rates were high during the epidemic but decreased only a couple of months after it declined. It should be noted also that overall, Denmark experienced one of the lowest mortality rates worldwide (Barro et al., 2020), 0.3% against a world average of 2%.

Barro et al. (2020) provide an overall assessment of the effect of epidemics in a cross-country comparative study. They regress the annual growth rate of per capita GDP between 1901 and 1929 against the current and lagged values of the flu death rate and the war death rate for a panel of 42 countries. They find a flu death rate coefficient of -3.0 meaning that, at the cumulative aggregate death rate of 2% for 1918-1921, the epidemic is estimated to have reduced real per capita GDP by 6% for the typical country.[5]

Several studies focus on the long-run consequence of the 1918 influenza. Almond (2006) shows that compared to other birth cohorts U.S. cohorts born during the pandemic have lower education attainment, increased rates of physical disability, and lower income. Percoco (2016) found that Italian cohorts born between 1918-20 experienced an average reduction of 0.3-0.4 years of schooling relative to other cohorts. Havari and Peracchi (2017) study war-related shocks (WWI, the Spanish Civil War, and WWII) and health shocks (the Great Influenza) and their links to childhood and adult outcomes for Europeans born during the first half of the 20^{th} century. They show that hardship during childhood or adolescence, particularly exposure to war events and hunger, is associated to worse physical and mental health, education, cognitive ability and subjective well-being at older ages. Guimbeau et al. (2020) find that in the Brazilian state of Sao Paolo the pandemic had significant effects on short-run infant mortality, sex ratios at birth, fertility and marriage patterns and a persisting impact on health, education attainment and productivity (as measured by the primary sector's output per employee and per establishment) in the long run. Using information on respondents' attitudes according to the General Social Survey (GSS), Le Moglie et al. (2020) suggest that experiencing the influenza pandemic had long-lasting consequences

[5] They also estimate the effect of death rates on consumption and asset prices. The effect on the consumption growth rate has the same sign as GDP, and is somewhat larger in magnitude. The effect of the flu death rate on both realized real returns on equity and short-term government bills is negative but only statistically different from zero for government bills.

on individuals' social trust. In particular, the authors find that lower social trust was passed on to the descendants of the survivors of the influenza pandemic who migrated to the U.S.

Finally, there is an important stream of work on the economic consequences of pandemics in Italy. For instance, Alfani (2013) emphasizes that as 17^{th} century plagues in Europe had more severe effects on Italy and Southern Europe generally, they hindered the economic performance of Italy relative to Northern European countries. Alfani and Percoco (2019) explore the effects of plagues for Italian cities in pre-industrial times. They show that the 1629-30 plague was linked to persistently lower economic growth in cities more exposed to the infection. Malanima (2018) points to the effect of the severe and frequent plagues that affected the Italian peninsula during the Renaissance (1350-1550) and shows that they were associated to an increase in resources per worker, and ultimately improving living standards which eventually converged to their low pre-Renaissance levels. Our study contributes to this strand of work by exploring the Great Influenza Epidemic which affected the Italian economy in a more recent historical period, and focusing on regional rather than aggregate economic growth.

4 Data

We use yearly data on real GDP per capita provided by Daniele and Malanima (2011) for the 16 Italian regions in 1918.[6] We link GDP data to information on influenza mortality from the 1918 Mortality Statistics Volume (*Statistica delle Cause di Morte 1918*) compiled by the Ministry of the National Economy (see Appendix B) which we digitized. These data provide information on causes of deaths. We follow the literature and measure deaths due to the Great Influenza by summing the deaths for two diseases (specifically we sum *influenza*, *broncopolmonite*, and *polmonite*). We construct the mortality variable by dividing the number of regional deaths from these diseases in 1918 by the population according to the 1911 Italian Statistical Office Population Census. Data for 1918 include most deaths from influenza. Our baseline estimates do not include data on influenza in 1919 but the robustness checks include 1919 deaths from influenza and pneumonia in the 1918 cases since these deaths occurred mostly in January and early February 1919.

We also digitized the number of deaths due to WWI from the *Albo d'Oro* archive

[6] Unfortunately, for the study period, yearly GDP data at finer levels of aggregation (province or municipality) are unavailable. After Italian unification, administration was the responsibility of central government, provinces and municipalities, with regions statistical units encompassing several provinces. They were introduced formally with the 1948 Constitution of the Republic but became effective only after the 1970 regional elections.

of the *Institute for History and Resistance and Contemporary Society* (Istoreco). Year of death often is uncertain because of late recording and lagged military deaths due to wounds. Thus, our variable for WWI death rates refers to the total number of military deaths during WWI in the 1911 population during the years when Italy was involved in the conflict (1915-1918) and is zero for the other years. For our long-run analysis, as outcome we use the regional share of the labor force employed in manufacturing taken from Daniele and Malanima (2014a). Appendix B provides further details on the variables definitions and sources.

5 Descriptive Evidence

To introduce the regression analysis, it is useful to report the correlations among flu mortality, GDP and human capital indicators in the pre-war period. Table 1 reports univariate regressions of per capita GDP in 1913, the share of manufacturing employment in 1911, the WWI death rate, 1911 literacy and the 1911 Human Development Indicator against the regional mortality rate due to the 1918 influenza. The regressions provide slight evidence that flu mortality was higher in those regions which before the war exhibited lower incomes and a lower share of labor employed in manufacturing. However, the standard errors (square brackets in Table 1) indicate that the correlations are not statistically different from zero.

Figure 2: Flu Mortality and WWI Mortality

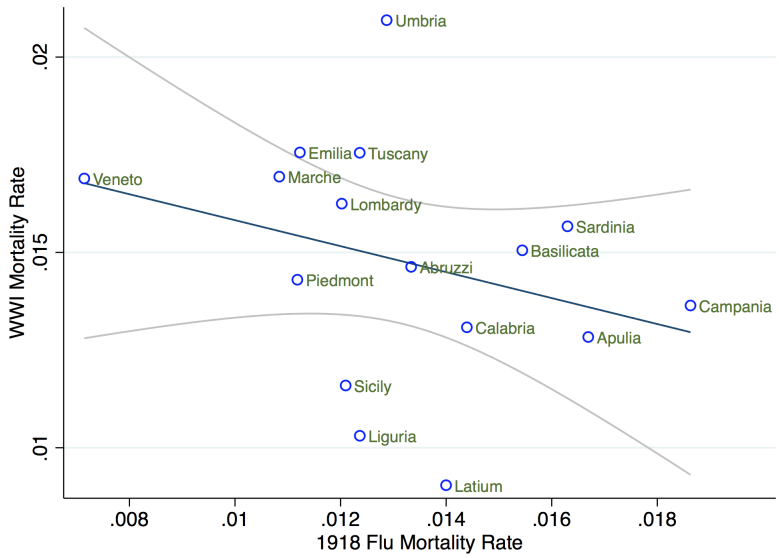


Table 1 and Figure 2 indicate that influenza mortality was lower in regions that suffered a high WWI death rate (the regression coefficient is -0.33 and statistically

Table 1: Flu Mortality and Pre-1918 Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variables:					
	Ln GDP pc Avg 1910-14	Ln GDP pc 1913	% Manuf. L.F. 1911	WWI Death Rate	Literacy 1911	HDI 1911
Flu Mortality 1918	-6.482	-7.753	-4.069	-0.332**	-40.349***	-36.143***
	[14.833]	[14.461]	[4.177]	[0.119]	[10.701]	[8.647]
Observations	16	16	16	16	16	16
R-squared	0.007	0.010	0.030	0.091	0.336	0.382

Notes: Observations are at the region-year level. Robust standard errors are reported in brackets. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

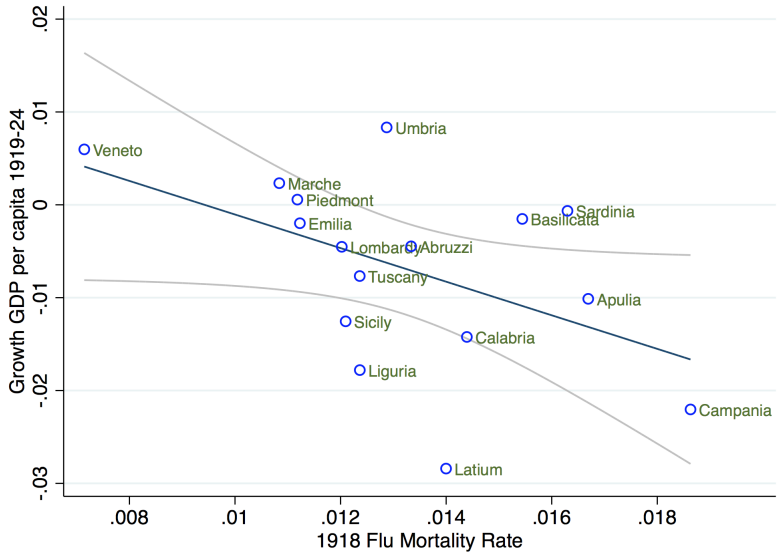
different from zero at the 5% level). For instance, Veneto has the lowest flu mortality but one of the highest WWI death rates; the central regions of Emilia, Marche and Tuscany exhibit relatively high war death rates but below average flu mortality. For our regression analysis the negative correlation between the two mortality rates helps to distinguish the separate effects of war and flu mortality on subsequent GDP growth. Table 1 shows also that flu mortality is correlated negatively to human capital indicators, as suggested also in Tognotti's (2015) historical account of the pandemic. Therefore, it is important in the empirical analysis to control for health conditions and education.

Figure 2 provides a first graphical analysis of the relation between the flu death rate and GDP growth rate in 1919-24. During this period, average growth was negative, reflecting the 1919-21 recession. However, regions with above average flu mortality (such as Calabria, Campania and Latium) exhibit lower than average growth, while regions with more limited mortality (Veneto and Marche) suffered a milder recession. Overall, Figure 2 shows that a doubling of the flu death rate (e.g. from 0.8% in Veneto to 1.6% in Sardinia and Apulia) is associated to a 1% reduction in subsequent annual growth.

6 Regression Analysis

In this section, we provide an empirical investigation of the link between our variable of interest (influenza mortality rate) and per capita GDP growth across the Italian regions. As described in Section 2, the highest levels of mortality due to the influenza pandemic occurred predominantly in 1918, and towards the end of the year in particular. Therefore, our variable of interest takes the value zero for the years before and after

Figure 3: Economic Growth and 1918 Flu Mortality



1918.

First, we explore the link between flu mortality and economic growth by means of an event-study analysis. We regress GDP per capita on flu mortality in 1918 with 10 year lags and 10 year leads. Specifically, we estimate the following empirical specification:

$$y_{it} = \alpha + \sum_{s=-10}^{+10} \beta_s \; flu\; mortality_{i,t+s} + \epsilon_{it} \tag{1}$$

where y_{it} is GDP growth in region i at time t, α is a constant, β_s is the set of the estimated coefficients, and ϵ_{it} is the error term. This allows us to check for the presence of pre-treatment trends in regional GDP growth and potential lags in the estimated relationship between mortality and growth. Figure 4 depicts the estimated β coefficients ordered by their distance from 1918, the year of the pandemic outbreak.

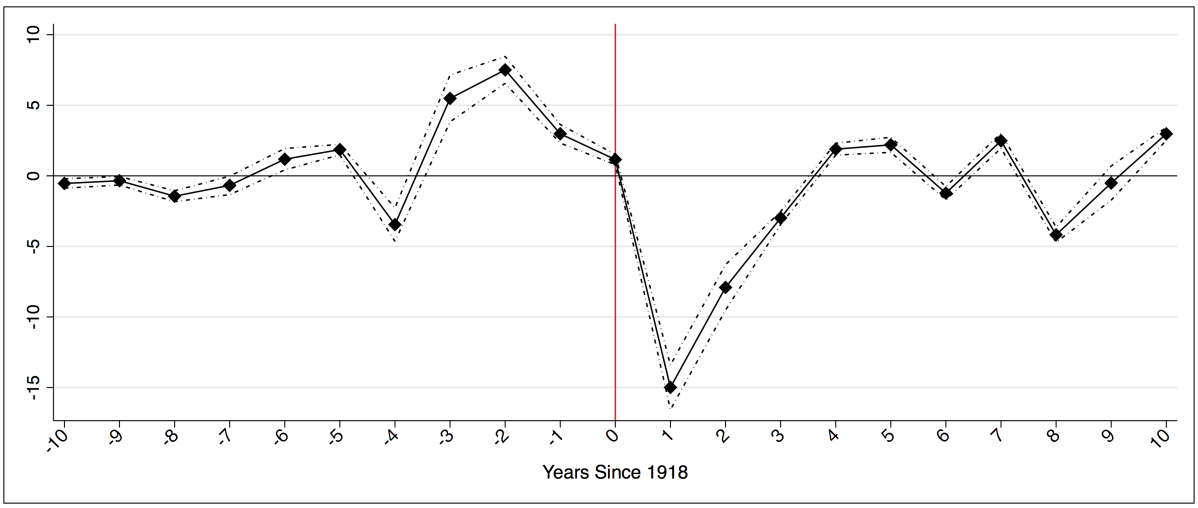
Figure 4 emphasizes three elements. First, the estimated coefficients for the 10th to the 5th year leads (from 1908 to 1913) do not reveal differential trends. However, from the 4th-year lead (1914) to 1918, the WWI period, we observe significant growth. Although there is no consensus among economic historians about the size of the economic boom during WWI, scholars agree that the war led to a significant expansion of GDP, led by large government expenditures and war-related production (Baffigi, 2015).

The pattern of pre-war coefficients points to the importance of explicit consideration of the differential exposure of regional growth rates to the war. Second, and in line

with the historical timing of the pandemic outbreak in Italy in late 1918, the negative link between flu mortality and economic growth emerges with a one-year lag (thus in 1919). This highlights the importance of introducing one-year lagged mortality in our empirical specifications.

Third, the estimated coefficients converge towards zero four years after the pandemic, and disappear in 1922. The pattern of the coefficients suggests that the growth effect of the influenza may have lasted about three years, pointing to the potential transitory nature of the adverse effect of the pandemic on local economic growth.

Figure 4: Economic Growth and Flu Mortality: Event-Study Analysis



Notes: The figure plots the estimated coefficients with a regression of regional growth in real GDP per capita on regional flu mortality in 1918 with 10 years lags and 10 years leads, and 95% confidence intervals. Robust standard errors are clustered at the regional level. The figure shows that the estimated link between influenza mortality and economic growth dissipated within 4 years of the event.

Table 2 presents our baseline specification. We restrict the sample of real per capita GDP growth to the years from 1919 to 1924 to capture the short-run effects of the pandemic and minimize concerns about the difficulty related to introducing WWI period data in the regression. Our variable of interest is influenza mortality in 1918 lagged one year. Figure 4 shows that this approach is consistent with the spread of the pandemic in Italy at the end of 1918, and its potential effect on living standards in 1919. Later, we extend the analysis by introducing both contemporary and lagged flu mortality effects. We correct the inference by clustering standards errors at the region level to allow serial correlation of the error terms across periods.

In column 1, the coefficient of flu mortality is -13.3 and is statistically different from zero at the 1% level. In terms of economic significance, an increase in influenza mortality equal to the 1918 average (1.32%) is associated to an average reduction of 17% in real GDP per capita growth, almost half of the overall decline in GDP in 1919-22. Alternatively, we could compare regions with relatively high and low mortality rates.

Table 2: Flu Mortality and Growth in GDP per capita 1919-1924

	(1)	(2)	(3)	(4)
Flu Mortality - 1 year lag	-13.371***	-10.841***	-10.492***	-11.440***
	[0.695]	[2.556]	[2.282]	[2.613]
Flu Mortality - 2 years lag				-7.904***
				[2.373]
Flu Mortality - 3 years lag				-1.927**
				[0.846]
Flu Mortality - 4 years lag				-0.485
				[0.526]
WWI Death Rate 1918		-2.402	-2.749	-3.334***
		[2.173]	[1.944]	[0.888]
Observations	96	96	96	96
R-squared	0.626	0.629	0.638	0.901
Initial GDP per capita	No	No	Yes	Yes
WWI Death Rate Lags	No	No	No	Yes

Notes: The dependent variable is the rate of growth of per capita GDP in 1919-1924. Observations are at region and year levels. Robust standard errors clustered at the regional level are reported in brackets. *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

For instance, going from Calabria or Basilicata which both have mortality rates of about 1.5%, to Marche or Piedmont which display rates of about 1%, is associated to a reduction in GDP growth of 6.5%.

These effects are broadly comparable in magnitude to Barro et al.'s (2020) around 6% estimated for a cross-country setting. Our coefficient is larger, possibly because interventions implemented by central and local authorities to limit the spread of the pandemics were weak or ineffective.

Table 2 column 2 controls for WWI mortality, i.e. the total number of military deaths during WWI over the population in 1911. The variable is lagged one year and takes the value zero for the years after 1918. The estimated coefficient of WWI mortality is negative but not statistically different from zero. However, the coefficient of flu mortality remains negative, statistically significant, and almost the same as the regression reported in column 1.

To take account pre-existing differences in levels of economic activity, column 3 controls for initial GDP per capita which refers to the initial year of the sample. Remarkably, this additional control has almost no effect on our coefficient of interest whose magnitude and statistical significance are almost unchanged. Since the previous discussion

shows that the effect of the influenza on economic growth could have extended over more than a single year, in column 4 we introduce four lags of flu mortality. As a control, we also introduce four lags for WWI mortality (coefficients not reported in Table 2). The coefficients of the lagged influenza variables are negative and significant up to the third lag, implying that the adverse effect of the pandemic on economic growth lasted for three years. This finding suggests that the effect of the Italian pandemic on regional economic growth was transitory which is consistent with recent findings for the effect of the 1918 influenza across Danish municipalities (Moller Dahl et al., 2020).

Table 3 extends the sample to 1929. We do not go beyond 1929 to avoid the confounding effect of the 1930s Great Depression. It can be seen that the estimated coefficients are very similar in magnitude and significance to those in Table 2. This further supports the conclusion that the adverse effects of the pandemic on growth were transitory.

Table 3: Flu Mortality and Growth of GDP per capita, 1919-1929

	(1)	(2)	(3)	(4)
Flu Mortality - 1 year lag	-13.371***	-10.841***	-10.492***	-11.440***
	[0.695]	[2.556]	[2.282]	[2.613]
Flu Mortality - 2 years lag				-7.904***
				[2.373]
Flu Mortality - 3 years lag				-1.927**
				[0.846]
Flu Mortality - 4 years lag				-0.485
				[0.526]
WWI Death Rate 1918		-2.402	-2.749	-3.334***
		[2.173]	[1.944]	[0.888]
Observations	96	96	96	96
R-squared	0.626	0.629	0.638	0.901
Initial GDP pc	No	No	Yes	Yes
WWI Death Rate Lags	No	No	No	Yes

Notes: The dependent variable is the rate of growth of per capita GDP in 1919-1929. Observations are at the region-year level. Robust standard errors clustered at the regional level are reported in brackets.
*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

Table 4 extends the sample backwards and includes the entire period 1901-1929. This longer sample allows us to include contemporaneous flu mortality, and lags up to the fourth year. The estimated coefficient of the contemporary effect in column 1 is positive and precisely estimated but is very small in magnitude. The contemporaneous coefficient refers to 1918 the last year of the war, which potentially might confound the estimates. In the next specification we control for WWI casualties to take account of

this effect. The coefficients of lagged flu mortality are negative and highly significant up to the third lag, in line with our previous findings. The coefficient of the fourth lag is positive and significant which suggests that the pandemic had only a transitory adverse effect on economic activity in line with the findings as in (Barro et al., 2020). However, our coefficient estimates are not robust across specifications, thus we cannot reject the hypothesis that the influenza had an effect on economic activity in the fourth year as well.

Table 4: Flu Mortality and Growth in GDP per capita 1901-1929

	(1)	(2)	(3)	(4)	(5)
Flu Mortality	0.586***	-0.210	-0.305	-0.230	-0.104
	[0.153]	[0.489]	[0.531]	[0.555]	[0.719]
Flu Mortality - 1 year lag	-15.555***	-13.392***	-13.565***	-13.619***	-13.390***
	[0.886]	[1.682]	[1.767]	[1.805]	[2.113]
Flu Mortality - 2 years lag	-8.474***	-4.857**	-5.031**	-4.985**	-4.756*
	[0.917]	[1.869]	[1.977]	[2.014]	[2.293]
Flu Mortality - 3 years lag	-3.555***	-3.805***	-3.978***	-3.824***	-3.595**
	[0.221]	[1.103]	[1.167]	[1.179]	[1.496]
Flu Mortality - 4 years lag	1.324***	-0.410	-0.505	-0.298	-0.172
	[0.243]	[0.944]	[0.994]	[0.965]	[1.123]
Observations	464	464	464	464	464
R-squared	0.562	0.715	0.718	0.726	0.726
WWI Death Rate	No	Yes	Yes	Yes	Yes
Initial GDP per capita	No	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes	Yes
Region FE	No	No	No	No	Yes

Notes: The dependent variable is the rate of growth of per capita GDP in 1901-1929. Observations are at the region-year level. Robust standard errors clustered at the regional level are reported in brackets.
*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

Table 4 column 2 includes the contemporaneous WWI death rate, and its lags up to four years. In line with the historical evidence, the contemporaneous effect becomes indistinguishable from zero, suggesting in turn that the potential confounding effect of WWI exposure may induce a bias with the opposite sign to the effect of flu mortality. The estimated coefficients of flu mortality lags are negative and significant up to the third lag. In column 3, we control for the initial level of per capita GDP. It is reassuring that the introduction of this control leads to only minor changes in the estimated coefficients. Column 4 accounts for potential common trends with the inclusion in the regression of a time polynomial of order 2. The results essentially remain unchanged, reducing concerns about the possible confounding effect of a common trend across

regions.

In column 5, we test the robustness of our results introducing regional (our geographical unit of analysis) fixed effects to control for heterogeneity in initial region specific conditions.[7] While this is not our preferred specification to gauge the magnitude of the estimated effect of flu mortality on growth, it should be noted that the estimates are robust to the introduction of fixed effects which absorb all regional (and time-invariant) differences in human capital, health status and population structure. Also, they control for specialization patterns across regions not captured by initial GDP. For instance, they control for differences between the North-West which was specialized in heavy industry, and the South which was specialized in agriculture.[8]

Overall, the regression results presented in this section point to a strong and negative association between flu mortality and economic growth in 1919, an effect that was absorbed over the next three years.

7 Influenza and Industrialization

Having explored the short-run nature of the link between the influenza and growth, we next analyze potential long-term effects of the pandemic. After WWI, Italy was a predominantly rural society, with 59% of the labor force employed in agriculture, 24% in industry and 17% in the service sector, and with less than one third of the population living in municipalities with more than 20,000 inhabitants (Malanima and Zamagni, 2010, Table A1). During the 1920s and 1930s, the process of industrialization was important for explaining the pattern of long-run regional development and labor force distribution (Carillo, 2020). Although the country growth rate did not keep up with other advanced economies, in the interwar period industrial output overtook agricultural output (Malanima and Zamagni, 2010). In this section, we explore whether the influenza epidemic slowed transition of the labor force towards the manufacturing sector in those regions with highest mortality rates, with persistent consequences for regional economic performance.

To test this hypothesis, we merge data on regional employment in the manufacturing employment (see Section 4 for sources) with our mortality data. Employment data are

[7] Appendix A, Table A.1, extends this specification and in the regression introduces additional variables (such as WWI-years fixed effects and national per-capita GDP), excludes potential outliers and reports the estimates with standard errors adjusted by two-way clustering.

[8] We introduced a dummy variable which takes the value 1 for regions specialized in heavy industries in what is known as the "industrial triangle" of Lombardy, Piedmont and Liguria, and its interaction with flu mortality. While the estimated coefficient of the variable "industrial triangle" is not statistically different from zero, the coefficient of the interaction term is negative and significant, suggesting that the adverse effect of influenza on growth was stronger in regions characterized by high capital intensity.

available only for the census years (1901, 1911, 1921, 1931 and 1936) but this allows us to check whether flu mortality had any effect on manufacturing employment in 1921 (3 years after the pandemic) and subsequent years. Table 5 presents the results.

Table 5: Flu Mortality and Industrialization

	(1)	(2)	(3)	(4)
Flu Mortality	-1.670**	-1.837**	-2.153*	-3.495***
	[0.588]	[0.682]	[1.102]	[1.011]
Flu Mortality - 1 period lag		-0.668	-0.984	-3.494*
		[0.895]	[1.529]	[1.803]
Flu Mortality - 2 periods lag			-0.949	-4.120
			[1.949]	[2.462]
WWI Mortality	0.382	0.673	1.269	0.041
	[0.419]	[0.483]	[0.843]	[1.145]
WWI Mortality - 1 period lag		1.161	1.758	-0.540
		[0.846]	[1.373]	[1.864]
WWI Mortality - 2 periods lag			1.790	-1.113
			[1.607]	[2.385]
Observations	80	80	80	80
R-squared	0.091	0.116	0.177	0.291
Region FE	Yes	Yes	Yes	Yes
Time Trend	No	No	No	Yes

Notes: The dependent variable is the share of the labor force employed in manufacturing from 1901 to 1936. Observations are at the region-year level. Robust standard errors clustered at the regional level are reported in brackets.
*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

Since there was no census conducted in 1918, Table 5 column 1 assigns flu mortality to 1921, the closest year to the year of the pandemic. We interpret the coefficient as the short- run effect of flu mortality on manufacturing employment. As in the growth regressions, we control also for WWI. All regressions include regional level fixed effects. The estimated coefficient of flu mortality is negative (-1.67) and statistically different from zero at the 5% level but small in terms of economic significance. For instance, comparing regions with 1% flu mortality with regions with 1.5% mortality is associated to a reduction in the share of manufacturing employment of 0.8%. The estimated coefficient of WWI mortality is not statistically different from zero.

In Table 5 column 2 we explore whether the effect of flu mortality persisted throughout the 1920s, introducing the lagged value of flu mortality in the regression. The coefficient is negative but not statistically different from zero suggesting that the effect of flu mortality was actually transitory. In column 3 we add a second lag and again

the coefficient is negative but not statistically significant. In column 4, we check the robustness of the results adding a linear and quadratic trend. Interestingly, the estimated coefficients are negative and significant only for 1921 (at the 1% level) and 1931 (at the 10% level) but are insignificant for 1936. This finding confirms that the pandemic had a small and transitory effect on the pace of industrialization in the interwar period.

8 Conclusions

In this paper, we conducted an empirical investigation of the link between pandemics and local economic growth in the context of the Italian 1918 influenza. Since public non-pharmaceutical interventions were either limited or mostly ineffective, the pandemic caused

about 600,00 deaths in a population of 36 million but distributed differently across regions. This variability allowed us to estimate the effect of flu mortality on regional per capita GDP growth. We found evidence of a strong and significant adverse effect of the pandemic on regional growth. For example, we found that comparing regions with the lowest and highest mortality rates there was negative GDP per capital growth of around 6.5%. The sign and magnitude of our estimated coefficients are comparable with recent findings for the cross country effect of the 1918 influenza pandemic on economic growth (Barro et al., 2020).

Our regressions show also that the link between flu mortality and growth dissipates three years after the shock, in line with recent studies of the influenza pandemic across localities in other countries. Furthermore, in the inter-war period we found no evidence of a persistent, long-run effect of the pandemic on the pace of regional development, measured by manufacturing employment share.

The limited interventions implemented to contain the pandemic combined with the inadequate health infrastructure that characterized many parts of Italy after WWI, make the Italian historical experience of the Great Influenza an important case to cast light on the economic consequences of pandemics in societies where it is impossible to implement lockdown policies or where health care systems are incapable of protecting citizens. The Italian case could be useful to compare the recessionary effects of pandemics in the absence of interventions with the harmful effects of interventions aimed at containing it. Given that exposure to pandemics depends also on pre-existing living standards, our findings should be interpreted cautiously and possibly considered an upper bound to the effects of pandemics on local economic growth. We hope that this study will stimulate future exploration of this important link and shed light on the

heterogeneous effects of pandemics across localities and individuals.

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Appendices

A Robustness

Table A.1: Alternative Specifications

	(1)	(2) Excluding Campania	(3) Excluding Veneto	(4)	(5)	(6)
Flu Mortality	-0.104	-0.126	-0.519	-1.935*	-1.826**	-1.826
	[0.719]	[0.879]	[0.771]	[0.921]	[0.803]	[1.909]
Flu Mortality - 1 year lag	-13.390***	-13.949***	-14.246***	-16.244***	-16.080***	-16.080***
	[2.113]	[2.574]	[2.287]	[3.447]	[3.537]	[3.284]
Flu Mortality - 2 years lag	-4.756*	-4.722	-5.649**	-3.925	-3.813	-3.813*
	[2.293]	[2.868]	[2.406]	[2.254]	[2.293]	[2.095]
Flu Mortality - 3 years lag	-3.595**	-3.988*	-4.481**	0.453	0.303	0.303
	[1.496]	[1.869]	[1.589]	[0.485]	[0.472]	[1.539]
Flu Mortality - 4 years lag	-0.172	-0.182	-0.748	5.239***	4.566***	4.566**
	[1.123]	[1.431]	[1.172]	[0.862]	[0.915]	[2.062]
Observations	464	435	435	464	464	464
R-squared	0.726	0.720	0.727	0.822	0.825	0.827
WWI Death Rate	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
National GDPpc	No	No	No	Yes	Yes	Yes
War Years FE	No	No	No	No	Yes	Yes
Two-Way Clustering SE	No	No	No	No	No	Yes

Notes: The dependent variable is growth of GDP per capita in 1901-1929. Observations are at region and year levels. For comparison, column 1 reproduces the same regression of the last column of Table 4. Columns 2 and 3 exclude, respectively, regions with the highest and lowest mortality rates (Campania and Veneto). WWI The "WWI Death rate" variables include the current value and four lags of the WWI death rate. The "Time trend" variables include a linear and quadratic time trend. National GDP per capita includes linear, quadratic and cubic terms of real national GDP per capita. War Years fixed effect is a dummy taking value one in the years in which Italy was in war (from 1915 to 1918). Robust standard errors clustered at the regional level are reported in brackets, except column 6 where standard errors are adjusted for two-way clustering over regions and years.
*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

Table A.2: Controlling for Age Structure and Sex Ratio

	(1)	(2)	(3)	(4)
Flu Mortality	-0.230	-0.205	-0.295	-0.302
	[0.555]	[0.567]	[0.588]	[0.601]
Flu Mortality - 1 year lag	-13.619***	-13.574***	-13.738***	-13.749***
	[1.805]	[1.837]	[1.870]	[1.899]
Flu Mortality - 2 years lag	-4.985**	-4.939**	-5.104**	-5.115**
	[2.014]	[2.021]	[2.073]	[2.073]
Flu Mortality - 3 years lag	-3.824***	-3.779***	-3.944***	-3.955***
	[1.179]	[1.217]	[1.248]	[1.285]
Flu Mortality - 4 years lag	-0.298	-0.273	-0.364	-0.371
	[0.965]	[0.969]	[0.996]	[0.998]
Observations	464	464	464	464
R-squared	0.726	0.726	0.726	0.727
WWI Death Rate	Yes	Yes	Yes	Yes
Initial GDP pc	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes
Share of Age $\in [20;40]$	No	Yes	No	Yes
Sex Ratio	No	No	Yes	Yes

Notes: The dependent variable is growth of GDP per capita in 1901-1929. Observations are at region and year levels. The table shows that the coefficient of flu mortality does not change appreciably when we introduce the age structure and the gender ratio as additional controls. For comparison, column 1 reproduces the same regression of column 4 of Table 4. Column 2 adds the regional share of the population aged 20 to 40 in 1911. Column 3 adds the regional gender ratio (number of males over number of females) in 1911. Robust standard errors clustered at the regional level are reported in brackets.
*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

Table A.3: Robustness to including Flu Mortality in 1919

	(1)	(2)	(3)	(4)	(5)
Flu Mortality (1918-19)	0.481***	-0.307	-0.401	-0.341	-0.274
	[0.124]	[0.428]	[0.472]	[0.493]	[0.634]
Flu Mortality (1918-19) - 1 year lag	-12.598***	-11.151***	-11.323***	-11.365***	-11.243***
	[0.702]	[1.431]	[1.516]	[1.548]	[1.809]
Flu Mortality (1918-19) - 2 year lag	-6.866***	-4.201**	-4.374**	-4.334**	-4.212**
	[0.737]	[1.576]	[1.681]	[1.713]	[1.954]
Flu Mortality (1918-19) - 3 year lag	-2.877***	-3.353***	-3.526***	-3.398***	-3.275**
	[0.171]	[0.966]	[1.036]	[1.047]	[1.319]
Flu Mortality (1918-19) - 4 year lag	1.082***	-0.464	-0.558	-0.386	-0.319
	[0.194]	[0.790]	[0.839]	[0.815]	[0.951]
Observations	464	464	464	464	464
R-squared	0.564	0.716	0.718	0.727	0.728
WWI Death Rate	No	Yes	Yes	Yes	Yes
Initial GDP pc	No	No	Yes	Yes	Yes
Time Trend	No	No	No	Yes	Yes
Region FE	No	No	No	No	Yes

Notes: The dependent variable is the growth rate of GDP in 1901-1929. Observations are at region and year levels. Robust standard errors clustered at the regional level are reported in brackets.

*** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.

B Data Description and Sources

Gross Domestic Product per capita: To explore the short-term link between flu mortality and economic activity, our study requires yearly GDP data. For this purpose, we rely on the series published by Daniele and Malanima (2011) for the 16 Italian regions. We are aware of the existence of other historical regional GDP data (Felice, 2013), and on the debate around them (Daniele and Malanima, 2014b), but to the best of our knowledge other sources provide regional GDP data only by decade, and thus cannot be used to estimate the short-term effects of the pandemic.

Flu Mortality Rate: The variable is defined as the number of deaths in 1918 for influenza and pneumonia (specifically we sum *influenza, broncopolmonite*, and *polmonite*) over population in 1911. The data are displayed in Table B.1. The source for flu mortality is the Mortality Statistics Volume for 1918 (*Statistica delle Cause di Morte 1918*) published by the Ministry of the National Economy. The source for population is the Italian Statistical Office Population Census.

There is no perfect way to measure flu mortality. One approach is to use official records. However, number of deaths for influenza and pneumonia may underestimate the actual number of deaths because official records may not count people that died from other diseases because of influenza contagion. On the other hand, the official numbers may over-estimate true mortality because they attribute to the pandemic mortality for influenza and pneumonia that would have occurred in the absence of the pandemic. An alternative approach is to estimate statistically excess mortality with respect to normal times.

We follow the first approach because we want to avoid ad-hoc decisions. But we also compare our estimate of flu mortality with existing estimates based on other approaches. We estimate 453,501 deaths in 1918 and 108,384 in 1919, a total of 561,885 deaths for influenza and pneumonia. An early study by Mortara (1925) found that deaths from August 1918 to March 1919 exceeded mortality for the same months of 1911-1913 by 532,457 units. Adding deaths of soldiers recorded by military authorities he raised the number to 600,000. Fornasin et al. (2018) use official death statistics and the *Albo d'oro*, a roll of honor of the Italians fallen in the WWI, placing the estimate at 466,000. Ansart et al. (2009) use an excess mortality approach. Using monthly data for the whole country they estimate a death toll of 544,288 individuals. These numbers are actually not far from our estimate of 532,457 deaths.

Furthermore, given that we control for WWI deaths, our estimated coefficient are potentially unaffected by military deaths due to influenza during the war. Finally, given that we rely on variability across regions, measurement error in flu mortality

would inflate standards errors without affecting the estimated coefficient under the assumption that measurement error is uncorrelated with regional economic growth in the year of the pandemic. Nevertheless, even if measurement error in influenza mortality was greater in regions characterized by slow growth it would induce a bias that is opposite in sign to the coefficient of interest.

World War I Death Rate: The variable is defined as the total number of military deaths during WWI over population in 1911. The year of death is not always certain and often military deaths occur with significant lags. Thus, our variable for WWI death rates takes value zero for the years before 1915 (the year in which Italy joined the war) and after 1918. Over the war years the variable equals the total number of military deaths due to WWI over population as of 1911. Source: *Albo d'Oro* archive of the *Institute for History and Resistance and Contemporary Society* (Istoreco).

Manufacturing Labor Force: Share of labor force employed in manufacturing in 1901, 1911, 1921, 1931, and 1936 (Daniele and Malanima, 2014a, Tab. 1).

Human Capital: We use the literacy rate in 1911 (Felice, 2007, Tab.6) and the Human Development Index (Felice, 2007, Tab.9;10) for the year 1911.

Table B.1: Flu Mortality and WWI Mortality by Region

Region	Flu Mortality in 1918	Flu Mortality in 1919	WWI Mortality	Population (000) in 1911
Abruzzi	20165	3939	22121	1512
Apulia	36639	6208	28173	2195
Basilicata	7505	1903	7316	486
Calabria	21963	4866	19965	1526
Campania	57789	13766	42315	3102
Emilia	31587	8498	49391	2813
Latium	24791	4083	16012	1771
Liguria	14924	4963	12440	1207
Lombardy	58780	13868	79437	4889
Marche	12410	3073	19395	1145
Piedmont	39078	12407	49982	3495
Sardinia	14147	3556	13600	868
Sicily	46111	8855	44197	3812
Tuscany	33009	7743	46860	2670
Umbria	7904	2129	12860	614
Veneto	26699	8527	63124	3737
Total	453501	108384	527188	35842

Notes: Column 2 reports the number of deaths in 1918 for influenza and pneumonia. Column 3 reports the number of deaths in 1919 for influenza and pneumonia. Column 4 reports the number of military deaths in WWI. Column 5 reports the population in 1911 (in thousands). See Appendix B for data sources.