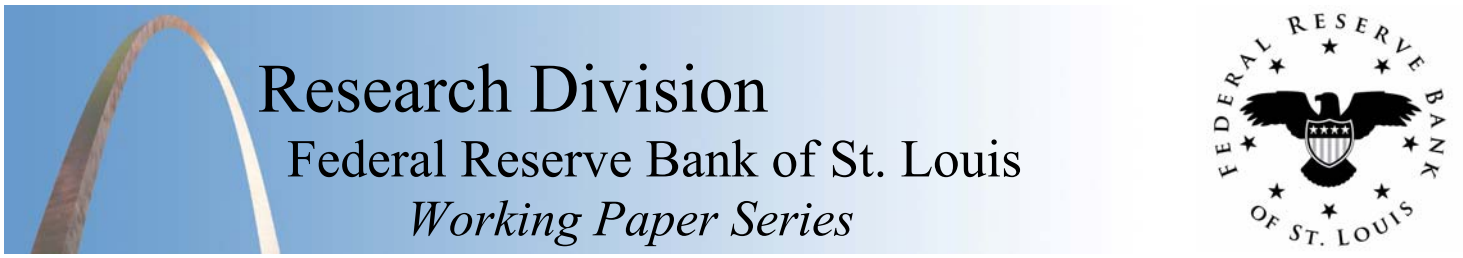

War and Pestilence as Labor Market Shocks: U.S. Manufacturing Wage Growth 1914-1919

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Abstract

This paper explores the effect of mortalities from the 1918 influenza pandemic and World War I on wage growth in the manufacturing sectors of U.S. states and cities from 1914 to 1919. The hypothesis is that both events caused a decrease in manufacturing labor supply, thereby initially increasing the marginal product of labor and wages. The results reveal that states and cities having had greater influenza mortalities experienced greater wage growth – roughly 2 to 3 percentage points for a 10 percent change in per capita mortalities. World War I combat mortalities also had a positive, but smaller, effect on wage growth.

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War and Pestilence as Labor Market Shocks:
U.S. Manufacturing Wage Growth 1914-1919

"…there is not a single expert machinist in the labor market today. If such a one exists he will be able to command his own wages….." *The Arkansas Gazette,* October 22, 1918.[1]

I. Introduction

The possibility of a world-wide influenza pandemic (i.e. the "Avian Flu") in the near future is of growing concern for many countries around the globe. The World Bank estimates that a global influenza pandemic would cost the world economy $800 billion and kill tens-of-millions of people.[2] Researchers at the U.S. Centers for Disease Control and Prevention calculate that deaths in the United States could reach 207,000 and the initial cost to the economy could approach $166 billion, or roughly 1.5 percent of GDP.[3] Long run costs are expected to be much greater. The U.S. Department of Health and Human Services paints a more dire picture – up to 1.9 million dead in the United States and initial economic costs near $200 billion.[4]

While researchers and public officials can only speculate on the likelihood of a global influenza pandemic, many of the worst case scenario predictions from a current pandemic are based on the global influenza pandemic of 1918-1919. This global pandemic (often termed the "Spanish Flu") killed 675,000 people in the United States (nearly 1 percent of the 1910 population) and nearly 40 million people world-wide.[5] Only the Black Death of 1348-1351 is estimated to have killed more people (roughly 60

[1] "Solving Problem of Labor with Dilution," *The Arkansas Gazette,* Little Rock, Arkansas, October 22, 1918, page 6.
[2] Brahmbhatt (2005).
[3] Meltzer et al. (1999).
[4] U.S. Department of Health and Human Services (2005).
[5] See Potter (2001). The 1918 influenza pandemic was termed the "Spanish Flu" by the Allies of World War I since Spain had one of the worst early outbreaks of the disease, with nearly 8 million people infected by early 1918.

million) over a similar time period.[6] The global magnitude and spread of the 1918 influenza pandemic was exacerbated by World War I, which itself is estimated to have killed roughly 10 million civilians and 9 million troops.[7] Not only did the mass movement of troops from around the world lead to the spread of the disease, tens of thousands of Allied and Central Power troops died as a result of the influenza pandemic rather than combat.[8] Although combat deaths in World War I did increase the mortality rates for participating countries, civilian mortality rates from the 1918 influenza pandemic were typically much higher. For the United States, estimates of combat related troop mortalities are about one-tenth that of civilian mortalities from the 1918 influenza pandemic.

Given the magnitudes and the concurrence of both the 1918 influenza pandemic and World War I, one would expect volumes of research on the economic effects of each event. Although there does exist a significant literature on the economic consequences of World War I (Rockoff, 2004), the scope of published research on the economic effects of the 1918 influenza pandemic is scant.[9] Most research that has been done has focused on the health and economic outcomes of decedents of pandemic survivors (Keyfits and Flieger, 1968; Almond, 2006) and mortality differences across socioeconomic classes (Noymer and Garenne, 2000; Mamelund, 2006).

This paper contributes to the literature on the economic effects of the 1918 influenza pandemic and World War I by exploring the influence of mortalities from these concurrent events on the growth of manufacturing wages in U.S. states and cities over the

[6] Bloom and Mahal (1997).
[7] See: http://en.wikipedia.org/wiki/World_War_I_casualties for a list of sources for the casualty statistics.
[8] See Ayres (1919).
[9] In their unpublished manuscript, Brainerd and Siegler (2003) conduct an analysis of the economic effects of the 1918 influenza in the decade following the pandemic.

period 1914-1919.[10] The general conceptual foundation for the paper is that, *ceteris paribus*, both of these events resulted in a large number of deaths which constituted a significant negative shock to manufacturing labor supply and thereby would have increased wages in the manufacturing sector immediately following both events. A similar conceptual framework has been used in studies that explored the economic effects of the Black Death (Campbell, 1997; Karakacili, 2004) and the effects of immigration on labor markets (Greenwood and McDowell, 1986; Borjas, 1987; Card, 1990).

The analysis presented here is the first to separate the potential manufacturing labor market effects of World War I and the 1918 influenza pandemic. This is an interesting exercise given that mortalities from the influenza pandemic were nearly ten times greater than World War I combat mortalities, but World War I combat mortalities were more likely men aged roughly 18 to 44, prime ages for manufacturing workers. The results reveal that state having had higher influenza and combat mortalities experienced greater growth in manufacturing wages over the period 1914 to 1919, and the greater number of influenza mortalities had a greater overall effect on manufacturing wage growth from 1914 to 1919 than did combat mortalities.

The paper is organized as follows: The next section presents state-level data on mortalities from the influenza pandemic and World War I and discusses differences in mortality rates across subpopulations. The third section of the paper discusses in more

[10] The manufacturing sector was chosen over other major employment sectors, such as agriculture, for several reasons. First, the Census of Agriculture prior to 1977 was conducted on a decennial basis (with the U.S. Census), thus only providing data for 1910 and 1920. It was thought that 1910 was too prior to the concurrence of the influenza pandemic and World War I to get reliable estimates of the influence of each event on agricultural wage growth. The coverage dates of the Census of Manufacturers (1914 and 1919) are more proximal to both events. Second, the U.S. Census of Agriculture only reported wage data for farm labor, which is only one of many classifications of agricultural employment. Third, many of the labor market control variables which are discussed later, such as value added and capital, are not available or, because of the limitations on the agriculture employment data, would provide misleading values for capital per worker and value added per worker.

detail the conceptual framework for the main hypothesis. The data and empirical methodology are discussed in the fourth section. The fifth section presents the empirical results from both state-level and city-level analyses and highlights the economic significance of the regression estimates. The final section of the paper concludes.

II. World War I and the Influenza Pandemic across the States

The influenza pandemic of 1918 began in early 1918 and lasted throughout the spring of 1919.[11] Unlike a typical influenza that predominately kills the youngest and oldest members of a population, Brainerd and Siegler (2003) report that the 1918 pandemic disproportionately killed people aged 15 to 44, with over one percent of the male population in the United States aged 25-34 dying from the disease. Data from the U.S. Bureau of the Census, *Mortality Statistics 1920* reveal that general population mortality rates in Maryland, Pennsylvania, and Colorado were the highest in the nation, with over one percent of the states' populations killed by the pandemic. Although male and female mortality rates are typically similar, Brainerd and Siegler (2003) report that the male mortality rate from the influenza pandemic was at least 50 percent higher than the female mortality rate.

Evidence also suggests that influenza mortality rates had no relationship with state economic conditions, climate, or geography (Crosby, 1989; Brainerd and Siegler, 2003). After providing a survey of anecdotal evidence and conducting statistical analyses, Brainerd and Siegler (2003, page 7) conclude that "The statistical evidence also supports the notion of influenza mortality as an exogenous shock to the population." Table 1 lists the states having the 5 highest and 5 lowest influenza mortality rates in

[11] See Crosby (1989) for a detailed discussion of the 1918-1919 influenza pandemic in the United States.

1916-1917 (non-pandemic years) and 1918, along with the average mortality rate for all other states.

[Table 1 about here]

American troops were deployed to Europe starting in the early summer of 1918 and remained there until the signing of the Armistice on November 11, 1918. The United States deployed over 4 million troops, and approximately 3 percent were killed in action (combat or otherwise). Table 1 lists the states having the 5 highest and 5 lowest combat mortality rates, as well as the average combat mortality rate for all other states. World War I combat mortality rates shown in Table 1 do not include death from diseases, such as the influenza pandemic. World War I combat mortality rates ranged from a low of about 19 per 100,000 population in Florida to over 161 per 100,000 population in Montana, with an average of about 52 per 100,000 population for all states.

III. The Conceptual Framework behind the Hypothesis

The testable hypothesis of this paper is that influenza and World War I mortalities had a direct impact on wage rates in the manufacturing sector immediately following both events. A neoclassical analysis of the market for manufacturing labor serves as the conceptual basis for this hypothesis. A decrease in the supply of manufacturing workers resulting from influenza and World War I mortalities would have had the initial effect of reducing manufacturing labor supply, increasing the marginal product of labor, and increasing real wages. Capital per worker would also have initially increased. In terms of the Solow (1956) growth model and the growth model of Romer (1986), this initial increase in capital per worker would have resulted in an increase in output per worker

and an increase in wages.[12] In the short term, labor immobility across cities or states is likely to have prevented wage equalization, and a substitution away from relatively more expensive labor to capital is unlikely to have occurred.[13]

The mortality rates and subpopulations most effected by each event are suggestive of the likely effect on wages. Mortalities from both events were disproportionately males aged 18 to 44. It is this subpopulation which constituted the common demographic of a manufacturing sector employee. For example, using 1910 data on the male population between the ages of 18 and 44, the average combat mortality rate from World War I was about 202 per 100,000 men aged 18 to 44, or about 4 times the total population mortality rate. The 1918 influenza pandemic also disproportionately killed men aged 25-34 compared to typical cases of influenza. Since state level mortality rates from the influenza pandemic were greater than the mortality rates from World War I, it seems reasonable that influenza mortality rates would have had a greater overall effect on manufacturing wage growth than World War I combat mortalities.

IV. Data and Empirical Methodology

To accurately assess the influence of influenza and World War I mortalities on the growth of manufacturing wages, it will be important when building the empirical model

[12] This framework assumes some degree of labor market flexibility during the late 1910s. There is no evidence that real or nominal wages were completely rigid during this period, although there is debate in the literature over wage flexibility (in response to the business cycle) at the beginning of the 20th century compared to the end of 20th century. See Gordon (1983), Schultze (1986), Allen (1992), Sundstrom (1992).

[13] The empirical models discussed later will capture the effect of labor mobility. The long run effect of influenza and war mortalities on manufacturing wage growth is less clear. Although the Solow (1956) growth model suggests that capital per worker will eventually fall (due to diminishing returns to capital) and therefore decrease wages, Romer's (1986) growth model predicts capital per worker will continue to rise over time as a result of non-diminishing returns to capital, thereby increasing wages. It is also possible that the war and the pandemic decreased consumer confidence, investment and savings, and long term income growth of households due to the death of households' primary breadwinners. These factors would result in lower aggregate output and production, thereby decreasing the demand for labor and placing downward pressure on manufacturing wages.

to consider others factors that are likely to have influenced the manufacturing labor market, and thus wage changes, over the period 1914-1919. For example, wartime production is likely to have increased wage rates as a result of an increase in labor demand. Also, general growth in manufacturing, and thus changes in labor supply and labor demand, from 1914 prior to World War I and the influenza pandemic should be considered. Finally, the capital stock available to manufacturing workers and the productivity of manufacturing labor are likely to have had effects on manufacturing wage growth. Descriptive statistics for all variables used in the analysis, which are discussed in detail below, are shown in Table 2.

[Table 2 about here]

Data

The dependent variable in the empirical model is the percentage change in real manufacturing wages per worker from 1914 to 1919. Data on the number of manufacturing wage earners and the total manufacturing wage bill for 1914 and 1919 were obtained from the 1919 U.S. Census of Manufactures. The 1919 estimates for the annual average wage per worker have been converted to 1914 prices using the national CPI.[14]

Influenza Mortalities 1918-1919

State-level mortality rates from the 1918 influenza pandemic were obtained from the U.S Bureau of the Census, *Mortality Statistics 1920* (page 30). The mortality rates

[14] The only effect of using real 1919 wages rather than nominal 1919 wages is that, with real 1919 wages, each coefficient estimate will differ from its value if nominal wages were used by a factor of θ, where θ is equal to the ratio of the 1914 and 1919 national CPI.

used in this study (and Brainerd and Siegler, 2003) represent deaths from both influenza and pneumonia because "it is not believed to be best to study separately influenza and the various forms of pneumonia….for doubtless many cases were returned as influenza when the deaths were caused by pneumonia and vice versa."[15]

Although the Census compilation is the most cited source for reliable influenza pandemic mortality estimates, the data do have several limitations, many of which can be remedied. First, only thirty states reported influenza and pneumonia deaths for 1918 and 1919.[16] Second, influenza and pneumonia were common diseases prior the 1918 pandemic, so an arguably better measure of how the pandemic affected mortality rates would be to compare mortality rates in non-pandemic years with the mortality rates in 1918 and 1919. One could then calculate how many more deaths than usual were from influenza and pneumonia in 1918 and 1919 and use this as an explanatory variable. Unfortunately, although *Mortality Statistics* contains annual data for a ten year period, these data are incomplete for many states for many years. For the thirty states that do report influenza and pneumonia deaths for 1918 and 1919, a portion of these states do not report mortality rates for other years, thus making a comparison between pandemic and non-pandemic years impossible. As a result, the state-level influenza and pneumonia mortality rate variable will be capturing "natural" influenza and pneumonia mortalities that occurred in 1918 and 1919 as well as the much higher number of deaths caused by the pandemic.[17] Table 1 allows a rough comparison of the "natural" influenza and

[15] U.S Bureau of the Census, *Mortality Statistics 1919*, page 28.
[16] The states excluded from the analysis are: Alabama, Arkansas, Arizona, District of Columbia, Delaware, Florida, Georgia, Iowa, Idaho, Mississippi, North Dakota, Nebraska, New Mexico, Nevada, Oklahoma, South Dakota, Texas, West Virginia and Wyoming.
[17] As is discussed later, city level mortality data is based on excess influenza mortalities as a result of the pandemic.

pneumonia mortality rate (1916-1917) and the rates from the 1918 pandemic. Mortality rates from the 1918 pandemic were roughly 2.5 times higher than in the non-pandemic years of 1916 and 1917.

A third issue is that the mortality death rates are based on annual state-level population values that were computed using linear interpolation between the 1910 and 1920 decennial census values.[18] By construct, this methodology imposes a constant growth rate in each state's population between 1910 and 1920. To correct for this fact, the mortality rates were re-computed using state 1914 population estimates based on U.S Census (1956) revisions of earlier estimates of state population.[19,20]

One final issue is the matching of influenza mortality to manufacturing employment. The majority of influenza mortalities were young to middle-aged men, which was a prime age for a manufacturing worker. However, men outside of this age range and some women were also employed in manufacturing. Thus, two different sets of mortality rates are employed for the state-level analysis to best link between influenza mortalities and manufacturing employment. The two mortality rates are: (1) total population mortality rates (men and women of all ages), and (2) mortality rates for men and women aged 20 to 49.

[18] See *Mortality Statistics 1920*, page 9.
[19] The mortality rates were re-computed as follows: First, the linearly interpolated population estimates were computed using the 1910 and 1920 decennial population estimates. The mortality rates for each of the 30 states in the sample were then each multiplied by the respective interpolated population value to get the number of deaths from influenza and pneumonia. The number of deaths was then divided by the revised U.S. Census (1956) estimates of 1914 population. The U.S. Census (1956) used statistical sampling rather than linear interpolation to re-estimate state population estimates for earlier years.
[20] State population in 1914 is used to normalize influenza and World War I mortalities because many of the labor market variables discussed later are normalized by the number of manufacturing workers in 1914. Normalizing influenza and World War I mortalities by state population in other years did not significantly change the empirical results. Differences in the mortality rates published in *Mortality Statistics* and the re-estimated mortality rates using the revised population estimates for 1914 were less than 1 percent.

World War I Mortalities

World War I servicemen mortality data are from the Adjutant General of the Army 1919 (1920). These data are quite detailed, listing the number of servicemen that died from various causes, such as accident, drowning, suicide, or homicide. Because the 1918 influenza pandemic affected troops during the war, the World War I combat mortality figures used in the empirical analysis are total serviceman mortalities minus the number of serviceman mortalities from disease. This is done to avoid double counting because soldiers who died from influenza are included in the pandemic mortality figures discussed earlier.[21] Like influenza mortalities, the number of serviceman combat mortalities from each state is normalized by 1914 state population.

One issue is the labor supply effect from the deployment of servicemen throughout 1918 to fight in World War I.[22] The absence of these troops from the manufacturing labor market would have immediately reduced the supply of labor and increased wages in that sector.[23] However, U.S. troops returned home after the signing of the Armistice in November 1918. Under the assumption that most of the servicemen who returned home from the war in late 1918 were re-employed (especially in a booming economy), then the labor supply shock lasting throughout 1919 would have been from combat mortalities. The fact that the 1919 U.S. Census of Manufacturers was taken in 1920 and covered the 1919 calendar year suggests a reasonable time period for the re-

[21] *Mortality Statistics 1920* (page 9). The combat mortality values also include deaths from accidents, etc.
[22] Contacts at the various branches of the armed services and the National Archives report that no comprehensive, official list of World War I servicemen by state exists. The population survey for the 1930 U.S. Census did ask the question of veteran status, but contacts at the Census Bureau report that this information has not been compiled by state and would likely be a misleading indicator of the number of servicemen during World War I due to mobility across states and the deaths of servicemen that occurred after the war but prior to the 1930 Census.
[23] The labor supply effect would have been less if servicemen were enlisted before the war began.

employment of returning troops and a reduction in labor supply resulting solely from combat mortalities.

Labor Market Control Variables

Because labor productivity influences wage rates, it is important to control for this influence in the empirical models. Capital per worker and value added per worker are included in the models to capture potential productivity differences across states. To avoid possible endogeneity problems, the 1914 value of both variables are included in the model rather than the percentage change in each variable from 1914 to 1919. Capital per worker in 1914 is computed using 1914 data on capital and the number of wage earners from the Census of Manufactures 1919. Similarly, value added in manufacturing in 1914 is divided by the number of wage earners in 1914 to get valued added per worker.

The effect of these two variables on the percentage change in wages is unclear. Theory suggests that states having had greater value added in manufacturing and greater manufacturing capital per worker were likely to have a higher *level* of wages. In fact, there is a high positive correlation between 1914 annual wages per manufacturing worker and 1914 value added per worker (ρ=0.81) and 1914 capital per worker (ρ=0.69). In terms of each variable's effect on the percentage change in wages, however, a story of convergence from Solow's (1956) growth model would suggest that a state having a lower initial level of productivity in 1914 would have had a greater percentage increase in productivity through 1919, and thus a higher rate of wage growth. Convergence would thus suggest a negative relationship between the two productivity variables and the percentage change in real wages per worker – higher levels of initial productivity (i.e.,

value added per worker and capital per worker) resulted in lower rates of wage growth. As support for the possibility of convergence in manufacturing wages, Barro and Sala-i-Martin (2004) provide evidence on the convergence of state personal income over decennial periods beginning in 1920 and twenty year intervals prior to 1920.

The United States did not officially enter World War I until President Wilson asked for and received a declaration of war on Germany by the U.S Congress in April 1917. Prior to this time, however, the United States did supply its European allies fighting the war with aircraft and weaponry. Shipbuilding and aircraft production encompassed the largest component of wartime production (Venzon, 1999). The New York Shipbuilding Company located in Camden, New Jersey was the predominant producer of World War I naval battleships and aircraft carriers, and employed 30,000 workers.[24] The largest contractors for military aircraft were located in Ohio, New York, and Michigan and employed nearly 200,000 workers.[25] It is reasonable to suspect that wartime production resulted in an increase in labor demand and thus wages in these states. To control for wartime production in the empirical models, a dummy variable is included that has the value of '1' if the state was involved in wartime production and a value of '0' otherwise. It is expected that the coefficient on wartime production is positive, reflecting the increase in labor demand and thus wage growth in war production states.[26]

[24] See http://members.aol.com/nyship/history.html.
[25] See http://centennialofflight.gov/essay/Aerospace/WWi/Aero5.htm.
[26] Certainly numerous states in addition to those listed here were involved in some form of wartime production. One cannot build ships and aircraft without steel and one cannot make steel without iron ore and coal, etc. The coefficient on the wartime dummy variable can thus be interpreted as wartime production of final goods.

The general growth of the manufacturing sector between 1914 and 1919 is another potential influence on manufacturing wage growth. A variable designed to capture the growth in a state's manufacturing sector is included in the models. Specifically, the variable is the percentage change in a state's manufacturing wage earner workforce between 1914 and 1919. This variable reflects the growth in a state's manufacturing sector from increases in labor demand and/or labor supply caused by factors such as population growth, immigration, labor force demographic change, technological change, etc.[27] If the percentage increase in the number of workers was predominately a result of increases in labor demand (supply), it is then expected that wage growth would have been higher (lower) in those states having had a manufacturing sector that increased more rapidly from 1914 to 1919.[28]

Empirical Methodology

To assess the influence of mortalities from the 1918 influenza pandemic and World War I on initial wage growth in the manufacturing sector, the percentage change in real manufacturing wages per worker from 1914-1919 is regressed on 1918-1919 influenza mortalities per capita, World War I mortalities per capita, value added per worker in 1914, capital per worker in 1914, the wartime production dummy variable, and the growth in manufacturing sector variable. In addition to the variables listed above, a

[27] For all states in the sample, the number of manufacturing workers increased from 1914 to 1919.
[28] Hausman tests reveal that the percentage change in manufacturing workers is exogenous to the percentage change in manufacturing wages. State population in 1914 and the percentage of children aged 5 to 18 that were enrolled in school in 1912 were used as instruments along with all exogenous variables listed in Table 2. The average *p*-value on the Hausman test statistics (*t*-statistic) was 0.71. The results will gladly be provided on request. The finding that the percentage change in manufacturing workers is exogenous is not too surprising given the time span used in this study, i.e., it is unlikely that a five-year period is long enough to capture the possible effect of higher wages inducing a substitution away from other sectors of the economy to the manufacturing sector.

set of three regional dummy variables based on U.S. Census regions are also included to capture unobserved differences in manufacturing wage growth, such as union activity.[29] Several regressions are run including or excluding variables as evidence for robustness across specifications.[30]

V. Empirical Results

The state-level results from eight different regression specifications are shown in Table 3. Influenza pandemic mortalities and World War I combat mortalities are included individually and together. The aggregate effect of mortalities from both events is also considered in specifications (7) and (8). Because of a relatively high level of correlation between value added per worker and capital per worker (ρ=0.76), regressions were estimated with and without both variables included as independent variables. To complement the empirical results in Table 3, evidence on the economic significance of each variable is shown in Table 4. The impact on wage growth from a 10 percent increase from the mean of each continuous independent variable is presented. The effect of each binary variable on manufacturing wage growth is also presented in Table 4.

[Table 3 about here]

[Table 4 about here]

The estimates shown in Table 3 reveal that most of the labor market control variables are statistically significant. The states involved in wartime production

[29] The dummy variable for the western region is omitted to avoid collinearity problems. The regional dummy variables may also capture the effects of African American emigration from the South as well as European emigration (Minns, 2000; Maloney, 2002).

[30] State population density was considered in all empirical models in order to test whether higher density states experienced greater growth in the manufacturing sector. Also, a measure of educational attainment (the percent of children aged 5 to 18 enrolled in public school in 1912) was considered. The coefficients were not statistically significant and the variables were thus omitted from the final regressions.

experienced a greater growth in manufacturing wages compared to non-production states (about 10 percentage points, on average, across specifications). Also, states with manufacturing sectors that grew at a faster rate over 1914-1919 experienced greater manufacturing wage growth. Specifically, the data in Table 4 reveal that growth in the manufacturing sector increased real manufacturing wage growth by 0.70 percentage points, on average. This suggests that overall increases in manufacturing labor demand were greater than overall increases in manufacturing labor supply. States with higher value added per worker in 1914 experienced a slower rate of real wage growth from 1914 to 1919 – a ten percent increase from the mean value is shown to have decreased manufacturing wage growth by 2.90 percentage points, on average. This finding supports the concept of convergence derived from the Solow (1956) growth model. Finally, the coefficients on the regional dummy variables reveal that the average growth in manufacturing wages was higher, on average, in southern and mid-western states (about 20 percentage points and 9 percentage points, respectively, on average) compared to states located in the west and northeast.

Turning to the variables of interest – influenza pandemic and World War I mortalities - the coefficient estimates on influenza and World War I combat mortalities reported in Table 3 are positive and significant, thus supporting the hypothesis that the reduction in manufacturing labor supply resulted in an initial increase in real wage growth in the manufacturing sector.[31] The coefficients on aggregated mortalities (specifications (7) and (8)) are also positive and statistically significant. The coefficient

[31] The marginal impact of an influenza death and a combat death on 1914-1919 wage growth was (statistically) the same. An F-test on the on the equality of the influenza mortality and the World War I combat mortality coefficients in specification (6) of Table 3 reveals that the null hypothesis of coefficient equality cannot be rejected at conventional levels (F=2.18).

estimates on influenza and World War I mortalities are also relatively stable across specifications.

The economic significance of the effect of influenza and World War I combat mortalities on manufacturing wage growth are shown in Table 4. Averaging across the predicted changes shown in Table 4, mortalities from the influenza pandemic and World War I resulted in a 1.93 and a 0.91 percentage point increase in real manufacturing wage growth, respectively.[32] The aggregate effect of influenza pandemic and World War I mortalities, shown in the fourth data column of Table 4, reveals a 2.49 percentage point increase in real manufacturing wage growth.

Influenza Mortalities Aged 20 to 49

Instead of considering the effect of all influenza deaths on manufacturing wage growth, empirical models are now estimated that consider influenza deaths of those aged 20 to 49. As reported earlier, influenza mortalities were disproportionately males aged 18 to 44.[33] The regression results are shown in Table 5. The first specification reveals that influenza deaths of those aged 20 to 49 had a positive and significant effect on manufacturing wage growth. The coefficient on influenza deaths is not significant in the second specification that also considers World War I mortalities, however. This is a likely result of the relatively high correlation between World War I mortalities and age 20

[32] Recall that the influenza mortality rate variable also contains a 'natural' rate of influenza mortality that would have occurred in the absence of a pandemic. On average, mortality rates from the influenza pandemic were about 2.5 times higher than the mortality rate in earlier non-pandemic years. If we assume that the pandemic's effect on wage growth is 2.5 times higher than the usual mortality rate, then this suggests that the net effect of the pandemic on wage growth was 1.16 percentage points (1.93-1.93/2.5).

[33] This variable was computed by summing influenza deaths in each state for those aged 20 to 29, 30 to 39, and 40 to 49. In the sample of states used here, influenza mortalities of those aged 20 to 49 averaged 46.1 percent of all influenza mortalities. This variable has a standard deviation of 6.4 percent, a minimum value of 35 percent, and a maximum value of 63 percent. The variable was normalized by 1914 state population.

to 49 influenza mortalities (ρ=0.60), which is supported by the large difference between the influenza mortality coefficients reported in specification (1) and (2). The total effect of World War I mortalities and age 20 to 49 influenza mortalities is positive and significant as seen in the third specification in Table 5, again suggesting that states having had more World War I and influenza mortalities experienced greater manufacturing wage growth.

[Table 5 about here]

The economic significance of World War I mortalities and age 20 to 49 influenza mortalities is demonstrated in Table 6 that considers the impact on wage growth from a 10 percent increase from the mean of the World War I mortality variable and the mean of the age 20 to 49 influenza mortality variable. Age 20 to 49 mortalities from the influenza pandemic and World War I mortalities resulted in a 1.21 and a 0.92 percentage point increase in real manufacturing wage growth, respectively. The aggregate effect of age 20 to 49 influenza mortalities and World War I mortalities reveals a 1.41 percentage point increase in real manufacturing wage growth.

[Table 6 about here]

City Influenza Mortalities and Wage Growth

An analysis similar to that done at the state level is now conducted using influenza mortality data for U.S. cities, but the analysis is absent any information about World War I mortalities since combat deaths by city are not available. All city labor market variables were obtained from the 1914 and 1919 U.S. Census of Manufacturers and are identical to those used in the state-level analysis. Mortality data are obtained

from a U.S. Public Health Service (1930) report on influenza mortality rates in 50 cities in the United States. The Public Health Service report provides monthly data on excess mortalities from the influenza on an annual basis.[34] For the purposes here, monthly city mortality rates were summed over the period March 1918 to April 1919 and then divided by twelve to get a city influenza death rate (per 100,000 population) during the pandemic. Excess influenza mortality rates by city during the pandemic are shown in Table 7.

[Table 7 about here]

The percentage change in city manufacturing wages per worker over the period 1914-1919 is regressed on excess influenza mortalities per capita (as described earlier), value added per worker in 1914, capital per worker in 1914, the wartime production dummy variable, and the growth in manufacturing sector variable. State dummy variables are included to capture any unobserved heterogeneity. Regression results are shown in Table 8.

[Table 8 about here]

The city-level regression results are somewhat different than the state-level results presented earlier. Although the coefficients on capital per worker and value added per worker (both highly correlated) retain their negative signs, the coefficients are not statistically significant. War production remains positive and significant, and the effect on wages is higher than in the state-level regressions – manufacturing wage growth was about 23 percentage points higher in war production cities (based on specifications 3 and 4). Also, the coefficient on the growth in manufacturing variable is positive and significant. The lower adjusted R^2 and a fewer number of significant coefficients

[34] 'Excess' deaths refers to those deaths above (or below) some historical median rate. The monthly rates were converted to an annual number by multiplying by 12. See U.S. Public Health Service (1930), Table A, page 27 for a specific discussion on how the rates were calculated.

compared to the state-level models suggests there is much more (unexplained) variation in wage growth across U.S. cities than across states.

Focusing on influenza mortalities, the regression results reveal that those cities having had higher excess influenza death rates experienced greater growth in manufacturing wages over the period 1914 to 1919. For each city used in the analysis (Table 7), the percentage point increase in wages resulting from a ten percent increase in the influenza mortality rate was calculated using the coefficient on influenza mortalities from the third specification of Table 8. These estimates are shown in Table 9 along with the actual increase in city manufacturing wages from 1914 to 1919. Comparing the two numbers for each city reveals the impact of influenza mortalities on wage growth relative to total city wage growth. On average, a ten percent increase in city-level mortality rates resulted in a 3.1 percentage point increase in city manufacturing wages. This estimate is about 1.0 to 1.5 percentage points higher than that found from the state-level regressions. Most manufacturing activity was located in urban areas and influenza mortality rates were higher in urban areas as well, so it seems reasonable that influenza mortalities in the city would have a greater impact on city manufacturing wages compared to more rural areas (which are included in the state-level analysis).

[Table 9 about here]

VI. Conclusion

The concurrence of the 1918 influenza pandemic and World War I resulted in a significant number of mortalities over a brief period in history. Mortalities from both events were disproportionately higher for males of prime working age, thus making it

likely that the manufacturing labor market was influenced by mortalities from the influenza pandemic and World War I. The hypothesis of this paper was that mortalities from both events constituted a significant decrease in the supply of manufacturing labor which initially increased both the marginal product of labor and capital per worker, and thus resulted in an immediate increase in wage rates. The empirical results obtained from a sample of U.S. states and cities support the theoretical predictions. Specifically, states and cities that had more influenza mortalities and states having had more World War I combat mortalities experienced greater growth in manufacturing wages over the period 1914 to 1919. The total effect of influenza mortalities on wage growth was greater than that from World War I combat mortalities.

Certainly the 1918 influenza pandemic had serious negative effects on state and national economies. While specific estimates are prohibited by the lack of detailed economic data of the era, the deaths of primary breadwinners left many families without sources of income, commerce was hindered, and a general fear by the public seriously hampered economic activity (Crosby, 1989). The findings here suggest that one benefit of the influenza pandemic was an immediate increase in wages, at least in the manufacturing sector, for those surviving the pandemic. Of course, no reasonable argument can be made that this benefit outweighed the costs from the tremendous loss of life and overall economic activity. Nonetheless, the results obtained here suggest that some labor markets today, especially those for hourly, lower-skilled employment without contracts, may provide workers with higher wages during and in the immediate aftermath of a modern day pandemic.

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Table 1 – Influenza and WWI Combat Mortality Rankings, By State

Influenza Mortalities Per 100,000 Population				World War I Combat Mortalities Per 100,000 Population	
Top 5 States	1916-1917	*Top 5 States*	1918-1919	*Top 5 States*	
Connecticut	455.5	Pennsylvania	1,119.6	Montana	161.1
Pennsylvania	413.3	Maryland	1,042	Wyoming	92.6
Vermont	410.2	Colorado	1,020	North Dakota	84.8
Maryland	407.7	New Jersey	995.9	Connecticut	83.1
Rhode Island	407.7	Connecticut	992.2	Idaho	77.1
Bottom 5 States	1916-1917	*Bottom 5 States*	1918-1919	*Bottom 5 States*	
Utah	252.2	Washington	599.4	Georgia	26.5
North Carolina	251.7	Wisconsin	584.1	Delaware	23.1
California	228.4	Michigan	581.5	Louisiana	22.3
Minnesota	209.8	Minnesota	557.4	Mississippi	18.7
Washington	157.7	Oregon	523.6	Florida	18.7
Average of other States	318.2	Average of other States	802.7	Average of other States	50.9

Note: Influenza mortalities include death from pneumonia. See text for explanation. Data are from U.S Bureau of the Census, *Mortality Statistics 1920*, page 30. Twenty-six states reported influenza and flu death rates in 1916 and 1917 and thirty states reported influenza and pneumonia mortality rates in 1918 and 1919. Influenza pandemic and World War I mortalities shown above are normalized by 1914 state population. See text for a further description of this variable. Combat mortality data are from the Adjutant General of the Army, *Summary of Casualties Among Members of the American Expeditionary Forces during The World War*. Mortality rates are computed using 1914 state population. Combat mortalities refer to all deaths in combat from any cause other than disease. *Summary of Casualties* also reports mortalities by disease. See text for a further description of this variable.

Table 2 – Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Percentage change in real manufacturing wages per worker 1914-1919	11.49	12.64	-15.85	38.05
1918-1919 Influenza mortalities per 100,000 population	829.28	171.64	544.41	1,154.14
World War I combat mortalities per 100,000 population	56.10	23.81	22.30	161.06
Influenza and WWI mortalities per 100,000 population	885.38	181.88	592.10	1,294.02
Capital per manufacturing worker 1914	$3,507	$1,109.40	$1,854.97	$6,663.48
Value added per manufacturing worker 1914	$1,427.43	$414.40	$666.66	$2,751.18
Wartime production	0.1333	0.3457	0	1
Growth in manufacturing sector 1914-1919 (percent change in workers)	32.64	24.96	2.41	103.10

Number of Observations = 30. All data for U.S. States. See text for data sources and descriptions.

Table 3: Influenza and WWI Mortalities on Manufacturing Wage Growth 1914-1919

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.216 (1.51)	0.218*** (2.87)	0.014 (0.08)	-0.079 (0.53)	0.052 (0.30)	0.015 (0.09)	0.009 (0.06)	-0.086 (0.64)
WWI Mortalities Per Capita	183.67*** (3.21)	183.41*** (3.45)	-------	-------	120.54** (2.25)	141.01** (2.56)	-------	-------
Influenza Mortalities Per Capita	-------	-------	31.39** (2.71)	27.30** (2.63)	22.59* (1.85)	19.22* (1.75)	-------	-------
WWI and Influenza Mortalities Per Capita	-------	-------	-------	-------	-------	-------	30.872*** (2.99)	28.109*** (3.03)
Capital Per Worker – 1914[a]	0.003 (0.02)	-------	-0.036 (1.54)	-------	-0.019 (0.85)	-------	-0.032 (1.47)	-------
Value Added Per Worker – 1914[a]	-0.239*** (5.08)	-0.239*** (5.54)	-0.136*** (5.53)	-0.167*** (5.37)	-0.201*** (4.53)	-0.227*** (4.87)	-0.152*** (6.99)	-0.179*** (6.16)
War Production Dummy	0.114*** (5.70)	0.114*** (6.21)	0.077** (2.55)	0.100*** (4.51)	0.087*** (2.92)	0.099*** (4.37)	0.077** (2.58)	0.097*** (4.37)
Growth in Manufacturing Sector	0.156** (2.78)	0.156*** (3.36)	0.234*** (3.22)	0.236*** (3.32)	0.227*** (3.33)	0.227*** (3.41)	0.239*** (3.41)	0.244*** (3.60)
Northeast Dummy	0.030 (0.39)	0.030 (0.65)	0.022 (0.30)	0.088* (1.85)	0.022 (0.33)	0.053 (1.11)	0.021 (0.30)	0.083* (1.87)
South Dummy	0.193** (2.23)	0.193*** (3.50)	0.174** (2.21)	0.239*** (4.20)	0.193** (2.54)	0.226*** (4.14)	0.180** (2.33)	0.241*** (4.43)
Midwest Dummy	0.063 (1.33)	0.062** (2.25)	0.099* (1.95)	0.134*** (3.01)	0.100* (2.06)	0.116** (2.60)	0.103** (2.12)	0.137*** (3.32)
Adjusted R^2	0.696	0.709	0.705	0.698	0.719	0.727	0.717	0.712

[a] Coefficients multiplied by 1,000.

Notes: *** denotes significance at 1%, ** at 5%, and * at 10 percent. *T*-statistics are in parentheses and are based on White's heteroscedasticity-corrected standard errors. The dependent variable is the percentage change in state-level real manufacturing wages from 1914 to 1919. Number of observations = 30. See text for a complete description of each variable.

Table 4 – Estimated Impact of Variables on Manufacturing Wage Growth 1914-1919

Variable	Change	Impact of Change on Wage Growth (Percentage Point Increase/Decrease) From Select Specifications in Table 3 (2)	(4)	(6)	(8)
WWI Mortalities Per Capita	Mean + 10 percent	**1.03**	-------	**0.79**	-------
Influenza Mortalities Per Capita	Mean + 10 percent	-------	**2.26**	**1.59**	-------
WWI and Influenza Mortalities Per Capita	Mean + 10 percent	-------	-------	-------	**2.49**
Value Added Per Worker – 1914	Mean + 10 percent	**-3.41**	**-2.38**	**-3.24**	**-2.56**
War Production Dummy	0 to 1	**11.4**	**10.00**	**9.90**	**9.70**
Growth in Manufacturing Sector	Mean + 10 percent	**0.51**	**0.77**	**0.74**	**0.80**
Northeast Dummy	0 to 1	3.00	**8.80**	5.30	**8.30**
South Dummy	0 to 1	**19.30**	**23.90**	**22.60**	**24.10**
Midwest Dummy	0 to 1	**6.20**	**13.40**	**11.60**	**13.70**

Note: Coefficient estimates and mean values from specifications (2), (4), (6) and (8) in Table 3 are used to estimate percentage point increases/decreases. Bold-face values reflect impacts based on statistically significant coefficient estimates in Table 3.

Table 5: Influenza Mortalities Aged 20 to 49 and Wage Growth 1914-1919

Variable	(1)	(2)	(3)
Constant	0.176 (1.03)	0.200 (1.25)	0.165 (1.02)
WWI Mortalities Per Capita	-------	163.73** (2.30)	-------
Influenza Mortalities Aged 20 to 49 Per Capita	31.384* (1.87)	8.910 (0.44)	-------
WWI and Influenza Mortalities Per Capita	-------	-------	31.926** (2.28)
Capital Per Worker – 1914[a]	-0.030 (1.24)	-0.005 (0.21)	-0.027 (1.15)
Value Added Per Worker – 1914[a]	-0.154*** (5.33)	-0.232*** (4.76)	-0.172*** (5.52)
War Production Dummy	0.104*** (4.47)	0.111*** (5.12)	0.103*** (4.35)
Growth in Manufacturing Sector	0.177** (2.44)	0.169** (2.61)	0.185** (2.65)
Northeast Dummy	0.029 (0.35)	0.029 (0.38)	0.028 (0.35)
South Dummy	0.185* (1.95)	0.197** (2.28)	0.192** (2.08)
Midwest Dummy	0.082 (1.35)	0.073 (1.30)	0.088 (1.53)
Adjusted R^2	0.654	0.683	0.669

[a] Coefficients multiplied by 1,000.

Notes: *** denotes significance at 1%, ** at 5%, and * at 10 percent. *T*-statistics are in parentheses and are based on White's heteroscedasticity-corrected standard errors. The dependent variable is the percentage change in state-level real manufacturing wages from 1914 to 1919. Number of observations = 30. See text for a complete description of each variable.

Table 6: Effect of Mortalities on Wage Growth

Impact of a Mean + 10 percent change on wage growth

	Percentage Point Increase from Table 6 specifications		
Variable	(1)	(2)	(3)
WWI Mortalities Per Capita	-------	**0.92**	-------
Influenza Mortalities Aged 20 to 49 Per Capita	**1.21**	0.34	-------
WWI and Influenza Mortalities Per Capita	-------	-------	**1.41**

Note: Coefficient estimates from specifications (1), (2), and (3) in Table 5 are used to estimate change. Bold-face values reflect impacts based on statistically significant coefficient estimates in Table 5.

Table 7 – (Excess) Influenza Pandemic Mortality Rates (per 100,000) For 50 U.S. Cities

Albany	583.3	Minneapolis	336.8
Atlanta	368.6	Nashville	781.9
Baltimore	616.0	New Haven	567.2
Birmingham	712.8	New Orleans	678.3
Boston	680.9	New York	466.6
Bridgeport	748.0	Newark	582.8
Buffalo	539.2	Oakland	531.5
Cambridge	503.1	Omaha	567.9
Chicago	361.4	Paterson	609.7
Cincinnati	552.6	Philadelphia	792.7
Cleveland	583.3	Pittsburgh	1104.7
Columbus	365.3	Portland	538.9
Dayton	429.3	Providence	625.0
Denver	688.6	Richmond	532.7
Detroit	354.3	Rochester	406.3
Fall River	641.1	San Francisco	656.9
Grand Rapids	226.1	Scranton	792.5
Indianapolis	419.9	Seattle	433.8
Jersey City	698.7	Spokane	494.1
Kansas City, MO	694.8	St Louis	415.5
Los Angeles	496.8	St. Paul	409.1
Louisville	637.3	Syracuse	485.0
Lowell	555.4	Toledo	354.6
Memphis	580.8	Washington, DC	579.2
Milwaukee	396.4	Worcester	617.7

U.S. Public Health Service (1930) provides monthly excess mortality statistics on an annual basis. To compute the data shown in the table, the monthly excess mortalities from U.S. Public Health Service (1930) from March 1918 to April 1919 were summed and then divided by twelve. 'Excess' deaths refers to those deaths above (or below) some historical median rate. See U.S. Public Health Service (1930), Table A, page 27 for more information.

Table 8 – City Influenza Mortalities and Wage Growth, 1914-1919

Variable	(1)	(2)	(3)	(4)
Constant	1.187*** (7.91)	0.636*** (4.02)	0.702*** (3.13)	0.703*** (3.13)
Influenza Mortalities Per Capita	6.843 (0.58)	37.688* (1.77)	56.407** (2.81)	56.844** (2.73)
Capital Per Worker – 1914[a]	-------	-------	-------	-0.004 (0.13)
Value Added Per Worker – 1914[a]	-0.279*** (3.31)	-------	-0.178 (1.61)	-0.173 (1.37)
War Production Dummy	0.217*** (2.88)	0.193*** (3.16)	0.232*** (3.48)	0.233*** (3.51)
Growth in Manufacturing Sector	0.095* (1.81)	-------	0.233*** (5.19)	0.232*** (5.19)
State Dummy Variables	No	Yes	Yes	Yes
Adjusted R^2	0.273	0.209	0.425	0.395

[a] Coefficients multiplied by 1,000.

Notes: *** denotes significance at 1%, ** at 5%, and * at 10 percent. *T*-statistics are in parentheses and are based on White's heteroscedasticity-corrected standard errors. The dependent variable is the percentage change in real city manufacturing wages from 1914 to 1919. Number of observations = 50. The mean value of influenza mortalities is 0.00556 (556 per 100,000). See text for a complete description of each variable.

Table 9 – Total City Wage Growth vs. Wage Growth From Influenza Deaths

City	Percent Change in Wages, 1914-1919	Percentage Point Increase in Wages from 10% increase in flu deaths	City	Percent Change in Wages, 1914-1919	Percentage Point Increase in Wages from 10% increase in flu deaths
Albany	61.2	3.29	Minneapolis	62.0	1.90
Atlanta	93.3	2.08	Nashville	74.1	4.41
Baltimore	119.0	3.47	New Haven	76.0	3.20
Birmingham	92.4	4.02	New Orleans	86.7	3.83
Boston	73.3	3.84	New York	106.5	2.63
Bridgeport	114.5	4.22	Newark	107.1	3.29
Buffalo	97.1	3.04	Oakland	74.7	3.00
Cambridge	66.1	2.84	Omaha	96.3	3.20
Chicago	84.5	2.04	Paterson	98.0	3.44
Cincinnati	77.9	3.12	Philadelphia	111.3	4.47
Cleveland	105.4	3.29	Pittsburgh	103.8	6.23
Columbus	78.6	2.06	Portland	90.8	3.04
Dayton	117.9	2.42	Providence	79.8	3.53
Denver	62.0	3.88	Richmond	86.7	3.00
Detroit	110.8	2.00	Rochester	80.0	2.29
Fall River	88.2	3.62	San Francisco	54.4	3.71
Grand Rapids	88.1	1.28	Scranton	72.2	4.47
Indianapolis	70.6	2.37	Seattle	94.2	2.45
Jersey City	102.5	3.94	Spokane	39.7	2.79
Kansas City, MO	65.9	3.92	St Louis	67.3	2.34
Los Angeles	51.9	2.80	St. Paul	64.4	2.31
Louisville	76.5	3.60	Syracuse	80.0	2.74
Lowell	111.8	3.13	Toledo	89.4	2.00
Memphis	50.0	3.28	Washington, DC	84.0	3.27
Milwaukee	82.0	2.24	Worcester	91.9	3.48

Note: The percentage point increase in computed by increasing influenza death rates (Table 7) by 10 percent and multiplying by the coefficient on influenza deaths in Table 8, specification 3 (56.407).