How the Boll Weevil Left Southerners Richer, Taller, and Better Fed

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Abstract

This paper studies the effects of a large exogenous and sustained negative agricultural shock in the American South on long run outcomes for individuals in a setting that shares a number of features with developing countries. To estimate the effect of the shock, the paper draws on a linked sample of over 325,000 black and white men in the South and a difference-in-differences framework. The estimates show that the arrival of the boll weevil between 1915 and 1922 increased inequality in the long-run outcomes of white and black men. Relative to men of the same race born before the boll weevil's arrival, the boll weevil increased the wages of white men by 2.1% and decreased the wages of black men by 2.6%. Black men who were born after the boll weevil's arrival had 0.14 fewer years of education than black men born before its arrival. The boll weevil did not have any effect on education for white men or on migration out of state by men of either race. The channels through which the boll weevil affected outcomes differed across races.

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1 Introduction

The long run effects of shocks in childhood have been linked to a wide variety of health, educational, and other outcomes (Almond, Currie and Duque (2018)). Because of data limitations, relatively little of this work focuses on developing countries. Yet, developing countries are likely to be places where shocks are severe and have significant long run effects.

This paper studies the effects of a large exogenous and sustained negative agricultural shock in the American South on long run outcomes for individuals in a setting that shares a number of features with developing countries. The boll weevil, a beetle that feeds on cotton leaves, squares (flower buds), and bolls, appeared in Texas in 1892. Between 1892 and 1922, it spread north and east from Texas until the entire cotton growing region in the United States was affected. Approximately 26 million people, or about 25% of the US population, lived in these cotton growing counties. This shock occurred in a region that had low levels of education, a very unequal wealth distribution, and large numbers of individuals who were agricultural laborers or tenants. A number of developing countries share one or more of these features with the early twentieth century American South.

This paper draws on a newly linked sample of 325,000 black and white men in the South and a difference-in-differences framework to examine the long run impact of the boll weevil on income, migration, and education. The primary analysis focuses on counties where the boll weevil arrived between 1915 and 1922. These counties are predominately located in Florida, Georgia, North Carolina, South Carolina, and Tennessee. 1915 marks the beginning of a period of high cotton price volatility, and the beginning of the first Great Migration. Further, in 1914 pellagra, a nutritional disease caused by niacin deficiency, had become sufficiently widespread that the National Health Service sent Dr. Joseph Goldberger to South Carolina to investigate. As shown in Clay, Schmick and Troesken (2017), improvements in nutrition are one potential channel through which the boll weevil could affect the long-run outcomes of children, so 1915 marks a time where nutritional deficiencies were sufficiently severe that the boll weevil could potentially improve them. Results are also provided for counties where the boll weevil arrived between 1892 and 1914. Linkages are from the 1900, 1910, 1920 and 1930 censuses to the 1940 census. For white men, we also use World War II military enlistment records height. Because men who were 0-3 when the boll weevil hit a county were likely to have been affected, the difference in difference analysis compares men who were ages 3-6 when the boll weevil arrived in a county with men who were born 0-4 years after the arrival of the boll weevil. The event studies do not show any pre-trends in income for white men who were ages 0-10 when the boll weevil arrived. Pretrends in income for black men suggest that income was declining for cohorts prior to the boll weevil.

The arrival of the boll weevil between 1915 and 1922 increased inequality in the long-run outcomes of white and black men. White men who were born after the boll weevil's arrival had wages that were 2.1% higher than white men born before its arrival. Much of the effect is from the two-thirds of individuals who lived in counties with high pre-boll weevil pellagra rates. Further, World War II data suggests that men in counties with high pre-boll weevil pellagra rates were 0.12 inches taller after the boll weevil. This suggests that nutrition, indeed, may have been an important channel through which the boll weevil affected income. The effects of the boll weevil on education and migration out of state for white men are small and not statistically significant.

Black men who were born after the boll weevil's arrival had wages that were 2.6% lower than black men born before its arrival. Thus, the boll weevil increased the black-white wage gap. In contrast to the effects on whites, the effect appears to apply across high and low cotton counties and high and low pellagra counties. The effects of the boll weevil on education are negative for black men. Black men who were born after the boll weevil's arrival had 0.14 fewer years of education than black men born before its arrival. The effects of the boll weevil on migration out of state are small, but there is some evidence that black men from high cotton producing counties were less likely to migrate out of state.

This paper contributes to two large and distinct literatures. The first is the literature on the relationship between early life environment and later life outcomes, which is reviewed in Almond, Currie and Duque (2018). This paper adds to the literature by using a large sample of linked data on a rich range of outcomes to examine the effects of a large agricultural shock that occurred in the late nineteenth and early twentieth century in a region that shares many features with developing countries today. The shock had positive effects on wages for white men, which seem to be driven by improved nutrition, and negative effects for black men, which seem to be driven by adverse effects of the boll weevil on the economic prospects of their parents.

The second is the literature on the effect of the boll weevil on the Southern economy. Some scholars argue that the boll weevil had a large negative impact on the Southern economy (Ransom and Sutch (2001), Lange, Olmstead and Rhode (2009), Ager, Brueckner and Herz (2017*a*), Bloome, Feigenbaum and Muller (2017)). Other scholars have argued that effects of the boll weevil were mitigated by the increase in cotton prices (Higgs (1976), Wright (1986), Giesen (2012)). Still others have shown that the boll weevil had benefits for specific groups. For example, Baker (2015) provided evidence that the boll weevil increased enrollment rates of blacks in Georgia. Our analysis finds that early childhood exposure to the boll weevil had long run benefits for whites and imposed long run costs for blacks that widened the black-white wage gap as measured in 1940.

2 Background

The boll weevil appeared in Texas in 1892. From there, it progressed North and East through the cotton belt. By 1922, the boll weevil had spread throughout the entire cotton growing region of the United States. Scholars have treated the arrival of the boll weevil in the cotton belt during the early 1900s as an exogenous shock that disrupted cotton production.

The U.S. Dept. of Agriculture (1951), Ransom and Sutch (2001), Lange, Olmstead and Rhode (2009), and Ager, Brueckner and Herz (2017*a*) all find that the arrival of the boll weevil had large negative effects on cotton yields and production. The U.S. Dept. of

Agriculture (1951) estimated that for the period 1909-1940 overall yield fell 10.5%. These effects are smaller than later authors, who account for secular trends toward higher cotton production. Using state-level data, Ransom and Sutch (2001) find reductions in acreage and yields of 27.4% and 31.3%. Using county-level data, Lange, Olmstead and Rhode (2009) (p. 685) find "the weevil was associated with a decline in total output of about 50 percent." Ager, Brueckner and Herz (2017*a*) find that on average cotton production, acreage, and yield decreased by 39%, 17%, and 21%.

The arrival of the weevil had a large positive effect on the production of other crops. Lange, Olmstead and Rhode (2009) report sizable increases in corn production, and note in a footnote that "hay, Irish potatoes, peanuts, rice, and sweet potatoes; sugar cane, among other crops, showed statistically significant increases after the arrival of the weevil" (Lange, Olmstead and Rhode (2009), p. 710). Clay, Schmick and Troesken (2017) find that there were increases in corn, peanut, and sweet potato acres per capita in North Carolina and Carolina after the arrival of the boll weevil.

Clay, Schmick and Troesken (2017) provide evidence that the arrival of the boll weevil may have led to improved nutrition. Pellagra, a nutritional disease caused by niacin deficiency, was widespread in the South during the early twentieth century. They find that after the arrival of the boll weevil, pellagra death rates fell and they fell more in counties with high pre-boll weevil cotton acres per capita and high pre-boll weevil pellagra death rates. Clay, Schmick and Troesken (2017) argue that pellagra fell, because the arrival of the boll weevil prompted farmers to diversify their crop mix. Increased production of foods that are relatively rich in niacin including corn, peanuts, and sweet potatoes increased the availability of niacin to nearby populations.

Ager, Brueckner and Herz (2017*a*), Bloome, Feigenbaum and Muller (2017), and Ager, Brueckner and Herz (2017*b*) show that the arrival of the boll weevil had an adverse effect on tenancy, local labor markets, marriage and fertility. Ager, Brueckner and Herz (2017*a*) find that the number of farms declined by 5% and that this was primarily driven by a 23% decline in fixed rate tenant farms. The effects were larger in counties with high shares of cotton acreage. Other types of tenant farms and owned farms saw no decline. Agricultural wages fell after the boll weevil by 8% and while there was no average effect on black female labor force participation, both wages and female labor force participation declined in counties with high shares of cotton acreage. Bloome, Feigenbaum and Muller (2017) also document the adverse effect on tenancy and investigate the implications for black marriage patterns. Ager, Brueckner and Herz (2017*b*) find substantial declines in fertility both for agricultural households, because of lower agricultural income, and for households the moved from agriculture to manufacturing, because of the higher costs of raising children.

As a result of these adverse effects on tenancy and local labor markets, many individuals migrated within and across states. Lange, Olmstead and Rhode (2009) find that many people migrated ahead of the boll weevil and that (p. 713) "population movements were the most pronounced among those counties that farmed little cotton and those heavily reliant on the crop." Ager, Brueckner and Herz (2017*a*) provide further evidence that migration from counties with high shares of cotton acreage to counties with low shares of cotton acreage was sizable in total and for blacks in particular.

Using detailed data for Georgia, a large cotton producing state, Baker (2015) finds that the boll weevil affected the enrollment in school of black children, but not white children. Black children often helped to harvest the cotton during the September to December time frame, which coincided with the traditional school year. Reductions in cotton production reduced demand for child labor, allowing more children to attend school. Baker (2015) estimates that the boll weevil increased enrollment by 2 percent and narrowed the racial gap in enrollment by 30 percent.

Finally, Baker, Blanchette and Eriksson (2018) examine the long-run impacts of the boll weevil on educational attainment using a sample of white and black men linked from the 1900, 1910, and 1920 censuses to their adult educational attainment in 1940. They find evidence that men who were 4-18 years old when they boll weevil arrived in a county had 0.25 years higher educational attainment than men who were 19-30 years old. This paper is, to our knowledge, the only paper that examines long-run outcomes stemming from the boll weevil invasion.

3 Data

3.1 Boll weevil, pellagra, and cotton data

Data on the year the boll weevil first arrived in a county are taken from Lange, Olmstead and Rhode (2009), which originally came from USDA boll weevil maps.[1] County-level data on cotton acres are taken from the 1909 Census of Agriculture. These data are compiled in Haines, Fishback and Rhode (2016). To calculate cotton acreage per capita we use population data from the 1900 to 1950 Censuses and linearly interpolate county populations between census years. Counties that were invaded by the boll weevil between 1915 and 1922 and, therefore, are used in our main empirical analysis are shown in the top panel of Figure 1 in dark grey. Counties in light grey are counties that were invaded by the boll weevil between 1892 and 1914.

We collected data on pellagra mortality at the county-level for South Carolina and Tennessee in 1915 and for Missouri and North Carolina in 1915 and 1916. Pellagra deaths come from state health reports. These are the only states, to our knowledge, to report pellagra deaths at the county level prior to the arrival of the boll weevil in the state.[2] The counties in Missouri, North Carolina, South Carolina, and Tennessee that were invaded by the boll weevil and, therefore, are used in our main empirical analysis when we examine differential effects based on pre-boll weevil pellagra death rates are shown in the bottom panel of Figure 1.

[1]We reviewed the original USDA boll weevil map published in Hunter and Coad (1923) and found a few discrepancies between the map and the coding of the boll weevil arrival in Lange, Olmstead and Rhode (2009). The map shows that the boll weevil arrived in Cherokee County, South Carolina in 1920, but it is coded as 1921 in Lange, Olmstead and Rhode (2009). The map shows the boll weevil arriving in Iredell County and Wake County, North Carolina in 1921, but it is coded in Lange, Olmstead and Rhode (2009) as 1922. We changed the coding in these cases to align with the original map.

[2]Maryland does report pellagra deaths, but it was never invaded by the boll weevil.

3.2 A linked sample

To measure adult outcomes for individuals born just before and after the arrival of the boll weevil in a county we construct a dataset of individuals linked from the 1900, 1910, 1920, and 1930 complete count censuses to the 1940 complete count census (Ruggles et al. (2018)). Linking individuals is necessary to match adults in 1940 to their likely county of birth.[3] We begin our linking procedure by restricting the 1900, 1910, 1920, and 1930 complete count censuses to males, who were aged 0 to 20 when the census took place, were living in the state they were born in, and were living in the South or the West North Central Census Region.[4]

We employ a linking procedure that is commonly used in economics and has been used by Abramitzky, Boustan and Eriksson (2012) and Long and Ferrie (2013) (i.e. the ABE linking algorithm) among many other papers. We begin by adjusting first names for common nicknames and then standardize each first and surname using the NYSIIS algorithm, which transforms a name into a phonetic code. We then restrict our sample to individuals who are unique by NYSIIS first name, NYSIIS surname, birthplace, and birth year. For each individual in the 1900, 1910, 1920, and 1930 census we search for records in the 1940 census that match exactly on NYSIIS first name, NYSIIS surname, birthplace, and birth year. If we find a unique match, then we declare this observation to be a match. If we find multiple matches, then the observation is discarded. If we do not find a unique match then we continue to search for individuals who match exactly on NYSIIS first name, NYSIIS surname, and birthplace, but we now allow birth year to differ by up to one year (e.g. if an individual in the 1910 census reports a birth year of 1902 we will search for individuals in the 1940 census with a birth year of 1901 and 1903). If no unique match is found we continue to search for individuals who match exactly on NYSIIS first name, NYSIIS surname, and birthplace, but we now allow birth year to

[3]The 1940 census only contains information on state of birth.

[4]The South and the West North Central Census Regions include the following states: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Iowa, Kansas, Kentucky, Louisiana, Maryland, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, Oklahoma/Indian Territory, South Carolina, South Dakota, Texas, Tennessee, Virginia, and West Virginia. We include the West North Central Census Region because Missouri, which is in this census region, had small amounts of cotton production and was invaded by the boll weevil.

differ by up to two years.

Appendix Table 1 displays the results of this linking procedure. From the 1900 complete count census we searched for 7,671,058 individuals and were able to find 1,792,381 of them in the 1940 census (a 23% link rate). We find that our link rates for 1910, 1920, and 1930 are 28%, 31%, and 35%, respectively. We also examine the representativeness of our linked sample. Even though significant differences exist along numerous dimensions between our final linked sample and the original sample these differences are, for the most part, small in magnitude and not economically meaningful.

One area where we do find larger differences between the linked and the original samples is for black children. For example, in 1900 black children made up 26% of our original sample, but they only make up 15% of our linked sample. Our algorithm, therefore, links black children at much lower rates than white children. We deal with this issue by estimating all of our main results separately by race. Accordingly, in Table 1, we display summary statistics for our outcomes variables by race. Panel A of Table 1 shows summary statistics for whites, while Panel B is for blacks. We, also, break all of the summary statistics down by whether a county has high cotton acreage per capita or a high pellagra death rate, since these are our main treatment variables. Men in high cotton counties generally had lower wages and educational attainment compared with men in low cotton counties. However, men in high pellagra counties typically had higher wages and educational attainment then men in low pellagra counties.

4 Event-study approach

We begin our analysis by conducting an event-study. Our empirical set-up takes the following form:

$$outcome_{itec} = \sum_{n=-10}^{4} \delta_n * \mathbb{I}[Years\, since\, boll\, weevil_{tc} = n] +$$
$$\sum_{n=-10}^{4} \gamma_n * \mathbb{I}[Years\, since\, boll\, weevil_{tc} = n] * [Intensity_c] + \xi * X_i + \beta_t + \beta_e + \beta_c + +\epsilon_{itec} \quad (1)$$

In the above equation, i indexes individuals, t indexes birth cohort, e indexes the census year that the child was enumerated in (1900, 1910, 1920, or 1930), and c indexes the county that the individual lived in as a child when they were enumerated, which we assume was their county of birth. Therefore, $outcomes_{itec}$ is the adult outcome of individual i, born in year t, in county c, and enumerated in census year e. $[Yearssincebollweevil_{tc} = i]$ are a series of dummy variables that indicate the year relative to the arrival of the boll weevil that cohort t in county c was born. We interact this series of dummy variables with a measure of the intensity of treatment at the county-level, $[Intensity_c]$. We use two different, county-level measures of the intensity of treatment, which are described below. X_i is the occupational income score of individual i's father. β_t are cohort-specific fixed effects, β_e are census year fixed effects, and β_c are county of birth fixed effects. Finally, we cluster standard errors at the county or birth level. We include individuals born up to ten years prior to and four years after the arrival of the boll weevil in our event-study. Panel A of Figure 2 helps clarify exactly who is included in our sample.

Our first intensity measure is an indicator variable if a county had above median cotton acres per capita during the 1909 Census of Agriculture. We use this measure because the boll weevil likely had a larger impact on counties with high cotton acreage per capita. In addition, cotton acreage per capita is a measure how much land could be transitioned from growing cotton to growing other crops. If the boll weevil improved nutrition then land needed to be transitioned from growing cotton to growing food crops.

Note, however, that this intensity measure does not directly measure the nutritional status of a cotton prior to the boll weevil. Counties with high cotton acres per capita might have had relatively good nutrition if they also had high corn, peanut, or sweet potato acres per capita.

A more direct measure of the nutritional status of a cotton prior to the boll weevil is the pellagra death rate. Therefore, our second intensity measure is an indicator if an individual was born in a county that had a high pellagra death rate prior to the arrival of the boll weevil. We use the pellagra death rate in 1915 for South Carolina and Tennessee and we use the average pellagra death rate in 1915 and 1916 for Missouri and North Carolina. This is a direct measure of the nutritional status of a county just before it was invaded by the boll weevil. Pellagra only occurs as a result of insufficient niacin consumption so counties with higher pellagra death rates had a higher portion of their population that was consuming a diet low in niacin and, presumably, other micro-nutrients as well.[5] It should also be noted that dying from pellagra is an extreme circumstance. One need not have developed a full-blown case of pellagra to have been poorly nourished.

The coefficients from the interactions between the year of birth relative to boll weevil arrival dummies and the high cotton dummy are plotted in Panel A of Figures 3 and 4. In these figure we hope to see relatively little difference in outcomes between men born in high and low cotton or pellagra counties three to nine years prior to the arrival of the boll weevil. If nutrition does improve because of the boll weevil we might see a relative increase in the outcomes of treated individuals starting about three years prior to the arrival of the boll weevil because there is strong evidence that the long-run effects of nutrition on health and wages accrue mainly during the first three years of life.[6] Therefore, a dashed

[5]Pellagra is suggestive of broader nutritional deficits (e.g., Etheridge et al. (1972), Youmans (1964)).

[6]One of the most important studies to show this took place between 1969 to 1977 in four rural villages in Guatemala. Two villages were randomly selected to receive a high-energy, high-protein nutrition supplement (atole) and two villages were selected to receive a low-energy, no-protein nutrition supplement (fresco). Supplements were provided freely to pregnant and lactating mothers and children under the age of seven. Schroeder et al. (1995) find that children receiving the nutritious supplement were taller and weighed more during the first three years of life. Rivera et al. (1995) find that children receiving the nutritious supplement were taller and weighed more during adolescence. Hoddinott et al. (2008) find that exposure to the nutritious supplement during the first three years of life significantly increased

line indicates individuals born three years prior to the arrival of the boll weevil in the figure. Finally, there is another dashed line indicating the year of boll weevil arrival.

Panel A of Figure 3 shows the coefficient estimates for white men and Panel A Figure 4 shows the coefficient estimates for black men. We see that the wages of white men in high cotton producing counties are similar to the wages of white men in low cotton producing counties prior to the arrival of the boll weevil. After the boll weevil arrives in a county the wages of white men in the high cotton producing counties increase relative to low cotton producing counties. For black men, it appears that there is a downward trend in the wages of men in high cotton producing counties that continues after the boll weevil arrives.

Panel B of Figures 3 and 4 plots the coefficient estimates from the interactions between the year of birth relative to the boll weevil dummies and the high pellagra dummy. There was almost no difference in weekly wages between white men born in high and low pellagra counties three to nine years prior to the arrival of the boll weevil. Men born in high pellagra counties three years prior to the arrival of the boll weevil begin to see a relative increase in weekly wages. This almost exactly corresponds with the literature on when nutrition matters for later life outcomes. Thus, we see a slight increase in weekly wages for men born zero to three years prior to the arrival of the boll weevil (in between the dashed lines) and we see significant increases in weekly wages for men born after the arrival of the boll weevil in high pellagra counties.

Finally, we see that there were no significant differences between black men born in high and low pellagra counties before and after the arrival of the boll weevil. These event-studies have demonstrated several things. First, it does not appear that weekly wages (the dependent variable) was trending in high cotton or pellagra counties prior to the arrival of the boll weevil for white men. This is a necessary assumption for the difference in differences specification that we adopt in the next section. Second, the wages of blacks born in high cotton counties was trending downward prior to the arrival of the boll weevil.

wages by approximately 46%. Finally, Haas et al. (1995) finds that consuming the nutritious supplement during the first three years of life increased physical work capacity (VO2max).

Third, whites born in high cotton and high pellagra counties have higher wages after the arrival of the boll weevil. And fourth, blacks born in high pellagra counties do not have any significant change in wages after the arrival of the boll weevil.

5 Pre-post comparison of outcomes

Having shown that the wages of white men born in high cotton and pellagra counties are not trending up or down prior to the arrival of the boll weevil we next perform a pre-post comparison of outcomes. Following Bleakley (2010) we restrict our sample to individuals who were either fully treated by the boll weevil or not treated at all. That is, individuals who might have been partially treated by the boll weevil are omitted from the analysis. We define partially treated individuals as those who were born zero to three years before the arrival of the boll weevil in a county. Individuals who were completely treated were born after the boll weevil arrived and individuals who were not treated at all were born more than three years prior to the boll weevil. We settled on these definitions for treated, partially treated, and untreated because, as mentioned above, there is strong evidence showing that nutrition matters for adult outcomes most during the first three years of life. Thus, if the boll weevil improved adult outcomes individuals who were between zero and three years old when it first arrived would be partially treated.

To further isolate the effect of the boll weevil we focus our attention on individuals who were born within a narrow, 10-year, time span of the boll weevil first arriving in a county. Figure 2 Panel B helps to clarify exactly who is included in our sample. To be included in the pre-post analysis an individual must be born either three to six years prior to the arrival of the boll weevil or zero to four years after the arrival of the boll weevil in a county. Again, individuals born zero to three years prior to the arrival of the boll weevil were partially treated during early childhood and are excluded from our analysis.[7]

[7] Note that men who lived in a county that was not invaded by the boll weevil are not included in our sample. As shown in Figure 1, there were many counties in MO, NC, and TN that did not grow cotton and, therefore, were unaffected by the boll weevil. All counties in SC grew cotton and were invaded by

With the experimental set-up explained, we adopt the following empirical specification to study the impact of the boll weevil on adult outcomes:

$$outcome_{itec} = \delta * [Post\ boll\ weevil_{tc} = 1] + \gamma * [Post\ boll\ weevil_{tc} = 1] * [Intensity_c] + \xi * X_i + \beta_t + \beta_e + \beta_c + \epsilon_{itec} \quad (2)$$

Equation (2) is identical to (1), but it replaces the series of dummy variables with a post boll weevil indicator, $[Post\ boll\ weevil_{tc} = 1]$. This variable equals one if individual i was born after the boll weevil arrived in their county of birth. We interact this dummy variable with the same two intensity measures as in the event study analysis. We estimate equation (2) for individuals born prior to 1922 and we remove the top and bottom one percent of wage earners.[8] Standard errors are, again, clustered at the county of birth level.

The results from estimating equation (2) using the log of an individual's weekly wage as the dependent variable are shown in Table 2. Panel A of Table 2 shows the estimates for white men's weekly wages. Columns (1)-(3) use the sample of individuals from counties that the boll weevil invaded between 1915 and 1922. We only look at individuals from counties that the boll weevil invaded after 1915 because this is when pellagra was beginning to become a serious indicator of poor nutrition, as demonstrated by the National Health Service sending Dr. Joseph Goldberger to the South in 1914. Column (1) of Panel A shows that white men born after the boll weevil arrived in a county had wages that were about 2.1% higher later in life. Column (2) shows that this effect is partially driven by men born in high cotton producing counties. In particular, white men born after the arrival of the boll weevil in high cotton producing counties had wages that were about 1.9% higher. Column (3) uses a restricted sample of individuals. To be included in the restricted sample an individual could not be self employed and could not be a farmer or work on a farm. We find similar results in this column. Individuals born in a high

the boll weevil.

[8] We use individuals born prior to 1922 because individuals born in 1922 and later would not have been 18 during the 1940 census. There are few men younger than 18 who report wages in the 1940 census.

cotton producing county after the arrival of the boll weevil had wages that were about 2.4% higher.

Columns (4) and (5) of Table 2 use the sample of individuals born in counties that we have pellagra data for (i.e. individuals born in Missouri, North Carolina, South Carolina, and Tennessee). Column (4) shows that white men born after the boll weevil in high pellagra (poor nutrition) counties had wages that were about 3% higher. The coefficient on high cotton counties remains about the same as in columns (2) and (3). Finally, column (5) repeats the specification in column (4), but uses the restricted sample. The coefficient on high pellagra is slightly smaller when using this restricted sample, but the estimates remain similar.

Panel B of Table 2 repeats the analysis from Panel A for black men. We find that black men were affected by the boll weevil very differently then white men. Black men that were treated by the boll weevil had wages that were about 2.6% lower (column (1)). We do not find any differential effects based on cotton production or pellagra (columns (2)-(5)), keeping in mind that the wages of black men born in high cotton producing counties were trending downward prior to the arrival of the boll weevil.

In Appendix Table 2, we repeat the analysis in Table 2 for counties that were invaded by the boll weevil from 1892-1914. The boll weevil initially spread slowly out of Texas. Thus, despite the longer time frame, the sample size in Appendix Table 2 is about the same as the sample in Table 2 and the number of counties invaded is actually smaller. In contrast to Table 2, the boll weevil did not have a statistically significant effects on the wages of white or black men. We speculate that this was driven in part by the nutritional channel. Midwestern corn meal was not widely available until the 1910s, so the arrival of the boll weevil may not have improved local diets to the same degree as it would later (Clay, Schmick and Troesken, 2017).

The results in Table 2 highlight a few important points. First, the boll weevil differentially affected whites and blacks. The arrival of the boll weevil in the South increased wages for white men in high cotton producing and poor nutrition counties. However, black men had significantly lower wages after the arrival of the boll weevil. Second, improved nutrition is a possible channel through which white men see better outcomes. Much of the increase in wages experienced by white men after the arrival of the boll weevil occurred in counties that had poor baseline nutrition and, therefore, had the most to gain from the nutritional improvements brought about by the arrival of the boll weevil.

While Table 2 provides some evidence that improved childhood nutrition might be responsible for the increase in white men's wages after the arrival of the boll weevil, there are alternative mechanisms that could bring about an increase in wages. For instance, Baker (2015) finds that arrival of the boll weevil in Georgia affected the school enrollment of black children, but not white children. In addition, Ager, Brueckner and Herz (2017*a*) and Lange, Olmstead and Rhode (2009) find that the population of counties decreased after they were invaded by the boll weevil, indicating that many people migrated in response to the boll weevil. Changes in education and migration could both affect wages. Accordingly, Table 3 shows the impact of the boll weevil on educational attainment and Table 4 shows the impact of the boll weevil on migration out of a state. Both tables are set-up analogously to Table 2.

Table 3 shows that there were no effects of the boll weevil on the educational attainment of white men. Black men born after the arrival of the boll weevil saw a decrease in educational attainment (column (1)), which, was concentrated in high cotton areas (column (2)). Panel A of Table 4 shows that white men born after the arrival of the boll weevil in a high cotton producing county were more likely to be living in a different state in 1940. However, we again find evidence that the boll weevil affected black men born after its arrival differently. Blacks born after the arrival of the boll weevil in high cotton producing counties were actually less likely to migrate out of the state (Table 4, Panel B, column (2)). Table 4 and 5 do not provide much evidence for increased educational attainment or increased mobility as potential mechanisms for the higher wages white men born after the arrival of the boll weevil experienced.

To more directly demonstrate the boll weevil's impact on nutrition we compare the height of World War II soldiers who were treated by the boll weevil to those who were not treated by the boll weevil. To perform this analysis we use the *U.S. World War II Army Enlistment Records, 1938-1946* from the National Archives and Records Administration. These records contain enlistment information for over 8.5 million individuals who served in World War II. Importantly, the records contain information on state and county of residence when the individual enlisted and their height, in inches. We restrict these records to white men, who lived in the same state they were born in, were drafted, were born before 1924 (there are very few records for individuals born after 1924), had a valid height and weight and enlisted in or after December 1941.[9] We restrict to individuals born before 1924 because those born after 1924 might still be growing when they enlist. After making these restrictions we make the assumption that individuals are living in the same county they were born in when they enlist.

We repeat our analysis from Tables 2-4, but now use height as the dependent variable. The results are displayed in Table 5. Individuals born after the arrival of the boll weevil in Missouri, North Carolina, South Carolina, and Tennessee are almost a fifth of an inch taller (column (1)) and this effect appears to be concentrated in counties that had high pellagra death rates (column (3)). We do not find any evidence that individuals in high cotton producing counties are taller after the arrival of the boll weevil.

Based on pre-post comparisons of outcomes it appears that white men born after the arrival of the boll weevil had significantly higher wages than white men who lived in the same county, but were not treated by the boll weevil. Two pieces of evidence point toward improved nutrition as a potential channel for this result. First, the increase in wages for white men treated by the boll weevil were concentrated in men from counties that had poor baseline nutrition levels. Second, the men from these same counties were taller after the arrival of the boll weevil, suggesting that nutrition improved after the boll weevil invaded. Finally, we found differential effects between blacks and whites. While white men had higher wages after the arrival of the boll weevil, black men actually had lower

[9] To serve in WWII an individual had to be between 5 and 6.5 feet tall and weigh over 105 pounds. Thus, a valid height is between 60 and 78 inches and a valid weight is 105 pounds and above.

wages and educational attainment after the arrival of the boll weevil. We are still working to determine why blacks and whites were affected so differently by the boll weevil.

6 Conclusion

In this paper we study the effects of the arrival of the boll weevil on the long-run outcomes of black and white men. In particular, we find that the boll weevil left white Southerners richer, taller, and potentially better fed. We find that white men born after the arrival of the boll weevil had weekly wages that were about 2% higher. To determine the mechanism driving this result we consider several explanations. First, we consider that explanation that the boll weevil might have led to increased educational attainment since, perhaps, young children were no longer needed to work in cotton fields. We, also, consider the explanation that the arrival of the boll weevil unleashed a wave of migration in across American South. Perhaps individuals have higher incomes because they were more likely to move after the arrival of the boll weevil. We find little support for either of these hypotheses.

The mechanism that we do find some support for is improved nutrition. In particular, Clay, Schmick and Troesken (2017) suggest that the arrival of the boll weevil might have improved the nutrition of Southerners by ending the Southern cotton monoculutre. Prior to the boll weevil, Southerners grew cotton and ate heavily processed food, with little nutritional value that was imported from the Midwest. After the arrival of the boll weevil, Southerns diversified their crop mixture and began eating healthy, locally grown crops. We believe that improved nutrition is the mechanism driving much of our results for white men for three reasons. First, we find that the increase in income experienced by white men was concentrated in counties with high pellagra death rates and, therefore, poor baseline nutrition prior to the arrival of the boll weevil. Places with poor baseline nutrition would have had the most to gain if the boll weevil did improve nutrition. Second, the arrival of the boll weevil was associated with increased height for individuals living in high pellagra counties. Height should only increase as the result of improved nutrition. Finally, the medical literature points to nutrition mattering the most for later life outcomes during the first three years of life. We find some evidence that the increase in income and height began to occur in individuals born about two to three years prior to the arrival of the boll weevil. These individuals would have been partially affected by nutritional improvements brought about by the boll weevil. Therefore, we believe that at least some of the increase in wages that are associated with the arrival of the boll weevil are the result of improved nutrition.

Finally, we find that black men were affected by the boll weevil very differently. In particular, it appears that black men born just after the arrival of the boll weevil had wages that were about 2.5% lower. Therefore, it is possible that the boll weevil increased inequality between blacks and whites. We are still working to understand why the boll weevil affected blacks and whites so differently.

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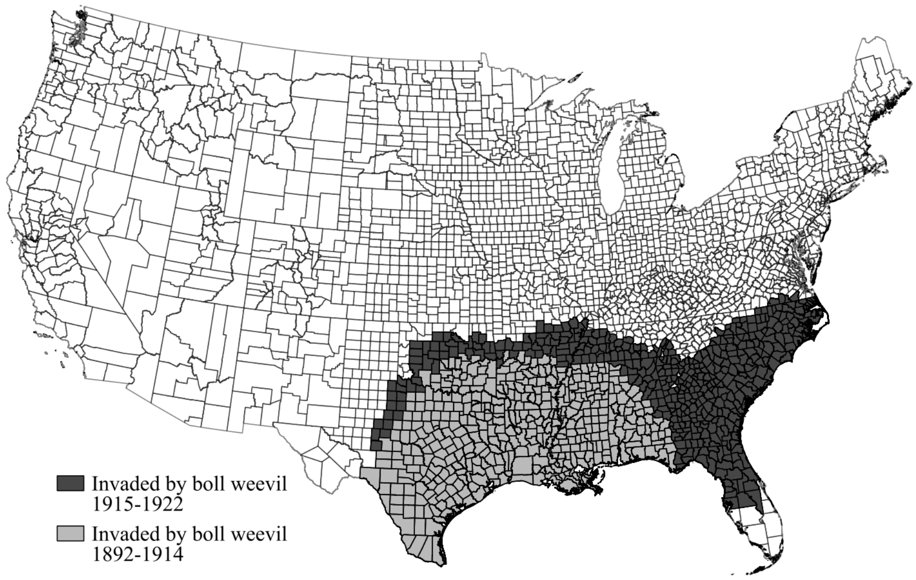
Figure 1

Panel A: Counties included in entire sample



Panel B: Counties included in sample MO, NC, SC, and TN

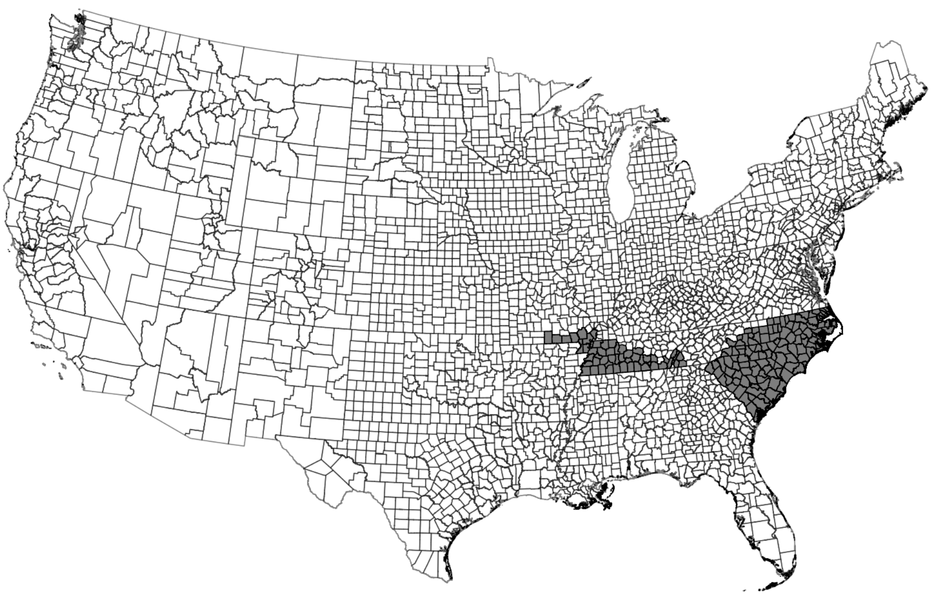
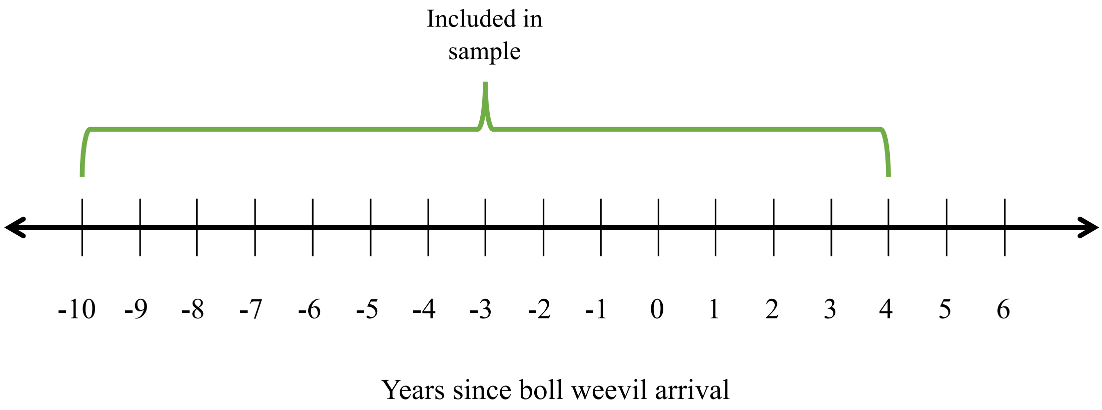


Figure 2

Panel A: Sample used in event study analysis



Panel B: Sample used in pre-post comparisons

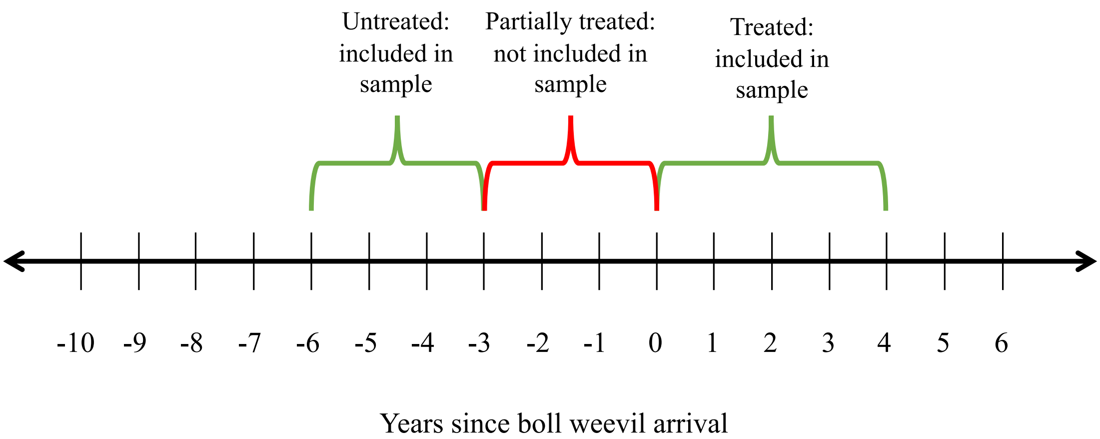
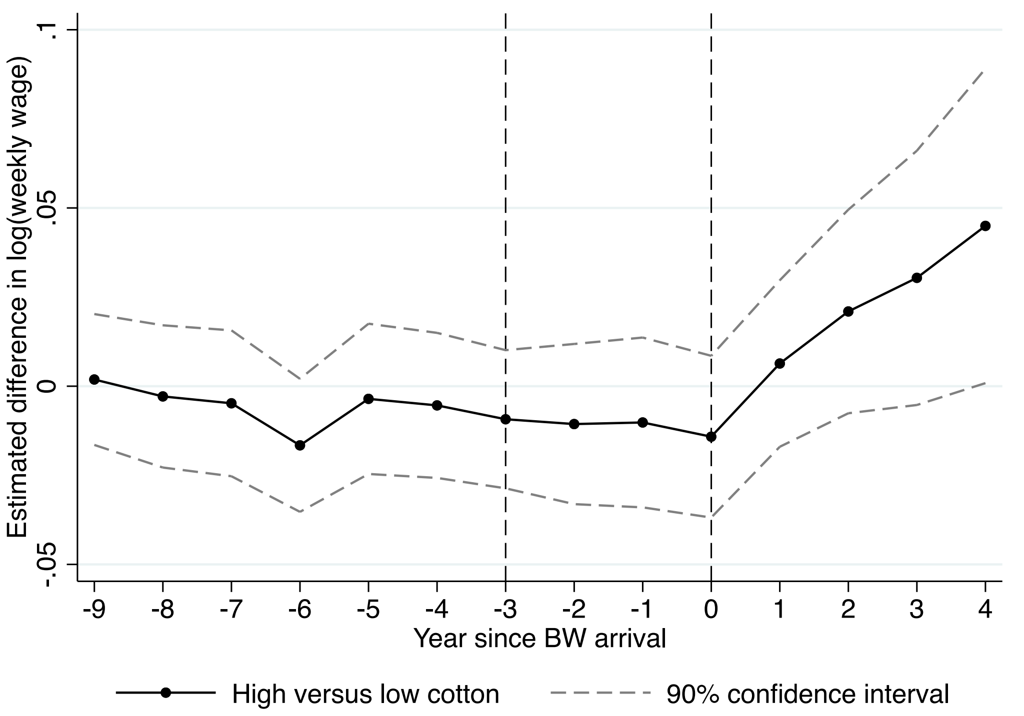


Figure 3

Panel A: Differences in weekly wages for whites by cotton production



Panel B: Differences in weekly wages for whites by pellagra mortality

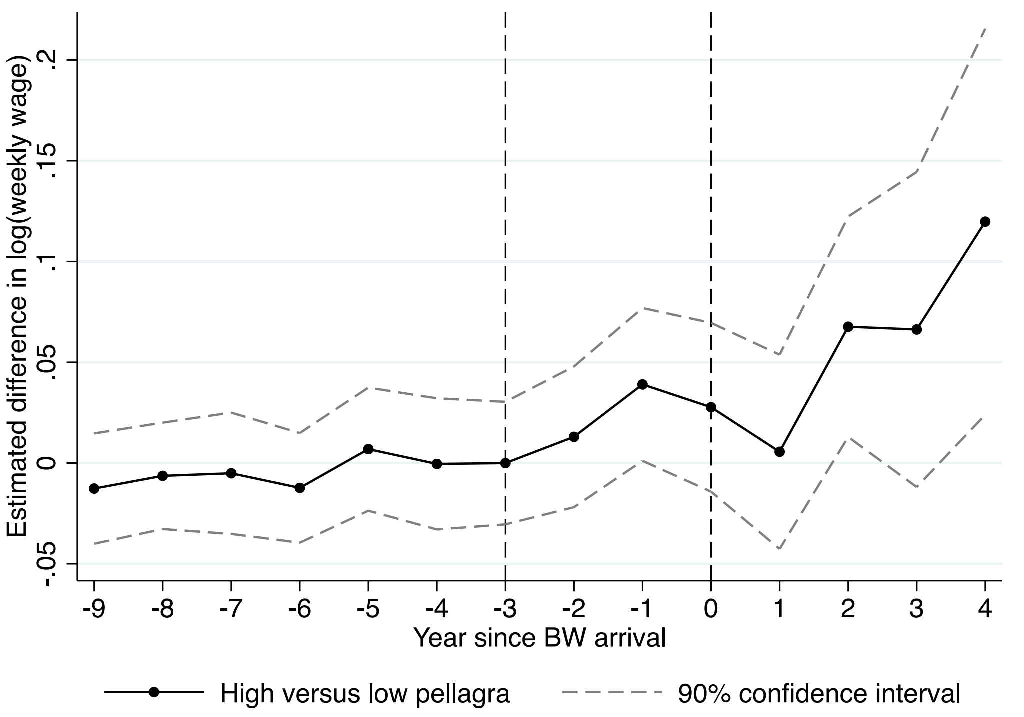
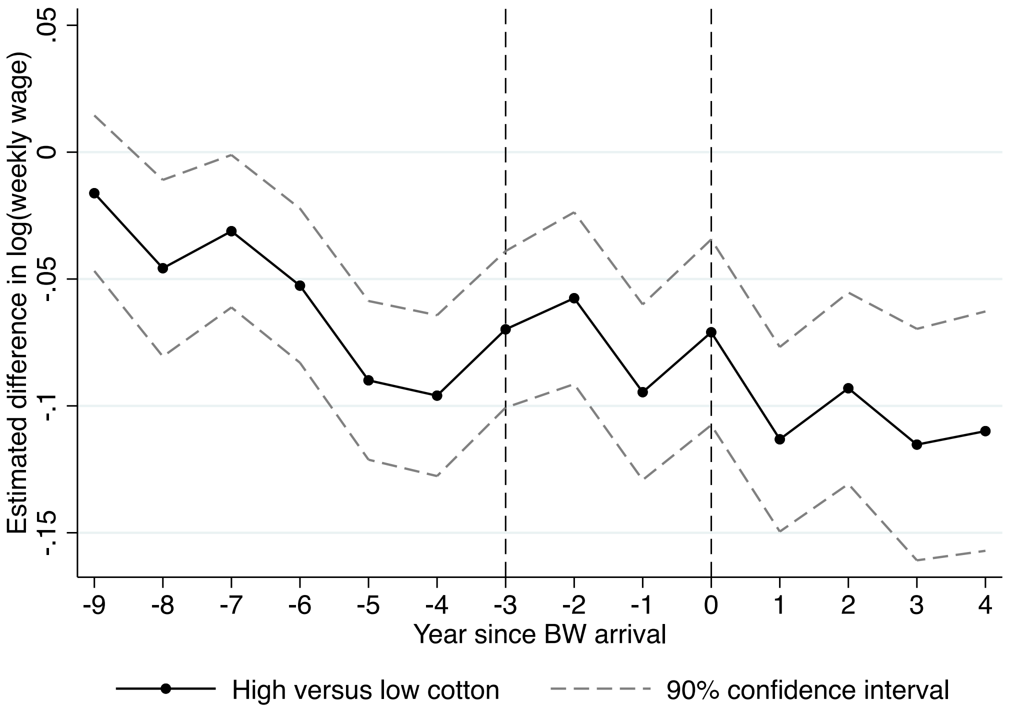


Figure 4

Panel A: Differences in weekly wages for blacks by cotton production



Panel B: Differences in weekly wages for blacks by pellagra mortality

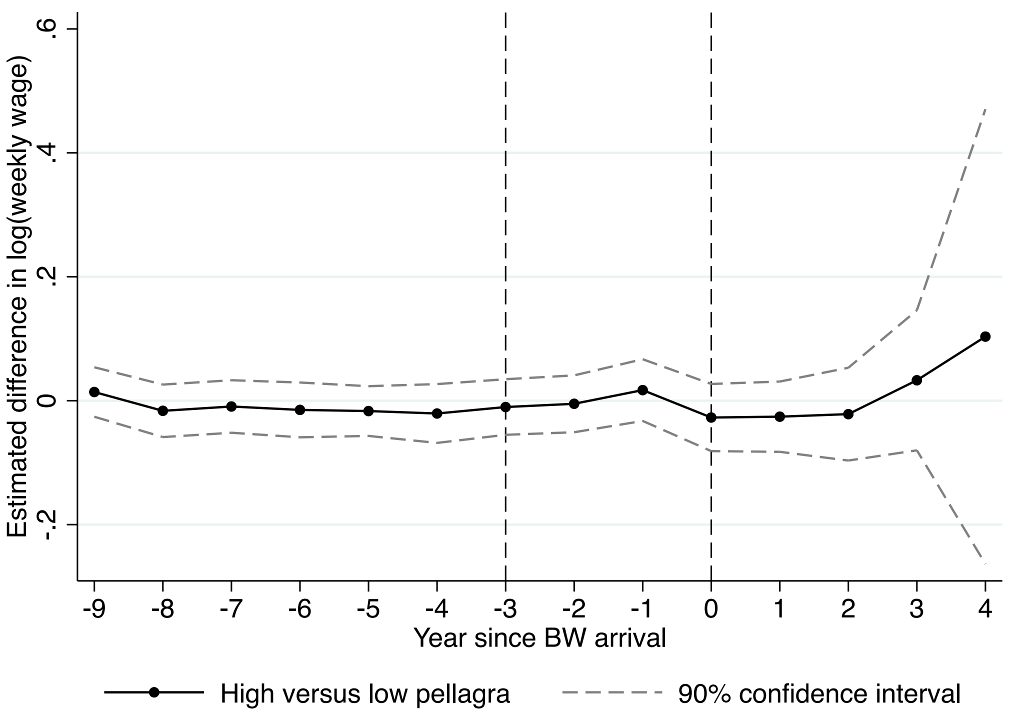


Table 1: Summary statistics

	All counties invaded by the boll weevil		Counties invaded by the boll weevil in MO, NC, SC, and TN	
	High cotton	Low cotton	High pellagra	Low pellagra
		Panel A: Whites		
Weekly wage	15.37	16.84	16.13	14.31
Educational attainment	8.95	9.57	9.27	8.89
Migrate out of state	0.25	0.23	0.16	0.19
Cotton acres per capita (unweighted)	2.05	0.25	1.12	0.74
Pellagra death rate per 10,000 (unweighted)	NA	NA	4.35	0.89
Observations	151,242	94,892	55,996	31,768
Counties	283	159	87	85
		Panel B: Blacks		
Weekly wage	9.54	10.29	9.7	9.24
Educational attainment	5.54	6.53	6.03	5.88
Migrate out of state	0.3	0.24	0.28	0.25
Cotton acres per capita (unweighted)	2.05	0.25	1.12	0.74
Pellagra death rate per 10,000 (unweighted)	NA	NA	4.35	0.89
Observations	57,309	23,189	23,314	9,817
Counties	283	158	87	84

Table 2: The impact of the boll weevil on wages

	Log(weekly wage)				
	All counties invaded by the boll weevil in 1915-1922			Counties invaded by the boll weevil in MO, NC, SC, and	
	(1)	(2)	(3)	(4)	(5)
			Panel A: Whites		
Post boll weevil	0.0209***	0.00891	0.00552	-0.0269	-0.0233
	(0.00764)	(0.00945)	(0.0105)	(0.0191)	(0.0216)
Post boll weevil * high county cotton acres per capita (1909)		0.0186*	0.0236**	0.0135	0.0230
		(0.0106)	(0.0113)	(0.0140)	(0.0149)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				0.0314**	0.0266
				(0.0153)	(0.0166)
N	246134	246134	193023	87764	70942
Counties	442	442	442	172	172
			Panel B: Blacks		
Post boll weevil	-0.0256*	-0.0144	-0.0339**	-0.0390	-0.0567*
	(0.0132)	(0.0167)	(0.0168)	(0.0309)	(0.0317)
Post boll weevil * high county cotton acres per capita (1909)		-0.0147	0.00826	-0.0155	-0.00528
		(0.0127)	(0.0131)	(0.0206)	(0.0200)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				-0.00912	-0.0158
				(0.0232)	(0.0228)
N	80498	80498	55915	33131	22647
Counties	441	441	441	171	171
Child county of residence fixed effects	Yes	Yes	Yes	Yes	Yes
Census year fixed effects	Yes	Yes	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes	Yes	Yes
Father's occscore fixed effects	Yes	Yes	Yes	Yes	Yes
Full sample	Yes	Yes	No	Yes	No
Restricted sample	No	No	Yes	No	No

Notes: This table reports OLS estimates from equation (1) in the text. The unit of observation is an individual. Standard errors, reported in parentheses, are clustered at the child county of residence level. The variable "high county pre-boll weevil cotton acres per capita" is an indicator if a county in Missouri, North Carolina, South Carolina, or Tennessee that was invaded by the boll weevil had above median cotton acres per capita in 1909 (the counties used in the sample in columns (1)-(4)). The variable "high county pre-boll weevil pellagra death rate" is an indicator if a county in Missouri, North Carolina, South Carolina, and Tennessee that was invaded by the boll weevil had an above median pellagra death rate in 1915 and 1916.

Table 3: The impact of the boll weevil on educational attainment

	Educational attainment				
	All counties invaded by the boll weevil in 1915-1922			Counties invaded by the boll weevil in MO, NC, SC, and	
	(1)	(2)	(3)	(4)	(5)
			Panel A: Whites		
Post boll weevil	-0.000504	0.0449	0.0140	0.0903	0.0918
	(0.0427)	(0.0485)	(0.0524)	(0.113)	(0.121)
Post boll weevil * high county cotton acres per capita (1909)		-0.0701	-0.0101	-0.110	-0.0602
		(0.0437)	(0.0451)	(0.0689)	(0.0735)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				-0.105	-0.109
				(0.0870)	(0.0950)
N	246134	246134	193023	87764	70942
Counties	442	442	442	172	172
			Panel B: Blacks		
Post boll weevil	-0.140**	-0.0527	-0.0891	-0.351**	-0.184
	(0.0711)	(0.0913)	(0.111)	(0.148)	(0.190)
Post boll weevil * high county cotton acres per capita (1909)		-0.114*	0.00231	0.0188	0.0472
		(0.0677)	(0.0802)	(0.0937)	(0.104)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				0.0502	-0.163
				(0.101)	(0.120)
N	80498	80498	55915	33131	22647
Counties	441	441	441	171	171
Child county of residence fixed effects	Yes	Yes	Yes	Yes	Yes
Census year fixed effects	Yes	Yes	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes	Yes	Yes
Father's occscore fixed effects	Yes	Yes	Yes	Yes	Yes
Full sample	Yes	Yes	No	Yes	No
Restricted sample	No	No	Yes	No	No

Notes: This table reports OLS estimates from equation (1) in the text. The unit of observation is an individual. Standard errors, reported in parentheses, are clustered at the child county of residence level. The variable "high county pre-boll weevil cotton acres per capita" is an indicator if a county in Missouri, North Carolina, South Carolina, or Tennessee that was invaded by the boll weevil had above median cotton acres per capita in 1909 (the counties used in the sample in columns (1)-(4)). The variable "high county pre-boll weevil pellagra death rate" is an indicator if a county in Missouri, North Carolina, South Carolina, and Tennessee that was invaded by the boll weevil had an above median pellagra death rate in 1915 and 1916.

Table 4: The effect of the boll weevil on the probability of migrating

	Pr(move states = 1)				
	All counties invaded by the boll weevil in 1915-1922			Counties invaded by the boll weevil in MO, NC, SC, and	
	(1)	(2)	(3)	(4)	(5)
			Panel A: Whites		
Post boll weevil	-0.000931	-0.00744	-0.00750	-0.00187	-0.0101
	(0.00580)	(0.00674)	(0.00718)	(0.0132)	(0.0142)
Post boll weevil * high county cotton acres per capita (1909)		0.0100*	0.0145***	0.00999	0.0166*
		(0.00546)	(0.00555)	(0.00930)	(0.0100)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				-0.00336	0.00207
				(0.00968)	(0.0108)
N	246134	246134	193023	87764	70942
Counties	442	442	442	172	172
			Panel B: Blacks		
Post boll weevil	-0.00996	0.00118	-0.00707	-0.0281	-0.0431*
	(0.00839)	(0.0108)	(0.0129)	(0.0196)	(0.0255)
Post boll weevil * high county cotton acres per capita (1909)		-0.0146*	-0.00633	-0.0267*	-0.0212
		(0.00870)	(0.00977)	(0.0153)	(0.0161)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916				0.0176	0.0204
				(0.0135)	(0.0174)
N	80498	80498	55915	33131	22647
Counties	441	441	441	171	171
Child county of residence fixed effects	Yes	Yes	Yes	Yes	Yes
Census year fixed effects	Yes	Yes	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes	Yes	Yes
Father's occscore fixed effects	Yes	Yes	Yes	Yes	Yes
Full sample	Yes	Yes	No	Yes	No
Restricted sample	No	No	Yes	No	No

Notes: This table reports OLS estimates from equation (1) in the text. The unit of observation is an individual. Standard errors, reported in parentheses, are clustered at the child county of residence level. The variable "high county pre-boll weevil cotton acres per capita" is an indicator if a county in Missouri, North Carolina, South Carolina, or Tennessee that was invaded by the boll weevil had above median cotton acres per capita in 1909 (the counties used in the sample in columns (1)-(4)). The variable "high county pre-boll weevil pellagra death rate" is an indicator if a county in Missouri, North Carolina, South Carolina, and Tennessee that was invaded by the boll weevil had an above median pellagra death rate in 1915 and 1916.

Table 5: The impact of the boll weevil on height

	Height (inches) Counties invaded by the boll weevil in MO, NC, SC, and TN		
	(1)	(2)	(3)
Post boll weevil	0.160*	0.174**	0.108
	(0.0816)	(0.0840)	(0.0935)
Post boll weevil * high county cotton acres per capita (1909)		-0.0456	-0.0478
		(0.0588)	(0.0562)
Post boll weevil * high county pre-boll weevil pellagra death rate (1915-1916 average)			0.120**
			(0.0565)
N	44486	44486	44486
Counties	172	172	172

Notes: This table reports OLS estimates from equation (1) in the text. The unit of observation is an individual. Standard errors, reported in parentheses, are clustered at the child county of residence level. The variable “high county pre-boll weevil cotton acres per capita” is an indicator if a county in Missouri, North Carolina, South Carolina, or Tennessee that was invaded by the boll weevil had above median cotton acres per capita in 1909 (the counties used in the sample in columns (1)-(4)). The variable “high county pre-boll weevil pellagra death rate” is an indicator if a county in Missouri, North Carolina, South Carolina, and Tennessee that was invaded by the boll weevil had an above median pellagra death rate in 1915 and 1916.

Appendix

Appendix Table 1: Comparison of linked children to the complete count sample; 1900, 1910, 1920, and 1930 full count censuses linked to 1940 full count census

Census Year:	1900		1910		1920		1930	
	Linked Sample	Complete Count Sample	Linked Sample	Complete Count Sample	Linked Sample	Complete Count Sample	Linked Sample	Complete Count Sample
Personal characteristics:								
Mean age	8.48	8.82	8.93	9.07	9.2	9.19	9.46	9.57
Median age	8	8	8	9	9	9	9	9
Literate	0.74	0.68	0.91	0.85	0.95	0.91	0.96	0.94
In school	0.69	0.67	0.48	0.46	0.48	0.46	0.51	0.49
Percent black	0.15	0.26	0.11	0.25	0.11	0.22	0.14	0.21
Household and family characteristics:								
In urban area	0.17	0.16	0.2	0.19	0.23	0.22		
Home owned	0.55	0.5	0.54	0.49	0.52	0.48		
Mother present	0.96	0.95	0.95	0.94	0.95	0.95	0.97	0.96
Father present	0.92	0.9	0.92	0.9	0.92	0.9	0.94	0.92
Mother literate if present	0.82	0.74	0.88	0.82	0.91	0.88	0.95	0.93
Father literate if present	0.84	0.78	0.89	0.84	0.9	0.87	0.94	0.92
Father occscore if present & occupation available	16.37	15.94	18.79	18.19	16.34	15.98	18.76	18.41
Observations	1,792,381	7,671,058	2,501,033	8,844,715	2,997,827	9,556,484	3,580,809	10,244,392

Notes: This table reports differences in means between individuals who were linked to the 1940 census, as described in the text, and the entire sample that we attempted to link from the complete count censuses. The census question on literacy only applied to persons 10+ years of age in 1910, 1920, and 1930. We do not have data on urban status or homeownership for 1930, although this data is available.

Appendix Table 2: The impact of the boll weevil on wages

	Log(weekly wage) All counties invaded by the boll weevil in 1892-1914		
	(1)	(2)	(3)
		Panel A: Whites	
Post boll weevil	-0.00364	0.0126	0.0141
	(0.00810)	(0.00997)	(0.00983)
Post boll weevil * high county cotton acres per capita (1909)		-0.0239**	-0.0195**
		(0.00933)	(0.00898)
N	269723	269723	214113
Counties	426	426	426
		Panel B: Blacks	
Post boll weevil	-0.00444	0.0142	-0.000325
	(0.0131)	(0.0155)	(0.0147)
Post boll weevil * high county cotton acres per capita (1909)		-0.0253**	-0.00649
		(0.0115)	(0.0104)
N	82281	82281	62982
Counties	425	425	423
Child county of residence fixed effects	Yes	Yes	Yes
Census year fixed effects	Yes	Yes	Yes
Birth year fixed effects	Yes	Yes	Yes
Father's occscore fixed effects	Yes	Yes	Yes
Full sample	Yes	Yes	No
Restricted sample	No	No	Yes

Notes: This table reports OLS estimates from equation (1) in the text. The unit of observation is an individual. Standard errors, reported in parentheses, are clustered at the child county of residence level. The variable “high county pre-boll weevil cotton acres per capita” is an indicator if a county in Missouri, North Carolina, South Carolina, or Tennessee that was invaded by the boll weevil had above median cotton acres per capita in 1909 (the counties used in the sample in columns (1)-(4)). The variable “high county pre-boll weevil pellagra death rate” is an indicator if a county in Missouri, North Carolina, South Carolina, and Tennessee that was invaded by the boll weevil had an above median pellagra death rate in 1915 and 1916.