A Blessing in Disguise: The Long-Term Effects of Childhood Exposure to the boll weevil on Old-Age Longevity*

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Abstract

The infamous agricultural pest, the boll weevil, spread across southern US counties between 1892 and 1920. It had devastating impacts on cotton production, a highly child-labor-intensive crop. This study examines how the arrival of the boll weevil and the subsequent reductions in child labor affect later-life mortality outcomes. Using Social Security Administration death records linked with the 1940 census, we document that the staggered spread of the boll weevil improved the longevity of exposed male children. Full exposure to the boll weevil is associated with an intent-to-treat effect of 2.9 months of higher longevity. We show that the estimated effects are robust across a wide array of specifications, are not driven by sociodemographic and socioeconomic compositional change in the final sample, and are not associated with pre-existing trends in the outcome. Further, we find larger impacts among Blacks, children of lower socioeconomic status families, and those in high cotton intensity counties. Moreover, the effects appear to be substantially larger among children in states with less restrictive child labor policies, implying the role of these policies in reducing the adverse effects of child labor in the absence of the boll weevil in cotton production counties. Affected children are more likely to migrate, and their destination counties have higher socioeconomic scores. The 1940 census suggests that the exposed children attain higher levels of education and have higher socioeconomic scores. We discuss the policy implications of these results in relation to child labor and school attendance policies in developing countries.

Keywords: Mortality, Longevity, boll weevil, Agricultural Shocks, Child Labor, Education

JEL Codes: I18, J18, N51, N52, Q19

* The authors claim that they have no conflict of interest to report. The authors would like to acknowledge financial support from NIA grants (R01AG060109, R01AG076830). We thank Joshua Goldstein for helpful comments.

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1. Introduction

A recently growing literature investigates determinants of disparities in aging and longevity and documents the influence of early life and childhood conditions and exposures (Aizer et al., 2016; Barker, 1992, 1994, 1995; Hayward & Gorman, 2004; Lindeboom et al., 2010; Myrskylä, 2010). Shocks in early life and childhood change the trajectory of developmental outcomes and can be detected in later-life health and longevity. For instance, one prominent line of research examines the effects of quantity and quality of education on later-life health and mortality and finds neutral (Albouy & Lequien, 2009; Meghir et al., 2018) or positive impacts (Buckles et al., 2016; Lleras-Muney, 2005; Lleras-Muney et al., 2022). Another line of research investigates the influence of family socioeconomic conditions, parental job loss, and worsening local economic conditions and documents negative consequences on an array of later-life outcomes, including mortality and longevity (Hayward & Gorman, 2004; Noghanibehambari et al., 2024; Scholte et al., 2015; Van Den Berg et al., 2006). However, many exposures are multifaceted and affect children's outcomes in several ways. For instance, negative demand-side shocks in local labor markets have a negative impact on household financial resources, meanwhile incentivizing migration to better places, which might turn out to be advantageous for children's outcomes in the short-run and long-run (Black et al., 2015; Finkelstein et al., 2021). Further, such negative shocks to local labor markets, specifically informal labor markets that employ children as low-wage workers, might incentivize parents to invest in children's schooling by lowering the opportunity cost of school attendance (Duryea & Arends-Kuenning, 2003).

The current study joins this literature by evaluating a unique and arguably exogenous agricultural labor market shock. Specifically, we focus on the cotton production sector in the early

decades of the 20th century in the US South. In this period, the cotton harvest required a significant influx of additional labor from September to December. Due to their small size and nimble fingers, children were often hired, both officially and unofficially, to meet the high demand for seasonal workers. The arrival of the boll weevil, an insect that feeds on cotton buds and flowers, caused widespread devastation to cotton crops, thereby reducing the demand for child labor in cotton harvesting.

Despite its negative impacts on agricultural output, income, land value, and parental employment opportunities, studies suggest that the staggered arrival of boll weevil resulted in overall improvements in children's educational outcomes. Baker (2015) employs county-level data from Georgia between 1914 and 1929 and uses the appearance of the boll weevil as an instrument for cotton production. He documents that a 10% decline in cotton production results in a 2% increase in the school enrollment rate among black children with no discernible impact on white children. Using the universe of southern counties, Baker et al. (2020) use the 1940 census and document that both white and black children who were 4-9 years old at the time of boll weevil's arrival reveal 0.24-0.36 additional years of higher completed education. Clay et al. (2020) document a 6% increase in wage income of black individuals who were exposed to the boll weevil during their childhood as observed in 1940. Lange et al. (2009) find that the boll weevil substantially reduced cotton production and cotton yield. They show that farmers shifted to other crops, although they faced reductions in land values. Further, they document considerable out-migration post-arrival of the pest, especially in counties with a higher baseline cotton production. Bloome et al. (2017) document reductions in the share of married individuals among African Americans following boll weevil's arrival. Among African Americans aged 20-29, the share of married individuals fell by roughly 3.7%.

These changes in social and economic conditions can affect children's outcomes in various ways, making a priori expectations about the net effects on later-life outcomes ambiguous. For example, the increases in schooling and migration likelihood could be at least partly counteracted by the worsening economic circumstances of the children's families and communities due to boll weevil infestations. We employ Social Security Administration male death records linked to the full count 1940 census to examine the effects of early life and childhood exposure to the boll weevil on later-life old-age longevity. Recent developments in cross-census linking algorithms allow us to link individuals from the 1940 census to historical full count censuses 1900-1930 in order to infer county of birth/childhood, an essential identifier in our setting. The data also provides a wide array of family socioeconomic and sociodemographic characteristics, which enables the implementation of heterogeneity analyses. We find net positive effects on the longevity of individuals who were exposed to the infamous agricultural pest during their childhood years. Specifically, full exposure to the boll weevil throughout childhood is associated with an increase in longevity of about 2.9 months. Among African Americans, the benefit rises to roughly 4.1 months of additional longevity. We document that the impacts are almost exclusively concentrated among families with low socioeconomic status and in counties with higher cotton production levels in 1900. Moreover, we find aspects of dynamic substitutability with state-level child labor laws whereby we observe considerably larger effects in states that have more liberal regulations regarding child labor and a small and insignificant effect in states with more restrictive child labor policies. In other words, negative labor demand shocks to a child-labor-intensive industry manipulate incentives similar to child labor policies.

Using alternative data, we examine the heterogeneity by gender. We find that the effects are exclusive to men and that the coefficient of women is economically small and statistically

insignificant. Since, during this period, a large portion of the child labor force consisted of boys, it is not surprising to observe such gender-specific impacts.

Further, we implement a wide array of sensitivity checks and document that the observed impacts are quite robust to alternative specifications, functional forms, and sample selections. A series of event studies rule out concerns regarding pre-existing trends in education and longevity outcomes. We also show that endogenous changes in the sociodemographic and socioeconomic composition of the individuals in the final sample are not likely to confound the estimated effects. We further provide arguments that the limited death window selection likely underestimates the results and that the true effects are likely larger.

Consistent with prior literature, we observe that exposed individuals are more likely to migrate out of their county of birth/childhood in 1940. We find larger coefficients among the subsample of migrants, an increase of 4.6 months in longevity, which suggests that migration provided benefits and might be a pathway for the observed long-term links.

To further examine the mechanisms, we use the 1940 census and assess the effects of exposure on measures of education and socioeconomic status, given the literature that documents a link between education, income, socioeconomic status, and longevity (Fletcher, 2015b; Galama et al., 2018; Lleras-Muney et al., 2022). Full exposure to the boll weevil during childhood is associated with 0.5 additional years of higher education, 16% higher college attendance, and about 3.8% increase in their socioeconomic index.

Finally, we implement two-stage least square estimations, using exposure to the boll weevil as the instrument for education, and examine education-longevity associations. While this analysis requires strong assumptions (i.e. the exclusion restriction that the boll weevil only affects longevity through its impact on education), we view the exercise as a useful addition to the underexamined

question of the causal effects of education on longevity. We observe that an additional year of schooling is associated with roughly 5.1 months of higher longevity.

This study makes three important contributions to the literature. First, it adds to the small literature that evaluates the impacts of the boll weevil on children's later-life outcomes (Baker, 2015; Baker et al., 2020; Bloome et al., 2017; Lange et al., 2009). Although the boll weevil was eradicated in the 1970s, many developing countries still face similar invasive pests, plant pathogen epidemics, and other viral diseases. For instance, many countries in recent decades experienced agricultural pest crises, including the infamous cotton pests in West Africa, coffee leaf rust in Central America, Maize Lethal Necrosis Disease (MLND) in East Africa, and many instances of locust outbreaks in Africa and Asia. Besides, there is evidence that climate change significantly contributes to the spread of agricultural pests, especially in temperate zones (Schneider et al., 2022). Since policy interventions are costly, it is important to have a full picture of their impacts and the relevant pathways and settings.

Second, since the findings point to a substitution of schooling for child labor as an important pathway, this paper also adds to the literature that examines the effects of education on mortality (Buckles et al., 2016; Fletcher, 2015; Fletcher & Noghanibehambari, 2023; Lleras-Muney, 2005, 2022; Noghanibehambari & Fletcher, 2024). The reduction in the marginal productivity of child labor was plausibly exogenous as it was tied to the spreading path of the boll weevil. The presence, pace of population growth, and expansionary path of the pest was difficult to anticipate as it depended on several unpredictable factors, including wind direction, humidity, temperature, trade routes for agricultural equipment and other inputs, biological resistance of each generation to certain local control measures, and other environmental barriers such as mountains, lakes, rivers, and dry regions (Fye, 1968; McKibben et al., 1991; Pierce, 1912). The unpredictable

spatial and timing movements of the boll weevil add to the exogeneity of the shock, hence arguably unconfounded long-term links.

Third, we contribute to the growing literature that examines the impacts of early life and childhood exposures and later-life mortality.[4] We provide evidence that reducing child labor and increasing schooling outcomes in the early years of childhood could outweigh the potentially negative effects of adverse economic shocks. This fact carries important policy implications, especially for developing countries with weak prevailing policies regarding child labor and education (Chorny et al., 2019).

The rest of the paper is organized as follows. Section 2 reviews the historical background. Section 3 introduces data sources and the process of sample selection. Section 4 discusses the econometric method. Section 5 reviews the results. Section 6 explores mechanism channels. Section 7 concludes the paper.

2. Historical Background

The boll weevil (scientific name: *Anthonomus grandis*) is a small beetle with a keen appetite for cotton buds and flowers. It is native to Central America and Mexico. In the late 19th century, it gradually spread northwards due to the expansion of cotton cultivation, migration, trade routes, and the movement of goods and agricultural products between Mexico and the US. It was first detected in the US in 1892 near Brownsville, Texas. After its arrival in Texas, the boll weevil expanded rapidly across the Southern United States, primarily because of its ability to fly short

[4] This literature examines a wide array of early life shocks, including family socioeconomic status, family structure, local economic shocks, social policies and cash transfers, natural disasters, pesticide exposures, and several county level, state-level, and federal policy reforms (Case & Paxson, 2009; Finch & Crimmins, 2004; J. Fletcher & Noghanibehambari, 2024; Hayward et al., 2013; Hayward & Gorman, 2004; Lindeboom et al., 2010; Montez & Hayward, 2011; Noghanibehambari et al., 2024; Noghanibehambari & Engelman, 2022; Noghanibehambari & Fletcher, 2023c, 2023d, 2023f, 2023a, 2023b; Noghanibehambari & Noghani, 2023; Schmitz & Duque, 2022; Scholte et al., 2015; Smith et al., 2006; Van Den Berg et al., 2006).

distances and its hitchhiking on cotton shipments. By 1903, it had spread to Louisiana, and within the next two decades, it reached most of the Cotton Belt, including Mississippi, Alabama, Georgia, and the Carolinas. By the 1920s, the boll weevil had infested the entire Cotton Belt, causing widespread destruction. The top panel of Figure 1 depicts the year of boll weevil's arrival across counties in the Cotton Belt.[5]

The boll weevil lays its eggs inside cotton buds and bolls (the rounded seed capsules of the cotton plant). The larvae feed on cotton bolls, resulting in the destruction of the plant. Many of the control measures, such as crop rotation, destruction of cotton stalks after harvest to reduce overwintering sites, and the development of early-maturing cotton varieties, produced limited impacts. Overall, the boll weevil's invasion significantly reduced cotton yields in cotton production counties and adversely affected local economies in the Cotton Belt. Lange et al. (2009) document that cotton production dropped by roughly 50% within five years of the boll weevil's arrival in a county.

Cotton was the staple crop of the US South. Roughly 75% of the total raw cotton production of the world came from Cotton Belt counties in the US during the early decades of the 20th century (Jordan, 1910). The mechanization of cotton production advanced in the years after World War II (Fite, 1950). Therefore, in prior decades, cotton bolls were picked by hand. The physical characteristics of the children made them suitable candidates for cotton harvesting during the harvest season, which lasted from September through December. Since many families were tenant farmers, it was common to use children as substitutes for adult labor. Early surveys from this period suggest that 66% of white children and 76% of black children engaged in farm work during

[5] Cotton Belt states in the final sample include Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia.

the harvest season, nearly all of whom were involved in picking cotton (Bradley & Williamson, 1969). The arrival of the boll weevil disrupted this long-standing equilibrium by reducing the marginal productivity of child labor.

3. Data Sources

The primary source of data for this study comes from Social Security Administration Death Master Files (henceforth DMF) provided by the Censoc project (Goldstein et al., 2021). The data reports deaths that occurred among men between the years 1975-2005. There are three advantages to using the DMF data in our setting. First, the data can be linked to the 1940 census at the individual level. The linkage allows us to observe all individual and family level characteristics as reported in the 1940 census, including several measures of socioeconomic status, education, family structure, and granular residential location. Second, the initial data contains roughly 8 million death records. After the sample selection procedures explained below, focusing on affected cohorts in affected locations, we are still left with a relatively large sample size. This is in sharp contrast with alternative data sources that can be linked to the 1940 census, such as the Health and Retirement Study, which produces considerably smaller sample sizes on the order of several thousand. Third, since a large portion of individuals in the 1940 census can be linked back to historical censuses from 1900 to 1930, we can extract their county of residence during early life and childhood. This sub-state location identifier for place of birth, early life, and childhood allows us to examine granular shocks on long-term outcomes. It is arguably a rare piece of information in primary datasets that also report mortality and longevity.

The procedure of inference of the early life county of residence is as follows. First, a subset of the DMF data is also recorded in the Numerical Identification death records (henceforth Numident) data. The Numident data covers a considerably shorter death window (i.e., 1988-2005).

However, it reports the county of birth as reported in individuals' Social Security records. We use county of birth in the Numident data for those observations in the DMF data that are also recorded in the Numident. Roughly 49% of observations are assigned county of birth using this method. Second, we employ cross-census linking rules provided by Price et al. (2021) to link 1940 records to full count historical censuses 1900-1930. Roughly 4.6% of observations are linked to the 1900 census and are assigned county of residence in 1900 as the county of early life and childhood. Similarly, 8.6%, 11.7%, and 13.4% of observations are linked to the 1910, 1920, and 1930 censuses, respectively. We use county of residence in those censuses, in ascending order, as the county of birth, early life, and childhood. The 1940 census asks about the county of residence five years ago, i.e., 1935. If the individuals have migrated during the past five years, we use the county of residence in 1935 as the early life county. That accounts for 1.5% of observations. Finally, for all unlinked observations, we use the county of residence in 1940 as a proxy for the early life county. About 10.5% of observations are assigned the 1940 county as the early life county.[6]

In the same manner that we extract early life county from historical censuses, we extract maternal literacy and paternal socioeconomic status. In addition, we restrict the sample to birth cohorts of 1890-1940, to cover several cohorts before and after the boll weevil expansions. To account for time-varying county characteristics, we construct a county-by-year panel based on information in historical censuses 1880-1940 and interpolate linearly for inter-decennial years. We merge this panel with our DMF data based on early life county and birth year.[7]

[6] In Appendix A, we compare statistics of the final sample with those of the original population observed in the 1940 census. Further, we show that exposed individuals are more likely to be in the final sample but that such selection appears to be race neutral. Moreover, the implied change of the selection is fairly small.

[7] The main results of the paper are based on a sample of counties that ever experienced the boll weevil as reported by Baker et al. (2020). In Appendix C, we include all US counties and replicate the main results. We observe comparable and, in the fully parameterized model, slightly larger coefficient sizes.

The data on the year of boll weevil's arrival is extracted from Baker et al. (2020). The data on agricultural production is taken from Gutmann (2005). All census data are extracted from Ruggles et al. (2020).

Summary statistics of the final sample are reported in Table 1. The final sample covers 1,279,569 observations. We split the sample into cohorts based on their exposure to the boll weevil in their county of birth-early life. The exposed group consists of those with any exposure to the boll weevil during their childhood (i.e., ages 5-17), and the non-exposed group contains individuals with no exposure during their childhood years (i.e., ages 17 and older). Although it seems an arbitrary split, the event studies disentangle the impacts across different ages at exposure (discussed in section 5.1).

Exposed individuals live on average 830.5 (69.2) months (years), while non-exposed individuals reveal a lifespan of 965 (80.4) months (years). Figure 2 illustrates the density distribution of age-at-death for the full sample.

Roughly 76.5% and 78.1% of observations in exposed and non-exposed groups are whites, respectively. In the exposed subsample, individuals are, on average, exposed to the boll weevil for roughly 64% of their childhood years. Exposed individuals consist of more later birth cohorts (on average, 1923), and non-exposed individuals comprise earlier cohorts (on average, 1906). The fact that control cohorts have, on average, higher longevity than exposed cohorts partly mitigates the concern that the limited death window (i.e., 1975-2005) adds selection bias to our estimates. If the impacts are confounded by death window selection, then we would observe higher longevity for earlier cohorts who were selected from comparably lower life expectancy cohorts and later cohorts. The positive impacts on longevity of later cohorts (with lower average longevity in the selected window) in comparison with earlier cohorts (with higher average longevity in the selected

window) operate in the opposite direction as one would expect from selections due to limited death window.

For the analysis regarding the mechanism channel, we restrict the sample to individuals above age 18 and focus on outcomes in the 1940 census. On average, individuals attain 8.4 and 8.1 years of schooling in exposed and unexposed groups, respectively.

4. Econometric Method

Our empirical method relies on the plausibly exogenous staggered spread of the boll weevil. The arrival of the boll weevil was likely exogenous, as it was connected to the boll weevil's unpredictable spatial and temporal diffusion. The pest's presence, population growth rate, and expansion path were challenging to forecast, influenced by various unpredictable factors, including wind patterns, humidity, temperature, agricultural trade routes, the biological resistance of each generation to local control efforts, and environmental obstacles like mountains, lakes, rivers, and arid areas. Therefore, it is unlikely that county-level arrival of the boll weevil correlates with determinants of local population health and longevity.

We implement difference-in-difference event study regressions to compare the longevity of individuals who were exposed to the boll weevil across different ages. We assume that the longevity of individuals across different ages at the time of the boll weevil's arrival would have followed the same evolutionary path in the absence of the arrival of the boll weevil. Specifically, we employ the following regressions:

$$y_{icb} = \alpha + \sum_{j \neq -1} \beta_j I(b + 5 - T_c^* = j) + \gamma X_{icb} + \lambda Z_{cb} + \xi_c + \zeta_b + \varepsilon_{icb} \quad (1)$$

The outcome, y, is age at death (measured in months) of individual i born in county c and year b. $I(.)$ equals one if the inside argument is true and zero otherwise. The parameter T^* represents county-specific year of boll weevil's arrival. Therefore, coefficients β represent longevity differences of cohorts at different ages at the time of boll weevil's arrival. In matrix X, we include race and ethnicity dummies as individual covariates and paternal socioeconomic status and maternal education dummies as parental covariates. In matrix Z, we include county by cohort covariates, including per capita homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in different industries, and share of married individuals. County fixed effects, represented by ξ, account for all unobserved characteristics of counties that affect children's outcomes and are common across birth cohorts. The parameter ζ represents birth year fixed effects, which absorb unobserved determinants of longevity that vary over time but are common across different counties. Finally, ε is a disturbance term. Standard errors are clustered at the county level to account for serial correlations in error terms.

To summarize the event study coefficients of equation 1, we construct an exposure variable that measures the share of childhood years between ages 5-17 that the individual was exposed to the boll weevil. If an individual turned age 5 or less at the time of the boll weevil's arrival, the exposure variable takes a value of one. If the individual turned age 18 at the time of the arrival, we assign an exposure of zero. If the individual turned age 10 at the time of the arrival, he was exposed to the boll weevil between ages 11-17, i.e., 7 years out of 12 years of childhood. Therefore, the exposure variable takes a value of 0.58. We then use this variable as the primary independent variable in regressions similar to equation 1, as follows:

$$y_{icb} = \alpha + \beta ExpShare_{cb} + \gamma X_{icb} + \lambda Z_{cb} + \xi_c + \zeta_b + \varepsilon_{icb} \quad (2)$$

All parameters are similar to those of Equation 1.

5. Results

5.1. Event Study Results

The main results of Equation 1 are depicted in the top panel of Figure 3. The coefficients associated with exposure to the first year of the arrival of the boll weevil across childhood ages post-age-6 are small and insignificant. Specifically, the coefficient that represents exposure at age 16-and-above (i.e., the coefficient labeled <-10) reveals an economically and statistically zero effect. However, for those aged five and under at the time of the boll weevil's arrival, we observe relatively larger and, in many cases, statistically significant coefficients. Suppose the effects, as we discuss in section 6, are partly driven by school attendance and educational outcomes. In that case, it may seem counterintuitive that we do not observe larger impacts among other childhood years as represented by negative event time dummies in this figure. We should note two facts to gain a better understanding of the overall pattern of the coefficients. First, the impacts on school enrollment and completed education were also substantially higher among younger children, especially ages 4-6 (Baker et al., 2020). Indeed, the event studies of educational outcomes, reported in section 6.4, produce a quite similar pattern as those of longevity. Second, the largest impacts of the boll weevil were not materialized in the first period that they were detected in a county. Maturation, proliferation, and establishment of the boll weevil in a cotton farm took more than a year (Lange et al., 2009). The spatial spread of the boll weevil across all farmlands in the county was also not a one-year phenomenon and took several periods. Therefore, it is possible that the impacts are concentrated among younger children. However, it is also possible that there is a lag

in the impacts, and the increase in the coefficients around age 5 may partly reflect these lags rather than indicating a specific critical age.

In the middle panel of Figure 3, we show that the results are quite robust when accounting for treatment heterogeneity using the method developed by Sun & Abraham (2021). In the bottom panel, we employ the method developed by De Chaisemartin & D'haultfoeuille (2020) that employs only not-yet treated groups for comparisons of two-way fixed effects. We observe comparable patterns and coefficient magnitudes across panels.

5.2. Difference-in-Difference Results

The main results of Equation 2 are reported in Table 2. We start with a parsimonious specification in column 1 and add more covariates across consecutive columns. The coefficients are fairly robust. The fully parameterized regression of column 3 suggests that full exposure during childhood to the boll weevil is associated with about 2.9 months increases in longevity.

We can understand the economic significance of this effect by looking at other long-term determinants of longevity. For instance, Noghanibehambari & Fletcher (2023e) examine the long-lasting legacies of early-life exposure to the Dust Bowl of the 1930s for later-life mortality. They find that the longevity of male individuals from farmer families who were exposed to topsoil erosions due to the Dust Bowl drops by about 2.5 months. Therefore, the benefits of reductions in child labor due to the boll weevil are roughly equivalent to the adverse impacts of substantial drops in agricultural income as a result of the Dust Bowl. Aizer et al. (2016) examine the impacts of the Mother Pension (MP) program under which poor single-mother families received cash transfers for up to three years in the early 20th century. These transfers accounted for about 40% of pre-transfer family income. They document that the MP is associated with roughly 12-month increases in longevity of male children. Therefore, the intent-to-treat the effects of the arrival of the boll

weevil is about 25% of treatment-on-treated effects of a relatively generous and long-lived social program. Chetty et al. (2016) use tax return data linked to death records and examine the relationship between income and longevity. They document that each additional income percentile is associated with roughly 1.4 months higher longevity. Therefore, the longevity effect of the boll weevil is equivalent to a rise in income distribution of about two percentiles. This is roughly a $16,000 change from the mean of income (in 2020 dollars).

5.3. Heterogeneity Analyses

Black children were more likely to work as child laborers in cotton cultivation forms than their white counterparts. Baker (2015) and Baker et al. (2020) find considerably larger impacts on school enrollment and completed education among black children compared to white children. Clay et al. (2020) also find larger impacts on the wage income of Blacks than whites for their early life and childhood exposure to the boll weevil. Therefore, one would expect to observe a similar pattern for longevity. In columns 1-2 of Table 3, we examine the impacts in the subsample of whites and Blacks, respectively. We observe a considerably larger coefficient among Blacks, suggesting increases in longevity of about 4.1 months.

In columns 3-4, we examine heterogeneity based on paternal socioeconomic index. We find economically small and statistically insignificant effects for the subsample of children from high socioeconomic status families. For those from families with lower socioeconomic status, we find a coefficient of 3.6 months. In these families, parents are more likely to be farm laborers, and it is not uncommon for them to employ children as extra hands during the harvest seasons. Moreover, these parents are also less likely to be educated and to invest in the human capital of their children, hence more likely to encourage child labor (Emerson & Souza, 2003; Mukherjee &

Das, 2008). Therefore, it is not surprising that the impacts are exclusively concentrated among families with low socioeconomic status.

Besides, we observe slightly larger impacts in counties that have above-median share of farmers (columns 5-6). We also find heterogeneity based on the intensity of cotton production in the year 1900. The effects become larger for the subsample of the top quartile of 1900 cotton production and become smaller and statistically insignificant for the subsample of the bottom-three quartiles of 1900 cotton production.

Early life Exposures and policies may interact to influence long-term outcomes (Conti et al., 2016; Cunha & Heckman, 2007; Johnson & Jackson, 2019). In our setting, an important factor that could dynamically interact with the aftermath of the boll weevil is the presence and stringency of child labor policies. We use data from Acemoglu & Angrist (2000) and assign different measures of child labor to individuals based on their state of birth. We then split the sample based on stringency and rigidity of child labor policies and replicate the results in columns 1-2 of Table 4. We observe an increase in longevity of about 7.3 months for full exposure of children to the boll weevil in states with liberal or no child labor policies. For states with more restrictive child labor laws, we observe an effect size of 1.7 months, although statistically insignificant. These results suggest that there is a degree of substitutability between child labor policies and changes in marginal productivity of child labor as a result of the arrival of the boll weevil.

Previous research suggests that the effects of early life and childhood exposures on later-life outcomes could operate through gender-specific pathways and, therefore, reveal heterogeneity by gender (Feeny et al., 2021; Hamil-Luker & O'Rand, 2007; Lee & Ryff, 2019). The DMF data excludes females. To examine the heterogeneity by gender, we employ the Berkeley Unified Numident Mortality Database (henceforth BUNMD) extracted from the Censoc Project (Goldstein

et al., 2021). The BUNMD reports deaths to both genders. Importantly, it also reports the county of birth of individuals as recorded by the Social Security Administration. However, the death window coverage is more comprehensive and usable for the years 1988-2007. Further, it cannot be linked to the 1940 census records. Using the county of birth, we merge BUNMD with the boll weevil data and our constructed county covariates database. We then implement regressions similar to Equation 2 (excluding family controls) and report the results in Table 5. The full sample of column 1 suggests an increase in longevity of about 1.8 months. The effect on male longevity (column 2) is almost identical to that of column 3 of Table 2. Nonetheless, we do not observe a significant change in female longevity (column 3). The respective coefficient implies an insignificant increase of 0.6 months.

5.4. Sensitivity Analyses

In Table 6, we investigate robustness checks to alternative specifications. To have a benchmark comparison, we replicate the results of column 3 of Table 2 in column 1 of this table. In column 2, we allow for the influence of time-invariant county characteristics to have a differential impact on longevity based on individual race, maternal literacy, and paternal socioeconomic status. The estimated coefficient is comparable to that of column 1. To account for cross-cohort differential evolution of longevity across different census divisions, we interact census-division-of-birth by birth-year fixed effects in column 3. The estimated effect is slightly smaller than the main results but remains economically and statistically meaningful.

To account for cross-state migration and specifically the influence of the great migration of Southerners to Northern states, we add the interaction of birth state fixed effects by state of residence in 1940 fixed effects. The results, reported in column 4, are almost identical to that of column 1.

A small strand of research documents the influence of the season of birth on later-life longevity (Vaiserman, 2021; Vaiserman et al., 2002). In addition, there is a narrow literature that documents the phenomenon of seasonality in mortality outcomes (Falagas et al., 2009; Seretakis et al., 1997). To address such seasonality concerns, we add birth month and death month fixed effects into our regressions. The results, reported in column 5, reveal a comparable coefficient to that of column 1.

In columns 6-9, we examine the robustness to alternative functional forms. In column 6, we replace the outcome with the log age-at-death. Full exposure is associated with 0.3% rise in longevity, which is similar to the implied percentage change with respect to the mean of the outcome in column 1. In columns 7-9, we examine the effects on longevity beyond ages 70, 75, and 80, respectively. Full exposure is associated with 1.7, 1.9, and 1.1 percentage points increases in the probability of longevity beyond age 70, 75, and 80, respectively. Comparing with the mean of the outcomes, these effects can be translated into a change of 2.8%, 4.2%, and 3.9%, respectively.

In column 10, we weight regressions by the share of farmers in 1900 to assign higher weights to counties with a higher share of farmlands. Although the estimated coefficient drops slightly, it remains comparable to that of column 1.

A research strand examines the influence of exposure to the 1918 influenza and later-life outcomes, including mortality and longevity (Almond, 2006; Fletcher, 2018a, 2018b, 2018c; Myrskylä et al., 2013; Noghanibehambari & Fletcher, 2023e). To mitigate the 1918 influenza's confounding influence on our results, we remove cohorts born between 1918 and 1919 and replicate the results. The estimated coefficient, reported in column 11, is almost identical to that of column 1.

In addition, several studies suggest that the Great Depression, the Dust Bowl, and the introduction of New Deal relief programs affected the later-life outcomes of exposed children (Arthi, 2018; Noghanibehambari et al., 2024; Noghanibehambari & Engelman, 2022; Schmitz & Duque, 2022). We remove cohorts of the 1930s (hence a large portion of treated individuals) and replicate the main results in column 12. The estimated effect suggests only a slight decrease in the magnitude.

Another concern is that the boll weevil affected counties/cohorts that were inherently different than unaffected groups. Similarly, post-boll weevil, out-migration could occur among certain subpopulations more than others, and the characteristics of migrants/stayers correlate with their health and longevity. We empirically address both of these concerns using balancing tests by regressing observable characteristics of individuals in the final sample on exposure measure, conditional on county and cohort fixed effects. These results are reported in Table 7. We find insignificant changes in the share of whites and Blacks (columns 1-2). The respective changes implied by these coefficients are also very small. For instance, the coefficient of white in column 1 implies a change of 0.2% with respect to the mean of the outcome. We observe increases in the share of people from low socioeconomic status families (column 3) and small reductions in the share of individuals from higher socioeconomic status families (column 4). Moreover, we observe a small and statistically insignificant change in the share of individuals with literate mothers (column 6).

Overall, the estimations of this table and specifically significant coefficients of columns 3-4 are not concerning for two main reasons. First, the implied percentage changes with respect to the mean of the outcome are quite small in magnitude. Second, if anything, they add a downward

bias into our regressions as children of low socioeconomic status families have lower later-life longevity. Therefore, the overall positive effects provide a lower bound of the true effects.

6. Mediatory Outcomes

6.1. Agricultural Production

In Appendix B, we investigate the effects on several agricultural production outcomes using data for a subset of counties. In so doing, we employ data from Gutmann (2005) that reports production data for decennial years and merge with the boll weevil's arrival date database. We Investigate the associations between production and a dummy variable indicating post-boll weevil year, conditional on year and county fixed effects. We observe a decrease of roughly 55% in cotton production post-arrival of the boll weevil. This is quite comparable to the estimates of Lange et al. (2009). Further, we do not find significant changes in the production of other crops, including barley, rye, or other legume production.

6.2. County-level socioeconomic and sociodemographic outcomes

The arrival of the boll weevil can change the landscape of affected counties in many ways, including compositional changes in sociodemographic characteristics or compositional changes in occupations and measures of occupational standing. We use decennial censuses between the years 1880-1940 to construct a county-by-year panel and examine the evolution of county-level characteristics using event studies of the following form:

$$y_{ct} = \alpha + \sum_{i \neq -1} \beta_i I(t - T_C^* = i) + \xi_c + \zeta_t + \varepsilon_{ct} \quad (3)$$

The parameters ξ and ζ represent county and year fixed effects. The parameters β_i $(i < -1)$ and β_i $(i > 0)$ represent the difference between the outcome in years before and after the boll weevil's arrival year (T^*) relative to the outcome in one year prior to the arrival (i.e., $i = -1$). To

ease the interpretation, we standardize outcomes with respect to the mean and standard deviation of the full sample.

The estimates of equation 3 are reported in different panels of Figure 5 through Figure 7. We observe a discernible drop in the share of individuals working on farms but increases in other blue-collar occupations and all other occupations. However, there is no overall impact on occupational income score (Figure 5).

We observe large and significant reductions in the share of married individuals, consistent with the findings of Bloome et al. (2017). Additionally, we observe reductions in the number of children under five years old, implying decreases in fertility (top right panel of Figure 6). Despite these changes, we do not observe discernible changes in the share of whites or Blacks (bottom panels of Figure 6). We also do not observe significant changes in the average socioeconomic index, the share of literate people, the share of homeowners, or population (Figure 7).

Although these results point to sharp drops in employment in the farming sector, the substitution of other occupations and other sectors appears to offset the overall negative impacts. This can partly explain why we do not observe significant changes in occupational income scores and socioeconomic index. Therefore, these substitutions limit the overall negative impacts of worsening local economic conditions on later-life outcomes. Further, even though we observe reductions in marriage and fertility, the fact that there are virtually no changes in the demographic composition of counties rules out the concern regarding the overrepresentation of certain demographic groups with differential longevity as the confounding influence in our estimates.

6.3. Migration

Prior research suggests in-migration to cotton production counties in years prior to the boll weevil and out-migration in years after the arrival of the boll weevil (Lange et al., 2009). By

comparing our inferred early life county with the county of residence in 1940, we construct a binary measure of cross-country migration. In column 1 of Table 8, we examine the influence of exposure to the boll weevil on migration. Full exposure is associated with a 2.5-percentage-point rise in the probability of migration, equivalent to roughly 5.9% change with respect to the mean. Migration exposes individuals to different landscapes with potential later-life benefits (Finkelstein et al., 2021) or adverse impacts (Aaronson et al., 2021). We use the average socioeconomic index in the destination county (i.e., 1940 county of residence) as a measure of place attainment and destination location place quality. In column 2, we observe an increase of about 0.5 units in the average socioeconomic index of the 1940 county, off a mean of 25.2.

Therefore, one possible mechanism is the exposure to better neighborhoods due to migration induced by the boll weevil. In columns 3-4 of Table 8, we examine the heterogeneity based on migration status. Among the migrant subpopulations, we observe an increase in longevity of about 4.6 months. The coefficient of stayers is quite similar to the main results. The benefits of better neighborhoods can operate through a number of channels with potential impacts on later-life outcomes (including mortality), such as better access to healthcare, higher schooling quality, lower crime, and lower pollution (Finkelstein et al., 2021).

6.4. Education and Socioeconomic Status

Several studies provide evidence that better-educated individuals and those with higher measures of socioeconomic status are healthier and live longer lives (Chetty et al., 2016; Fletcher et al., 2021; Galama et al., 2018; Lleras-Muney, 2005). Since reductions in the availability of child-labor-intensive cotton cultivation lower the opportunity cost of schooling and incentivize school attendance, affected children might attain higher education and socioeconomic status levels later

in life (Baker et al., 2020). To investigate these mechanism channels, we limit the sample to individuals above age 18 and explore the effects of exposure on outcomes in the 1940 census.

These results are reported in Table 9. We observe an increase of roughly 0.5 years in schooling (column 1). Moreover, we observe a reduction of 4.2 and 2.8 percentage points in the probability of education less than high school and education less than 12 years, respectively (columns 2-3). We further find an increase of 1.6 percentage points in the probability of any college education, equivalent to a change of 16.4% comparing with the mean of the outcome. We also observe that even post-age 18, the affected individuals are still more likely to attend schools (column 5). Finally, we observe an increase of about 0.9 units in the socioeconomic index, off a mean of 23.5 (column 6).

In Figure 4, we examine the overall pattern and evolution of coefficients across different cohorts using event studies of equation 1 for several measures of education. There are two facts worth mentioning here. First, we do not observe discernible pre-existing trends in educational outcomes. Second, the overall patterns are quite similar to those of Figure 3, specifically that there is a possible lag in the effects that appear for these outcomes.

Halpern-Manners et al. (2020) use twin fixed effect strategy and examine the effects of education on longevity. They find that each additional year of schooling is associated with approximately 3.4 months higher longevity. Using their results and the estimated coefficient of column 1 of Table 9, we can calculate an increase of 1.7 months in longevity as a result of improvements in education. This is about 60% of the reduced form effect we observe in Table 2. Fletcher & Noghanibehambari (2023) examine the effects of college openings on college education and later-life longevity. They estimate that any college education is associated with about 15.6 months higher longevity. Combining their estimates and the coefficient of column 4 of

Table 9, we can calculate an increase of about 2.5 months in longevity as a result of increases in college education due to early life exposure to the boll weevil. This is about 86% of the reduced form effects documented in Table 2. Therefore, we conclude that improvements in educational outcomes drive a large portion of the observed effects.

Finally, we use exposure to the boll weevil as an instrument in a two-stage least square estimation setting to examine the effects of education on longevity. This specification assumes that the boll weevil affects longevity exclusively through its effects on education, which is a strong assumption. The results are reported in Table 10. As expected from the results of Table 9, we have a strong first stage with F-statistics around 70. The fully parameterized regression of column 2 suggests that each additional year of schooling is associated with 5.1 months higher longevity. This estimate is larger than the findings of Halpern-Manners et al. (2020) (3.4 months) but very similar to the findings of Lleras-Muney et al. (2022), who report an increase in longevity of roughly 5 months for each additional year of schooling.

7. Conclusion

In the early 20th century in the US South, between 30-50% of school-aged children were employed in agriculture and other industries (Walters & Briggs, 1993). Despite significant reductions in child labor and increases in education due to policy changes, growing social awareness, and higher returns to education, the enduring impacts of child labor and education remain important topics for policy analysis. Moreover, many countries today experience similar social and economic developmental stages as the early 20th century US. For instance, among poor and middle-income countries, between 5-28% of children aged 5-17 are engaged in child labor (UNICEF, 2024). Therefore, it is important for policymakers in developing countries to understand the benefits of reductions in child labor and improvements in their schooling.

In this paper, we exploited sudden and unexpected reductions in labor demand for a child-labor-intensive industry to examine its impacts on later-life mortality. Specifically, we focused on the Cotton Belt counties in the US South. We examined how the arrival of the infamous boll weevil, the destructive pest for cotton cultivation, in a county affected children's later-life outcomes. We found a large decrease in cotton production and agricultural employment in the county following the arrival of the boll weevil. Further, exposed children revealed considerable improvements in education and socioeconomic status during midlife, as observed in the 1940 census. The exposed children are also more likely to migrate out of their county of birth and to counties with a higher socioeconomic index. Employing Social Security Administration death records linked with the 1940 census, we found improvements in the longevity of men. Full exposure to the boll weevil during childhood is associated with about 2.9 months higher longevity. This effect is larger among Blacks and concentrated among children of low socioeconomic status families residing in counties with high cotton production intensity. Moreover, the effects appear to be substantially larger among children in states with less restrictive child labor policies, implying the role of these policies in reducing the adverse effects of child labor in the absence of the boll weevil in cotton production counties. We showed that the results are quite robust across a wide range of specification checks and alternative functional forms. We also implemented two-stage least square estimations and used the boll weevil exposure as an instrument for education in order to examine the education-longevity relationship. We found that each additional year of schooling is associated with roughly 5.1 months of higher longevity, a value quite similar to previous literature.

Between the years 1890-1940, life expectancy in the US increased from 44.5 to 62.1 years, an increase of roughly 17.6 years (O'Neill, 2023). The intent-to-treat impacts of the boll weevil is equivalent to about 1.4% of the overall improvements in longevity across these cohorts.

In the original 1940 census population, about 12.4 million individuals lived in Cotton Belt counties who belonged to birth cohorts 1890-1940 (Appendix Table A-1). The average exposure variable among these cohorts is 45.5%, implying that about 6.6 million individuals experience a full exposure to the boll weevil. Using the estimates of Table 2, we can calculate roughly 19 million life-years gained due to exposure to the boll weevil, reductions in child labor, and improvements in schooling outcomes. One way to understand the magnitude of this gain is to use the Value of Statistical Life (VSL) tables. Studies estimate a VSL of about $10 million for US residents (Kniesner & Viscusi, 2019; Viscusi, 2018). The average longevity in the final sample is 73.3 years. A simple back-of-an-envelope calculation suggests roughly $136K for each additional year. Using this estimate and the implied gains in life years due to the exposure to the boll weevil, we calculate a monetary equivalent of the observed longevity improvements across the whole population of roughly $2.6 trillion.

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Tables

Table 1 - Summary Statistics

	Exposed		Non-Exposed	
	Mean	**SD**	**Mean**	**SD**
Age at death (months)	830.46159	126.1624	964.97489	100.42091
Log age at death	6.70971	.15957	6.86651	.10667
Age at death > 70	.44604	.49708	.85711	.34997
Age at death > 75	.27068	.44431	.7056	.45578
Age at death > 80	.13097	.33737	.49764	.49999
Birth year	1923.3644	8.5691	1906.044	7.64582
Death year	1992.5723	8.53809	1986.4787	7.9377
White	.76459	.42425	.78055	.41388
Black	.23205	.42214	.21653	.41188
Year of first arrival of boll weevil	1908.8938	7.51479	1913.8022	6.09735
Exposure share	.64014	.32844	0	0
Father socioeconomic index below median	.58234	.49317	.61216	.48726
Father socioeconomic index above median	.27076	.44435	.18911	.3916
Father socioeconomic index missing	.1469	.35401	.19873	.39905
Mother literate	.55674	.49677	.73814	.43965
Mother literacy missing	.37743	.48474	.16675	.37275
County covariates:				
Share of homeowners	.42747	.10767	.42006	.13395
Number of under-five children	.51791	.1507	.68061	.15343
Share of immigrants	.04012	.07605	.02203	.04714
Occupational income score	18.78654	3.00875	17.54755	2.57908
Per capita literate	.77611	.21609	.82321	.10519
Per capita employed	.54008	.06771	.61056	.0946
Per capita workers in manufacturing sector	.10827	.08787	.0768	.07034
Per capita workers in mining sector	.01422	.03789	.01013	.03566
Per capita workers in construction sector	.04055	.02505	.02717	.02283
Per capita workers in transportation sector	.05454	.04417	.04154	.03698
Per capita farmers	.20744	.12003	.25582	.11002
Share of married	.61997	.0329	.59688	.03439
Observations	758,023		521,547	
Mechanism sample:				
Years of schooling	8.38408	3.57042	8.07474	3.81469
Education less than high school	.49575	.49998	.57074	.49497
Education less than 12 years	.75153	.43212	.75385	.43077
Any college education	.08107	.27295	.09792	.2972
School attendance	.16955	.37524	.01957	.13852
Socioeconomic index	21.21043	18.06833	24.81467	20.88055
Observations	376,175		521,547	

Notes. The data covers men from birth cohorts of 1890-1940 born in cotton counties and died between 1975-2005.

Table 2 - Exposure to boll weevil During Childhood and Later-Life Old-Age Longevity

	Outcome: Age-at-Death (months)		
	(1)	(2)	(3)
Exposure Share	3.30441***	3.27231***	2.8963***
	(.74189)	(.73638)	(.79792)
Observations	1279569	1279569	1279569
R-squared	.50638	.50677	.50681
Mean DV	885.289	885.289	885.289
Birth county FE	✓	✓	✓
Birth year FE	✓	✓	✓
Individual/family controls		✓	✓
Birth county covariates			✓

Notes. Standard errors, clustered on county, are in parentheses. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1

Table 3 - Heterogeneity Analysis in the Effects of Childhood Exposure to boll weevil and Later-Life Longevity

	Outcome: Age-at-Death (Months), Subsamples:							
	Whites	Blacks	Father socioeconomic index above median	Father socioeconomic index below median	Below median share of farmers	Above median share of farmers	Top quartile of 1900 cotton production	Bottom-three quartiles of 1900 cotton production
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exposure Share	2.97229***	4.09621***	.32624	3.58505***	2.76341**	3.1365***	3.342**	.84708
	(.86495)	(1.49012)	(1.41847)	(.87517)	(1.08636)	(1.15574)	(1.64331)	(.9071)
Observations	986672	288825	303867	760695	639784	639782	319002	960567
R-squared	.49486	.53674	.48265	.51034	.47136	.51079	.49887	.50883
Mean DV	890.184	869.038	866.999	886.602	907.881	862.697	892.571	882.870

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1

Table 4 - Heterogeneity in the Effects Based on Restrictiveness of State-Level Child Labor Laws

	Outcome: Age-at-Death (months), Subsamples:	
	Less restrictive child labor law states	More restrictive child labor laws states
	(1)	(2)
Exposure Share	7.28809*	1.68749
	(3.93598)	(1.54274)
Observations	162752	512225
R-squared	.27228	.25395
Mean DV	857.700	797.694

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1

Table 5 - Heterogeneity in the Effects Based on Gender Using BUNMD Data (1988-2007)

	Outcome: Age-at-Death (months), Subsamples:		
	Full sample	Males	Females
	(1)	(2)	(3)
Exposure Share	1.82956***	3.00724***	.59005
	(.33769)	(.42883)	(.40402)
Observations	5254887	2548616	2706271
R-squared	.7158	.66597	.72988
Mean DV	911.632	885.877	935.886

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 6 - Robustness Checks to Alternative Specifications

	Column 3 of Table 2	Interacting birth county fixed effects by individual/family dummies	Adding birth region by birth year fixed effects	Adding birth state by 1940 state fixed effects	Adding birth month and death month fixed effects	Outcome: log age at death
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure Share	2.8963***	2.99835***	2.42589***	2.84937***	2.8833***	.00312***
	(.79792)	(.80906)	(.80752)	(.83326)	(.79964)	(.00094)
Observations	1279569	1279563	1267353	1278916	1279569	1279569
R-squared	.50681	.50797	.50547	.50779	.50748	.4974
Mean DV	885.289	885.288	884.350	885.251	885.289	6.774
	Outcome: age at death > 70	Outcome: age at death > 75	Outcome: age at death > 80	Weighted by county share of farmers in 1900	Removing birth cohorts of 1918-1919	Removing birth cohorts of 1930-1940
	(7)	(8)	(9)	(10)	(11)	(12)
Exposure Share	.01764***	.01976***	.01132***	2.42018***	3.05768***	2.3409***
	(.00322)	(.00358)	(.0032)	(.79526)	(.84408)	(.87897)
Observations	1279570	1279570	1279570	1250578	1205467	1084410
R-squared	.37358	.37293	.32676	.51115	.52376	.38315
Mean DV	0.614	0.448	0.280	888.379	885.708	913.389

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married. The outcome in columns 1-5 and 10-12 is age at death measured in months.
*** p<0.01, ** p<0.05, * p<0.1

Table 7 - Examining Changes in Sociodemographic and Socioeconomic Composition of the Final Sample Due to Childhood Exposure to boll weevil

	Outcomes:						
	White	Black	Father socioeconomic index below median	Father socioeconomic index above median	Father socioeconomic index missing	Mother literate	Mother literacy missing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Exposure Share	.00214	-.00269	.02153***	-.01291*	-.00862	-.0113	.01695
	(.0048)	(.00476)	(.00681)	(.00754)	(.00815)	(.00914)	(.01038)
Observations	1267355	1267355	1267355	1267355	1267355	1267355	1267355
R-squared	.17184	.17482	.1323	.11852	.03983	.31447	.37866
Mean DV	0.769	0.228	0.598	0.238	0.164	0.634	0.289

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects and birth year fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

Table 8 - Childhood Exposure to boll weevil, Migration, and Later-Life Longevity

	Outcomes and Subsamples:			
	Outcome: Cross-county migrant from birth to 1940	Outcome: Average 1940 County level socioeconomic index	Subsample of migrants Outcome: age-at-death	Subsample of non-migrants Outcome: age-at-death
	(1)	(2)	(3)	(4)
Exposure Share	.02465***	.54142***	4.57467***	2.93588***
	(.00925)	(.08454)	(1.1026)	(1.09778)
Observations	1279570	1279543	542326	737243
R-squared	.14909	.43656	.42643	.50644
Mean DV	0.424	25.214	923.056	857.506

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1

Table 9 - Exploring Mechanism Channels between Childhood Exposure to boll weevil and Later-Life Longevity

	Outcomes:					
	Years of schooling	Education less than high school	Education less than 12 years	Education college-and-more	School attendance	Socioeconomic index
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure Share	.48212***	-.04237***	-.02808***	.01572***	.03899***	.88729***
	(.05683)	(.00793)	(.00626)	(.00391)	(.00581)	(.28589)
Observations	874007	897722	897722	897722	897722	781576
R-squared	.27083	.18802	.14265	.08626	.31494	.19864
Mean DV	8.205	0.539	0.753	0.091	0.082	23.457

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Table 10 - Two-Stage Least Square Estimations to Examine the Impacts of Education on Longevity

	Outcome: Age-at-Death (months)	
	(1)	(2)
Years of schooling	6.75001***	5.07651**
	(1.85036)	(2.04351)
Observations	874006	874006
R-squared	.26938	.28657
Mean DV	935.669	935.669
%Change	0.721	0.543
First-Stage F-Stat	67.440	71.903
Birth county FE	✓	✓
Birth year FE	✓	✓
Individual/family controls		✓
Birth county covariates		✓

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1

Figures

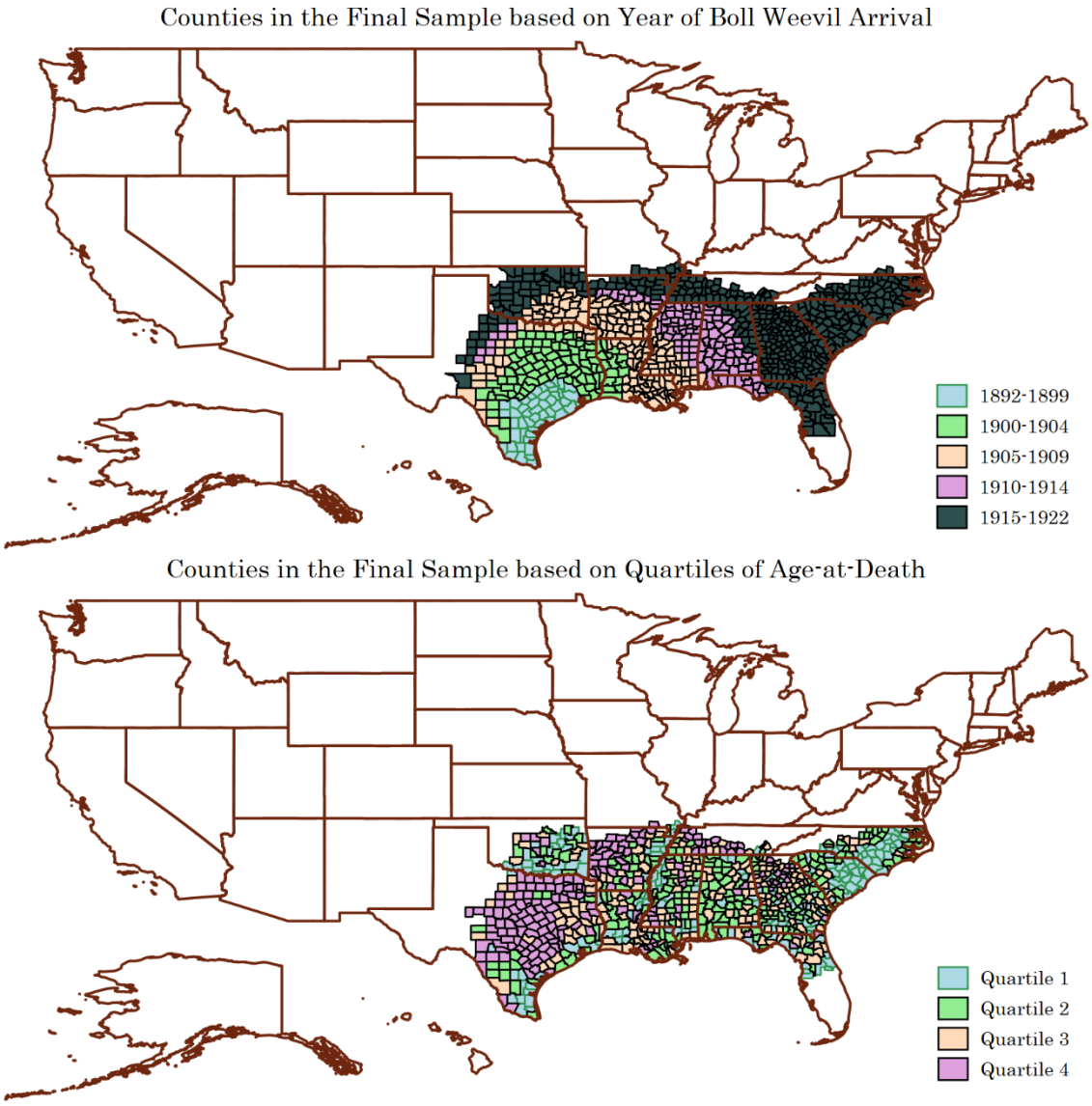


Figure 1 - Geographic Distribution of Arrival of boll weevil and Longevity across Affected Counties

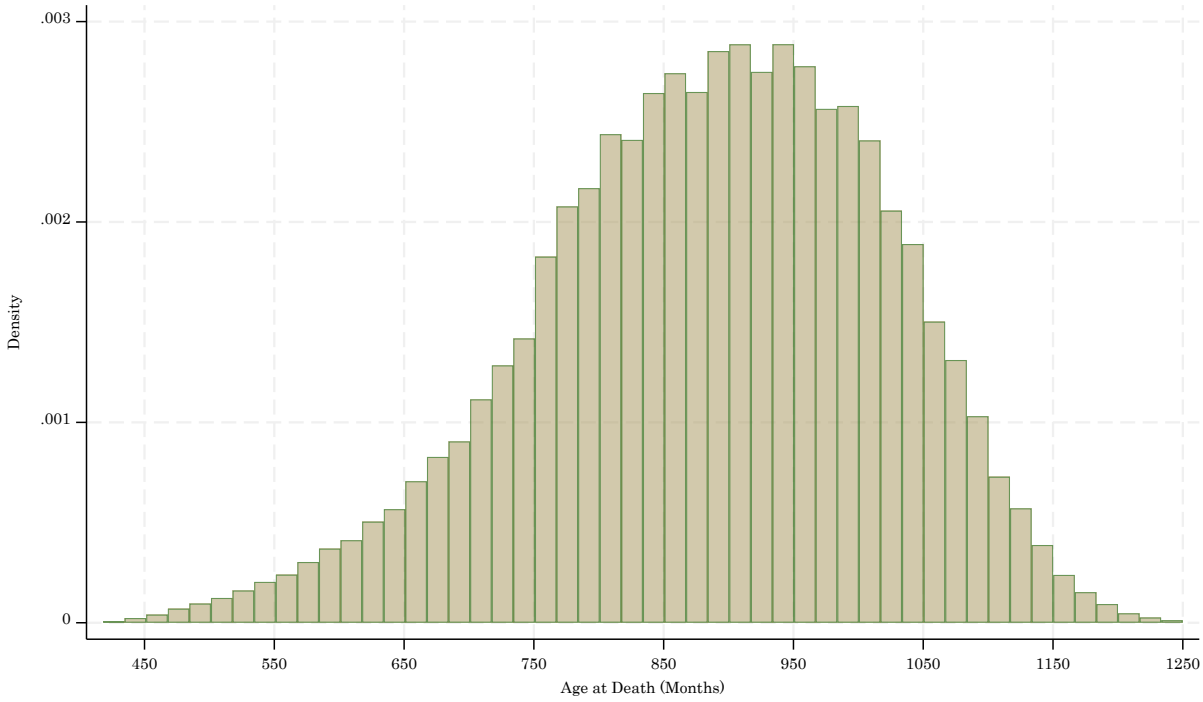


Figure 2 - Density Distribution of Age-at-Death in the Final Sample

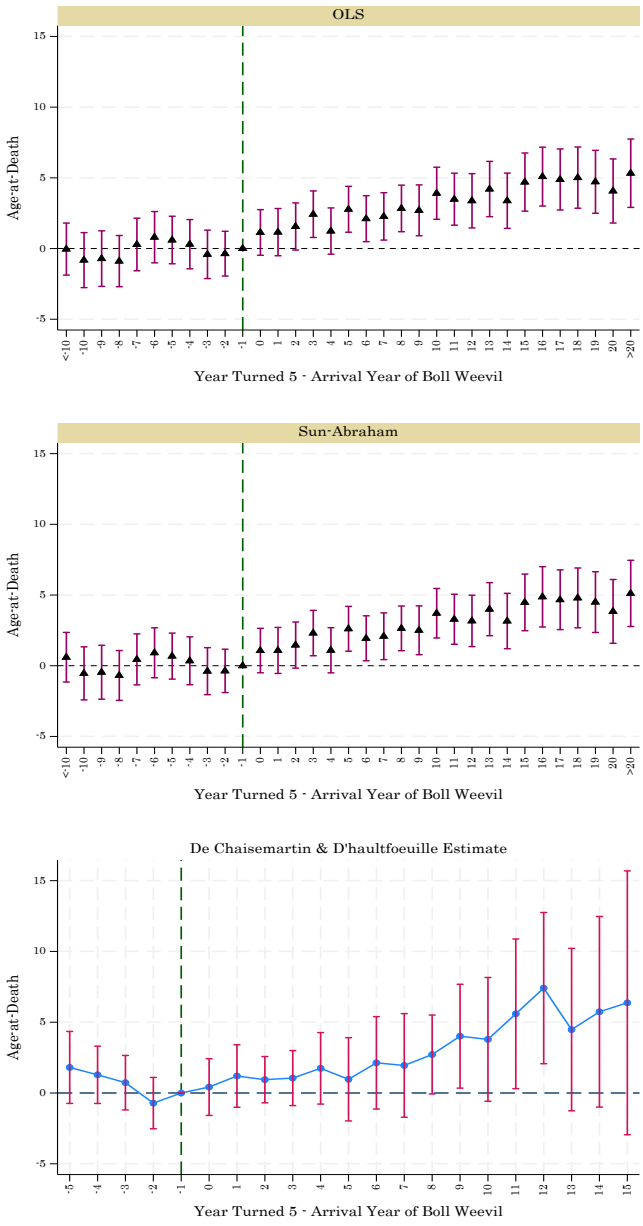


Figure 3 - Event Study Analysis to Examine the Effects of Childhood Exposure to Boll Weevil on Later-Life Longevity

Notes. Point estimates and 95% county-clustered confidence intervals are illustrated. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include share of homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in manufacturing sector, per capita workers in mining sector, per capita workers in construction sector, per capita workers in transportation sector, per capita farmers, and share of married.

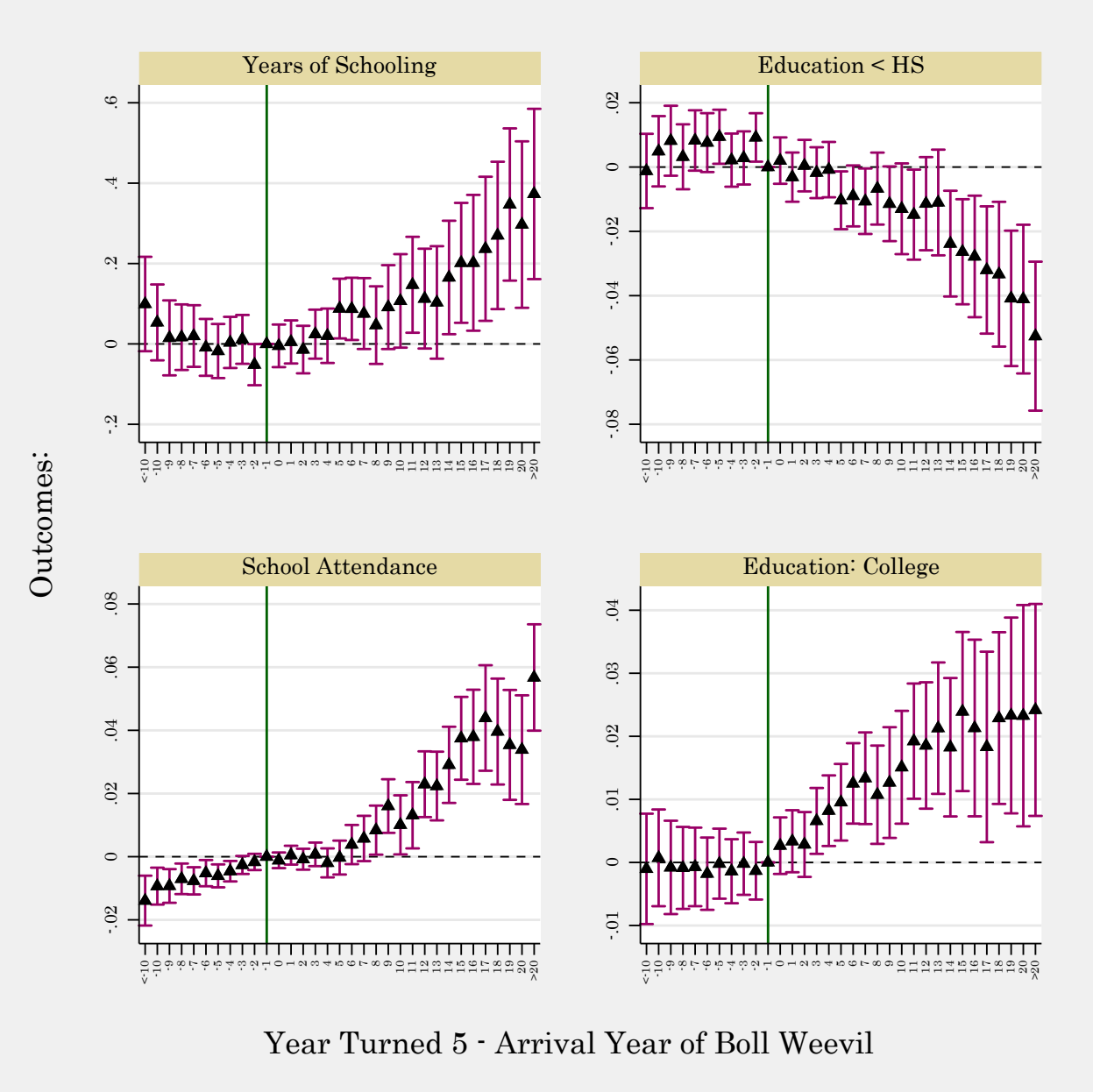


Figure 4 - Event Study Analysis to Examine Mechanism Channels between Childhood Exposure to Boll Weevil on Later-Life Longevity

Notes. Point estimates and 95% county-clustered confidence intervals are illustrated. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include share of homeowners, number of under-five children, share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in manufacturing sector, per capita workers in mining sector, per capita workers in construction sector, per capita workers in transportation sector, per capita farmers, and share of married. The sample is restricted to individuals above age 18.

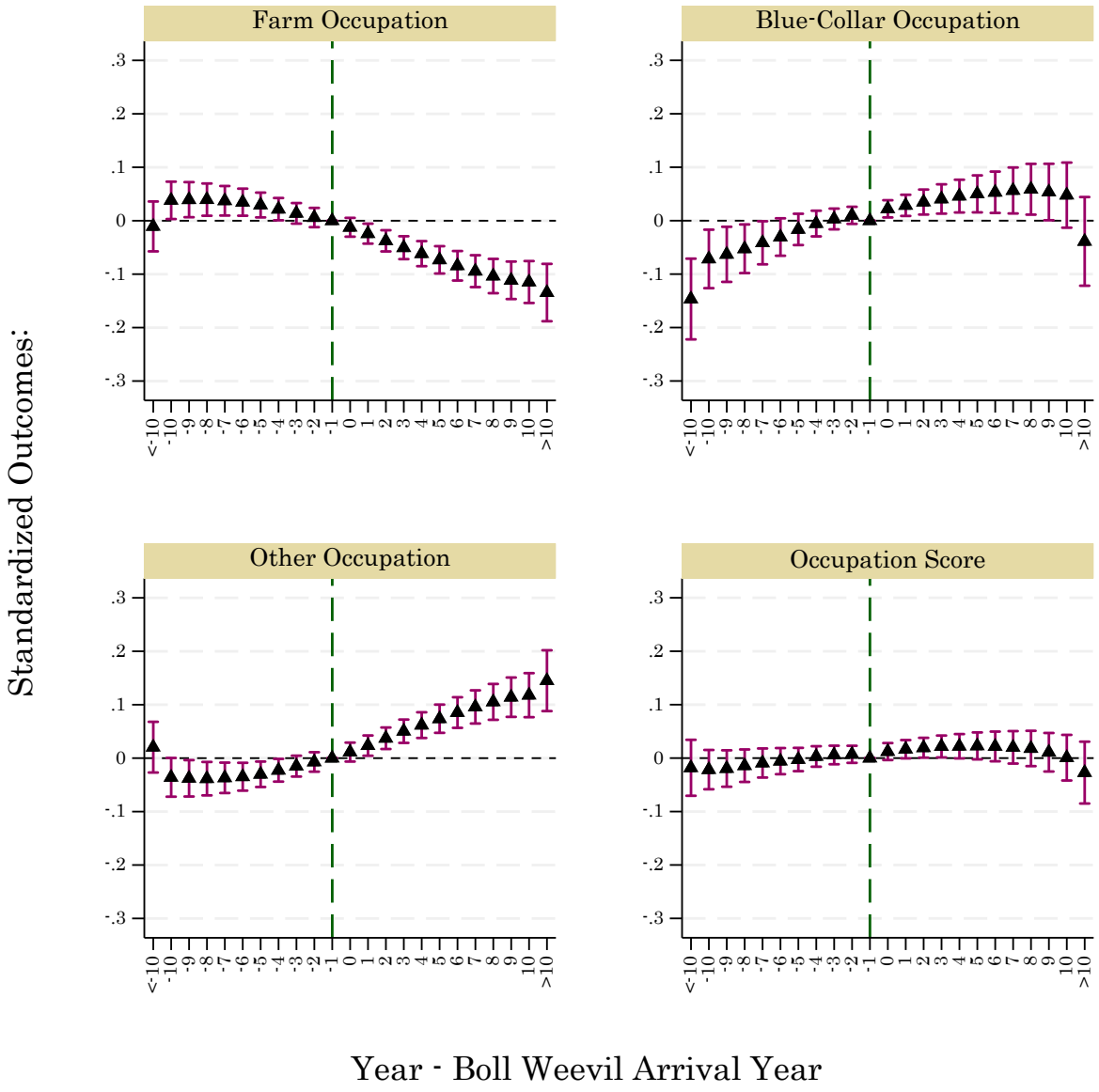


Figure 5 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county by year panel is extracted from decennial censuses 1890 – 1940 and interpolated for inter-decennial years.

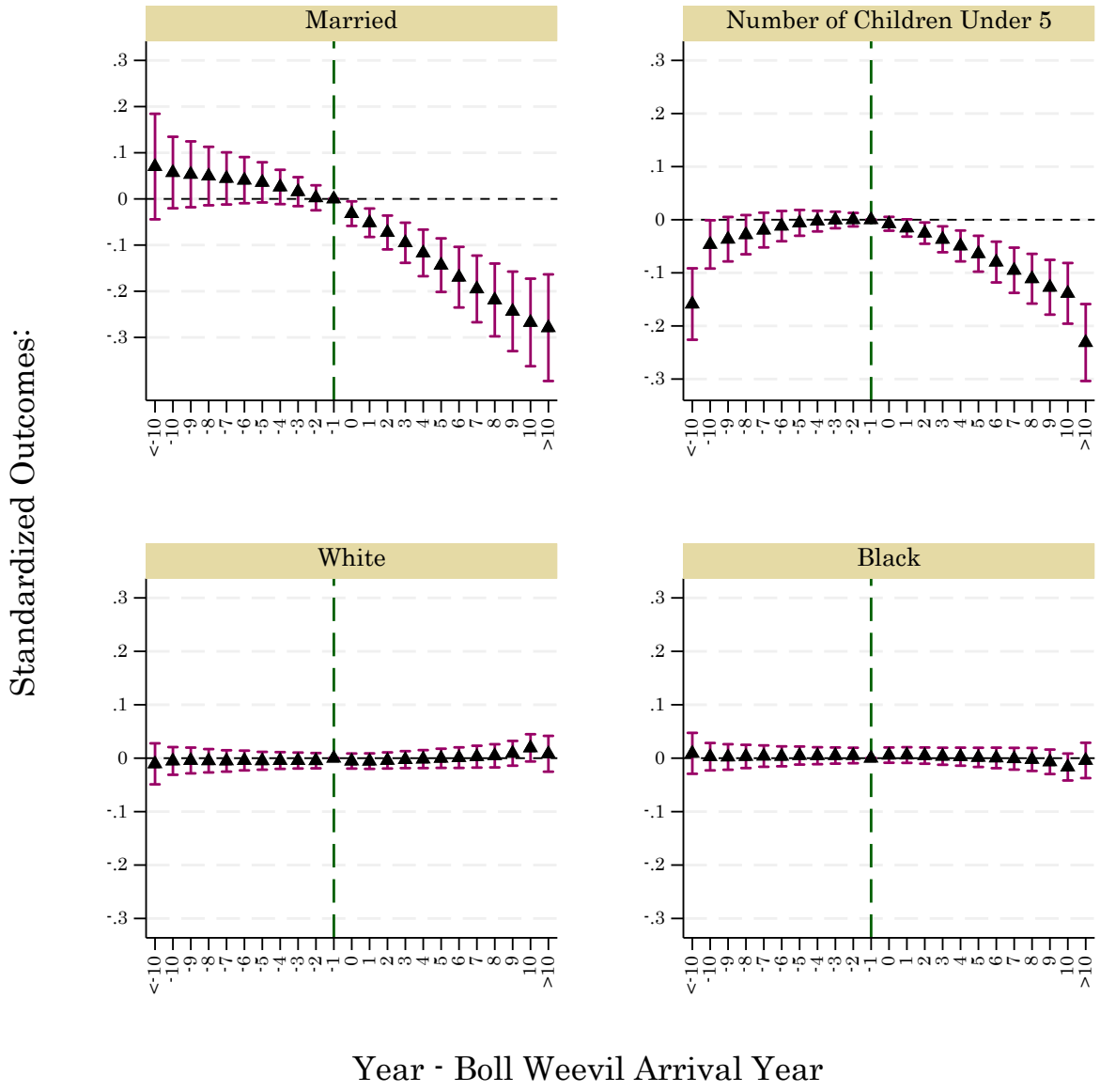


Figure 6 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county by year panel is extracted from decennial censuses 1890 – 1940 and interpolated for inter-decennial years.

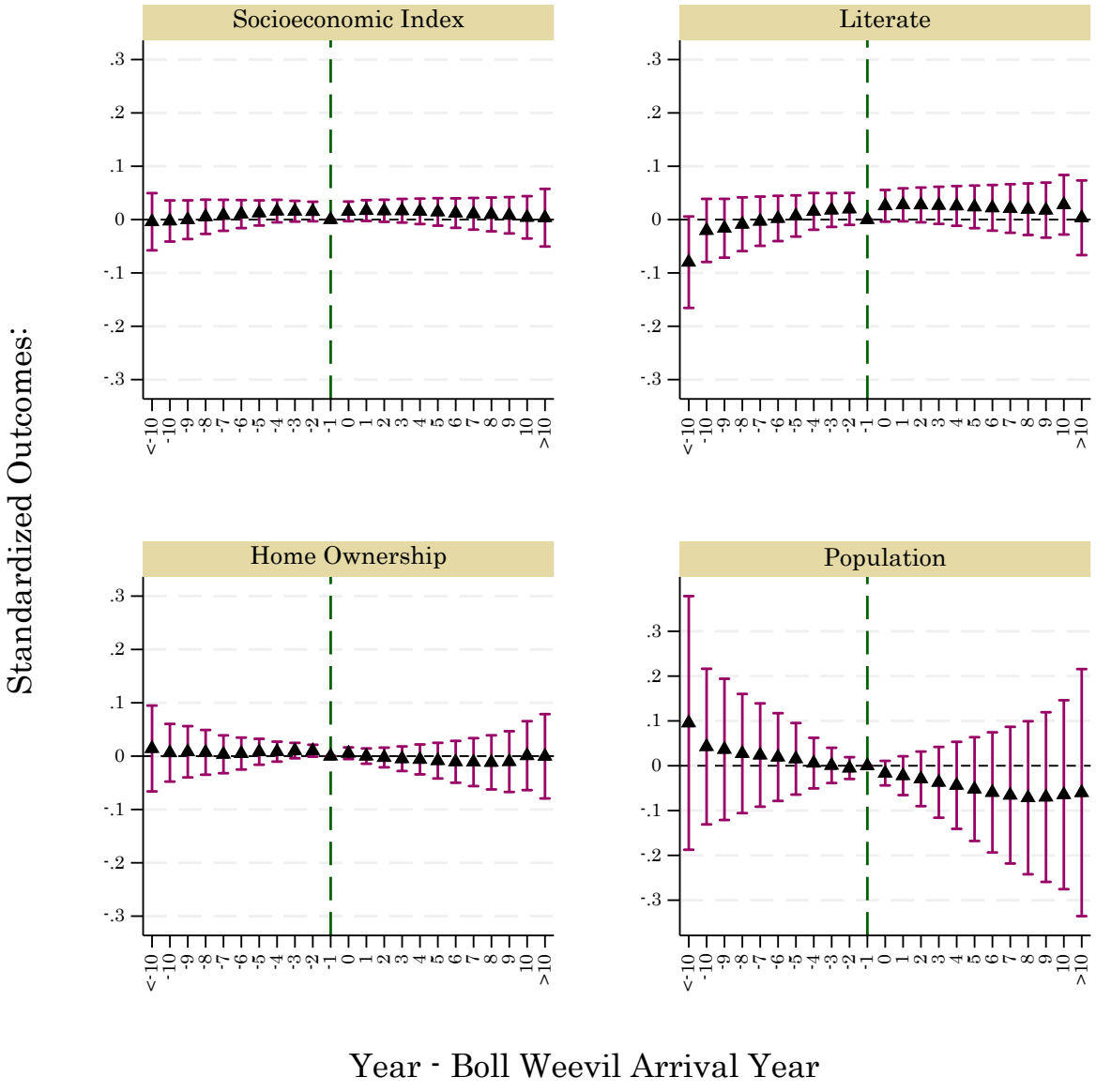


Figure 7 - Event Study Analysis to Examine the Evolution of County Characteristics in Years Before and After the Arrival of Boll Weevil

Notes. Point estimates and 95% confidence intervals are depicted. All regressions include county and year fixed effects. Regressions are weighted using county level population. The county-by-year panel is extracted from decennial censuses 1890-1940 and interpolated for inter-decennial years.

Appendix A

Appendix Table A-1 reports selected summary statistics in the final sample (first panel) versus the original population of 1940 whose early life county was in the Cotton Belt and who belong to birth cohorts of 1890-1940 (second panel). We observe a higher share of whites and a lower share of Blacks in the final sample compared with the original population. Breen & Osborne (2022) suggest that Although the DMF data overrepresents white populations and underrepresents Blacks, black and white subpopulations contain fairly similar characteristics as those in the original 1940 census population. As we look at other statistics related to maternal education and paternal socioeconomic status, we observe comparable values in the final sample to the original population.

Next, we empirically examine the association between exposure and successful data linking. In so doing, we merge the final sample (left panel of Appendix Table A-1) to the original population (right panel of Appendix Table A-1) and generate a dummy variable indicating successful merging. We then regress the merging indicator on exposure measure, conditional on county and birth year fixed effects. The results are reported in Appendix Table A-2. Exposed individuals are more likely to be in the final sample. Compared with the mean of the outcome, full exposure is associated with 17.5% higher chances of being in the merged data. However, this is not driven by a higher merging of different subpopulations. We observe very similar coefficients (compared with the mean of the outcome) when we look at the subsample of whites and nonwhites in columns 2-3.

Appendix Table A-1 - Comparing Characteristics of the Final Sample with Original Population of 1940 Census

	Final sample		*Original population*	
	Mean	SD	Mean	SD
Birth year	1916.3047	11.8222	1917.8373	13.9115
White	.7711	.4201	.705	.4561
Black	.2257	.4181	.2919	.4546
Year of boll weevil's arrival	1910.9086	7.3913	1911.9677	7.2618
Exposure share	.4175	.4115	.4551	.4295
Mother education less than high school	.351	.4773	.3615	.4804
Mother education high school	.1106	.3137	.1229	.3283
Mother education college	.0222	.1474	.0253	.157
Mother education missing	.5162	.4997	.4904	.4999
Father socioeconomic status first quartile	.1093	.312	.1204	.3254
Father socioeconomic status second quartile	.1817	.3856	.1879	.3906
Father socioeconomic status third quartile	.0428	.2025	.0471	.2118
Father socioeconomic status fourth quartile	.1042	.3055	.1067	.3087
Father socioeconomic status missing	.562	.4961	.538	.4986
County covariates:			.4138	.1223
Share of homeowners	.4243	.1192	.563	.1747
Number of under-five children	.5835	.1717	.0285	.0609
Share of immigrants	.033	.0667	18.4319	2.943
Occupational income score	18.2966	2.9169	.7408	.2378
Per capita literate	.7955	.1809	.567	.0931
Per capita employed	.5687	.087	.0997	.0859
Per capita workers in manufacturing sector	.0957	.0829	.0126	.0363
Per capita workers in mining sector	.0126	.037	.0381	.0266
Per capita workers in construction sector	.0352	.0251	.0471	.0395
Per capita workers in transportation sector	.0494	.042	.2203	.1178
Per capita farmers	.2266	.1187	.6119	.036
Share of married	.6106	.0354	.612	.0361
Observations	1,279,570		12,409,342	

Notes.

Appendix Table A-2 - Examining the Association Between Exposure to boll weevil and Successful DMF-Census Merging

	Outcome: successful merging between DMF (final sample records) and 1940 census, Subsamples:		
	Full sample	Whites	Nonwhites
	(1)	(2)	(3)
Exposure Share	.01868***	.01628***	.0089***
	(.00205)	(.00261)	(.00159)
Observations	12409342	8748279	3661063
R-squared	.02707	.02994	.01325
Mean DV	0.103	0.113	0.080

Notes. Standard errors, clustered on county, are in parentheses. All regressions include birth county fixed effects, birth year fixed effects, individual/family controls, and birth county covariates. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.

*** p<0.01, ** p<0.05, * p<0.1

Appendix B

Gutmann (2005) reports county-level agricultural production data for a limited number of counties in decennial years. We restrict the sample to the years between 1890-1940 and counties in the Cotton Belt. Based on the county-specific year of arrival of the boll weevil, we generate a dummy variable indicating post-weevil years. We then regress cotton production (in bales) on the post-weevil dummy, conditional on county and year fixed effects. The results are reported in Appendix Table B-1. We observe significant reductions in cotton production. In the years following the arrival of the boll weevil, cotton production dropped by roughly 55%. Although there are changes in the production of other crops, the estimated coefficients remain comparably small and statistically insignificant.

Appendix Table B-1 - Examining the Effects of County Exposure to boll weevil and Agricultural Productions

	Outcomes:			
	Log cotton production (bales)	Log barley production (bales)	Log rye production (bales)	Log Pea/Bean production (bales)
	(1)	(2)	(3)	(4)
Post boll weevil	-.54629***	-.15373	.01442	-.27668
	(.15698)	(.31578)	(.392)	(.20518)
Observations	1312	588	565	705
R-squared	.77073	.76648	.67377	.7703
Mean DV	8.263	6.811	5.676	5.723

Notes. Standard errors, clustered on county, are in parentheses. All regressions include county and year fixed effects. Regressions are weighted using share of farmland in the county in 1900.
*** p<0.01, ** p<0.05, * p<0.1

Appendix C

The final sample of the paper includes only counties that experienced boll weevil. In this appendix, we include all counties in the US in our analysis sample. For all individuals whose early life county is a non-weevil county, the exposure variable takes a value of zero. We then replicate the results of Table 2 and report them in Appendix Table C-1. The fully parameterized regression suggests an increase in longevity of about 3.6 months, which is roughly 24% larger than that of the main results.

Appendix Table C-1 - Replicating the Main Results Including Never Treated Counties as the Control Group

	Outcome: Age-at-Death (months)		
	(1)	(2)	(3)
Exposure Share	2.65292**	2.95631**	3.58911***
	(1.23811)	(1.24897)	(1.30933)
Observations	6697773	6697773	6697773
R-squared	.44569	.44593	.44596
Mean DV	890.206	890.206	890.206
Birth county FE	✓	✓	✓
Birth year FE	✓	✓	✓
Individual/family controls		✓	✓
Birth county covariates			✓

Notes. Standard errors, clustered on county, are in parentheses. Individual controls include dummies for race and ethnicity. Family controls include dummies for maternal literacy and paternal socioeconomic status. Birth county covariates include the share of homeowners, number of under-five children, the share of immigrants, average occupational income score, per capita literate, per capita employed, per capita workers in the manufacturing sector, per capita workers in the mining sector, per capita workers in the construction sector, per capita workers in the transportation sector, per capita farmers, and share of married.
*** p<0.01, ** p<0.05, * p<0.1