# THE IMPACT OF THE BOLL WEEVIL, 1892-1932

Fabian Lange, Yale University

Alan L. Olmstead, UC Davis

Paul W. Rhode, Univ. of Arizona & NBER

February 2008

Abstract: The boll weevil is America's most celebrated agricultural pest. We assemble new county-level panel data on the insect's geographic spread and on farm activity to investigate the weevil's effects on the southern economy between 1892 and 1932. Our study provides sharp estimates of the full time path of the pest's local impacts. We find that instead of diversifying away from cotton in anticipation of the weevil's appearance, farmers attempted to squeeze one last large crop out of their land just prior to contact. Upon arrival, the weevil had a large negative impact on production which required up to five years to be fully manifest and which did not disappear within our study period. Cotton yields fell substantially; acreage declined by less. In response, farmers did not take land out of agricultural use instead shifting to other crops. We also find striking effects on land values and population movements, indicating the pest's spread redistributed economic activity within the South.

**THE IMPACT OF THE BOLL WEEVIL, 1892-1932**

The boll weevil, with its entourage of songs and folklore, is enshrined in many popular accounts as America's most destructive agricultural pest. Testifying before Congress in 1903, the chief of the USDA's Bureau of Plant Industry referred to the insect's advance as "the wave of evil."[1] In his Annual Address to Congress in 1905, President Theodore Roosevelt discussed biological warfare when he alerted anxious cotton producers that USDA scientists had imported a predatory ant from Guatemala that fed on the weevil.[2] The weevil was indeed a headline grabber.

Social scientists offer two competing accounts of the weevil's impact on the economic development of the American South. Many scholars view the arrival of the boll weevil in 1892 as a major negative productivity shock in a poor, cotton-dependent region, one which unleashed a revolution. In *One Kind of Freedom*, Roger Ransom and Richard Sutch wrote: "It required a shock nearly equal to emancipation to jolt the agrarian South out of the routine it followed for the four post-emancipation decades. That shock was the coming of the boll weevil."[3] Although it is unlikely that Ransom and Sutch still hold this view, many historians do. Carolyn Merchant has argued that because of the boll weevil "the entire economy of the South was at risk."[4]

By contrast, scholars such as Robert Higgs, Kent Osband, Douglas Helms, and Gavin Wright have argued that the insect had only a negligible impact on the southern cotton industry specifically and southern society as a whole. The fundamental insight is that due to conditions in world cotton markets, the reductions in supply caused by the weevil led to offsetting increases in prices. In *Old South, New South*, Wright argued that given the elasticity of demand for cotton, "the South as a whole did not suffer as a result

---

[1] Testimony of B. T. Galloway, *Hearings*, U.S. House Agriculture Committee, p. 16. Almost surely other insects, including the Hessian fly, caused more damage than the boll weevil.
[2] See http://www.infoplease.com/t/hist/state-of-the-union/116.html for T. Roosevelt's address. The weevil-killing ant proved to be a humbug.
[3] Ransom and Sutch, *One Kind of Freedom*, pp. 171-72, 174.
[4] Merchant, *Columbia Guide*, p. 55. Merchant continues (p. 56) "Although the new methods were helpful, they were also expensive, and the combination of declining yields and higher costs drove many farmers out of business."

of the boll weevil… . Each new attack simply caused the price received by all the other areas to be raised, thus serving, if anything, to keep cotton culture strong in older areas of the East longer than it otherwise would have been." While the weevil did have "a lasting effect on cultivation practices… most parts of the South worked it into their routine and returned to 'normal.' What it did not do was to trigger a major diversification of southern agriculture or a new shift of resources out of agriculture into industry or other pursuits."[5]

There is therefore a tension between the early accounts emphasizing the destructive impact of the weevil and the later general equilibrium analysis arguing that the response of cotton prices shielded the American South from this negative productivity shock. The "Great Migration" of African-Americans represents an example of how this tension affects our understanding of the social history of the United States. By some accounts, the weevil helped trigger the mass movement of African-Americans to northern cities, a view countered by Higgs who found that "the boll weevil infestation was neither a necessary nor a sufficient condition underlying the Great Migration."[6]

This tension can be resolved by realizing that the weevil did in fact inflict serious and lasting damage on local economies even though the cotton industry as a whole expanded during this period. Due to a lack of sufficiently disaggregated data, the existing literature was forced to focus on the effect of the weevil across the 13 southern states or on the South as a whole. We assembled new county-level data on the production of both cotton and corn, (the main alternative crop), on total land use, land values, and on population movements. Based on this new data set, we can investigate how the spread of the weevil affected local economies and provide sharp estimates of the overall impacts and their timing relative to the date of contact. We show that as the weevil traversed across the American South, it seriously disrupted local economies, significantly reduced the value of land (at this time still the most important asset in the American South) and triggered substantial intra-regional population movements. Yet, while our analysis reveals that the impact of the weevil was substantial, we also support the insight that the

[5] Wright, *Old South, New South*, p. 122. For how this passage fits into the literature, see Wright "Reflections," p. 44. See also Osband, "Boll Weevil," pp. 627-43 and Helms, "Just Looking."

[6] Crew, "Great Migration," pp. 34-36. The article summarizes material for the exhibit, *Field to Factory: Afro-American Migration 1915–1940*, at the Smithsonian's National Museum of American History; for the counterview, see Higgs, "Boll Weevil," p. 350. Giesen, "South's Greatest," pp. 1-2, 211-12, 346-50 also seeks to debunk the "myth" linking the boll weevil and the Great Migration.

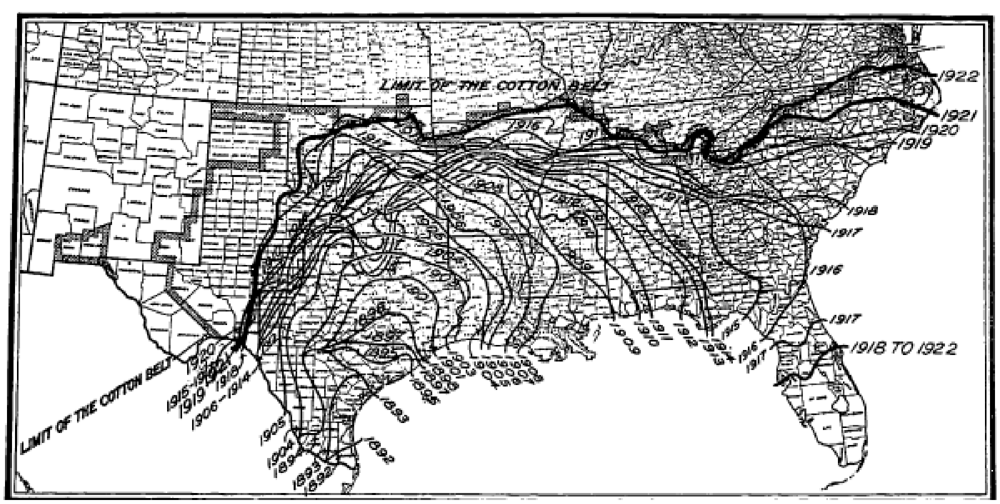
weevil did not undermine the cotton industry as a whole. Our findings are consistent with James Giesen's observation that the South produced more cotton in 1921 than in 1892.[7]

The paper has the following form: The next section documents the coming of the boll weevil and describes its life cycle, migration patterns, and means of damaging cotton to inform our investigation of the impact of the insect. The second section discusses the limited methods – by altering cultural practices and applying chemicals—available to farmers to combat the pest threat. The third section explores the existing literature on the costs imposed by the weevil. Section Four describes the two new county-level panel data sets we have constructed. Section Five presents our results on the local area impacts of the boll weevil on agricultural production. The next section analyzes impacts on land values and population. Section Seven concludes.

## I. The Coming of the Boll Weevil

The boll weevil, *Anthonomus grandis* Boheman, is a small beetle—about ¼ inch long --with wings and a very pronounced snout.[8] A native to Mexico and Central America, the weevil entered the United States in 1892 near Brownsville, Texas and thereafter advanced 40 to 160 miles a year (see Figure 1). By 1922 it had swept up the Atlantic seaboard and infested virtually the entire Cotton Belt.

Figure 1: USDA Map of Spread to Boll Weevil, 1892-1922




[7]Giesen, "South's Greatest," p. 2. Comparisons between production in 1892 and 1921 are problematic because both had short crops. But taking a longer view also indicates rising cotton acreage and output.
[8] Parts of this section and the next are drawn from Olmstead and Rhode, *Creating Abundance*.

In the environment of the American South, the weevil fed almost exclusively on the cotton plant. Early in the season the weevil would consume leaves and later they would attack the young cotton bolls. Cotton was planted in March and April and 6 to 8 weeks later the young plant formed buds or squares. Adult weevils punctured the squares to lay their eggs. Inside the protective squares, the weevil larvae would feed and grow into pupae and then adults. This would cause the bolls to shed, fall to the ground and release the new adult. As the season progressed, the weevil population multiplied with female weevils each producing 100 to 300 eggs, typically depositing one egg to a square. Weevils could produce up to eight generations per year. Warm, wet, cloudy summers were conducive to the greatest infestations whereas very hot, dry summers killed off the weevil's larvae and pupa in the squares and young bolls, thereby limiting crop damage. The cotton plant's bolls opened and were ready to harvest from late August through early January. One consequence of the build-up of boll weevil population over the summer was that the late-season crop suffered the greatest losses. The weevils continued to feed until the cotton plant was destroyed or killed by frost.

Adult weevils survived the winter without food by going into hibernation. Cold weather and standing water could kill the overwintering adults, but yard and field trash, nearby woods, and Spanish moss provided protection. Many of the control efforts were devoted to denying the weevil a safe place to survive the winter. Weevils that did survive the winter emerged during the warm days from March until July. Even a small number of survivors can cause serious problems as one pair of weevils would typically generate about 2 millions of progeny in a single season.[9]

During most of the year, a weevil would fly only short distances. But in August, a period on seasonal migration began. Through a series of undirected short flights, a weevil could travel about one hundred miles, typically following the prevailing wind. Weather events such as the great Galveston hurricane of September 1900 carried weevil far beyond their existing range.

---

[9] Brown, *Cotton*, 2nd ed., pp. 339-46; Gains, "Boll Weevil," pp. 501-04; Oosterhuis and Jernstedt, "Morphology and Anatomy of the Cotton Plant," pp. 175-206.

Farmers and local authorities could do little to prevent the boll weevil from entering their territory. The timing of arrival was largely independent of their individual behavior. Once the insect hit, it would occasionally be driven out by unfavorable weather and was subject to limited control by cultivation practices as discussed below.[10] First contact usually occurred during the August seasonal migration, too late to build up significant populations or do much damage in that year. Maximum damage occurred after the local weevil population became established and multiplied. Thus, the classic USDA maps detailing the spread of the weevil present a somewhat misleading picture of the area being ravaged by the insect.[11] The invaded territory in such maps creates slightly inaccurate impression for another reason. Many counties initially attacked, for example in southern Texas, were not producing much cotton. The same is true of many of counties on the fringes of the cotton belt that were never infested.

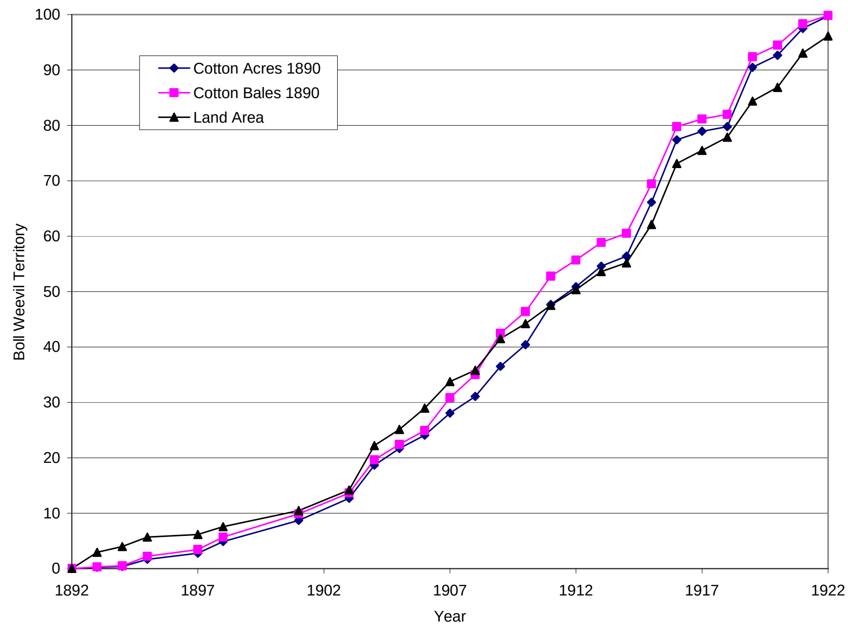
To put these issues into context, we have assembled data showing when the weevil invaded each county in the Cotton Belt weighted by the county's cotton acreage and production as reported to the 1890 census. The series are graphed in Figure 2 which also shows the land area covered - the usual measure of the boll weevil's progress. These production- and acreage-weighted series of the weevil's spread generally fit the standard S-shaped diffusion curve, with an acceleration in diffusion over the 1898-1905 period. This was the period when the insect's path of destruction made its eastward turn. By 1907, the weevil crossed the Mississippi River and thereafter it advanced from east to west along a fairly regular front until in 1921-22 when the insect completed its geographical conquest.

---

[10] Population density appears to have an inverted U-shaped relationship with damage. The weevils needed cotton to survive and reproduce, but they also required a safe environment to overwinter. The worst damage occurred in cotton producing areas characterized by small fields, nearby woods especially those with hardwoods, and rolling or hilly terrain. Alluvial areas with large blocks of land completely cultivated in cotton land and cleaned properly after harvest (especially if the fields were covered with standing water over part of the winter and the nearby trees did not bear Spanish moss) might suffer only spot infestations. Contrary to popular opinion, monoculture was not the problem. Regions on the fringes of the Cotton Belt with very little production could also escape serious damage. High rates of infestation did encourage the weevil to move on to look for additional sources of food. Brown, *Cotton*, 1st ed., pp. 295-97; Brown and Ware, *Cotton* 3rd ed., pp. 202-06.

[11] These widely-publicized maps did allow farmers and local authorities further east to form expectations about when the weevil would strike.

Figure 2: The Spread of the Boll Weevil, 1892-1922




## II. Control Methods

From 1894 onwards, the USDA, various state agencies, private companies, amateur scientists, farmers, and numerous quacks sought ways to limit the insect's damage. Insecticides proved ineffectual. Efforts to erect quarantine buffers also came to naught. An early proposal in Texas to establish a 50-mile wide cotton-free zone ran into legislative resistance.[12] By 1904 when Georgia adopted quarantine measures, the weevil was too well established in the South to pause for long.

Many ideas on how to coexist with the weevil diffused rapidly. Entomologists recommended early maturing varieties, using fertilizers to hasten ripening, early planting, more thorough cultivation, destroying stalks and brush, and locating fields away from woods and other places that harbored the pest. It did not take farmers long to switch to earlier maturing varieties. The boll weevil entered Robertson County, Texas between 1898 and 1901. By 1901 farmers in that county were importing seed from northern Texas, and by early 1904 the Dallas Jobbers' Cotton Association had imported 19 carloads of seed from North Carolina. According to Douglas Helms, "One estimate held

[12] Helms, "Just Looking," pp. 56-57.

that Texas farmers imported thousands of car loads of short staple cotton seed in the rush to adjust to weevil destruction." As the weevil spread, so did the transition in varieties, with some farmers such as those in the Yazoo-Mississippi Delta apparently switching in advance of the destruction.[13] In addition to adopting earlier ripening varieties, farmers sought other means to promote earlier crop development, such as moving up their planting dates by several weeks.[14]

Figure 3 offers a quantitative indication of the movement to earlier ripening varieties and associated cultural changes by charting the dates of cotton ginning. In the 1902-07 period, less than 45 percent of U.S. cotton was ginned before the 18th of October. By 1934-39, almost 70 percent was ginned by that date. Over the period of the weevil's spread, cotton production was moving onto the High Plains of Texas and Oklahoma as well as shifting to the irrigated fields of Arizona, California, and New Mexico. The spread of the boll weevil accelerated this trend, because the arid West was inhospitable to the weevil.[15] But in Arizona, California, Oklahoma, and New Mexico ginning occurred much later than the national average, and consequently the regional shift of production meant that the trend toward early ginning in the Cotton South was far more rapid than implied in Figure 3.[16]

For over a century southern plant breeders had selected and acclimated cottons for specific areas. The boll weevil caused a switch away from later-maturing, longer-staple varieties, rendering much of this investment obsolete. Characteristics such as fiber quality, picking ease, and storm resistance lost importance in the face of one overriding concern - early maturation. Picking efficiency and quality suffered as growers abandoned 1 1/8th inch "Big Boll" cotton for varieties with small bolls and very short

---

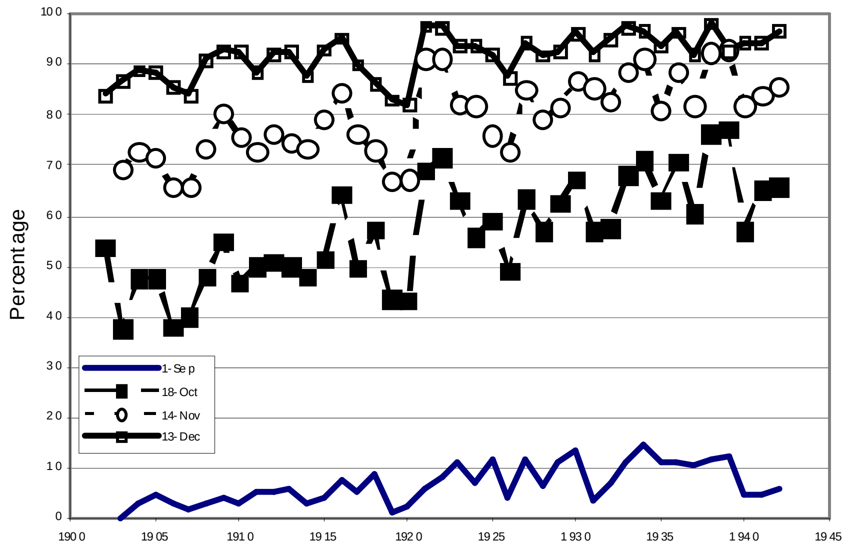
[13] Helms, "Revision and Revolution," pp. 109-11; Giesen, "South's Greatest," Ch. 4 and 5 provide a detailed account of the adjustment process in the Delta.

[14] Brown, *Cotton,* 2nd ed,, pp. 351-53; Helms, "Revision," pp. 112-14. In other areas, farmers attempted to plant later in hopes of depriving food from the weevils emerging from hibernation.

[15] Osband, "Boll Weevil, pp. 627-43 downplays the weevil's role on the westward expansion of cotton production. In fact the weevil greatly accelerated this movement. The USDA's research program in the West was dedicated to developing varieties that would offset the loss of the longer Cotton Belt varieties.

[16] The advent of the boll weevil and the shift to earlier maturing varieties altered the picking season. It reduced demands for labor late in the Autumn (November and especially in December) and likely increased demands in September. These changes likely have effects, not explored here, on the attendance behavior of children enrolled in southern schools. It is also beyond the scope of the present paper to consider the impact of the infestation on health, as in recent study by Banerjee, et al.. "Long Term," of phylloxera in nineteenth-century France.

Figure 3: Percentage of US Cotton Ginned by Selected Dates, 1902-42




5/8th inch staples. Roughly 50 long-staple varieties of cotton (as well as a number of high-quality mid-staple varieties) ceased to be commercially viable and eventually became extinct.[17]

Cotton scientists found that burning or plowing under the cotton stalks immediately after harvest reduced the number of weevils before they hibernated and significantly reduced next year's damage. But according to Helm's careful investigation of this issue, the practice was not widely adopted, not only because it required much additional labor, but also because farmers would not capture the full social benefit of their labor. The weevils could migrate to nearby fields, meaning that an individual farmer would not be fully protected unless his neighbors followed suit. Success required a community effort. USDA scientists understood this externality problem and in 1896 unsuccessfully urged Texas state officials to enact legislation to establish mandatory stalk destruction dates.[18]

Effective poisons, which would eventually become the farmers' key line of defense, were not available during the first wave of destruction. This was not for want of

[17] Brown, *Cotton*, 2nd ed., pp. 339-55; Helms, "Revision," pp. 110-11; Ware, "Origin," pp. 50-81, 95-97. The extinction was nearly complete. A long-staple cotton named Sunflower was the only variety of "the old Mississippi Valley series" to survive the devastation. Sunflower became a parent for most of the important long staple varieties later developed. Ware, "Origin," p. 67.
[18] Brown, *Cotton*, 2nd ed., pp. 351-54; Helms, "Revision," pp. 118-20..

trying, as both farmers and entomologists experimented with the insecticides, including arsenic sprays and powders, that had been used against other pests. But the weevil grubs feeding inside the squares were well protected from toxins and the cotton plant's foliage gave the adults considerable shelter from contact poisons. The first really effective poison arrived in 1918 when the USDA's B. R. Coad developed a calcium arsenate mixture for dusting. The calcium helped the insecticide adhere to the plant, making it more accessible to the weevils. The discovery of an effective poison was only part of the story because application methods also had to be perfected. After numerous experiments, the USDA recommended that farmers raise a large dust cloud at night or in the early morning and let it settle while dew was still on the plants. In addition, there were trials with dusting machinery ranging from hand dusters, to mule and tractor towed devices, to airplanes. Calcium arsenate was costly and beyond the reach of many farmers.[19] In the period under consideration, farmers had limited means, besides shifting to lower-yielding earlier-maturing varieties or curtailing cotton production, to combat the bug.

## III. Economic Impacts of the Boll Weevil

There is considerable controversy about the economic magnitude of boll weevil damage. The conventional view is that the weevil devastated production in the affected areas, but that the detrimental impact on production was relatively short-lived. A typical view is that the weevil destroyed "between one-third and one-half of the crop in newly infested areas."[20] A number of studies report large losses due to the arrival of the weevil. The Bureau of Agricultural Economics (BAE) began estimating annual boll weevil losses from full yield in 1909. Over the 1909 to 1940 period, the estimated reduction in yield for the United States (excluding the weevil-free Far West) ranged from a high of 31.0 percent in 1921 to a low of 1.3 percent in 1911 and averaged about 10.5 percent overall.[21]

Researchers from the Bureau of Entomology and Plant Quarantine (BEPQ) arrived at substantially higher estimates. They conduced a study across the South that

[19] Brown, *Cotton,* 2nd ed., pp. 348-52; Helms, "Technological Methods for Boll Weevil Control," p. 291; Haney, Lewis, and Lambert, "Cotton Production and the Boll Weevil," pp. 8-11.
[20] Manners, "Persistent Problem," p. 25.
[21] U. S. Bureau of Agricultural Economics, *Statistics,* pp. 67-80.

compared “the yield in plots where the boll weevil was controlled with that in untreated plots. . . .”[22] The results, summarized in Table 1, suggest that average physical losses were in the range of 11-33 percent, substantially higher than the average BAE estimates.

Table 1: Bureau of Entomology and Plant Quarantine Estimates of Weevil Damage

| Locality | Period | Yield Reduction |
|---|---|---|
| Talluah, LA | 1920-34 | 32.2 percent |
| Florence, SC | 1928-35 | 23.6 percent |
| Oklahoma (eastern) | 1928-35 | 32.8 percent |
| Mississippi (hill section) | 1934-36 | 10.8 percent |

Source: Hyslop, “Losses Occasioned by Insects, Mites, and Ticks,” pp. 4-5.

In *One Kind of Freedom*, Roger Ransom and Richard Sutch present even larger estimates of the short-run losses caused by the boll weevil. Using annual state-level data for Louisiana, Mississippi, Alabama, Georgia, and South Carolina, they compare average cotton acreage and yields for the four years before the weevil first entered each state with the four years after the weevil had completely crossed through. Adopting these wide time frames was necessary because damage increased for several years after contact as the weevil population built up. The weevil typically required about 6 years to cross a state, making the mid-points of the periods under comparison roughly a decade apart. These calculations reveal the infestation reduced cotton acreage by an average of 27.4 percent and yields by 31.3 percent.[23]

By way of contrast, Kent Osband, one of Sutch’s students, presents considerably smaller estimates of the financial (as opposed to crop) losses. Osband noted that for all the damage done when the weevil arrived in a particular locale, the Cotton South as a whole was resilient.

> Cotton farmers learned to cut their losses to the weevil: They changed their cultivation methods, harvested sooner and applied poisons. After the initial shock, every state witnessed a decline in weevil losses and resurgence of cotton production …. the weevil seems a symbol less of King Cotton’s collapse than of its perseverance.[24]

[22] Hyslop, “Losses Occasioned by Insects, Mites, and Ticks,” pp. 4-5. Hyslop also raises the question of increased cost of production, but only gives a rough estimate of dusting for 1926--30. On average in this period farmers dusted over 3.2 million areas. At an estimated cost of $2 per acre and assuming one-half of the dusting was directed at the boll weevil, meant about $3.2 million a year spent to dust the weevil.
[23] Ransom and Sutch, *One Kind of Freedom*, pp. 174-76.
[24] Osband, “Boll Weevil,” p. 628.

The key observation was that the demand for southern cotton as a whole was characterized by an elasticity close to unitary. As a result, weevil-induced reductions in cotton output led to almost exactly offsetting increases in prices. Osband estimated that the aggregate annual revenue loss to southern cotton producers was a modest 2 percent. From this perspective, the higher cotton prices greatly benefited foreign producers and hurt consumers everywhere. Even within the South, some producers initially benefited while others suffered. Osband argues that taking into account the elasticity of cotton demand, the micro-level evidence that "the weevil triggered a transition out of cotton" is consistent with macro-level evidence of little long-term impact.[25]

Osband's argument is consistent with the finding that the weevil reduced yields and production over long periods of time. The observed production in an area might have recovered because high cotton prices led farmers to intensify their production. Yet, these same farmers would have produced even more (and far higher quality) cotton in the absence of the weevil. This distinction is crucial and to understand the role of the weevil in the American South we require both estimates of the direct impact of the weevil as well as of the equilibrium response to increases in world prices that were observed as the weevil affected larger and larger areas of the South. In his work, Osband argues that equilibrium production did not fall, and indeed rose, as the weevil affected ever larger areas of the South. By contrast, we focus on local production impacts.

Osband's finding that changes in prices largely offset output losses for the South as a whole adds significantly to our understanding of the pest's impacts. But it tells us little about how the arrival of the weevil affected the local economies within the region or about the afflicted local economies recovered from this shock. Furthermore, regional-level analysis does not reveal how farmers adjusted either before or after the weevil's

[25] Osband, "Boll Weevil," p. 627. His analysis uses the state-level USDA production data to estimate the supply functions of each state and assumes the weevil reduced yields in line with the BAE estimates. He then simulates the changes in cotton acreage, outputs, and prices as the boll weevil spreads across the South. The model does assume that land taken out of cotton earned a smaller return in other uses.

The argument regarding southern resilience in response to the boll weevil should not be exaggerated. Yields were permanently decreased (until the advent of the modern eradication campaign ) and the use of extra fertilizer and pesticides increased costs. The main thrust of Osband's case is that increased prices compensated from the reduced production. This effect would have occurred if output fell because labor and other resources were withdrawn from cotton and put into productive uses. Instead the region gained a new large insect population to support.

arrival nor how local-level migration patterns and land values were affected. Price increases might have reduced the overall impact of the weevil on the prosperity of the cotton-growing region. However, most accounts suggest that the boll weevil hit local communities with those force of a tsunami, causing large and immediate changes in production relationships. Investigating how these local economies responded to such a great adverse shock to the leading staple commodity promises to advance our understanding the South's economic institutions and long-run performance.

## IV: Two New Data Sets

This study departs from previous research by assembling and analyzing new county-level panel data sets to investigate the magnitude and timing of the effects of the boll weevil. A county-level approach avoids many of the aggregation problems plaguing state-level studies and, obviously, increases by orders of magnitude the number of degrees of freedom. We utilize two new sets of data:

a. The first (which we call the "census" data) uses information from the Census of Agriculture for the years *1889, 1899, 1909, 1919*, *1924*, *1929*. This data set contains county level data on production and acres and allows constructing a measure of yields. This data-set also has county-level characteristics from the Census of Agriculture and Population, among other sources.

b. The second data (which we call the "ginning" data) contains annual data on cotton ginned within each county from *1899* to *1940*. We inputted these statistics from a set of surveys of local ginners conducted by the U.S. Department of Commerce. Local ginning is not a direct measure of local production. However, the ginning data is very highly correlated with the production data from the census. For example, the correlation coefficient across counties in 1899 census is 0.99. Unlike the census data, the ginning data do not allow calculating yields. However, they have the great advantage of being available annually.[26]

Both data sets make use of the same information on when the boll weevil arrived in a county. We have coded the year when the weevil first arrived in a county, when it passed completely through as well as the years of various retreats and returns from the classic USDA boll weevil maps. The frontier lines are drawn for the end of the crop year, after the weevil's period of seasonal migration. In the analysis below, we use the average of the start and through years to indicate the weevil's presence in a county. To provide for weather controls at the local level, we have created selected temperature and precipitation variables from two historical climate data sets. Specifically, we construct variables for each county's mean temperature in January and its precipitation in May, June and July based on data from nearby weather stations. See the Appendix for a fuller description of the data.

To create our panels, we must address the problem that numerous southern counties (N=138) changed the boundaries over our sample period. For example, new units were frequently created out of one or more existing units. We have formed multi-county aggregates (N=44) to use in place of those counties that experienced boundary changes. We use these multi-county aggregates together with the counties with consistent boundaries (N=1,165 in the full data set).[27] We will refer to these geographical units as "counties" even though of course some are aggregated out of several counties.

## Sample Selection

We select the sample with the goal of creating a balanced panels of uniform, consistently-defined geographic units that were hit by the weevil and that possess continuous measures of activity (production and acreage in the census sample and ginning in the ginning sample) for the period 1889-1929. To analyze the data we require a simple time-pattern for the presence of the boll weevil, which leads us to drop those

[26] The historical literature has referred these ginning data when reporting stories about the impact of the weevil in selected counties. We subject the series to the first systematic investigation.
[27] The full data set includes all of the counties in Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Note that only a handful of counties in Missouri and Virginia reported cotton and that many in Tennessee and Texas were also marginal producers.

counties that saw a temporal disappearance of the weevil. Most of these counties were located at the edge of the Cotton Belt. Many of our specifications have log production, log acres, or log yields as their dependent variables. Thus, we are wary of putting undue weight on tiny producers. Consequently, we exclude counties with minimal initial cotton acreage/production and drop some observations that have very small production in some years. The next two paragraphs describe the sample selection for each of the samples:

**Census data:** We have 808 geographical units in the data set that were hit by the weevil during the period covered by the USDA maps and that had consistent boundaries throughout 1889-1929. Across 6 years with census data, this makes for a total of 4,848 observations. We drop 97 counties where the weevil entered, retreated, and then re-entered. To avoid putting undue weight on small producers, we remove 90 counties that farmed less than 100 acres of cotton or had missing information on cotton production in the 1890 Census (the last taken before the arrival of the weevil in the United States). We also remove all those counties with less than 20 acres (or missing acres) of cotton production in any of the other census years. This step removes an additional 17 counties with 102 observations. We are left with 604 counties and a total of 3,624 observations. This amounts to 75 percent of the counties with consistent boundaries for whom we know the date of arrival of the weevil from the USDA maps.

**Ginning data:** The ginning data covers the period 1899-1940. To examine the timing of the impact of the weevil, we use data up to 10 years after the last county was affected by the boll weevil. This means that we use data up to 1932. We limit ourselves to the years 1899-1929 whenever we compare results from the ginning data with those from the census data. As for the census data, we have 808 'counties' with consistent geographic boundaries throughout the entire period 1899-1940. For the 34 years between 1899 and 1932 we have a total of 27,472 observation years. As for the census data, we drop 97 counties that experience retrenching and re-entering of the weevil. Again, we eliminate marginal counties by dropping those with cotton acres less than 100 or missing cotton acres in 1889, as well as those with missing cotton ginning data or that ginned less than

20 bales in any year. Together these steps remove 173 counties. This leaves the ginning sample with 538 counties and 18,294 observations, a retention rate of 66 percent.

**V: Local Impacts of Boll Weevil on Agricultural Production**

The newly assembled data allows us to look at the overall trends in agricultural production over the 1889-1929 period, but also at the localized impact of the weevil on agricultural production. Using the local data on agricultural production and the arrival of the weevil, we investigate how the weevil affected local output of cotton and corn, the main alternative crop. We consider both the overall impact and how farming changed in anticipation of the arrival of the weevil and how the impact of the weevil varied with time after contact.

Our analysis shows consistently that the arrival of the boll weevil had large, permanent effects on local agricultural production activity in the American South. To provide a first look at the overall impact of the weevil on corn and cotton production, Table 2 reports results from a simple specification – a regression of various production measures on Year and County fixed effects, local weather controls $W_{it}$ as well as an indicator $bw_{it}$ for whether the weevil was present in the county i at year t.[28] We also include a polynomial time trend interacted with share of cotton $s_c$ in total acres harvested in 1889 to account for the growth of new cotton producers in this time period.

(1) $$y_{it} = \beta * bw_{it} + \alpha W_{it} + \varsigma_1 t s_c + \varsigma_2 t^2 s_c + \theta_i + \theta_t + \varepsilon_{it}$$

We initially focus on how the weevil affected cotton production. The first four columns of Table 2 show the results for cotton using both the census data (cols 1-3) and the ginning data (column 4).

The year dummies shown in the table (census) and Figure 4 (ginning) inform us about the overall trends in cotton production. Cotton production increased substantially during this period, partially because yields increased, but more importantly because cotton acreage expanded. Production increased especially quickly between 1899 and

[28] It is worthwhile emphasizing that the Year fixed effects capture common factors affecting the entire sample of counties, including general cotton market conditions, regional-wide weather, and any common effects of the boll weevil independent of local contact.

1909 and between 1924 and 1929, confirming the increases in cotton production reported by Giesen.

This secular trend towards increased cotton production contrasts sharply with the impact of the weevil on local production conditions. Our estimates from Table 2 suggest that the impact of the weevil on local production was huge. These (within county-) estimates imply that the weevil was associated with a decline of total output by about 50 percent. Comparing columns (2) and (3) indicates that both yields and acreage declined, but that the contact with the weevil led to greater yield losses than acreage reductions.

One might be concerned that our estimates may be contaminated by reverse causation: locally favorable production conditions for cotton are likely to have favored the weevil's spread. Mindful of this possibility, we instrument for the presence of the boll weevil using the geographic location of the county. In a given year, the distance of a county from Brownsville, Texas (the weevil's entry point) predicts extremely well whether the weevil was present in that county. The relationship between the county's distance from the point of entry and the indicator variable for the presence of the weevil obviously changed as the weevil advanced across the South, suggesting an instrumental variable strategy that exploits the geographic location of each county interacted with the year of measurement. Therefore our instruments consist of the distance in longitude east and west of the county of first appearance of the boll weevil as well as the latitude of each county interacted with the years 1899, 1909, and 1919.[29] The exclusion restriction for this set of instruments is that production conditions did not change differentially with respect to the latitude and longitude during the period 1899-1919.

[29] In 1889 the weevil was not yet present in the US and in 1924 and 1929 all counties were affected.

*Table 2: Impact of Boll Weevil on Agricultural Production*

| | Cotton | | | | Corn | | | Total Farm Land |
|---|---|---|---|---|---|---|---|---|
| | (1) Log Bales | (2) Log Acres | (3) Log Yield | (4) Log Ginning | (5) Log Bushels | (6) Log Acres | (7) Log Yield | (8) Log Farm Acres |
| 1889 | -1.868 | -1.49 | -0.378 | | -0.240 | -0.090 | -0.151 | -0.019 |
| | (0.089)** | (0.087)** | (0.043)** | | (0.055)** | (0.039)* | (0.035)** | (0.029) |
| 1899 | -1.698 | -1.442 | -0.256 | | 0.255 | 0.263 | -0.008 | 0.052 |
| | (0.100)** | (0.089)** | (0.047)** | | (0.053)** | (0.034)** | (0.035) | (0.029) |
| 1909 | -0.949 | -0.577 | -0.372 | | -0.087 | 0.174 | -0.262 | 0.280 |
| | (0.083)** | (0.078)** | (0.037)** | | (0.053) | (0.033)** | (0.035)** | (0.026)** |
| 1919 | -0.571 | -0.518 | -0.053 | | 0.195 | 0.216 | -0.021 | 0.072 |
| | (0.063)** | (0.054)** | (0.032) | | (0.037)** | (0.025)** | (0.025) | (0.018)** |
| 1924 | -0.380 | -0.587 | 0.207 | | -0.029 | -0.017 | -0.012 | |
| | (0.077)** | (0.069)** | (0.037)** | | (0.042) | (0.032) | (0.029) | |
| Jan Temp | -0.006 | -0.054 | 0.048 | 0.001 | 0.016 | -0.006 | 0.022 | -0.034 |
| | (0.012) | (0.011)** | (0.006)** | (0.003) | (0.006)* | (0.005) | (0.004)** | (0.004)** |
| Summer Rain | -0.499 | -0.245 | -0.254 | -0.376 | 0.367 | 0.089 | 0.278 | -0.07 |
| | (0.070)** | (0.066)** | (0.029)** | (0.019)** | (0.043)** | (0.026)** | (0.028)** | (0.020)** |
| **Is Weevil present?** | **-0.618** | **-0.257** | **-0.361** | **-0.520** | **0.123** | **0.177** | **-0.053** | **0.006** |
| | **(0.046)**** | **(0.041)**** | **(0.025)**** | **(0.014)**** | **(0.028)**** | **(0.018)**** | **(0.019)**** | **(0.013)** |
| Observations | 3624 | 3624 | 3624 | 16678 | 3618 | 3618 | 3618 | 3020 |
| R-squared | 0.83 | 0.85 | 0.49 | 0.78 | 0.86 | 0.91 | 0.68 | 0.94 |

Standard errors (in parentheses) are robust to heteroskedasticity (Huber-White). * significant at 5%; ** significant at 1%
Cotton: Col 1-3 on census data for 1889, 1899, 1909, 1919, 1924, and 1929. Col 4 on annual ginning from the commerce data 1899-1929. Corn and Total Farm Land: Col 5-8 on census data weighted by the share of cotton in total production in 1899. Currently do not have data on total farm land in 1924. All Specifications with year and county fixed effects as well as polynomials in the fraction of farmland in 1889 planted as cotton in 1889 interacted with a time trend; 1929 is the omitted year.

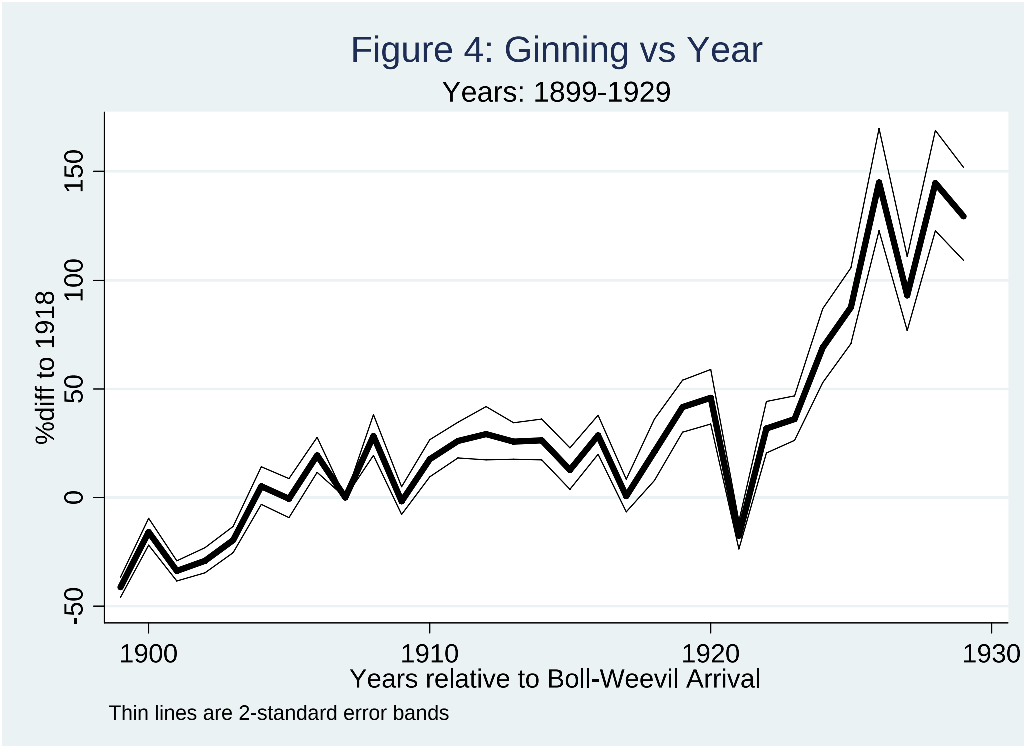



Table 3 displays the results for the second stage of the regressions on log bales, acres, yields, and ginning (The first stages for presence of boll weevil has an F-statistic (72 numerator dfs) of 101.76 for the ginning data. For the census data, the F has 9 numerator dfs and a value of 268.61). We find that the estimated effect of the weevil on cotton production is stronger in the IV rather than the OLS regressions.

*Table 3: IV-regression using longitude and latitude*

| | (1) | (2) | (3) | (7) |
|---|---|---|---|---|
| | Log Bales 1889-1929 | Log Acres 1889-1929 | Log Yield 1889-1929 | Log Ginning 1899-1929 |
| **Is BW present?** | **-0.733 (0.074)**** | **-0.084 (0.068)** | **-0.650 (0.039)**** | **-0.423 (0.030)**** |
| Observations | 3624 | 3624 | 3624 | 16678 |
| R-squared | 0.83 | 0.85 | 0.51 | 0.77 |

Standard errors (in parentheses) are robust to heteroskedasticity (Huber-White).
* significant at 5%; ** significant at 1%
With Year and County Fixed Effects and weather controls.
IV are distance (west, east, or north-south) from entry of boll-weevil interacted with year dummies for years with a boll weevil presence in more than 0% and less than 100% of counties.

Both our OLS and IV results on the production of cotton are therefore consistent with the existing literature that shows that the weevil had a devastating local impact on cotton production. If anything we find that the weevil's impact was even larger than the numbers traditionally asserted.

The results in Tables 2 and 3 do not reveal how the impact of the weevil was distributed relative to the time of its arrival. Due to limitations arising from the use of state-level data, the existing literature contains only fragmentary evidence on this question. We observe local production measures relative to the arrival of the weevil and across several decades, allowing us to determine much more precisely how the impact of the weevil on local production was distributed relative to its time of arrival.

We replace the variable for the boll weevil's presence with 10 leads and 10 lags for the weevil's arrival. The specification retains the local weather variables, the interaction of 1889 share of cotton in production with a time polynomial, as well as the County and Year fixed effects.

(2) $$y_{it} = \beta_k \sum_{k \geq -10, k \neq 0}^{k \leq 10} 1[t - h_i = k] + \alpha W_{it} + \varsigma_1 t s_c + \varsigma_2 t^2 s_c + \theta_t + \theta_i + \varepsilon_{it}$$

In equation (2), $h_i$ represents the year that the weevil entered county i. We omit the indicator variable for the year when the weevil arrived in a county and thus measure all effects relative to its arrival. The years 10 or more after or before being hit are combined into single categorical variables.

Figure 5 presents the coefficient on the timing variable for log ginning,[30] bales, yields and acreage. The graph shows the main effects as well as two standard deviation bounds. These production graphs put the destructive impact of the weevil into sharp relief. Ginning for instance fell by about 10 percent in the year after first contact and by more than 50 percent within the first 5 years of the arrival of the weevil. There is no sign that local activity rebounded within a decade after being hit. It is possible, indeed likely,

[30] Panel d.) also shows the results from estimating the ginning results using the census years only. These follow close the results on total bales in panel a.) providing further support that ginning is in fact a good measure of total local output. Furthermore, contrasting the ginning results on the full data with those on the census years highlights that the overall results from the commerce data are consistent with those from the Census data, but that sizeable temporal deviations are possible.

that without the mitigating efforts of farmers, the local impact of the weevil would have been even larger.

The coefficient estimates for the pre-contact period inform us about how farmers behaved in anticipation of the arrival of the weevil.  One might expect that as the weevil's approached a given locality, its farmers would have lessened their dependence on cotton in order to reduce their exposure to the impending threat. But our results show that in the year of contact, more land was put into cotton, and more cotton was harvested and ginned than two or three years before contact. The magnitude of the effect is statistically significant and economically large. For instance, at least 10 percent more cotton was ginned in the year of contact than in any of the preceding or following periods.

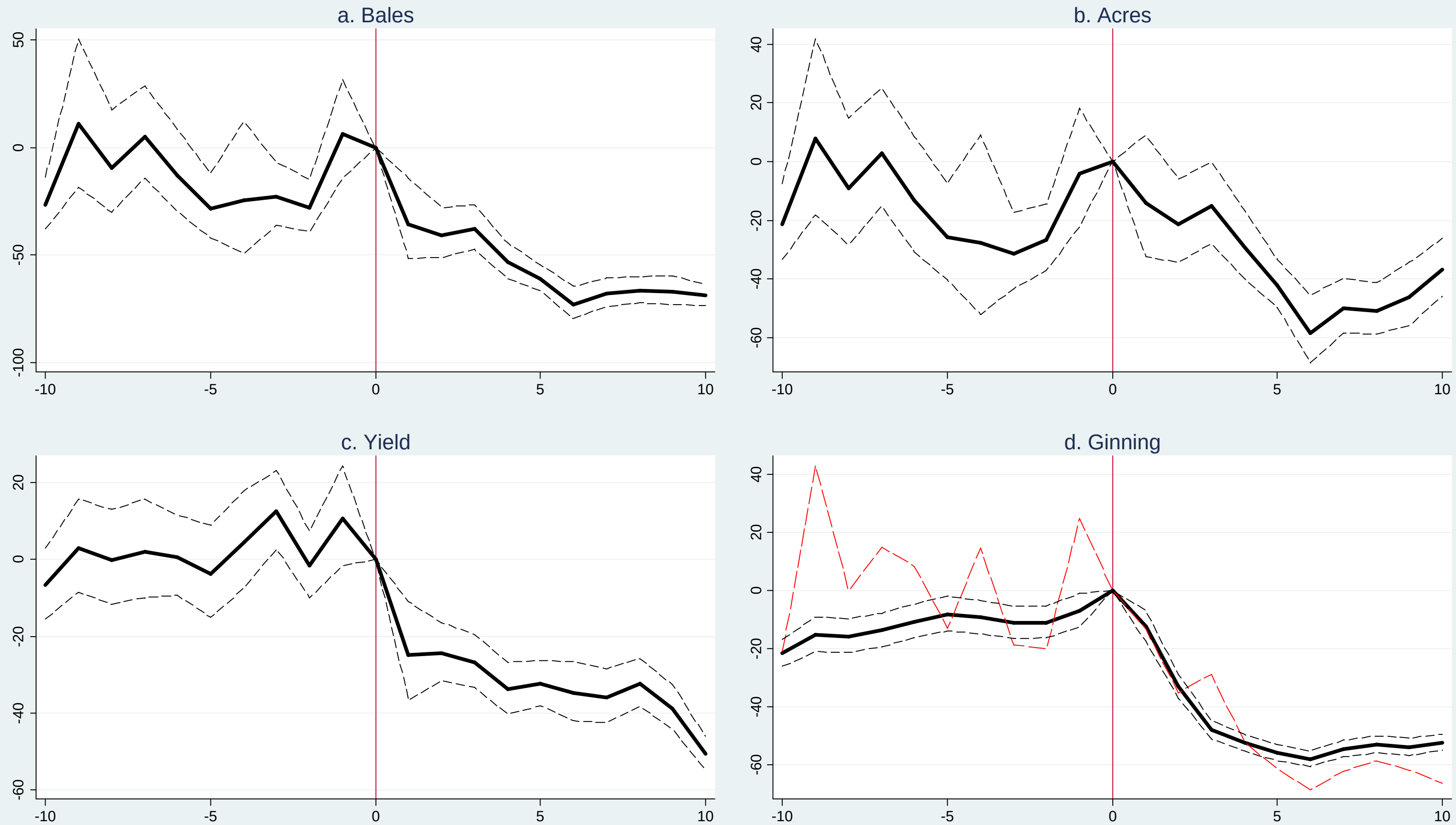
Several explanations are possible. One is that this relationship is not the product of human intention. For example, good cotton-growing weather covering a large region might encourage both a big crop and a large population of exceptionally fast migrating weevils. (Poor cotton-growing weather might lead both to a bad crop and a delay in being hit, which accounts for the dip in the years immediately before contact.) The regressions include partial controls for local weather with variables for January temperature and summer rain but there may remain some omitted variable bias.

A second, more intriguing alternative is that the rise in production immediately before contact was a conscious human choice. Helms observed “farmers too often attempted to grow that last ‘big crop’ after the boll weevil arrived….”[31] It might be economically rational to seek to depreciate rapidly cotton-specific assets (equipment and soils) before the insect's attack lowered their productivity. It might also be a response to enlarged local labor pools swollen by cotton hands moving east to escape the wave of destruction.[32]

We attempt to distinguish between reverse causality and purposeful human behavior by instrumenting for the arrival of the boll-weevil. Technically, specification (2) contains 20 endogenous variables, one for each dummy describing the time difference from the arrival of the weevil. However, the time difference from the arrival of the weevil is generated only by one variable: the actual arrival date of the boll-weevil and there is

[31] Helms, “Just Looking,” p. 399 citing the *Southern Cultivator*, Dec. 1 1916, p. 2
[32] Giesen, “South’s Greatest,” p. 137 recounts that in the late 1900s several thousand of African-Americans entered the Delta region to escape the ravages of the weevil further west.

# Fig 5: Production Measures Relative to Arrival of Weevil




x-axis: years relative to weevil arrival
y-axis: percentage difference to t=0
thin lines are two-standard error bands
Red line in ginning (panel d) estimated on census years only

therefore only one source of endogeneity here. To make progress, we estimate an ordered logit regression predicting the probability that the boll-weevil arrives in a given year based on a flexible functional form measuring the distance from the point the boll-weevil was first observed in the South.[33] Using this estimated probability of arrival, we can generate for each year and county a vector of probabilities measuring the probability that the weevil will arrive within k years. The variation in this probability that is orthogonal to the included independent variables in (2) is generated by the distance of the county from the initial point of entry of the weevil into the United States. We use this vector in probabilities of local arrival as an instrument for the timing variables. Figure 6 contrasts the OLS estimates on timing from the ginning data with the IV estimates.

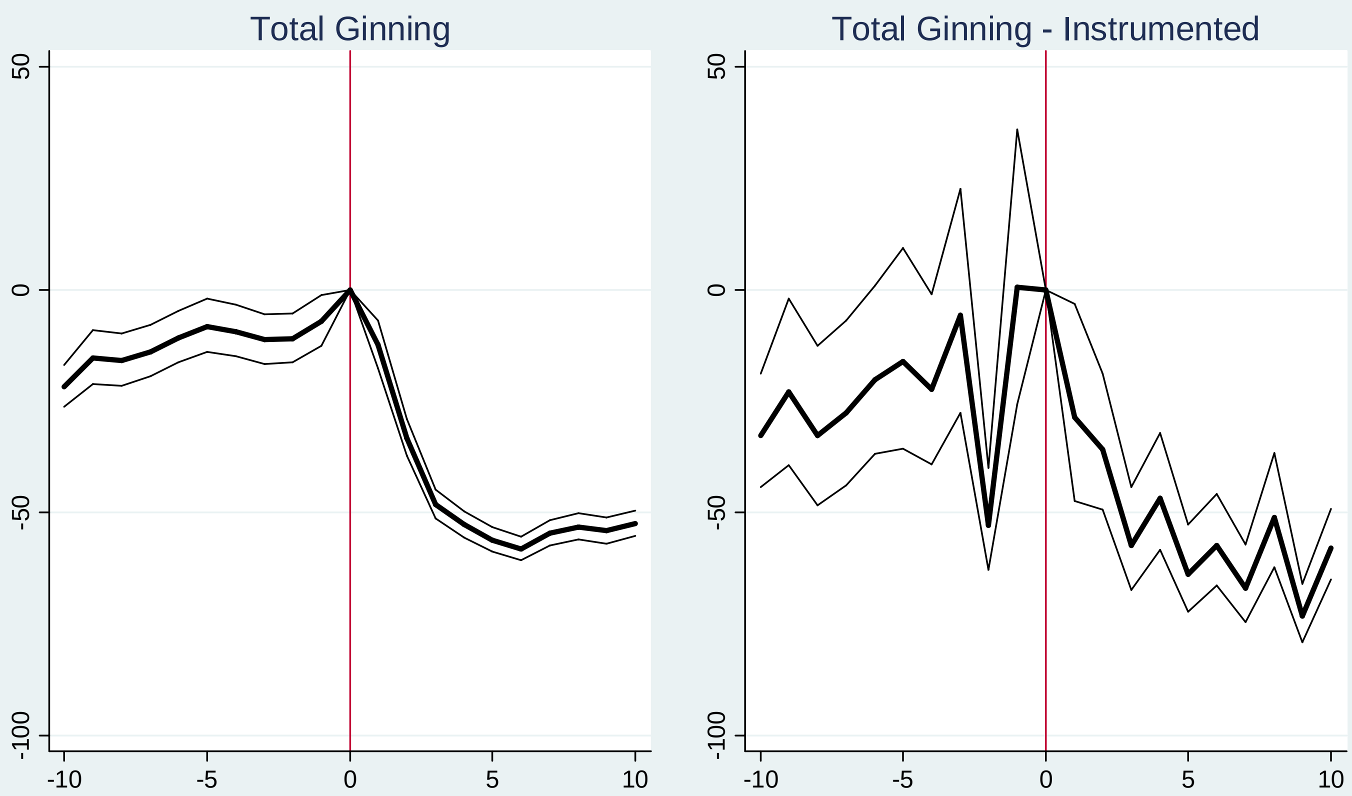
The instrumental variable estimates of the timing pattern in Figure 6 do show the same general patterns as the OLS estimates. Both the OLS and the IV results show that cotton ginned declined rapidly after the weevil arrived. The estimates obtained from the IV procedure also confirm ginning increased as the weevil approached. This suggests that indeed the run up before the weevil's arrival is at least partially generated by human behavior and not due to reverse causality. However, the estimates from the IV are noisy and should be interpreted with caution. Implementing the IV procedure for timing on the Census data proves a fruitless exercise because noise dominates the data.

We also explore the possibility that the impact of the weevil differed across counties depending on the prior intensity of cotton production. To measure the cotton-intensity of a county, we calculate the ratio of cotton acres to total farm acres in 1889 (the last Census information before the weevil arrived in the United States). Figure 7 illustrates the distribution of this measure of intensity of cotton, ($s_c$). It shows that the most counties had less than 25 percent of their land in cotton production and only a few devoted more than 30 percent of land to the crop. We have already employed the variable $s_c$ in specifications (1) and (2) by interacting it with time polynomials. Here we investigate the interaction of this measure of cotton-production intensity with our main variable of interest: the presence of the weevil.

---

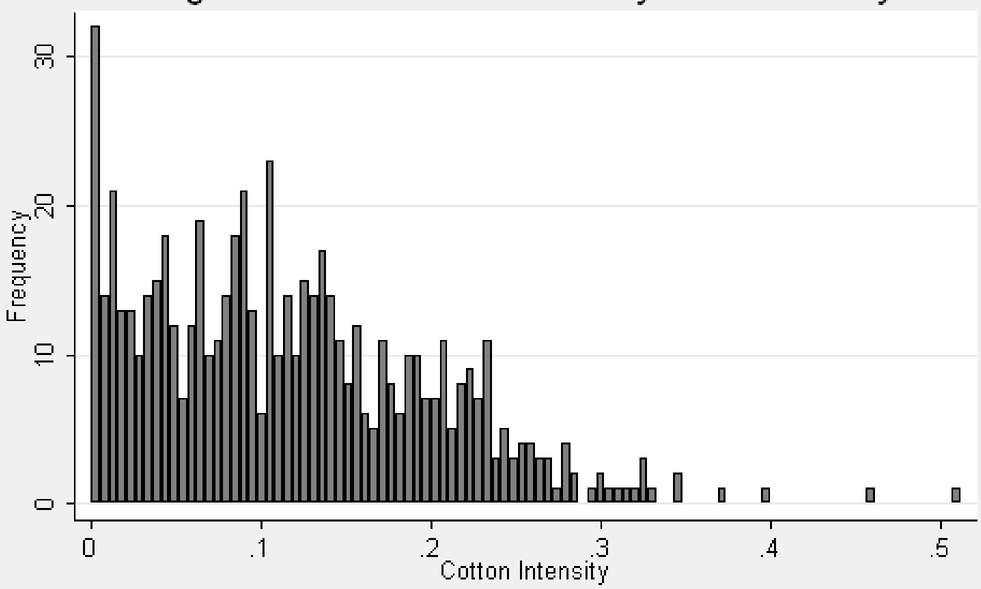
[33] The distance is measured as distance west and east from the initial point of entry as well as North-South as well as squares of these terms. We furthermore include interactions of these distances (east or west with the latitude).

# Fig 6: Ginning vs. Arrival of Weevil - OLS and IV




x-axis: years relative to weevil arrival
y-axis: percentage difference to t=0
thin lines are two-standard error bands

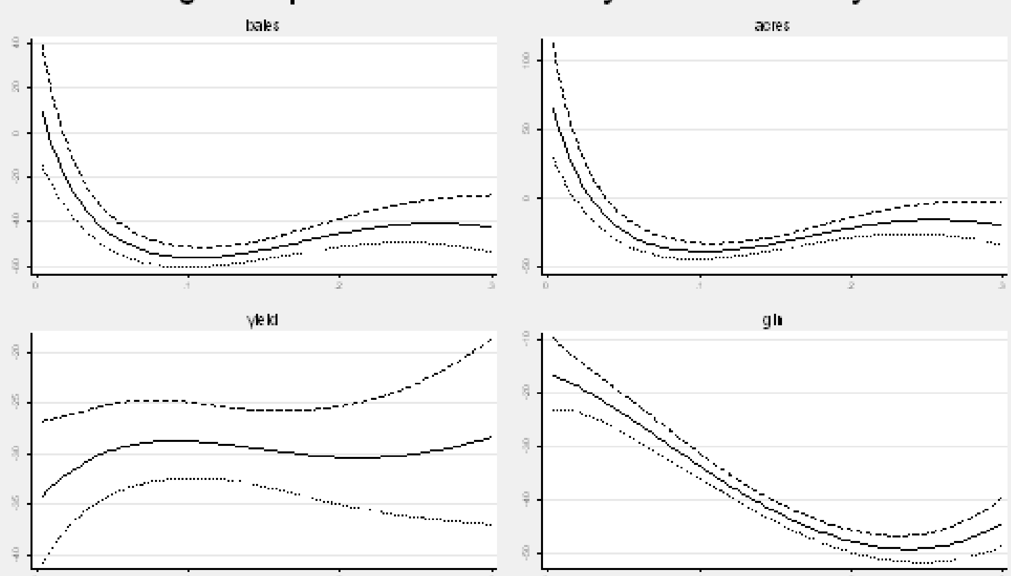
Fig. 7: Distribution of Counties by Cotton Intensity




Intensity of Cotton measured as fraction of farmland in cotton in 1890

We augment specification (1) with a 4th-order polynomial of $s_c$ interacted with the variable indicating the presence of the weevil. This allows us to predict the impact of the weevil by cotton-intensity of the counties. Figure 8 shows how the predicted impact of the weevil varies across cotton-intensity of the counties for our production measure.

Fig. 8: Impact of Boll-Weevil by Cotton-Intensity




Intensity measured as fraction of farm land in cotton in 1890
thin lines are 2 se bounds

These figures indicate that the impact on total production and on acres is increasing with the intensity with which a county engaged in cotton farming. The log ginning results differ from the log bales in that the latter indicate that the increase in the impact of the weevil is relatively constant across between a cotton intensity of 0 and 20 percent and only then levels off. The results from the Census data by contrast suggest that the impact on acres and bales increase rapidly as the intensity of cotton farming rises from low levels, but ‘flattens out’ subsequently. Yields however are evenly affected by the arrival of the weevil.

**Summary of Cotton Production Results**

The estimates from both the Census and the ginning data provide a consistent picture of the devastation the arrival of the boll weevil visited on local cotton production. Within 5 years of contact, total cotton production declined by about 50 percent. This decline relative to unaffected counties was permanent and evident in both cotton acreage and yields. The negative effects on yields appear to out-weigh those on acreage. The weevil impacted those counties most severely that were heavily concentrated in cotton in 1889. This might have reduced their economic position relative to counties that were only small producers before the arrival of the weevil. While the arrival of the weevil was locally devastating, its spread occurred during a period when overall cotton production in the South increased tremendously. Growth was especially rapid from 1900 to 1909 and 1924 to 1929 and was associated with increases in acreage (rather than yields).

**Total Corn Bushels, Yields, and Acreage**

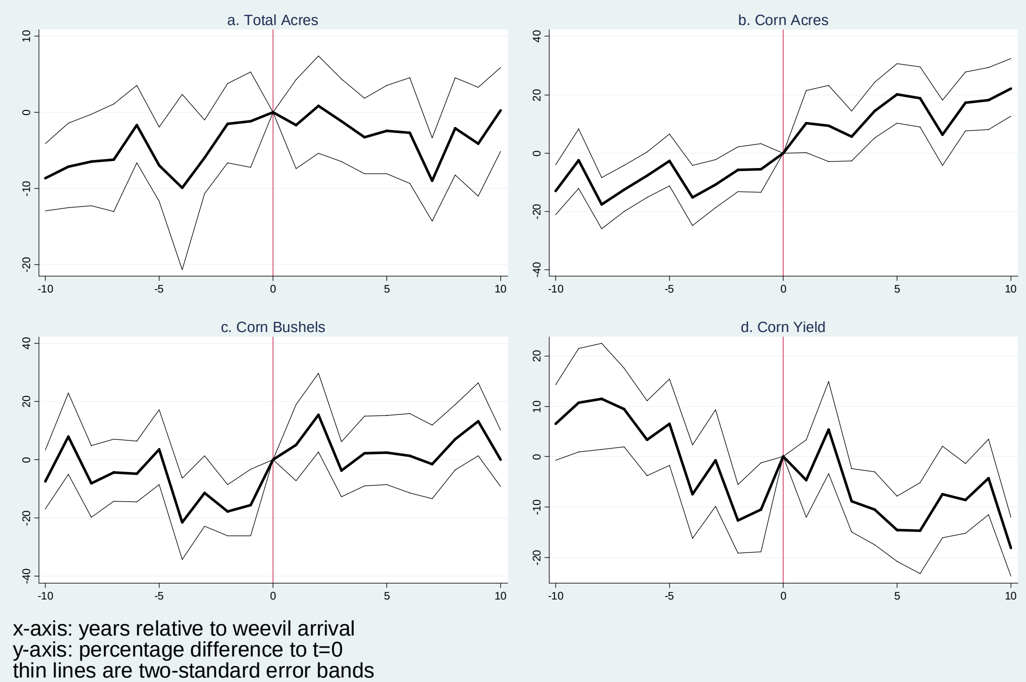
The decline in cotton acreage raises the question of what southern farmers did with the released land. Some have argued that instead of shifting land to alternative crops, southern farmers simply abandoned cultivation.[34] Table 2 as well as panels a and b in Figure 9 show that this was not the case. Total farm land (Table 2, column 8 and Figure 9 a) barely budged as the weevil moved through a county. Instead, southern farmers increasingly shifted production to the main alternative crop, corn. As seen in panel b, the

[34] See Giesen, “South’s Greatest,” pp. 29, 134, 250 for a critical evaluation of the contemporary claims that many southerners were abandoning their land, farms, and small towns in the weevil’s wake.

acreage of land devoted to corn production increased by about 20 percent subsequent to the arrival of the weevil.

Our estimates of the impact of the weevil on corn production and yields are noisy, but do nevertheless display some interesting patterns. Panel c shows that total production of corn increased by only 10 percent even though land allocated to corn rose by about twice that amount. Corn yields declined subsequent to the arrival of the weevil, possibly because farmers differentially shifted less fertile land to its cultivation. Overall the corn data indicate a greater movement to alternative crops than suggested in the literature downplaying the boll weevil's effects on diversification.

Fig 9: Alternative Land Uses relative to Weevil Arrival




## VI. Local Impacts on Land Values and Population

We now investigate the local impact of the weevil's arrival on land values and population movements. The evidence in Table 4 indicates that real land values per acre declined on average by about 10 percent after contact. Perhaps more surprising, local populations appear to have increased with the arrival of the weevil.

| Table 4: Land Values and Population | | | |
|---|---|---|---|
| | Log Real Value of Farm Land | Log Population | Log Black Population |
| **Is BW present?** | -0.088<br>(0.018)** | 0.032<br>(0.014)* | 0.069<br>(0.028)* |
| Observations | 3624 | 3018 | 3003 |
| **R-squared** | 0.88 | 0.92 | 0.96 |

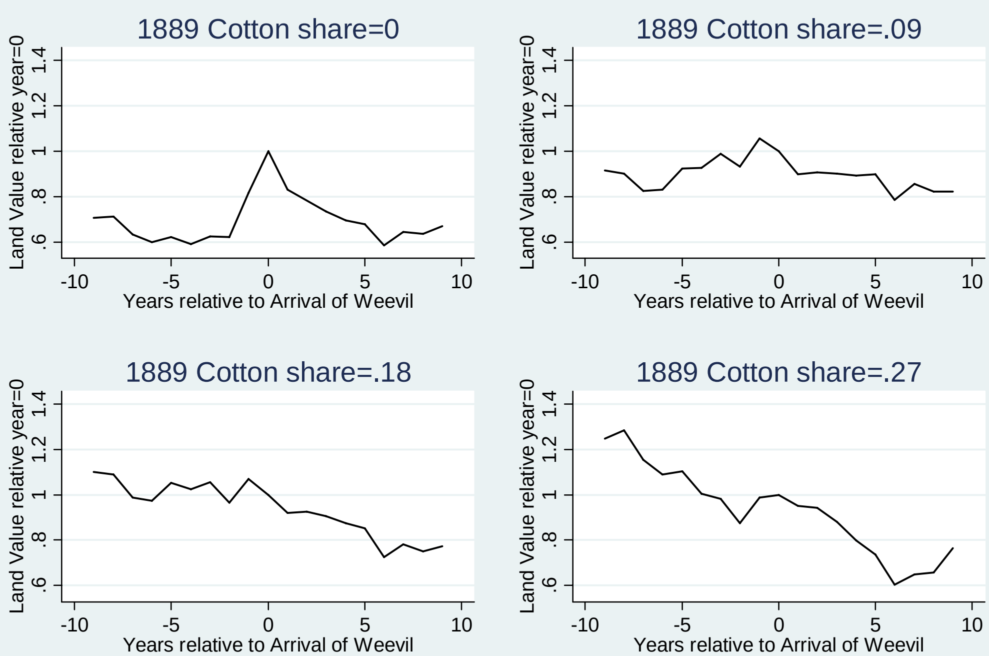
Robust Standard errors in parentheses.
* significant at 5%; ** significant at 1%
With Year and County Fixed Effects and quadratic in years interacted with the share of land in cotton in 1889.

The results presented in column 1 of Table 4 obscure interesting variations in the responses of land values. These responses differed across counties depending on importance of cotton in the local economy. And the response of land values to the arrival of the weevil varied over time. Indeed, well-functioning real estate markets should capitalize the pest's impact into land values long before it arrived in a given county. Thus, we need to consider how land values evolved prior to and after the weevil's arrival.

We can enrich specification (2) to allow the effect of the weevil on land values to differ with the share of cotton in local agricultural production in 1889. That is, we interact a polynomial in the share of cotton in total acreage with time to and from the arrival of the boll-weevil. This allows estimating a differential effect of the weevil on land values by share of production. The lines in Figure 9 graph the how local land values varied in the 10 years before and after the weevil arrived in a county relative to the land price in the year the weevil arrived in a county. The two points placed at each end of the lines represent the long run values more than 10 years before and after the weevil arrived. In each panel, we show the effect on land prices for counties that differ in their intensity of cotton farming in 1889. We choose four values for the intensity that cover most of the support of the distribution in counties in 1889.

As expected, the measured impact of the arrival of the weevil on land values depended on how much land was employed in farming cotton and varied with time relative to contact. In addition, we find important interactions between the dependency on cotton and time. Counties that were heavily engaged in cotton farming (shares 0.18 and 0.27) saw dramatic long run declines in prices of around 20-40 percent in the 10 years prior and subsequent to the arrival of the weevil. Furthermore, these declines commenced long before the weevil arrived in a location. The arrival of the weevil and its effect on the productivity of land were well known and the real estate markets of the South succeeded, at least partially, in pricing this into local farm land values prior to contact. However, for counties that were heavily engaged in cotton farming, land values continued to decline until about 5 years after the weevil arrived, mirroring the declines in productivity displayed in Figures 5 and 6.

Fig. 10: Observed Time Variation in Land Prices




The top two panels in Figure 10 display the impact of the arrival of the weevil on land prices in counties that were less dependent on cotton. Here, land values were basically unchanged more than 5 years prior or after contact. However land prices rose rapidly for a short window of about 7-8 years around the arrival of the weevil. About 2 years prior to the arrival of the weevil land prices increased rapidly about 2 years prior to contact, peaked around the time the weevil entered the county and then declined gradually until reaching their pre-period level about 5 years after the weevil finally appeared. This bump is pronounced for those counties with very low shares of cotton and more moderate for counties with higher shares. There are several possible explanations for this run-up in prices around the time the weevil arrived. Farmers and specialized inputs in agriculture might have been bidding for land suitable for other crops as cotton farming became less attractive. We do not have break downs of plot prices by prior use and can therefore not investigate the time-patterns in land values in more detail.

An alternative explanation is that the approach of the weevil released labor from cotton farming and thus lowered local wages. This would benefit land owners engaged in activities other than cotton farming. If the approach of the weevil indeed released large numbers of laborers from cotton-intensive counties, then we would expect that the population would rise in neighboring counties that were not heavily engaged in cotton farming. Furthermore, we would expect that migrant workers might move in advance of the weevil, swelling populations in those counties heavily engaged in cotton farming but not yet hit by the weevil. That is, we would expect a peak in population numbers in the year the weevil arrived in a county and when farmers hoped to harvest one last bumper crop. Figure 11 shows total population movements surrounding the arrival of the weevil and Figure 12 shows movements in the black population. These movements are consistent with the notion that labor moved in advance of the arrival of the weevil and did affect land values for acreage that was suitable for crops other than cotton.
The population movements among those counties that were moderately specialized in farming cotton are relatively small, but those counties that farmed either no cotton at all or relied heavily on cotton did indeed witness dramatic population swings.

As the weevil approached, population numbers swelled and persisted for a several years subsequent to contact. For the least cotton intensive counties we find an increase in population as the weevil moves through and we find that this increase persisted for a number of years after the weevil moved through. These counties then saw population numbers return to the values before the weevil arrived. In counties that were heavily engaged in cotton production (share=0.27) there is likewise a rapid increase in population just prior to the arrival of the weevil, but population numbers then declined to about 10 percent lower levels than in the period prior to the arrival of the weevil. Population numbers then seem to have recovered about 8 to 9 years after the weevil arrived.

Fig. 11: Observed Time Variation in Log Population

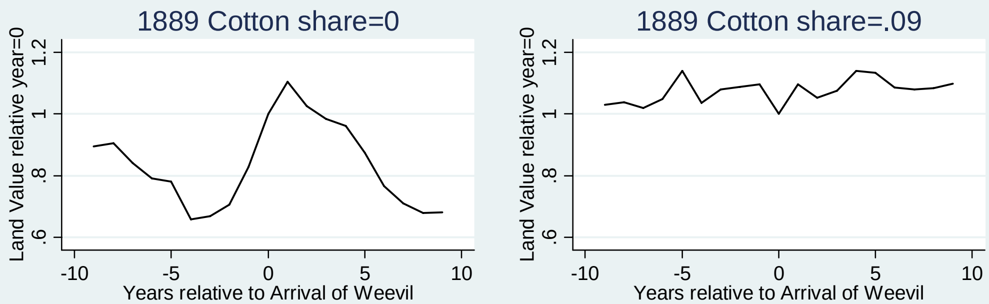
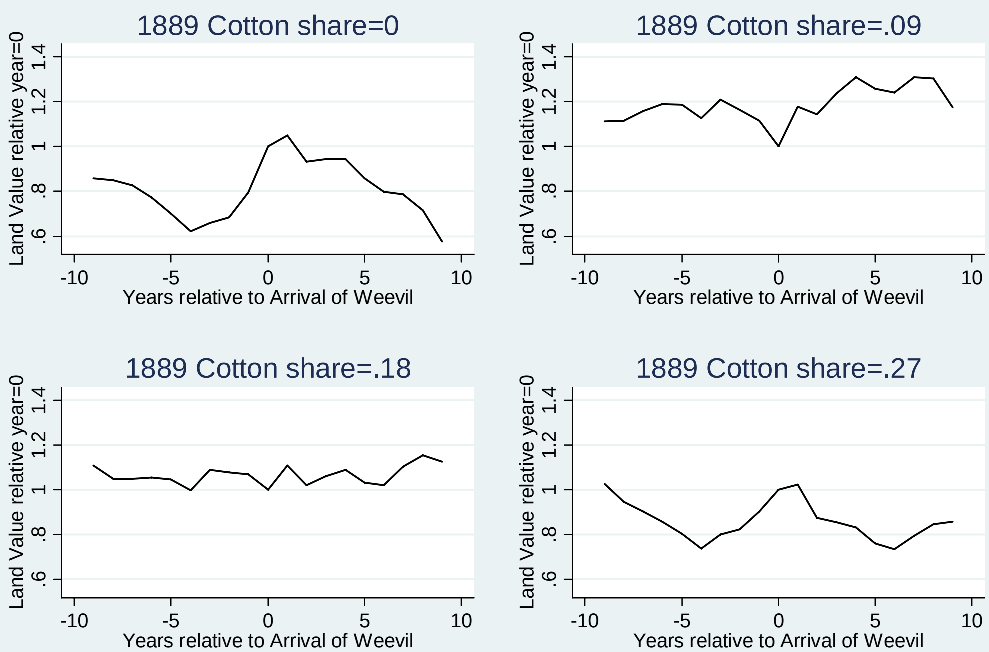



Fig. 12: Observed Time Variation in Log Black Population



We can conclude with some certainty that as the weevil approached land values in counties specialized in cotton production declined dramatically and we do not see that this decline in land values away from the trend was reversed during the time for which we have data available. Interestingly, the movements in land values (Figure 10) and mirrored in the population numbers.

**VII: Conclusion**

This paper examines county-level evidence on the impact of the spread of the boll weevil through the Cotton South after 1892. Our focus on the local impacts of the weevil differs from much of the existing Cliometrics literature, which has largely explored the "global" or Southern-wide effects of the boll weevil and consequently downplayed the pest's importance. Our findings may be summarized as follows: (1) contact with the boll weevil had large, immediate, negative effects on local cotton production, acreage, and especially yields; (2) these adverse effects grew in magnitude during the first five years after contact and persisted for a least a decade ; there is no evidence of "local" recovery independent of changes in cotton-production conditions common to the entire South; (3) the impacts on yields exceeded those on acreage; (4) and just before contact, southern farmers expanded cotton production – as if trying to squeeze out one last big crop -- rather than beginning to diversify away from their threatened staple.

Turning to the effects beyond cotton production, we find (5) little land was abandoned from agricultural production after contact; instead acreage was shifted to corn and other crops; (6) local real estate values declined both in anticipation and in the aftermath of the weevil's arrival, especially in areas heavily dependent on cotton; (7) the weevil appears to have unleashed a wave of internal migration, leading to local population gains before contact and substantial losses after the outset of significant crop damage; and (8) the effects on land values and population varied systematically with the county's pre-boll weevil dependence on cotton.

Our findings of large local effects of the weevil open up interesting possibilities for future research. The spread of this pest through a relatively poor region that was heavily dependent on cotton represents an exogenous productivity shock that can be used to identify the internal workings of the southern economy. Understanding the response of the farm tenancy system to this shock promises to shed light on long-standing questions regarding the Southern economic institutions. Tracing out the impacts on the allocation of the time of Southern children between work and school would also be informative.

In summary, we document that the march of the weevil had dramatic, persistent consequences for those cotton producers in its way. It is true that in 1921, cotton production in the American South exceeded that in 1892, before the pest appeared. But the cotton grown in 1921 was on average of much lower quality than that of the 1890s. In addition, as the weevil advanced through the American South, it triggered massive changes in the years before and after and its arrival. Studies of the twentieth-century South cannot ignore the dramatic impacts this pest wrought on those in its path.

## References

Banerjee, Abhijit, Esther Duflo, Gilles Postel-Vinay, Timothy M. Watts, “Long Run Health Impacts of Income Shocks: Wine and Phylloxera in 19th Century France,” NBER Working Paper No. 12895. Feb. 2007.

Brown, Harry Bates. *Cotton: History, Species, Varieties, Morphology, Breeding, Culture, Diseases, Marketing, and Uses*. 1st ed. New York: McGraw-Hill, 1927.

Brown, Harry Bates. *Cotton: History, Species, Varieties, Morphology, Breeding, Culture, Diseases, Marketing, and Uses*. 2nd ed. New York: McGraw-Hill, 1938.

Brown, Harry Bates, and Jacob Osborn Ware. *Cotton: History, Species, Varieties, Morphology, Breeding, Culture, Diseases, Marketing, and Uses*. 3rd ed. New York: McGraw-Hill, 1958.

Crew, Spencer R. “The Great Migration of Afro-Americans, 1915-40,” *Monthly Labor Review* 110: 3 (March 1988): 34-36.

Gains, R. C. "The Boll Weevil." In *Yearbook of Agriculture 1952*, pp. 501-504. Washington, DC: GPO, 1952.

Giesen, James C. "The South’s Greatest Enemy: The Cotton Boll Weevil and Its Lost Revolution, 1892-1930." PhD diss., University of Georgia, 2004.

Haines, Michael R. *Historical, Demographic, Economic, and Social Data: The United States, 1790-2000.* Inter-university Consortium for Political and Social Research Study No.2896.

Haney, Philip B., W. J. Lewis, and W. R. Lambert. *Cotton Production and the Boll Weevil in Georgia: History, Cost of Control, and Benefits of Eradication.* Georgia Agricultural Experiment Stations Research Bulletin No. 428 (1996).

Helms, Douglas. "Just Looking for a Home: The Cotton Boll Weevil and the South." PhD Diss., Florida State University, 1977.

———. "Revision and Revolution: Changing Cultural Control Practices for the Cotton Boll Weevil." *Agricultural History* 54, no. 1 (1980): 108-125.

———. "Technological Methods for Boll Weevil Control." *Agricultural History* 53, no. 1 (1979): 286-299.

Hinds, W. E. *Facing the Boll Weevil Problem in Alabama.* Alabama Polytechnic Institute, Alabama Agricultural Experiment Station Bulletin No. 146 (1909): 82-102.

Higgs, Robert. “The Boll Weevil, The Cotton Economy, and Black Migration: 1910-1930,” *Agricultural History* 50 (April 1976):335-50

http://www.infoplease.com/t/hist/state-of-the-union/116.html

Hunter, W. D. *Methods of Controlling the Boll Weevil*. USDA Farmers' Bulletin No. 163. Washington, DC: 1903.

Hunter, W. D. and B. R. Coad. *The Boll-Weevil Problem*. USDA Farmers' Bulletin No. 1329. Washington, DC: 1923.

Hyslop, J. A. *Losses Occasioned by Insects, Mites, and Ticks in the United States*. Washington, DC: U. S. Bureau of Entomology and Plant Quarantine, Division of Insect Pest Survey and Information, 1938.

Manners, Ian R. “The Persistent Problem of the Boll Weevil: Pest Control in Principle and in Practice.” *Geographical Review*. 69:1 (Jan. 1979) 25-42.

Merchant, Carolyn. *Columbia Guide to American Environmental History*. New York: Columbia Univ. Press, 2002.

Olmstead, Alan L., and Paul W. Rhode. "Hog-Round Marketing, Seed Quality, and Government Policy: Institutional Change in U.S. Cotton Production, 1920-1960." *Journal of Economic History* 63, no. 2 (2003): 447-488.

Olmstead, Alan L., and Paul W. Rhode. *Creating Abundance: Biological Innovation and American Agricultural Development*. New York: Cambridge Univ. Press, forthcoming.

Oosterhuis, Derrick M., and Judy Jernstedt. "Morphology and Anatomy of the Cotton Plant." In *Cotton: Origin, History, Technology, and Production*, edited by C. Wayne Smith and J. Tom Cothren, 175-206. New York: J. Wiley, 1999.

Osband, Kent. "The Boll Weevil Versus 'King Cotton'." *Journal of Economic History* 45, no. 3 (1985): 627-643.

Ransom, Roger, and Richard Sutch. *One Kind of Freedom: The Economic Consequences of Emancipation*. New York: Cambridge Univ. Press, 1977.

Smith, C. Wayne, and J. Tom Cothren, eds. *Cotton: Origin, History, Technology, and Production*. New York: J. Wiley, 1999.

U.S. Bureau of the Census. *Quantity of Cotton Ginned in the United States*. Washington, DC: GPO, 1900-1904.

U.S. Bureau of the Census. *Cotton Production in the United States*. Washington, DC: GPO, 1905-1940.

U.S. Bureau of the Census. *Fifteenth Census of the United States: 1930, Agriculture.* Vo. II Part 2 *The Southern States, Reports by States, with Statistics for Counties and a Summary for the United States*. (Washington, DC: GPO, 1932).

U.S. Bureau of Agricultural Economics, *Statistics on Cotton and Related Data*, Statistical Bulletin No. 99. Washington, DC: 1951.

U.S. Congress, House of Representatives. *Hearings of the House Committee on Agriculture.* 58th Congress. Washington: GPO, 1904.

U.S. Department of Agriculture. *Yearbook of Agriculture*, *1921*. Washington, DC: GPO, 1922.

Ware, Jacob Osborn. "Origin, Rise and Development of American Upland Cotton Varieties and Their Status at Present." *University of Arkansas College of Agriculture, Agricultural Experiment Station Mimeo,* 1950.

Wright, Gavin. *Old South, New South: Revolutions in the Southern Economy since the Civil War*. New York: Basic Books, 1986.

Wright, Gavin. “Reflections on One Kind of Freedom and the Southern Economy.” *Explorations in Economic History* 38: 1 (Jan. 2001): 40-47.

## Appendix: Data Description and Sources

### Extent of Boll Weevil Infestation

The extent of boll weevil infestation was based on the 1922 map appearing in the Hunter and Coad, *The Boll-Weevil Problem.*

### Ginning Data

Annual county-level data on cotton ginning are available beginning in 1899 from the U.S. Bureau of the Census, *Quantity of Cotton Ginned in the United States* (Washington, DC : GPO, 1900-1904); *Cotton Production in the United States* (Washington, DC : GPO, 1905-1940). The data including both the upland and Sea Island crops (exclusive of linters) are in number of 500-pound equivalent bales. Local agents collected the data based on a comprehensive canvas of southern ginneries.

County-level ginning is very closely correlated to county-level production; the R-squared equaled 0.99 in the 1899 Census data.

### Production and Farm Characteristics

U.S. Census of Agriculture collected data on acreage, production, and thus yields for cotton, corn, and other crops by county for 1889, 1899, 1909, 1919, 1924, and 1929. Census data are drawn from ICPSR Study No.2896, Historical, Demographic, Economic, and Social Data: The United States, 1790-2000, Michael R. Haines, Colgate University, Inter-university Consortium for Political and Social Research and US Bureau of the Census, *Fifteenth Census of the United States: 1930*, *Agriculture*, Vo. II Part 2 *The Southern States, Reports by States, with Statistics for Counties and a Summary for the United States*, (Washington, DC: GPO, 1932). Value of Land and Buildings per Acre for 1924 are from ICPSR No. 9 and is in whole dollars.

### Weather

The weather data come from two sources: (a) United States Historical Climatology Network (USHCN): http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html; and (b) National Oceanic and Atmospheric Administration, Nineteenth Century U.S. Climate Data Set Project (based primarily on records kept at US forts): http://lwf.ncdc.noaa.gov/oa/climate/onlinedata/forts/forts.html. We merge these data sources to estimate the temperature and precipitation variables for each county.