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Philipp Ager, Markus Brueckner and Benedikt Herz

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Department of Business and Economics
Faculty of Business and Social Sciences
University of Southern Denmark
Campusvej 55, DK-5230 Odense M
Denmark

E-mail: lho@sam.sdu.dk / http://www.sdu.dk/ivoe

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Philipp Ager Markus Brueckner Benedikt Herz†

Abstract

This paper provides new insights on the link between structural change and the fertility transition. In the early 1890s agricultural production in the American South was severely impaired by the spread of an agricultural pest, the boll weevil. We use this plausibly exogenous variation in agricultural production to establish a causal link between changes in earnings opportunities in agriculture and fertility. Our estimates show that lower earnings opportunities in agriculture lead to fewer children. We identify two channels: households staying in agriculture reduced fertility because children are a normal good, and households switching to manufacturing faced higher opportunity costs of raising children. The rather bleak outlook for unskilled agricultural workers also increased the demand for human capital, which reinforced the fertility decline that occurred in the American South during the late 19th and early 20th centuries.

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JEL codes: J13; N31; O15

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†Corresponding authors: Philipp Ager, University of Southern Denmark; phag@sam.sdu.dk and Benedikt Herz, European Commission, 1049 Brussels, Belgium; benedikt.herz@gmail.com.

1 Introduction

The fertility transition that countries in North America and Europe experienced during the 19th and 20th centuries is regarded as one of the most important determinants of rapid and sustainable long-run growth. Falling fertility rates allowed the transition from a Malthusian regime, where income per capita was roughly constant, to a regime with lower population growth and higher living standards. For example, the number of children per white woman in the United States fell from around seven to two between 1800 and 2000, while at the same time real GDP per capita increased from 1,296 dollars in 1800 to 28,702 dollars in 2000 (Haines and Steckel, 2000; Bolt and Van Zanden 2014; Bailey and Hershbein, 2015).[1] Despite its importance, the reasons for the fertility transition remain unclear. Explanations range from changes in social norms, innovations in contraceptive methods, declines in infant and child mortality to increases in the direct cost of children, such as child labor laws and urbanization, or changes in the returns to child quality (Guinnane, 2011). Some scholars even argue that economic factors have little to do with the fertility transition (Coale and Watkins, 1986; Cleland and Wilson, 1987).

This paper provides new empirical evidence that the structural transformation, a sustained shift from agriculture to manufacturing, was essential for the fertility transition in the American South during the late 19th and early 20th centuries. We exploit the arrival of an agricultural pest, the boll weevil, which adversely affected the cotton producing counties of the American South after the early 1890s as a quasi-experiment (Lange et al., 2009).[2] Since the spread of the boll weevil was determined by geographic conditions, mainly prevailing wind and weather conditions, it provides a plausibly exogenous source of variation in the earnings potential in the agricultural sector. Our estimation strategy uses two sources of county-level variation: the timing of the boll weevil's arrival and its stronger impact on local economies that were more dependent on cotton cultivation. Our econometric model combines this county-level variation with individual Census data to estimate the causal link between structural change and fertility.

We find evidence that the lower earnings opportunities in the agricultural sector decreased fertility during the 1880-1930 period via two channels: households staying in agriculture (*stayers*) reduced fertility due to lower income—consistent with children being a normal good (Becker,

[1] The GDP data are retrieved from `http://www.rug.nl/ggdc/historicaldevelopment/maddison/`.

[2] Ransom and Sutch (2001, Table 9.2) document that the arrival of the boll weevil caused large declines in cotton yields and cotton acreage in five cotton producing states of the American South (Louisiana, Mississippi, Alabama, Georgia, and South Carolina) during 1889–1924. For the four years preceding 1920, the United States Department of Agriculture (USDA) estimated the average annual loss due to boll weevil infestation around 200-300 million US dollars (Hunter and Coad, 1923). For further information on the boll weevil's role for economic development in the American South we refer to Bloome et al. (2017), Ager et al. (2016), Giesen (2012), Lange et al. (2009), and the references therein.

1960)[3]—and households that left agriculture (*switchers*) reduced their fertility because of the higher implicit and direct costs of raising children in the manufacturing sector.

The first channel is compatible with Becker's theory and in line with the view that the opportunity cost of child rearing was relatively low for farm work in the American South at the beginning of the 20th century, and potentially in agrarian economies more generally.[4] In order to estimate the effect of a decline in agricultural income on fertility for stayers we use the interaction between the boll weevil incidence and counties' (initial) dependence on cotton production as an instrumental variable. Our second-stage estimates reveal that lower agricultural income led to lower fertility among agricultural households, independent of race. A one-standard-deviation decrease in household income derived from agriculture decreased the number of children below age 5 by about 0.12. Since the overall decline of children below age 5 in the Cotton Belt of the American South was 0.44 over the sample period, this effect is quantitatively important.[5]

Our second channel is that the arrival of the boll weevil led to a shift away from the agricultural sector in cotton-dependent counties. Households increasingly switched from farming to manufacturing activities. Upon arrival of the boll weevil, a 10-percentage point increase in the initial cotton share decreased the ratio of workers in agriculture vs. manufacturing by more than 4 percent. This shift out of agriculture reinforced the fertility decline, since manufacturing households had substantially fewer children than agricultural households during our sample period.[6] Both channels imply that there is an unambiguously negative association between lower earnings opportunities in agriculture and fertility. Our findings also suggest, in line with the theoretical framework by Mookherjee et al. (2012), that the wage-fertility relation is positive within broad occupational categories but negative across occupational categories.

Our finding that switcher households have fewer children is in line with the view that industrialization might have increased the implicit cost of raising children (Goldin, 1995; Guinnane, 2011, Section 4.4). Three possible mechanisms have been proposed by the literature, all of which are in line with our results. First, working on the factory floor is less compatible with raising children than working on a farm, for example, due to various health risks (Jones, 1985; Guinnane, 2011). Unlike farm work, factory work usually takes place at a central location, implying a separation of the job and the home, which increased the implicit cost of child rearing. Second, increased job op-

[3]A recent literature shows that when income/wealth shocks are properly identified, children are indeed a normal good (e.g., Lindo, 2010; Black et al., 2013; Lovenheim and Mumford, 2013; Brueckner and Schwandt, 2015).

[4]In the American South during that time period it was not uncommon for women to carry their infants and young children with them to the cotton field (Jones, 1985).

[5]The positive relationship between income and fertility has also been documented for pre-industrial societies and predominantly agrarian economies (Simon, 1977; Lee, 1987; Wrigley, 1988; Clark, 2005, 2007; Clark and Hamilton, 2006).

[6]For example, according to the 1910 Census married 20 to 49-year-old women in the Cotton Belt in agricultural households reported having 1.07 children under age 5, while it was 0.78 for non-agricultural households.

portunities outside agriculture might have affected the old-age security motive of having children (e.g., Sundstrom and David, 1988; Ransom and Sutch, 1989). Third, as human capital became more important during the process of industrialization, households might have reduced fertility if they decided to invest more in their children's education (Galor and Weil, 1999; 2000), consistent with the quantity-quality (Q-Q) theory discussed in Becker and Lewis (1973).

In accordance with the human capital channel, we find a negative link between the earnings potential in agriculture and education. Since cotton cultivation in the American South was relatively low-skilled at that time, a negative shock to agricultural production raises children's returns to education relative to income prospects in agriculture and induces parents to invest more in child quality.[7] We find that the boll weevil infestation increased school enrollment rates of children in counties with a higher intensity of cotton production. This result is in line with recent macroeconomic models of the fertility transition arguing that human capital is an important mechanism through which changes in income affect fertility (e.g., Galor and Weil, 2000; Galor and Moav, 2002; Galor and Mountford, 2008). It is also consistent with the theoretical literature implying that there is a negative relationship between fertility and education (e.g., Moav, 2005).

We further demonstrate that the positive effect on schooling varies by age and race. In line with an underlying Q-Q mechanism the lower earnings opportunities in agriculture led parents of young white children (ages 5-9) to invest more in schooling, while we find no effect on black children of the same age. This pattern is different for older children (ages 10-15), where the increase in school enrollment rates in highly cotton-dependent counties after the arrival of the boll weevil is entirely driven by black children.[8] Diminishing returns to child labor in agriculture provide an alternative explanation for the rise in school attendance of black children, because they lower the opportunity cost of sending children to school and reinforce the demand for human capital (Galor, 2005). Consistent with this argument, we document that the lower earnings opportunities in agriculture reduced the demand for child labor, as fewer 10-15-year-old black children reported a gainful occupation in highly cotton-dependent counties after the boll weevil's arrival.[9]

The hypothesis that the decline in returns to child labor increased the demand for schooling of black households in the Cotton Belt is supported by the fact that the boll weevil infestation triggered the demand for so-called Rosenwald schools, particularly in the sample of counties with a higher initial share of child labor.[10] While lower returns to child labor in agriculture increases the

[7] In the Cotton Belt of the American South the average literacy rate for 16-65-year-old workers in manufacturing is 88 percent during the 1880-1930 period, while in agriculture it is 59 percent (own calculations based on mircocensus data from the Integrated Public Use Microdata Series (IPUMS)).

[8] In a related study, Baker (2015) shows for counties within the state of Georgia that school enrollment rates of black children increased in response to the adverse impact of the boll weevil on cotton production.

[9] The decline in child labor is in line with the view that children had a comparative advantage within the agricultural sector in picking cotton (Goldin and Sokoloff, 1984; Baker, 2015).

[10] The Rosenwald Rural Schools Initiative (1914-1931) supported the construction of schools for black children in

direct cost of having children, the Q-Q theory emphasizes the effect of lower earnings opportunities in agriculture on the returns to schooling. However, both mechanisms are complementary in amplifying the negative effect of a lower earnings potential in agriculture on fertility.[11] Overall, the presented evidence supports the view that industrialization and the associated increase in human capital formation contributed to the fertility transition in the American South during the late 19th and early 20th centuries.

2 Related Literature

Proponents of unified growth theory argue that the process of industrialization contributed to the onset of the fertility decline (Galor, 2005; Galor and Mountford, 2008; Galor, 2012),[12] yet empirical evidence using plausible exogenous variation to identify this relationship is relatively scarce.[13] We contribute to this literature by investigating the link between the structural transformation and the fertility transition in the American South using exogenous variation in the earnings opportunities in agriculture due to the boll weevil infestation.

Our finding that switcher households decreased fertility because the implicit and direct cost of child rearing were higher in the manufacturing sector complements the study by Wanamaker (2012), who exploits variation in the diffusion of textile mills in South Carolina between 1880 and 1900 to evaluate the importance of industrialization for the fertility transition. Wanamaker shows that fertility dropped by 6 to 10 percent in townships where textile mills were established. This effect is mainly driven by migrating households—a consequence of the separation from their extended family network and the associated increased cost of childbearing. Our study differs from Wanamaker, as we show that migration is unlikely the main driver of our results, and we present evidence in line with unified growth theory which stresses the importance of human capital formation during the process of industrialization for the fertility decline (Galor, 2005).

Becker and Lewis (1973) propose a different angle for the fertility decline and argue that rising incomes induce parents to invest more in child quality. Their Q-Q model demonstrates that increased expenditure on the quality of each individual child increases the price of fertility and that the quality and quantity of children are therefore substitutes. When returns to education are relatively high, an increase in income might lead to a decrease in the number of children. The Q-Q model is well supported by the data: there is ample evidence of a negative relation between

rural counties in the American South (Aaronson and Mazumder, 2011).

[11] Vogl (2015) argues that increasing returns to child investment and a declining value of child labor are complementary mechanisms in explaining differential fertility by parents' income and skills.

[12] Further examples linking the demographic transition to the higher living standards that the industrial revolution brought to industrial countries are Clark (2005) and Bar and Leukhina (2010).

[13] Exceptions are Wanamaker (2012) for the United States, Franck and Galor (2015) for France, and de Pleijt et al. (2016) for England.

family size and child quality, which is mostly interpreted as evidence of an existing Q-Q trade-off (e.g., Hanushek, 1992).[14] More recently, the literature has examined the Q-Q trade-off by using plausibly exogenous variation in the returns to education. Ager et al. (2017) exploit the roll-out of kindergartens to investigate the role of early-childhood education for the fertility transition in American cities during the late 19th and early 20th centuries. In line with a Q-Q model where parents can invest both in preschool and schooling they show that the establishment of kindergartens in American cities contributed to the fertility transition, because it increased children's returns to education due to strong complementarities between preschool and school education. Bleakley and Lange (2009) exploit the sudden eradication of the hookworm in the American South during the 1910s as a quasi-experiment. Since a hookworm infection affected returns to child investment via child morbidity, its eradication led to an effective decrease in the price of child quality, particularly in areas with high pre-treatment infection rates. Bleakley and Lange find that a substantial decline in fertility is associated with the hookworm eradication and interpret this as evidence in favor of the Q-Q model.[15]

The study by Aaronson et al. (2014) extends the standard Q-Q framework by the option of couples remaining childless. They use the roll-out of the so-called Rosenwald schools in the American South during the early 20th century to test the model and find, consistent with the Q-Q trade-off, that black women who were too old to attend a Rosenwald school reduced fertility along the intensive margin, but in line with their theoretical framework these women were also more likely to have one child. Aaronson et al. (2014) also document that women educated through the Rosenwald school initiative delayed childbearing along both the extensive and intensive margin because of higher opportunity costs of child rearing.[16]

An alternative mechanism that is consistent with rising school enrollment rates and falling fertility rates during the process of industrialization is the decline in the value of child labor. Galor (2005), for example, argues that the decline in child labor reinforces the demand for human capital (see also Hazan and Berdugo, 2002; Doepke, 2004). The enactment of child labor laws could have further contributed to a fertility decline (Doepke and Zilibotti, 2005), but Moehling (1999) argues that for the United States child labor laws had little impact on the substantial decrease of child labor during our sample period. Consistent with Moehling, we find that after the arrival of the boll weevil

[14] A large literature uses twinning and sibling sex composition as instruments for family size (e.g., Rosenzweig and Wolpin, 1980).

[15] However, Bleakley and Ferrie (2016) find no evidence that winners of Georgia's Cherokee Land Lottery of 1832 invested more in child quality than lottery losers, despite the substantial size of the financial windfall (lottery winners won on average about 700 US dollars, which was close to the median wealth of 1850).

[16] Further evidence for the United States is provided by Hansen et al. (2017), who find a robust negative relationship between years of schooling and fertility over the 1850-1980 period based on state-level panel data. Cross-sectional evidence on the negative relationship between education and fertility during the demographic transition is provided in the studies by Murphy (2015) and Bignon and García-Peñlosa (2016) for France, Becker et al. (2010) for Prussia, and Klemp and Weisdorf (2012) for England.

fewer 10-15-year-old children reported a gainful occupation in highly cotton-dependent counties, where child labor laws were rather difficult to enforce (i.e., monitoring child labor violations on farms is a rather complicated task). Our findings suggest, that for black households in the Cotton Belt the decline in the value of child labor increased the direct cost of having children and was the driving force behind the reduction in fertility, while white households had fewer children as they decided to invest more in child quality as a consequence of the lower earnings opportunities in agriculture. In our case, after households experienced a negative shock to agricultural production both mechanisms contributed to the increased demand for schooling in the Cotton Belt during our sample period.

Since the structural transformation went along with increases in household income, our findings are also in line with a literature that documents a negative relationship between parental wages and fertility (see Jones et al., 2010, for an overview). However, our results suggest that this overall negative correlation masks more complex mechanisms as pointed out by Mookherjee et al. (2012). The correlation between parental wages and fertility is driven by two potential confounding effects: higher income within the same occupational category could increase fertility depending on whether the income effect dominates the substitution effect, while across occupational categories this effect is supposed to be negative because with upward mobility rising incomes induce parents to invest more in child quality. For empirical studies investigating the relationship between parental wage and fertility it is therefore important to identify the effect of a wealth/income shock for households staying within the same occupation and for households switching occupations separately. In our case, the unambiguous negative effect that the lower earnings opportunities in agriculture had on fertility is a product of switcher households investing more in their children's education because of future income gains and stayer households facing income losses.[17]

The overall negative correlation between household income and fertility and our result that children are normal goods (in the agricultural sector) therefore do not stand in contradiction, as has been previously argued by Blake (1968). It is in line with recent empirical evidence showing that – when income/wealth shocks are properly identified – children are indeed a normal good as suggested by Becker (1960).[18] For example, Lovenheim and Mumford (2013) exploit regional variation in the U.S. housing market to show that family wealth positively affects fertility. Bleakley and Ferrie (2016) show that winners of the Georgia Cherokee Land Lottery of 1832 had slightly more children than lottery losers. Lindo (2010) and Black et al. (2013) reach the same conclusion

[17] Our finding also reveals that the opportunity costs of raising children for farm families in the American South were rather low at that time, such that changes in household income and fertility within the agricultural sector went hand in hand.

[18] One rational argument that is consistent with Becker's theory and can account for the negative correlation between parental wages and income documented in many empirical studies is that the increasing opportunity costs of having children are associated with the rise of female wages (Butz and Ward, 1979; Schultz, 1985; Heckman and Walker, 1990).

by exploiting exogenous shocks to household income. The positive relationship between household income and fertility within agricultural occupations is also consistent with the finding in some earlier literature based on cross-sectional U.S. data that higher income leads to more children within the same occupation (Freedman, 1963; Simon, 1969).

Our paper also relates to a large literature on the fertility transition in the United States and in particular on the American South. Economic historians suggested various competing hypotheses to explain the United States' fertility decline during the 19th and early 20th centuries, ranging from changes in the cost of acquiring land (Yasuba, 1962; Forster et al., 1972; Easterlin, 1976) over increasing the default risk of children to provide old-age care for parents (Sundstrom and David, 1988; Carter et al., 2004) to economic modernization such as rising literacy and urbanization rates (Vinovskis, 1976; Guest, 1981).[19] The importance of economic modernization for the fertility transition in the United States has been emphasized by many studies, especially for the period after the Civil War (Guest, 1981; Tolnay, 1986; Wahl, 1992; Wanamaker, 2012). While the fertility transition spread throughout the United States, there existed sizable regional differences: compared to the rest of the United States, southern regions experienced only a modest decline in the child-women ratio during the 19th century, while most of the fertility transition occurred during the first decades of the 20th century (Steckel, 1992; Tolnay, 1996). Consistent with the economic modernization hypothesis recent empirical studies find industrialization (Wanamaker, 2012), better access to education (Aaronson et al. 2014), and health improvements (Bleakley and Lange, 2009) to be important determinants of the southern fertility decline during the late 19th and early 20th centuries. Our findings provide further evidence that economic modernization led to a fertility decline in counties of the American South that relied heavily on cotton production. The lower earnings potential in the agricultural sector contributed to the fertility transition in the American South by accelerating the process of industrialization and increasing the demand for human capital.

It should be noted that the southern fertility pattern also differed by race. While black women have had a higher total fertility rate than whites throughout American history, black birth rates declined sharply after Reconstruction and even faster than those of whites between 1880 and 1930 (Meeker, 1977, Table 1; Haines and Hacker, 2011, Table 3.1; Elman et al., 2015). Explanations for the more rapid black fertility decline range from involuntary restrictions due to race specific health disparities, such as higher incidence of venereal diseases (Farley, 1970; Tolnay, 1989) to more traditional explanations that voluntarily restricted family size due to economic forces such as increased urbanization (Okun, 1958; Meeker, 1977; Engerman, 1977). Our results are not entirely driven by black households, as we show that also white households adjusted fertility in response

[19] Further classical references are Coale and Zelnik (1963), Haines (1978; 1979), Lindert (1978), Tolnay et al. (1982), Wahl (1986), and Steckel (1992). We refer the reader to Haines (2000), Jones and Tertilit (2008), and Bailey and Hershbein (2015) for detailed summaries of the literature on the US fertility transition.

to the lower earnings potential in agriculture, although this effect varies by age.

3 Data

We use micro-level US census data from the Integrated Public Use Microdata Series (IPUMS) to construct the relevant outcome measures for fertility, occupational choices, and school attendance (Ruggles et al., 2015). The data consist of a repeated cross-section of individuals that resided in the Cotton Belt of the American South during the period 1880–1930.[20] We use the following data sets for the empirical analysis: (a) to study fertility, we use a sample of 20-49-year-old married women;[21] (b) to study structural change and occupational choices, we use individuals of working age (16-65); and (c) to analyze school attendance, we use a sample of school-age children that are listed together with their mothers in the Census (i.e., the fertility sample). To overcome some of the drawbacks of a purely cross-sectional analysis, we further use data provided by the IPUMS that link records from the 1880 complete-count database to the 1-percent samples of the 1900, 1910, and 1920 Censuses at various points in the paper.

Our study uses two measures of household income. The first measure combines various sources of agricultural income covering the decades 1880-1930. Farm income is based on county-level measures of farm revenues and expenditure from the United States Censuses of Agriculture (Haines et al., 2015). Wages for farm laborers are retrieved from various public sources and vary by state over time; see the data appendix for details. Unpaid family workers are assumed to receive a constant fraction of the county-specific farm income. We then assign agricultural income to individuals who report an agricultural occupation in a given year. This variable varies across agricultural occupations (farmers, farm laborers (wage workers), and unpaid family workers) by county or state and over time, and is denoted in constant prices.[22] The data appendix provides a detailed description of how this measure is constructed.

The second measure is the occupation-based income score ("OCCSCORE") from the IPUMS. The occupation score is based on median incomes for occupations from a special report of the 1956 Census on occupational characteristics that reflects the relative economic standing of occupations in 1950. The IPUMS then assigned the respective value to any individual with an occupational response ("OCC1950"). As above, the measure is converted to constant prices. The occupation-based income score allows us to capture the variation in individuals' income that arose from the boll weevil infestation of the Cotton Belt, which is the case if the boll weevil induced individuals

[20] The year 1890 is omitted from the analysis since the completed census forms were lost in a fire (Blake, 1996).

[21] We only include married women with spouse present in the sample (the spouse is present for circa 96 percent of the 20-49-year old married women in the Cotton Belt of the American South).

[22] We used `https://www.measuringworth.com/uscompare/` to convert the variable into constant prices. We use 1900 as the reference year.

to change their occupation within the agricultural sector (i.e., a movement along the agricultural ladder), between sectors, or dropping out of the labor force. The main advantage of using the occupation-based income score is that we can distinguish between agricultural and other (manufacturing and service) income. It is important to note that the occupation-based income score only captures variation across occupations, not within occupations. Second, we need to assume that relative incomes of different occupations were constant over time. Despite these limitations, the IPUMS occupation score has been used in the literature as an approximation for income over longer periods of time (e.g., Angrist, 2002; Jones and Tertilt, 2008; Abramitzky et al. 2014).

We then merge the microdata with county-level data on the arrival of the boll weevil and cotton production in 1899. Arrival dates of the boll weevil are based on the USDA boll weevil map reported in Hunter and Coad (1923, p.3). This map shows the spread of the boll weevil from its first appearance in 1892 near Brownsville (TX) until 1922 when the whole Cotton Belt was almost completely infested.[23] County-level data on cotton acreage are from the Census of Agriculture in 1889 (Haines et al., 2015). Descriptive statistics are shown in Appendix Table 1.

4 Reduced Form Evidence

In this section we quantify the reduced form effects that the boll weevil infestation of the southern cotton fields had on fertility. Our econometric model follows a differences-in-differences (DiD) strategy exploiting the fact that the boll weevil arrived in different counties at different times (variation over time) and that the boll weevil had a stronger impact in highly cotton-dependent counties (variation across counties).[24] Under the hypothesis that the boll weevil affects fertility behavior, we would expect to find the largest fertility declines in counties with a high initial intensity of cotton production after the arrival of the boll weevil.

4.1 Estimation Strategy

The reduced form equation is given by

$$Fertility_{ict} = \alpha_c + \alpha_{st} + \beta Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + e_{ict}, \qquad (1)$$

where $Fertility_{ict}$ denotes mother i's number of own children under age 5.[25] Equation (1) further controls for county fixed effects, α_c, state-by-time fixed effects, α_{st}, and a set of individual control variables, X_{ict}. This set includes mother's age fixed effects, indicator variables for race, and

[23] We thank Fabian Lange, Alan Olmstead, and Paul Rhode for sharing their boll weevil data.

[24] Ager et al. (2016) show that highly cotton-dependent counties were the most affected places in the Cotton Belt.

[25] We follow Bleakley and Lange (2009) and rely on "NCHLT5" from IPUMS as our main measure of fertility.

whether the mother lives in a rural area. To account for potential time-varying effects of the latter variables, we also include race-by-rural-by-time fixed effects and all potential interactions among these three variables. The main variable of interest, $Boll\ Weevil\ Intensity_{ct}$, is the interaction between a dummy variable that equals one if county c was infested by the boll weevil at time t and county c's acreage share of cotton planted in 1889.[26] We use data from the pre-infestation year 1889 to ensure that the interaction term is exogenous to fertility changes during the boll weevil infestation period. Observations are weighted to reflect the racial composition in the Cotton Belt of the American South. We compute standard errors that are Huber robust and clustered at the county level.

Since fertility is highly age dependent, we also use an extended specification that allows the effect of the boll weevil on fertility to vary by age. The modified specification is given by

$$Fertility_{ict} = \alpha_c + \alpha_{st} + \sum_{g=1}^{G} \beta_g Age_g \times Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + \epsilon_{ict}. \qquad (2)$$

Our variable of interest, $Boll\ Weevil\ Intensity_{ct}$, is now interacted with a set of dummy variables that capture mother i's age cohort g in Census year t. We differentiate between women aged 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49 years. To capture cohort-specific differences in fertility that are independent of the boll weevil infestation, this specification also includes cohort fixed effects (interacted by county and time). Under the hypothesis that the boll weevil has a negative effect on fertility, we would expect $\beta < 0$ in equation (1). In equation (2), we would expect $\beta_g < 0$ with a larger coefficient in absolute size for mothers in their prime childbearing years.

4.2 Results

Table 1 reports estimates of equations (1) and (2) for our sample of married women in the Cotton Belt of the American South during the 1880-1930 sample period.[27] Column (1) shows that, in line with our hypothesis, the coefficient on $Boll\ Weevil\ Intensity_{ct}$ is negative and highly statistically significant. Quantitatively, the estimate implies that in a county with median cotton dependency, the arrival of the boll weevil led to a reduction of the number of children less than 5 years old by 0.026. This accounts for about 6 percent of the total decline between 1880 and 1930.[28] Columns (2)-(7) report results using estimating equation (2). Column (2) documents that 20-34-year-old

[26]The cotton share is constructed as in Ager et al. (2016, footnote 14). Note, there is no need to include the cotton share in 1889 in the empirical specification, since the direct effect of cotton production in 1889 on fertility is captured by the county fixed effects.

[27]Results of Table 1 remain qualitatively unchanged if no sample weights are applied (available upon request).

[28]The median cotton share in 1889 was 42.4 percent. According to the estimated coefficient in column (1) of Table 1, the weevil's effect on fertility is therefore $0.424 \times 0.0615 = 0.026$. The average number of children below age 5 per household in our sample fell by about 0.44 between 1880 and 1930.

women were the most affected. For example, in the median cotton-dependent county, the arrival of the boll weevil reduced the number of children below age 5 for 25-29-year-old women by about 0.04. The effect for 35-39-year-old women is smaller in absolute terms, but still statistically significant at the 10 percent level. There is no statistically significant effect for women over age 40. This finding is reassuring and serves as a placebo test since we would not expect a systematic fertility adjustment of older women in reaction to the boll weevil's arrival. Our results remain qualitatively unchanged when using a dummy whether the mother has any child below age 5 or the number of own children below age 10 as alternative measures of fertility (available upon request).

Columns (3) and (4) report the estimates by race. The estimates reveal significant fertility differences by age-cohorts. For white women, the most affected cohort was between ages 25 and 39, while for black women it was the 20-29 age cohort. This finding is probably due to the fact that black women married earlier and had children at younger ages (Haines, 1996; Table 2). Columns (5) and (6) report results when equation (2) is estimated separately for households below and above median household income. While we find that the boll weevil reduced fertility in both samples, there are stronger effects for households with above median income. Our results therefore suggest that the effects of the boll weevil on fertility that we find are not driven by credit constrained households.

Since estimating equations (1) and (2) include state-by-time fixed effects, our econometric model accounts for potential confounding factors at the state level, even when they vary over time. For example, changes in state-specific laws, such as regulating child labor and school attendance, which potentially directly affected fertility outcomes, are captured by our econometric model and therefore do not bias our estimates. However, there is still a potential threat from confounding factors that vary over time at the county level, such as variation in county-specific farm gate prices for cotton. We address these concerns in column (7). Since equation (2) estimates the effect of the boll weevil on fertility separately by age cohorts within a county, this specification allows to include county-by-time fixed effects. That is, identification comes from within-county variation across age cohorts only. While older women are not the optimal control group for this specification, the estimates turn out to be similar to column (2) and hence suggest that it is not very likely that county-specific omitted variables are driving our findings.

Another potential concern is that, since we use data from the decennial US Census, we observe women's fertility at a rather low frequency. An alternative way of measuring the impact of the boll weevil on fertility is to construct a flow fertility measure. Since the US Census reports the age of each child in a household, it is straightforward to calculate the birth year of each child.[29] We use this information to construct each mother's fertility history. That is, for every mother in our sample

[29]We constrain the sample to children less than age 15 at the time of the Census since older children are likely to have left the household.

we construct a time-varying indicator variable, which is one if a child was born in a given year, and zero otherwise. We keep only observations where the mother's age when giving birth would have been between 15 and 44. Since we know exactly the year when the boll weevil entered into a Cotton Belt county, we can use this data set to explore the boll weevil's effect on the probability of a woman giving birth in a given year. The estimates using this alternative approach are reported in column (8) of Table 1. The specification controls for birth year fixed effects and mother fixed effects.[30] Hence, identification comes from within mother variation in the probability of giving birth in a given year due to differences in the timing of the arrival of the boll weevil in counties with different cotton intensities. In line with our baseline results, we find that the arrival of the boll weevil yields a highly statistically significant negative effect on the probability of giving birth in counties with a higher initial cotton intensity. Quantitatively, this estimate implies that in a county with median cotton dependency the boll weevil accounted for about 9 percent of the decline in the probability of giving birth between the 1900 and 1930 censuses.[31]

A potential concern is that our results are driven by composition bias. The arrival of the boll weevil might have triggered selective migration of households. Households that migrated as a response to the boll weevil's arrival might on average have been richer and have more children. To address this issue we look at a sample of households from the 1900, 1910, and 1920 Censuses which have been linked to the 1880 Census by the IPUMS (Ruggles et al. 2015). These linked samples allow us to evaluate the effect of migration on fertility. We only consider linked households where a wife of age 20-39 is present in the terminal period. Reassuringly, columns (1) and (2) of Appendix Table 2 show that households that migrated out of a county did not have higher fertility, but that it was actually lower. As an alternative test, in columns (3)-(6) of Appendix Table 2 we replicate the specifications of Table 1 columns (2) and (8) while restricting the sample to mothers who report to reside in their state of birth. Since the estimates are similar to the baseline estimates in Table 1 we can rule out that our findings are driven by inter-state migration. In conclusion, the presented evidence on migration corroborates our baseline results and makes it unlikely that composition bias is of great concern.

To address potential concerns regarding identification, we estimate a placebo specification, where we include the interaction of county c's acreage share of corn planted in 1889 and the boll weevil incidence in equation (1) and (2). Appendix Table 3 shows that our main results are unchanged, while the interaction effect between the boll weevil and the corn share is small and always statistically insignificant. One further concern is that mothers might have adjusted their fertility behavior in anticipation of the boll weevil's arrival. To address this issue, we add a placebo

[30]Note that county-specific effects are captured by the mother fixed effects (in case the mother stayed throughout her fertility history at her place of residence listed in the Census).

[31]The probability of giving birth in a given year in our sample declined from 0.228 in 1886 to 1900 to 0.191 in 1916 to 1930.

intensity measure to estimating equations (1) and (2), assuming that the boll weevil's arrival date in each county occurred three or five years earlier. Appendix Table 4 summarizes the results of this placebo test. Again, our main findings remain unaffected, while the placebo intensity measure is small in magnitude and except once (the last coefficient of column (6) in Appendix Table 4) always statistically insignificant.

5 Structural Change: The Boll Weevil as a Quasi-Experiment

Recent research has documented that the boll weevil had a detrimental effect on the agricultural earnings potential in infested counties (Lange et al., 2009; Ager et al., 2016). In this section we quantify the income losses that agricultural households experienced due to the boll weevil (subsection 5.1) and we document that a substantial amount of households reacted to the reduced earnings prospects by leaving the agricultural sector to start working in manufacturing (subsection 5.2). We think of this as evidence that the boll weevil triggered a structural change in the affected areas.

5.1 The Boll Weevil's Effect on Agricultural Income

We define a household as *agricultural* if the household is listed as residing on a farm or if the household head reports employment in a farm occupation.[32] Based on this sample of about 285,000 agricultural households, we re-estimate equation (1) using measures of agricultural household income as the dependent variable (see Section 3):[33]

$$Income_{ict} = \alpha_c + \alpha_{st} + \beta Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + e_{ict}. \tag{3}$$

Column (1) of Table 2 shows results based on the "OCCSCORE" variable, which is readily available from the IPUMS. We create household income as the sum of the wife's and husband's occupation scores. We find a negative effect of the boll weevil on household income in more cotton-dependent counties, which is statistically significant at the 1-percent level. The estimate implies that households living in a county with median cotton dependency experienced a 2.7 percent decrease in household income upon the boll weevil's arrival. Consistent with the findings of Ager et al. (2016), this effect can be interpreted as some households moving down the agricultural ladder.

[32]Whether a household lives on a farm is indicated in IPUMS by the variable "FARM". We regard the following IPUMS occupation codes (OCC1950) as farm occupations: farm foremen (810), farm laborers, wage workers (820), farm laborers, unpaid family workers (830), farm service laborers, self-employed (840), farmers (owners and tenants) (100), and farm managers (123).

[33]Observations are weighted to reflect the racial composition in the Cotton Belt of the American South.

As discussed in Section 3, one problem with the IPUMS occupation score is that it only captures variation across occupations, not within occupations. Column (2) of Table 2 presents estimates that are based on a more sophisticated measure of agricultural income (see the data appendix for further details). Using this measure of agricultural income, which also captures variation over time, across agricultural occupations, and across counties (for farmers) or states (for farm laborers) reveals that the impact of the boll weevil on agricultural households is quantitatively substantially more important than suggested by the simple occupation-based income score from IPUMS. Quantitatively, the estimates imply that households residing in a county with a median intensity of cotton production experienced a decline of agricultural income by about 18 percent upon arrival of the boll weevil.

5.2 The Boll Weevil's Effect on Industrialization

In this subsection, we document that the boll weevil triggered a shift from agriculture to manufacturing in affected counties. We estimate equation (1) using a set of dummy variables as outcome variables that indicate whether an individual is working either in manufacturing, farming, as a professional, or in the service sector.[34] Our sample consists of all men and women in the working age (16-65 years old) residing in the Cotton Belt of the American South during the 1880-1930 sample period. Observations are weighted to reflect the racial composition in the Cotton Belt of the American South. The estimating equation is

$$occ_{ict} = \alpha_c + \alpha_{st} + \beta Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + e_{ict}. \quad (4)$$

Note that, since this sample consists of both men and women, we now also include controls for gender. Table 3 presents the results. Column (1) shows that individuals in boll weevil infested counties are more likely to be employed in manufacturing. For example, individuals living in a county with a high cotton intensity (at the 75th percentile) are about 1 percentage points more likely to be employed in manufacturing upon the boll weevil's arrival (about 8 percent of individuals are employed in manufacturing; see Appendix Table 1). Column (2) reports a significant decline in agricultural employment consistent with the findings of Ager et al. (2016). Quantitatively, the effect is also relatively strong. In a county with a high intensity of cotton production (at the 75th percentile) the employment share went down by about 2.8 percentage points. Columns (3) and (4) document that there is no significant effect on the likelihood of being employed in a professional occupation or in the service sector.

Columns (5)-(6) complement the micro-level results with county-level evidence revealing that

[34] Based on the variable OCC1950 from the IPUMS, the categories are defined as follows: manufacturing is 500-690, professionals is 0-99 and 200-490, the service sector is 700-790, and farming is 100, 123, and 800-840.

the boll weevil led to a shift from farming to manufacturing. For a county with an initial cotton share at the 75th percentile, the arrival of the boll weevil decreased the ratio of expenditures for agricultural labor over manufacturing labor by approximately 66 percent (see column (5)), while the ratio of persons employed in agriculture over persons employed in manufacturing declined by about 20 percent (see column (6)).[35] Overall, the evidence presented in this section suggests that the boll weevil triggered a shift out of agriculture in highly cotton-dependent counties. The relative increase in manufacturing activities in these counties is also in line with Ager et al. (2016), who find that the number of farms and agricultural land usage declined more strongly in counties with a higher initial cotton intensity after the boll weevil's arrival.

One potential concern is that the results documented above might be driven by a composition effect. That is, the shift to manufacturing might be a consequence of selective migration. Using a set of linked representative samples from the IPUMS, we show in columns (7) and (8) that in infested counties stayer households were more likely to leave the agricultural sector after the boll weevil's arrival. Using households linked from the 1880 full-count sample to the 1910 1 percent sample, we show in column (7) that in a boll weevil infested county, every 10 percent increase in the initial cotton share increases the probability that households moved out of the agricultural sector by 1.4 percentage points. This figure is somewhat lower in column (8) when we add data on households linked from the 1880 to the 1920 sample.

6 Structural Change and the Fertility Transition

In this section we exploit the boll weevil as a quasi-experiment to provide evidence of a causal link between agricultural earnings potential and fertility. We document two separate channels: (i) lower agricultural income reduces fertility of stayer households, consistent with the notion that children are a normal good (Lindo, 2010; Black et al., 2013; Lovenheim and Mumford, 2013), and (ii) switcher households reduce their fertility, potentially because working in manufacturing is less compatible with childbearing. These two channels are in line with the theoretical framework by Mookherjee et al. (2012), who argue that the wage-fertility relation can be positive within broad occupational categories but negative across occupational categories.

[35] Cash expenditure for farm labor is retrieved from the Census of Agriculture at the county level. In 1900, only the sum of cash and board expenditures are available from the Census of Agriculture. We therefore use data from 1910 and 1920 to calculate the ratio of cash vs. board expenditures. Assuming that this ratio is of comparable size in 1900, we then use this ratio to calculate cash expenditures from the sum of cash and board expenditures in 1900. This variable is retrieved from the ICPSR 35206 file (Haines et al., 2015) and is available for the period 1900–1930. Total wage costs in manufacturing vary also only at the county level and are retrieved from the ICPSR 2896 file (Haines, 2010), which is available for all years except 1910.

6.1 Effect of Agricultural Income on Fertility

In this section, we quantify the effect of agricultural income on fertility for households staying in agriculture. We would expect this relationship to be positive within agricultural occupations, since the income effect is likely to dominate the substitution effect when the opportunity costs of child rearing are low. To estimate the causal relationship between agricultural income and fertility our empirical analysis exploits exogenous variation due to the boll weevil infestation in a two-stage least squares approach. The estimating equation is

$$Fertility_{ict} = \alpha_c + \alpha_{st} + \delta Income_{ict} + \Gamma X_{ict} + \epsilon_{ict}. \tag{5}$$

$Fertility_{ict}$ and $Income_{ict}$ are measures of household i's fertility and labor income from agricultural activities. The empirical specification controls for county fixed effects, α_c, state-by-time fixed effects, α_{st}, and a vector of control variables, X_{ict}, that includes a dummy if the household head is a farmer, fixed effects for mother's age, and indicator variables for race and whether the mother lives in a rural area. To account for potential time-varying effects of the latter variables, we also include race-by-rural-by-time fixed effects and all potential interactions among these three variables. Observations are weighted to reflect the racial composition in the Cotton Belt of the American South. We compute standard errors that are Huber robust and clustered at the county level.

The excluded instrument in the two-stage least squares regression is the interaction between the incidence of the boll weevil and the initial intensity of cotton production. The first-stage equation is identical to estimating equation (3):

$$Income_{ict} = \alpha_c + \alpha_{st} + \gamma Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + \epsilon_{ict}, \tag{6}$$

where $Boll\ Weevil\ Intensity_{ct}$ is defined as described in Section 4. Identification in the two-stage least squares estimation comes from the differential effect that the incidence of the boll weevil had on agricultural income and fertility due to differences in the importance of (initial) cotton production in the Cotton Belt counties of the American South. As shown in Table 4, the estimated β is negative and strongly significant. That is, in counties where cotton production is relatively more important, the boll weevil infestation has a larger, negative effect on agricultural income. In terms of instrument quality, the two-stage least squares estimation strategy yields a reasonable first-stage fit, as the Kleibergen-Paap F-statistic always exceeds the critical value of 10 (Stock and Yogo, 2005).

Since the reduced-form results shown in Section 4 reveal that the boll weevil mainly affected the fertility behavior of 20-39-year-old women, we restrict the sample in this subsection to this age group. Table 4 presents the two-stage least squares results. Columns (1)-(3) show the results for age groups 20-39, 20-29, and 30-39. We find the effect to be strongest for younger women but we also document positive and weakly significant effects for the 30-40-year-olds. For 20-39-year-old women, the estimate in column (1) implies that a one-standard-deviation decrease in agriculture income reduces the number of children below age 5 by about 0.12; this effect is substantial, considering that the the total decline of the number of children below age 5 between 1880 and 1930 was about 0.44. Columns (4)-(9) show the results by race. Similar to the reduced form results of Section 4, the effects differ by cohorts and race. For white women, the cohort of 30-39-year-olds are the most affected, while for black women it is the cohort of 20-29-year-olds.

A potential threat to identification is that the boll weevil might have affected the fertility behavior of agricultural households through other channels than current income. For example, mothers might have adjusted their fertility behavior in anticipation of the boll weevil's arrival due to expected income losses in the agricultural sector. To address this issue, we repeat the specifications of Appendix Table 4 using only the sample of agricultural households. Analogous to the unrestricted sample, the effects of the placebo intensity measure are small in magnitude and statistically not different from zero (available upon request).

One further possible scenario would be that the boll weevil increased child mortality due to poorer nutrition or even starvation, although recent evidence from Clay et al. (2016) suggests that this was not the case. We explore the effect of the boll weevil infestation on child mortality using information from the 1900 and 1910 Censuses on the number of children ever born and the number of surviving children.[36] Columns (1)-(2) of Appendix Table 5 replicate estimating equations (1) and (2), but using the survival ratio (fraction of surviving children over children ever born) as the dependent variable. The reduced-form effects of the boll weevil infestation on child survival are not statistically different from zero, except in column (2) for women aged 20-24 (where it is positive). We further construct a yearly county-level panel over the period 1921-1929 using data on child mortality and stillbirths provided by Fishback et al. (2007). Column (3) shows that the reduced-form effect of the boll weevil infestation on child mortality per capita is not significantly different from zero.[37] There is even a negative effect on the number of stillbirths per births in column (4), which, however, turns insignificant when we use the log number of stillbirths per births as the dependent variable instead (available upon request).

One further concern is whether the boll weevil's arrival impaired fecundity, for example, due to greater maternal stress. Since the Censuses in 1900 and 1910 list the number of children ever born, we can construct a dummy for being childless for married women aged 20-49 in the sample to

[36] We refer the reader to the IPUMS variable descriptions of "CHBORN" and "CHSURV" for further details.

[37] This effect remains insignificant when we use the log number of child mortality per capita as the dependent variable (available upon request).

proxy for impaired fecundity.[38] The insignificant estimates in columns (4)-(5) suggest that this was not the case. Overall, the results of Appendix Table 5 support the view that households staying in agriculture decided to have less offspring because of lower income and that this effect is not just a result of increased child mortality or impaired fecundity. Moreover, even though we only consider married mothers in our analysis, it could well be that in infested counties mothers have fewer children because they married at a later age (Bloome et al., 2017). To address this concern, we include duration of marriage as an additional control to estimating equation (1). Reassuringly, our results indicate that the fertility behavior of married women in our sample is not driven by delayed marriage in boll weevil infested counties (available upon request).[39]

One further threat to identification is that our results might be driven by differential fertility dynamics in counties were plantation farming was considered to be important. Large-scale plantation favored family formation and provided strong intensives for child bearing since farm allotments were determined by family size (Elman et al., 2015). In Appendix Table 6, we show that mothers' fertility behavior in plantation counties, as defined by Brannen (1924, p.69), did not respond differentially after the boll weevil's arrival. Since these counties were also characterized by relatively high (land) inequality, this finding can also be regarded as suggestive evidence that inequality is not a main driver of the impact of the boll weevil infestation on fertility.

6.2 Effect of Employment in Manufacturing on Fertility

In this section, we show that non-agricultural households have lower fertility than agricultural households, potentially because working in manufacturing is less compatible with raising children. For example, according to the 1910 Census among married 20-49-year-old women residing in the Cotton Belt, women in agricultural and non-agricultural households reported to have 1.07 and 0.78 children below the age of 5, respectively. One concern with these descriptive statistics is that they may be biased by a composition effect. For example, households with a stronger preference for offspring might also be more likely to work in the agricultural sector, independent of whether raising children is relatively less costly for agricultural households.

In order to address this issue, we show complementary evidence based on a sample of households from the 1900, 1910, and 1920 Censuses, which have been linked to the 1880 Census by the IPUMS. Using this linked sample allows us to compare the fertility of switcher households to that of households remaining in the agricultural sector throughout the period.[40] Since we restrict our

[38]In the American South at that time it was not common for married women to voluntarily delay the first marital birth; see, for example, Elman et al. (2015).

[39]The duration of marriage is constructed using the IPUMS variables "DURMARR" (available for the Census years 1900 and 1910) and "AGEMARR" (available for the Census year 1930).

[40]As shown in Section 5.1, the arrival of the boll weevil decreased agricultural income and therefore led to a decrease of fertility by an income effect. In order to obtain unbiased estimates, we therefore exclude from the sample

sample to households that were initially (in 1880) in the agricultural sector, this alleviates concerns regarding the importance of selection on our estimates.

Columns (1) and (2) of Table 5 report results for households which can be linked from the 1880 Census to the 1900, 1910, and 1920 Censuses, respectively. The dependent variable is the number of children below age 5 in the household in the terminal year. For both subsamples, we find that switcher households report to have substantially less fertility. The effect is quantitatively important: switcher households report to have around 0.25 fewer children below age 5 than stayer households.

In columns (3)-(6) we show that switching to manufacturing also went along with a substantial increase in income. In columns (3) and (4), the dependent variable is the income difference of the household head between 1880 and 1910 (column (3)) and 1880-1920 (column (4)) based on the "occscore" variable. According to both subsamples, switching to manufacturing increases income by over 40 percent. We obtain very similar results when instead of income of the household head total household income is used in columns (5) and (6). The results in this and the previous section are therefore consistent with the theoretical framework by Mookherjee et al. (2012), which indicates a positive wage-fertility correlation *within* broad occupations or human capital categories, but a negative correlation between parental wages and fertility *across* occupations.[41]

7 Human Capital Formation as a Reinforcing Mechanism

This section documents that the lower earnings opportunities in agriculture that households in the Cotton Belt experienced during the late 19th and early 20th centuries increased the demand for human capital.[42] We argue, in line with existing theory (e.g., Galor, 2005), that the rise of school enrollment rates in the infested counties reinforced the fertility decline in the American South during the period 1880-1930. Our sample consists of 5-15-year-old children who can be matched to their mothers.[43] The estimating equation is

$$Schooling_{ict} = \alpha_c + \alpha_{st} + \beta Boll\ Weevil\ Intensity_{ct} + \Gamma X_{ict} + e_{ict}. \tag{7}$$

households that stayed in agriculture and lived in a county where the boll weevil was present in the terminal year (1900, 1910, or 1920).

[41]Their argument is based on the scenario that there is upward mobility if households switch occupations; we find support for this in our data.

[42]Note that our evidence suggests that the increase in school enrollment rates was a direct consequence of lower earnings opportunities in agriculture. The exclusion restriction that is implicitly assumed when estimating equation (5) in Section 6.1 is therefore not violated.

[43]The variables "MOMLOC", "SERIAL", and "YEAR" from IPUMS are used to link children to their mothers. We only link children if their mother is married and between 20-49-year-old which corresponds to the age cohort of mothers in our fertility sample.

We include county fixed effects, state-by-time fixed effects, and a vector of individual controls that includes indicator variables for race, rural residence, gender, and age fixed effects. As in the previous sections, we also include race-by-rural-by-time fixed effects and all potential interactions among these three variables. We further account for potential differences in parental education levels by including dummies for father's and mother's literacy. Observations are weighted to reflect the racial composition in the Cotton Belt of the American South. We compute standard errors that are Huber robust and clustered at the county level.

Table 6 presents the results for school attendance of 5-15-year-old children. The dependent variable is a dummy that equals one if a child attended school which is based on the IPUMS variable "SCHOOL".[44] Column (1) documents a statistically significant increase of school enrollment for 5-15-year-old children. This finding is in line with relatively low-skilled agricultural work becoming less profitable after the boll weevil's arrival. For a county at the 75th percentile (ranked according to cotton dependency), the boll weevil infestation led to an increase in school attendance of 1.7 percentage points. Considering that the average school enrollment rate for this age group was about 50 percent (see Appendix Table 1), this effect is quantitatively important. Columns (2) and (3) present results by race. For white children there is a statistically significant increase of school attendance, while for black children the effect is quantitatively similar but statistically not distinguishable from zero.

Two distinct mechanisms are compatible with our findings and both reinforce the channels described in Sections 6.1 and 6.2. According to the first mechanism, the boll weevil decreased the earnings opportunities in the agricultural sector relative to manufacturing. Since manufacturing work is usually more skill-intensive, the boll weevil infestation increased the returns to education, which would result in fewer children working and a higher demand for schooling.[45] Our findings are also compatible with a second mechanism as a result of which the boll weevil increased the direct cost of having children via reducing the returns to child labor. The result would be lower fertility rates and higher levels of human capital due to lower opportunity costs of schooling. If the first mechanism is at play parents face a Q-Q trade-off, while the second mechanism works through reduced household income.

The remaining part of Table 6 differentiates between younger and older school-age children in order to provide more insights on whether a Q-Q trade-off or a decline in the value of child labor account for the documented rise in school enrollment rates. Columns (4)-(6) report the results for the sample of 5-9-year-old children. Overall, we find a positive but statistically insignificant effect

[44]The Census asked whether the child was enrolled in school during a specified period. For 1880 and 1900 this period refers to within the past year, while for 1910-1930 it refers to the time since September 1st before the enumeration day. We refer to the IPUMS variable description for further details.

[45]Empirical support for the existence of a Q-Q trade-off in the American South has been provided by Bleakley and Lange (2009) and Aaronson et al. (2014).

for the younger cohort. However, columns (5) and (6) reveal that this result masks substantial differences by race. For white young children, there is a positive and statistically significant increase of school attendance, while for black children of the same age the effect is literally zero. The sample of 10-15-year-old children displays a different pattern. Columns (7)-(9) document that black children account for the significant increase of school enrollment rates for this older cohort.[46]

Our age and race-specific results of Table 6 indicate that both the Q-Q mechanism and the child labor mechanism are at play. Since sending children at relatively early ages to school can be regarded as a commitment of parents to invest in child quality, we interpret the higher school enrollment rates of 5-9-year-old white children to be consistent with the Q-Q model. For the older cohort, there is little evidence that the Q-Q mechanism was central in explaining the increase of school enrollment rates after the boll weevil's arrival. This becomes evident when we examine whether a decrease in child labor accounts for the rise in school enrollment rates after cotton cultivation became less profitable. Based on historical accounts, children and women had a comparative advantage within the agricultural sector in connection with crops that required extensive cultivation, such as cotton and tobacco (Metzer, 1975; Goldin and Sokoloff, 1984), and it would be reasonable to assume that the boll weevil infestation led to a stronger decline in the returns to child labor in more cotton dependent counties. The Census reported the occupation for every person of age 10 and older. This information allows us to construct a proxy for child labor based on whether a child aged 10-15 is in the labor force.[47] The results of Table 7 reveal that the lower earnings opportunities in agriculture had a negative effect on child labor in highly cotton dependent counties. Consistent with our previous findings in columns (7)-(9) of Table 6, this effect is mainly driven by black children. These findings are compatible with the interpretation that the boll weevil infestation decreased the returns to child labor in the agricultural sector, especially for black households. The lower earnings opportunities in agriculture decreased the opportunity cost of sending children to school and reinforced the demand for human capital in the American South during our sample period (Galor, 2005).

Table 8 provides additional county-level evidence that the boll weevil increased the demand for schooling in the Cotton Belt. One prominent education program at that time was the Rosenwald Rural Schools Initiative (Aaronson and Mazumder, 2011; Carruthers and Wanamaker, 2013; Aaronson et al., 2014). The objective of this program was to narrow the racial education gap that existed in the American South at that time, especially in rural areas.[48] Between 1914 and 1931 the

[46]While we find a positive effect on school enrollment for black children, as in Baker (2015), there is also a statistically significant increase of white children's school attendance in cotton dependent counties in our sample.

[47]In the 1880 and 1900 Censuses occupations were reported for persons age 10 and above, while for 1920 and 1930 occupation were reported for all persons; see IPUMS variable description for "OCC1950".

[48]The racial gap in school attendance in the American South at the beginning of the 20th century was substantial and is largely explained by differences in school characteristics and the lower economic status and education levels of black parents (Orazem, 1987; Margo 1987, 1990; Fishback and Baskin, 1991). Moehling (2004) shows that racial

Rosenwald Program constructed about 5,000 new schools throughout the rural American South targeted to the black rural population. Since the roll-out of the Rosenwald schools started during the 1910s, we include only Cotton Belt counties that were infested by the boll weevil after 1910. Consequently, the sample spans the period 1910-1930.[49] All specifications control for county fixed effects, state-by-time fixed effects, and the black population share. The results of Table 8 document that the boll weevil infestation had a substantial impact on where schools were constructed during the 1910-1930 period. Columns (1) and (2) reveal that for infested counties, a 10 percentage point higher initial cotton share implies the construction of about one more school and having about 2.7 more teachers. Columns (3) and (4) show that, for a county at the 75th percentile, in terms of cotton-dependency, the number of schools and teachers per 1,000 inhabitants increased by 0.12 and 0.28 after the boll weevil's arrival.

Since the Rosenwald schools targeted the rural black population and we found that the increase in black school enrollment rates was related to the decline in the value of child labor in the boll weevil infested counties, we split the sample into counties with an initial (1910) child labor share above and below the median.[50] Columns (5) and (6) present the results for the sample of counties with a share of child labor above the median. Heavily cotton-dependent counties had a significantly higher number of Rosenwald schools and teachers per 1,000 inhabitants after the boll weevil infestation. Columns (7)-(8) present the results for the sample of counties with a share of child labor below the median. The estimated coefficient of the main variable of interest, $Boll\ Weevil\ Intensity_{ct}$, is about half the size, but still statistically significant. This result suggests that the construction of Rosenwald schools in more cotton-dependent counties was at least partially driven by the boll weevil induced decline in the value of child labor during the sample period.[51] Since the decline in the value of child labor can be considered as part of the lower earnings opportunities in the agriculture sector this evidence is in line with our finding that agricultural households reduced fertility because of lower earnings opportunities after the arrival of the boll weevil as described in Section 6.1.

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differences in the southern family structure also matter for the racial education gap but to a lesser extent than school quality and parental characteristics.

[49] Note, that there are no county-level population data available for the year 1925. These are imputed using the mean of the total population from the 1920 and 1930 Censuses.

[50] The child labor share is calculated as the fraction of 10-15-year-old children who report an occupation in the 1910 Census.

[51] This finding is even more pronounced when we restrict the sample only to counties of the state of Alabama, where the roll-out of the Rosenwald schools was initiated. For this case, we find a positive and statistically significant effect of the number of schools and teachers per 1,000 in the sample of counties with an initial child labor share above the median, while the effect turns out to be insignificant and close to zero in the below median sample (available upon request).

8 Conclusion

A prominent hypothesis in growth and economic development is that modernization contributed to the historical fertility decline of today's modern societies (Galor, 2012). Yet, empirical evidence providing plausible exogenous variation to identify this relation remains relatively scarce. One challenge in identifying the causal effect of economic modernization on fertility is omitted variables and reverse causality. The present paper fills this gap in the literature by using credibly exogenous variation in agricultural earnings opportunities to estimate the causal link between structural change and the fertility transition.

We show that the lower earnings opportunities in agriculture decreased fertility of both households staying in agriculture (stayers) and households switching to the manufacturing sector (switchers). We argue, in line with the notion that children are a normal good, that stayer households reduced fertility as they experienced income losses, while switcher households reduced fertility because manufacturing work is generally less compatible with raising children. These findings imply, in line with theoretical work by Mookherjee et al. (2012), that there are more complex mechanisms behind the negative correlation between fertility and parental income as documented in many emprical studies (e.g., Jones and Tertilt, 2008).

We also find that human capital formation played an important role in reinforcing the fertility decline. The lower earnings opportunities in agriculture triggered the demand for schooling in the American South during the sample period. We argue that the increase in school enrollment rates after the boll weevil infestation can be explained by two complementary mechanisms: child labor became less productive, implying a direct increase in the cost of raising children, which led to fewer offspring and lowered the costs of sending children to school, and the relatively skill-intensive manufacturing sector became more important, which changed the Q-Q trade-off faced by parents towards child quality. Both mechanisms reinforced the fertility decline and therefore complement the channels we have described above.

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Table 1: The Impact of the Boll Weevil Infestation on Fertility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent Variable:							
	Number of Children Below Age 5							== 1 if Birth
Boll Weevil Intensity	-0.0615***							-0.00804**
	(0.0200)							(0.00324)
Age 20-24 x Boll Weevil Intensity		-0.0815***	0.00212	-0.0940**	-0.0928**	-0.0955***	-0.0725**	
		(0.0277)	(0.0367)	(0.0415)	(0.0423)	(0.0332)	(0.0333)	
Age 25-29 x Boll Weevil Intensity		-0.100***	-0.0948**	-0.117**	-0.114**	-0.111***	-0.0860***	
		(0.0298)	(0.0402)	(0.0473)	(0.0450)	(0.0373)	(0.0329)	
Age 30-34 x Boll Weevil Intensity		-0.0901**	-0.158***	-0.0501	-0.0643	-0.123***	-0.0757**	
		(0.0369)	(0.0511)	(0.0467)	(0.0525)	(0.0427)	(0.0353)	
Age 35-39 x Boll Weevil Intensity		-0.0523*	-0.118***	-0.00421	-0.0433	-0.0820**	-0.0406	
		(0.0314)	(0.0422)	(0.0442)	(0.0502)	(0.0347)	(0.0340)	
Age 40-44 x Boll Weevil Intensity		-0.00977	-0.0292	0.0547	0.0417	-0.0528	0.00778	
		(0.0314)	(0.0400)	(0.0439)	(0.0482)	(0.0363)	(0.0356)	
Age 45-49 x Boll Weevil Intensity		-0.0132	0.0428	0.0193	0.0387	-0.0510		
		(0.0241)	(0.0277)	(0.0403)	(0.0346)	(0.0330)		
Sample	All	All	White	Black	Below Median HH Income	Above Median HH Income	All	All
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Mother FE	No	No	No	No	No	No	No	Yes
Year of Birth FE	No	No	No	No	No	No	No	Yes
Observations	556,034	556,034	324,142	231,892	277,785	271,033	556,034	4,014,811
R-squared	0.165	0.175	0.207	0.151	0.163	0.174	0.182	0.084

The dependent variable is the number of own children under age 5 in columns (1)-(7) and an indicator variable that equals one if a mother gave birth in a given year t in column (8). For columns (1)-(7) the sample consists of married women of age 20 to 49 over the decades 1880 to 1930. In column (8) the sample consists of married mothers of age 15 to 44 at time of birth for the Census years 1900 to 1930. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. Column (1) controls for race, rural, age fixed effects, and interactions between race, rural, and time fixed effects. Columns (2) and (7) further include cohort x time fixed effects and cohort x county fixed effects. In columns (3)-(4) the sample is split by race (race dummies and its interactions are dropped). In columns (5)-(6) the sample is split by median household income. Column (7) adds county x time fixed effects. The specifications in columns (1)-(7) all include county fixed effects, time fixed effects, and state x time fixed effects. Column (8) includes mother fixed effects and year of birth fixed effects. See Sections 4.1 and 4.2 for more details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 2: The Boll Weevil's Effect on Agricultural Income

	(1)	(2)
	Dependent Variable: Agricultural Income	
Boll Weevil Intensity	-0.0647***	-0.443***
	(0.0125)	(0.0516)
County FE	Yes	Yes
Time FE	Yes	Yes
State x Time FE	Yes	Yes
Observations	286,921	285,750
R-squared	0.211	0.688

The dependent variable is income of agricultural households. Column (1) uses the occupation score as a measure of income; column (2) uses a measure of income based on official sources (see Data Appendix for further details). The sample consists of married women of age 20 to 49 in agricultural households for the decades 1880 to 1930. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. The specifications include controls for race, rural, age fixed effects, county fixed effects, time fixed effects, and state x time fixed effects, interactions between race, rural, and time fixed effects, and a dummy whether the household head was a farmer. See Section 5.1. for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 3: The Boll Weevil's Impact on Industrialization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent Variable							
	Works in Manufacturing	Works in Agriculture	Works as Professional	Works in Service Sector	Agricultural Ratio (Wages)	Agricultural Ratio (Workers)	Leaves Farm 1880-1910	Leaves Farm 1880-1920
Boll Weevil Intensity	0.0176**	-0.0523***	-0.00376	-0.00630	-1.155***	-0.378***	0.137***	0.0574*
	(0.00699)	(0.0171)	(0.00926)	(0.00587)	(0.250)	(0.134)	(0.0395)	(0.0331)
Sample	Individual Level	Individual Level	Individual Level	Individual Level	County Level	County Level	Linked Sample	Linked Sample
County FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	No	No	No	No
Observations	2,265,188	2,265,188	2,265,188	2,265,188	1,863	3,233	4,753	6,140
R-squared	0.105	0.381	0.102	0.083	0.822	0.783	0.031	0.029

In columns (1)-(4), the dependent variable is a dummy variable that indicates whether a person works in manufacturing (column 1), agriculture (column 2), as a professional (column 3), or in the service sector (column 4). In columns (5)-(6), the dependent variable is the log ratio of wages and employment in agriculture over manufacturing. In columns (7)-(8), the dependent variable is an indicator variable that is one if an individual left agriculture. The sample consists of individuals of working age (16 to 65) for the decades 1880 to 1930 in columns (1)-(4), county level data (1880-1930) in columns (5)-(6), and a linked sample of male household heads in columns (7)-(8). *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. In columns (1)-(4), the set of individual controls includes dummies for gender, race, and age fixed effects, and interactions between race and time fixed effects. The specifications further include county fixed effects, time fixed effects, and state x time fixed effects. The county level regressions in columns (5)-(6) include city and year fixed effects. The linked sample includes a dummy for race, a quadric of age, the cotton share in 1889, time fixed effects, and state fixed effects. See Section 5.2 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 4: The Impact of Agricultural Income on Fertility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent Variable: Number of Children Below Age 5								
	Farm Households			*White Farm Households*			*Black Farm Households*		
Agricultural Income	0.190***	0.226***	0.163*	0.173	0.0797	0.325*	0.221**	0.393***	0.0391
	(0.0714)	(0.0816)	(0.0970)	(0.112)	(0.115)	(0.182)	(0.0861)	(0.124)	(0.102)
Sample	Age 20-39	Age 20-29	Age 30-39	Age 20-39	Age 20-29	Age 30-39	Age 20-39	Age 20-29	Age 30-39
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	285,750	163,078	122,672	143,824	78,966	64,858	141,926	84,112	57,814
F Statistic	73.73	73.96	66.89	33.63	35.97	27.67	79.51	74.12	72.07

The dependent variable is the number of own children under age 5. The sample consists of married women of age 20 to 39 in agricultural households over the decades 1880 to 1930. The variable of interest, Agricultural Income, is based on official sources (see Data Appendix for further details). The method of estimation is two-stage least squares. The instrumental variable, *Boll Weevil Intensity*, is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. The set of individual controls includes dummies for race, rural, an indicator that is one if the household head is a farmer, age fixed effects, and interactions between race, rural, and time fixed effects. No race dummy and its interactions are included in columns (4)-(9). The specifications further include county fixed effects, time fixed effects, and state x time fixed effects. The F Statistic refers to the Kleibergen-Paap rk F Statistic. See Section 6.1 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Changes in Income and Fertility of Switcher Households

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable					
	Number of Children Below Age 5		*Income Differences (Household Head)*		*Income Differences (Household)*	
Leaves Farm	-0.235***	-0.251***	0.452***	0.447***	0.472***	0.466***
	(0.0424)	(0.0399)	(0.0327)	(0.0330)	(0.0323)	(0.0327)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,054	2,346	1,074	1,113	1,074	1,113
R-squared	0.090	0.116	0.306	0.309	0.303	0.304

In columns (1)-(2), the dependent variable is the number of own children under age 5. In columns (3)-(6), the dependent variable is the change in income of the household head (columns 3-4) and the household (columns 5-6). We use a linked sample of male household heads. In columns (1)-(2) we restrict the sample to men with a spouse of age 20-49 in the terminal year; in columns (3)-(6) we restrict the sample to men of age 20 or older in 1880 and not older than 65 in the terminal year. *Leaves Farm* is an indicator variable whether the individual left the agricultural sector during the sample period. Further control variables are a dummy for race, age and age squared, the cotton share in 1889, time fixed effects, and state fixed effects. See Section 6.2 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 6: The Impact of the Boll Weevil on Schooling

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent Variable: School Attendance								
		Age 5-15			*Age 5-9*			*Age 10-15*	
Boll Weevil Intensity	0.0320**	0.0342**	0.0307	0.0231	0.0386**	-0.00465	0.0433**	0.0304	0.0704**
	(0.0135)	(0.0145)	(0.0212)	(0.0148)	(0.0153)	(0.0213)	(0.0194)	(0.0219)	(0.0285)
Sample	All	White	Black	All	White	Black	All	White	Black
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	832,731	484,225	348,506	449,465	260,664	188,801	383,266	223,561	159,705
R-squared	0.361	0.360	0.336	0.356	0.361	0.329	0.253	0.206	0.262

The dependent variable is an indicator variable that is one if a child of school age attended school in a given Census year. The sample consists of children of age 5-15 for the decades 1880 to 1930 in columns (1)-(3), of age 5-9 in columns (4)-(6), and of age 10-15 in columns (7)-(9). *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. Columns (1), (3), and (7) include the following set of individual controls: dummies for gender, race, rural, parents' literacy, age fixed effects, and interactions between race, rural and time fixed effects. In columns (2), (3), (5), (6), (8), and (9) the sample is split by race (race dummies and its interactions are dropped). All specifications include county fixed effects, time fixed effects, and state x time fixed effects. See Section 7 for more details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 7: The Impact of the Boll Weevil on Child Labor

	(1)	(2)	(3)
	Dependent Variable: ==1 if child works		
	All	White	Black
Boll Weevil Intensity	-0.0547***	-0.0126	-0.0970***
	(0.0163)	(0.0161)	(0.0282)
County FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes
Observations	383,615	223,769	159,846
R-squared	0.251	0.210	0.236

The dependent variable is an indicator variable that is one if a child of age 10-15 reported an occupation in a given Census year. The sample consists of children of age 10 to 15 for the decades 1880 to 1930. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. Column (1) includes the following set of individual controls: dummies for gender, race, rural, parents' literacy, age fixed effects, and interactions between race, rural and time fixed effects. In columns (2)-(3) the sample is split by race (race dummies and its interactions are dropped). All specifications include county fixed effects, time fixed effects, and state x time fixed effects. See Section 7 for more details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 8: The Boll Weevil's Impact on the Rosenwald School Program

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent Variable							
	Number of Schools	Number of Teachers	Schools per capita	Teachers per capita	Schools per capita	Teachers per capita	Schools per capita	Teachers per capita
Boll Weevil Intensity	10.19***	27.15***	0.212***	0.514***	0.255***	0.636***	0.116**	0.296**
	(2.127)	(6.354)	(0.0440)	(0.103)	(0.0633)	(0.153)	(0.0558)	(0.142)
Sample	All	All	All	All	Above Median Child Labor Share in 1910		Below Median Child Labor Share in 1910	
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Black Share	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,700	1,700	1,700	1,700	900	900	800	800
R-squared	0.742	0.730	0.785	0.774	0.802	0.782	0.775	0.777

The dependent variable is the number of Rosenwald schools (column 1) and teachers (column 2), columns (3)-(8) show results in per capita terms. The sample spans counties for the decades 1900 to 1930. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. All specifications include county fixed effects, time fixed effects, state x time fixed effects, and the share of blacks in county c at time t. Columns (5)-(8) split the sample by the median share of child labor in 1910. See Section 7 for more details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Supplementary Appendix

to

Structural Change and the Fertility Transition in the American South

Philipp Ager Markus Brueckner Benedikt Herz*

*Corresponding authors: Philipp Ager, University of Southern Denmark; phag@sam.sdu.dk and Benedikt Herz, European Commission, 1049 Brussels, Belgium; benedikt.herz@gmail.com.

Appendix Table 1: Descriptive Statistics

Sample of 20-49 year old married women	(1) N	(2) mean	(3) sd	(4) min	(5) max
Own children under age 5 in household	556,034	0.848	0.941	0	7
Age	556,034	32.26	8.170	20	49
White	556,034	0.640	0.480	0	1
Black	556,034	0.360	0.480	0	1
Household Income (based on occscore)	556,034	678.1	403.6	0	5,440
Agricultural Income	375,472	545.3	419.3	-1,352	20,484
Cohort Age 20-24	556,034	0.213	0.409	0	1
Cohort Age 25-29	556,034	0.215	0.411	0	1
Cohort Age 30-34	556,034	0.179	0.383	0	1
Cohort Age 35-39	556,034	0.163	0.370	0	1
Cohort Age 40-44	556,034	0.127	0.333	0	1
Cohort Age 45-49	556,034	0.103	0.304	0	1

Individuals of working age (16-65)	(1) N	(2) mean	(3) sd	(4) min	(5) max
Works in Agriculture	2,332,787	0.364	0.481	0	1
Works in Manufacturing	2,332,787	0.0773	0.267	0	1
Works as Professional	2,332,787	0.0792	0.270	0	1
Works in Service Sector	2,332,787	0.0521	0.222	0	1

Sample of school-age children	(1) N	(2) mean	(3) sd	(4) min	(5) max
Child works	383,615	0.260	0.439	0	1
Child works (white)	223,769	0.184	0.387	0	1
Child works (black)	159,846	0.397	0.489	0	1
Age 5-15	832,731	0.530	0.499	0	1
Age 5-15 (white)	484,225	0.588	0.492	0	1
Age 5-15 (black)	348,506	0.423	0.494	0	1
Age 5-9	449,465	0.392	0.488	0	1
Age 5-9 (white)	260,664	0.442	0.497	0	1
Age 5-9 (black)	188,801	0.300	0.458	0	1
Age 10-15	383,266	0.690	0.463	0	1
Age 10-15 (white)	223,561	0.759	0.428	0	1
Age 10-15 (black)	159,705	0.564	0.496	0	1

IPUMS Linked Sample (Household Heads)	(1) N	(2) mean	(3) sd	(4) min	(5) max
Leaves Farm (from 1880 to 1900/1910)	4,753	0.185	0.388	0	1
Leaves Farm (from 1880 to 1900/1910/1920)	6,140	0.199	0.399	0	1

County-Level Variables	(1) N	(2) mean	(3) sd	(4) min	(5) max
Boll Weevil Incidence x Cotton Share 1889	3,572	0.189	0.247	0	0.854
Cotton Share 1889	3,572	0.383	0.212	0	0.854
Boll Weevil Incidence	3,572	0.468	0.499	0	1
Corn Share 1889	3,572	0.429	0.140	0.0224	0.981
Ln(Agr. Wage/Manufacturing Wage)	1,863	-0.609	1.742	-6.769	4.997
Ln(Agr. Workers/Manufacturing Workers)	3,233	2.687	1.488	-3.707	6.995

Mother Panel	(1) N	(2) mean	(3) sd	(4) min	(5) max
Birth	4,014,811	0.201	0.400	0	1

Appendix Table 2: Robustness to Migration

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Number of Children below Age 5				*== 1 if Birth*
	1880-1910	1880-1920	Lives in State of Birth		
== 1 Migrant Out of County	-0.113***	-0.112***			
	(0.0365)	(0.0335)			
Age 20-24 x Boll Weevil Intensity			-0.114***	-0.0795**	
			(0.0300)	(0.0321)	
Age 25-29 x Boll Weevil Intensity			-0.0974***	-0.0669**	
			(0.0304)	(0.0323)	
Age 30-34 x Boll Weevil Intensity			-0.0590*	-0.0295	
			(0.0352)	(0.0379)	
Age 35-39 x Boll Weevil Intensity			-0.0549*	-0.0316	
			(0.0320)	(0.0344)	
Age 40-44 x Boll Weevil Intensity			-0.00927	0.0133	
			(0.0355)	(0.0379)	
Age 45-49 x Boll Weevil Intensity			-0.0382	-0.0177	
			(0.0271)	(0.0311)	
Boll Weevil Intensity					-0.00781**
					(0.00364)
Sample	Linked	Linked	All	All	All
County FE			Yes	Yes	No
Time FE			Yes	Yes	No
State x Time FE			No	Yes	No
Mother FE			No	No	Yes
Year of Birth FE			No	No	Yes
Observations	2,626	3,120	407,794	407,794	3,052,974
R-squared	0.027	0.047	0.168	0.169	0.085

The dependent variable is the number of own children under age 5 in columns (1)-(4) and an indicator variable that equals one if a mother gave birth in a given year t in column (8). In columns (1)-(2) the sample consists of linked men with a spouse of age 20-39 in the terminal Census year. The variable of interest in columns (1)-(2) is an indicator variable whether the indiviudal moved out of the county between 1880 and the terminal Census year. Further control variables are a dummy for race, a quadratic in age, the cotton share in 1889, time fixed effects, and state fixed effects. In columns (3)-(5), we restrict the sample to women who report to reside in their state of birth. Columns (3)-(4) replicate the result of Table 1 column (2) with and without state x time fixed effects. Column (5) replicates the result of Table 1 column (8). For columns (3)-(4) we use the same set of controls as in Table 1 column (2) and for column (5) we use the same set of controls as in Table 1 column (8); see Table 1 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 3: Placebo Boll Weevil Intensity

	(1)	(2)	(3)	(4)
	Dependent Variable			
	Number of Children below Age 5			
Boll Weevil Intensity (Cotton)		-0.0616***		
		(0.0200)		
Boll Weevil Intensity (Corn)	0.0172	0.0178		
	(0.0337)	(0.0329)		
Age 20-24 x Boll Weevil Intensity (Cotton)				-0.0836***
				(0.0283)
Age 25-29 x Boll Weevil Intensity (Cotton)				-0.104***
				(0.0300)
Age 30-34 x Boll Weevil Intensity (Cotton)				-0.0909**
				(0.0376)
Age 35-39 x Boll Weevil Intensity (Cotton)				-0.0461
				(0.0316)
Age 40-44 x Boll Weevil Intensity (Cotton)				-0.0108
				(0.0312)
Age 45-49 x Boll Weevil Intensity (Cotton)				-0.0106
				(0.0241)
Age 20-24 x Boll Weevil Intensity (Corn)			0.0322	0.0369
			(0.0416)	(0.0411)
Age 25-29 x Boll Weevil Intensity (Corn)			0.0357	0.0463
			(0.0428)	(0.0417)
Age 30-34 x Boll Weevil Intensity (Corn)			0.0210	0.0270
			(0.0541)	(0.0551)
Age 35-39 x Boll Weevil Intensity (Corn)			-0.0198	-0.0242
			(0.0448)	(0.0445)
Age 40-44 x Boll Weevil Intensity (Corn)			0.0419	0.0307
			(0.0440)	(0.0439)
Age 45-49 x Boll Weevil Intensity (Corn)			0.0121	0.00120
			(0.0327)	(0.0327)
Sample	All	All	All	All
County FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes
Observations	556,034	556,034	556,034	556,034
R-squared	0.165	0.165	0.175	0.175
County FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

The dependent variable is the number of own children under age 5. The sample spans married women of age 20 to 49 for the decades 1880 to 1930. Boll Weevil Intensity (Corn) is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of corn planted in 1889. *Boll Weevil Intensity (Cotton)* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. We refer to the specifications of Table 1 columns (1)-(4) for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 4: Placebo Boll Weevil Arrival before Actual Infestation

	(1)	(2)	(3)	(4)	(5)	(6)
			Dependent Variable			
			Number of Children below Age 5			
Boll Weevil Intensity	-0.0640***	-0.0685***	-0.0685***			
	(0.0218)	(0.0232)	(0.0234)			
Placebo Boll Weevil Intensity (3 yrs)	-0.0125		-0.0217			
	(0.0254)		(0.0288)			
Placebo Boll Weevil Intensity (5 yrs)		-0.0223	-0.0229			
		(0.0246)	(0.0282)			
Age 20-24 x Boll Weevil Intensity				-0.0886***	-0.0944***	-0.0947***
				(0.0291)	(0.0309)	(0.0309)
Age 25-29 x Boll Weevil Intensity				-0.0991***	-0.103***	-0.102***
				(0.0315)	(0.0320)	(0.0322)
Age 30-34 x Boll Weevil Intensity				-0.0958**	-0.0968**	-0.0975**
				(0.0395)	(0.0409)	(0.0412)
Age 35-39 x Boll Weevil Intensity				-0.0541	-0.0569*	-0.0570*
				(0.0330)	(0.0341)	(0.0343)
Age 40-44 x Boll Weevil Intensity				-0.00846	-0.0147	-0.0140
				(0.0328)	(0.0344)	(0.0344)
Age 45-49 x Boll Weevil Intensity				-0.0119	-0.0224	-0.0211
				(0.0256)	(0.0267)	(0.0269)
Age 20-24 x Placebo Boll Weevil Intensity (3 yrs)				-0.0487		-0.0594
				(0.0426)		(0.0449)
Age 25-29 x Placebo Boll Weevil Intensity (3 yrs)				0.0135		0.00565
				(0.0464)		(0.0483)
Age 30-34 x Placebo Boll Weevil Intensity (3 yrs)				-0.0365		-0.0431
				(0.0515)		(0.0539)
Age 35-39 x Placebo Boll Weevil Intensity (3 yrs)				-0.00750		-0.0151
				(0.0485)		(0.0503)
Age 40-44 x Placebo Boll Weevil Intensity (3 yrs)				0.0155		0.00518
				(0.0490)		(0.0508)
Age 45-49 x Placebo Boll Weevil Intensity (3 yrs)				0.0148		0.000832
				(0.0388)		(0.0412)
Age 20-24 x Placebo Boll Weevil Intensity (5 yrs)					-0.0483	-0.0368
					(0.0351)	(0.0435)
Age 25-29 x Placebo Boll Weevil Intensity (5 yrs)					-0.00219	-0.0102
					(0.0400)	(0.0559)
Age 30-34 x Placebo Boll Weevil Intensity (5 yrs)					-0.0213	0.00172
					(0.0436)	(0.0556)
Age 35-39 x Placebo Boll Weevil Intensity (5 yrs)					-0.0117	-0.00810
					(0.0412)	(0.0546)
Age 40-44 x Placebo Boll Weevil Intensity (5 yrs)					-0.0137	-0.0333
					(0.0401)	(0.0537)
Age 45-49 x Placebo Boll Weevil Intensity (5 yrs)					-0.0328	-0.0722*
					(0.0329)	(0.0422)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	556,034	556,034	556,034	556,034	556,034	556,034
R-squared	0.165	0.165	0.165	0.175	0.175	0.175

The dependent variable is the number of own children under age 5. The sample spans married women of age 20 to 49 for the decades 1880 to 1930. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. *Placebo Boll Weevil Intensity* is constructed analogously to *Boll Weevil Intensity*, but assuming that the boll weevil infestation of a given county *c* occurred already 3/5 years before the actual arrival date *t*. The placebo arrival date is denoted by "(3 yrs)" and "(5 yrs)", respectively. We include the same set of controls as in Table 4, columns (1)-(2); see Table 1 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 5: The Boll Weevil Infestation and Child Mortality

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable					
	Survival Ratio		Child Mortality	Stillbirths	== 1 Childless	
Boll Weevil Intensity	0.0202		0.00584	-0.0167**	-0.0173	
	(0.0137)		(0.0133)	(0.00698)	(0.0136)	
Age 20-24 x Boll Weevil Intensity		0.0474*				-0.0245
		(0.0252)				(0.0286)
Age 25-29 x Boll Weevil Intensity		0.0116				-0.0143
		(0.0210)				(0.0231)
Age 30-34 x Boll Weevil Intensity		-0.000732				-0.0129
		(0.0229)				(0.0224)
Age 35-39 x Boll Weevil Intensity		0.0190				-0.0199
		(0.0188)				(0.0255)
Age 40-44 x Boll Weevil Intensity		0.0336				-0.00929
		(0.0247)				(0.0232)
Age 45-49 x Boll Weevil Intensity		0.0103				-0.00634
		(0.0287)				(0.0226)
Sample	Individual Level	Individual Level	County Level	County Level	Individual Level	Individual Level
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	No	No	Yes	Yes
Observations	79,749	79,749	2,530	2,530	91,762	91,762
R-squared	0.060	0.086	0.687	0.761	0.071	0.091

The dependent variable is the survival ratio (columns 1-2), child mortality per capita (column 3), the number of stillbirths per births (column 4), and an indicator variable whether a women remained childless (columns 5-6). In columns (1), (2), (5), and (6) the sample consists of married women of age 20-49 during the period 1900-1910. In columns (3)-(4) the sample spans the years 1921-1929 at the county level. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. Except for the county level regressions (columns 3-4) which only control for county and year fixed effects, the same set of controls are used as in Table 1 columns (1)-(2). See Table 1 and Section 6.1 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 6: The Boll Weevil Infestation and Plantation Counties

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Dependent Variable			
				Number of Children Below Age 5			
Boll Weevil Intensity	-0.0791***				-0.0893***	-0.0892**	-0.0915*
	(0.0217)				(0.0312)	(0.0407)	(0.0472)
Boll Weevil Intensity x Plantation	0.0318				0.0146	0.0743	-0.0155
	(0.0407)				(0.0483)	(0.0796)	(0.0589)
Age 20-24 x Boll Weevil Intensity		-0.0942***	-0.0233	-0.124**			
		(0.0307)	(0.0385)	(0.0486)			
Age 25-29 x Boll Weevil Intensity		-0.111***	-0.110**	-0.108**			
		(0.0329)	(0.0434)	(0.0532)			
Age 30-34 x Boll Weevil Intensity		-0.122***	-0.186***	-0.0593			
		(0.0393)	(0.0525)	(0.0550)			
Age 35-39 x Boll Weevil Intensity		-0.0763**	-0.129***	-0.0310			
		(0.0337)	(0.0442)	(0.0492)			
Age 40-44 x Boll Weevil Intensity		-0.0292	-0.0506	0.0425			
		(0.0340)	(0.0428)	(0.0509)			
Age 45-49 x Boll Weevil Intensity		-0.00430	0.0455	0.00335			
		(0.0266)	(0.0303)	(0.0456)			
Age 20-24 x Boll Weevil Intensity x Plantation		0.0157	0.0498	0.0760			
		(0.0485)	(0.0716)	(0.0591)			
Age 25-29 x Boll Weevil Intensity x Plantation		0.00905	0.00329	-0.0119			
		(0.0500)	(0.0735)	(0.0616)			
Age 30-34 x Boll Weevil Intensity x Plantation		0.0699	0.0537	0.0283			
		(0.0536)	(0.0810)	(0.0659)			
Age 35-39 x Boll Weevil Intensity x Plantation		0.0468	-0.0174	0.0693			
		(0.0495)	(0.0751)	(0.0580)			
Age 40-44 x Boll Weevil Intensity x Plantation		0.0355	0.0274	0.0372			
		(0.0506)	(0.0676)	(0.0613)			
Age 45-49 x Boll Weevil Intensity x Plantation		-0.0490	-0.0734	0.0465			
		(0.0486)	(0.0651)	(0.0590)			
Sample	All	All	All	All	Agr. Households	Agr. Households (White)	Agr. Households (Black)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plantation County x Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	556,034	556,034	324,142	231,892	287,808	145,251	142,557
R-squared	0.165	0.175	0.207	0.151	0.066	0.066	0.069

The dependent variable is the number of own children under age 5. For columns (1)-(4), the sample consists of married women of age 20 to 49 over the decades 1880 to 1930. For columns (5)-(7), the sample consists of married women of age 20 to 39 in agricultural households. *Boll Weevil Intensity* is the interaction between a dummy variable that equals one if county c was infested at time t and county c's acreage share of cotton planted in 1889. In addition, we interact Boll Weevil Intensity with a dummy which equals one for plantation counties according to Brannen (1924). Columns (1)-(4) include the same set of controls as Table 1. Columns (5)-(7) includes the same set of controls as Table 4, column (1). See Tables 1 and 4 for further details. Robust standard errors clustered at the county level in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Data Appendix

Construction of Agricultural Income 1880-1930

Wages of Farm Laborer: Wages for farm laborer are available for the years 1880–1882, 1885, 1888, 1890, 1892–1895, 1898–1899, 1902, 1906, and 1909–1930 from several sources (see below). Monthly wages are transformed into yearly wages. Wages for farm laborer are reported for men only. We assume that female farm laborer received 2/3 of a male wage (see Young Report 1871, p.218). Since fertility data from IPUMS are only available every decade (except 1890), we only use the data for the years 1880, 1900, 1910, 1920 and 1930.[1] We assign farm labor wages to individuals with occupation 820 and occupation 970 if the household's location was rural following the IPUMS classification "OCC1950" and "URBAN". Wages for farm laborer are denoted in constant prices using 1900 as reference year. The following information is used to construct wages of farm laborer:

- U.S. Department of Agriculture, Bureau of Statistics Bulletin 99, 1912 (Holmes data): Table 11 contains the average wage rates of outdoor labor of men on farms per month without board for the years 1879-1880, 1880-1881, 1881-1882, 1884-1885, 1887-1888, 1889-1890 and 1909. Table 14 contains the same information for the years 1891-1892, 1893, 1894, 1895, 1898, 1899, 1902, 1906 and 1906. Table 17 contains average wage rates of outdoor labor of men on farms per day for day labor in harvest work without board by states. The years covered coincide with Table 11 and Table 14. All wages are reported by states.

- U.S. Department of Agriculture, Bureau of Statistics Bulletin 26, 1903 (Blodgett data): Table 12 contains wages of farm labor per month without board for the years 1898, 1899, and 1902 by state and by race. Table 14 contains the same information for wages of farm labor per day in harvest.

- U.S. Department of Agriculture, Bureau of Statistics Farmers Bulletin 665, 1915: Table 11 contains wages of farm labor per month and per day at harvest without board for the years 1909, 1913, and 1914 by state.

- Crop Reporter (May 1889-June 1913); Monthly Crop Report (May 1915-January 1919); Monthly Crop Reporter(February 1919-): Wages without board of male farm labor per month and per day at harvest by state for the years 1911, 1912 (see March 1913, p.21), for 1915 (see March 1916, p.25); for the years 1910, 1916, and 1917 (see March 1918, p.27); for 1918 (see December 1918, p.157); for 1919 (see December 1919, p.135); for 1920 (see December 1920, p.147); for 1921 (see December 1921, 159).

[1] We use the 1899 wage data for the census year 1900.

- Agriculture Yearbook (1925): Contains quarterly data on wages of male farm labor by states for 1924 per month and per day without board.

- History of Wages in the United States, Bulletin of the United States Bureau of Labor Statistics, No.604, 1934: Table D-3 contains information on male average wages rates without board per month and per day (other than harvest) at the state level for the years 1922, 1923, 1925, 1926, 1927 and 1928. The supplement Table D-3 contains the same data on male farm laborers for the years 1929 to 1933 by state.

Farmer Income: For farmers, we obtain farm income from county-level measures of farm revenues and expenditures from the Censuses of Agriculture provided by the ICPSR file 35206 (Haines et al. 2015). The calculation of farm income is based on Abramiztky et al. (2012, Online Appendix Table 3, p.8). Farm income is denoted in constant prices using 1900 as reference year. We assign farm income to individuals with occupation 100 and 123 following the IPUMS classification "OCC1950". The following information is used to construct farm income:

- The following measures are used to calculate farm output: the variable "FARMOUT" for the Census years 1879 and 1899; the sum of the variables "CROPVAL", "LIVSLVAL", "WOOLVAL", "HWAXVAL", "POUPRVAL", "DAIRYVAL" for the Census year 1909; the sum of the variables "VAR114 (Value of dairy products)", "VAR121 (Value of chickens & eggs produced)", "VAR125 (Value of honey & wax produced)", "VAR128 (Value of wool produced)", "VAR138 (Total value of all crops)" for the Census year 1919; and the variable "VAR1112 (Total farm products sold, traded, or used by value)" for the Census year 1929; see the ICPSR 35206 codebook for more details. Farm output per farm is multiplied by the factor 1.265 to account for the value of house rent and food/fuel produced on a farm and consumed by the farm family. This ratio is taken from Goldenweiser (1916).

- The following measures are used to calculate total cash expenditure for farm labor (with board): the variable "FARMLAB" for the Census year 1899, the sum of the variables "FAWAGES" and "FAREBORD" for the Census year 1909, the variable "VAR308 (Total expenditure for labor)" for the Census year 1919, the variable "VAR1007 (Farm expenditures for: farm labor, exclusive of housework (cash))" for the Census year 1929. We use the average share of cash to total expenditure for hired labor over the period 1910-1920 to obtain total cash expenditure for 1929. For the year 1879, we use price adjusted total cash expenditure for farm labor in 1870 due to missing data.

- Expenditure for fertilizer is constructed from variables "FARMFERT"' for the Census years 1879 and 1899, "FERTEXP" for the Census year 1909, "VAR312 (Expenditure for fertilizer)" for the Census year 1919, and "VAR1003 (Farm expenditures for: fertilizer (including commercial fertilizer, manure, marl, lime & ground limestone)" for the Census year 1929. The sum of expenditure for farm labor per farm and expenditure for fertilizer per farm is multiplied by the factor 1.765 to account for expenditures for feed, seed, and threshing. This ratio is taken from Goldenweiser (1916).

- Tax costs per farm is based on the information on the average value of farmland and buildings per acre ("FAVAL"). Following Abaramitzky et al., we assume a tax rate of 0.6 percent on the total value of the farm.

- Depreciation costs are based on the value of equipment and machinery ("EQUIPVAL" in 1879; "FARMEQUI" in 1899 and 1909; "VAR25" in 1919; and "VAR125" in 1929) and buildings (assumed to be 15% of the value of farmland and buildings per acre). The depreciation rate for machinery is assumed to be 15 percent and 5 percent for buildings.

- In addition we subtract expenditure for unpaid farm labor from farm income—a common source of labor in the Cotton Belt of the American South at that time. We use the county-level number of unpaid farm family workers (derived from individuals reporting occupation 830 following the IPUMS classification "OCC1950") multiplied with the occupation-based income score for unpaid farm labor from IPUMS (in constant prices using 1900 as reference year) per farm in 1910. The 1910 unpaid farm worker expenditure ratio is also used for all other Census years.[2]

Unpaid Family Wage: Unpaid family laborer are assumed to receive a constant fraction of farm income as a wage. The fraction is based on the ratio of the IPUMS "OCCSCORE" for "OCC1950" code 830 (farm laborers, unpaid family workers) and "OCC1950" code 100 (farmers). We assign this wage to individuals with occupation 830 following the IPUMS classification "OCC1950" and to spouses living on farms without occupation.

Overseers or Foremen: Wages for overseers/foremen are retrieved from the U.S. Department of Agriculture, Bureau of Statistics Bulletin 26, 1903 (Blodgett data). Table 17 contains wages of overseers or foremen per month without board for the years 1898, 1899, and 1902 by state and by race. We assume that the female overseer/foremen wage is 2/3 of a male overseer. For the year 1900 we use the actual wage data of white overseers/foremen. For all other census years wages of overseers/foremen are constructed as a fraction of farm labor wages (for a given Census year, farm labor wages are multiplied by the average ratio of wages for overseers/foremen over farm laborers

[2]The 1910 Census included specific instructions to enumerators to record unpaid family labor which tended to be understated in the other Census years (Goldin 1986, p.574).

for the years 1898, 1899, and 1902). Wages of overseers/foremen are denoted in constant prices using the year 1900 as reference year. We assign overseer wages to individuals with occupation 810 following the IPUMS classification "OCC1950".

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