"THE DUST WAS LONG IN SETTLING": HUMAN CAPITAL AND THE LASTING IMPACT OF THE AMERICAN DUST BOWL

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(*This is a preliminary draft; all results and analysis are subject to change.*)

Abstract: I use variation in childhood exposure to the Dust Bowl, an environmental shock to health and income, as a natural experiment to explain variation in adult human capital. I find that the Dust Bowl produced significant adverse impacts in later life, especially when exposure was *in utero*, increasing rates of poverty and disability, and decreasing rates of fertility and college completion. Dependence on agriculture exacerbates these effects, suggesting that the Dust Bowl was most damaging via the destruction of farming livelihoods. This collapse of farm incomes, however, had the positive effect of reducing demand for child farm labor and thus decreasing the opportunity costs of secondary schooling, as evidenced by increases in high school completion amongst the exposed.

Keywords: Dust Bowl, environmental shock, human capital formation, early life health

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> "The sun flared down on the growing corn day after day until a line of brown spread along the edge of each green bayonet…The surface of the earth crusted, a thin hard crust, and as the sky became pale, so the earth became pale, pink in the red country and white in the gray country…In the roads where the teams moved, where the wheels milled the ground and the hooves of the horses beat the ground, the dirt crust broke and the dust formed. Every moving thing lifted the dust into the air: a walking man lifted a thin layer as high as his waist, and a wagon lifted the dust as high as the fence tops, and an automobile boiled a cloud behind it. The dust was long in settling back again."
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> — John Steinbeck, *The Grapes of Wrath*

1. INTRODUCTION

The American Dust Bowl, a prolonged ecological event characterized by drought, extensive accelerated soil erosion, and severe dust storms, represents one of the most devastating environmental catastrophes in American history.[1] During this crisis, which lasted throughout the 1930s, a series of dust storms ravaged the US Great Plains, destroying land, property, and agricultural livelihoods; disrupting public services; and causing injury to health and nutrition.[2] Recent literature indicates that early-life shocks and interventions can radically change the course of human capability formation, and thus shape adult outcomes.[3] In light of this literature, the Dust Bowl's shocks to health and incomes would be expected to have non-negligible adverse effects on wellbeing in later-life; however, these long-run human costs have been little studied.[4]

In this paper, I analyze the long-term consequences of the Dust Bowl on the human capital of the children who lived through it. Specifically, I use exogenous variation in the severity of this environmental shock across space—proxied by Dust Bowl soil erosion—to explain variation in adult human capital and socioeconomic outcomes. I thus test for the degree to which the Dust Bowl scarred human capital in the long run, the mechanisms by which any such scarring occurred, and the way parental investment in human capital responded to the shock. I find that exposure to the Dust Bowl in childhood has statistically significant and economically meaningful adverse impacts on later-life outcomes, for instance, increasing

[1] D. Worster, p. 4.
[2] D. Worster (1979), Z. Hansen and G. Libecap (2004), R. Hornbeck (2012a), K. Burns et al (2012), and A. Carlson (1935).
[3] Studies detailing the impacts of early-life interventions, especially on adult outcomes, include F. Cunha and J. Heckman (2008); D. Almond and J. Currie (2011b); D. Almond (2006); D. Almond et al. (2009); D. Barker and C. Osmond; J. Heckman; S. Bhalotra and A. Venkataramani.
[4] D. Cutler et al. represents one study quantifying later-life health effects of the Dust Bowl.

disability and reducing fertility and college completion.[5] Furthermore, I find that the Dust Bowl's adverse impacts are more numerous and severe for those born in more agriculture-dependent states, and that effects for health and poverty outcomes are strongest amongst those exposed *in utero*, while those for secondary education are strongest for those exposed in late childhood. Lastly, results imply that parental investment post-shock likely compensated for rather than reinforced child endowments.

Together, these findings suggest that the Dust Bowl produced its greatest adverse impacts through lowered agricultural incomes, and thus acted primarily as an economic shock. Indeed, direct exposure to the Dust Bowl in childhood was less important to later-life poverty and disability than indirect exposure *in utero*. These outcomes likely manifest fetal maldevelopment resulting from poor maternal health and nutrition, a fact that in turn may implicate low incomes and material deprivation.[6] Such congenital complications in capability development, together with low parental incomes, may also be to blame for lower rates of college completion. Indeed, where child ability and parental incomes were no object, as in secondary education, outcomes are counterintuitively positive: high school completion rates among the exposed rise dramatically. Here too, livelihoods play a role, as the collapse of farming incomes likely lowered the opportunity cost of schooling as child farm labor opportunities became fewer.[7] Tests of the influence of patriarchal culture and institutions on parental investment responses suggest that both men and women exposed to the Dust Bowl in more patriarchal states experienced adverse outcomes that reflected patriarchal gender norms, and received lower rates of compensating investment than did

[5] The magnitudes of impact I find are in line with many studies on early-life shocks and interventions; for instance, Almond (2006) finds a roughly 1-2% higher chance of work disability amongst men exposed to the 1918 flu pandemic, a figure similar to the disability increases I find. My estimates of the reduction in the probability of college completion (roughly 1-3%) and the increase in disability rates (roughly 1-2%) are also similar in magnitude to the effects on those variables found in S. Bhalotra and A. Venkataramani (2012), which tracks the effects of pneumonia vaccines. (Notably, since this study is of a positive intervention, the signs are generally opposite of those I find.) Surprisingly, I also find positive effects on high school completion similar, both in sign and magnitude (ranging from 50-100% of their magnitudes, depending on the specification), to those in S. Bhalotra and A. Venkataramani (2012). For further discussion of the magnitudes of impact of childhood health shocks on later life outcomes, see S. Bhalotra and A. Venkataramani (2012), p. 32 and D. Almond and J. Currie (2011a).

[6] D. Almond and J. Currie (2011a & 2011b); J. Heckman (2007); F. Cunha and J. Heckman (2008); D. Barker and C. Osmond (1986).

[7] Prior to the Dust Bowl's destruction of farms, child farm labor was prevalent. R. Whaples (2005) shows that in 1930, 74.5% of boys and 61.5% of girls aged 10-15 were employed in agriculture, and K. Clay et al. (2012), p. 8 indicates that child labor was extensive even in the face of compulsory schooling laws, which were not strictly enforced. Laws restricting child labor, such as the 1938 Fair Labor Standards Act, contained many exemptions for child labor in agriculture, especially on family farms (U.S. Department of Labor, 2007 and 2013). Thus, the collapse of agriculture in the Great Plains had scope to reduce opportunities for child labor. Child labor, schooling, and the opportunity cost of schooling have been shown to be closely related (K. Clay et al. 2012, S. Bhalotra 2007, K. McNay et al. 2005). For instance, in the context of present-day developing countries, Bhalotra (2007) finds that lowering the opportunity cost of schooling, in her case through poverty-alleviating cash transfers, is essential to reducing child labor and increasing schooling. Poverty may have remained an issue for Dust Bowl households, but for them, the lack of opportunities for labor in agriculture, whether for children or adults, likely drove the drop in the opportunity cost of schooling. Indeed, K. McNay et al. (2005), p. 666, find this phenomenon at play where higher rates of girls' schooling in 19th Century Britain are found in regions where opportunities for girls' (but not boys') employment were few.

those exposed in less patriarchal states. The findings in this study are consistent with a multi-stage model of human capability formation, in which investments in one period respond to endowments in a previous one, and may either reinforce or compensate for these endowments.[8]

1.1. Related Literature

Historical Background

During the period from 1930 to 1940, poor rainfalls and strong winds precipitated a series of massive dust storms across the US Great Plains that blew away roughly 480 tons of fertile topsoil per acre,[9] with many regions in the plains having lost over 75% of their original topsoil by 1940.[10] By blowing soil away altogether, winds wrought permanent damage[11] and destroyed agricultural productivity; they decimated existing crops through exposure and abrasion, and prevented new ones from being planted.[12] Dirt deposited downwind suffocated livestock, buried property, and smothered yet other crops.[13] Accordingly, crop yields were low[14] and agricultural recovery was slow.[15]

The Dust Bowl was not just an environmental crisis, but a human tragedy as well.[16] As the country struggled with the Great Depression and the attendant high rates of unemployment, the Dust Bowl further compounded misfortunes, especially for the farming communities of the Great Plains.[17] Economic hardship was widespread: poor agricultural productivity and meager harvests meant low incomes, nutritional deprivation—and, for many, farm foreclosure, eviction, and migration.[18] More directly, dust storms were both an everyday nuisance and a health hazard to Great Plains inhabitants. Poor air quality and dust inhalation made respiratory illnesses such as "dust pneumonia" and asthma common and at times life-threatening complaints. [19] Eye infections and influenza, too, were reported at greater rates in Dust Bowl-affected counties.[20] Furthermore, these storms and the associated economic hardships disrupted schooling directly, by lowering attendance in response to poor air quality and dangerous weather conditions, and indirectly, by prompting taxpayers to reprioritize spending and cut or cease funding to schools.[21] The prolonged stress experienced by Great Plains residents was also psychological: survivors

[8] J. Heckman (2007).
[9] Z. Hansen and G. Libecap, p. 666.
[10] R. Hornbeck (2012a), p. 1478.
[11] Soil Conservation Service, p.1.
[12] Soil Conservation Service, p. 13.
[13] Soil Conservation Service, p. 13; Z. Hansen and G. Libecap, pp. 667-8.
[14] D. Cutler et al., pp. 13245-6.
[15] R. Hornbeck (2012a), p. 1500.
[16] K. Burns et al. (2012); D. Worster (1979); and A. Carlson (1935).
[17] D. Cutler et al., p. 13245.
[18] D. Worster, pp. 120-6 & Ch. 3.
[19] Soil Conservation Service, p. 13; Oral histories in K. Burns et al., Z. Hansen and G Libecap, p. 668.
[20] Z. Hansen and Libecap, p. 668.
[21] D. Worster, p. 126; Oral histories in K. Burns et al., Soil Conservation Service, p. 13; Oral histories in K. Burns et al., Z. Hansen and G Libecap, p. 668.

felt constantly under siege, and recall feelings of powerlessness, demoralization, and uncertainty at their inability to sustain incomes, ensure the family's health and nutrition, and even maintain the normalcy of a clean and respectable home.[22]

Although much has been studied on the Dust Bowl's impact on land management and conservation, agricultural recovery, and migration,[23] a gap exists in the literature: although qualitative sources on the Dust Bowl's short-term health effects abound, only one study, which using different data sources and methods found limited Dust Bowl effects, has attempted to quantify the long-term human costs of the natural disaster.[24] As such, it is possible we currently underestimate the damage caused by the Dust Bowl. By quantifying the later-life impacts of the Dust Bowl on human capital, I corroborate qualitative accounts on near-term health effects and contribute to our understanding of the full toll of this seminal event in American history.

Early-Life Health and Human Capability Formation

Current research indicates that stress, deprivation, and early-life shocks to income and health can have long-term adverse impacts on health and wellbeing.[25] For instance, experiences of famine in early life have been implicated in later-life coronary heart disease and schizophrenia.[26] Similarly, infections such as pneumonia in early life have been shown to subvert cognitive development by producing an inflammatory response that diverts resources from normal mental development processes as survival is prioritized.[27] As such, human capital development and wellbeing may be impaired indirectly through poor prenatal conditions (that is, maternal stress, illness, or malnutrition), or through low incomes and nutritional deprivation in early life that in turn hamper the successful development of capabilities such as cognitive skills, non-cognitive skills, metabolism, and immunity. [28] Given the destruction of livelihoods and the direct health and educational disruptions documented during this period,[29] Dust Bowl survivors are likely to suffer just such adverse effects on human capital formation. In turn, such low stocks of human capital may in turn negatively impact other wellbeing outcomes such as later-life income and employment.[30]

The case of the Dust Bowl is rare in that it represents a prolonged experience of stress and deprivation more akin to famine,[31] as opposed to the sharp shocks—for instance, a sudden

[22] D. Worster, Ch. 8 & 11; Oral histories in K. Burns et al., especially those of Charles Shaw; J. Steinbeck, pp. 1-4.
[23] For instance, Z. Hansen and G. Libecap, B. Cook et al., J.D. Helms et al., D. Worster, G. Cunfer, and R. Hornbeck (2012a).
[24] D. Cutler et al. (2007).
[25] D. Almond and J. Currie (2011b), pp. 154, 158, and 160.; D. Barker and C. Osmond ; J. Heckman, p. 1.; S. Bhalotra and A. Venkataramani, pp. 2-3; D. Cutler et al., p. 13244.
[26] See overview of famine and fetal programming literature in C. Ó Gráda (2011).
[27] S. Bhalotra and A. Venkataramani, p. 2.
[28] D. Cutler et al., p. 13244; J. Heckman, p. 1.
[29] D. Nealand (2008), K. Burns et al. (2012), and D. Worster (1979).
[30] J. Heckman (2007) and S. Bhalotra & A. Venkataramani (2012).
[31] C. Ó Gráda (2011), C. Ó Gráda (2009), D. Almond et al. (2007).

disease outbreak, policy change, or health intervention—more often studied in the literature.[32] As such, it allows me to test for the effects of a "shock" event where individuals have greater time to respond to the event, and may even adjust to the shock event while it is still ongoing. Furthermore, this study allows me to analyze the impact of what is ultimately an agrarian or an economic shock resulting from an environmental catastrophe. While studies of the health impacts of environmental disasters exist,[33] much of the research in human capital formation focuses on shocks and interventions directly related to health;[34] fewer still track the effect of short-term physiological and developmental changes and subsequent investment responses on adult outcomes.[35] The fact that the Dust Bowl constitutes an economic shock allows me to show that incomes acted through childhood health and education to produce lasting effects in adults—in this case, permanent damage to health and socioeconomic status.

I also contribute to our understanding of the technology of human capital formation. By testing for parental investment responses to exogenous, Dust Bowl-induced changes in children's human capital endowments I disentangle changes in human capital due to the shock itself from those due to investments made to ameliorate or reinforce these changes to the endowment. Specifically, by combining variation in Dust Bowl exposure with gender-based variations in returns to human capital investments,[36] I identify regions where compensating investments may have responded to systemic economic and cultural barriers to women and thus resulted in poorer recovery from childhood insults. I find that both men and women living in more patriarchal states experience worse adverse outcomes consistent with the enforcement of patriarchal gender roles. This finding suggests that exposed children in more patriarchal states received less investment in their recovery from the shock. Thus, I provide empirical support for theories of self-productivity and dynamic complementarity in capability formation, such as those advanced by Becker and Tomes (1976) and Heckman (2007).

The remainder of the paper proceeds as follows. In Section 2, I describe my methodological approach, including identification strategy and data. In Section 3, I outline results, with a focus on tests of the mechanisms by which the Dust Bowl impacted later-life health and wellbeing. In Section 4, I combine these findings to explain how childhood economic shocks resulted in increases in secondary schooling alongside permanent health damage, and to discuss the implications of agriculture-dependence and patriarchy results in light of an existing model of human capital formation. In Section 5, I conclude.

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[32] Such as D. Almond (2006), S. Bhalotra & A. Venkataramani (2012), H. Bleakley (2007), E. Duflo (2001)

[33] For instance, D. Almond et al. (2009) and D. Cutler et al. (2007)

[34] A great many studies, like D. Almond (2006), S. Bhalotra & A. Venkataramani (2012), H. Bleakley (2007), E. Duflo (2001) focus on shocks and interventions directly targeting health; however, studies like A. Banerjee et al. (2010) and A. Adhvaryu et al. (2013) focus on the adverse health outcomes induced by shocks to income, and G. Duncan and J. Brooks-Gunn (1997) on those due to childhood poverty.

[35] S. Bhalotra & A. Venkataramani, p. 3.

[36] My approach follows the technique used in S. Bhalotra and A. Venkataramani, pp. 2-3, in the context of race-based access to good institutions and its influence on returns to human capital across races and regions.

2. IDENTIFICATION STRATEGY & DATA

2.1. Identification Strategy

I exploit exogenous environmental shocks to income and health—in the form of Dust Bowl-induced soil erosion—to identify impacts on later-life human capital outcomes. I use a differences-in-differences strategy to identify the treatment impact of Dust Bowl exposure, with a baseline regression as follows, estimated by OLS:

$$h_{bst} = \alpha + \beta_1 * \text{treated}_b * \text{erosion}_s + \psi * x_{bst}' + \theta_s + \lambda_b + \eta_t + \gamma_s + u_{bst} \qquad (1)$$

Here, h_{bst} represents the later-life human capital outcome of interest for individuals born in year *b* in state *s* and observed in census year *t*.

The term $\text{treated}_b * \text{erosion}_s$ is the chief variable of interest in this paper, and refers to whether or not an individual was a child during the Dust Bowl and whether they were exposed to high erosion. It may thus be interpreted as the reduced form effect of childhood Dust Bowl exposure on adult outcomes.

Treated_b is equal to 1 for individuals aged -1 to 12 at any time during the Dust Bowl[37] so as to capture the effects of the shock during childhood, which has been defined so as to span the period *in utero* up to the onset of puberty.

Erosion_s is a variable representing the erosion intensity in a given state over the Dust Bowl period—that is, "treatment" by the Dust Bowl, where treatment refers to the degree of exposure to this random environmental shock. Since county-level erosion is known but county of birth is not, in the baseline, erosion_s is constructed as the proportion of the state population in 1930 living in high-erosion counties within that state, and so may be interpreted as the probability an individual born in a given state was born into a high-erosion county.

Furthermore, since census data does not allow for the identification of those who may have migrated away from the state of birth during childhood, the $\text{treated}_b * \text{erosion}_s$ term may be interpreted as an intent-to-treat estimate. Thus, the coefficient on the $\text{treated}_b * \text{erosion}_s$ variable, β_1, describes the causal effect of Dust Bowl treatment relative to those not exposed. As such, a negative sign on β_1 implies that Dust Bowl exposure during childhood reduces the human capital outcome of interest (for instance, number of children ever born), while a positive β_1 implies Dust Bowl exposure raises the human capital outcome (e.g. the probability of physical disability).

x_{bst}' represents a vector of controls (in the baseline, race; outside the baseline, race, veteran status, and state-level drought). Lastly, θ_s, λ_b , and η_t represents birth state fixed effects, birth year fixed effects, and census year fixed effects, respectively, while γ_s represents state trends. Together, the set of individual controls and fixed effects allow me to control for

[37] That is, all children born between 1918 and 1941, inclusive.

individual characteristics, such as race, that may affect the degree to which Dust Bowl exposure manifests in later-life human capital, as well as to remove the effects of any time-invariant state heterogeneity (such as differences by state in quality of land), unobserved heterogeneity across time (such as differences by birth year in state per capita income or public service expenditure), and unobserved heterogeneity across census waves (such as systematic differences in enumeration methods). The inclusion of state trends further allows me to strip away the effects of larger-scale trends in outcomes during this period, such as the baby boom or declining ages at marriage (see Figures 2b & 2a, respectively), such that β_1 may be interpreted as the causal effect of Dust Bowl exposure above and beyond these phenomena.

Standard errors are clustered at the birth state and birth year levels so as to adjust for serial correlation in outcomes,[38] and the equation is estimated separately for males and females in order to identify differences by gender in Dust Bowl impacts.[39]

The preceding description has outlined the baseline specification; details of robustness checks and further tests are discussed in Sections 3 and 4.

2.2. Data

Dust Bowl Severity

To identify the scope and intensity of Dust Bowl exposure, I use measures of soil erosion for 15 Great Plains and adjacent states[40] (see Figure 1a), taken from the US Soil Conservation Service. Beginning in 1934 in response to the Dust Bowl and continuing over its course, the Soil Conservation Service conducted comprehensive surveys of soil conditions across the United States, identifying thousands of regions of erosion classified by the severity (e.g. slight, moderate, severe) and the type (e.g. sheet, wind, gullying) of erosion damage observed.[41] By 1948, the office had created the first of a series of maps cataloging the cumulative erosion experienced throughout the entire Dust Bowl period.[42] I take my erosion figures from this 1948 map, which characterizes erosion severity by percentage of original topsoil lost: high (75% or more), medium (25-50%), and low (0-

[38] M. Bertrand et al. (2004).
[39] My approach closely resembles that in S. Bhalotra and A. Venkataramani pp. 11-2.
[40] The states in the sample account for 23% of US population in 1930 (U.S. Census Bureau, 2002a & 2002b), and 47% of US landmass in 1930 (U.S. Census Bureau, 2013). The choice of these 15 states accords with qualitative and quantitative accounts such as the Soil Conservation Service (1935), Z. Hansen and G. Libecap (2004), R. Hornbeck (2012a), D. Nealand (2008), and D. Worster (1979), and the Great Plains Committee (cited in p. 669 of Z. Hansen and G. Libecap), that place the epicenter of the Dust Bowl in the Great Plains region and nearby states. Indeed, previous studies using erosion-based methodologies to study Dust Bowl phenomena, such as Z. Hansen and G. Libecap (2004) and R. Hornbeck (2012a), have used a similar sample of states. By including states on either side of the core Great Plains region, I ensure sufficient variation in erosion severity to allow for differences-in-differences analysis. For further discussion of the states included in the sample, see the Data Appendix.
[41] Soil Conservation Service, pp. 19-22.
[42] R. Hornbeck (2012a), p. 1484.

25%) erosion.[43] To control for possible changes to county boundaries during the Dust Bowl period, per Hornbeck (2012a), 1910 county boundary definitions are enforced for measures of erosion, population, and farm value.[44] For further discussion of the Soil Conservation Service and its erosion maps, please see Hornbeck (2012a). [45]

Since the severity of the Dust Bowl in human terms depends on population distribution over space within a given state, I weight erosion measures by population, taken from the US Census[46], such that states with a greater proportion of population residing in high-erosion counties are deemed to have been more severely treated by the Dust Bowl. Erosion measures are constructed on the state level so as to correspond to individual outcomes, which can only be measured at the birth state level.[47]

Although the 1948 map captures the erosion wrought by many of the Dust Bowl's worst storms, such as April 1935's Black Sunday,[48] a notable weakness of the erosion data is the lack of baseline (that is, pre-1930) erosion measures, since no erosion surveys were made prior to 1934.[49] In order to account for possible measurement error due to the absence of information on pre-1930 erosion levels, I substitute data from the US Census of Agriculture[50] on the percentage change in farm values between 1930 and 1940 for the $erosion_s$ term in (1) as a robustness check, since 1930 farm values provide a useful proxy for the quality of land prior to the Dust Bowl. As a further robustness check, I substitute Dust Bowl drought for erosion as a measure of Dust Bowl exposure. For this analysis, I use state-level climate station data on rainfall during the 1930-40 period, taken from the National Oceanic and Atmospheric Administration[51] and constructed, using the SPI method, as the total magnitude of all drought events in the state during the period[52] (see Data Appendix). Maps detailing severity of Dust Bowl exposure by measures of erosion, change in farm values, and drought are detailed in Figures 1b-1d.

Human Capital Outcomes

Data on later-life health, educational, and socioeconomic outcomes for individuals born between 1900 and 1959, inclusive, is taken from the Integrated Public Use Microdata Series (IPUMS), a dataset culled from US Census responses, which are reported every 10 years.[53] Given the timeframe of the Dust Bowl, I use 5%-sample data collected in the 1980, 1990, and 2000 US Censuses to capture stable adult outcomes of those who were children, as

[43] R. Hornbeck (2012a), pp. 1484-5.
[44] R. Hornbeck (2012a).
[45] R. Hornbeck (2012a).
[46] Included in R. Hornbeck (2012b) dataset; for underlying sources, see R. Hornbeck (2012a), p. 1484.
[47] IPUMS data and censuses do not include more granular information on nativity, such as birth county or birth city.
[48] National Weather Service: Norman Oklahoma Weather Forecast Office (2013), A. Carlson (1936), and H. Choun (1936).
[49] Soil Conservation Service (1935), and R. Hornbeck (2012a), pp. 1484 & 1502.
[50] Included in R. Hornbeck (2012b) dataset; for underlying sources, see R. Hornbeck (2012a), p. 1484.
[51] National Climatic Data Center of the National Oceanic and Atmospheric Administration (2013).
[52] T. McKee at al. (1993).
[53] S. Ruggles et al. (2010).

defined in Section 2.1, between 1930 and 1940—that is, individuals born between 1918 and 1941, inclusive.[54]

The IPUMS data contains individual-level information on demographics, employment and income, educational attainment, and disability; [55] my analysis tests for the effects of Dust Bowl exposure on outcomes such as age at first marriage, children ever born, probability of high school completion, and probability of cognitive disability. Furthermore, via disaggregation by developmental stage cohort, this data allows me to test for both direct (e.g. respiratory illness, absence from school) as well as indirect (e.g. poor nutrition due to low incomes or developmental complications due to poor maternal health) effects of Dust Bowl exposure in childhood.

Summary statistics on adult outcomes by gender are available in Table 1. Graphs of outcome summary statistics by gender and year, with 95% confidence intervals, are provided in Figures 2a-2j.

3. RESULTS

3.1. Overall

I begin by testing the impact of Dust Bowl exposure on later-life outcomes across all males and females. Table 2 lists the values for β_1 from equation (1) for each of the later-life outcomes considered. I find that individuals exposed to the Dust Bowl as children suffered permanent and damage to human capital and wellbeing on a scale that is both statistically and economically significant.[56]

Under the baseline specification in column (1), I find that exposed women have a 1.17% lower probability of completing college, and a 0.466% higher probability of living in poverty, defined as living at or below the census poverty line (see Data Appendix). The poverty effects for men are even starker: exposed men have a 0.802% greater likelihood of living in poverty than men who were not exposed, as well as a receipt of $15.05 more in welfare payments. Furthermore, exposed men have a 1.1% greater chance of experiencing physical disability.

In column (2), percentage change in farm values between 1930 and 1940 takes the place of erosion as the measure of Dust Bowl severity. Percentage change in farm value is a particularly useful proxy for Dust Bowl exposure since it does not penalize states that may naturally experience poor land quality or higher levels of baseline erosion in a way that this model would interpret as being attributable to the Dust Bowl. Under this specification, I find similar effects on poverty and welfare payments. However, a number of additional impacts are also statistically significant: exposed men see a nearly quarter-year reduction

[54] Those who were children (that is, 0-12) during the Dust Bowl would be aged roughly 40-62 years in 1980.
[55] S. Ruggles et al. (2010).
[56] Magnitudes are similar to those found in studies such as S. Bhalotra and A. Venkataramani (2012) and D. Almond and J. Currie (2011a).

in the age at marriage, and a 1.12% greater chance of experiencing self-care and independent mobility disability; exposed women see a $15.37 increase in welfare receipt, as well as 1.45%, 0.942%, and 1.29% increases in in cognitive, vision and hearing, and self-care and independent mobility disabilities, respectively. Exposed women also experience 3.71% greater likelihoods of high school completion than their unexposed counterparts. The positive effects of Dust Bowl exposure on high school completion may at first seem counterintuitive. However, as will be discussed in Section 3.2 with reference to agricultural communities, increases in the rates of secondary schooling reflect the drop in the opportunity cost of schooling as farms, and thus, the need for child farm and household labor, declined.[57] These results stand as a contrast to college completion rates, which fall amongst the exposed, and in which arena child cognitive ability was a likely barrier.[58]

In column (3), when the sum of the magnitudes of all drought events during the period 1930 to 1940 takes the place of erosion in the baseline equation, the signs are as in columns (1) and (2), although the magnitudes are slightly larger (for instance, a shift from the least to the most drought-affected state in the sample—that is, a 126-point or roughly four-fold increase in drought magnitude—would entail a 5.37% increase in high school completion for women, as opposed to a 3.71% increase under (2), or a 1.47% increase in the probability of cognitive disability for women, as opposed to a 1.45% increase under (2)) and the effects on a greater number of outcomes, such as age at marriage for women, and probability of completing high school for men, are statistically significant.

Results are intuitive, and are consistent with the literature on childhood shocks[59]: the Dust Bowl had negative consequences for health, human capital, and indicators of wellbeing, increasing poverty and disability, and decreasing ages at marriage and college completion. Furthermore, results are consistent with historical and qualitative scholarship on the Dust Bowl:[60] the stress, deprivation, poor nutrition, and ill health documented as short-term consequences of the catastrophe are manifest in the later-life disability and poverty outcomes seen here, while low Dust Bowl incomes, coupled with cognitive and developmental problems, are likely to blame for the lower rates of postsecondary education observed. In Section 3.2 I test these hypotheses as to the mechanisms through which the Dust Bowl produced the effects discussed here; indeed, I show that many of the Dust Bowl's adverse effects stem from low incomes and developmental complications in early life.

3.2. Mechanisms

In Tables 3-5, I report results on tests of the pathways and mechanisms through which the Dust Bowl affects later-life outcomes. First, I test the hypothesis that individuals born in

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[57] See footnote in Section 1 for a discussion of the prevalence of child farm labor and the opportunity cost of schooling; K. McNay et al. (2005), p. 666 discuss how poor opportunities for child labor can raise schooling rates by lowering the opportunity cost of schooling.

[58] J. Heckman, p. 13252.

[59] D. Almond (2006), D. Almond et al. (2007), D. Almond et al. (2009), A. Banerjee et al. (2010), studies surveyed in Ó Gráda (2010).

[60] D. Worster (1979) and K. Burns et al. (2012).

more agriculture-dependent states experienced worse adverse effects of Dust Bowl exposure—that is, that the income channel effects of the Dust Bowl mattered. Second, I test whether individuals born in states with greater levels of cultural and institutional patriarchy experienced worse Dust Bowl effects than those in less patriarchal states. Here, the aim is to test whether state-level institutional or cultural barriers to women produced gender gradients in the returns to human capital investment that would have led in turn to greater initial insults and/or lower compensatory investments in girls living in more patriarchal states. Lastly, I disaggregate the analysis to test whether the presence or severity of adverse effects is linked to the developmental stage at which children were exposed to the Dust Bowl.

Agriculture

In Columns (1) and (2) of Table 3, I test for the impact of the Dust Bowl on more agriculture-dependent states. I find that agriculture-dependence exacerbates the adverse effects of the Dust Bowl.

Column (1) presents the β_1 values for regressions in which the $erosion_s$ variable in equation (1) is weighted by proportion of farm population rather than by proportion of overall population, such that erosion is defined as the proportion of the state's farm population living in high erosion counties (see definition of *Farm Population-Weighted Erosion* in Data Appendix). That is, in these regressions, it is the proportion of the population in farming that matters—if a county hit by the Dust Bowl contained no farmers, it would not be considered exposed to the Dust Bowl, and would not contribute to the state's erosion level. This measure of erosion allows me to test for the effects of the Dust Bowl on states based on the degree to which they depended on agricultural livelihoods. Although individuals' household farm status in childhood is unknown, the measure used here is still helpful since even non-farmers in agriculture-dependent regions would have found their fortunes intimately linked to the success or failure of agriculture; for instance, shop owners or local creditors serving a largely agricultural clientele would surely suffer from the collapse of farming incomes,[61] while the destruction of farming livelihoods would also have an impact on local tax bases and thus public service provision for all in a given community, regardless of occupation.[62]

Under this specification, exposed women see a reduction in fertility of 0.345 children ever born, as well as a 2.09% decrease in the probability of completing college, the latter outcome nearly twice as severe as that in the baseline. Exposed women are 0.771% likelier to be living in poverty than their unexposed counterparts, while for men, the impact is even starker, with a 1.27% increase in the likelihood of poverty. Exposed men similarly have a 1.73% increase in the probability of physical disability, a figure roughly 50% more severe than the adverse impact in the baseline specification.

[61] Oral histories in K. Burns et al. (2012).
[62] D. Worster, pp. 125-6.

Column (2) reports the β_1 and β_2 coefficients for regressions in which a binary variable for agriculture dependence (defined as 1 where the proportion of the state's population engaged in agriculture in 1930 is above average for the sample; see Data Appendix) is interacted with the original treated_b*erosion_s term, as follows:

$$h_{bst} = \alpha + \beta_1 * \text{treated}_b * \text{erosion}_s + \beta_2 * \text{farm}_s * \text{treated}_b * \text{erosion}_s + \psi * x_{bst}' + \theta_s + \lambda_b + \eta_t + \gamma_s + u_{bst} \quad (2)$$

Here, statistically significant adverse effects are similar to those in (1). I find that agriculture-dependence made the effects of Dust Bowl exposure more severe (i.e. larger in magnitude), although its contribution to the impact is smaller than the simple effect of Dust Bowl exposure.

The effects of Dust Bowl exposure for those born in agriculture-dependent states are generally greater in magnitude than those not born in such states. That is, often β_1 and β_2 move in the same direction, and $|\beta_1+\beta_2| > |\beta_1|$. This is especially the case amongst women, although the interaction coefficients are in most cases statistically insignificant.

On the whole, the coefficients (β_1) of the main effect are larger than those (β_2) on the farm interaction term. Thus, for exposed individuals in agriculture-dependent states, the greater portion of the effects they experience result from merely being exposed to the Dust Bowl rather than result from dependence on agricultural livelihoods conditional on Dust Bowl exposure. A notable exception is found in the probability of high school completion. Here, for men but not for women, the interaction coefficient is greater than the main effect coefficient. Men exposed to the Dust Bowl in farm states experience high school completion rates 3.818% higher than those of unexposed men, and 2.92% higher than those for exposed men from non-farm states, who themselves have a 0.898% higher chance of completing high school than the unexposed. For contrast, amongst exposed farm-state women, $\beta_1 > \beta_2$, meaning the bulk of the effect is in simple Dust Bowl exposure, and not in farm-dependence combined with Dust Bowl exposure. Since farm status appears to change the high school completion effect of Dust Bowl exposure more for men than for women, this result accords with the fact that boys were more active than girls in agricultural child labor,[63] such that when farms failed, their opportunity cost of schooling rose more sharply than that of their sisters.

Lastly, as found under the regressions weighting erosion by farm population, in specifications where the farm_s variable in equation (2) is the proportion of the state's population engaged in agriculture in 1930 (not reported), exposed women in more agriculture-dependent states have 2.256 fewer children than those not exposed—a meaningful reduction in a sample where the mean number of children born is 2.4.

Tellingly, it is only in the farm specifications that women's adverse effects on fertility become statistically significant, indicating that girls born into more agriculture-dependent states during the Dust Bowl had fewer children over the course of their lifetimes. Since

[63] R. Whaples (2005).

higher ages at marriage, higher rates of college completion (and thus long-term career planning), and lower levels of income in adulthood are not implicated for women, [64] these fertility declines are most likely due to early-life developmental complications in or damage to their reproductive health. This finding is particularly striking given the nationwide post-war "baby boom" trend in fertility experienced by the generation born in the 1920s and 1930s (see Figure 2b).

Patriarchy

Since in many cases, I find that women experience more numerous and stronger adverse effects of early-life Dust Bowl exposure, I test for whether girls exposed to the Dust Bowl in more patriarchal states received lower levels of compensating investment than their male peers in the same state or than girls in less patriarchal states. Since patriarchal culture and institutions may have posed barriers to the realization of returns to human capital investments in girls, girls in more patriarchal states would be expected to suffer in later life even while others recovered from the Dust Bowl shock.[65]

In Column (3) of Table 3, I report reports the β_1 and β_2 coefficients for regressions that test for the effects of patriarchal culture and institutions in strengthening the adverse effects of Dust Bowl shocks, as follows:

$$h_{bst} = \alpha + \beta_1 * \text{treated}_b * \text{erosion}_s + \beta_2 * \text{patriarchy}_s * \text{treated}_b * \text{erosion}_s + \psi * x_{bst}' + \theta_s + \lambda_b + \eta_t + \gamma_s + u_{bst} \quad (3)$$

Here, the original treated_b*erosion_s term is interacted with a binary variable taking the value 1 for states more patriarchal than the sample average. This variable is based on a a patriarchy index containing measures of customary (that is, not economically strategic or rational) sexism.[66] The index is constructed using data on female suffrage,[67] the female-friendliness of state divorce laws,[68] sex ratios in childhood,[69] and the average normalized marital age gap[70] (see Data Appendix for a detailed definition of the underlying patriarchy index).

Adverse effects here can be interpreted in two ways. First, they may be seen as a more dramatic initial insult due to the Dust Bowl shock, under the assumption that women in more patriarchal states were already customarily disadvantaged in the intra-household

[64] C. Goldin and L. Katz (2002), and M. Bailey (2006).
[65] As in the case of race in S. Bhalotra and A. Venkataramani (2012).
[66] The distinction between customary and rational discrimination is necessary given the "earner bias" in intra-household allocation found in studies such as D. Meredith and D. Oxley (2013), and the portion of the gender wage gap attributed to legitimate gender differences in productivity and time worked in studies such as C. Goldin (1990). Such differences are sometimes mistaken for gender bias although they represent strategic responses to women's work or earning potential.
[67] M. Shuler (1920).
[68] M.S. Jones (1987).
[69] U.S. Census Bureau (1933).
[70] S. Ruggles et al. (2010).

allocation of resources prior to the Dust Bowl, and that this made them more susceptible to the Dust Bowl shock. Second, they may be interpreted as a poorer compensatory investment response by parents in children who would enjoy low returns to human capital investments as a result of cultural or institutional sexism.[71]

If customary patriarchy influenced a child's resilience to Dust Bowl shocks and/or the compensatory investment response made by parents, we would expect to see an adverse effect on women in patriarchal states but not on men in those same states. Indeed, patriarchy strengthens the effect of the Dust Bowl shock for women: those born in more patriarchal states have a 1.73% higher likelihood of cognitive disability and a 2% higher likelihood of vision and hearing difficulty than exposed women in less patriarchal states. However, men experience adverse outcomes as well. Namely, an exposed man in a more patriarchal state sees a roughly $18.31 increase in welfare receipts and a 0.711% higher likelihood of self-care and independent mobility difficulty than his exposed counterpart in a less patriarchal state.

That both men and women experience negative outcomes due to patriarchy indicates that patriarchy places burdens on men and women alike, especially in ways that reflect prevalent gender norms and divisions of labor, for instance by upholding male breadwinner norms and penalizing men who, perhaps due to early-life health insults, fail to conform to these pressures.

Although patriarchy may generally worsen the effects of the Dust Bowl, it is notable for making the positive effect of Dust Bowl exposure on high school completion considerably larger for both men and women. Here, women experience the most dramatic rise in high school completion: exposed women in more patriarchal states are 6.52% more likely than exposed women in less patriarchal states and 8.86% more likely than unexposed women to complete high school. (For men, the figures are 4.76% and 5.91%, respectively). These results may, like the results on agriculture, reflect relative changes to the opportunity costs of schooling for boys and girls due to a drop in the demand for gendered household chores and child labor.[72] Thus, the Dust Bowl was a disruptive force, even if temporarily, in patriarchal states, where girls' opportunity cost of schooling perhaps stood to drop the most as demands on their time spent in household work relaxed, both in absolute terms and as relative to their brothers.

[71] Per S. Bhalotra and A. Venkataramani (2012), who find that racial barriers in access to institutions lowers returns to human capital amongst African-Americans, and thus reduces responsive investments by parents.

[72] S. Bhalotra (2007), pp. 46-7, for example, finds cash transfers reduce the need for child labor and thus the opportunity cost of schooling for boys but not for girls, for whom patriarchal cultural norms, differences by gender in the type of child labor, and low returns to education may be to blame for the lack of response to such cash transfers.

Developmental Stage

In order to pinpoint the effect of the age at which the Dust Bowl shock occurs, I estimate equation (1), substituting the proportion of a given developmental age band spent during the Dust Bowl period for the original $treated_b$ term. Thus, where all those aged -1 to 12 at any point between 1930 and 1940 would have been counted as treated on a binary basis, now each individual receives a duration-weighted measure of exposure during each development stage, which are defined as follows: -1 to 0 (*in utero*/neonatal), 1 to 3 (infancy), 4 to 6 (early childhood), 7 to 9 (prime school age), and 10 to 12 (early adolescence). (See Data Appendix for further discussion of development stage measures).

In Table 4 I report the β_1 values from these of regressions for men, and in Table 5, for women. Patterns by outcome and developmental stage are also plotted in Figures 3-12. I find that age at exposure matters, both to the severity of adverse effects and to the significance of effects; indeed, disentangling effects by developmental stage allows me to clarify pathways of impact that the baseline or overall regressions obscure.

For men, adverse effects on poverty, disability, and age at marriage outcomes are worst amongst those exposed *in utero* and in infancy, consistent with congenital health defect and maldevelopment explanations of later-life outcomes. These explanations are most intuitive in understanding disability outcomes, which may result from the Dust Bowl's effects on fetal/infant nutrition and health, whether directly, or indirectly through poor maternal health or low incomes in childhood. We might expect poor socioeconomic outcomes to result from poor labor market readiness or employability, perhaps due to shocks at school or child labor age. However, given the greatest adverse impacts for poverty and age at marriage outcomes is in early childhood, these results suggest that poor health and development complications rather act (perhaps through disability) to produce lower adult socioeconomic status.

Men exposed during the -1 to 0 age band get married 0.21 years younger, and those exposed between ages 1 and 3 get married 0.193 years younger; notably, these negative effects on age at marriage for the treated cohorts are found above and beyond the national trend in declining ages at marriage during the period (see Figure 2a). Men exposed from ages -1 to 0 receive $16.29 more in welfare income, while those exposed from 1 to 3 receive $14.15 more. Physical disability rates rise as well: men exposed *in utero* are 1.69% likelier to suffer physical disability, while those exposed in infancy are 1.89% likelier to be physically disabled. Adverse effects appear to dampen as the age of exposure rises, except notably in disability outcomes; in the early adolescence period, shocks that in early childhood produced greater likelihoods of physical disability instead produce lower likelihoods of physical and vision and hearing disabilities.[73]

Indeed, those exposed in late childhood—that is, school age and beyond—also enjoy better outcomes than their unexposed counterparts in high school completion: men exposed

[73] These findings are consistent with theory in J. Heckman (2007), F. Cunha and J. Heckman (2008), and D. Almond and J. Currie (2011a).

between the ages of 7 and 9 see a 3.42% greater chance of finishing high school; amongst men exposed between 10 and 12, the increase in the probability of high school completion is 3.61%. Positive outcomes on schooling may appear counterintuitive on their face, although the age at impact for this outcome, together with the results on farm-dependence, suggest that secondary schooling rates may have risen as the collapse of agricultural incomes reduced chances for child labor and decreased the opportunity cost of schooling.[74]

For women, fertility outcomes are negatively impacted across developmental stages, while college completion, poverty, and disability effects are worst in early childhood, and high school completion rates are most positively affected in later childhood.

Women exposed to the Dust Bowl from ages 1 to 12 face a 0.184 to 0.268-child reduction in fertility, with the greatest adverse impact occurring in the 4 to 6 age range. That fertility reduction effects are greatest well before puberty, and that they occur in the absence of rises in age at marriage or in labor force participation, suggests early damage to reproductive health, perhaps through poor nutrition or endocrinal maldevelopment. This non-negligible decline in fertility amongst women exposed to the Dust Bowl is especially remarkable in light of the baby boom experienced by their unexposed counterparts in the 1918-1941 birth cohort. Women exposed between the ages -1 and 6 also had a 1.36-1.54% lower chance of completing college, with the greatest adverse effects accruing to those exposed *in utero*. A similar pattern follows for probability of poverty (0.728% higher for those exposed -1 to 0 and 0.509% higher for those exposed 1 to 3) and for physical disability (1.28% higher for those exposed *in utero*) and self-care and independent mobility difficulty (0.574% higher for those exposed *in utero*). As was the case for men, chances of disability decrease in later childhood, and the greatest positive effects on secondary schooling occur amongst schooling-age children: an increase of 4.89% in the probability of high school completion amongst women exposed between ages 7 and 9, and an extraordinary 6.39% increase amongst those exposed between 10 and 12.

For both men and women, the preponderance of adverse effects for health- and ability-related outcomes in early childhood suggest that the pathway of impact is largely through problems in capability formation, while the positive effects observed for secondary schooling in later childhood implicate labor markets and access to public services.

3.3. Robustness

As discussed above, results are robust to the definition of Dust Bowl severity—that is, the $erosion_s$ term in equation (1). Results are also robust to alternate definitions of the timing of Dust Bowl exposure ($treated_b$ in equation (1)), such as those just discussed, that narrow the treatment period from childhood as a whole to specific age ranges spent during the Dust Bowl period.

[74] Studies such as D. Worster (1979) describe the destruction of farms during the Dust Bowl, while R. Whaples (2005) establishes the high rates of child farm labor prior to this period. K. McNay et al. (2005) discusses the relationship between availability of profitable child labor opportunities and schooling rates.

Results for specifications including controls for veteran status (to account for possible G.I. Bill benefit effects on postsecondary education and income/wealth[75]) and drought (to account for Dust Bowl effects not fully captured by erosion alone[76]) are similar to those obtained in the baseline (not reported).

Results are also robust to alternate means of clustering and to the removal of trends (not reported). Under these less rigorous specifications—first, clustering by birth state alone, and second, removing state trends—the signs and magnitudes of β_1 remain intuitive and similar to those in the baseline. As might be expected of these specifications, many more coefficients are statistically significant: most notably, those on high school completion (effects large and positive) and age at marriage (effects large and negative).

Confounding Factors & Threats to Inference

The period under study coincides with three major phenomena that could be said to have confounded effects here attributed to Dust Bowl exposure: the Great Depression, which could have affected childhood incomes independently of the Dust Bowl; migration from the Great Plains to the American West, which could have affected duration of treatment and selection into the sample; and selection into (fertility) or out of (mortality) the sample. These should not, however, confound my analysis for the following reasons:

The Great Depression

First, the differences-in-differences model is designed to exploit both spatial and temporal variation in Dust Bowl exposure.[77] As such, it tests for the effect of differences in severity of Dust Bowl exposure even within cohorts in which all individuals were exposed to the Depression, thus isolating in the coefficient β_1 the treatment effect of the Dust Bowl above and beyond any effects of the Great Depression. Second, I control for a variety of fixed effects and trends. These include birth state fixed effects, which takes into account a state's level of economic development and average per capita incomes, and state trends, which captures trends in state income, economic performance, and public spending over time. Only if the Depression's effects varied dramatically within a state (for instance, spatially or demographically) might such a control be insufficient to capture the average effect of the Depression on all individuals in a given state. Thus, I would have liked to have been able to control for an individual's household income during childhood; unfortunately, however, these figures are not available in the census. Nevertheless, the inclusion of state fixed effects and state trends should account for state-by-state variation in economic performance or shocks beyond those due to the Dust Bowl. Similarly, since the Depression constituted a country-wide shock, the birth year fixed effects included in the model should further control for any such national events like the stock market crash in 1929 that may affect later-life outcomes, for instance, through household incomes in childhood.

[75] G. Altschuler and S. Blumin (2009).
[76] G. Cunfer (2005) and R. Hornbeck (2012a) draw the distinction between drought and erosion effects and timing.
[77] J. Angrist and J.S. Pischke (2009), pp. 227-43.

Migration

First, as discussed in Section 2.1, since migration status during childhood is unknown, equation (1) proceeds as an intent-to-treat analysis and should not be interpreted as a measure of actual treatment. As such, the estimates of adverse effects presented here are a lower bound on the true treatment effect of the Dust Bowl. In fact, regressions disaggregating outcomes experienced by migrants from those of non-migrants by interacting likely migrant status (defined as individuals residing outside their birth state as adults; see Data Appendix) with the Dust Bowl exposure term indicate that migrants had similar-to-significantly-better wellbeing outcomes than non-migrants (not reported), again suggesting that the adverse effects presented here are less severe than those experienced by actual exposed non-migrants.

Second, it is unlikely that individuals would have escaped treatment during the most critical phase for the shaping of outcomes. I find that the adverse impact of the Dust Bowl on later-life outcomes is greatest amongst those exposed *in utero* and in the first year of life, a narrow and precarious period in a family's life cycle, during which out-migration is unlikely to have occurred. Furthermore, differences-in-differences regressions of children's migrant status (that is, whether a child moved out of their birth state between the treatment ages of birth and age 12) on Dust Bowl exposure and a variety of individual and household characteristics, using data on children 12 and under from the 1% samples of the 1920, 1930, 1940, and 1950 US Censuses,[78] indicate that neither Dust Bowl treatment nor this same term interacted with measures of household income and socioeconomic status, are significant in determining the likelihood of migration in childhood (not reported). In fact, Dust Bowl-exposed children from farm households were 31.6% less likely to have migrated before age 12 than the nonfarm exposed. As such, interstate migration during the childhood treatment window is unlikely to influence exposure measures.

Third, it is unclear whether out-migrants would have had systematically different characteristics than those who stayed in the sample region; while some accounts suggest that those with the means to migrate did, yet others suggest that those who held greater land and wealth felt tied to these assets and were thus reluctant to leave.[79] The regressions on childhood migrants discussed above, wherein household characteristics on the whole have no significant impact on migrant status, corroborate these qualitative accounts. Indeed, even the severity of Dust Bowl exposure in childhood does not have an effect on eventual migration: regressions of the effect of Dust Bowl exposure on migrant status as adults show no statistically significant effects of exposure on the decision to migrate for men or women (not reported).

[78] S. Ruggles et al. (2010).

[79] D. Nealand (2008), and K. Burns et al. (2012), and D. Worster (1979), Ch. 8.

Fertility Selection

Work on famine indicates that often in such periods of crisis, only those who can afford to provide for children will choose to continue bearing them.[80] If such a phenomenon were at play in my data, I would expect that women of greater means and socioeconomic status would continue to have children during the Dust Bowl, while poorer mothers would choose not to until the crisis had passed. Such behaviors would mean the individuals likely to be most resilient to and most capable of compensating for the Dust Bowl shock would disproportionately enter my sample, while many of the most vulnerable would never been born at all, thus overstating adult wellbeing and underestimating the adverse effects of the shock. I test for fertility selection into my sample using data on ever-married women from the 1% samples of the 1920, 1930, 1940, and 1950 US Censuses.[81] Similar to the specification in (1), using a differences-in-differences model I test for whether ever-married women enumerated in 1940 had fewer children in the preceding 10 years (that is, for those enumerated in 1940, had fewer children during the Dust Bowl), or had lower probabilities of having had a child in the preceding 10 years, than those ever-married women not exposed to the Dust Bowl. I interact the Dust Bowl treatment term with measures of household income, socioeconomic status, farm status, and maternal education. I find no statistically significant differences in fertility between higher- and lower-socioeconomic status women in response to the Dust Bowl (not reported). Similar differences-in-differences analysis of yearly state-level US Vital Statistics birth rate data spanning 1915-60[82] corroborates that birth rates and erosion timing/severity have little relationship: states experienced no significant change in birth rates during the Dust Bowl period (not reported), a finding consistent with Fishback et al. (2007)[83].

Mortality Selection

Given that the individuals in the Dust Bowl cohort are aged 39-62 when I first observe them as adults in the 1980 Census, and are 59-82 by the time I observe them for the final time in 2000, survivorship bias may be a concern. That is, it is possible that many of the individuals in poorest health as a result of Dust Bowl exposure may have died at some point before being observed in 1980, biasing the health and wellbeing outcomes of individuals appearing in my sample upwards. I thus test for differences in yearly state-level stillbirth rates and infant mortality rates over the period 1915-1960,[84] using a differences-in-differences model as above. I find no significant change in either measure of early-life mortality (not reported). I also use the differences-in-differences approach on decadal state-level mortality rates from 1930-2000[85] to test for whether the Dust Bowl cohort had significantly higher mortality rates at any stage (under age 1, 1-4, 5-14, 15-24, 25-34, 45-

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[80] C. Ó Gráda (2011).
[81] S. Ruggles et al. (2010).
[82] Public Health Service (1947) and National Center for Health Statistics (1968).
[83] P. Fishback et al. (2007).
[84] Public Health Service (1947) and National Center for Health Statistics (1968).
[85] Public Health Service (1947); National Center for Health Statistics (1968, 1974, 1985, and 1994); Centers for Disease Control and Prevention (2000a, 2000b, and 2013); and National Bureau of Economic Research (2006).

54, 55-64, 65-74, and 74-85) up to and including my observation period, than those not exposed. I find no significant difference in mortality rates by age bin for the Dust Bowl cohort, except for in the 5-14 age bin, during which boys in the Dust Bowl cohort experienced marginally (0.406 point) lower mortality rates than those not exposed, and in the 55-64 age bin, during which men exposed to the Dust Bowl as children experienced a 3.212-point lower mortality rate than their unexposed counterparts (not reported). These results indicate that mortality selection and survivorship bias are unlikely to influence my results.

4. DISCUSSION

These results indicate that the primary pathway of impact on later-life health was likely through poor prenatal and early-life conditions rather than through direct health and educational insults in childhood. The finding that disability outcomes are determined *in utero* and within the first year of life is intuitive enough, given the literature on fetal programming. However, it is striking that this indirect health and early-life development pathway would also be responsible for outcomes like college completion and poverty, which might more intuitively be associated with direct disruptions in schooling and labor-market preparedness occurring in later childhood. Indeed, given that high school completion rates rise amongst the exposed, why didn't college completion rise as well, and poverty levels fall with this acquisition of education? The answer might be that cognitive and physical impairments accrued *in utero* influenced individuals' ability to enter and complete college, to hold down jobs, and to earn income as adults.

The fact that strong adverse effects for disability, poverty, and college completion are found amongst those exposed *in utero* suggests that the Dust Bowl acted primarily through unsuccessful fetal development rather than through childhood illness or school absence. Such prenatal maldevelopment may result from household income shocks that lowered levels of maternal nutrition, and made mothers both more vulnerable and less resilient to health shocks such as respiratory disease. Added to the evidence presented here indicating that the Dust Bowl's effects were more severe amongst the more farm-dependent, it is possible that despite the representations in art and culture that emphasize the direct health impacts of the Dust Bowl, it may be better interpreted as a fundamentally economic shock that had permanent health consequences.

Indeed, the most intriguing result, that of substantial increases in high school completion amongst those exposed, also suggests the importance of shocks to agricultural incomes.[86] Together with the evidence that high school completion rates surged amongst those exposed to the Dust Bowl in prime schooling age (7-12), which incidentally corresponds to the ages at which children may have been employed in household and farm work[87]; and the

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[86] D. Cutler et al., pp. 13245-6; and D.Worster, pp. 120-6. C. Ó Gráda (2011) discusses a phenomenon in the famine literature by which many wellbeing outcomes are actually improved by exposure, although these impacts are generally the result of mortality and fertility selection and are more numerous than the positive effects seen here.

[87] U.S. Department of Labor (2007).

evidence that Dust Bowl effects were more severe in more agriculture-dependent states; the observed increase in high school completion implies that a reduction in the need for child labor in agriculture following the destruction of farms and the collapse of agricultural incomes, may have dropped the opportunity cost of secondary schooling for school/working-age children who now had no more profitable way to spend their time.[88] Of course, increased high school completion rates may also reflect increased public spending[89]—for instance, on school-building—as a response to the natural disaster, a matter currently under investigation.

Notably, high school and college completion rates are impacted at different developmental stages: the former in late childhood, and the latter prenatally. This contrast underlines the importance of childhood time allocation concerns to the decision to primary and secondary school,[90] and the cognitive and intellectual capability barriers to college entry and completion.[91] While for present-day households credit constraints have been found less important than cognitive ability in determining college enrollment,[92] it should be noted that the same low incomes that may have played a role in producing poor college outcomes through poor fetal nutrition and thus cognitive impairments *in utero,* may also have produced poor college outcomes through constraints on a parent's ability to afford college.

I now continue with the findings on education, but turn attention to the role of gender. I find that women see a steeper decline in the probability of college completion than do men; given the likely role of cognitive maldevelopment in lowering college completion rates, this finding suggests that cultural sexism may have lowered female enrolments and performance even where cognitive ability across genders was the same[93] or that households in this period may have weighed child ability more heavily in the decision to send a child to college when the child was a girl. For contrast, I find that exposed women saw larger increases in the probability of high school completion than exposed men. Whether women gained more relative to men because their household and farm labor had previously been more intensively employed than that of their brothers, or because after the Dust Bowl began there was greater use for male than female farm and household labor is unclear. However, perversely, and at least in terms of high school completion, the Dust Bowl was good for women, and may have served as an equalizer that helps explain their lower rates of poverty than their male counterparts (although it is possible that marriage market effects, such as the possibility that exposed men's marriage prospects suffered

[88] D. Worster (1979) discusses the collapse of aàiculture in the Great Plains during the Dust Bowl, while R. Whaples (2005) finds extensive child farm labor in the 10-15 age range in 1930. K. McNay et al. (2005) indicates the link between child labor opportunities and schooling rates.
[89] P. Fishback et al. (2006) discuss infrastructure projects, such as school construction, completed under the New Deal, as well as the migration response to these projects.
[90] K. McNay et al. (2005), p. 666; K. Clay et al. (2012), p. 8; C. Moehling (1999); S. Bhalotra (2007).
[91] J. Heckman, p. 13252.
[92] J. Heckman, p. 13252.
[93] American Psychological Association (2006).

relative to exposed women's due to male breadwinner expectations, could explain the differences by gender in poverty magnitudes.)[94]

A similar male breadwinner burden may explain the results found on the role of cultural and institutional patriarchy in influencing parental human capital investment responses. Here, patriarchy was found to exacerbate the Dust Bowl's effects for both men and women, indicating that parents in more patriarchal states did not compensate for Dust Bowl insults to the degree that parents in less patriarchal states did, especially for women. Furthermore, adverse effects reflect customary gender roles of the period[95]: for instance, they are especially punitive of Dust Bowl-exposed men who due to poor health endowments may have been less capable of success in the labor- and marriage markets.[96]

Indeed, the influence of gender roles and the division of labor into household (female) and extra-household (male) spheres[97] is seen even more generally in the main results, where women's adverse outcomes in fertility and post-secondary education echo their role as homemakers, and where men's adverse outcomes in disability and poverty reinforce burdens on their ability to earn a living outside the home.

On the issue of parental investment response, the results on patriarchy indicate that parents did indeed make compensating investments in child human capital, as evidenced by the fact that adverse outcomes were less severe for those in less patriarchal states. Here, however, it is difficult to disambiguate whether patriarchy made individuals more susceptible to shocks, thus lowering the initial endowment by a greater degree than in less patriarchal states, or whether lower returns to human capital investment caused parents in more patriarchal states to make investments that reinforced rather than compensated for losses in the child's human capital endowment, losses which would have been equivalent to the initial losses sustained by those in less patriarchal states. Similarly, the fact that farm-dependent individuals were more responsive to Dust Bowl treatment either indicates that they were harder-hit by the shock, which is likely since it directly affected agriculture, or that they received fewer compensating investments. However, given that farm incomes were affected, the failure of households to make compensatory investments need not be taken as evidence of a strategic decision to reinforce the lowered child endowment. For instance, poor households such as these may have faced credit constraints limiting the possibility of investment in health and education, even where the parental will to invest existed.[98] Similarly, parents may have invested less in ameliorating health insults if their investment decisions anticipated a lack of old-age support from their children,[99] especially in light of the absence of a social safety net the likes of which would eventually be

[94] D. Almond et al. (2007) find marriage market effects of the 1959-61 famine in China, albeit they find women suffered poorer matches in the marriage market due to increased male mortality.
[95] S. Ware; and R. Lynd and H. Lynd (1937).
[96] For example, see C. Goldin (2002), where as in other studies of marriage markets, income prospects are paramount in determining matches.
[97] S. Ware; and R. Lynd and H. Lynd (1937).
[98] For a theoretical discussion, see D. Almond and J. Currie (2011b), p. 1327, where parents' utility trades off the child's human capital against the parents' own consumption, subject to a budget constraint.
[99] V. Bhaskar and B. Gupta (2012).

implemented as a part of the New Deal.[100] However, if the findings here on investment are interpreted as in S. Bhalotra and A. Venkataramani (2012), these imply that households made compensating rather than responsive investments in human capital, a finding that is striking since much of the literature on human capital upholds a reinforcing-investments explanation of shock- and intervention-response even while the multi-stage model of human capital formation allows for the possibility of compensating investments, for instance, in early childhood, when these investments are most likely to be productive and efficient.[101]

5. CONCLUSION

Using a differences-in-differences approach, I leverage variation in Dust Bowl exposure in childhood to explain variation in adult human capital and socioeconomic outcomes. Testing for the effects of agriculture-dependence, patriarchy, and developmental stage at impact allows me to identify the channels through with the Dust Bowl had greatest adverse impact. Through this analysis, I show that the Dust Bowl had meaningful long-term health and human capital costs for those exposed as children. For women, fertility and college completion rates fell, while poverty rates rose. For men, age at marriage fell, while poverty rates, welfare receipts, and disability rates rose. Notably, the adverse effects on the preceding outcomes were most severe for those exposed *in utero* and in early childhood, implicating an indirect health pathway—that is, poor prenatal nutrition and health, and through it, disrupted capability development—in the production of these impacts. For all, but especially for women, high school completion rates rose; these impacts, for contrast, were greatest amongst children in late childhood and early adolescence, when the tradeoff between child farm labor and formal schooling likely dictated time use. Thus, when agricultural livelihoods fell off, as indicated both by the secondary literature and by the income-pathway effects shown here among the farm-dependent, the opportunity cost of schooling likely fell, prompting increased high school attendance but not college attendance, where cognitive ability—which suffered as a result of Dust Bowl exposure—was a barrier to entry. Results on patriarchal and farm-dependent states suggest that households made human capital investments that compensated for rather than reinforced poor initial endowments.

My analysis is limited by a key weakness in census data: the lack of information on individuals' circumstances as children. Although this prevents analysis of the effect of differences in parental characteristics or household farm and socioeconomic status in childhood, the limitation is most detrimental to establishing an individual's birthplace and thus accurately gauging their Dust Bowl exposure. Since only an individual's birth state is listed in the census, adult outcomes cannot be linked to erosion at a more granular level. As such, great spatial variation in childhood Dust Bowl exposure is aggregated to the state

[100] Social Security Administration (2005).
[101] D. Almond et al. (2009) and S. Bhalotra and A. Venkataramani (2012) find empirical evidence of reinforcing investments; D. Almond and J. Currie (2011a), pp. 1326-7 and J. Heckman (2007), p. 13253 discuss the possibility of compensatory investments where investments in different periods are substitutable.

level, entailing a loss in predictive power over adult outcomes, in which there is naturally considerable variation. The county-level population-weighting I have employed in the construction of state-level exposure variables does, however, allow for a more realistic measure of spatial variation in the severity of exposure. Furthermore, the inclusion of controls and farm population weights provide a rough proxy for childhood economic circumstances, while the facts that these results are intent-to-treat estimates and are disaggregated by developmental stage mitigate concerns about the age at and duration of treatment. Indeed, as intent-to-treat rather than treatment-on-the-treated estimates, my results represent the lower bounds on the actual later-life effects of childhood Dust Bowl exposure. Together, these strategies attempt to overcome the data's limitations until the expiry of the 72-year rule for this generational cohort allows for back-linkage through censuses to actual, granular childhood residency and household details.

The results presented here represent an important contribution to our understanding of the impacts of the Dust Bowl; namely, they show quantitatively that exposed children suffered long-term and practically meaningful damage to health and human capital,[102] and that there is a role for compensating investments in mitigating environmental insults to health.[103] This study also offers policy-relevant findings, for example, adding to the literature urging intervention in child labor as a means of boosting schooling,[104] and substantiating the hypothesis that college-readiness is largely determined *in utero* and in early childhood and suggesting that postsecondary educational interventions should be targeted accordingly.[105] Perhaps most intriguing is the finding that economic shocks can have as large an effect on health as shocks directly targeting health.

[102] Magnitudes are similar to those found in studies such as S. Bhalotra and A. Venkataramani (2012) and D. Almond and J. Currie (2011a).

[103] D. Almond et al. (2009) in the case of a negative shock and S. Bhalotra and A. Venkataramani (2012) in the case of a positive intervention emphasize the role of reinforcing investments.

[104] Either in complement with schooling reforms per K. Clay et al. (2012) and K. Basu (1999) or via alleviation of poverty constraints per S. Bhalotra (2007; rather than through child labor restrictions, which have been shown in C. Moehling (1999) to be ineffective in influencing schooling outcomes, or through anti-child labor trade sanctions, which K. Basu (1999) suggests can expose children to poverty and more hazardous work.

[105] J. Heckman (2007), and F. Cunha and J. Heckman (2008).

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Table 1 — Summary Statistics

	All		Men		Women	
	Mean	N	Mean	N	Mean	N
Age at First Marriage	22.09	1,379,007	23.47	638,996	20.90	740,011
Children Ever Born	2.40	1,601,986			2.40	1,601,986
Probability of Completing High School	0.70	1,590,689	0.70	760,484	0.70	830,205
Probability of Completing College	0.15	1,590,689	0.18	760,484	0.12	830,205
Welfare Income	101.08	4.256,983	73.56	1,997,206	125.41	2,259,777
Probability of Poverty	0.12	4,256,983	0.10	1,997,206	0.14	2,259,777
Probability of Cognitive Disability	0.08	4,256,983	0.07	568,197	0.09	657,791
Probability of Physical Disability	0.19	1,225,988	0.17	568,197	0.21	657,791
Probability of Vision & Hearing Difficulty	0.08	1,225,988	0.09	568,197	0.08	657,789
Probability of Self-Care & Independent Mobility Difficulty	0.12	2,666,294	0.10	1,236,722	0.14	1,429,572

Table 2 — Impact of Childhood Exposure to the Dust Bowl on Later-Life Outcomes

	Baseline (1)		Δ Farm Values (2)		Drought (3)	
	Men	Women	Men	Women	Men	Women
Age at First Marriage	-0.132 (0.139)	-0.00343 (0.123)	-0.249* (0.128)	-0.152 (0.121)	-0.00347*** (0.00036)	-0.00278*** (0.0004)
Children Ever Born		-0.206 (0.132)		0.0659 (0.115)		0.00147* (0.00081)
Probability of Completing High School	0.0169 (0.0152)	0.0307 (0.0192)	0.0236 (0.0165)	0.0371** (0.0176)	0.000209** (8.74E-05)	0.000425*** (8.68E-05)
Probability of Completing College	-0.0107 (0.0075)	-0.0117** (0.00536)	-0.0000172 (.00908)	-0.00678 (0.00552)	5.30E-05 (8.51E-05)	-7.34E-05 (5.48E-05)
Welfare Income	15.05* (9.147)	16.54 (10.2)	22.83*** (6.884)	15.37** (6.414)	0.215*** (0.0465)	0.0566 (0.121)
Probability of Poverty	0.00802* (0.00419)	0.00466* (0.00278)	0.0111* (0.00577)	0.00363 (0.00645)	7.63e-05*** (2.91E-05)	3.83E-05 (2.58E-05)
Probability of Cognitive Disability	0.00654 (0.00685)	-0.00538 (0.00618)	0.003 (0.0102)	0.0145** (0.00655)	9.76e-05*** (3.55E-05)	0.000116*** (3.11E-05)
Probability of Physical Disability	0.0110*** (0.00408)	-0.0021 (0.011)	0.00687 (0.0102)	-0.0144 (0.00908)	-5.93E-06 (5.06E-05)	-0.000217*** (7.62E-05)
Probability of Vision & Hearing Difficulty	-0.00273 (0.00662)	-0.00228 (0.005)	0.00802 (0.00667)	0.00942** (0.00369)	0.000102* (5.38E-05)	-1.87E-05 (3.43E-05)
Probability of Self-Care & Independent Mobility Difficulty	-0.00028 (0.00388)	-0.00146 (0.00293)	0.0112* (0.00475)	0.0129*** (0.00425)	5.26e-05*** (1.71E-05)	-1.62E-05 (3.58E-05)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$; Note: Table reports $treated_b$*$erosion_s$ coefficients. Each row in the left-hand column refers to the regression's dependent variable, while the remaining column headings indicate the definition of Dust Bowl severity (i.e. $erosion_s$) used. All regressions are estimated by OLS and include controls for race; birth year, birth state, and census state fixed effects; and state trends. Standard errors, clustered by birth state and birth year, are reported in parentheses below each coefficient.

Table 3 — Impact of Childhood Exposure to the Dust Bowl on Later-Life Outcomes: Mechanisms

		Farm (1)		Farm * Erosion (2)		Patriarchy * Erosion (3)	
		Men	Women	Men	Women	Men	Women
Age at First Marriage	*Main*	-0.219	-0.056	-0.132	0.0241	-0.1	0.0156
		(0.211)	(0.186)	(0.135)	(0.111)	(0.125)	(0.11)
	Interaction			1.04E-05	-0.101	-0.286	-0.171
				(0.109)	(0.0778)	(0.204)	(0.122)
Children Ever Born	*Main*		-0.345*		-0.122		-0.219
			(0.199)		(0.0857)		(0.144)
	Interaction				-0.311		0.109
					(0.214)		(0.16)
Probability of Completing High School	*Main*	0.0318	0.0473	0.00898	0.0264*	0.0115	0.0234
		(0.0211)	(0.0297)	(0.0108)	(0.0152)	(0.0107)	(0.0143)
	Interaction			0.0292*	0.016	0.0476***	0.0652***
				(0.0168)	(0.0294)	(0.0143)	(0.0119)
Probability of Completing College	*Main*	-0.0153	-0.0209***	-0.0103	-0.0110**	-0.0105	-0.0125**
		(0.012)	(0.00736)	(0.00711)	(0.00478)	(0.00697)	(0.00583)
	Interaction			-0.0014	-0.00232	-0.00238	0
				(0.00503)	(0.00998)	(0.0102)	(0.00831)
Welfare Income	*Main*	21.47	23.26	17.29**	21.51**	12.87	15.97*
		(15.22)	(17.23)	(8.093)	(9.576)	(8.654)	(9.643)
	Interaction			-8.124	-18.2	18.31**	4.825
				(16.02)	(13.88)	(9.302)	(7.503)
Probability of Poverty	*Main*	0.0127*	0.00771*	0.0103**	0.00683*	0.00690*	0.00583**
		(0.00696)	(0.00425)	(0.00513)	(0.0038)	(0.00402)	(0.00296)
	Interaction			-0.00835	-0.00795*	0.00943	-0.0100*
				(0.00889)	(0.00459)	(0.00724)	(0.00608)
Probability of Cognitive Disability	*Main*	0.0114	-0.00832	0.00411	-0.00331	0.00769	-0.0075
		(0.0107)	(0.0102)	(0.00556)	(0.00388)	(0.00753)	(0.00632)
	Interaction			0.00845	-0.0074	-0.00917	0.0173*
				(0.0124)	(0.0134)	(0.0101)	(0.00892)
Probability of Physical Disability	*Main*	0.0173***	-0.00348	0.00974***	-0.00794	0.0126***	0.00178
		(0.00617)	(0.0187)	(0.00335)	(0.00943)	(0.0039)	(0.0117)
	Interaction			0.00437	0.0208	-0.0125*	-0.0317*
				(0.0106)	(0.0211)	(0.00652)	(0.0181)
Probability of Vision & Hearing Difficulty	*Main*	0.00104	-0.00464	-0.00306	-0.00315	-0.00352	-0.00472
		(0.0106)	(0.0084)	(0.00697)	(0.00415)	(0.0063)	(0.00427)
	Interaction			0.00114	0.00312	0.00627	0.0200***
				(0.00645)	(0.0112)	(0.00877)	(0.00702)
Probability of Self-Care & Independent Mobility Difficulty	*Main*	-0.00121	-0.00224	0.00041	-0.00309	-0.00116	-0.00188
		(0.0061)	(0.00482)	(0.00339)	(0.00275)	(0.00382)	(0.00225)
	Interaction			-0.00247	0.0059	0.00711***	0.00351
				(0.00541)	(0.00597)	(0.00272)	(0.0105)

*** p<0.01, ** p<0.05, * p<0.1; Note: Table reports $treated_b$*$erosion_s$ coefficients (main effect) and interaction*$treated_b$*$erosion_s$ coefficients (interaction effect). Each row in the left-hand column refers to the regression's dependent variable, while the remaining column headings indicate the definition of Dust Bowl severity (i.e. $erosion_s$) or the interaction used. All regressions are estimated by OLS and include controls for race; birth year, birth state, and census state fixed effects; and state trends. Standard errors, clustered by birth state and birth year, are reported in parentheses below each coefficient.

Table 4 — Impact of Exposure to the Dust Bowl by Development Stage on Later-Life Outcomes: Men

	Men				
	-1 to 0 (1)	1 to 3 (2)	4 to 6 (3)	7 to 9 (4)	10 to 12 (5)
Age at First Marriage	-0.21* (0.113)	-0.193* (0.114)	-0.0743 (0.113)	0.039 (0.114)	0.0368 (0.125)
Probability of Completing High School	-0.00524 (0.0139)	0.0105 (0.0133)	0.0188 (0.0124)	0.0342*** (0.0127)	0.0361** (0.0167)
Probability of Completing College	-0.011 (0.0103)	-0.00883 (0.00815)	-0.00719 (0.00648)	-0.00222 (0.00584)	-0.00237 (0.00631)
Welfare Income	16.29** (6.794)	14.15* (8.37)	5.762 (7.673)	8.366 (8.306)	5.422 (8.606)
Probability of Poverty	0.00387 (0.00323)	0.00311 (0.00365)	0.00402 (0.0037)	0.00426 (0.00358)	0.00651 (0.00402)
Probability of Cognitive Disability	0.0116 (0.00757)	0.00264 (0.00834)	-0.00592 (0.00729)	-0.0114 (0.0076)	-0.0121 (0.00948)
Probability of Physical Disability	0.0169*** (0.00423)	0.0189*** (0.0045)	0.0062** (0.00274)	-0.00539 (0.00839)	-0.0164** (0.00816)
Probability of Vision & Hearing Difficulty	0.00674 (0.00542)	0.00812 (0.0068)	-0.001 (0.00803)	-0.0114 (0.00799)	-0.0154* (0.00863)
Probability of Self-Care & Independent Mobility Difficulty	0.00253 (0.00411)	-0.00236 (0.00414)	-0.00784** (0.00381)	-0.00569 (0.00424)	-0.00507 (0.00433)

*** p<0.01, ** p<0.05, * p<0.1; Note: Table reports $treated_b$*$erosion_s$ coefficients. Each row in the left-hand column refers to the regression's dependent variable, while the remaining column headings indicate the developmental stage that defines $treated_b$. All regressions are estimated by OLS and include controls for race; birth year, birth state, and census state fixed effects; and state trends. Standard errors, clustered by birth state and birth year, are reported in parentheses below each coefficient.

Table 5 — Impact of Exposure to the Dust Bowl by Development Stage on Later-Life Outcomes: Women

	Women				
	-1 to 0 (1)	1 to 3 (2)	4 to 6 (3)	7 to 9 (4)	10 to 12 (5)
Age at First Marriage	-0.0757 (0.115)	-0.0384 (0.129)	0.0329 (0.125)	0.0574 (0.132)	0.0768 (0.105)
Children Ever Born	-0.165 (0.103)	-0.241* (0.131)	-0.268* (0.138)	-0.238* (0.132)	-0.184* (0.111)
Probability of Completing High School	-0.0128 (0.00901)	-0.00072 (0.0129)	0.0203 (0.0178)	0.0489** (0.0221)	0.0639** (0.0278)
Probability of Completing College	-0.0154*** (0.00397)	-0.0136*** (0.00354)	-0.0144** (0.00633)	-0.0104 (0.00651)	-0.00481 (0.0064)
Welfare Income	14.9** (7.103)	14.19 (9.361)	10.85 (9)	13.47 (11.07)	12 (11.38)
Probability of Poverty	0.00728*** (0.00275)	0.00509* (0.0028)	0.00103 (0.00308)	0.00227 (0.00235)	0.000504 (0.00334)
Probability of Cognitive Disability	0.00821 (0.00532)	3.35E-05 (0.00599)	-0.00702 (0.00486)	-0.0153*** (0.00427)	-0.0208*** (0.00226)
Probability of Physical Disability	0.0128* (0.00713)	0.00538 (0.00786)	-0.0119 (0.00952)	-0.0191** (0.00935)	-0.0252** (0.00999)
Probability of Vision & Hearing Difficulty	0.00109 (0.00424)	0.00287 (0.00375)	-0.00079 (0.00398)	-0.00433 (0.00499)	-0.00513 (0.00582)
Probability of Self-Care & Independent Mobility Difficulty	0.00574* (0.00321)	-0.00023 (0.00296)	-0.00751** (0.00321)	-0.0104** (0.00487)	-0.00994* (0.00604)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$; Note: Table reports $treated_b$*$erosion_s$ coefficients. Each row in the left-hand column refers to the regression's dependent variable, while the remaining column headings indicate the developmental stage that defines $treated_b$. All regressions are estimated by OLS and include controls for race; birth year, birth state, and census state fixed effects; and state trends. Standard errors, clustered by birth state and birth year, are reported in parentheses below each coefficient.

Figures 1a-1d— Dust Bowl Severity

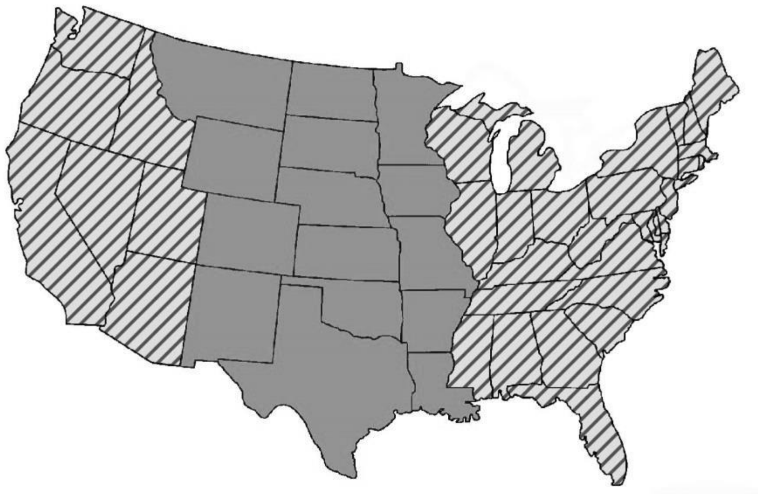

Figure 1a: Sample coverage

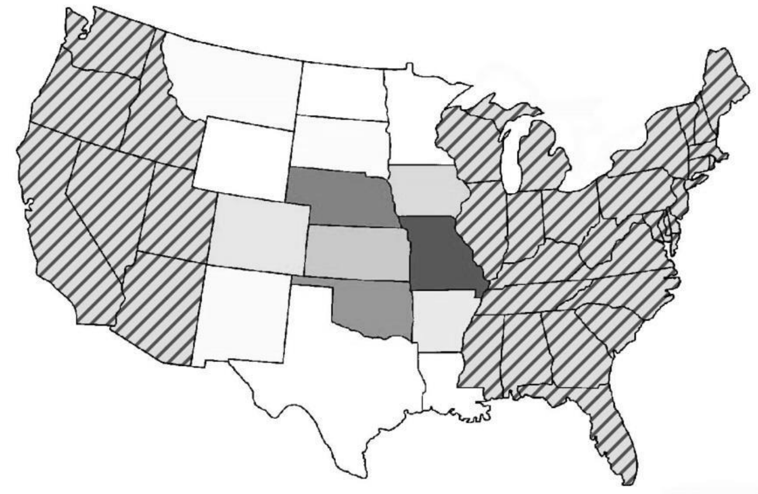

Figure 1b: Proportion of state population living in high erosion areas

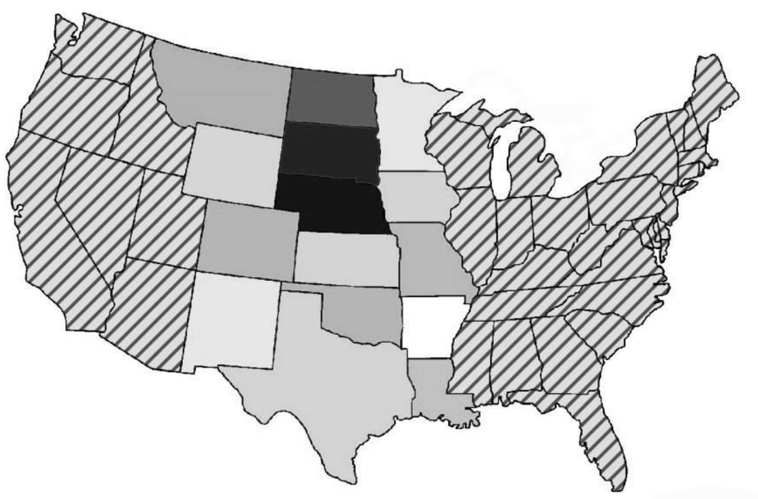

Figure 1c: Proportion of state population living in high farm value loss areas

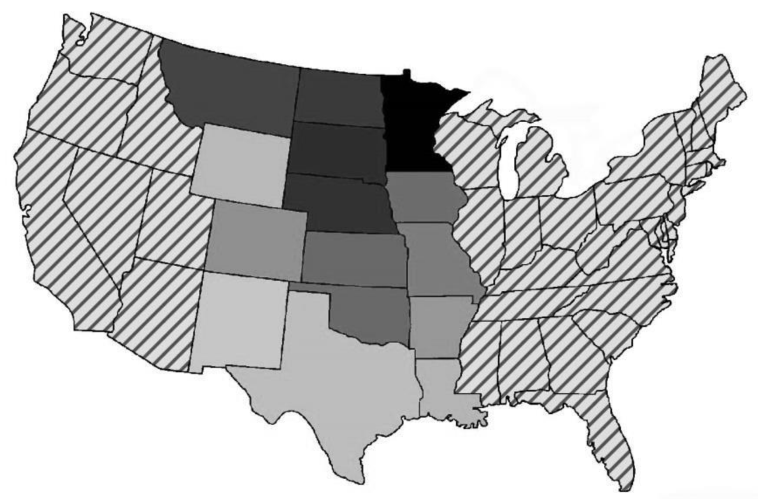

Figure 1d: Sum of magnitudes of drought events between 1930 and 1940

Figures 2a-2j— Summary Statistics: Average Later-Life Outcomes by Birth Year and Sex

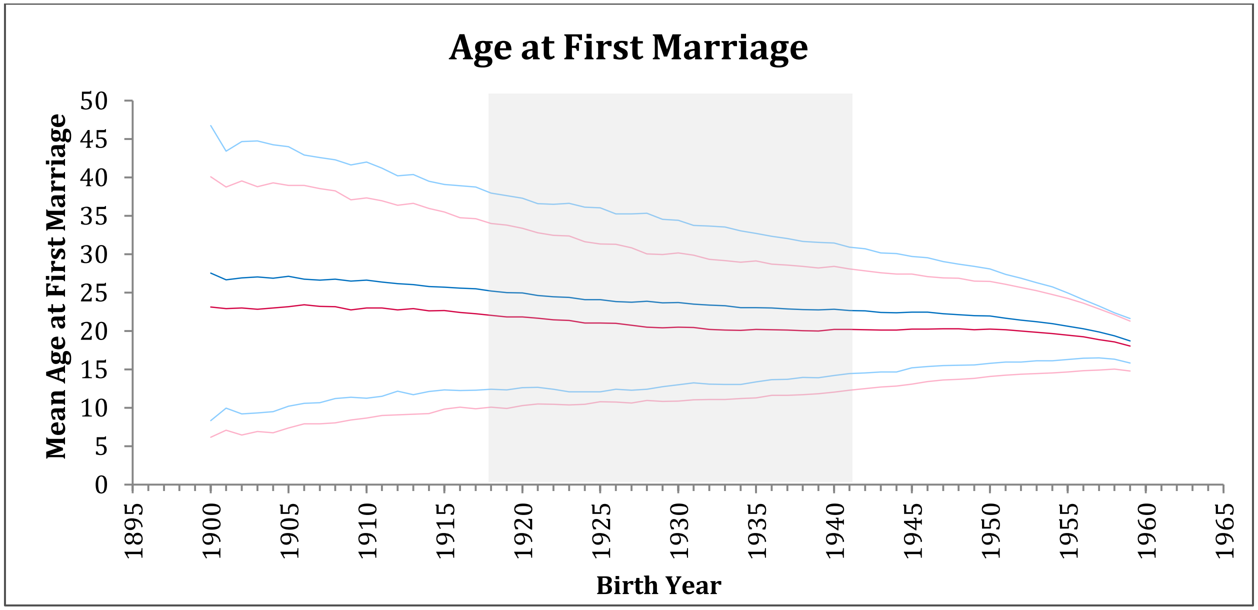

Figure 2a

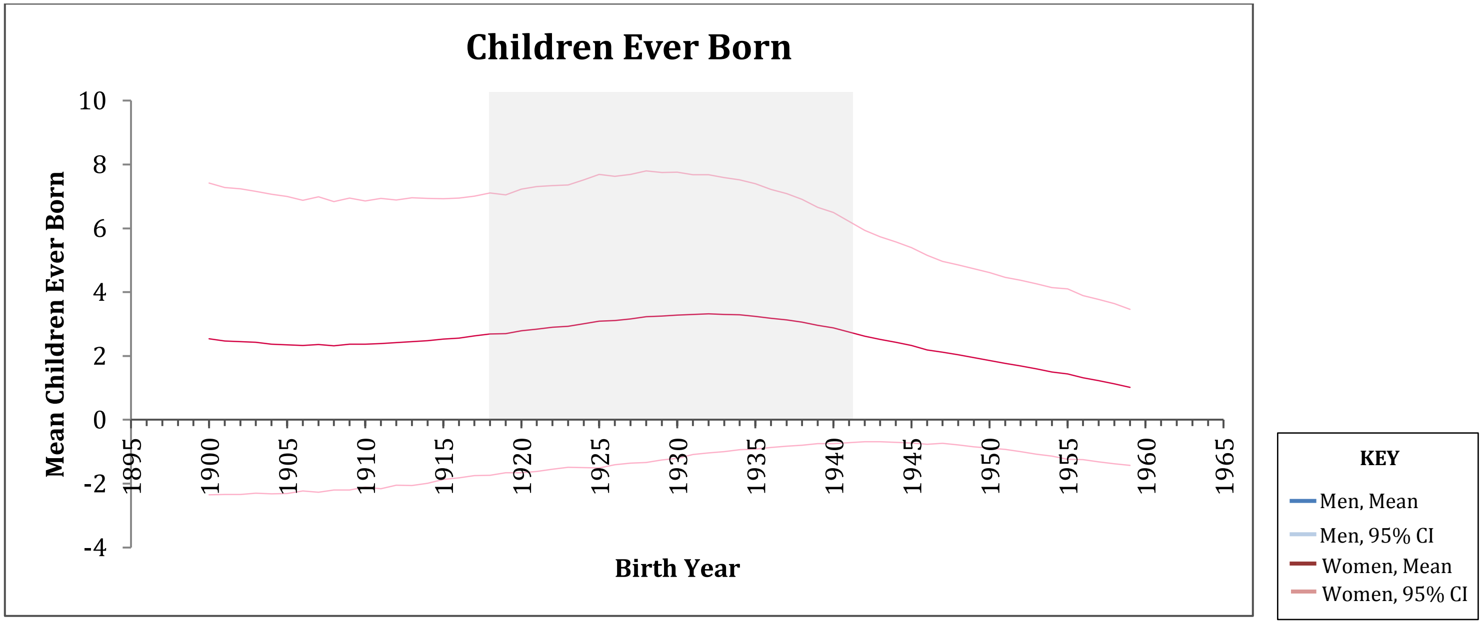

Figure 2b

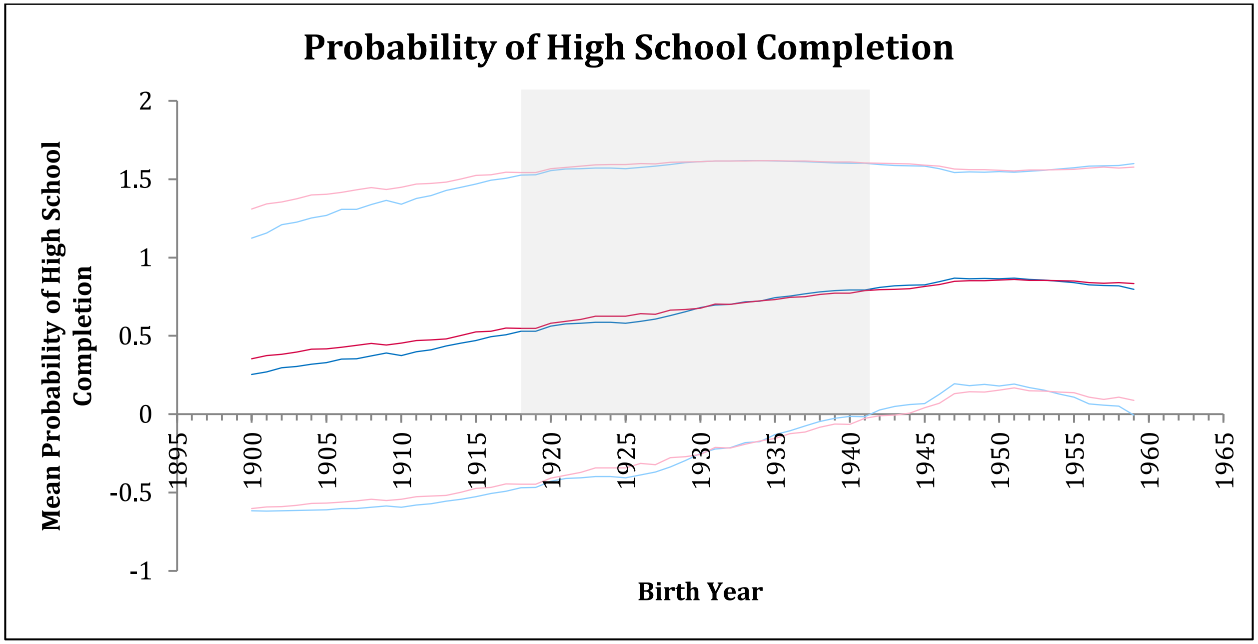

Figure 2c

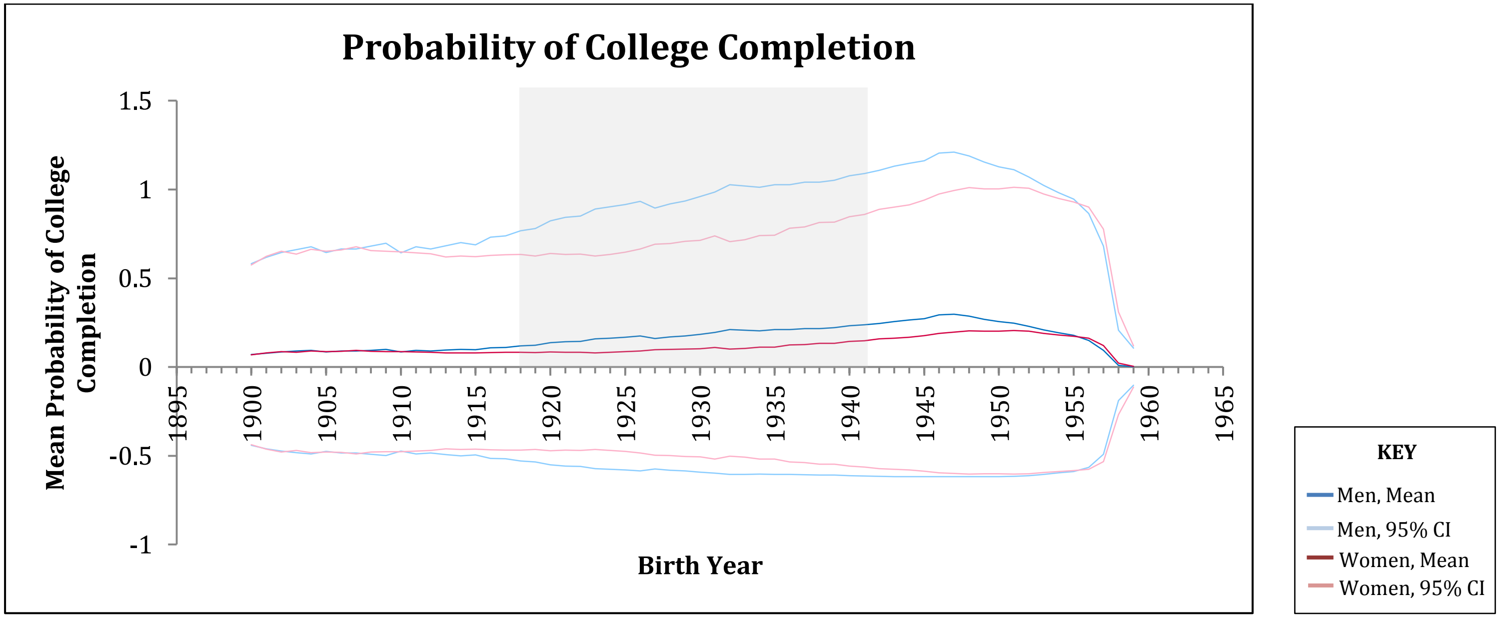

Figure 2d

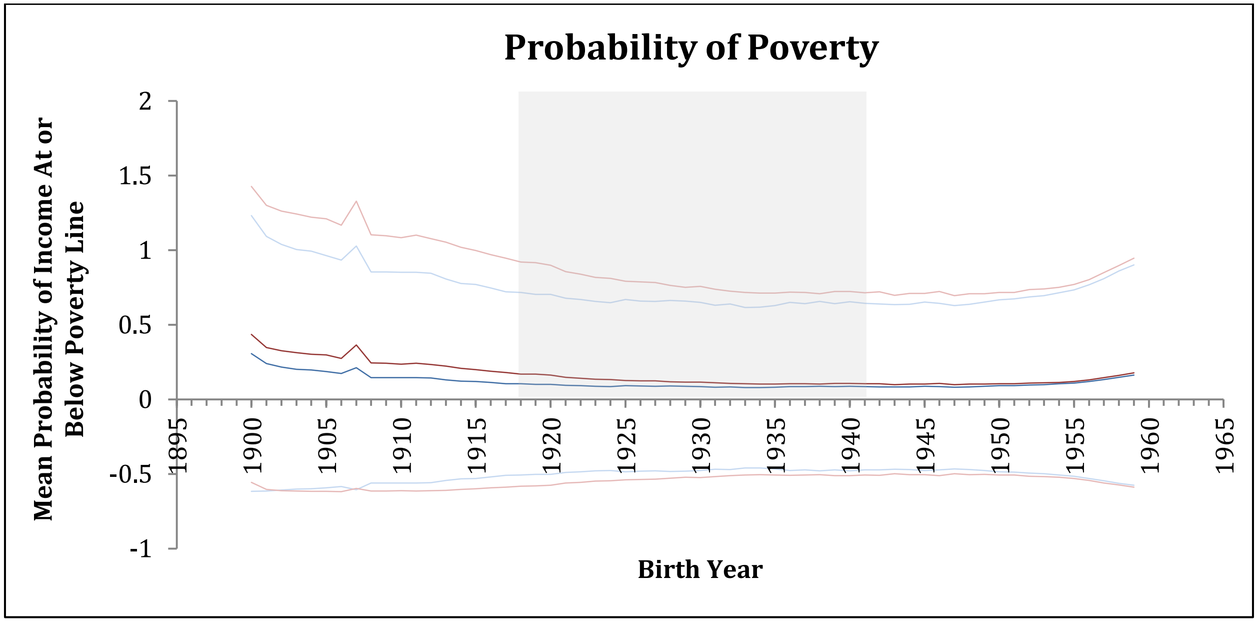

Figure 2e

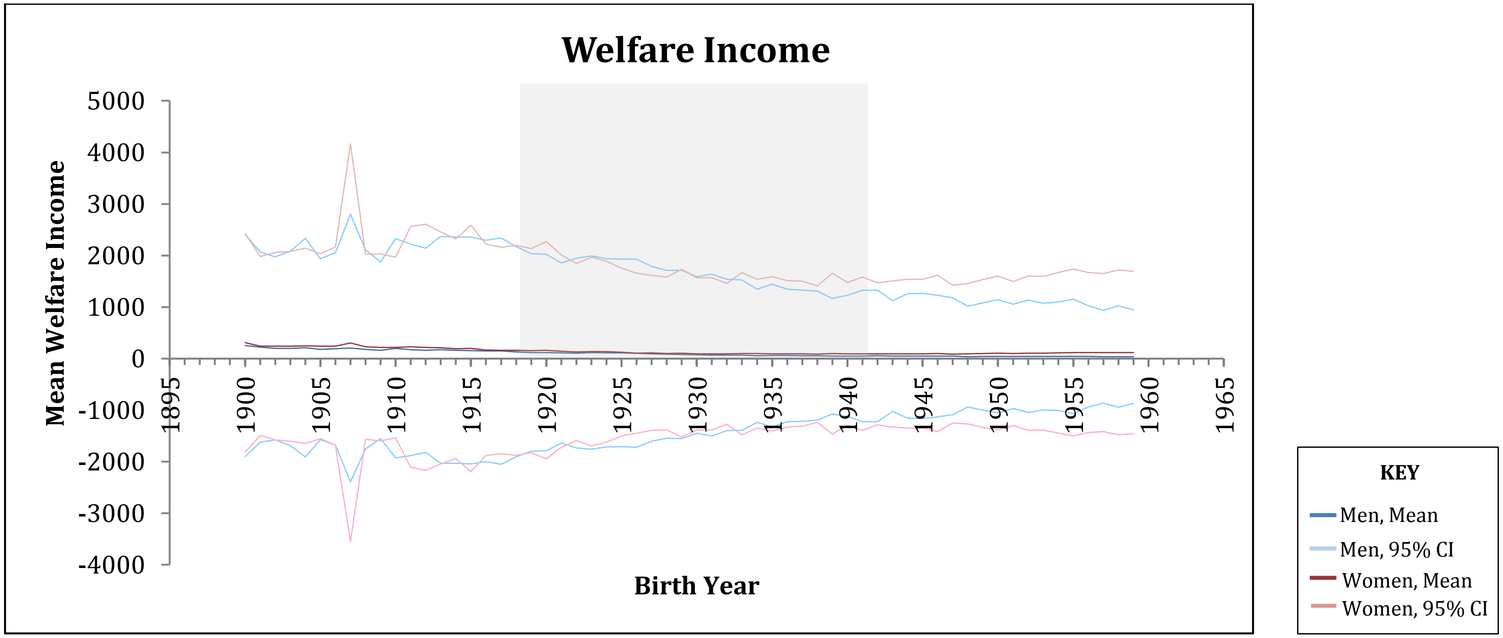

Figure 2f

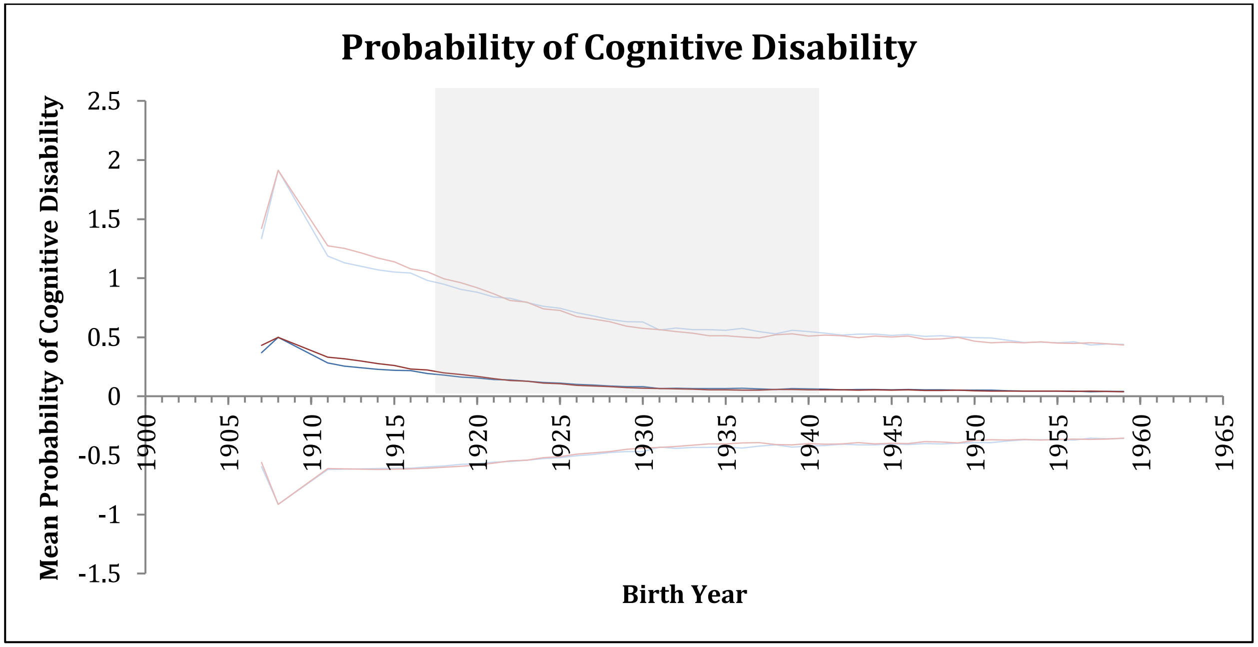

Figure 2g

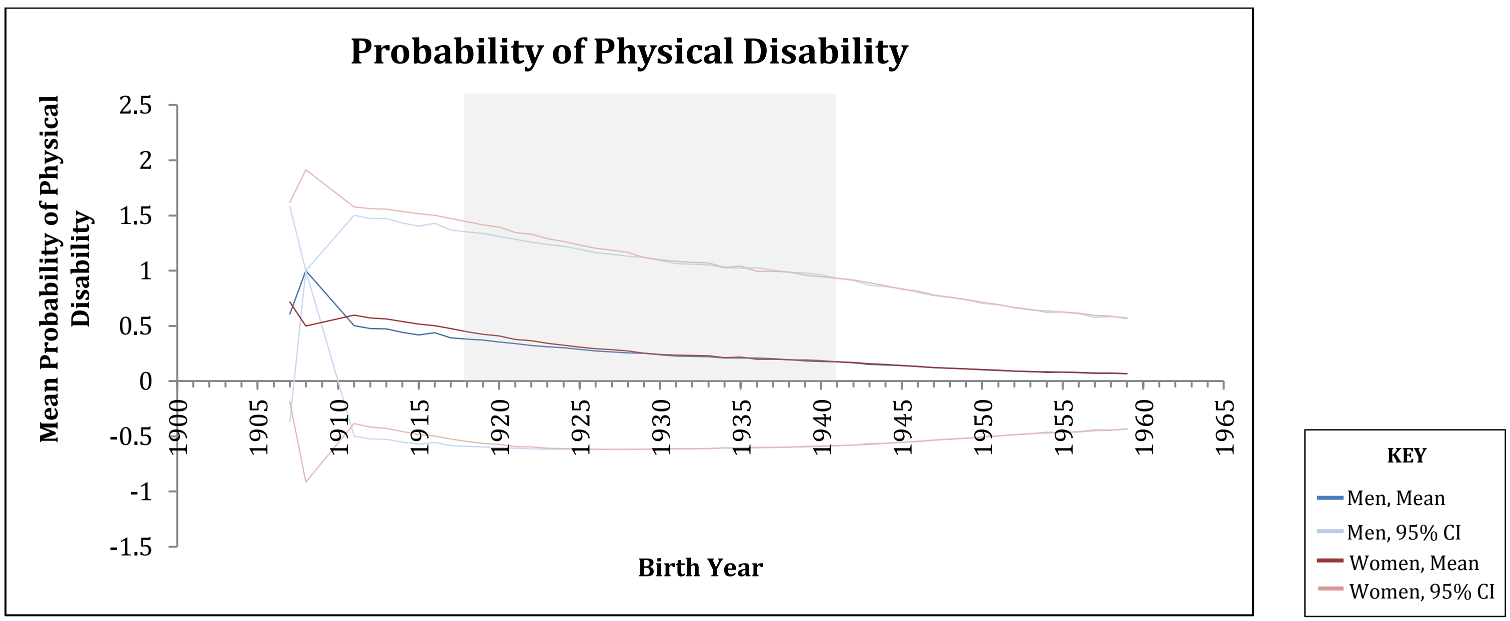

Figure 2h

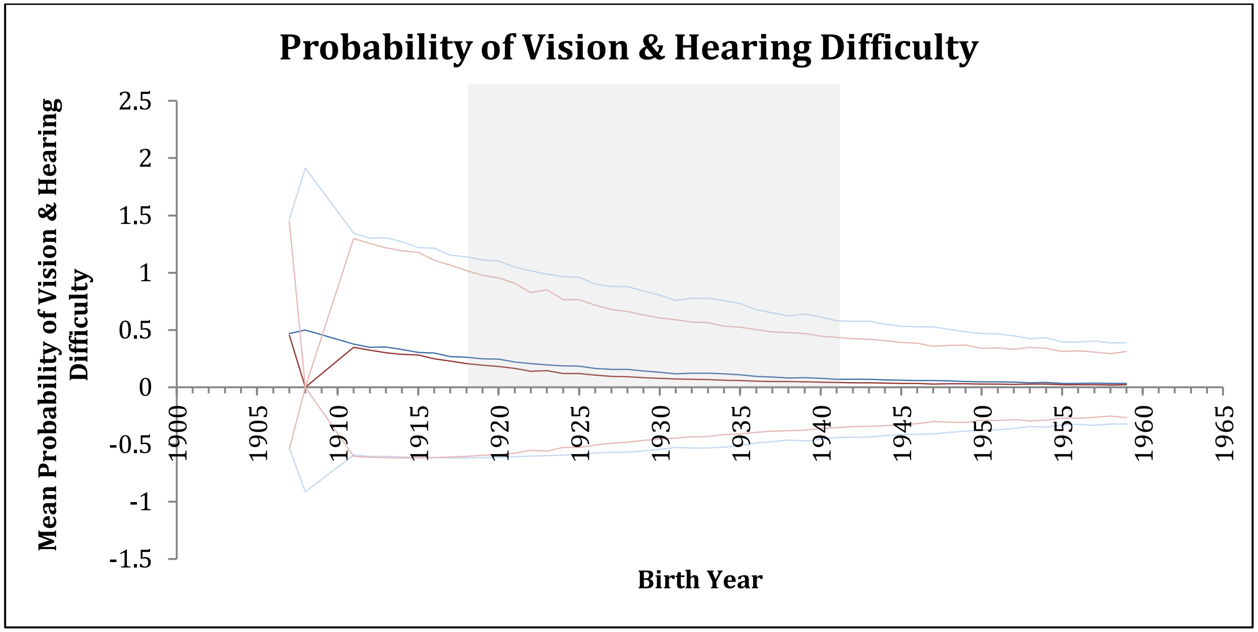

Figure 2i

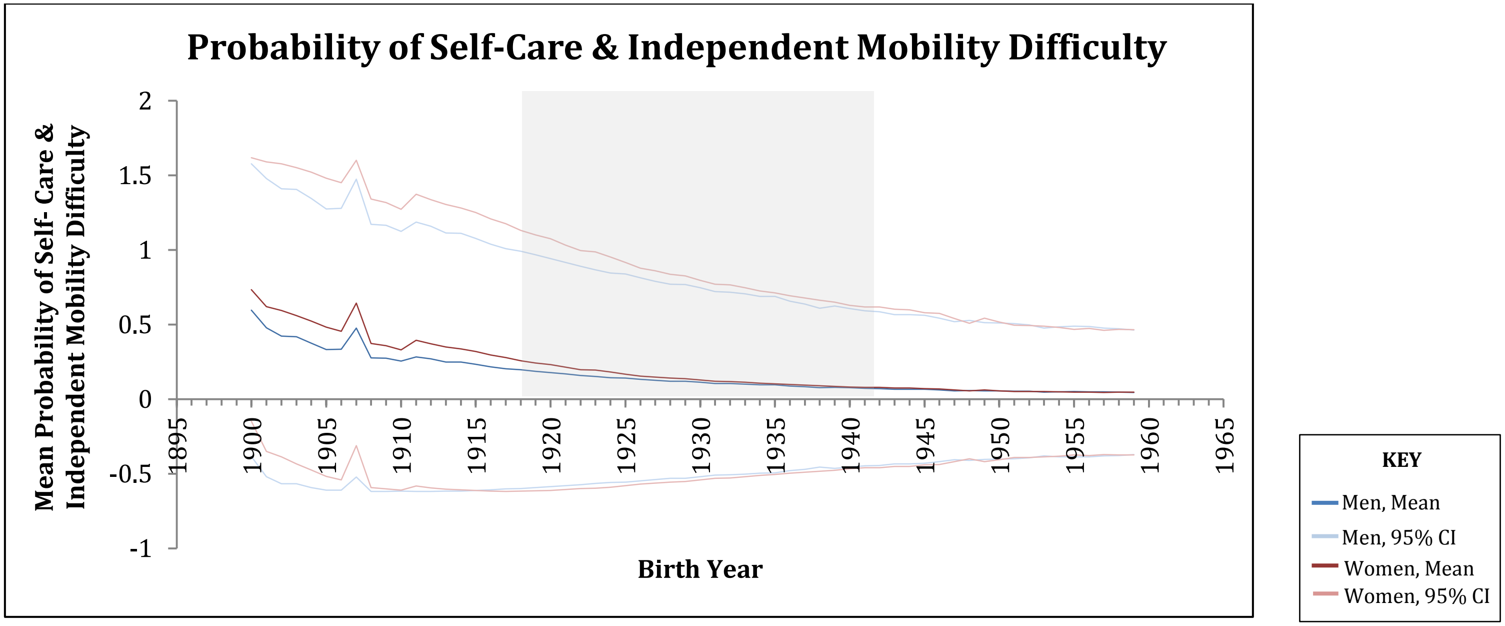

Figure 2j

Figures 3-12— Impact of Exposure to the Dust Bowl by Development Stage on Later-Life Outcomes

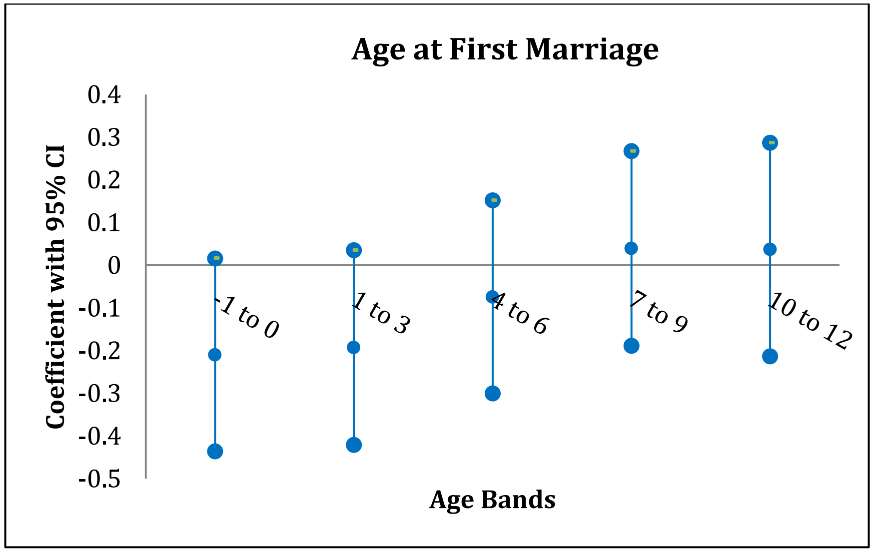

Figure 3a: Men

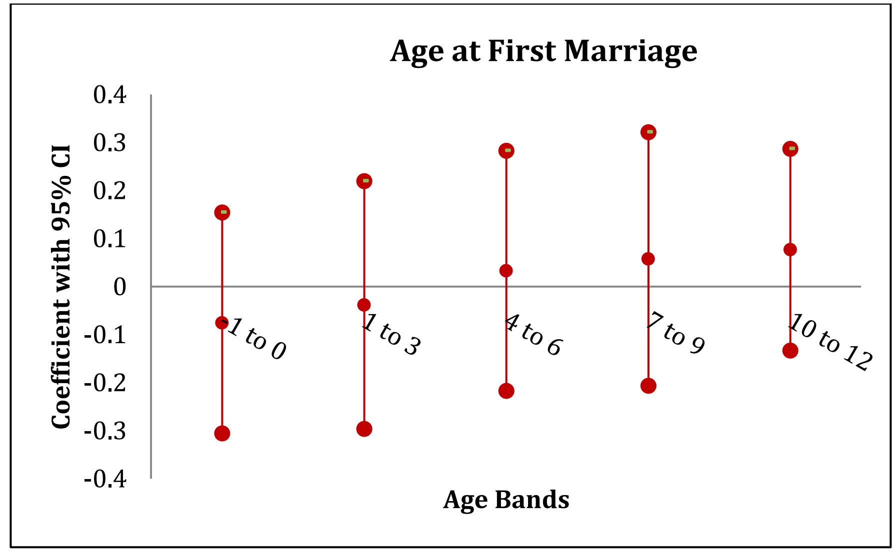

Figure 3b: Women

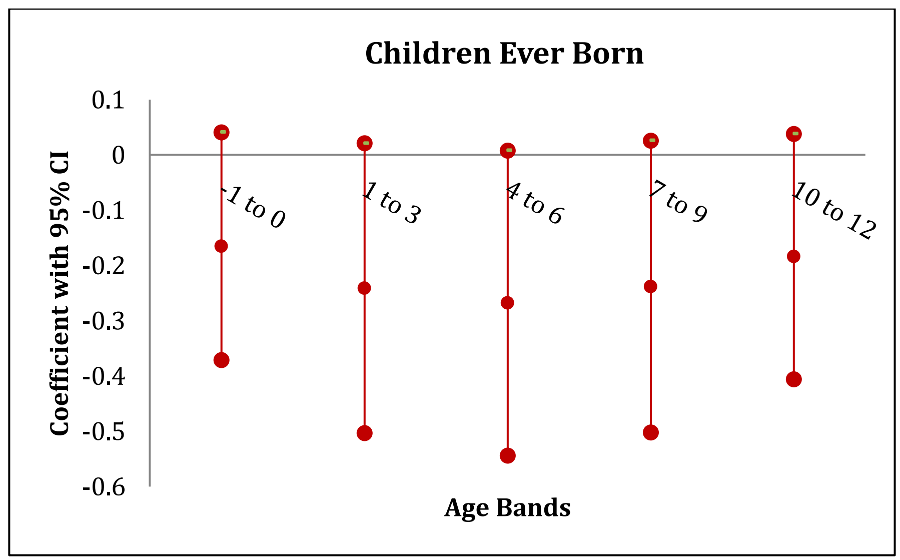

Figure 4b: Women

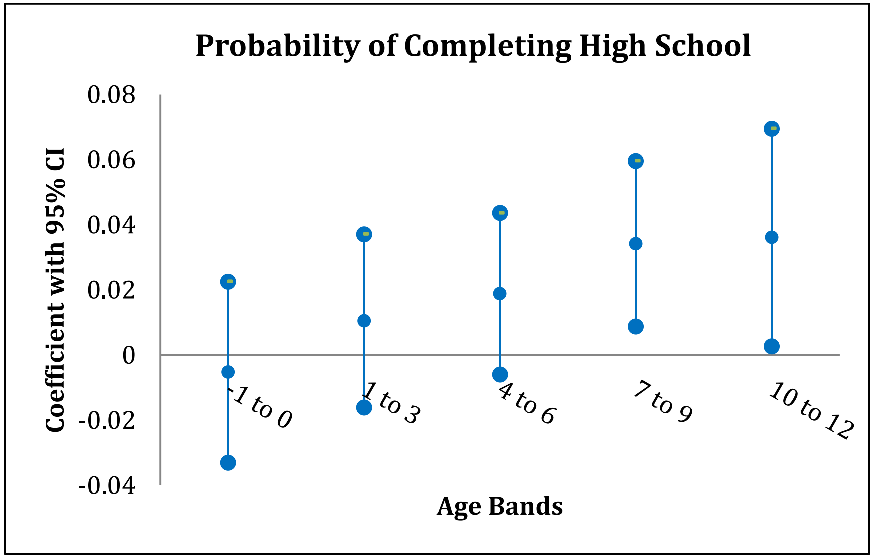

Figure 5a: Men

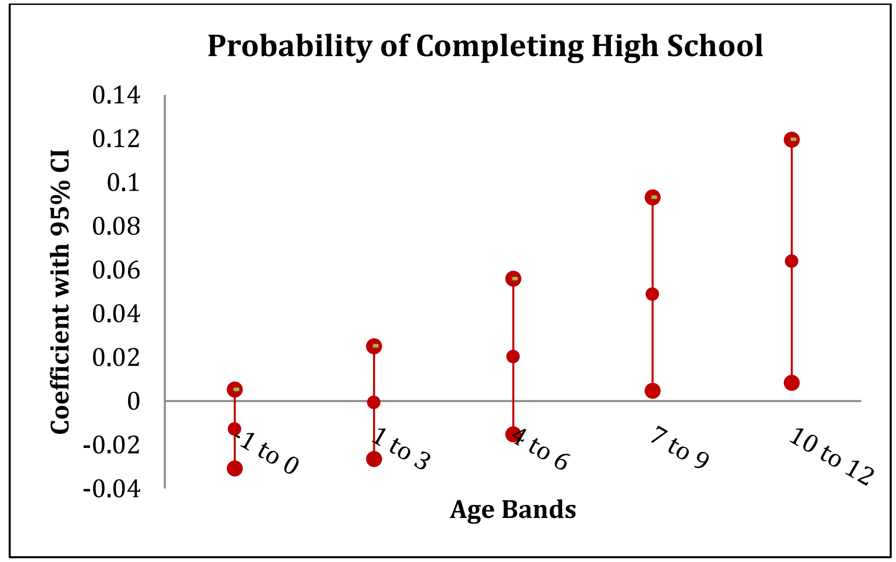

Figure 5b: Women

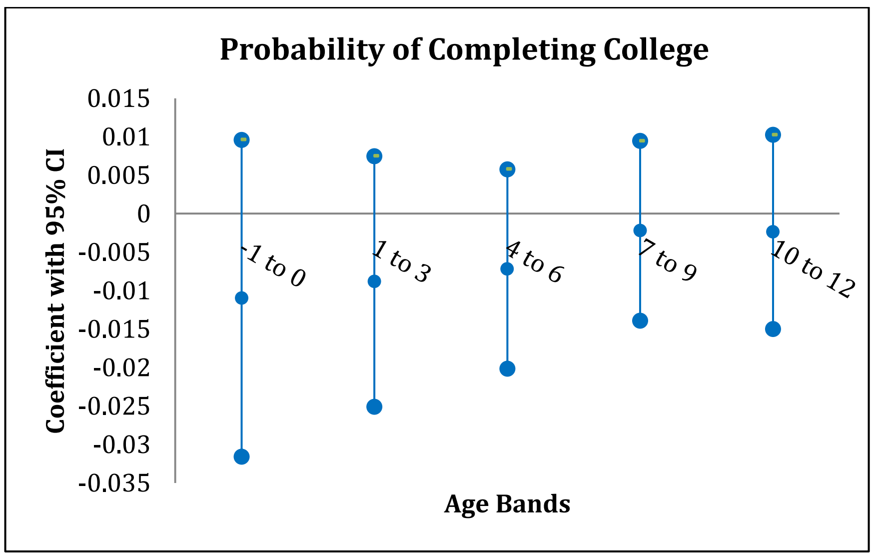

Figure 6a: Men

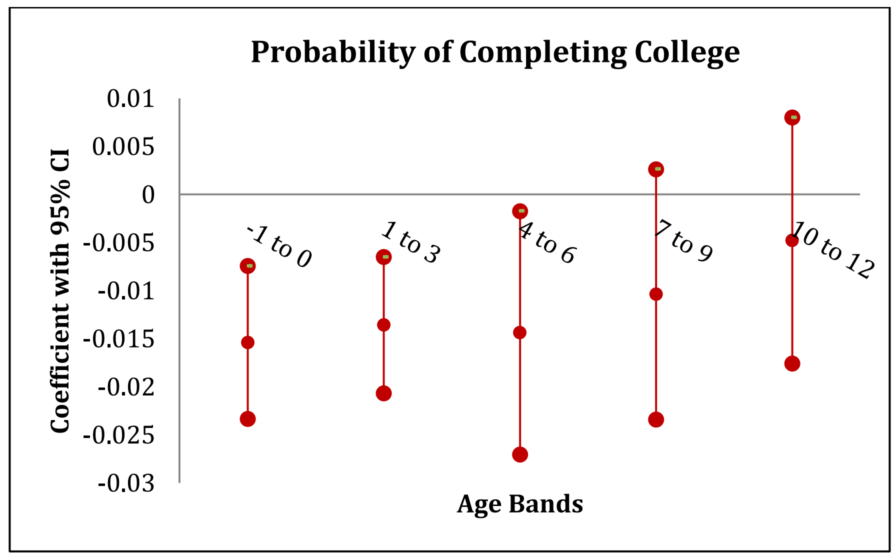

Figure 6b: Women

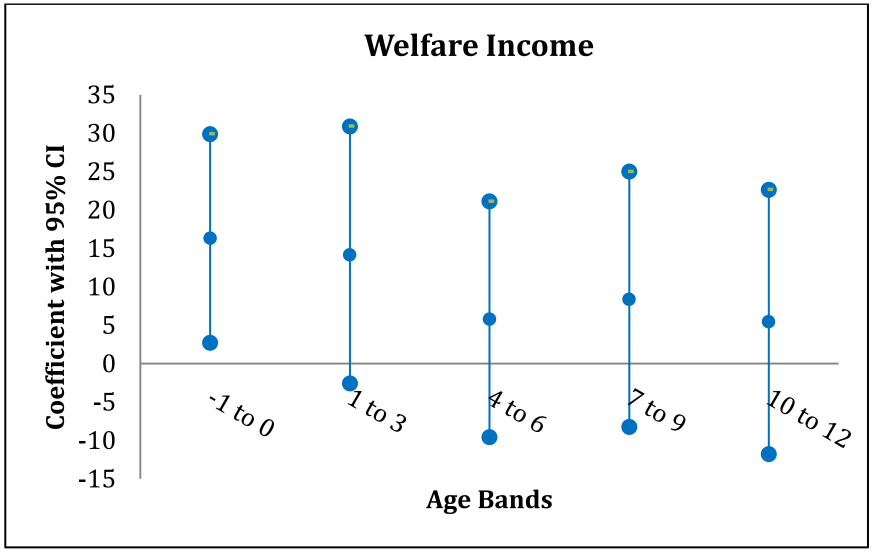

Figure 7a: Men

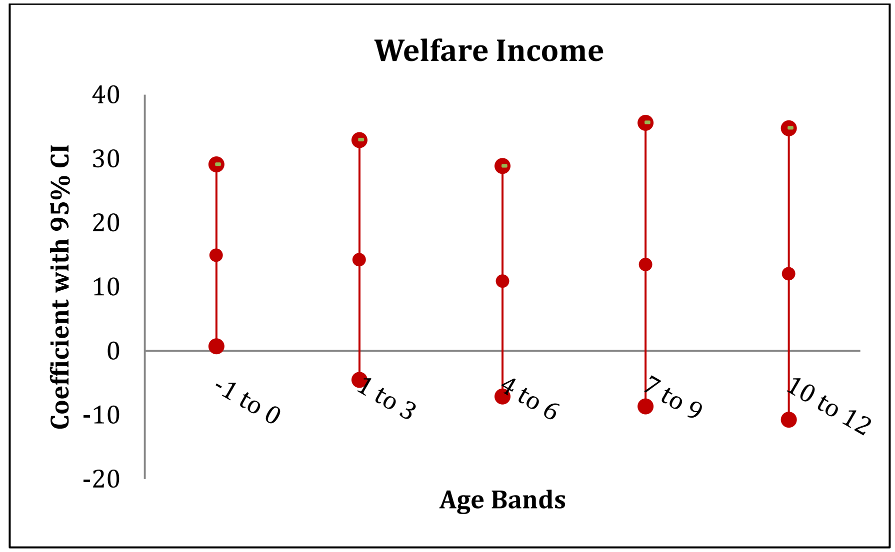

Figure 7b: Women

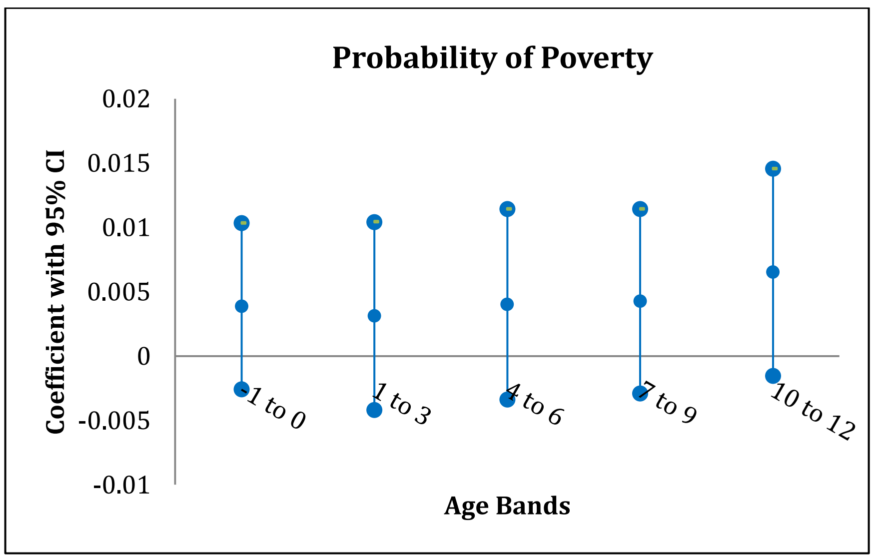

Figure 8a: Men

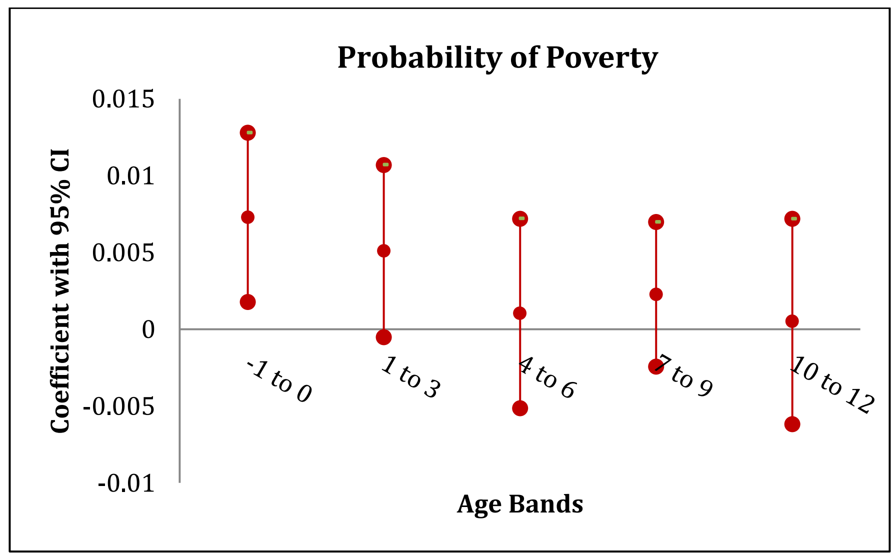

Figure 8b: Women

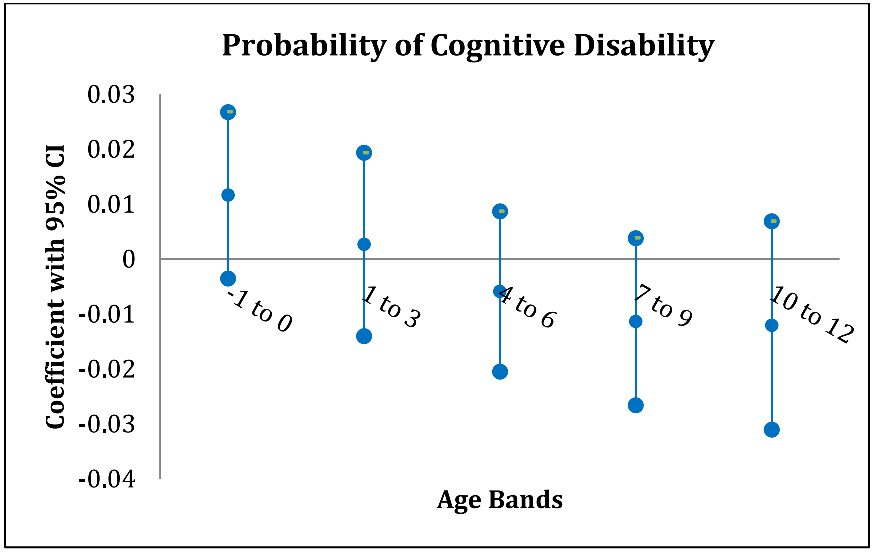

Figure 9a: Men

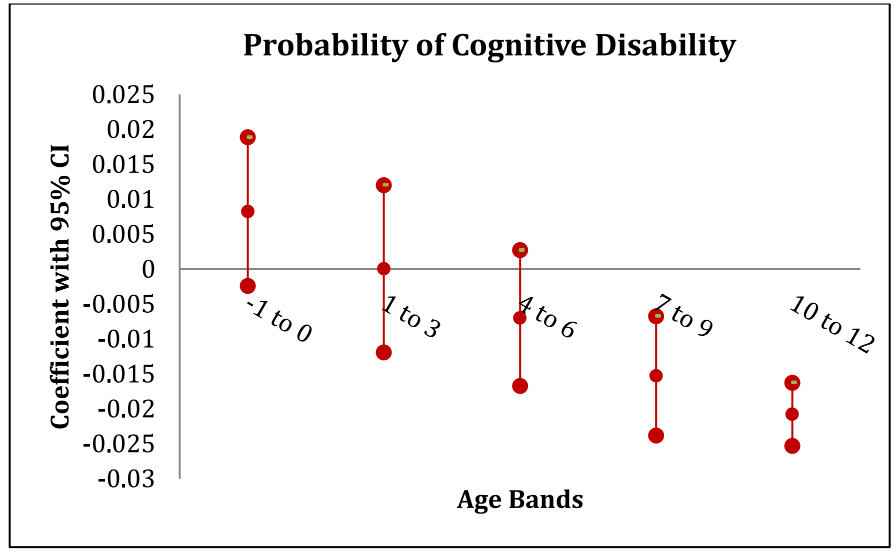

Figure 9b: Women

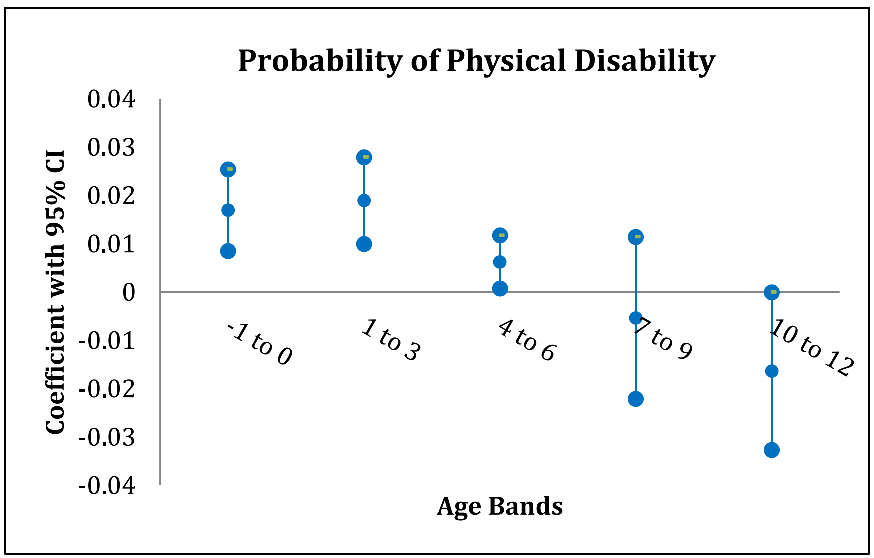

Figure 10a: Men

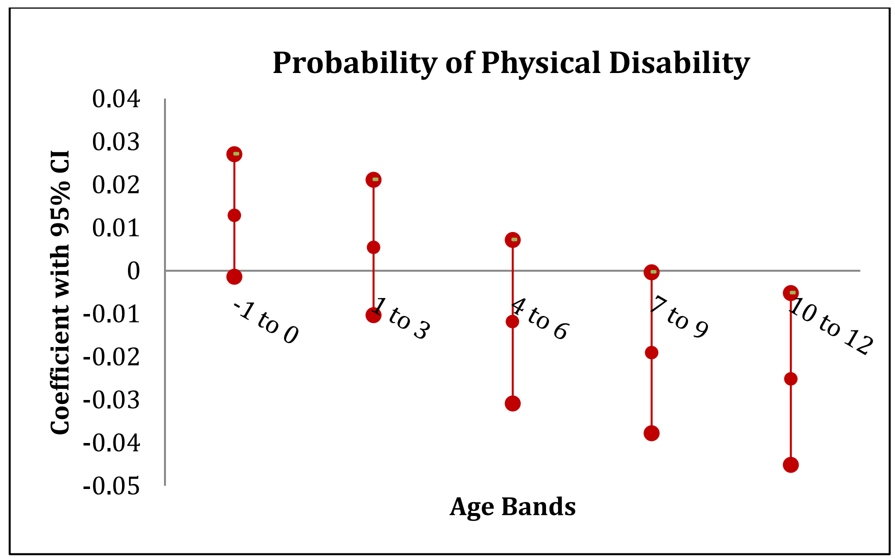

Figure 10b: Women

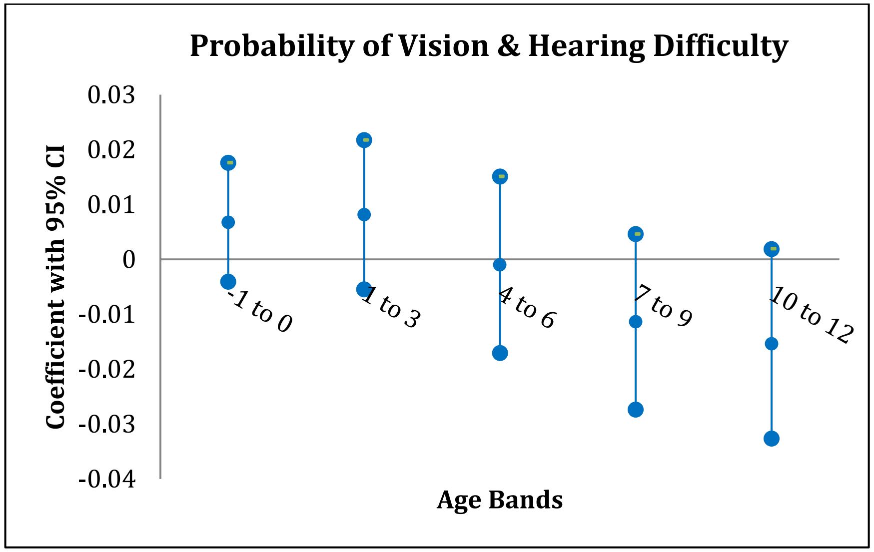

Figure 11a: Men

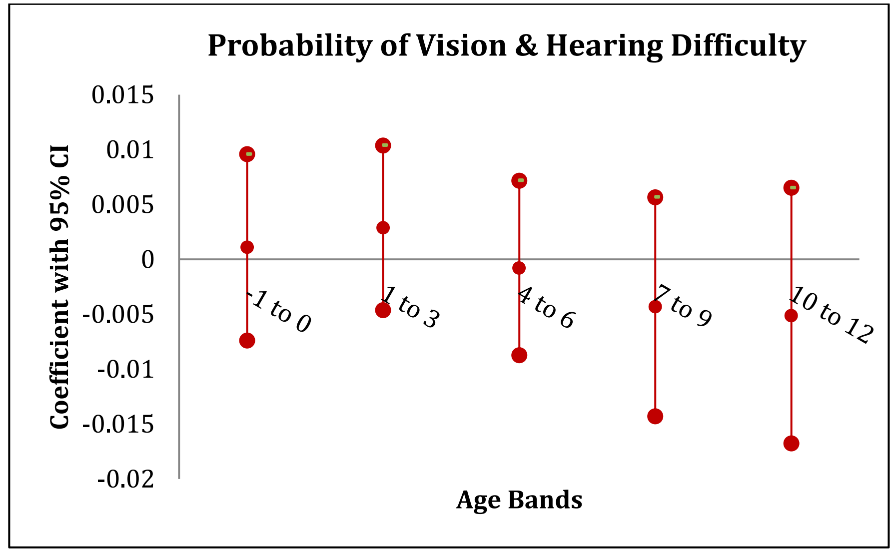

Figure 11b: Women

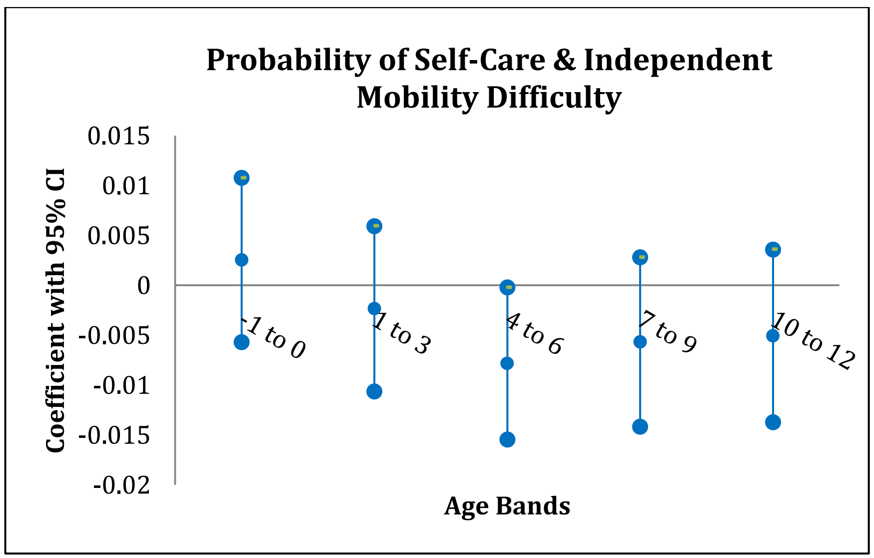

Figure 12a: Men

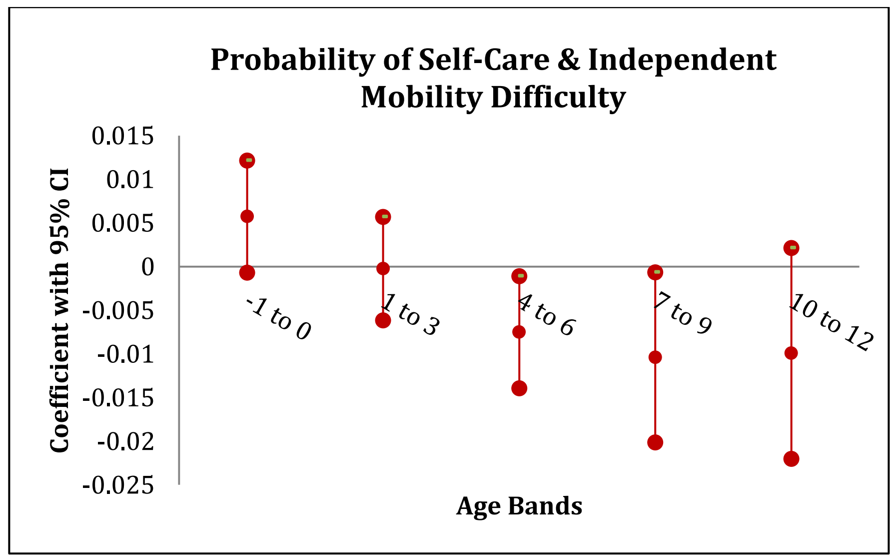

Figure 12b: Women

DATA APPENDIX

Outcome Variables

As discussed in Section 2.1, all data on adult outcomes are taken from the 5% samples of the 1980, 1990, and 2000 US Censuses, available through IPUMS.[1] The sample is restricted to individuals born between the years 1900 and 1959, inclusive, in the 15 Great Plains and adjacent states: Arkansas, Colorado, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming.

Individual-level outcomes are as follows:

Age at First Marriage — The individual's age at first marriage ("AGEMARR" in IPUMS). Regressions on age at marriage are restricted to only those individuals who have been married at least once, and for whom age at marriage is known.

Children Ever Born — The total number of children born to the individual, excluding stillbirths, adopted children, and stepchildren (reported only for female respondents in the census; "CHBORN" in IPUMS). IPUMS "Not applicable" values have been excluded, and regressions on children ever born are restricted to women where the number of children born is known.

Probability of Completing High School — 1 if the individual completed high school, and 0 if not (Constructed based on "HIGRADE" in IPUMS, such that individuals with 13 or more years of schooling [HIGRADE ≥ 15] are deemed to have completed high school).

Probability of Completing College — 1 if the individual completed college, and 0 if not (Constructed based on "HIGRADE" in IPUMS, such that individuals with 17 or more years of schooling [HIGRADE ≥ 19] are deemed to have completed college).

Welfare Income — The contemporary dollar amount of pre-tax income, if any, the individual received through public assistance programs including federal/state Supplemental Security Income, Aid to Families with Dependent Children, and General Assistance, but excluding private charitable sources of income ("INCWELFR" in IPUMS).

Probability of Poverty — 1 if the individual is living at or below the official federal poverty threshold designated for their household size and structure, and 0 if not (Constructed based on "POVERTY" in IPUMS, such that individuals for whom POVERTY ≤ 100 are deemed to be living in poverty).

Probability of Cognitive Disability — 1 if the individual has cognitive difficulties such as those involved in learning, decision-making, concentrating, or remembering; and 0 if not

[1] S. Ruggles et al. (2010).

(Constructed based on "DIFFREM" in IPUMS such that individuals experiencing any sort of cognitive impairment are deemed to suffer from cognitive disability).

Probability of Physical Disability — 1 if the individual suffers from conditions that significantly limits one or more essential day-to-day physical activities, such as walking, lifting, climbing, etc.; and 0 if not (Constructed based on "DIFFPHYS" in IPUMS such that individuals experiencing any sort of ambulatory difficulty are deemed to suffer from physical disability).

Probability of Vision & Hearing Difficulty — 1 if the individual has long-lasting blindness, deafness, or other severe vision or hearing difficulty; and 0 if not (Constructed based on "DIFFSENS" in IPUMS such that individuals experiencing any sort of vision or hearing impairment are deemed to suffer from cognitive disability).

Probability of Self-Care & Independent Mobility Difficulty — 1 if the individual has lasting (i.e. non-temporary) conditions that cause difficulty in performing basic personal activities either within or outside the home (e.g. bathing, dressing, shopping, visiting the doctor); and 0 if not (Constructed based on "DIFFCARE" and "DIFFMOB" in IPUMS such that individuals experiencing any sort of impairment in either variable are deemed to suffer from self-care and independent mobility difficulty).

Dust Bowl Exposure Variables

Erosion — The proportion of the state population in 1930 living in high-erosion counties in the individual's birth state (constructed using 1930 county population figures and county-level erosion classifications from the U.S. Census[2]). This variable may be interpreted as the probability that an individual in a given state experienced high erosion. Census data, through which only birth state, rather than birth county or birth city is known, does not allow me to pinpoint the actual Dust Bowl severity experienced by an individual in childhood. I attempt to overcome these limitations by constructing this variable such that it accounts for the distribution of population over space. By incorporating county-level information on human geography, I arrive at a measure of Dust Bowl severity more appropriate to a study of the human costs of the disaster than those not "weighted" by population, such as those weighted by county area.

Change in Farm Values — The proportion of the state population in 1930 living in high-farm value-loss counties in the individual's birth state (constructed using 1930 county population figures and 1930 and 1940 county-level farm values from the U.S. Census of Agriculture[3]). To construct this figure, I calculate for each county the percentage change in farm values over the Dust Bowl period, that is, between 1930 and 1940. I then classify the tercile of counties in my sample that experienced the greatest drop in farm values over the period as experiencing "high" farm value loss. I then calculate the proportion of the 1930

[2] R. Hornbeck (2012b).
[3] R. Hornbeck (2012b).

population in each state living in high farm value loss counties. By accounting for farm values prior to the Dust Bowl, this variable overcomes the weaknesses in erosion data, for which pre-Dust Bowl baselines do not exist.[4] Furthermore, farm values may capture Dust Bowl effects—for instance, economic ones—that erosion alone does not.

Drought — The sum of drought magnitudes for all official drought events occurring between 1930 and 1940 in the individual's birth state. Drought figures are calculated using monthly climate station-level NOAA data on historical rainfall collected from 1910 to 2010;[5] the 100-year span of data used exceeds the minimum roughly 50-year sample recommended to establish state baselines.[6] Since not all states had climate stations in every county in the early- to mid-20th Century, it is not possible to gather county-level drought data nor is it possible to weight drought by county-level population as in the erosion and farm value measures of Dust Bowl severity. Instead, I summed the precipitation levels of each climate station within a state in a given month and divided it by the number of climate stations in that state in that month to create monthly state-level precipitation averages. To normalize the rainfall data to allow comparability both across states and across time within a state, these raw precipitation figures were converted to a monthly Standardized Precipitation Index (SPI) figure using a 12-month timescale to capture both short- and longer-term drought effects. The SPI method is preferred by climatologists to other common drought indices, such as the Palmer Drought Index, because of its simplicity and its incorporation of climatological timescales.[7] Per McKee et al. (1993), the monthly state-level SPI figures were used to identify official drought events,[8] and the magnitudes of these events (which capture both severity and duration of drought) were summed over the 1930 to 1940 period to create a single state-level variable representing the total severity of drought in a state during the Dust Bowl timeframe, relative to the state's own historic rainfall baseline.

Treated (Baseline) — 1 if the individual was aged -1 to 12 at any point during the Dust Bowl period of 1930 to 1940, and 0 if not. This age span represents childhood, here defined as the time *in utero* to the onset of puberty. This variable denotes whether an individual was a child during the Dust Bowl, and thus may plausibly have been exposed to Dust Bowl shocks such as dust storms.

Treated (Developmental Stage) — The proportion of the given age range (-1 to 0, 1 to 3, 4 to 6, 7 to 9, and 10 to 12) spent in (i.e., that coincides with) the Dust Bowl period of 1930 to 1940. For example, an individual born in 1941 spent 50% of the -1 to 0 age range in the Dust Bowl, while an individual born in 1940 spent 100% of the same age range in the Dust Bowl, and an individual born in 1942 spent 0% of this age range in the Dust Bowl. Similarly, an individual born in 1919 would have spent 66.7% of the 10 to 12 age range but 0% of the 7 to 9 age range in the Dust Bowl timeframe. This variable is thus a measure of the

[4] Soil Conservation Service (1935), and R. Hornbeck (2012a), pp. 1484 & 1502.
[5] National Climatic Data Center of the National Oceanic and Atmospheric Administration (2013).
[6] H. Wu et al. (2004), and T. McKee et al. (1993).
[7] World Meteorological Organization (2009); H. Wu et al. (2004); T. McKee et al. (1993); and N. Guttman (1999).
[8] T. McKee et al. (1993).

developmental stage or age at plausible exposure to the Dust Bowl, weighted more heavily for those that spent a greater proportion of the developmental stage during the Dust Bowl period.

Individual Characteristics

Sex — 1 if the individual is female, 0 if male.

Race — 1 if the individual is non-white, 0 if white. (Constructed based on "RACE" in IPUMS such that all individuals not identifying exclusively as "white" are deemed non-white).

Veteran Status — 1 if the individual has ever served in the US armed forces on active duty, 0 if not (Constructed based on "VETSTAT" in IPUMS such that only individuals explicitly listed as veterans are deemed veterans; those where veteran status is unknown are counted as non-veterans). For all the census waves used in this study, women are included in this definition of military service.

Migrant Status — 1 if the individual is living in a state other than the birth state at the time of the census, 0 if not (Constructed based on "BPL" and "STATEFIP" in IPUMS such that individuals for whom BPL ≠ STATEFIP are deemed migrants.) Although the age at which migration took place is unknown, and although it is possible that even those who are currently found living in their birth state migrated out at some point before returning, this variable serves as a rough proxy for individuals who may have migrated out of the sample during childhood.

Fixed Effects & Trends

Birth State — The individual's state of birth (identified using "BPL" in IPUMS). Note that in censuses from 1940 onwards, no detail below birth state (such as birth county) is available. In this paper, only those born in Arkansas, Colorado, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming are included in the sample. These states are selected for being states in the Great Plains region or states neighboring the Great Plains. Studies using Dust Bowl erosion to explain agricultural and environmental phenomena have used a similar if slightly smaller set of states;[9] my sample adds states like Missouri and Arkansas that the qualitative literature suggests may have also suffered from the Dust Bowl.[10] The use of states beyond those strictly in the Great Plains/those hardest hit by the Dust Bowl allows me to exploit a greater degree of variation in shock severity. Such variation is necessary for differences-in-differences analysis.

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[9] Z. Hansen and G. Libecap (2004), and R. Hornbeck (2012a).
[10] D. Nealand (2008).

Birth Year — The individual's year of birth (identified using "BIRTHYR" in IPUMS). In this paper, only those born in the years 1900 to 1959, inclusive, are included in the sample. Since individuals born between 1918 and 1941, inclusive, are the cohort of interest, the inclusion of individuals born before and after this period allows for differences-in-differences estimation against those who could not possibly have been exposed to the Dust Bowl.

Census Year — The census year in which the individual's data is reported (identified using "YEAR" in IPUMS). In this paper, the 5% sample of the US census for 1980, 1990, and 2000 are used. These census waves are chosen in part for the specific variables they report which other censuses do not (such as the highest grade achieved, or a standardized veteran status), as well as to enable capture adult outcomes that are relatively stable (such as those for schooling and fertility, which an individual may not yet have completed if using earlier censuses).[11]

State Trends — A linear time trend for each birth state in the sample (constructed using "BPL" and "BIRTHYR" in IPUMS).

Agriculture

Farm Population-Weighted Erosion — replaces $erosion_s$ in equation (1); The proportion of the state's farm population in 1930 living in high-erosion counties in the individual's birth state (constructed using 1930 county farm population figures and county-level erosion classifications from the U.S. Census[12]). This variable may be interpreted as the probability that those engaged in agriculture in a given state experienced high erosion, and thus, as a measure of the severity of the Dust Bowl for agriculture-dependent communities.

Farm-Dependence — $farm_s$ in equation (2); 1 if the individual is born into a state where the farm population as a proportion of total population in the individual's birth state is above the sample average, 0 if below average (constructed using 1930 county farm population and general population figures from the U.S. Census[13]). This variable is a proxy for the state's dependence on agricultural livelihoods, and is interacted with the baseline equation's standard treated*erosion term to test whether agriculture-dependence changes effect of the Dust Bowl shock. As a measure of farm-dependence, this variable serves as an alternative definition to that used in *Farm Population-Weighted Erosion.*

Patriarchy

Patriarchy — $patriarchy_s$ in equation (3); 1 if the individual is born into a state where the patriarchy index is above the sample average, 0 if below average (patriarchy index

[11] S. Bhalotra and A. Venkataramani, p. 10.
[12] R. Hornbeck (2012b).
[13] R. Hornbeck (2012b).

constructed using data on female suffrage, divorce laws, under-10 sex ratios, and the age gap between the average husband and wife, normalized by the average wife's age). The patriarchy index underlying the binary patriarchy$_s$ variable is a composite measure of the strength of patriarchal culture and institutions in an individual's birth state, and has been explicitly designed to exclude measures, such as female labor force participation rates or female household income share, which may be endogenous to investments in women's and girls' human capital.[14] A higher value for the patriarchy index indicates a state with stronger patriarchal gender norms. State-by-state information on historical divorce laws is taken from Jones (1987).[15] The easier it is to obtain a divorce in a given state in the 1860s-1940s, the more progressive the state is deemed to be with respect to patriarchal gender roles,[16] and the lower the value of the patriarchy index. A higher number of explicitly female-benefitting grounds for divorce also lowers the patriarchy index. Data on suffrage is taken from Shuler (1920).[17] The earlier a state institutes full female suffrage or any type of national female suffrage, the lower the patriarchy index. The more permissive the pre-19th amendment female suffrage in a state, the lower the patriarchy index. Since actual couples' marital age gaps are unknown, the 5% sample of 1930 census records taken from IPUMS[18] are used to find the average age at marriage for men and for women, which are then used to construct a marital age gap based on averages and normalized by the average age at marriage for women. Normalizing by the age at marriage for women allows me to take account not just of whether the age gap is large, but also of whether the age at marriage for women is low, both features of patriarchal societies and both contributors to lower intra-household bargaining power for women.[19] Thus, a lower normalized marital age gap lowers the patriarchy index, while a higher one raises it. Lastly, the sex ratio between male and female children aged 0-9 is calculated using data from the statistical abstract of the 1930 U.S. census.[20] Here, a greater ratio of boys to girls represents customary sexism (since below working-age, discrimination against girls in health and nutrition is likelier customary than economically strategic)[21], and thus lowers the patriarchy index.

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[14] K. Basu (2006).
[15] M.S. Jones (1987).
[16] Although in male breadwinner households, permissive divorce laws could be said to expose female homemakers to greater economic vulnerability, L.M. Fenton (2010) suggests that divorce benefitted women by providing them greater freedom and a way out of abusive or otherwise disadvantageous marriages.
[17] M. Shuler (1920).
[18] S. Ruggles et al. (2010).
[19] S. Gruber and M. Szołtysek (2012).
[20] U.S. Census Bureau (1933).
[21] For instance, it would not be likely a reflection of the sort of earner bias D. Meredith and D. Oxley (2013) find in intra-household human capital allocations unless households' time horizons were very long; instead, it is likelier a function of customary discrimination in the prenatal and early life periods, per A. Sen (2003).