HEALTH, EDUCATION AND INCOME IN THE UNITED STATES, 1820-2000

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ABSTRACT

We document the correlations between early childhood health (as proxied by height) and educational attainment and investigate the labor market and wealth returns to height for United States cohorts born between 1820 and 1990. The nineteenth century was characterized by low investments in height and education, a small correlation between height and education, and positive but small returns for both height and education. The relationship between height and education was stronger in the twentieth century and stronger in the first part of the twentieth century than later on (when both investments in education and height stalled), but never as strong as in developing countries. The labor market and wealth returns to height and education also were higher in the twentieth compared to the nineteenth century. We relate our findings to the theory of human capital formation and speculate that the greater importance of physical labor in the nineteenth century economy, which raised the opportunity cost of schooling, may have depressed the height-education relationship relative to the twentieth century. Our findings are consistent with an increasing importance of cognitive abilities acquired in early childhood.

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I. Introduction

The United States experienced large increases in educational attainment starting in the late nineteenth century and well into the twentieth century. Years of schooling among those in the labor force rose by about 6 years, from about 7.5 years in 1915 to 13.5 years in 2005 (Goldin and Katz 2008). Incomes also rose quite substantially, with real GDP per capita growing an average of 2.23% per year in the same period. A large amount of research has been devoted to understanding the factors that led to the rise in education, whether these increases in education led to the higher incomes we observe, or whether other factors led to the rapid increases in both (Card 2001).

Did improvements in health throughout the same period contribute to the observed changes in educational attainment and incomes? Health has improved dramatically: life expectancy at birth rose by about 30 years in the twentieth century—an unprecedented increase. Mortality decreases were mostly concentrated among children before 1950. These declines were mostly due to the eradication of infectious and parasitic diseases, which reduced morbidity in the population (Bleakley 2010a). However there were also substantial improvements in the health and mortality of the elderly, particularly after 1950 (Cutler, Deaton and Lleras-Muney 2006). Fogel estimates that improvements in health account for at least 20% and up to 30% of British economic growth between 1800 and 2000 (Fogel 1994; Floud et al. 2011: 127). In contrast, Easterlin (1996) is skeptical of the link between health and economic growth.

The main difficulty in establishing the effects of health improvements on education and productivity is to find variation in health that is not driven by the same factors that determine education and income. Additionally, exploring the long-term relationships between these factors requires comparable measures of health, income and education and these are difficult to obtain. Using many individual datasets covering cohorts born between 1810 and 1990, we are the first to examine how the relationships between health, income, and education have changed over time in the United States. As our health measure we use adult height, which has the advantage of being determined by early childhood, prior to obtaining schooling and entering the labor market.

Height is a good proxy for general health conditions in childhood. Height is a measure of *net* nutritional status during the growing years, including the fetal period. Differences in height across individuals are determined by environmental factors, such as the availability of food and the presence of disease, as well as by genetics (Steckel 1995). Most of the relative differences in height appear to be determined by age 3: for example the correlation between height at age 3 and height in adulthood is as large as 0.7 or larger (Case and Paxson 2008). Stunting starts in utero or in early childhood (before age 3) and usually persists to give rise to a small adult. Based on extensive studies in Guatemala, Martorell, Rivera and Kaplowitz (1990) concluded that stunting is "a condition resulting from events in early childhood and which, once present, remains for life." [1]

Although height is a rough measure of health, short stature is associated with worse health later in life. Waaler (1984), using a sample of Norwegian males age 40-49 in 1963-79, was the first to show that mortality rises at a diminishing rate when height increases until height reaches 187cm. After that point mortality rates begin to rise as height increases. Costa (1993) and Floud et al. (2011) report a similar functional relation between height and subsequent mortality among white

[1] The extent to which catch-up is possible is not known, but it appears that full catch up is not possible after age 3. Rat pups and piglets that were malnourished for a period shortly after birth never caught up, suggesting that stunting in humans may be permanent (Widdowson and McCance 1960). Although there is usually definite catch-up growth in studies of adoptees, emigrants, or children treated for diseases it is often not to the NCHS standards (Proos, Hofvander and Tuvemo 1991). There may be a limitation imposed on an individual's maximum height by genetic imprinting in very early development. Full catch-up appears to take place at young ages (Barhman et al 2013) but is followed by an advanced puberty and early cessation of growth (Proos, Hofvander and Tuvemo 1991).

American males in 1986-1992 and among Union Army veterans.[2] Height appears to be inversely related to heart and respiratory diseases and positively related to the hormonal cancers (Barker 1992).

Height is also strongly associated with wages and productivity in a variety of settings. Surveying the evidence from developing countries, Schultz (2002) concludes that an additional centimeter of adult male height is significantly associated with a higher wage of 1.5% in Ghana and 1.4% in Brazil. Historical data also shows that height was associated with productivity in now-developed countries. Data from the antebellum American South shows that height and weight were positively associated with slave value, suggesting that better fed, healthier slaves were more productive (Margo and Steckel 1982). In the contemporary US, taller individuals also earn higher wages (Case and Paxson 2008), although the "height premium" is higher in developing countries than in the US (where one more centimeter raises wages by 0.45%). However, this evidence does not purely reflect the better physical health of taller individuals—improved conditions in childhood will often result in better health and cognitive abilities both, even in developed countries (Case and Paxson 2008, Schick and Steckel 2012, Barham et al 2013).[3] For example, early life health interventions providing extra medical care in both Chile and Norway, two countries at very different stages of development, led to higher academic achievement in school (Bharadwaj, Løken, and Neilson 2013).

One of the implicit assumptions in the literature has been that in the US past, returns to height were as high as they are in developing countries today, thus suggesting that improvements in health account for a large fraction of productivity gains (e.g. Floud et al. 2011: 21-23; Costa and Steckel 1998). But improvements in nutritional status or health may not even lead to increases in education, which is widely viewed as a key determinant of economic growth in general and of twentieth century US economic growth in particular (Goldin and Katz 2008; Acemoglu and

[2] A caveat is that the relationship between height and subsequent mortality only shows up in large samples and is sensitive to the choice of follow-up period. When we tried to reproduce Costa's (1993) results using a larger sample of Union Army recruits, we obtained suggestive evidence of a J-shaped relationship between height and mortality but the height that minimized mortality was about 10 cm shorter than in Waaler's (1984) Norwegian sample and the odds of death was greater at taller than at shorter heights.

[3] An alternative explanation for the returns to height is that height is correlated with personal traits conducive to worker productivity, such as emotional skills and extraversion. For example, if the tall receive more investments and praise they become more optimistic and also have better communication skills (e.g. Persico et al. 2004; Mobius and Rosenblatt 2006).

Autor 2012). In the nineteenth century economy where, prior to widespread mechanization, brawn relative to brain must have been of greater relative value, improvements in child health could even have raised the opportunity cost of schooling, particularly for adolescents, thus reducing the optimal time spent in school.

Formal education was often not a job requirement in the nineteenth century. Abraham Lincoln had roughly one year of formal education, taught by itinerant school teachers. As we later show, in climbing the occupational job ladder, the returns to formal education in the mid-nineteenth century were roughly 1% whereas in the twentieth century they were up to 13%.[4] In this economy improvements in health may have increased the marginal cost of schooling. In contrast, in the twentieth century, when wage returns to education are high, if healthier students have a large advantage in learning the advanced concepts taught at higher educational levels, the marginal benefit of schooling is rising at higher educational levels. Yamauchi (2008), Bleakley (2010), and Pitt, Rosenzweig, and Hassan (2012) present empirical examples of the ambiguity in the effect of childhood health on schooling.

We obtain correlations between height and educational attainment over a century and a half that are consistent with a model of human capital formation in which physical labor was more important in the nineteenth century, thus raising the opportunity cost of schooling and depressing the height-education relationship relative to the twentieth century. We find that the nineteenth century was characterized by low investments in height and education, a small correlation between height and education, and positive but small returns for both height and education. The relationship between height and education was stronger in the twentieth century and stronger in the first part of the twentieth century than later on (when both investments in education and height stalled), but never as strong as in developing countries. The labor market and wealth returns to height and education also were higher in the twentieth compared to the nineteenth century. Our findings are consistent with an increasing importance of cognitive abilities acquired in early childhood.

[4] We are not implying that the returns to skill, more broadly defined, were only 1.2%. Apprenticeships are not included in formal years of education. Neither is being self-taught.

II. Theoretical Framework: Brain or Brawn?

We interpret height as a proxy for early-life health endowments that manifest themselves both in increased physical capability ("brawn") as well as in improved cognitive ability ("brain"). The nineteenth century economy, in which physical labor was used to do a variety of things that today would be done by machine, was one of brawn. The twentieth century, the human capital century, was a brain economy.

We can think of the effect of health on income as coming through three distinct channels:

1. An unskilled worker is more productive if he is healthier.
2. Better health helps a student learn, thus he obtains more value from his infra-marginal (i.e., 'would have attended anyway') time in school.
3. Better health might motivate a student to spend more time in school.

A simple decomposition illustrates these points.[5] Let *y(e)* be the lifetime income (in present discounted value) that accrues to a worker who has *e* years of schooling. Suppose the optimal choice of education is e^* and define $y^*=y(e^*)$. We are interested in the question of how a worker's productivity increases as his health endowment *h* changes: *i.e.*, the derivative dy^*/dh. This full derivative of y^* w.r.t. *h* can be decomposed as

$$\frac{dy^*}{dh} = \left.\frac{\partial y}{\partial h}\right|_{e^*} + \frac{de^*}{dh}\left.\frac{\partial y}{\partial e}\right|_{e^*}.$$

The first term gives us the direct effect of health on income, holding education fixed. The second term values the re-optimized schooling choice at the marginal return to schooling. It is helpful to further decompose the direct effect of health on income into two components, which yields this expression for the full derivative:

$$\frac{dy^*}{dh} = \left.\frac{\partial y}{\partial h}\right|_{e=0} + \int_0^{e^*} \frac{\partial^2 y}{\partial h \partial e} de + \frac{de^*}{dh}\left.\frac{\partial y}{\partial e}\right|_{e^*}.$$

The first term (channel 1) is the effect of the health endowment on the productivity of an unskilled (unschooled, possibly illiterate if $e=0$) worker. The complementarity between school and health is seen in both the second and third terms (channels 2 and 3, respectively), which

[5] The theoretical presentation in this subsection borrows heavily from Bleakley (2010a, pp. 292-4), who presents a simple version of the Ben Porath model.

measure the infra-marginal and marginal effects, respectively, of health on income by way of schooling.

The first, "unskilled" channel arises disproportionately because of physical strength and stamina. This effect diminishes over time as machines replace humans for brute force and repetitive assembly. But even if there were cognitive returns to height in the nineteenth century, improved health could produce less education. We start with two plausible intuitions: (i) schooling is of less value when much of the labor is physical and (ii) a healthier child might be a better student, but is also a better unskilled worker, especially in an economy dominated by physical labor.

We explicitly model the effects of improved health on educational attainment. We augment the *y* function of lifetime income above to include both education and health (*h*) as arguments, and recall that it is a discounted sum of period-specific incomes, $\tilde{y}(e, h, t)$:

$$y(e,h) = \int_e^{\infty} \beta(t)\, \tilde{y}(e,h,t)\, dt \; - \hat{c}(e),$$

in which t is time, the β*(t)* term reflects both discounting and wage growth that comes with age and/or economy-wide growth, and $\hat{c}$ are out-of-pocket costs of schooling.

To compute the optimal choice of education, we take the derivative of *y* with respect to *e*, which yields two groups of terms:

$$\frac{\partial y}{\partial e} = \underbrace{\int_e^{\infty} \beta(t) \frac{\partial \tilde{y}}{\partial e}\, dt}_{\substack{marginal \\ benefits}} - \underbrace{\left(\beta(e)\tilde{y} + \frac{d\hat{c}}{de}\right)}_{\substack{marginal \\ costs}}$$

The marginal benefits (call them MB) are the appropriately discounted sum of gains in future earnings. The marginal costs (MC) are both direct and opportunity costs of schooling. The usual assumptions are that the marginal benefit of schooling declines with more time in school but that the marginal cost rises: $MC_e > 0$ and $MB_e < 0$, where subscripts denote partial derivatives. These assumptions turn the optimization problem into an "optimal stopping rule": stay in school as long as marginal benefits exceed marginal costs; when MB=MC, leave school and work. This is shown graphically in Figure 1 (as the "Baseline model") and a dashed, vertical line denotes the optimal choice of time in school.

In this standard model, the effect of childhood health on years of schooling could be positive or negative. Taking full differentials of the condition for optimization (*MB=MC*), we derive the optimal response of schooling to health as

$$\frac{de^*}{dh} = -\left(\frac{MB_h - MC_h}{MB_e - MC_e}\right)$$

By assumption, the denominator is negative. If childhood health raises the marginal benefit of schooling, then $MB_h>0$. Nevertheless, it might also be the case that $MC_h>0$ i.e. a healthier child is more productive (for reasons that we discuss below). Thus, the sign of the expression is ambiguous. We consider four cases here in our analysis of the health/education relationship. The associated MB and MC curves for each case are shown in Figure 1. In each case, the baseline equilibrium is also shown in gray. The three cases are as follows:

Case 1: *Healthier children get (relatively) stronger as they mature.* Height is associated with physical strength and stamina, which would have commanded a relatively higher wage premium in the era prior to mechanization. This raises the opportunity cost of school for healthy children, and especially when they are in adolescence and thus closer to physical maturity. This raises and rotates up the MC curve, depressing the optimal time in school.

Case 2: *Healthier children learn more in school (parallel shift).* Learning more from the same time in school shifts up the MB curve. (In this and the remaining cases, $MB_h>0$.) But yesterday's marginal benefits raise today's marginal costs.[6] Put another way, more education raises the worker's productivity and therefore raises the opportunity cost of getting even more education. If health raises the MB of schooling equally at all (inframarginal) levels of schooling, then the MC curve shifts up in parallel, with little effect on the choice of time in school. Note that this is true even in an economy with no emphasis on physical labor, as long as health induces a parallel shift of the MB curve. In terms of the equations above, this neutral effect of

[6] One additional assumption, verified by Mincer and commonly used for this model, is that more education shifts up the $\tilde{y}$ function in a manner that is essentially independent of *t*. In words, more education raises period-specific productivity in roughly equal proportion across the working life. This imposes a good deal of structure on the model in that each point on the marginal-cost curve includes the (amortized) sum of earlier marginal benefits. The curves that we draw in Figure 6 reflect this relationship. An excel spreadsheet with supporting calculations is available from the authors upon request.

health on the education choice obtains if $MB_{eh}=0$. (This second derivative of MB is in reality a third derivative of the production function $\tilde{y}$. This is one more derivative beyond than the usual criterion for complements or substitutes because education is purchased with time rather than money, and education raises the value of time.)

Case 3: *Health and school are strongly complementary*. Informed by the previous case, we see that the MB curve needs to shift up *more* at higher levels of schooling if optimal time in school is to increase: $MB_{eh}>0$. This is to say that healthier children are not much better at learning basic school skills like literacy and numeracy, but do have an advantage at more advanced concepts.

Case 4: *Health and school are less than strongly complementary*. For completeness, we consider this case as a counterpoint to cases 2 and 3. In this case, learning better basically equates to learning faster, allowing the child to get to the labor market earlier with the same amount of schooling human capital. This case is best understood with the example of child prodigies, where the cognitive endowment is sufficient to allow children to 'blast through' school. Norbert Weiner (noted early-twentieth century child prodigy and PhD in math at age 17) and Doogie Howser (noted 1980s-TV-fictional-character child prodigy and MD at age 14) could have obtained three doctoral degrees at an age before any of the co-authors of this chapter had obtained even one. But the opportunity cost of their time was apparently too high at the conclusion of their first doctorate. Bill Gates and Mark Zuckerberg, both Harvard College dropouts who founded lucrative companies, might also be examples. For Case 4, $MB_{eh}<0$. (We do not graph this case to save space.)

Whether Case 4 is mostly an intellectual curiosity (only holding in extreme cases) is debatable. But Cases 1-3 all seem pertinent to some aspects of the results from the nineteenth and twentieth centuries.

We hypothesize that in the nineteenth, relative to the twentieth century, the height/education gradient will be much weaker because of some combination of Case 1 and Case 2. The greater weight on physical labor in the nineteenth century economy could had reduced or even flipped the relationship between height and education (Case 1). It may also be that the nature of the technology frontier was sufficiently different back then, such that one could acquire a high level of relative skill without having to delve into subjects that might be more cognitively taxing. This puts us closer to the realm of Case 2 if the complementarity between health and education was not so strong.

We hypothesize that in the twentieth century the height/education gradient will be stronger than in the nineteenth century because the health endowment is strongly complementary with education (Case 3) in this period. Because the Mincerian returns to education were highest before WWII and in the last two decades of the twentieth century (Goldin and Margo 1992; Goldin and Katz 2000; Autor et al. 2004), we also expect the height/education gradient to be lower for those cohorts in school in the several decades following WWII.

III. Data

We explore how health relates to education and income or wealth using many individual datasets spanning the 1860s to 2000. To obtain a picture of trends over the very long run in the United States, we make use of three datasets coming from Army recruits prior to 1950 (the Union Army data, The Gould sample and the World War II data) and combine them with data from the National Health and Nutrition Examination Surveys (1971 and later), the National Longitudinal Surveys (1966 and later), and the Health and Retirement Surveys (1992 and later). Together these data cover cohorts born between 1810 and 1990 and contain information on height, education, and productivity or income measures.

A challenge for this study is to construct measures of education that are comparable over time. Years of schooling (the standard measure used for education) are generally unavailable prior to the 1940 census in the US. The World War II data allow us to look at years of schooling because it was collected of all enlisted men. The older Union Army samples do not contain comparable measures of education—therefore, we develop a measure to transform the information in these older data sets into units comparable to modern measures.

A second challenge is obtaining comparable productivity or income measures. Wages and income data are not available for the entire US prior to the 1940 census. There are large numbers of sources describing wage rates and annual incomes for groups of people well before 1940, as well as sources allowing us to infer incomes. All the data we have contain measures of occupation, which we convert into a ranking reflecting the wages associated with each occupation in 1950.[7] We compare the occupation results to those we obtain using earnings in modern data sets. Finally we also make use of the wealth measures available in various samples.

a. Union Army Sample

Our analysis will use two subsets of the roughly 39,000 white Union Army (UA) soldiers collected under the *Early Indicators* project (NIA AG10120, Robert Fogel, PI) and available for download at www.cpe.uchicago.edu. At enlistment the white Union Army sample was representative not just of the Union Army but also of the northern population of military age in height, wealth and literacy rates (Fogel 1993). Although men could purchase a substitute once the draft was imposed, more than 90% of soldiers were volunteers with the remainder evenly divided between substitutes and draftees. At older ages, these men experienced the same mortality rates seen in samples based on genealogies (Fogel 1993) and thus remain representative of their birth and nativity cohort.

The military service records provide information on height at enlistment. The full sample is linked to the 1850 and 1860 censuses (among others), which provides information on the school attendance of children and on the literacy of those age 21+, and a subset is linked to the 1870 census, which provides information on real-estate and personal-property wealth of $100 or more. We sum both real-estate and personal-property wealth and attribute zero wealth to those with less than $100 in wealth. The censuses also provide geographic, demographic and socioeconomic information. In addition, we use occupational information in the 1870 census to construct an occupational income score based on the median income in that occupation in 1950.[8] The final sample covers the cohorts born between 1819 and 1850.

We construct several proxies for education using observations in the linked census manuscripts of the UA soldiers when they were of school age. Typically, the concept used for education is a

[7] We use the occupational score created by IPUMS. Occupational score has been used by Sacerdote (2005) and Bleakley (2010b), and a modified version has been used by Angrist (2002).
[8] The variable is constructed first by re-coding the 1870 occupations into the 1950 coding scheme and then using the "occscore" classifications of income from ipums.org.

stock variable: years of schooling. This presents a measurement difficulty in that the nineteenth century censuses contain information on the flow of school attendance and not the stock of schooling.[9] School attendance is informative of time spent in school: if we observe a thirteen-year old child in school in 1850, it should raise our expectation about the total years of schooling that he attains. Nevertheless, the variable only has information content during school ages; at other ages the attendance indicator is negligible and probably dominated by measurement error.

The definition of "school age" is complicated by the school-starting age having a large variance. We examined the fraction at school by age for the Northern states in the 1850 and 1860 IPUMS data.[10] Rather than a spike at 5 or 6 years, the attendance rate slopes up gently and only peaks around 10 years. We opted for a conservative approach and use the raw school-attendance variable only if that variable is observed sometime after the latest likely age at which someone would have started school (say 10 or 11 years) and before the age at which very few still attend school (say 21 years). So, we only include in the sample those who were linked to an antebellum census for which their ages were on the range [11, 21] at the time of the census.

We impute years of schooling based both on attendance and on the age at which the boy was observed. Consider two examples. Observing a 10-year-old boy in school in these data imparts relatively little information about his eventual attainment in that he may have just started school and may drop out at the end of the year. In contrast, a 20-year-old boy observed in school probably had above-average years of schooling. Following this logic, we construct the first measure of education, E_1, as follows,

$$E_1 = S_a * (a - a_0),$$

where a is age, a_0 is 10, E_1 is measure 1 for years of schooling, and S is the dummy variable for school attendance. This measure is an imputation of "years of school after turning 11" rather than simply total years in school. This measure is highly correlated with the dummy variable: the R^2 in a regression of measure 1 on the attendance dummy is 0.57 and the slope is 5.61.

[9] Using linked census samples, Long (2006) shows that childhood school attendance is predictive of higher occupational standing in the nineteenth century UK. Bleakley and Ferrie (2012) show that this variable predicts both higher occupational score as well as higher wealth in nineteenth century Georgia.

[10] The IPUMS sample that we used was restricted to boys and excludes the three Southern census regions.

We construct one additional imputation of years of schooling ("measure 2") using three factors: school attendance, age when attendance status was observed, and contextual information on the rates of school attendance by age. One difficulty with the previous two measures is that they ignore the information in the overall distribution of attendance by age. To account for this information, we first treat flows of school attendance across the observed school ages as if they come from a single cohort. This is similar to work done by Margo (1986), who cumulates the flows of school attendance across ages within a particular year to compute years of schooling by cohort.[11]

We use the observed flows of schooling to adjust the imputed years of schooling for those observed out of school. Note that we assumed for measure 1 that the $S_a=0$ boys got zero time in school, which is obviously extreme. If those in school at age a have been in school continuously since age a_0, it must be that

$$\underline{E}_a = q_a\,(a-a_0) + (1-q_a)\,X_a,$$

where $\underline{E}_a$ is the (cumulated) stock of years in school at age a, q_a = the fraction in school at age a and X_a is the average years in school of those that dropped out before age a. We estimate q_a using aggregate data on school attendance by age in the antebellum IPUMS data.[12] Again maintaining the assumption of continuous schooling since a_0 if a boy is observed in school at age a, we set measure 2 equal to measure 1 if S_a=1. If $S_a=0$, however, we set measure 2 equal to X_a. For example, for 11-year-old boys, we impute an E_2=1 if they are in school and E_2=0 if not. For 21-year-olds, however, we set E_2=11 if they are in school and E_2=5.1 if not, which keeps the average years of schooling consistent with what is implied by cumulating the flows of attendance over those ages.

b. The Gould Sample of Union Army Soldiers

[11] This method has been also used more recently by Hazan (2009) to construct school attendance by cohort over 150 years of cohorts in the US and by Bleakley and Hong (2013) to examine changes in school quality by US region in the nineteenth century.

[12] These flows of school attendance (the q measures) are computed by age, but not decomposed by area, except that the Southern regions are excluded. The correlation between measure 2 and a version constructed instead with region-specific schooling flows is 0.9719. We also constructed state-specific approximations, but concluded that the flow measures were too noisy. When the full-count files for the 1850 census becomes available, it may be possible to do state-specific imputations, but the existing IPUMS samples were too thin at the state x age level.

In the early part of 1863 the United States Sanitary Commission began its inquiry into the physical and social condition of soldiers by sending sixteen examiners to specific locations, including Washington, where the armies of the Potomac and the West were concentrated. Examiners were instructed to measure as many men as possible. When necessary, additional examiners were sent to a location and then sometimes accompanied an army corps to obtain further measurements. Trained examiners armed with andrometers, spirometers, dynamometers, facial angle instruments, platform balances, calipers, and measuring tape measured men's body dimensions, weight, lifting strength, and vital capacity, and obtained basic demographic and socio-economic information. The data were first analyzed by Gould (1869) and the original forms were collected by Costa (2004) and include 15,866 white Union Army soldiers and sailors. Of these men, 11,710 are native-born.

Compared to the Union Army as a whole, the location of the examiners increases the proportion of recruits who were born in the Middle Atlantic (especially New York City) relative to the Union Army. Therefore, the average recruit was shorter and the proportion of recruits who were farmers was smaller than in the Union Army. The average recruit in the Gould sample was also more likely to be native-born.

We restrict ourselves to the native-born and use the height and educational information in the Gould sample. After limiting the sample to men for whom education is available, we are left with 7,624 men born between 1793 and 1851. Education is described as none, limited common school, common school, college, or professional. We attribute 0.5 years to education to none, 4 years of education to limited common school, 8 years of education to common school, 10 years of education to high school, and 14 years of education to college or professional. There is quite a bit of variation in schooling. Among the native-born of all ages (including those too young to have attended college), 5.3% had no years of education, 49.7% had limited common school, 39.2% had common school, 4.8% had high school, 0.6% had college, and 0.2% had a professional education.

The limited information on apprenticeships in sample shows that years of education and the probability of ever having had an apprenticeship were positively correlated among the native-born age 21-49. Because we know apprenticeship status for only 154 native-born men age 21-49 (of which 104 were non-farmers), we make no adjustment for skill beyond years of education.

c. World War II Enlisted Men

The World War II (WWII hereafter) data contain 9.2 million observations of individuals enlisted in the Army between 1938 and 1946. The records contain the information reported at the time of enlistment, including measured height, educational attainment and occupation prior to enlistment. A total of about 16 million men served in all branches of the military, and a total of 11 million served in the Army. About 60% were drafted and 40% volunteered. The records in the WWII data contain about 85% of those who served in the Army (15% of the original records are unreadable). Thus the data are likely to be representative of the men who served in the Army.

However, because of drafting criteria, these men are not necessarily representative of the US population of men of drafting ages. To serve in WWII, a man had to be between five and six and a half feet tall, weigh at least 105 pounds, and have good vision and good teeth. Additionally men had to be able to read and write. Those convicted of a crime were not eligible to serve. Finally there were exemptions based on occupation (men in a few agricultural and war-related production occupations were exempt), and initially, married men and fathers were exempt. Because of segregation relatively few blacks were drafted. Acemoglu, Autor and Lyle (2004) and Goldin and Olivetti (2013) provide evidence that these exemptions generated substantial differences in the likelihood of serving in the war: blacks, farmers and individuals of German descent were much less likely to have served.

To obtain a sample that is likely to be representative by cohort, we keep all white men born in the United States between 1898 and 1923 (other cohorts have very few observations), ages 20-45, with valid heights (between 60 and 78 inches), valid weight (over 105 pounds), and valid enlistment year (1938-1946). The final data we use contain about four million observations.

We construct years of schooling based on reported educational attainment. No individual is listed as having less than primary school—we impute those with exactly 8 years of schooling as having 4.5 years.[13]

We matched occupation to occupational scores using the 1950 occupation categories. To each occupation in the WWII records we assign the occupational score associated with that occupation in the 1950 census. When multiple 1950 occupational categories were assigned to WWII civilian occupations we used the average occupational score for 25- to 49-year-old white males across the listed occupations. We then compute the log of the occupation score, which is a positive value for everyone except for those that declared "no occupation" or "student" as their occupation prior to enlistment.

d. Commonly used contemporary samples

We cover as many cohorts and time periods as possible by using several well-known recent data sets that contain standard measures of years of schooling, height, occupation and earnings. The National Health and Nutrition Examination Surveys I (1974-4), II (1976-80), III (1988-94) and 1999-2010 combine survey information on education and labor market outcomes with physical examination measurements, including height and death certificates. We use the 1961 wave of the National Longitudinal Survey of Old Men, the 1981 wave of the National Longitudinal Survey of Young Men, and the 1996 wave of the National Longitudinal Survey of Youth. Heights are self-reported but the surveys have good information on incomes and wealth for individuals in their prime labor market years. We also use the Health and Retirement data—it contains excellent measures of wealth but individuals are only sampled after age 55 and their heights are also self-reported. Finally, we include results from the National Health Interview surveys to examine the most recent cohort of men. These data do not contain wealth, heights are self-reported and income is reported in categories only.

IV. Trends in height and education

[13] We also experimented with coding them as illiterate, and all others as literate, under the assumption that the literacy requirement resulted in the education always being coded as at least 8 years of schooling/primary grade.

a. Height and other health measures

Figure 2 illustrates the well-known long-term trend in heights in the United States, compiled from heights of native-born soldiers from the eighteenth through the twentieth centuries and of native-born men in the last decades of this century.[14] The data, which are arranged by birth cohort, show that troops who fought in the French and Indian War of the 1750s and the 1760s or who fought in the American Revolution of the 1770s nearly attained 1930s heights of 175 cm. Cohorts born from the early 1700s to those born in 1830 achieved a gradual increase in average stature of approximately one centimeter. Average heights fell by approximately 4 cm in the ensuing half-century, reaching a trough among births in the 1880s.[15]

Corroborating evidence for the decline in stature among whites is found in mortality data from genealogies. Life expectancy at age 20 declined from approximately 47 years at the beginning of the century to slightly less than 41 years in the 1850s and recovery to levels of the early 1800s was not attained until the end of the century (Pope 1992). The decline in black stature is consistent with Steckel's (1979) finding of a decline of two and a half to seven and half centimeters in the heights of slave children born in the two decades after 1830. Other work has documented that industrialization (and perhaps the accompanying urbanization) was associated with a mortality "penalty"—but the height decline is observed in both rural and urban areas and few Americans lived in urban areas.

After the 1880s, American men experienced the familiar secular increase in stature of recent times, gaining approximately six centimeters by the mid-twentieth century. This large increase in heights occurs at the same time that life expectancy and health are rising substantially.

The secular increase in heights continues in recent decades, although at a much slower pace. As others have documented (Komlos and Lauderdale 2007), there is a stagnation in height growth, the causes of which are not understood.

[14] Since the sample sizes are substantial, particularly for those periods before the large wars, the major movements in the series are unlikely to represent sampling variation. In fact, the difference in average height between rejectees and those who served in the Union Army was 0.25 inches. The averages have been corrected for minimum height standards.

[15] No national height series is available for the end of the nineteenth century. Interpolation was based upon the assumption that the time pattern for the country followed that for Ohio.

We plot the height series we obtain from our datasets in Figure 3. As in Figure 2, we observe that heights steadily increased in the early period, and then reached a plateau for the post-WWII birth cohorts.

The increase in heights coincides with a decline in the variance of heights. The estimates in Table 1 reveal that the correlation in adult heights between brothers has increased since the US Civil War. The most likely cause for the low correlation in the past is families' inability to protect themselves against disease and nutritional shocks. Among brothers in the Union Army heights were lower in more populous counties and the variability in height was greater, suggesting that the environmental contribution to variability in height is of greater relative importance in populations reared in worse environments (Lauderdale and Rathouz, 1999). The US decline in brother-brother correlations is consistent with the increase in height heritability observed among Finnish twins born in the first half of the twentieth century and those born later (Silventoinen et al. 2000).

Finally the trend in height appears to follow the declines in infectious disease mortality: Panel b of Figure 3 shows that infectious disease mortality fell dramatically until about mid-century and then remained at a very low and stable level—cardiovascular mortality by comparison starts falling much later. This coincidence in the trend for height and for mortality is consistent with the notion that adult heights are most affected by conditions early in life, at least proxied by infectious disease mortality, which mostly kills children.

b. Trends in education

Figure 4, which plots the average years of education by year of birth for various samples, shows that educational attainment steadily increases beginning in the nineteenth century and continuing up to about 1950, at which point education plateaus. The increase in years of schooling from 1900 to 1960 is about 5.5 years. These trends are consistent with the patterns that have been documented for the nation as a whole, although the stagnation for the very last few cohorts is atypical compared with other data for the population (however, our data for these later cohorts are noisy). The plateau in years of schooling coincides with the plateau in heights and in infant mortality.

c. Summary

Our evidence on long-run trends implies that both childhood health and education improved substantially in the early twentieth century. We next look at the consequences of these improvements on long-term measures of labor market success. We start by assessing the extent to which education was determined by early childhood health, proxied by heights. Then we move on to examine how height and/or education affected our measures of labor market success and wealth.

V. The effects of height on education

For each of our cross-sectional data sets we estimate OLS regressions of the form

$$e_i = \beta_0 + \beta_1 h_i + \beta_2 C_i + u_i,$$

where *e* is years of education for individual *i*, *h* is height in centimeters, *C* is a vector of control variables and *u* is an error term..

Table 2 shows that heights had little effect on educational attainment in either the Union Army or the Gould sample. The most that an extra centimeter of height contributed to years of education was 0.009, a 0.3% increase relative to the mean. Heights had no effect on illiteracy rates. Recall that the main difficulty with these data is that we have to impute education based on enrollment and age. It is possible that our measures of education are too noisy. Nevertheless the results suggest a small effect of height.

We find a small effect of height on education even under various sample restrictions. When we restricted height to men above 5 feet and below 6 feet, 5 inches (the restriction for WWII enlisted men) in the Gould sample, the coefficient rose only to 0.003 ($\widehat{\sigma} = 0.005$) from 0.002. When we restrict to men who were younger than 25 at enlistment the coefficient on the second measure of education in the Union Army sample rises from 0.005 to 0.008 ($\widehat{\sigma}$=0.036). When we restrict the sample to men who were older than age 35 at enlistment the coefficient falls to -0.031 ($\hat{\sigma} =$ 0.322). So these results suggest that the effect of heights is larger among the more recent cohorts in the nineteenth century sample.

Table 3, which presents results from identical models estimated with twentieth and twenty-first century data, reveals that, relative to the nineteenth century, the effect of height on education is much larger in magnitude and is statistically significant in all cases.[16] For cohorts born between 1897 and 1959 (Panels A-C) we find that a one centimeter increase in height is associated with 0.08 more years of schooling.[17] But the coefficient of height on education is smaller in more recent cohorts: for the birth cohorts 1943 to 1974 the effect falls to 0.05 and then to 0.04 for the most recent cohorts.

We used the World War II sample to test for non-linearities in the education-height relationship using height dummies. Although there is suggestive evidence that the relationship between years of education and height becomes weaker at tall heights, the effects are still positive for heights of 193.4cm and over (more than 6'3").

A caveat to our cross-sectional results is that unobserved family or environmental effects may lead us to overstate the cross-sectional height-education relationship. Case and Paxson (2008) find that controlling for mother fixed effects in the NLSY attenuates but still leaves statistically significant the relationship between test scores and children's height. By linking the WWII enlistment data to earlier censuses, Parman (2010) was able to identify brothers and also finds an attenuated but still statistically significant relationship between height and education among brothers.[18]

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[16] An important caveat is that our results would change substantially in magnitude if we did not drop individuals with heights within enlistment parameters. If all height observations are included then the coefficients on height would be substantially smaller. However, the overall pattern would be similar.

[17] When we accounted for the left censoring of education in the WWII data we obtained a coefficient of 0.072 ($\hat{\sigma} =$ 0.000).

[18] Parman (2010) concluded that a one inch difference in the height of brothers leads to 0.03 years of education compared to 0.07 years of education in a naïve regression that does not control for family effects. (An extra centimeter would lead to 0.01 years of education compared to 0.03 years in a naïve regression. Parman restricted his sample to privates but we do not find that this explains the difference between our results and his. His sample over-represents men from large families.)

We assess the magnitude of our effects in Table 3 by computing the fraction of the changes in education that can be "explained" by changes in heights. Height increased by about 1.2 centimeters across cohorts in Panels A-C, thus the increase in education it is associated with is about 0.1 years of school, a small fraction of the increases in education across these cohorts (years of schooling increases by about 2.9 years). The decline in education in panels D through H is -0.02. Heights fell by 1.56 centimeters, and given the coefficient of -0.05, height accounts for about 0.0078 of the 0.02 decline, or about 40%.

The overall patterns suggest there are three periods. During the nineteenth century a large fraction of the sample is in farming occupations and average heights and education were low and tended not to be correlated with each other. From the late nineteenth century up to the 1940s, height and education increased rapidly and the correlation between them was high. Finally, from about 1940 onward average education levels and heights are falling, and the correlation between the two falls.

Our results raise multiple questions. What drove the tremendous improvements in education and health observed in the first part of the twentieth century? Were both driven by the same factors? A large number of policies were directed at improving maternal and child health as well as increasing education during the progressive era. This era also saw large increases in incomes and nutrition, as well as increases in the returns to school. Finally, what explains the stagnation since 1940? Is it possible that declines in childhood investments have consequences for the labor market?

VI. Height, Wealth and Income

We estimate OLS regressions of the form

$$\ln(p_i) = \beta_0 + \beta_1 h_i + \beta_3 C_i + u_i$$

$$\ln(p_i) = \beta_0 + \beta_1 h_i + \beta_2 e_i + \beta_3 C_i + u_i$$

where *p* is a measure of individual *i*'s productivity, such as occupational score, wage, or wealth, *h* is height in centimeters, *e* is years of education, and *C* is a control variable. We estimate these regressions for each of our cross-sectional data sets with information on productivity.

a. The Nineteenth Century

We analyze the relationship between height and productivity measures in the nineteenth century data using the Gould sample of Union Army soldiers and the Union Army enlistment records linked to the 1870 Census. In both data sets, as a proxy for income, we use the "occupational income score," which combines the occupation reported in the nineteenth century data with a tabulation of median income by occupation in 1950. Linkage of the Union Army enlistment records to the 1870 records provides us with a wealth variable which is the sum of real estate and personal property wealth. We transform both variables into natural logarithms.

Figures 5A, 5B and 5C show the basic results for the 1870 data for farmers, non-farmers, and the pooled sample, respectively. Panel C of each of these figures displays the estimated distribution of heights. Panels A and B depict the estimated non-parametric regression of the relationship between height and outcomes. (In these figures, the estimated relationship is not adjusted for controls. We present regression-adjusted results below.)

In both the farmer and non-farmer subsamples of the 1870 data the (logarithm of the) value of wealth increases almost linearly with height for most of the distribution, although apparently peaking a bit below six feet (see Figures 5A and 5B, Panel B). The wealth/height gradient is steeper among farmers than among non-farmers. Overall, in the pooled sample (Figure 5C, Panel B), wealth and height are positively associated.

Height is also associated with a higher occupational score among farming occupations. (The main two occupations in this category are farmers, who might own their farm, and farm laborers, who presumably do not.) In contrast, among non-farmers height is negatively correlated with occupation. Occupational score and height are negatively related in the pooled sample as well. The negative relationship is stronger in the pooled sample because farmers have low occupational scores and were on average taller because they were less exposed to disease. We therefore focus on the non-farmer samples in looking at occupational scores in a regression framework.

The upper panels of Table 4 show that although among non-farmers height increased occupational score, the effect was modest. One additional centimeter in height among non-farmers in the Gould sample was associated with a 0.2% increase in the occupation score, and this coefficient remains unchanged when we control for education. For the 1870 UA sample, the increase in occupation score with height was 0.1% and not significantly different from zero.

Table 4 also reveals that even among non-farmers, returns to education, although positive, were low. An additional year of education increased the occupation score by only 1.2% circa 1860 and by 1.3% circa 1870. Recall that because education and apprenticeships were positively correlated, these low estimates of the positive effects of education are biased upwards.

Table 5 reports that in 1870 a centimeter of height is associated with an additional 1% of wealth. This result is unchanged by controlling for education.[19] A similar pattern emerges from regressions that control for place of birth using alternative levels of geographic detail, use various sampling weights to make the sample more representative of the 1860 US population, drop outliers in height, or compute wealth in alternative ways.[20] We also found that while there is some evidence of non-linearities in the height-wealth relationship, the non-linearities are present only at heights of about 188cm (6'2"). Because few men are so tall, they have a minimal effect on our estimated wealth-height relationship.

The height-wealth relationship was stronger among the farm population (see Table 5). When we split the sample between farmers and non-farmers, we obtained coefficients on height of 0.009 and of 0.022 for the non-farm and farm samples, respectively, with controls for education. The returns to height may have been greater for farmers because the physical demands of farming put a premium on health.

[19] However, the coefficient on education might be biased downward by measurement error; we note that the coefficient on height drops to 0.7% if we fix the coefficient on education to be 0.4, roughly in line with what is estimated in the 20th century data.
[20] Results available upon request.

b. The Twentieth Century

The results for the twentieth century paint a different picture (see Table 4). In the first two columns of Table 4 we report the coefficient from a regression of the logarithm of the 1950 occupational score on height with and without controls for education, and with basic geographic and age controls. Several patterns emerge. The returns to height increased substantially throughout the century. Without education controls the returns to height increased from about 0.2% to 0.9%, and controlling for education they rose from 0.2% to 0.4% (panel A v. panel F). The returns to education also rose dramatically from 1.2% to 12.9%. In the twentieth century samples (Panels B-F) controlling for education substantially lowers the returns to height, unlike in the nineteenth century samples, suggesting that the returns to height in the twentieth century are driven in part by cognitive improvements associated with both height and education. [21]Interestingly in the WWII enlistment data, we also observe positive and statistically significant effects of height and education for women and for black males.[22]

Results without farmers are very similar; for example, in the WWII data, the coefficient on height controlling for education is 0.0010 for the full sample (panel B of Table 2), 0.0013 for non-farmers, and 0.0002 for farmers. Farmers constituted at this point less than 20% of the labor force (Wyatt and Hecker 2006). The last two columns show that despite the coarseness of our occupation score measure, the same basic patterns are observed with wages. In fact the returns to height are larger when we use wages—suggesting that within occupations there are substantial returns to height that are not accounted for when we use variation in income across occupations only.

Table 6 presents the results for wealth in the twentieth century samples. Unfortunately the WWII enlistment data contain no information on wealth. It also is substantially more difficult to construct comparable wealth measures over time. For instance the NLS samples collected

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[21] In the World War II data we also ran specifications controlling for compulsory schooling laws and child labor laws. Our results remained unchanged.

[22] Results available upon request. Women who enlisted to serve in the Army in WWII are unlikely to be representative of women at the time, and in previous research blacks were under-represented (Acemoglu et al 2004).

different information about wealth over time. Therefore it is more difficult to compare these coefficients and their evolution. However, in all of the samples we observe a very large and robust association between early investments and wealth. Both education and height are positively associated with wealth. The coefficients on height in these late twentieth century samples range from 0.024 to about 0.04. In all of these samples height and education have larger coefficients than in the nineteenth century samples. The wealth results are consistent with the occupation and wage results.

Overall a picture emerges with the nineteenth century having lower health and human capital (height and education), and positive but small wealth returns for both education and height. In the first part of the twentieth century, there are large increases in education and height, yet at the same time returns appear to have increased substantially.

c. Interpretation of the Results

Our productivity regressions have treated the causality as going from childhood health, proxied by adult height, to adult productivity. In our interpretation, adult height is a marker of both strength and cognition. But even the genetic return to height could have a productivity return if the tall receive more investments which in turn makes them more outgoing or if they are groomed for leadership roles simply by virtue of their height. In addition, height may be endogenous if unobserved variations in parents' endowments, prices, and preferences affect their children's early life height inputs and also enhance their adult health status and lifetime productivity. Instrumental variable estimates for Ghana, Brazil, and the United States are many times larger than the OLS estimates (Schultz 2002). Nonetheless, both OLS and IV estimates show that the wage returns to height are smaller in the US than in Ghana and Brazil. Because our primary interest is in determining how the relationship between height and productivity has changed and because we do not have instruments for US heights over a century and half, reduced form estimates, estimated using similar specifications and sample restrictions, are used to establish long-run trends.

VII. Comparisons with US Slaves and Developing Countries

Studies of the effects of health on long-run economic growth commonly cite the relationship between US slave height and prices and the height and productivity relationship in developing countries as evidence of the importance of health to productivity (e.g. Floud et al. 2011: 21-23; Costa and Steckel 1998). Floud et al. (2011: 132) use the estimated effect of height and weight on slave prices to estimate the effect of changes in height and weight on earnings and therefore of changes in body size on British economic growth. How do our height and productivity results compare to those for slaves and for developing country populations?

a. Comparisons with US Slaves

The only other study examining the relationship between height and wealth in the nineteenth United States is Margo and Steckel's (1982) examination of the relationship between height and slave prices. Their Table 6 reports a coefficient of log slave price on height of 2.1% per cm. Although this coefficient is similar to the height-wealth relationship we observe for farmers in Table 6, slave prices exhibit a steeper gradient for height than those for all free men. Throughout this chapter we interpret the returns to height being returns to both broader health and cognition. But this cognition interpretation does not seem consistent with the returns to height being higher for slaves than free men. Slaves were not being purchased for their cognitive skills, by and large. The labor services provided by slaves *circa* 1860 were likely more physical than cognitive, especially relative to *circa* 1870 free whites in the North. We argue that there is no inconsistency, however, for both theoretical and econometric reasons.

Why would the measured return to some endowment be higher in the slave price than in the wealth accumulation of a free person? We suggest two relevant distinguishing characteristics:

(i) is the variable forward or backward looking?
(ii) what is the endowment effect if the labor endowment belongs to someone else?

The first point (point i) is that the slave price is an asset value, and thus forward looking, while a free man's wealth is the result of an accumulation process, and thus backward looking. This indicates that we should compare the gradient among young (adult) slaves with that of older free men. Indeed, if we re-estimate the height/wealth model with an interaction term between age and height, it is strongly positive and statistically significant. Evaluating the coefficient at age

25, we find a return to height of .01 per cm.[23] Evaluating instead at age 55, we obtain .04, which is double the Margo/Steckel number for slaves.

Now consider the endowment effect (point ii). If the taller free man has in effect a more valuable labor endowment, he might work less (and thus accumulate less wealth) because of the endowment effect (some might call this a wealth effect instead). Whether this effect is strong enough to generate backward-bending labor supply is not the point. The point is that the endowment effect is weaker for slaves, *who did not own their own labor endowment*. Thus, we would expect that the marginal value of height to be higher for slaves. (Note that this difference would disappear if we could control for labor effort, but the price or wealth data is not adjusted for hours worked.) Furthermore, combining points (i) and (ii), we note that the slave price also incorporates the productive value of their progeny, which might be higher for taller men.

Further, the gradient in slave prices with height becomes considerably smaller than the estimated wealth/height gradient in 1870 if we account for two important differences between our specification and the one used by Margo and Steckel. First, their specification included weight as well as height, while ours above does not. Those authors sought to relate observed anthropometric measures to slave prices, and thus it was appropriate to control for height and weight simultaneously. For the purposes of the present study, however, we are interested in height as a proxy of early-life endowments. We are therefore cautious about over-controlling for too many physical attributes. Fortunately, the data employed in their study was conserved as ICPSR study #9427 (Margo, 1979), and therefore we can estimate comparable specifications using their original data.[24] When we re-estimate their model dropping both weight and the interaction of weight and height from the specification, we obtain a coefficient on height of .005 per cm. This is considerably smaller than our results above using 1870 wealth. At first glance, this was perplexing because our intuition was that the coefficient on height would rise after

[23] We also found evidence of increasing age profiles for occupation in the WWII data and for wealth in the NLS data. Results available upon request.

[24] In our attempt to replicate their results in Table 6, we drop females, those with age less than 18, and those with height or weight coded to zero. Light skin complexion is coded as stated in the data documentation. Nevertheless, the sample that we obtain is substantially larger (871 versus 523 observations) and the coefficient of log slave price on height in inches is 0.043 rather than their reported estimate of 0.053. The pattern of statistical significance across variables is similar to their results. Most of the other coefficients are smaller in magnitude in our estimates than those reported by Margo and Steckel. Note that our focus here is on how much the price/height gradient attenuates when adjusting the specification to match ours, and we suppose that the comparative values of coefficients would be similar if we were able to match their sample exactly.

dropping the weight controls, because height and weight are positively correlated. But this brings us to a second issue in their specification: namely, the construction of the interaction term. Their interaction between height and weight appears to be the simple product of the two variables. Constructing the interaction term this way forces the main effect of height to be evaluated at a weight equal to zero. For the present purposes, this is not an interesting point in the distribution at which to evaluate productivity/height gradient. With an interaction term constructed by first removing the means from height and weight, the coefficient on height is now evaluated at the mean of the weight distribution. When estimating their equation with this alternative construction of the interaction term, we obtain a coefficient on height of .004 per cm.[25] This is 2 to 4 times lower than what we estimate in Section VI.a above for height and 1870 wealth, suggesting that the cognitive channel plays a role in interpreting these results, even in the nineteenth century. If the wealth return to brawn is 0.004 then the wealth return to cognition is 0.005 (=0.009-0.004) for non-farmers and 0.018 (=0.022-0.004) for farmers, suggesting that a good part of the return to height was via cognitive human capital rather than physical strength, even in the nineteenth century.

b. Comparisons with Developing Countries

Findings from developing countries on the relationship between education and health include work by Glewwe and Jacoby (1995) on Ghana, which finds that the shorter sibling receives less schooling, and work by Paxson and Schady (2007) showing that taller children in Ecuador have better cognitive outcomes.

One of the difficulties, however, in comparing our results with those from developing countries is that specifications and sample restrictions differ, and more importantly large representative samples of adult males with height measures are uncommon. We therefore use the 2005-2006 Indian Demographic and Health Survey (hereafter DHS) to examine the relationship between height, education, and wealth among Indian men age 20-45. The DHS is a unique dataset for our purposes: it sampled all men age 15-54 (regardless of marital status), and the sample is very large. The survey covered 99% of the population and was designed to be representative of the nation and of rural and urban areas both. It contains years of schooling, occupation and a

[25] We found some suggestive evidence of non-linearities at heights of 188cm (6`2”) and above but few men were in this height range.

measure of wealth. Height and weight were measured by interviewers.[26] Although wealth is difficult to measure in agrarian societies, the wealth index provided by the DHS survey is an excellent measure of resources.[27] We restrict attention to men ages 20 to 45, with non-missing values for height and education and use survey weights. The final sample has about 48,000 observations. On average these men have about 8 years of school and measure 164cm.

Panel A of Table 7 shows that the relationship between height and education in India was 0.15 for all men with slightly smaller effects for farmers. The effects, as measured by the height coefficients, were larger than for the twentieth century United States. The effects of a standard deviation increase in height were also larger than for the United States (see Table 8). Interestingly, the Mincerian wage returns to education are also higher in developing than in developed countries (Psacharopoulos 1994).

Panel B of Table 7 shows that the wealth returns to height in India are 0.018 without controls for education and 0.008 controlling for education. The returns are thus similar to those observed in the nineteenth century United States and lower than those observed in the twentieth century United States.

Comparing our results for the occupational score and wage returns to height with studies of the wage returns to height for various developing countries suggests that returns are higher in developing countries. [28] Using data from Colombia (the ENH), Ribero and Nuñez (2000, Table 5, Column 6) report a coefficient of log wages on height of 0.008 when controlling for education, which is identical to the estimate from India just reported. Vogl (2011, Table 2, Column 4, and Table 4, Column 1) finds in Mexican data (the MxFLS) that an additional centimeter of height is associated with 0.023 higher log wages and 0.16 extra years of schooling. Controlling for education, Schultz's OLS estimates of the coefficients on height in a log wage regression are 0.015 for Ghana and 0.014 for Brazil. With the exception of the height coefficient for

[26] http://www.measuredhs.com/pubs/pdf/FRIND3/00FrontMatter00.pdf
[27] http://www.measuredhs.com/pubs/pdf/CR6/CR6.pdf
[28] Our review of the developing-country literature is selective, however, because the heterogeneity in specifications makes it difficult to compare results from all of the studies we found. As we saw above in the comparison with slave prices, seemingly small differences in the specification can make major differences in comparability of the coefficients. We restrict ourselves here to a few cases where it seemed clear that we are making an apples-to-apples comparison.

Columbia, all of these coefficients are larger than for the twentieth century US and therefore for the nineteenth century US as well.

Why are the returns to height and education so much stronger in developing countries than in the United States, both in recent data and in the past? One tempting hypothesis is that the returns to education are generally higher in contemporary developing economies. But this explanation raises a puzzle. The difference in height coefficients in the log-wage-height relationships between developing countries and the US is about 0.01. The difference in height coefficients in the education-height relationship between India and the US is about 0.07. Asssuming that the return to education is about 0.05 and 0.10 then the decomposition of the effects of health on education

$$\frac{dy^*}{dh} = \left.\frac{\partial y}{\partial h}\right|_{e=0} + \int_0^{e^*} \frac{\partial^2 y}{\partial h \partial e} de + \left.\frac{de^*}{dh}\frac{\partial y}{\partial e}\right|_{e^*}$$

implies that all of the effects of height on education are working through the third term (better health increases years of education). The puzzles is why there are no first term effects given the continued presence of brawn-intensive jobs in the developing world and why, if health is a complement with education at the margin, it does not complement infra-marginal education (the second term). For the moment, we leave this inconsistency for future research.

VIII. Education and mortality

We have focused thus far on the effect of early life investments on economic success. We finish this chapter by considering how education affects adult mortality—another welfare measure. We examine the effects of education on mortality among native-born Union Army veterans alive and on the pension rolls in 1900 and age 55-74 and men of the same age in the second and third NHANES surveys. To ensure comparability across the surveys we examine 12-year mortality rates. We run Gompertz hazard models of the form,

$$h(t) = h_0(t)e^{x\beta}, h_0(t) = e^{\gamma t} .$$

We control for age at time of observation, population (size of city of enlistment for Union Army veterans and whether in a metro area for NHANES), state of enlistment or residence fixed effects, and, for Union Army veterans, a dummy for census year used and age in 1850 or 1860 fixed effects.

Table 9 shows that education was not a statistically significant predictor of 12-year middle and older age mortality rates among native-born Union Army veterans. When we use our first measure we obtain a coefficient of 0.994 ($\hat{\sigma}$ =0.030). When we instrument using our first measure of education we obtain a coefficient of 0.991 ($\hat{\sigma}$ =0.050). We also performed additional robustness tests. The results were similar even controlling for occupation in 1900 (or past occupation if retired). We also obtained similar results using a Cox proportional hazards model. When we looked at cause of death, we found that the more educated were less likely to die of stroke but were more likely to die of ischemic heart disease.

However, education was a statistically significant predictor of mortality rates in all three late twentieth century samples, and its effect appears to be increasing. However the hazard ratios suggest that the relative risk of death for a year of education fell from 0.989 in the Union Army to 0.969 in NHANES I to 0.956 in NHANES II and then to 0.948 in NHANES III, only the differences between the Union Army sample and NHANES II and III were statistically significant in a pooled sample.

These results are consistent with the labor market and wealth results—the returns to early investments appear to have increased substantially in the twentieth century, and this is also true for mortality.

Conclusion

We document trends in early childhood investments measured by height and educational attainment for cohorts born in the United States between 1820 and 1990 and the extent to which height and education were correlated over time. We then relate the heights and education to various measures of labor market success and wealth. To investigate these relationships we make use of a large number of data sets containing the highest-quality comparable measures of height and economic success.

Overall a picture emerges with the nineteenth century having low investments in height and education, and positive but small returns for both education and height in non-farm occupations. Height was a significant predictor of wealth in the population; however, height was negatively associated with occupational scores among farmers.

In the first part of the twentieth century, there are large increases in education and height but these investments stall in the second part of the twentieth century. At the same time returns to height and education, though not as large as in developing countries today, appear to have increased substantially all throughout the twentieth century and appear to be at their highest today.   Investments in both health and education are thus even more potentially valuable today. Interestingly investments in college education seem to have stalled despite persistently high returns the second half of the twentieth century (Goldin and Katz 2008, Oreopolous and Petronijevic 2013). Understanding the determinants of investments in early human capital investments, and why these investments slowed down significantly after WWII but started increasing after 2000 (New York Times June 29, 2013[29]) is an important topic for future research.[30]

We speculate that the greater importance of physical labor in the nineteenth century economy, which raised the opportunity cost of schooling, may have depressed the height-education relationship relative to the twentieth century.   Technological change, leading to a move from a brawn- to a brain-based economy, and the rise in publicly funded education (Goldin and Katz 2008) lowered the opportunity cost of schooling and increased the marginal benefit of time spent in schooling.   Taking full advantage of the returns to health may thus require both a modern brain-based economy and the availability of education.

References

Acemoglu, Daron and David H. Autor. 2012. What Does Human Capital Do? A Review of Goldin and Katz's The Race Between Education and Technology.   National Bureau of Economic Research Working Paper No. 17828. February.

Acemoglu, Daron, David H. Autor, and David Lyle. 2004. "Women, War, and Wages: The

[29] http://www.nytimes.com/interactive/2013/06/12/us/across-the-board-growth-in-college-degrees.html?ref=education&_r=0

[30] Unfortunately our data sets are not well-suited to investigate the determinants of education and height over time since the WWII records and the UA data contain very little information on parental of family background.-

Effect of Female Labor Supply on the Wage Structure at Midcentury," *Journal of Political Economy* 112 (June): 497-551.

Angrist, Joshua. 2002. "How do Sex Ratios Affect Marriage and Labor Markets? Evidence from America's Second Generation." *The Quarterly Journal of Economics*, 117(3): 997-1038.

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney. 2006. "The Polarization of the U.S. Labor Market." *The American Economic Review*, 96(2): 189-194.

Barham, Tania, Karen Macours, and John A. Maluccio. 2013. "Boys' Cognitive Skill Formation and Physical Growth: Long-Term Experimental Evidence on Critical Ages for Early Childhood Interventions." *American Economic Review*, 103(3): 467-71.

Barker D.J.P. 1992. *Fetal and Infant Origins of Adult Disease*. London: British Medical Publishing Group.

Bharadwaj, Prashant, Katrine Velleson Løken, and Christopher Neilson. 2013. "Early Life Health Interventions and Academic Achievement." *American Economic Review*. 103(5): 1862-91.

Bleakley, Hoyt. 2010a. "Health, Human Capital, and Development." *Annual Review of Economics*, 2:283–310.

Bleakley, Hoyt. 2010b. "Malaria in the Americas: A Retrospective Analysis of Childhood Exposure." *American Economic Journal: Applied*, 2(2):1-45, April.

Bleakley, Hoyt and Joseph Ferrie. 2012. "Shocking Behavior: The Cherokee Land Lottery of 1832 in Georgia and Outcomes Across the Generations," Unpublished manuscript, September.

Bleakley, Hoyt and Sok Chul Hong. 2013. "When the Race between Education and Technology Goes Backwards: The Postbellum Decline of White School Attendance in the Southern US." Unpublished manuscript, University of Chicago. April.

Card, David. 2001. "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems." *Econometrica* 69(5): 1127-1160.

Case, Anne and Christina Paxson. 2008. "Stature and status: Height, ability, and labor market outcomes." *Journal of Political Economy*. 116: 491-532.

Costa, Dora L. 1993. "Height, weight, wartime stress, and older age mortality: Evidence from Union Army records." *Explorations in Economic History*. 30: 424-449.

Costa, Dora L. 2004. "The Measure of Man and Older Age Mortality: Evidence from the Gould Sample." *Journal of Economic History*. March 2004. 64(1): 1-23.

Costa, Dora L. and Richard H. Steckel. 1997. "Long-Term Trends in Health, Education, and Economic Growth in the United States." In R.H. Steckel and R. Floud, Eds., *Health and Welfare during Industrialization*. Chicago: University of Chicago Press for NBER: 47-89.

Cutler, David, Angus Deaton, and Adriana Lleras-Muney, Adriana. 2006. "The Determinants of Mortality." *Journal of Economic Perspectives* 20(3): 97-120.

Easterlin, Richard A. 1996. *Growth Triumphant: The Twenty-First Century in Historical Perspective.* Ann Arbor: University of Michigan Press.

Floud, Roderick, Robert W. Fogel, Bernhard Harris, and Sok Chul Hong. 2011. *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700*. Cambridge University Press: Cambridge.

Fogel, Robert W. 1993. "New sources and new techniques for the study of secular trends in nutritional status, health, mortality, and the process of aging. *Historical Methods* 26(1): 1-44.

Fogel, Robert W. 1994. "Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy." *American Economic Review*. 84(3): 369-95.

Glewwe, P., & Jacoby, H.G. 1995. "An economic analysis of delayed primary school enroll-ment in a low income country: The role of early childhood nutrition." R*eview of Economics and Statistics* 77(1): 156-169.

Goldin Claudia and Lawrence Katz. 2008. *The Race between Education and Technology*. Cambridge, MA: The Belknap Press of Harvard University Press

Goldin, Claudia and Lawrence F. Katz. 2000. "Education and Income in the Early Twentieth Century: Evidence from the Prairies." *Journal of Economic History* 60(3): 782-818.

Goldin Claudia and Claudia Olivetti. 2013. "Shocking Labor Supply: A Reassessment of the Role of World War II on U.S. Women's Labor Supply." National Bureau of Economic Research Working Paper #18676. January.

Goldin, Claudia and Robert A. Margo. 1992. "The Great Compression: The Wage Structure in the Unted States at Mid-century." *Quarterly Journal of Economics* 107(1): 1-34.

Gould, Benjamin Apthorp. 1869. *Investigations in the Military and Anthropological Statistics of American Soldiers.* New York: Published for the U.S. Sanitary Commission by Hurd and Houghton. Cambridge: Riverside Press.

Hazan, Moshe. 2009. "Longevity and lifetime labor supply: Evidence and implications," *Econometrica* 77 (6), 1829-1863.

Katz, Lawrence F. and Robert A. Margo. 2013. "Technical Change and the Relative Demand for Skilled Labor: The United States in Historical Perspective" In L. Boustan, C. Frydman, and R.A. Margo, Eds., Human Capital and History: The American Record. University of Chicago Press.

Komlos, John and Benjamin Lauderdale. 2007. "Underperformance in Affluence: The Remarkable Relative Decline in U.S.Heights in the Second Half of the 20th Century" *Social Science Quarterly*, 88(2): 283-305.

Lauderdale, Diane S and Paul J Rathouz. 1999. "Evidence of environmental suppression of familial resemblance: height among US Civil War brothers." *Annals of Human Biology*. Sep-Oct;26(5):413-26.

Long, Jason. 2006. "The Socioeconomic Return to Primary Schooling in Victorian England," *Journal of Economic History* 66 (4), December.

Margo, Robert A. 1979. *Union Army Slave Appraisal Records from Mississippi, 1863-1865*. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor].

Margo, Robert. 1986. "Race, Educational Attainment, and the 1940 Census," *Journal of Economic History* 46 (March): 189-198.

Margo, Robert A. 1990. *Wages and Labor Markets in the United States, 1820-1860.* University of Chicago Press: Chicago.

Margo, Robert A. and Steckel, Richard. 1982. "The heights of American slaves: New evidence on slave nutrition and health." *Social Science History*. 6, (4), 516-538.

Martorell R, Rivera J & Kaplowitz H. 1990. "Consequences of stunting in early childhood for adult body size in rural Guatemala." *Ann. Nestlé* 48, 85-92.

Mazumder, Bhaskar. 2004. "Sibling Similarities, Differences and Economic Inequality." Federal Reserve Bank of Chicago WP 2004-13.

Mobius, Markus M., and Tanya S. Rosenblat. 2006. "Why Beauty Matters." *The American Economic Review* 96 (1):222-235.

National Archives and Records Administration. *U.S. World War II Army Enlistment Records, 1938-1946* [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2005. Original data: Electronic Army Serial Number Merged File, 1938-1946 [Archival Database]; World War II Army Enlistment Records; Records of the National Archives and Records Administration, Record Group 64; National Archives at College Park, College Park, MD.

Oreopoulos, Philip and Uros Petronijevic. 2013. "Making College Worth It: A Review of Research on the Returns to Higher Education." National Bureau of Economic Research Working Paper No. 19053.

Parman, John. 2010. “Childhood Health and Human Capital: New Evidence from Genetic Brothers in Arms.” Unpublished MS. Williams College. http://wmpeople.wm.edu/asset/index/jmparman/childhoodhealthandeducationalattainment

Paxson, C., & Schady, N. 2007. “Cognitive development among young children in Ecuador the roles of wealth, health, and parenting.” *Journal of Human Resources* 42(1): 49-84.

Persico, Nicola, Andrew Postlewaite, and Dan Silverman. 2004. “The Effect of Adolescent Experience on Labor Market Outcomes: The Case of Height.” *Journal of Political Economy.* 112:1019-1053.

Pitt, Mark M., Mark R. Rosenzweig, Nazmul Hassan. 2012. “Human Capital Investment and the Gender Division of Labor in a Brawn-Based Economy,” *American Economic Review*, 102(7):3531-60, December.

Pope CL. 1992. “Adult mortality in America before 1900: A view from family histories.” In *Strategic Factors in Nineteenth-Century American Economic History,* ed. Goldin C, Rockoff H, 267-296. Chicago: University of Chicago Press.

Proos LA, Hofvander Y & Tuvemo T. 1991. “Menarcheal age and growth pattern of Indian girls adopted in Sweden. Catch-up growth and final height.” *Indian Journal of Pediatrics. (*58): 105-114.

Psacharopoulos, George. 1994. “Returns to Investment in Education: A Global Update.” In: *World Development*, 22(9): 1325-43.

Ribero, Rocío and Jairo Nuñez (2000). “Adult Morbidity, Height, and Earnings in Colombia.” in W. D. Savedoff and T. P. Schultz, eds., Wealth from Health: Linking Social Investments to Earnings in Latin America, Washington, D.C.: Inter-American Development Bank.

Sacerdote, Bruce. 2005. "Slavery and the Intergenerational Transmission of Human Capital." *The Review of Economics and Statistics.* 87(2): 217-34.

Schick, Andreas; Steckel, Richard H. 2010. “Height as a Proxy for Cognitive and Non-Cognitive Ability.” NBER Working Paper Series. w16570.

Schultz, T. Paul. 2002. “Wage gains associated with height a form of health human capital.” *American Economic Review*. 92.

Silventoinen K, Kaprio J, Lahelma E, Koskenvuo M. 2000. “Relative effect of genetic and environmental factors on body height: differences across birth cohorts among Finnish men and women.” *American Journal of Public Health*. 90(4):627-30.

Steckel, Richard. 1979. “Slave Height Profiles from Coastwise Manifests.” *Explorations in Economic History*. 16: 363-380.

Steckel, Richard. 1995. "Stature and the standard of living." *Journal of Economic Literature.* 33: 1903-40.

Vogl, Tom. 2011. "Height, Skills, and Labor Market Outcomes in Mexico." Unpublished manuscript. May.

Waaler, Hans T. 1984. "Height, weight, and mortality: The Norwegian experience." *Acta Medica Scandinavia Supplement.* 679: 1-51.

Widdowson EM and McCance RA. 1960. "Some effects of accelerating growth. I. General somatic development." *Proceedings of the Royal Society, Ser. B* 152, 188-206.

Wyatt, Ian D and Daniel A Hecker. 2005. "Occupational Changes during the 20th century" *Monthly Labor Review* March: 35-57.

Yamauchi, F. 2008. "Early Childhood Nutrition, Schooling and Sibling Inequality in a Dynamic Context: Evidence from South Africa." *Economic Development and Cultural Change* 56:657–8.

Table 1: Brother-Brother Adult Height Correlations Among Whites

Union Army, 1861-65 (1812-1844 Cohort)	World War II, 1939-45 (1909-1924 Cohort)	PSID (1959-1968 Cohort)
0.394	0.462	0.492
(0.024)	(0.024)	(0.017)

All correlations are estimated using Restricted Maximum Likelihood (REML). Standard errors are in parentheses. We thank John Parman for estimating the WWII correlation for us. The PSID estimates are from Mazumder (2004).

Table 2: The effect of height on schooling in the Nineteenth Century (birth cohorts)

	Union Army, Dummy=1 if in school, 1850 or 1860 $\partial P/\partial x$	Union Army, Years Education, Measure 1	Union Army, Years Education, Measure 2	Gould Sample, Years Education	Union Army, Dummy=1 if illiterate (age 21+) $\partial P/\partial x$
Mean dependent Variable	0.652	3.322	4.072	5.766	0.026
Height (cm)	0.001	0.009*	0.005*	0.002	-0.000
	(0.001)	(0.004)	(0.003)	(0.003)	(0.000)
State FE	Y	Y	Y	Y	Y
Age census FE	Y	Y	Y		
Age enlistment FE	Y	Y	Y	Y	Y
Log population in town of enlistment	Y	Y	Y		Y
Population in town of enlistment >= 50,000				Y	
Year census dummy	Y	Y	Y		
Adjusted R-squared or Pseudo R-Squared	0.151	0.281	0.567	0.056	0.086
Observations	10,606	10,615	10,615	6,695	8,518

Standard errors clustered on state. The Gould sample is restricted to the native-born. Because the first three columns of the Union Army sample (except for the last column) are restricted to children in 1850 or 1860, it consists predominately of the native-born. The two education measures for the Union Army sample are constructed from the school attendance from linked antebellum censuses. See Section II.a for further information.

Table 3: Effect of Height on schooling in twentieth century White native-born males (OLS)

	Effect of height on years of schooling	Education mean (sd)	Height mean (sd)	N	Year data collect ed	Birth cohorts
Panel A: WW2 Sample.						
height (cms)	0.080 ***	9.8	175.4	3,862,228	1939-45	1897-23
	[0.000]	(3.6)	(6.62)			
Panel B: NLS Old men						
height (cms)	0.076***	10.16	177.20	1,266	1961	1904-21
	[0.015]	(3.72)	(6.95)			
Panel C: NHANES I & II						
height	0.074***	12.7	176.6	4,155	1971-76	1930-59
	[0.006]	(3.03)	(6.79)			
Panel D: NLS young men						
height (cms)	0.044***	13.64	179.86	1,597	1981	1941-52
	[0.010]	(2.66)	(6.69)			
Panel E: NLSY79						
height (cms)	0.047***	13.44	178.53	2,615	1996	1957-64
	[0.007]	(2.56)	(7.31)			
Panel F: NHANES III						
Height (cms)	0.054***	12.8	175.9	1,566	1988-94	1943-74
	[0.009]	(2.66	(6.99)			
Panel G: NHANES 1999-10						
Height (cms)	0.037 ***	13.5	178.5	2,556	1999-10	1954-90
	[0.005]	[1.9]	(6.88)			
Panel H: NHIS samples						
height (cms)	0.039 ***	13.4	178.3	43,190	2000-11	1955-91
	[0.002]	[2.71]	(7.14)			

All samples are restricted to white native males between the ages of 20 and 45. NHANES 1 and 2 controls include state/place of birth dummies, year of survey dummies, age dummies, and 10 year cohort dummies. NHANES III only includes AGE dummies (neither survey year nor year of birth are given), region of residence dummies, and metro area. NHANES 1999-2010 includes age dummies and survey dummies. Sample weights were used. NHIS samples include age dummies, year of survey dummies, and region of residence dummies. NHIS uses sample weights.

Table 4: Effect of Height and education on labor market outcomes 1870-1996

Dependent variable:	log (occupational score)		log(annual wages)	
Panel A: UA Gould Sample (non-farmers)				
height	0.002*	0.002*		
	[0.001]	[0.001]		
years of school		0.012***		
		[0.003]		
Panel B: UA 1870 (non-farmers)				
height	0.001	0.001		
	[0.001]	[0.002]		
years of school		0.013*		
		[0.006]		
Panel C: WW2 Sample.				
height	0.003***	0.001***		
	[0.000]	[0.000]		
years of school		0.031***		
		[0.000]		
Panel D: NHANES I & II (1971-76)				
Height	0.008***	0.004***		
	[0.001]	[0.001]		
years of school		0.044***		
		[0.002]		
Panel E: NLS 1961				
height (cms)	0.008***	-0.000	0.012***	0.004*
	[0.002]	[0.002]	[0.002]	[0.002]
years of school		0.097***		0.084***
		[0.004]		[0.005]
Panel F: NLS 1981				
height (cms)	0.009***	0.004**	0.011***	0.008***
	[0.002]	[0.002]	[0.002]	[0.002]
years of school		0.129***		0.079***
		[0.005]		[0.006]
Panel G: NLS 1996				
height (cms)			0.013***	0.008***
			[0.002]	[0.002]
years of school				0.108***
				[0.006]

Occupational score is based on 1950 incomes. We imputed 1950 occupation codes and matched to occupational score in the 1950 census. When multiple 1950 occupation codes were imputed to an occupation, we took a population weighted mean of income.

The WWII sample is restricted to white males ages 25-45 with no missing values for education, height and year of birth and within enlistment parameters. Those without occupation codes, or reporting their occupation as “Student” or “None” are excluded in the occupation regressions. Regressions include state/place of birth dummies and year of birth dummies.

Gould sample controls include age, whether the soldier was US-born and whether he enlisted in city with a population of 50,000+.

Controls for the 1870 Union Army sample include age and region of birth dummies.

Controls for NHANES 1 and 2 include age and whether the man was US-born.

NLS notes: Sample includes all white males with no missing values for education, height and year of birth from the 1961 wave of the of National Longitudinal Survey of Old Men, the 1981 wave of the National Longitudinal Survey of Young Men, and the 1996 wave of the National Longitudinal Survey of Youth. Regressions include age dummies, year dummies and a dummy for foreign-born. We did not impute occupation scores for the NLSY79 because it uses 1960 occupation codes which are not detailed enough. Individuals with zero or missing values for annual earnings are not included in the earnings regressions.

Table 5: Height, Education, and Wealth Among Union Army Veterans in 1870

Dependent Variable: Logarithm of Wealth		
All		
Height	0.010***	0.017**
	(.003)	(0.005)
Years of Education		0.064***
		(0.014)
Non-farmers		
Height	.001	0.009
	(.003)	(0.006)
Year of Education		0.053**
		(0.018)
Farmers		
Height	0.012*	0.022*
	(.005)	(0.009)
Years of Education		0.056**
		(0.021)

All regressions include state fixed effects. Standard errors are in parentheses. *** p < 0.001, ** p < 0.010, * p < 0.100. Total wealth is the sum of real estate and personal property wealth, as transcribed from the 1870 Census manuscripts. The years of school are "measure 2" of education, imputed using the data on school attendance in 1850 or 1860 (depending on the census year in which the veteran was observed when age 11 to 21. The regression includes controls for age in 1870, age at enlistment, and region of birth (all entering as dummy variables).

Table 6: The relationship between height, education and wealth measures, 1961-2004
White Males

Dependent variable:	log (all observed wealth)		log(real estate and business wealth)	
Panel A: NLS 1961				
height (cms)	0.053***	0.025**	0.061***	0.038**
	[0.012]	[0.012]	[0.017]	[0.017]
years of school		0.318***		0.269***
		[0.024]		[0.034]
Panel B: NLS 1981				
height (cms)	0.040***	0.024*	0.037*	0.022
	[0.013]	[0.013]	[0.020]	[0.020]
years of school		0.368***		0.326***
		[0.034]		[0.051]
Panel C: NLS 1996				
height (cms)	0.099***	0.075***	0.105***	0.081***
	[0.012]	[0.012]	[0.019]	[0.019]
years of school		0.517***		0.505***
		[0.034]		[0.054]
Panel D: HRS Samples 1992, 1998 and 2004				
height (cms)	0.053***	0.032***	0.070***	0.045***
	[0.005]	[0.004]	[0.01]	[0.01]
years of school		0.238***		0.276***
		[0.015]		[0.034]
X (1998 dummy)		0.095***		0.038
		[0.026]		[0.057]
X (2004 dummy)		0.084***		0.172***
		[0.026]		[0.057]

NLS notes: real estate wealth is the sum of the reported value of house owned, farm owned, business or other real estate owned. All wealth is the sum of real estate wealth, savings, bonds, and stocks. Value of automobiles is never included as it was not collected prior to 1996. The data collection is, however, not identical over the years so the wealth measures are not exactly identical. Missing and non-reports are treated as zeros, and set to 0.01 before taking logs.

Table 7: Height, Education, and Wealth Among Indian Males, Age 20-45, in 2005-6

Panel A: Dependent Variable=Years of Education

	All	Farmers	Non-Farmers
Height	0.151***	0.114***	0.161***
	[0.003]	[0.006]	[0.004]
State and Age FE	Y	Y	Y
Observations	48,670	11,978	36,692
R-squared	0.115	0.131	0.102

Panel B: Dependent Variable=Logarithm of Wealth Index

	All		Farmers		Non-Farmers	
Height	0.018***	0.008***	0.015***	0.009***	0.018***	0.008***
	[0.000]	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]
Years of Education		0.063***		0.049***		0.060***
		[0.000]		[0.001]		[0.000]
State and Age FE	Y	Y	Y	Y	Y	Y
Observations	48,670	48,670	11,978	11,978	36,692	36,692
R-squared	0.193	0.447	0.210	0.370	0.184	0.440

Estimated from the Indian DHS 2005-6. The mean of years of education is 7.97 and mean height is 164.73cm.

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

Table 8: Comparisons of Effects of Standard Deviation Increase in Height on Years of Education

Sample	Coefficient Height	Std Dev Height	Increase in Years of Education	% Increase in Years of Education
Gould	0.002	6.36	0.01	0.21%
Union Army	0.009	6.57	0.06	1.79
WWII	0.080	6.62	0.53	5.40
NHANES 1&II	0.074	6.62	0.49	3.82
NHANES III	0.054	6.98	0.38	2.92
NHANES 1999-2010	0.037	6.87	0.25	1.88
India, 2005-6	0.151	6.75	1.02	12.98

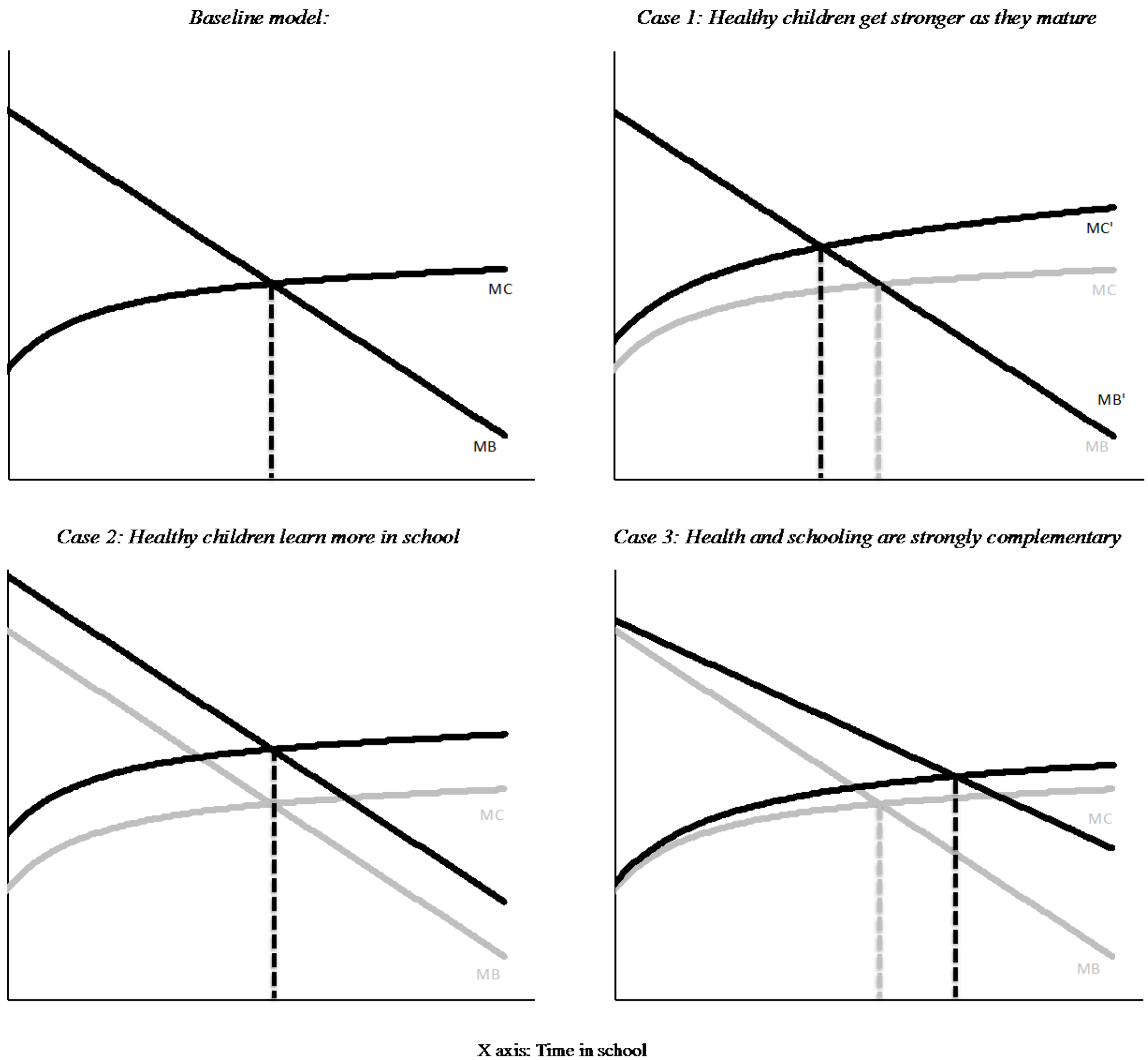
Estimated from Tables 2, 3, and 7.

Table 9: Effect of education on mortality over time

	Union Army	NHANES I (1971-1975)	NHANES II (1976-80)	NHANES III (1988-94)
	Hazard Ratio	Hazard Ratio	Hazard Ratio	Hazard Ratio
Years Education, Measure 2	0.989			
	(0.025)			
Years Education		0.969***	0.956***	0.948***
		(0.007)	(0.010)	(0.008)
Age in 1900 or at survey (NHANES)	Y	Y	Y	Y
Log(population in city of enlistment) or metro dummy (NHANES)	Y	Y	Y	Y
1860 census dummy	Y			
State of enlistment FE or residence (NHANES III)	Y	N	N	Y
Region of residence		Y	Y	
Age in 1850/60 census FE	Y			
γ	0.047***	0.060***	0.089***	0.094***
	(0.015)	(0.005)	(0.011)	(0.017)
Number of observations	4,143	1,797	1,902	1,430

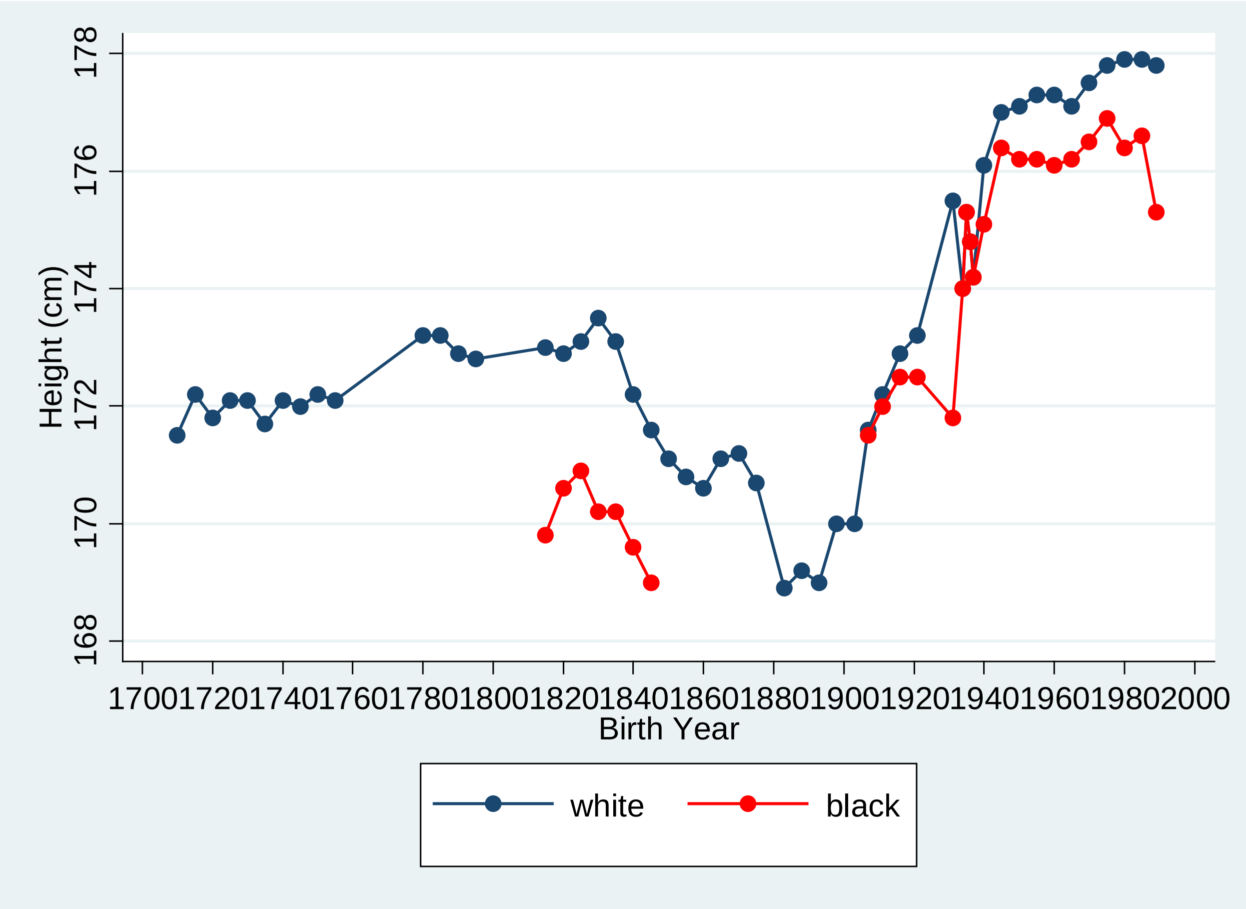
The samples exclude deaths due to violence. We use the survey sample weights for NHANES.

Figure 1: Health and the standard model of schooling



Notes: this figure displays simulations of the Ben Porath model of schooling choice under alternative assumptions about how childhood health affects the marginal benefits (MB) and marginal costs (MC) of time in school. The *x* axis is time in school (modeled as a time at which a child leaves school and starts working). The *y* axis measures present discounted value on a logarithmic scale. For further description of the model and cases, see Section IV.c of the chapter. An excel spreadsheet containing these simulations is available from the authors upon request.

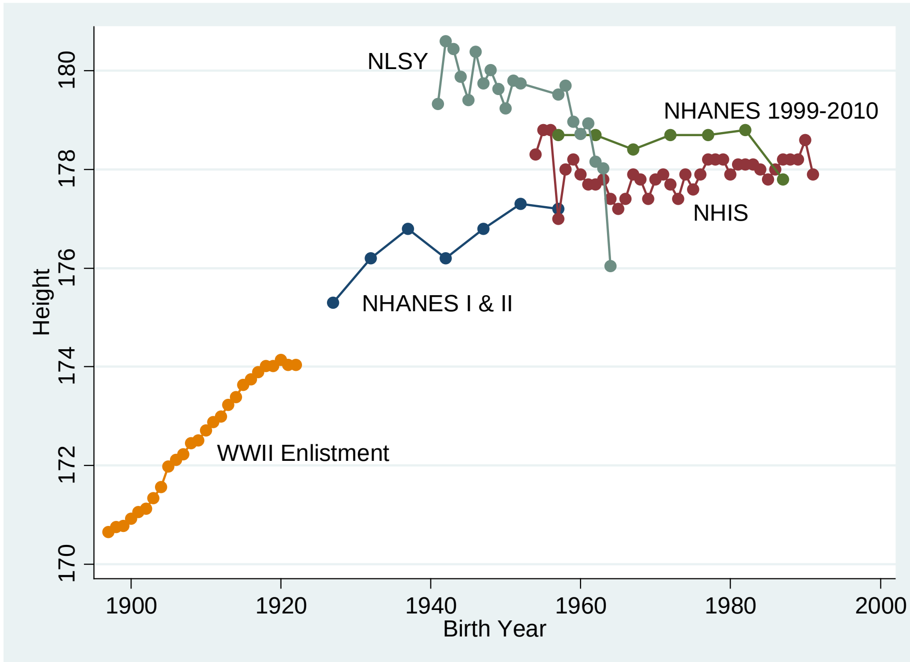
Figure 2: Long-Term Trends in US Heights



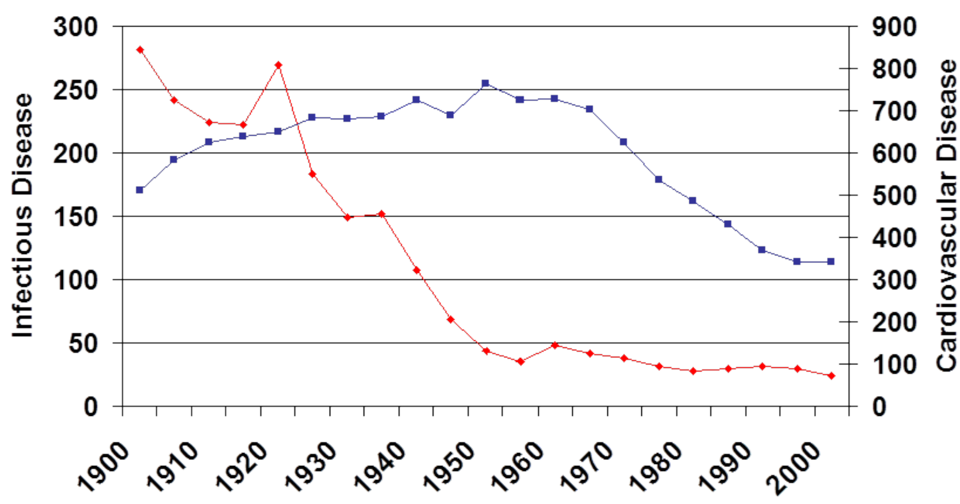
This figure updates the white height series in Figure 2.1 in Costa and Steckel (1997) using the 1963-2010 NHIS and adds a height series for blacks using Union Army records, published WWII heights, and the NHIS. Year of birth is centered at the marks. Estimates using the NHIS were adjusted to account for biases resulting from self-reporting in the NHIS.

Figure 3: Evolution of heights and mortality in the twentieth century United States

Panel A: Trends in Heights



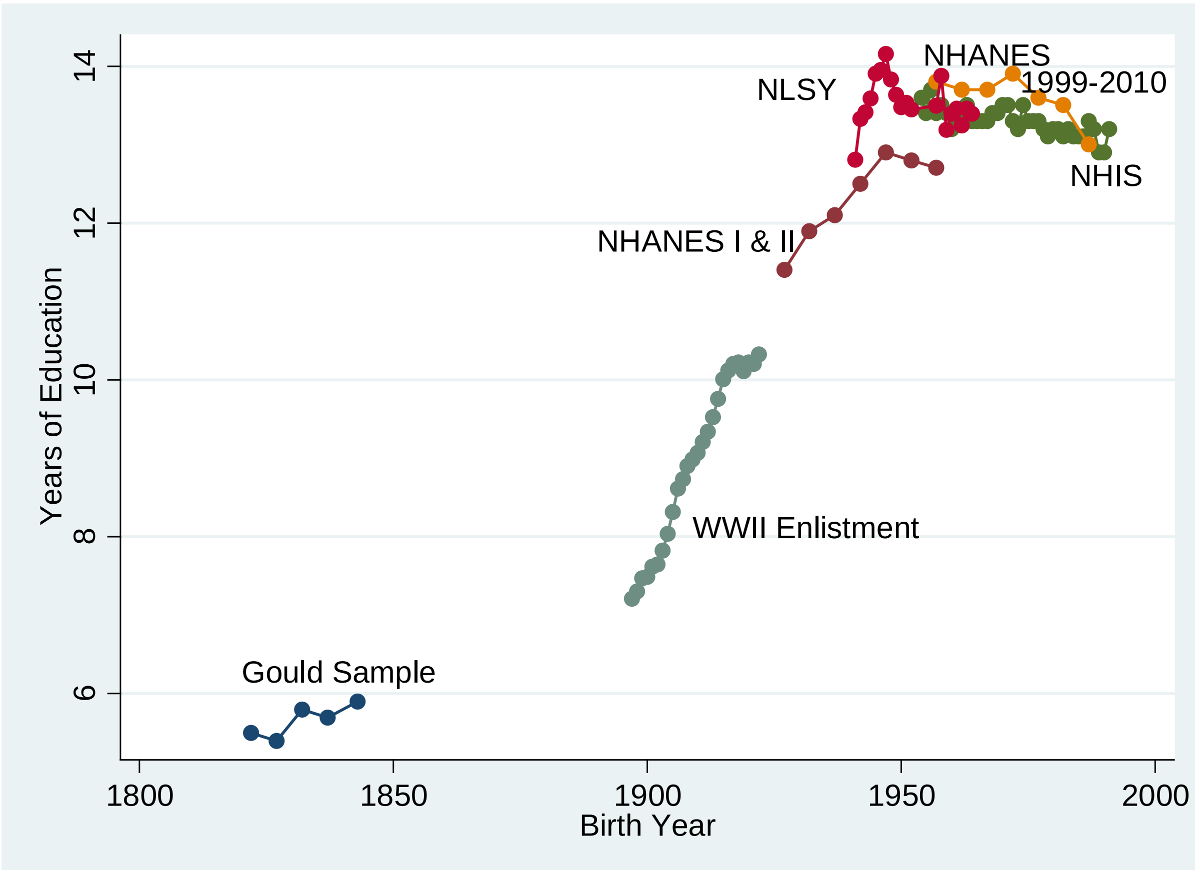
Panel B: Mortality rates over time



Panel A: The means are centered at the mark. We do not have exact year of birth for NHANES 1999-2010. The surveys were done over a two-year period but the year of the survey was not recorded. Year of birth is not available for NHANES III.

Panel B: Figure 3 from Cutler et al. 2006.

Figure 4: Trends in educational attainment in some of our samples



The means are centered at the mark. We do not have exact year of birth for NHANES 1999-2010. The surveys were done over a two-year period but the year of the survey was not recorded. Year of birth is not available for NHANES III.

Figure 5A: Height, Occupation and Wealth in the Nineteenth Century among Farmers. Union Army sample linked to 1870

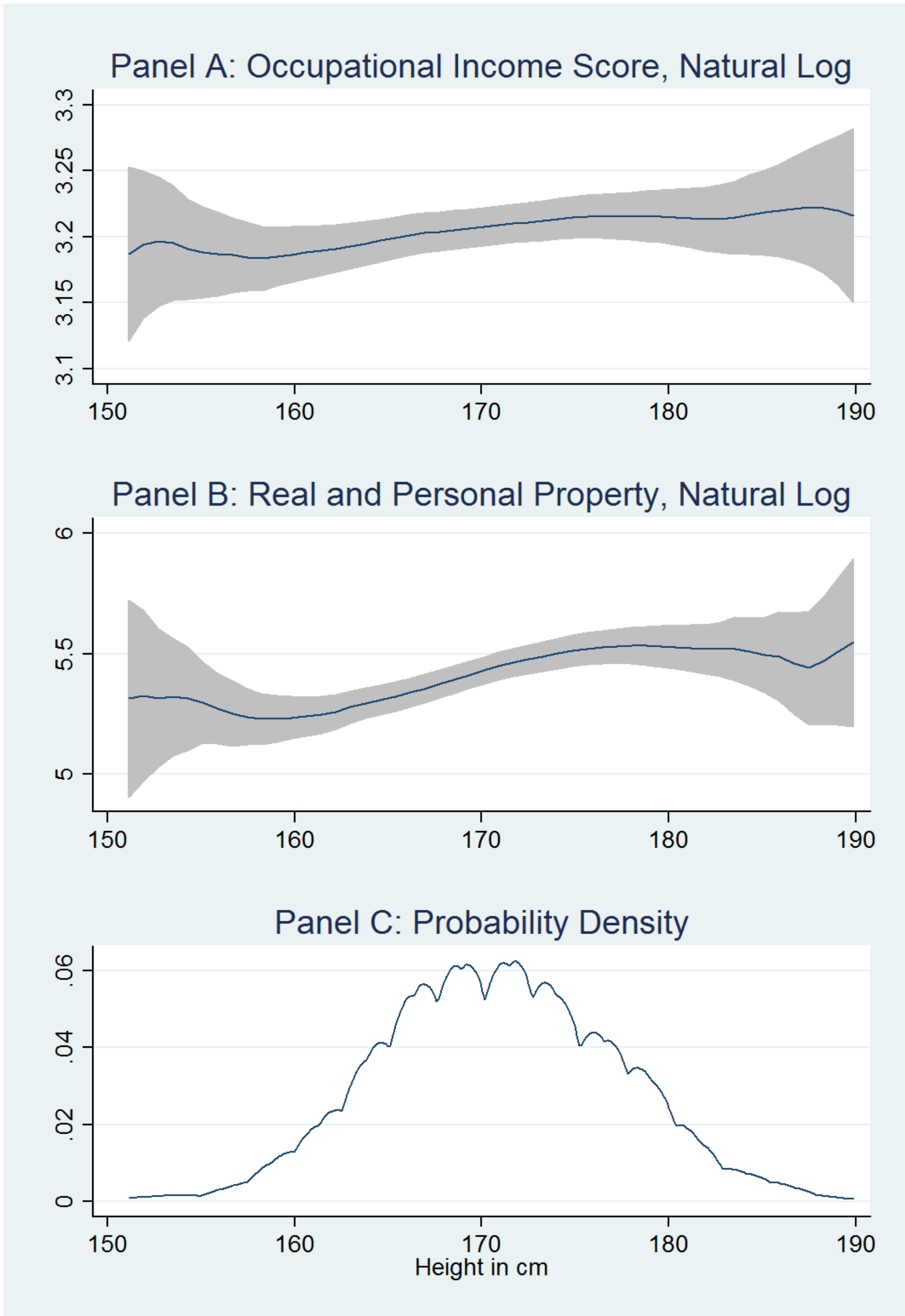


Figure 5B: Height, Occupation and Wealth in the Nineteenth Century among Non-Farmers, Union Army Sample Linked to 1870

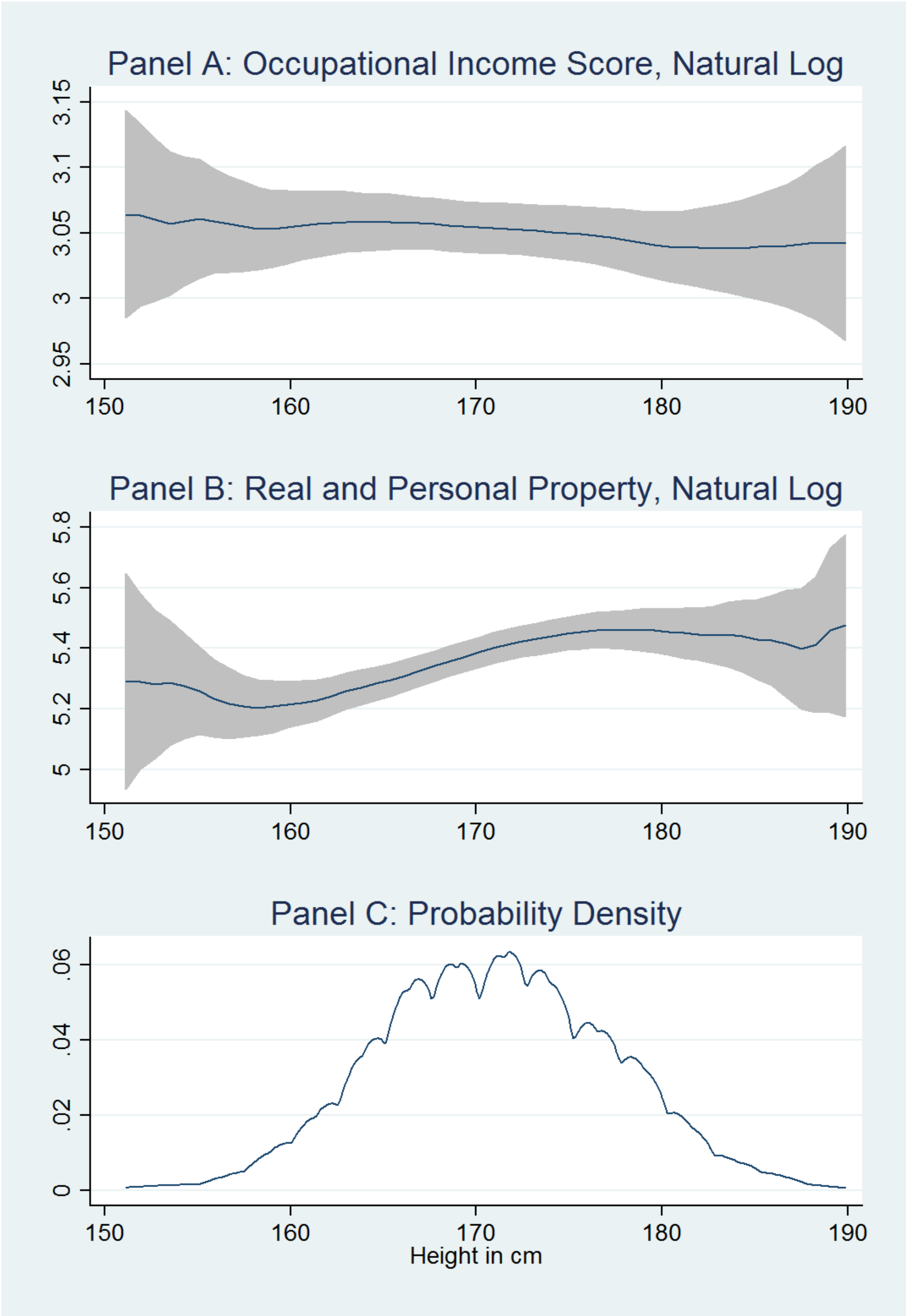


Figure 5C: Height, Occupation and Wealth in the Nineteenth Century. Full sample, Union Army Sample Linked to 1870