An Anthropometric History of the Postbellum US, 1847-1894

Inaugural-Dissertation

zur Erlangung des Grades

Doctor oeconomiae publicae (Dr. oec. publ.)

an der Ludwig-Maximilians-Universität München

2010

vorgelegt von

Matthias Zehetmayer

Referent: Prof. John Komlos, Ph.D.
Korreferent: Prof. Dr. Ekkehart Schlicht

Promotionsabschlussberatung: 17. November 2010

Mündliche Prüfung am 2. November 2010

Berichterstatter:

Prof. John Komlos, PhD (vertreten durch Prof. Ray Rees, PhD)

Prof. Dr. Ekkehart Schlicht

Prof. Dr. Joachim Winter

ACKNOWLEDGEMENTS

I am extremely grateful for the advice and support of Prof. John Komlos, for being such a dedicated and enthusiastic mentor, and for awakening my interest in economic and anthropometric history.

I thank Takeshi Amemiya, Olga Arnold, Jörg Baten, Ariane Breitfelder, Ted and Diane Bright, Francesco Cinnirella, Timothy Cuff, Özgür Ertac, Michael Haines, Martin Hiermeyer, Daniel Koch, Michal Masika, Ruth and Steve Nash, Linda Rousova, Michael Specht, Martin Spindler, Marco Sunder, Marianne Wanamaker, Martin Watzinger, Tom Weiss, Andreas Widenhorn, Gordon Winder, Dong Woo Yoo, Michael Zabel, and Barbara and Simon Zehetmayer for helpful comments and conversations.

I would like to thank Prof. Ray Rees, Prof. Ekkehart Schlicht, and Prof. Joachim Winter for agreeing to be on my doctoral committee.

I am also grateful to the seminar participants at the Economic History Association's 2009 meeting and the faculty research seminar participants at the University of Munich for valuable comments and suggestions. All remaining errors are solely mine.

I am very grateful for the support and encouragement of my parents who have made all this possible.

TABLE OF CONTENTS

Introduction

Stature is an important measure of the standard of living, supplementing as it does other, more conventional economic measurements, such as Gross Domestic Product (GDP) and personal income. It is an invaluable resource when it comes to times and places in which such measurements cannot be made because the data are either unavailable or unreliable. In contrast, height data from more or less distant times and places are plentiful, waiting to be gleaned from documents featuring vital statistics on military recruits, students, convicts, oath takers, passport applicants, runaway slaves, and even skeletal remains (Steckel, 1995).

Height is determined by a mixture of genetic and environmental factors - about 80 and 20%, respectively (Silventoinen, 2003) - but the genetic component's preponderance disappears when average heights of (homogeneous) populations are analyzed (Steckel, 1995). Height summarizes an individual's history of net nutrition. Since physical labor as well as ill health take their tolls on the body's energy, and the residual energy is used for growth, not only nutritional intake but also energy expenditure matters (Fogel, 1994; Steckel, 1995). Macronutrients and micronutrients that have a direct impact on stature include protein, calcium, vitamin D, and zinc (Waterlow, 1994). Whenever a diet is deficient in calories in general and in these nutrients in particular, an individual's growth rate declines. However, if provided with adequate net nutrition following periods of deprivation the human body is capable of catch-up growth, and the normal growth period can even be extended by several years. However, if deprivation prevails then stunting results (Waterlow, 1994; Steckel, 1995). The most severe consequences of short stature are an increase in the risk of chronic diseases and a decrease in life expectancy (Waaler, 1984; Fogel, 1994). Since height has an upper limit and nutrient intake produces diminishing returns, stature is an excellent measure of inequality as well (Steckel, 1995; Komlos, 2009).

Human height has been studied since the 18^{th}-century, but it is only in the past 30 years that, thanks to research in the field of anthropometric history its status as an accurate indicator of the biological standard of living has been established (Steckel, 1995; Steckel, 2009; Komlos, 2009). Between the late 1970s and 1994 papers dealing with human height appeared at the rate of about five a year, most of the authors approaching the issue from the vantage point of economic history or development economics; five were published in the four most highly rated economics journals. Between 1995 and 2008 the number increased more than fourfold, to 23.3 per year, among them 13 in those four journals (Steckel, 2009). Such a dramatic increase clearly indicates that the study of stature is an increasingly significant tributary to mainstream economics.

For economic historians, interested as they are in the economic forces that affect stature, the United States during the second half of the 19^{th}-century - with the Civil War (1861-65) as the pivot of an extended period of exceptional economic growth, urbanization, and market integration - is a particularly fertile field of research. During the period under consideration here (1847-94) GDP per capita grew 105% and industrial production grew 600% despite the war (Davis, 2004; Johnston and Williamson, 2008). A national economy emerged as railroad and telegraph networks reduced transportation and communication costs (Rosenbloom, 1990). Produce, lumber, and coal could now be shipped long distances, a development that facilitated regional specialization and market integration (James, 1983). The composition of the labor force changed from nearly 60% agricultural workers in 1850 to fewer than 40% in 1899 (Lewis, 1979; Weiss, 1992). Farmers in the North and especially in the Midwest had already begun to shift from self-sufficiency to commercial agriculture, marketing their surplus (Atack and Bateman, 1984). There was also a shift from home manufacturing and agriculture to factory production, which, with its crowded and unsanitary working conditions, facilitated the spread of diseases (Costa and Steckel, 1997). Over the course of the 19th-century American cities grew dramatically, their share of the nation's total population increasing from about 6 to 40% (Haines, 2001), but public sanitation, water, and sewage systems were rudimentary throughout much of the period (Preston and Haines, 1991). It is therefore not surprising that urban death rates were 1.4 times that of rural ones (Condran and Crimmins-Gardner, 1980; Haines, 2001). From the 1820s to the 1850s urban inequality, as measured by Williamson's (1975, 1976) urban inequality index of pay differentials by skill, grew by over 60%; it then declined for about a decade, recovering only after the Civil War.

It is not surprising that such an eventful century has prompted a number of noteworthy discoveries, chiefly that of the Antebellum Puzzle (Margo and Steckel, 1983; Komlos, 1987): a pattern of declining heights despite rising per capita income, indicating that the biological standard of living was not in conformity with the conventional welfare indicators in the first half of the 19th-century - despite an annual 1.4% increase in per capita output between 1830 and 1860 (Weiss, 1992). Exempt from this decline were an odd couple: the upper classes whose wealth permitted them to eat well despite rising food prices; and male slaves, because their owners had a financial incentive to feed them well: so that they could work with maximum efficiency (Komlos and Coclanis, 1995; Sunder, 2007).

In the three essays presented here we draw on anthropometric data to better understand this crucial transition period. Nationwide data on US Army recruits permit us to pinpoint, for the first time, the trends, levels, and determinants of height in the general population[1]. To shed further light on height correlates, we supplement this broad military sample with data at three lower levels: county, city, and family.

[1] So far, trends have been mostly based on extrapolation of local trends derived from Ohio (Steckel and Haurin, 1994).

In the first chapter we analyze the physical stature of US-born recruits into the Federal Army for the birth cohorts from 1847-1894. We find that the decline in height that began in the 1830s continued into the 1850s. The decline in the 1850s was about 0.4 in. (1 cm) from 67.64 in. (171.8 cm) in the early 1850s birth cohort to a nadir of 67.26 in. (170.8 cm) in the cohort born during the Civil War and heights remained virtually unchanged until the 1880s, when they started to increase. Our findings show that heights stagnated for a generation after the Civil War (1861-65) in spite of the substantial postbellum economic growth, especially in the North and the West.

This study also examines how and to what degree local nutrients, urbanization, market integration, occupations, and a disease-prone environment affected stature. We find that protein and calcium availability were positively correlated with height both at the national level and in the Northeast. The association of height and urbanization (towns as well as cities) was significant and negative and infant mortality, used as an indicator for the disease environment, was also significantly and negatively associated with height.

In the second paper we analyze the subsample of the urban-born together with city-level variables. This subsample is of particular interest because the process of urbanization and the urban sanitation movement were under way during this half century (Preston and Haines, 1991; Haines, 2001). We find that recruits born in rural regions were consistently taller than those born in cities. Urban heights declined significantly after 1855 and then stagnated until the end of the century, whereas rural heights were stagnating until they began to increase significantly in the late 1880s. In the second half of the 19th-century there was an urban height penalty of between 0.58 in. (1.5 cm) in the ten largest cities and 0.34 in. (0.9 cm) in the next ninety cities (ranked by size). This penalty is of a magnitude similar to that reported in other studies. We present evidence that average urban heights converged over time with heights in larger cities approaching those in smaller ones: While in the 1850s and 1860s heights decreased with city size at a decreasing rate, in the late 19th-century we find this relationship to be inversely U-shaped with largest heights in cities of about 250,000 inhabitants.

City dwellers' height was positively correlated with expansion of the railroad network because it led to increased market integration, which decreased the price and increased the quality of the food that city dwellers purchased and consumed, and this improvement in their nutrition soon translated into a height increase. Since real wages determined one's quality of life (the quality of one's food and shelter, chiefly), their level was positively, and the death rate negatively, correlated with height. Industrialization, too, as measured by the share of the urban population working in the manufacturing sector, was negatively correlated with stature because the working conditions and disease environment in factories compared unfavorably with those of small-scale, rural manufacturing (Costa and Steckel, 1997).

The third paper investigates occupational mobility, occupational height premiums, and family-level correlates of height. Drawing on the North Atlantic Population Project's 1880 manuscript census, which enabled us to link data on recruits with data on their families, we find that occupational mobility was on the rise during the period under consideration. Sons of farmers were most likely to hold the same job as their father, followed by laborers, skilled workers, upper-level white-collar workers, and semi-skilled workers compared with lower-level white-collar workers.

We find that when controlling for the son's instead of the father's occupation we overestimate the heights of all occupational categories except for that of skilled workers, but only by at most 0.5%, or about 0.40 in. (1.0 cm). In the absence of information on the father's occupation, using the son's as a proxy leads to a very small bias; the signs and significance of all other coefficients remain unchanged. This finding should come as good news to researchers who use this son-for-father proxy in anthropometric studies.

Our analysis of family-level correlates of height reveals that the number of siblings in a household and being born in an urban area was negatively associated with height, whereas having a father who was a farmer conveyed a height premium. These results (with the exception of occupational categories) corroborate our findings in the preceding two papers even when we control for family-level variables. The fact that the average height of recruits whose parents were foreign-born did not differ significantly from that of other recruits (who had native-born parents) suggests that living standards in the US at that time were so beneficial for growth that it took just one generation for heights to reach American levels.

While these three papers compose a single dissertation, it was the author's intention that each of the three be independent of the others. This approach obliges a certain amount of repetition in the data and methodological sections; those who read more than any one of the three are therefore encouraged to skip passages rendered redundant by preceding discussions of the same materials. In any case, it is recommended that these readers begin with the first paper, because it draws on the full sample of recruits in order to present an overview of height trends and levels, whereas the second and third papers use subsamples linked with city-level and family-level data.

References

Atack, Jeremy, and Fred Bateman. 1984. "Self-Sufficiency and the Marketable Surplus in the Rural North, 1860." *Agricultural History*, 58 (3): 296-313.

Condran, Gretchen A., and Eileen Crimmins-Gardner. 1980. "Mortality differentials between rural and urban areas of states in the northeastern United States 1890–1900." *Journal of Historical Geography*, 6 (2): 179-202.

Costa, Dora, and Richard Steckel. 1997. "Long-Term Trends in Health, Welfare, and Economic Growth in the United States." In*: Health and Welfare during Industrialization,* ed. Richard Steckel and Roderick Floud, 47-90. Cambridge, MA: National Bureau of Economic Research, Inc.

Davis, Joseph H. 2004. "An Annual Index of U.S. Industrial Production, 1790-1915." *Quarterly Journal of Economics*, 119: 1177-1215.

Fogel, Robert. 1994. "Economic Growth, Population Theory, and Physiology: the Bearing of Long-term Processes on the Making of Economic Policy." *American Economic Review,* 84: 369–395.

Haines, Michael. 2001. "The Urban Mortality Transition in the United States, 1800-1940." *Annales de démographie historique*, 101 (1): 33-64.

James, John. 1983. "Structural Changes in American Manufacturing, 1850-1890." *The Journal of Economic History,* 43 (2): 433-459.

Johnston, Louis D., and Samuel H. Williamson. 2008. "What Was the U.S. GDP Then?" Measuring Worth. http://www.measuringworth.org/usgdp/ (accessed September 27, 2009).

Komlos, John. 1987. "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America." *The Journal of Economic History,* 47: 897-927.

Komlos, John. 2009. "Anthropometric history: an overview of a quarter century of research." *Anthropologischer Anzeiger; Bericht über die biologische-anthropologische Literatur,* 67 (4): 341-356.

Komlos, John, and Peter A. Coclanis. 1995. "Nutrition and Economic Development in Post-Reconstruction South Carolina: An Anthropometric Approach." *Social Science History*, 19 (1): 91-115.

Lewis, Frank. 1979. "Explaining the Shift of Labor from Agriculture to Industry in the United States: 1869 to 1899." *The Journal of Economic History,* 39 (3): 681-698.

Margo, Robert, and Richard Steckel. 1983. "Heights of Native Born Northern Whites during the Antebellum Period." *Journal of Economic History,* 43: 167-184.

Preston, Samuel H., and Michael Haines. 1991. *Fatal Years: Child Mortality in the Late Nineteenth-Century America*. Princeton, NJ: Princeton University Press.

Rosenbloom, Joshua. 1990. "Labor Market Institutions and the Geographic Integration of Labor Markets in the Late Nineteenth-Century United States." *The Journal of Economic History,* 50 (2): 440-441.

Silventoinen, Karri. 2003. "Determinants of variation in adult body height." *Journal of Biosocial Science,* 35: 263-285.

Steckel, Richard. 1995. "Stature and the Standard of Living." *Journal of Economic Literature,* 33 (4): 1903-1940.

Steckel, Richard. 2009. "Heights and human welfare: Recent developments and new directions." *Explorations in Economic History,* 33 (4): 1-23.

Steckel, Richard, and Donald Haurin. 1994. "Health and Nutrition in the American Midwest: Evidence from the Height of Ohio National Guardsmen, 1850-1910." In: *Stature, Living Standards, and Economic Development: Essays in Anthropometric History,* ed. John Komlos, 117-128. Chicago: The University of Chicago Press.

Sunder, Marco. 2007. "Passports and Economic Development: An Anthropometric History of the U.S. Elite in the Nineteenth Century." PhD diss. University of Munich.

Waaler, Hans. 1984. "Height, Weight and Mortality: The Norwegian Experience." *Acta Medica Scandinavica*, Supplement, 679: 1-51.

Waterlow, John. 1994. "Summary of Causes and Mechanisms of Linear Growth Retardation." *European Journal of Clinical Nutrition,* 48: (Suppl 1): S210.

Weiss, Thomas. 1992. "U.S. Labor Force Estimates and Economic Growth, 1800-1860," In: *American Economic Growth and Standards of Living Before the Civil War,* ed. Robert Gallman and John Wallis, 19-75. Chicago: University of Chicago Press.

Williamson, Jeffrey G. 1975. "The Relative Costs of American Men, Skills, and Machines: A Long View." Discussion Paper, No. 289-75. Institute for Research on Poverty, University of Wisconsin-Madison.

Williamson, Jeffrey G. 1976. "American Prices and Urban Inequality Since 1820." *The Journal of Economic History,* 36 (2): 303-333.

1. The Postbellum Continuation of the Antebellum Puzzle: Stature in the US, 1847 - 1894

ABSTRACT

This paper explores whether the antebellum decline in heights continued in the post-Civil War period by using a data set of more than 58,000 US Army recruits born between 1847 and 1894. The main finding is that heights continued to decline during the Civil War by about 0.4 in. (1.0 cm) and stagnated for an extended period of time before they began to increase among the birth cohorts of the late 1880s. Height was positively correlated with proximity to protein-rich nutrients during childhood and with geographic mobility and was negatively correlated with urbanization, and infant mortality rates.

1.1 Introduction

Economic historians, using height as an indicator of the biological standard of living, have discovered anomalies in history such as the Antebellum Puzzle: a pattern of declining stature among American men despite a growing economy in the years before the Civil War (Komlos, 1987; Fogel, 1994; Steckel, 1995). Much work has been done in order to understand the causes of the decline in the biological standard of living prior to the Civil War, but the post-bellum epoch has received less attention with the exception of Steckel and Haurin (1994) on Ohio National Guardsmen, Komlos and Coclanis (1995) on Citadel students, Sunder (2007) on passport applicants, Maloney and Carson (2008) on Ohio prison inmates, and Hiermeyer's (2008) continuation of Komlos's (1987) analysis of West Point Cadets. Therefore it is to this period that we have turned our attention. We analyze the physical stature of 58,512 US Army recruits who enlisted between 1898 and 1912 and were born from 1847 to 1894, together with explanatory variables from the US aggregate census of 1880.

1.1.1 Historical Background

The period from 1850 to 1890 is of great interest not only because of the Civil War but because it was a time of rapid growth in Gross National Product (GNP), industrial production, urbanization, transportation, and communication, all of which dramatically changed the US economy. The history of physical stature enables us to assess the Civil War's impact on the US population, because height data supplement the scanty evidence derived from conventional measures of the standard of living.

Civil War and Spanish American War

The Civil War, which lasted from April of 1861 to April of 1865 and its burden manifested itself in the destruction of property, inflation, a rise in foreign-exchange prices (declining greenbacks making imports more expensive), and falling cotton prices all of which hurt the

South more than the North (Hughes and Cain, 2002). By the end of the war wealth in the South had fallen by 30% while wealth in the North had increased by 50% (between 1860 and 1870). Between 1860 and 1866 farm real estate fell by 50% and the number of livestock had dropped between 32 and 42% in the South (Sellers, 1927).

Our enlistment period ranges from 1898 to 1912 including the Spanish American War which lasted from April until August of 1898. Congress passed the Mobilization Act in 1898, thereby increasing the size of the Army and when President McKinley called for volunteers, the Army's ranks soon swelled by 182,687 men (Smith, 1994; Crawford, Hayes, and Sessions, 1998).

Conventional Economic Indicators

Conventional economic indicators were constructed and periodically refined by Robert Gallman for the period from 1834 to 1909 (Gallman, 1960, 1966, 2000; Rhode, 2002). We use Rhode's (2002) corrected and revised estimates of Gallman's (1966) annual GNP figures. Between 1847 and 1894 GNP (excluding inventory changes in 1860 dollars) grew more than fourfold, from $2.4 to $13.6 billion dollars. GNP per capita increased by 74% with the US population more than doubling. The decade ending in 1869, which included the Civil War, shows a 4% decline in output per capita with a hiatus from 1860 to 1868 which was especially pronounced in agriculture and manufacturing (Table 1.1) (Gallman, 1960; Rhode, 2002).

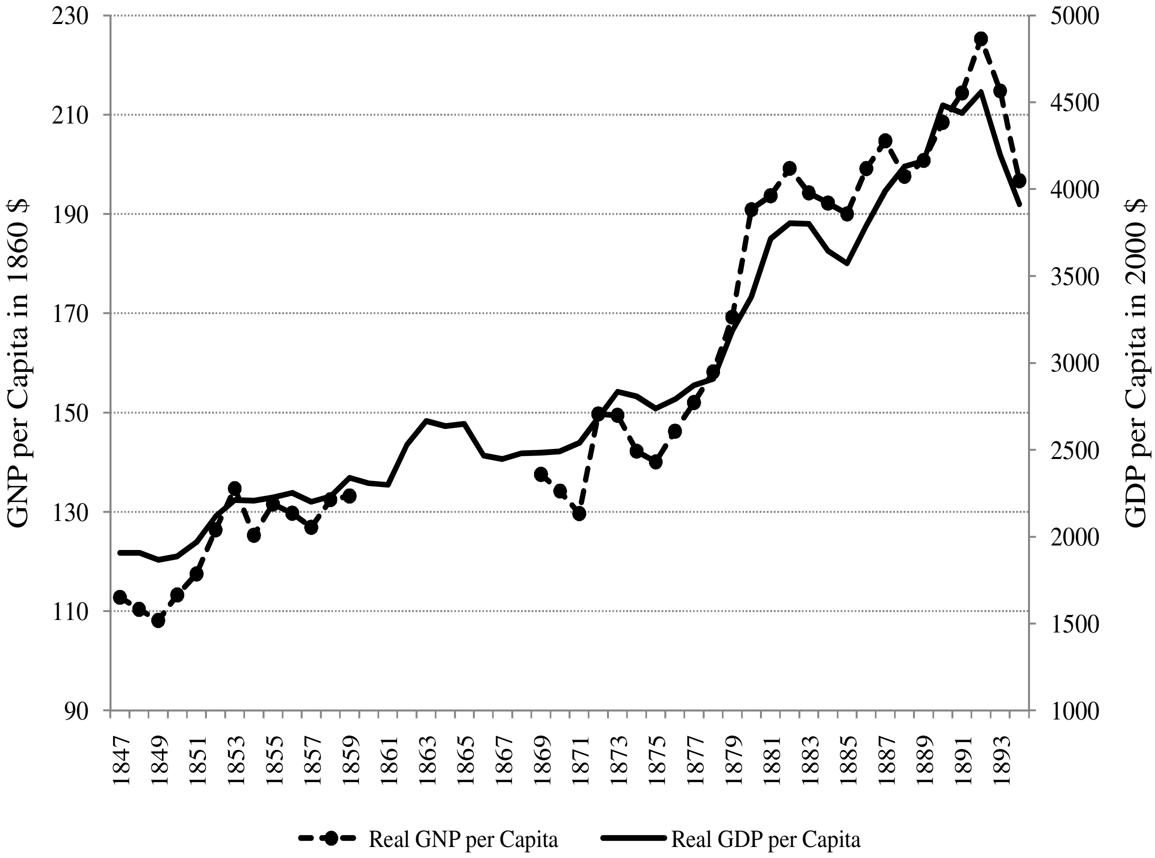
TABLE 1.1
DECENNIAL RATES OF CHANGE OF VALUE ADDED IN 1879 PRICES BY SECTOR

Decade ending in	Agriculture	Mining	Manufacturing
1849	26	138	152
1859	51	88	76
1869	15	114	26
1879	51	118	82
1889	25	126	112

Notes: Geometric means calculated from terminal values.
Sources: Gallman, 1960, p. 24.

The Johnston and Williamson (2008) estimates for GDP use multiple sources including Gallman's estimates and yield similar results as the Gallman GNP estimates. All of these estimates indicate clearly that there were substantial gains in the conventional standard of living measured by GNP (74%) and GDP (105%) per capita during the period under consideration despite the Civil War.

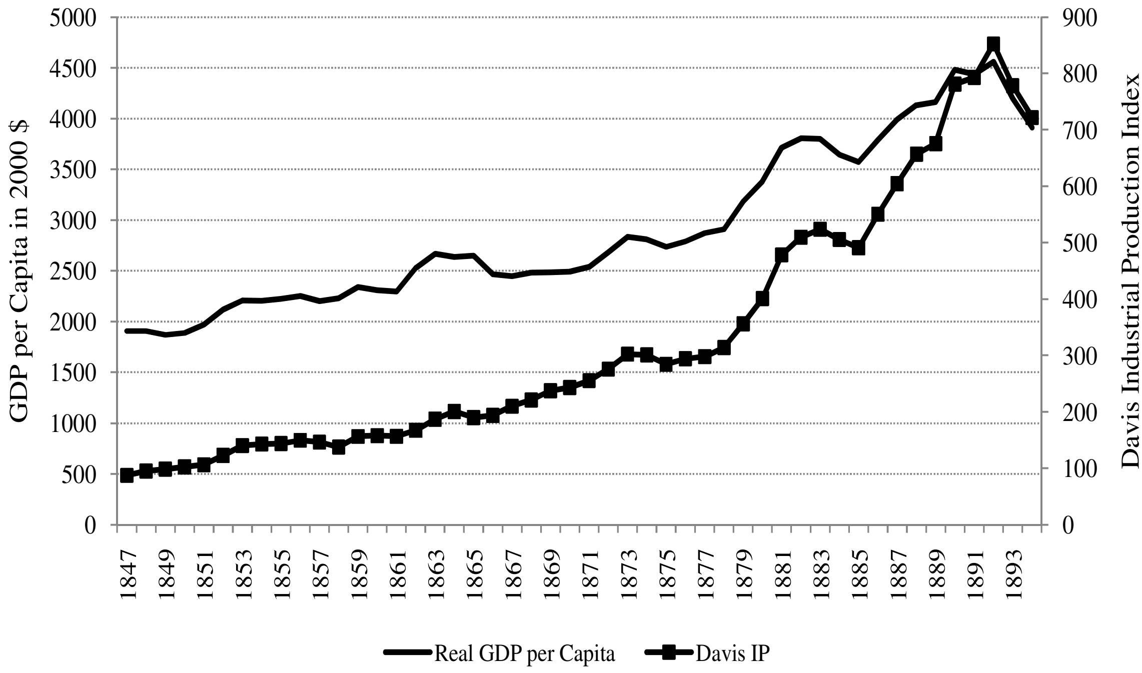
FIGURE 1.1
REAL GNP AND GDP PER CAPITA, 1847-1894



Sources: Gallman, 1966; Rhode, 2002; Johnston and Williamson, 2008.

Another conventional economic indicator is measured by the Davis IP (industrial production) index (Davis, 2004). This index comprises annual physical-volume series from manufacturing and mining industries, weighted by their relative importance. While the trend of this index is similar to that of the Gallman GNP estimates, it also includes data for the Civil War years. From 1847 to 1894 the Davis IP index grew by a factor of over seven - another conventional indicator that shows a positive trend with strong growth.

FIGURE 1.2
DAVIS IP (INDEX OF INDUSTRIAL PRODUCTION) AND GDP PER CAPITA, 1847-1894



Notes: Davis Index of Industrial Production: 43 quantity based annual series 1849/50 census base year (=100); GDP per capita in year 2000 $.
Sources: Davis, 2004; Johnston and Williamson, 2008.

1.2 Data and Methodology

We sampled 58,512 recruits from digitized US Army muster rolls 49 to 68 from the National Archives in Washington D.C. who enlisted between 1898 and 1912. The data set, with recruits born between 1847 and 1894, includes each recruit's name, date of enlistment, place of enlistment, duration of his service, place of birth, occupation, height, regiment, and the number of times he enlisted. Recruits had to be "effective and able-bodied men" between the ages of 16 and 30 at the time of their first enlistment. In time of peace this age limit was binding and recruits were also required to be able to speak, read, and write English. Recruits enlisted for a period of 3 years but were usually allowed to re-enlist, and at a higher level of pay, unless they had been dishonorably discharged (Davis, 1898).

All recruits born outside of the continental US and those for whom there is no record of the state where they were born were excluded from our analysis (N=68) because we cannot control for their net-nutritional experience while they were growing up. This exclusion also applies to observations above a physiologically plausible maximum height of 78 in. (198.1 cm) (N=41). We also excluded recruits under the age of 18 (N=56); although the Army permitted boys as young as 16 to enlist if they had parental consent, it was likely that they were too far from their maximal adult height[2] for our purposes (Davis, 1898; Tanner, 1978). Also excluded were recruits over the age of 50 (N=102), because by that age there is usually some loss of height, and therefore inclusion of these data would have biased our estimation (Komlos, 2004b). These exclusions reduced the sample to 58,512 US-born recruits, between the ages of 18 and 50, with a minimum height of 63.79 in. (162.0 cm) and a maximum height of 78 in. (198.1 cm).

The recruits were assigned state and county National Historical Geographic Information System (NHGIS) codes that identify a county. This geo-coding process allowed us to combine the enlistment records with county-level statistics from the 1880 US Census in order to relate information on agriculture, demographics, and wages to the recruits' places of birth (Minnesota Population Center, 2004). For county-level analysis we excluded all those recruits for whom the county of birth could not be identified (38.2%, N=22,362), but we included them in our estimate of national height trends. These recruits were on average 0.27 in. (0.7 cm) taller than those who could be geo-coded (1% level of significance). This height advantage could be explained by the fact that those who could not be geo-coded tend to have been born in remote rural regions, and in such regions nutrition was often better than in more populated areas (Komlos, 1987). In order to combine information from the US Census with the recruit data set it was necessary to correct the spelling of place names in about 8.1%

[2] In the 19th century, maximal adult height was often not reached until about the age of 23 (Komlos, 2004b).

(N=3,772) of the cases. Recruits born in counties that merged with other counties or changed names were assigned to the successor counties. At the time of enlistment a recruit had a choice between identifying the town or the county of his birth; this latitude complicated our task when a town and a county shared the name in question, but where the town was not located in the county by the same name. These cases therefore could not be county-coded, and were used only in our state-level analysis.

County-level census data are problematic because height reflects the long-term environmental conditions during periods of growth, whereas census data, being decadal, can provide only a snapshot of conditions at one particular time. We assume that county-level census variables follow an autocorrelated process: for instance, that in 1880 each county's agricultural output is correlated with its past output. Since data from the 1880 census are more satisfactory than those of any previous census year and since about 98% of our county-coded recruits were still growing in 1880, we chose this census year for our analysis. We must further assume that the county of birth had an effect on the height of recruits because there is no information in the muster rolls on places other than those of birth and enlistment. Further hindering our analysis is the fact that county-level statistics on most of the variables of interest say little about the distribution of food or wages among individuals or about their choice of consumption bundles. Data on these variables just indicate the potential availability of nutrients in a given county.

Adult heights of a homogenous population are, as a rule, asymptotically normally distributed (Tanner, 1978; Bogin, 1999). The Army's minimum height requirements (MHR) could introduce an upward bias in our sample heights, if we were to analyze the data using OLS. Visual inspection of the height distribution permits one to identify the MHR, which is crucial to estimate regressions consistently. The distribution above the MHR should resemble a truncated normal distribution, whereas the existence of an underrepresented range, called the shortfall, means that the truncation is imperfect (Komlos, 2004b).

A measurement error in the height variable is very likely, on account of heaping not only at the MHR, where there was probably an upward bias due to rounding but also at integer heights[3]. Signs of heaping are abnormally high frequencies of integer heights (Figure 1.3), whereas the distribution of non-integer heights is much smoother. In any case, symmetric heaping would not seriously bias our results (Komlos, 2004a).

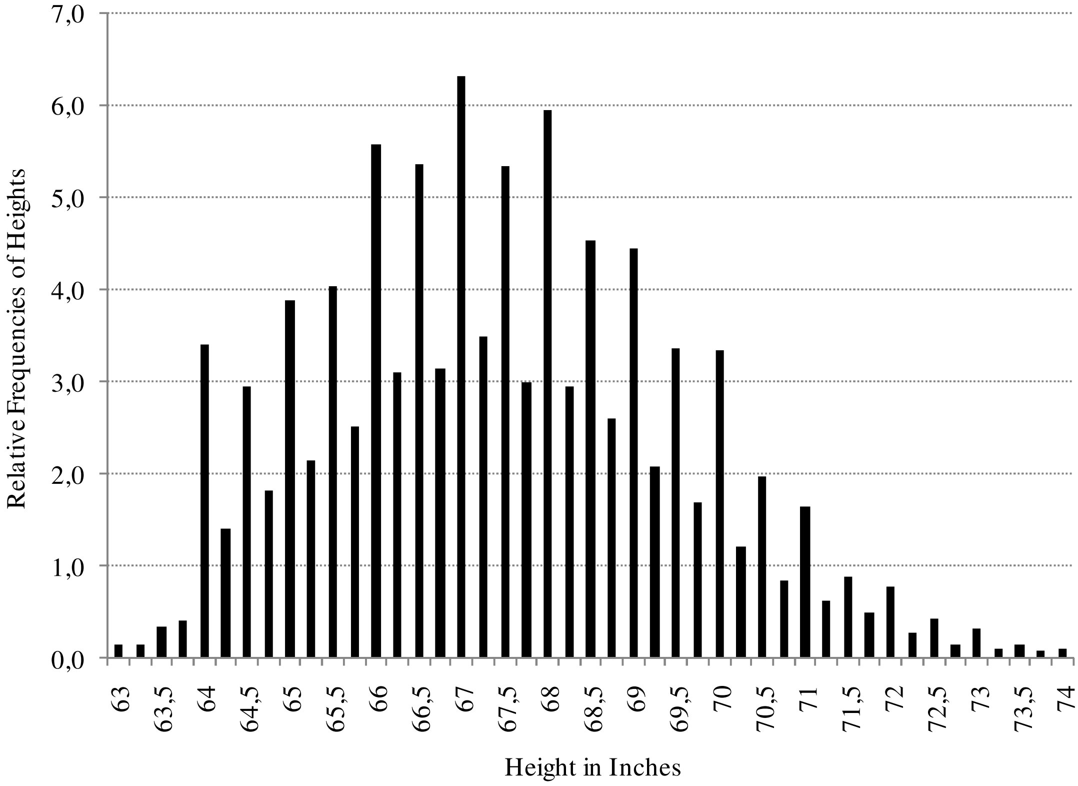
Figure 1.3 indicates that there was a minimum height requirement (MHR) of 64 in. (162.6 cm) to join the military, therefore truncated maximum likelihood estimation (TMLE) is used for consistent estimates and all regression analysis is carried out with TMLE (Komlos, 2004b). Some models are estimated with a constrained standard deviation of today's adult population, which is 2.7 in. (6.86 cm), according to Frisancho (1990) and Cole (2000). The advantage of restricting the standard deviation of height is increased precision and reduced variance, but it might bring about a trade-off between bias and precision of the estimator. That is why we present estimation both ways, with and without constraining the standard deviation of the height distribution. Simulations show that the restriction's effect on time trends in heights and explanatory variables is minimal but the effect on levels can be substantial (A'Hearn, 2004; Komlos, 2004a).

The spatial distribution of our sample is different from the distribution of white males between the ages of 15 and 49 in the 1880 census: the West is underrepresented by 3.5 percentage points, the Midwest by 2.3 percentage points, the South by 6.1 percentage points, whereas the Northeast is overrepresented by 12.6 percentage points (Figure 1.4). This is factored in by the use of weights in the calculation of national height levels.

---

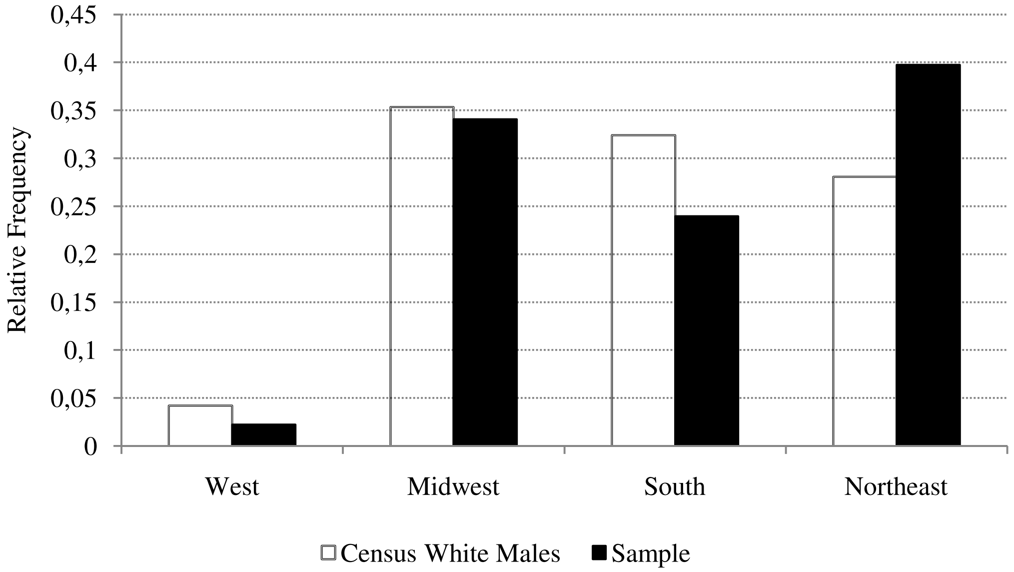
[3] Only 2% of the heights in enlistment records were reported in fractions smaller than a quarter inch.

FIGURE 1.3
RELATIVE FREQUENCY OF HEIGHTS:
ENLISTMENT YEARS 1898-1912



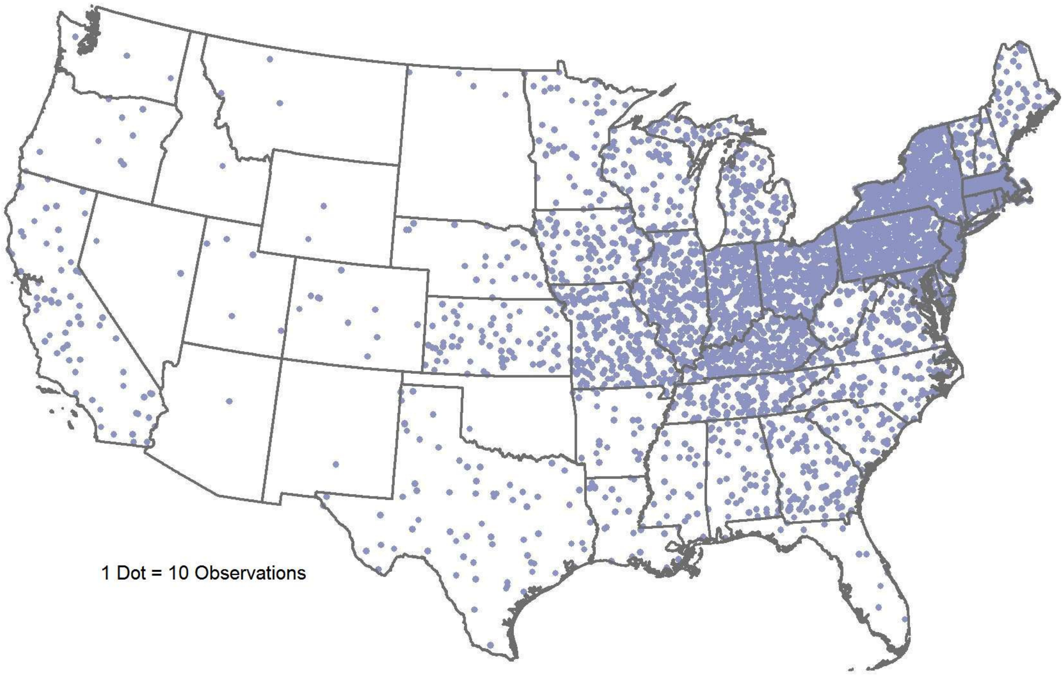
Sources: See the text.

FIGURE 1.4
DISTRIBUTION OF RECRUITS BY CENSUS REGION

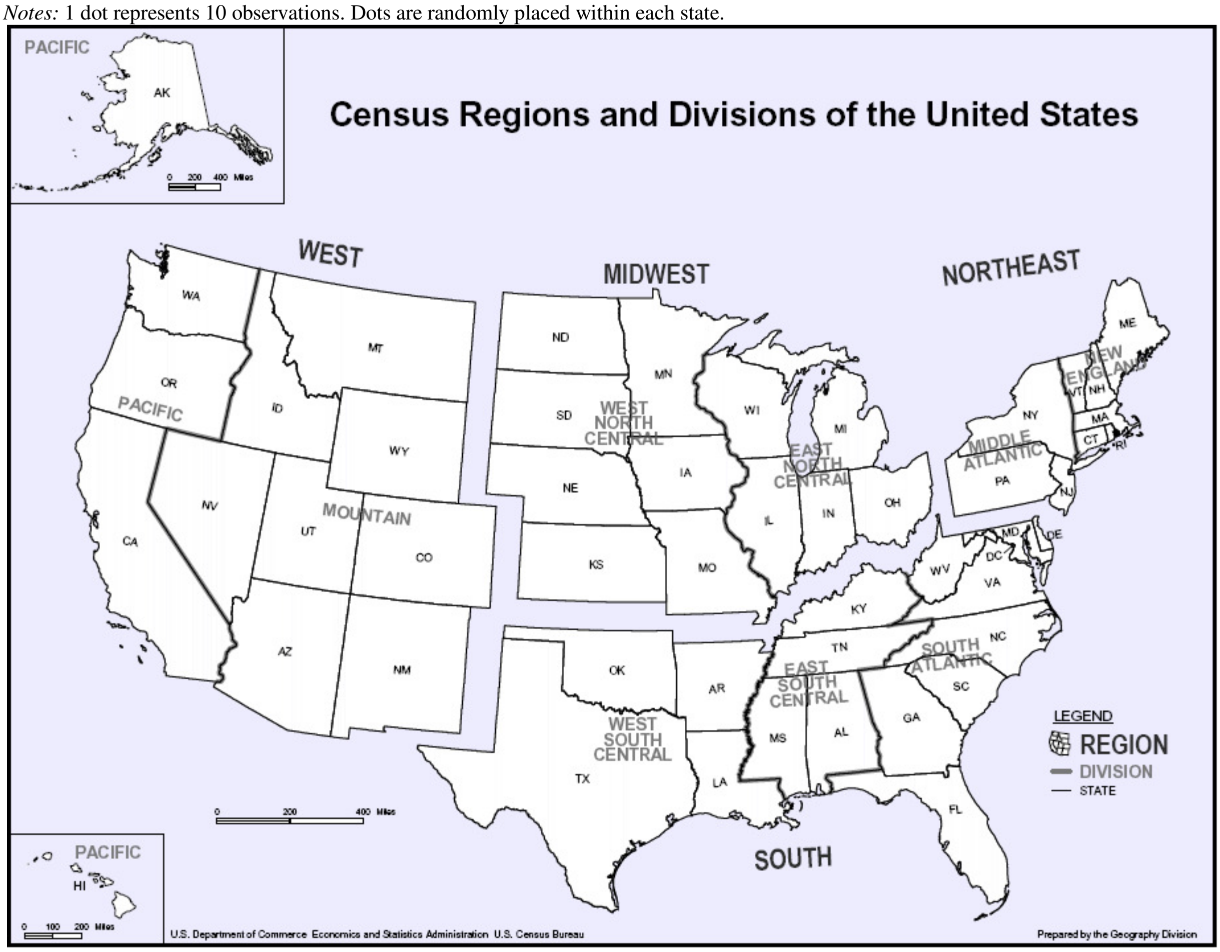


Notes: Census white males is the number of white males aged between 15 and 49 in each census region divided by the number of white males between 15 and 49 nationwide in 1880.
Sources: Minnesota Population Center, 2004.

FIGURE 1.5
DOT DENSITY MAP OF OBSERVATIONS BY STATE
AND PRESENT DAY CENSUS REGIONS AND DIVISIONS



Notes: 1 dot represents 10 observations. Dots are randomly placed within each state.



Sources: See the text. U.S. Census Bureau, 2002.

TABLE 1.2
DESCRIPTIVE STATISTICS

	Full Data Set					Geo-coded Data Set				
Variable	μ	σ	Min	Max	N	μ	σ	Min	Max	N
Birth Cohorts										
1847-1854	0.01	0.08	0.00	1.00	381	0.01	0.08	0.00	1.00	296
1855-1859	0.01	0.10	0.00	1.00	545	0.01	0.10	0.00	1.00	415
1860-1864	0.02	0.15	0.00	1.00	1,415	0.03	0.16	0.00	1.00	1,121
1865-1869	0.08	0.27	0.00	1.00	4,699	0.09	0.28	0.00	1.00	3,636
1870-1874	0.22	0.41	0.00	1.00	12,842	0.24	0.43	0.00	1.00	9,935
1875-1879	0.50	0.50	0.00	1.00	29,048	0.52	0.50	0.00	1.00	21,608
1880-1884	0.12	0.32	0.00	1.00	6,742	0.09	0.27	0.00	1.00	3,787
1885-1889	0.04	0.18	0.00	1.00	2,062	0.02	0.13	0.00	1.00	720
1890-1894	0.01	0.11	0.00	1.00	778	0.01	0.07	0.00	1.00	312
West	0.02	0.14	0.00	1.00	1,215	0.02	0.14	0.00	1.00	798
Midwest	0.34	0.47	0.00	1.00	19,919	0.34	0.47	0.00	1.00	14,158
South	0.26	0.44	0.00	1.00	15,080	0.22	0.41	0.00	1.00	9,150
Northeast	0.38	0.49	0.00	1.00	22,160	0.42	0.49	0.00	1.00	17,720
Pacific	0.02	0.12	0.00	1.00	893	0.02	0.13	0.00	1.00	665
Mountain	0.01	0.07	0.00	1.00	322	0.00	0.06	0.00	1.00	133
West North C.	0.10	0.30	0.00	1.00	5,991	0.09	0.29	0.00	1.00	3,973
West South C.	0.03	0.16	0.00	1.00	1,631	0.02	0.15	0.00	1.00	948
East North C.	0.24	0.43	0.00	1.00	13,928	0.24	0.43	0.00	1.00	10,185
East South C.	0.11	0.32	0.00	1.00	6,613	0.1	0.31	0.00	1.00	4,349
Middle Atlantic	0.28	0.45	0.00	1.00	16,177	0.31	0.46	0.00	1.00	12,984
South Atlantic	0.12	0.32	0.00	1.00	6,836	0.09	0.29	0.00	1.00	3,853
New England	0.10	0.30	0.00	1.00	5,983	0.11	0.32	0.00	1.00	4,736
Laborer	0.21	0.41	0.00	1.00	12,309	0.21	0.41	0.00	1.00	8,821
Semi-skilled	0.37	0.48	0.00	1.00	21,393	0.37	0.48	0.00	1.00	15,304
Skilled	0.20	0.40	0.00	1.00	11,751	0.21	0.41	0.00	1.00	8,823
Farmer	0.12	0.33	0.00	1.00	7,211	0.11	0.31	0.00	1.00	4,498
Lower w. c.	0.07	0.26	0.00	1.00	4,301	0.08	0.27	0.00	1.00	3,219
Upper w. c.	0.03	0.16	0.00	1.00	1,586	0.03	0.17	0.00	1.00	1,180
Mover	0.54	0.50	0.00	1.00	31,595	0.51	0.50	0.00	1.00	21,205
Age	24.18	4.94	18.0	50.0	58,512	24.17	4.92	18.00	50.00	41,830
Age 18	0.05	0.22	0.00	1.00	3,064	0.05	0.22	0.00	1.00	2,139
Age 19	0.05	0.21	0.00	1.00	2,733	0.05	0.21	0.00	1.00	2,029
Age 20	0.03	0.18	0.00	1.00	2,008	0.04	0.19	0.00	1.00	1,506
Age 21	0.23	0.42	0.00	1.00	13,672	0.23	0.42	0.00	1.00	9,627
Age 22-50	0.63	0.48	0.00	1.00	37,054	0.63	0.48	0.00	1.00	26,529
Enlistment Years										
1898	0.45	0.50	0.00	1.00	20,191	0.45	0.50	0.00	1.00	16,680
1899	0.28	0.45	0.00	1.00	12,439	0.27	0.45	0.00	1.00	10,082
1900	0.28	0.45	0.00	1.00	12,395	0.28	0.45	0.00	1.00	10,189
1901	0.09	0.29	0.00	1.00	5,516	0.04	0.21	0.00	1.00	1,855
1902	0.05	0.23	0.00	1.00	3,191	0.03	0.17	0.00	1.00	1,231
1909	0.03	0.17	0.00	1.00	1,656	0.01	0.12	0.00	1.00	612
1910	0.02	0.13	0.00	1.00	983	0.01	0.09	0.00	1.00	359
1911	0.03	0.18	0.00	1.00	1,968	0.02	0.13	0.00	1.00	753
1912	0.01	0.05	0.00	1.00	173	0.00	0.04	0.00	1.00	69
Census Variables										
Rural						0.57	0.37	0.00	1.00	41,830
Town						0.12	0.17	0.00	0.92	41,830
Urban						0.31	0.40	0.00	1.00	41,830
Wheat p.c.						7.80	13.02	0.00	345.90	41,830
Milk cows p.c.						0.19	0.18	0.00	2.18	41,830
Pigs p.c.						0.70	0.89	0.00	7.30	41,830
Wages						315.95	95.50	25.00	1112.27	41,830
Infant mortality						12.04	2.57	6.63	17.05	41,713
Railroad miles						391,137.40	207,823.40	20,998.00	756,239.00	41,713

Notes: North C. is North Central. South C. is South Central. Laborer includes those with unknown occupations. w. c. is white-collar. Skilled is skilled worker. Semi-skilled is semi-skilled worker. A mover enlisted in a state other than his state of birth. P.c. is per capita. Wheat is measured in 100 bushels. Wages are annual manufacturing wages per manufacturing worker. Infant mortality is measured in deaths per 1,000 births. Railroad miles are miles in a state completed as of June 1st 1880.Those in the geo-coded data set could be assigned to their counties of birth. Rural is the proportion of county inhabitants living in places with fewer than 2,500, Town with more than 2,500 and fewer than 25,000, and Urban with more than 25,000 inhabitants.
Sources: See the text.

We begin by estimating time trends of height in the sample with controls for standard census regions and divisions of birth. Thereafter we estimate trends in individual census regions and divisions separately in order to account for spatial differences in levels and trends. In the second section we include county-level variables to control for nutrient availability, urbanization, socio-economic background, geographic mobility, transportation access, infant-mortality rates, and manufacturing wages.

1.3 Results

1.3.1 Time Trends in Height

Heights declined in the 1850s, leveled off and stagnated until they increased in the 1880s. This trend is identical when the sample is restricted to adults only and there is a height gradient from the Northeast towards the South and the West[4].

[4] Those that enlisted during the Spanish American War were by 0.11 in. (0.3 cm) significantly shorter than recruits who enlisted in times of peace. Estimating separate regressions by different precisions of reported height (quarter, half, and integer inch) did not change results in Table 1.3.

TABLE 1.3
HEIGHT OF US ARMY RECRUITS NATIONWIDE:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Regions Age (18-50)	(2) Divisions Age (18-50)	N	(3) Divisions Age (21-50)	N
Age 18	-0.90***	-0.89***	3,046		
Age 19	-0.70***	-0.70***	2,733		
Age 20	-0.44***	-0.45***	2,008		
Age 21	-0.16***	-0.16***	13,671	-0.16***	13,671
Age 22-50	Ref.	Ref.	37,054	Ref.	37,054
Birth Cohorts					
1847-1854	0.38***	0.39***	381	0.39***	381
1855-1859	0.03	0.04	545	0.04	545
1860-1864	-0.01	0.00	1,415	0.00	1,415
1865-1869	0.09*	0.09*	4,699	0.09*	4,699
1870-1874	Ref.	Ref.	12,842	Ref.	12,842
1875-1879	0.02	0.01	29,048	0.01	25,872
1880-1884	0.11**	0.10**	6,742	0.17***	2,706
1885-1889	0.33***	0.33***	2,062	0.32***	1,987
1890-1894	0.37***	0.37***	778	0.27*	278
Census Regions					
Midwest	Ref.		19,919		
West	0.07		1,215		
South	0.29***		15,080		
Northeast	-0.73***		22,160		
Census Divisions					
Pacific		-0.06	893	-0.09	769
Mountain		-0.06	322	-0.07	275
South Atlantic		0.02	6,836	0.04	6,112
West South Central		0.31***	1,631	0.28***	1,428
West North Central		Ref.	5,991	Ref.	5,163
East North Central		-0.18***	13,928	-0.17***	11,915
East South Central		0.28***	6,613	0.33***	5,634
Middle Atlantic		-0.87***	16,177	-0.86***	14,055
New England		-0.81***	5,983	-0.80***	5,250
Constant	67.42***	67.54***		67.53***	
Sigma	2.32***	2.32***		2.33***	
Observations	58,512	58,512		50,725	

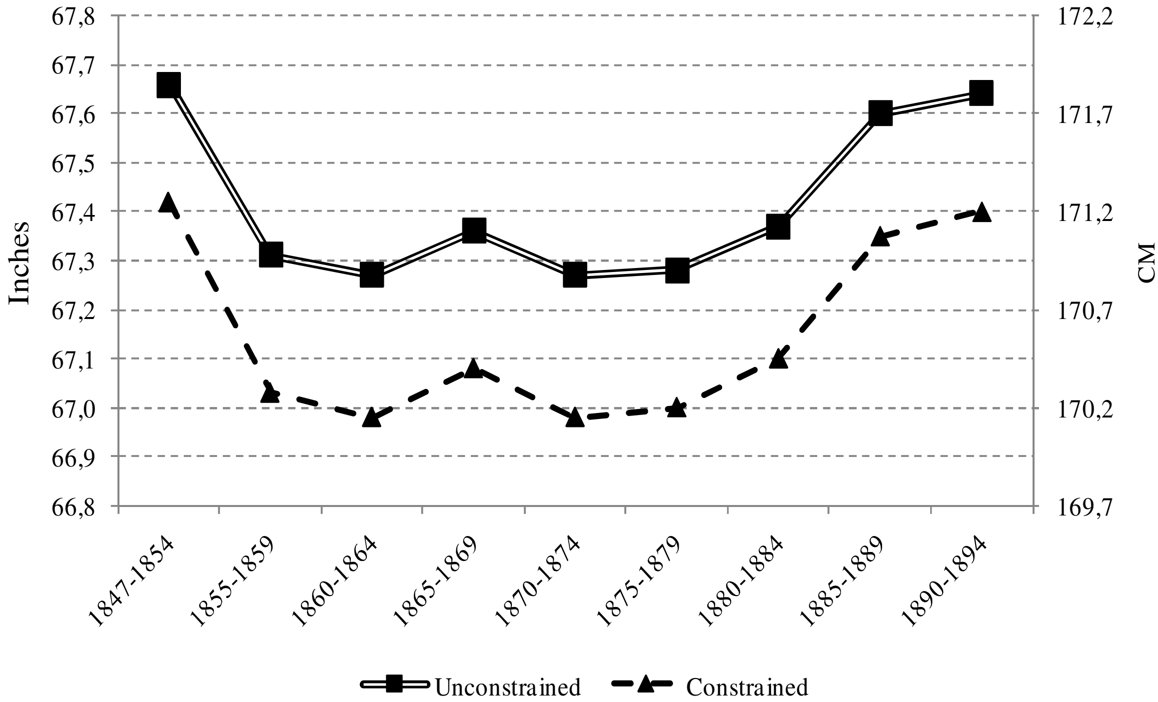
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights.
Sources: See the text.

TABLE 1.4
NATIONWIDE ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS, 1847-1894

	Nationwide (Region)		Nationwide (Region) Constrained		Nationwide (Division)		Nationwide (Division) Constrained	
	Inches	CM	Inches	CM	Inches	CM	Inches	CM
1847-1854	67.64	171.8	67.40	171.2	67.66	171.9	67.42	171.2
1855-1859	67.29	170.9	67.01	170.2	67.31	171.0	67.03	170.3
1860-1864	67.26	170.8	66.97	170.1	67.27	170.9	66.98	170.1
1865-1869	67.35	171.1	67.07	170.4	67.36	171.1	67.08	170.4
1870-1874	67.26	170.8	66.97	170.1	67.27	170.9	66.98	170.1
1875-1879	67.28	170.9	66.99	170.2	67.28	170.9	67.00	170.2
1880-1884	67.38	171.1	67.10	170.4	67.37	171.1	67.10	170.4
1885-1889	67.59	171.7	67.35	171.1	67.60	171.7	67.35	171.1
1890-1894	67.63	171.8	67.39	171.2	67.64	171.8	67.40	171.2

Notes: Estimated heights are weighted with the proportion of white adult males in each census region or division in 1880. Region is controlling for census regions. Division is controlling for census divisions. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm).
Sources: Table 1.3 (Models 1 and 2).

FIGURE 1.6
NATIONWIDE ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS, 1847-1894



Notes: Estimated heights from Table 1.3 Model 2 weighted with the proportion of white adult males in each census division in 1880. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm).
Sources: Table 1.4.

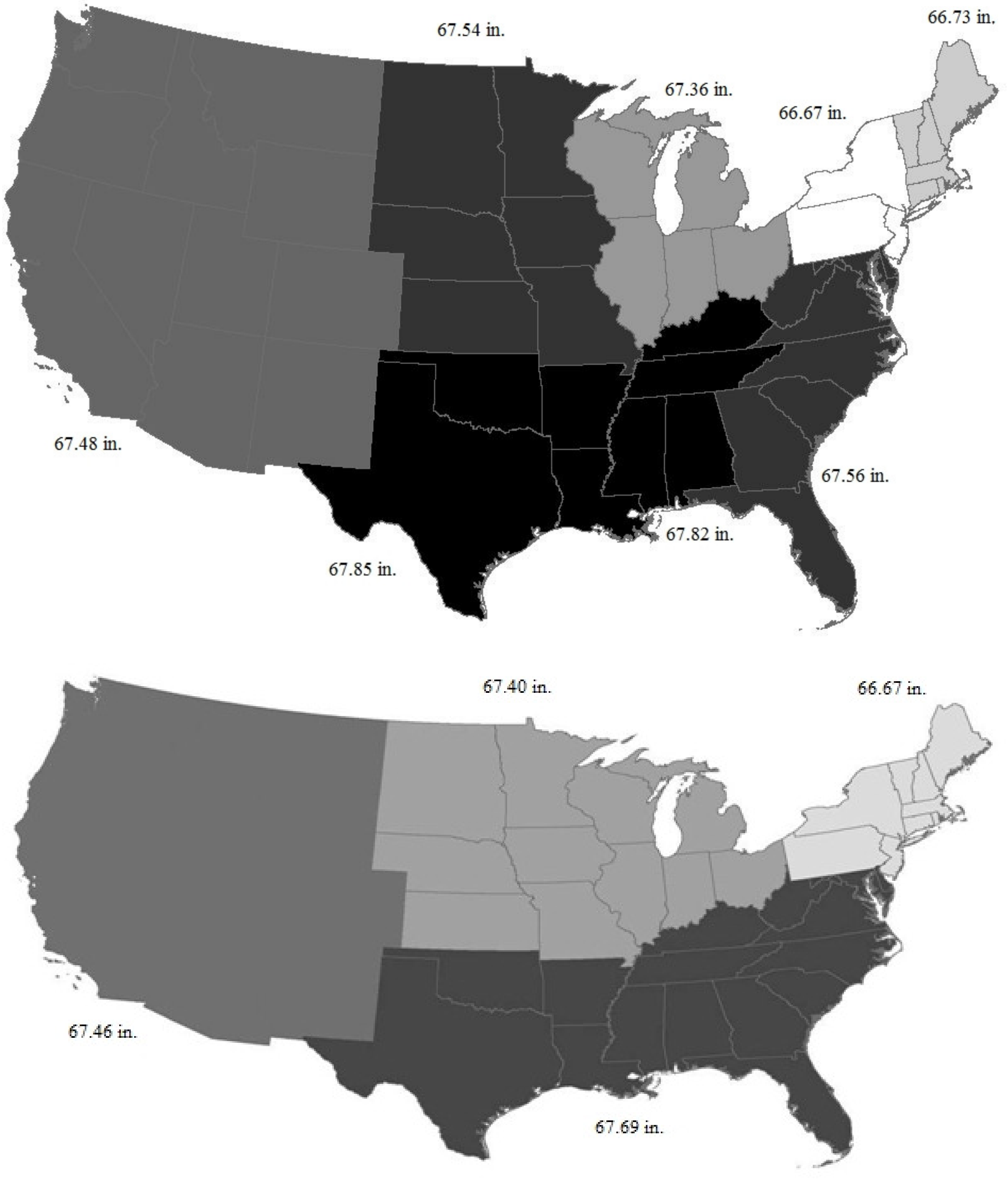
Both graphs (Figure 1.6) show a decline in heights after 1854, stagnation until 1879 followed by increasing heights thereafter. The height prediction from the constrained estimation is consistently lower by about 0.3 in. (0.8 cm) although the trends are identical. The positive coefficients of the 1880, 1885, and 1890 cohorts and the decline in 1855 are significant in all regressions. Southern recruits were the tallest (67.69 in.; 171.9 cm) followed by the West (67.46 in.; 171.3 cm) and Midwest (67.40 in.; 171.2 cm), while Northeasterners (66.67 in.; 169.3 cm) were the shortest (Table 1.3, Model 1).

The results by smaller census divisions are similar: recruits from the West South Central division were the tallest (67.85 in.; 172.3 cm), followed by East South Central (67.82 in.; 172.3 cm), the South Atlantic (67.56 in.; 171.6 cm), West North Central (67.54 in.; 171.6 cm), Pacific and Mountain (67.48 in.; 171.4 cm) and East North Central (67.36 in.; 171.1 cm).

The two shortest divisions were New England (66.73 in.; 169.5 cm) and Middle Atlantic (66.67 in.; 169.3 cm) (Table 1.3, Model 2). The difference between the shortest and tallest region was 1.02 in. (2.6 cm) and 1.18 in. (3.0 cm) among divisions.

Recruits from the South and in particular from the East South Central and the West South Central divisions remained the tallest, despite the Civil War. This pattern corresponds to the findings of Komlos (1987) that Southern-born West Point cadets were the tallest group until the 1870s. Hiermeyer (2008) finds the Upper South, West, and (lower) South to be the tallest and the Northeast to be the shortest regions. A'Hearn (1998) and Margo and Steckel (1983) also find Westerners and Southerners to be taller than Northeasterners.

FIGURE 1.7
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS DIVISION
AND REGION OF BIRTH, 1847-1894



Notes: Estimated heights from Models 1 and 2 (Table 1.3) averaged over birth cohorts 1847-1894.
Sources: See the text.

TABLE 1.5
HEIGHT OF US ARMY RECRUITS BY CENSUS REGION:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) West	N	(2) Midwest	N	(3) South	N	(4) Northeast	N
Age 18	-0.59	66	-0.83***	1,174	-1.09***	688	-0.80***	1,110
Age 19	-0.42	58	-0.57***	933	-0.82***	700	-0.71***	1,039
Age 20	-0.03	47	-0.41***	737	-0.57***	518	-0.38***	706
Age 21	0.33*	281	-0.14***	4,900	-0.18***	3,471	-0.18***	4,992
Age 22-50	Ref.	763	Ref.	12,211	Ref.	9,703	Ref.	14,313
Birth Cohorts								
1847-1864	0.85*	26						
1865-1879	Ref.	1030						
1880-1894	0.51**	159						
1847-1854			0.14	76	-0.06	118	0.87***	187
1855-1859			-0.13	137	0.13	154	0.11	247
1860-1864			0.10	430	0.13	358	-0.14	603
1865-1869			0.09	1,570	0.06	1,153	0.14*	1,886
1870-1874			Ref.	4,209	Ref.	3,214	Ref.	5,113
1875-1879			0.04	10,065	0.05	7,350	-0.04	10,958
1880-1884			0.06	2,522	0.17*	1,811	-0.02	2,277
1885-1889			0.35***	708	0.37***	675	0.16	622
1890-1894			0.49**	238	0.35**	247	0.25	267
Mountain	-0.04	322						
Pacific	Ref.	893						
Iowa			0.07	1,266				
Nebraska			0.21	307				
Kansas			0.20	968				
Missouri			-0.17	2,811				
Wisconsin			-0.05	896				
Michigan			-0.44***	1,716				
Illinois			-0.22**	3,427				
Indiana			0.08	3,154				
Ohio			-0.32***	4,735				
Minnesota			Ref.	599				
Dakota			-0.11	76				
Oklahoma					1.04***	44		
Arkansas					0.88***	349		
Texas					1.01***	970		
Louisiana					0.46**	268		
Kentucky					0.78***	3,662		
Tennessee					1.03***	1,923		
Mississippi					0.89***	343		
Alabama					0.89***	685		
West-Virginia					0.89***	668		
Virginia					0.69***	1,309		
North Carolina					1.13***	1,138		
South Carolina					0.72***	568		
Georgia					0.69***	1,358		
Florida					0.70**	158		
D.C.					Ref.	340		
Delaware					-0.46	114		
Maryland					-0.20	1,093		
New York							0.08*	7,635
Vermont							0.54***	299
New Hampshire							-0.03	271
Massachusetts							-0.03	3,471
Connecticut							0.15	830
Rhode Island							0.14	503
Maine							0.52***	609
New Jersey							0.03	1,626
Pennsylvania							Ref.	6,916
Constant	67.32***		67.57***		66.97***		66.66***	
Sigma	2.28***		2.28***		2.30***		2.34***	
N	1,215		19,955		15,080		22,160	

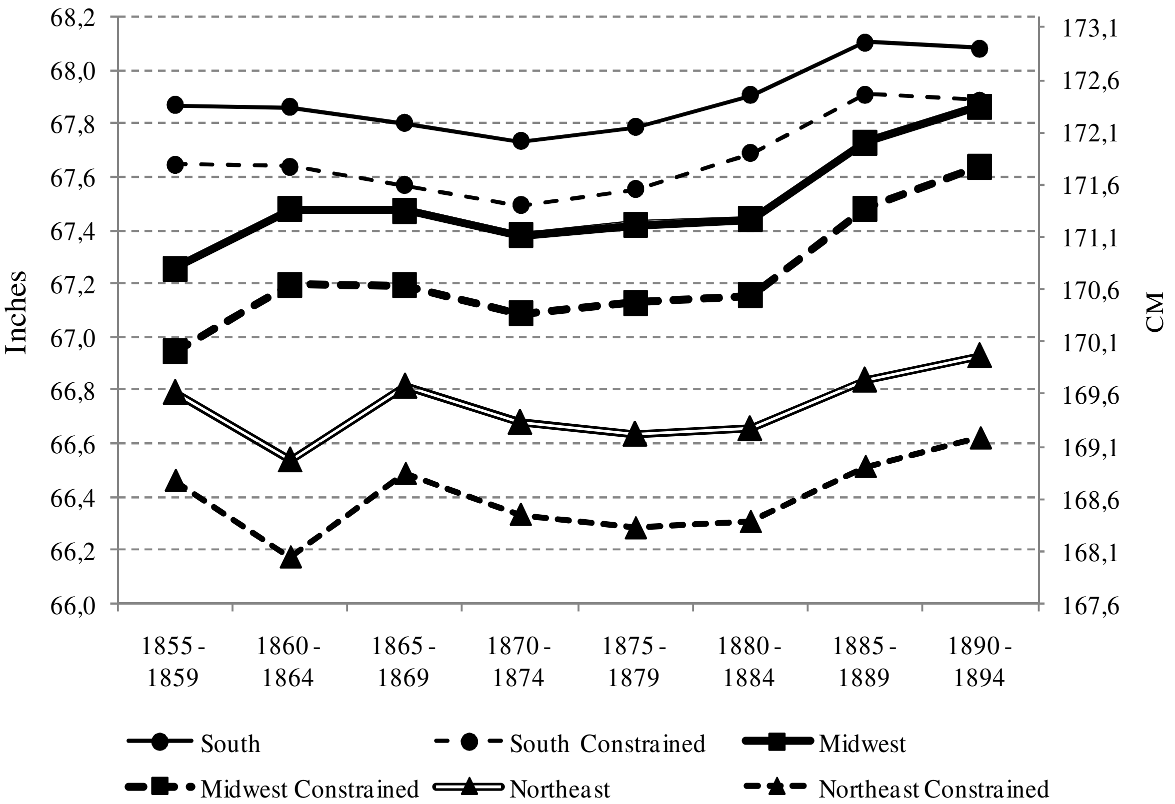
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. D.C. is Washington D.C. Dakota corresponds to North and South Dakota.
Sources: See the text.

TABLE 1.6
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS REGION, 1855-1894

	Midwest		South		Northeast	
	Inches	CM	Inches	CM	Inches	CM
			Unconstrained Estimation			
1855-1859	67.26	170.8	67.87	172.4	66.79	169.6
1860-1864	67.48	171.4	67.86	172.4	66.54	169.0
1865-1869	67.48	171.4	67.8	172.2	66.82	169.7
1870-1874	67.38	171.1	67.73	172.0	66.68	169.4
1875-1879	67.42	171.2	67.79	172.2	66.64	169.3
1880-1884	67.44	171.3	67.9	172.5	66.66	169.3
1885-1889	67.74	172.1	68.11	173.0	66.84	169.8
1890-1894	67.87	172.4	68.08	172.9	66.93	170.0
			Constrained Estimation			
1855-1859	66.94	170.0	67.64	171.8	66.46	168.8
1860-1864	67.20	170.7	67.64	171.8	66.17	168.1
1865-1869	67.19	170.7	67.57	171.6	66.49	168.9
1870-1874	67.09	170.4	67.49	171.4	66.33	168.5
1875-1879	67.13	170.5	67.55	171.6	66.28	168.4
1880-1884	67.15	170.6	67.69	171.9	66.31	168.4
1885-1889	67.50	171.5	67.91	172.5	66.51	168.9
1890-1894	67.65	171.8	67.89	172.4	66.62	169.2

Notes: Estimated heights are weighted with the proportion of white adult males in each state in 1880. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm).
Sources: Table 1.5.

FIGURE 1.8
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS REGION, 1855-1894



Notes: Estimated heights from Table 1.5 weighted with the proportion of white adult males in each state in 1880. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm).
Sources: Table 1.6.

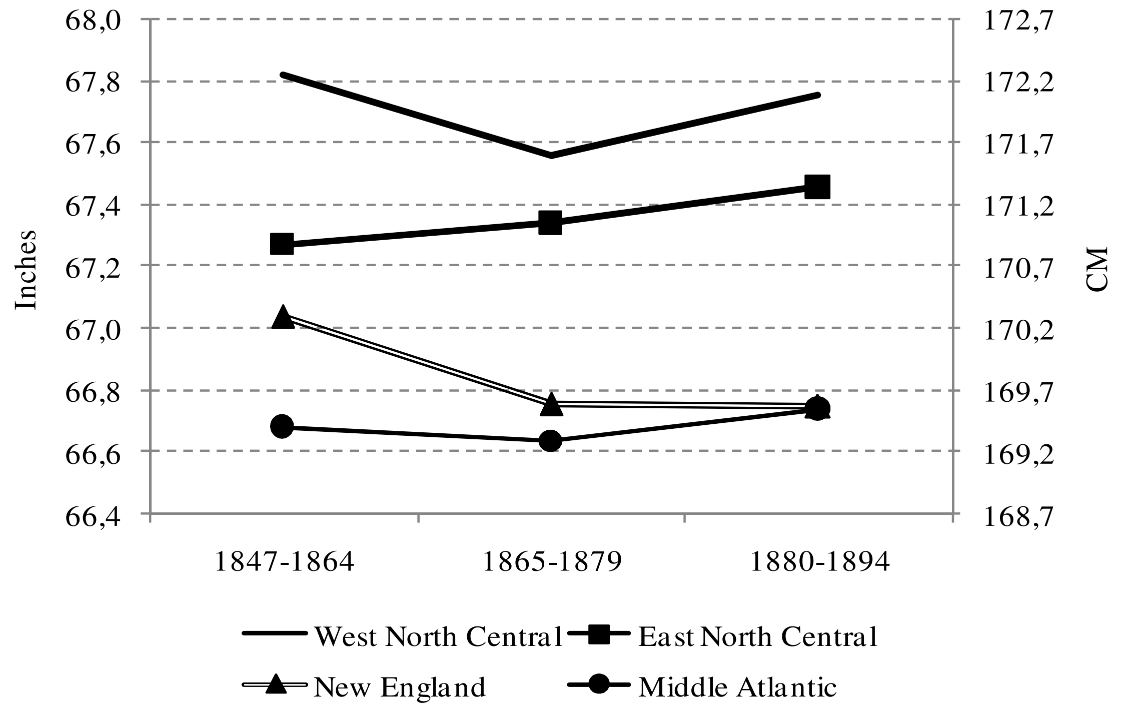
The trends over time differ by region: The South is the tallest region and experiences stagnation until 1880, the Midwest is second with stagnation until 1885, trailed by the Northeast with declines in the 1850s followed by stagnation (Table 1.5 and Figure 1.8). The trends by census division are very heterogeneous (Tables 1.7 and 1.8; Figures 1.9 and 1.10). The time dummy variables are divided into decades instead of quinquennia as above in order to attain an adequate sample size for each period. The Pacific and Mountain divisions were excluded because of their small sample size.

TABLE 1.7
HEIGHT OF US ARMY RECRUITS BY CENSUS DIVISION IN NORTHEAST AND MIDWEST: TRUNCATED NORMAL REGRESSION (in inches)

	(1) East North Central	N	(2) Middle Atlantic	N	(3) West North Central	N	(4) New England	N
Age 18	-0.88***	837	-0.92***	832	-0.91***	337	-0.72***	278
Age 19	-0.53***	664	-0.87***	763	-0.79***	269	-0.48**	276
Age 20	-0.48***	512	-0.41***	527	-0.32*	225	-0.48**	179
Age 21	-0.12**	3,330	-0.30***	3,735	-0.19**	1,570	0.01	1,257
Age 22-50	Ref.	8,585	Ref.	10,320	Ref.	3,626	Ref.	3,993
Birth Cohorts								
1847-1864	-0.07	476	0.05	749	0.26	167	0.28*	
1865-1879	Ref.	11,041	Ref.	13,124	Ref	4,803	Ref.	
1880-1894	0.12	2,411	0.10	2,304	0.20**	1,057	-0.01	
Michigan	-0.38***	1,716						
Illinois	-0.16*	3,427						
Wisconsin	Ref.	896						
Indiana	0.13	3,154						
Ohio	-0.27***	4,735						
New York			0.09*	7,635				
Pennsylvania			Ref.	6,916				
New Jersey			0.03	1,626				
Iowa					0.07	1,266		
Minnesota					Ref	599		
Dakota					-0.13	76		
Nebraska					0.22	307		
Kansas					0.2	968		
Missouri					-0.17	2,811		
Vermont							0.02	299
New Hampshire							-0.57***	271
Maine							Ref.	609
Massachusetts							-0.56***	3,471
Connecticut							-0.38***	830
Rhode Island							-0.40**	503
Constant	67.54***		66.67***		67.62***		67.15***	
Sigma	2.30***		2.35***		2.25***		2.31***	
N	13,928		16,177		6,027		5,983	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Dakota corresponds to North and South Dakota.
Sources: See the text.

FIGURE 1.9
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS DIVISION
IN NORTHEAST AND MIDWEST, 1847-1894



Notes: Estimated heights from Table 1.7 weighted with the proportion of white adult males in each state in 1880.
Sources: Table 1.9.

FIGURE 1.10
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS DIVISION
IN THE SOUTH, 1847-1894

Notes: Estimated heights from Table 1.8 weighted with the proportion of white adult males in each state in 1880.
Sources: Table 1.9.

TABLE 1.8
HEIGHT OF US ARMY RECRUITS BY CENSUS DIVISION IN THE SOUTH: TRUNCATED NORMAL REGRESSION (in inches)

	(1) South Atlantic	N	(2) West South Central	N	(3) East South Central	N
Age 18	-1.06***	257	-0.59*	66	-1.29***	365
Age 19	-0.80***	280	-0.51*	78	-0.95***	342
Age 20	-0.42**	187	0.06	59	-0.83***	272
Age 21	-0.18**	1,496	0.04	404	-0.22**	1,571
Age 22-50	Ref.	4,616	Ref.	1,024	Ref.	4,063
Birth Cohorts						
1847-1864	0.35**	368	-0.30	47	-0.33*	215
1865-1879	Ref.	5,352	Ref.	1,264	Ref.	5,101
1880-1894	0.20*	1,116	0.20	320	0.22**	1,297
West Virginia	0.93***	668				
Virginia	0.70***	1,399				
D. C.	Ref.	340				
Maryland	-0.20	1,093				
Delaware	-0.48	114				
North Carolina	1.16***	1,138				
South Carolina	0.75***	568				
Georgia	0.72***	1,358				
Florida	0.73**	158				
Texas			0.12	970		
Oklahoma			0.15	44		
Arkansas			Ref.	349		
Louisiana			-0.35*	268		
Mississippi					0.00	343
Alabama					Ref.	685
Tennessee					0.14	1,923
Kentucky					-0.10	3,662
Constant	66.94***		67.83***		67.95***	
Sigma	2.35***		2.18***		2.28***	
N	6,836		1,631		6,613	

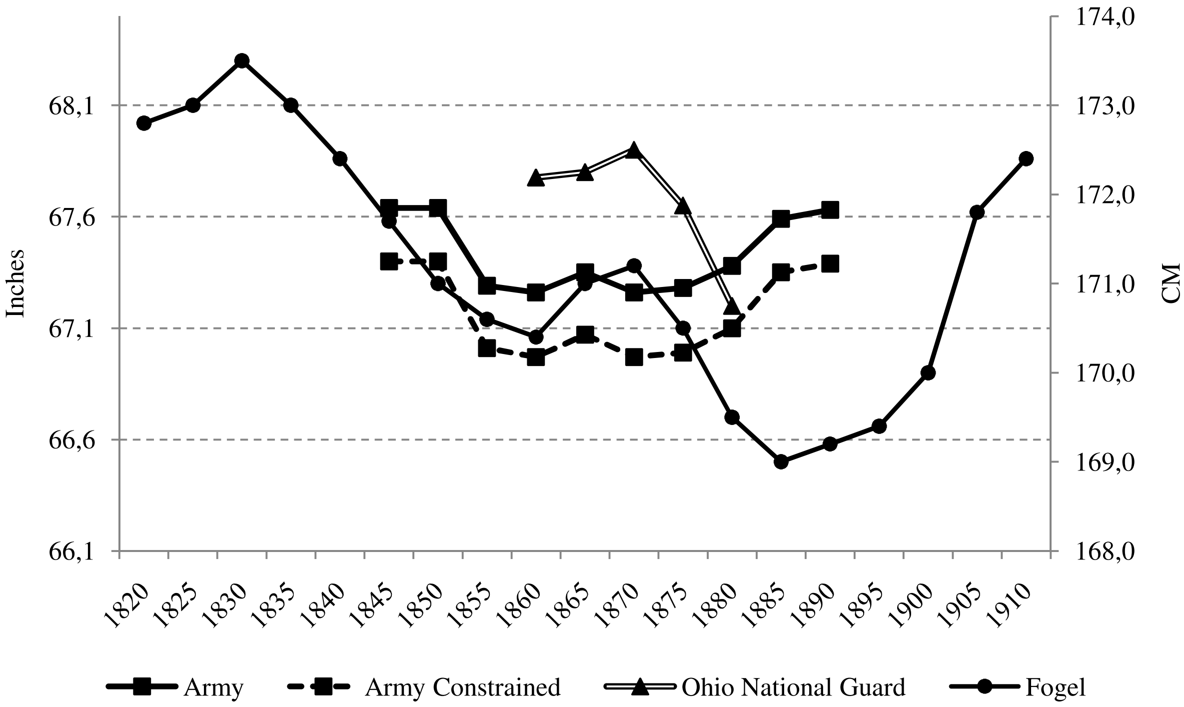
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. D.C. is Washington D.C.
Sources: See the text.

TABLE 1.9
ESTIMATED HEIGHT OF US-BORN ADULT RECRUITS BY CENSUS REGION, 1847-1894

Midwest & Northeast:	East North Central		Middle Atlantic		West North Central		New England	
Cohorts	Inches	CM	Inches	CM	Inches	CM	Inches	CM
1847-1864	67.27	170.9	66.68	169.4	67.82	172.3	67.04	170.3
1865-1879	67.34	171.0	66.64	169.3	67.56	171.6	66.75	169.6
1880-1894	67.46	171.3	66.74	169.5	67.75	172.1	66.75	169.5
South:	South Atlantic		West South Central		East South Central			
Cohorts	Inches	CM	Inches	CM	Inches	CM		
1847-1864	67.91	172.5	67.50	171.5	67.53	171.5		
1865-1879	67.55	171.6	67.81	172.2	67.87	172.4		
1880-1894	67.75	172.1	68.01	172.8	68.08	172.9		

Notes: Estimated heights are weighted with the proportion of white adult males in each state in 1880.
Sources: Tables 1.7 and 1.8.

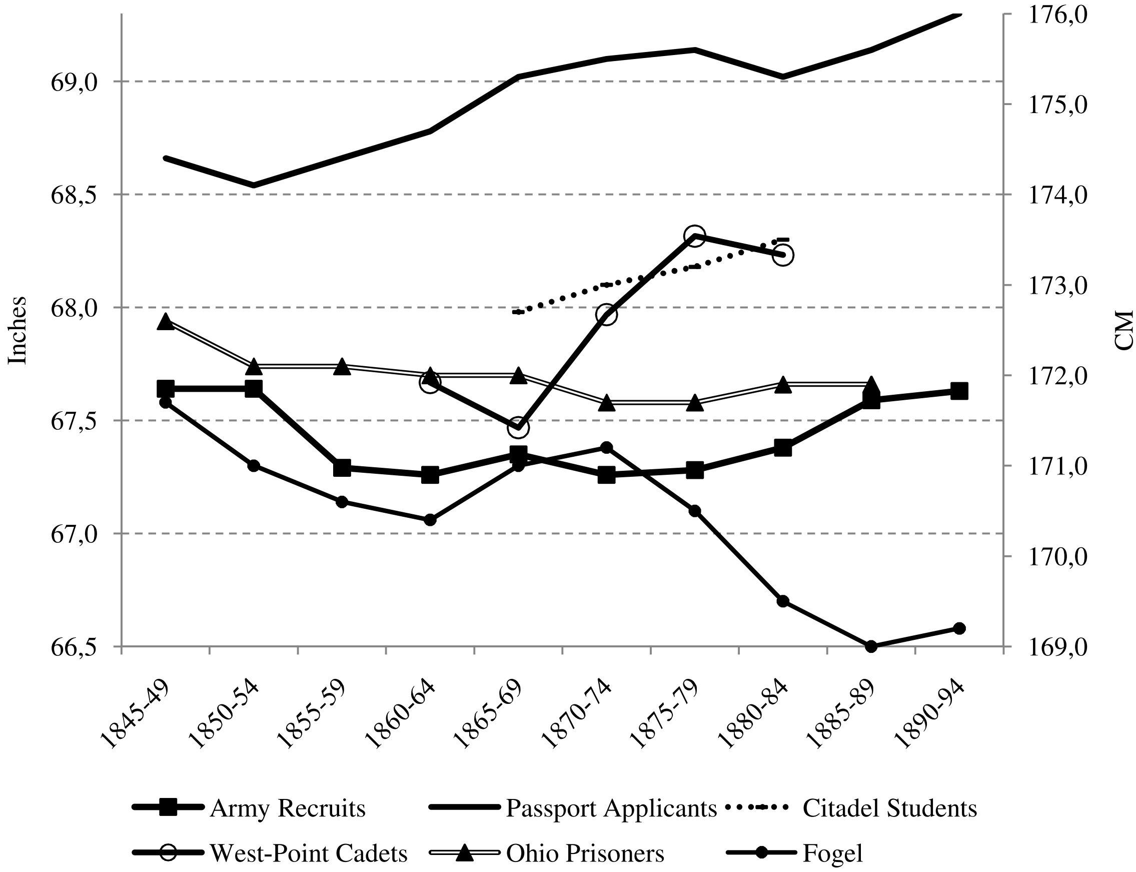
FIGURE 1.11
COMPARISON OF VARIOUS HEIGHT TREND ESTIMATES



Notes: Estimated heights for Army recruits weighted with the proportion of white adult males in each region in 1880. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm).
Sources: Fogel (1986, 2004) and Steckel (2006), Ohio National Guard (Steckel and Haurin, 1994), Army (see the text).

Figure 1.11 compares our findings with Fogel's (1986) estimates that are extrapolated from the Ohio National Guard data, and which have been copied so often that it has become a standard in the literature. The average heights in the nationwide sample of Army recruits show a less severe decline after 1850 and an increase in 1880 rather than a decrease starting in 1875. The difference is substantial: by 1890 it is 1.02 inches (2.6 cm). Figure 1.12 compares our findings with other studies of this time period.

FIGURE 1.12
COMPARISON WITH PREVIOUS STUDIES



Sources: Passport Applicants (Sunder, 2007), Army Recruits (see the text), Fogel (1986, 2004) Steckel (2006), West-Point Cadets (Komlos, 1987), Citadel Students (Komlos and Coclanis, 1995), White Ohio Prisoners (Maloney and Carson, 2008).

In Europe, Cole (2003) finds a secular increase in adult heights since the middle of the 19th-century and Komlos (2007) finds increases in the heights of recruits in the Habsburg Monarchy beginning in the 1860s that lasted until the 20th-century. This is in stark contrast to the stagnation and late recovery in the US found in this study. The present study bridges a gap in human-height analysis, and sheds light on one of the darkest eras, when it comes to this measurement of biological well-being in US history.

1.3.2 County and State Level Determinants of Height

We include county-level variables in order to test how urbanization, the availability of nutrients, wages, transportation, geographic mobility, and the epidemiological framework affected stature as in Craig and Weiss (1998), Haines, Craig, and Weiss (2003), and Sunder (2007). The sample is reduced to 41,830 recruits because 16,682 recruits could not be assigned to their counties of birth. For state-level data the sample is further reduced to 41,713 because data on infant mortality and the railroad network were not available for all states.

We begin by examining the hypothesis that population density affected exposure to diseases and nutrition, and consequently height. During the period of US history under consideration, urban food prices were more expensive than in rural areas, because of transportation costs, and of inferior quality, because of deterioration in the course of transportation (refrigeration was just beginning) (Komlos, 1987, 2003; Craig, Goodwin, and Grennes, 2004). Furthermore, poor sanitation, a large immigrant population, and overcrowded living conditions facilitated the transmission of diseases, and thereby stunted growth (Preston and Haines, 1991; Steckel, 1995; Lee, 1997; Craig and Weiss, 1998; Haines, Craig, and Weiss, 2003). In order to distinguish varying degrees of urbanization, three census categories are adopted[5]. The reference category is "rural," that is, agglomerations of no more than 2,500 inhabitants. The other categories are towns with populations between 2,500 and 25,000 and urban areas with more than 25,000 inhabitants.

The agricultural-output variables reflect the local availability of nutrients. For instance, those living in counties with dairy and livestock operations faced lower prices for these products insofar as they did not have to pay transportation costs or for the profits of middlemen. As a consequence they would consume more calcium and protein and thereby

[5] The categories measure the proportion of county inhabitants in each group.

grow taller than those less fortunate in their location: thus one can infer that there should be a height premium for nutrient propinquity. Indeed many studies have documented such a premium (Komlos, 1987; Craig and Weiss, 1998; Haines, Craig, and Weiss, 2003). Because milk could not be transported over long distances, milk cows per capita influenced height locally (Baten, 1999). Since butter and cheese, unlike milk, could be shipped, dairy farmers near cities supplied those cities with milk, whereas dairy farmers in more remote areas produced butter and cheese. Beginning in the 1870s, improvements in transportation and refrigeration meant that milk could be transported over longer distances (Bateman, 1968). The meat industry, too, was transformed by these improvements. Dressed beef could be transported; previously, livestock had to be transported close to the market in question and only then slaughtered and dressed (Yeager Kujovich, 1970). Hence, market integration, which in turn depended upon good transportation networks, was important for nutritional status. In other words, height is in part a function of nutrient availability, which is in part a function both of its distribution and of market integration. Equal distribution and easy access to locally produced nutrients would have a positive effect on local height. Market integration, made possible by improvements in transportation, would affect the height of agricultural populations because nutrients would be shipped to distant markets rather than consumed locally.

The nominal annual wage per manufacturing worker is the best proxy available for non-farm incomes in the census at the county level. Higher income was accompanied by higher meat consumption, and animal protein promotes growth (Cuff, 2005). Furthermore, a rise in income permits a move to better housing, which is associated with a decline in illness and in infant mortality (Preston and Haines, 1991). Categories for civilian occupations were included to control for the socio-economic background of the recruits. A simplifying assumption is that there was little intergenerational mobility: a recruit's occupation prior to joining the service is a valid predictor of his parent's occupations[6]. These occupations were coded into the following categories: farmers, laborers (including those temporarily unemployed or with no reported occupation), lower-level white-collar workers, upper-level white-collar workers, semi-skilled blue-collar workers, and skilled blue-collar workers. Recruits from higher socio-economic strata are expected to be taller than the others, in line with findings by Komlos (1987), Steckel (1995), Sunder (2007), and Hiermeyer (2008). Higher socio-economic status would have a positive effect on stature; well-to-do families could afford more and better quality food and better housing (Preston and Haines, 1991). On the other hand, it is possible that those who were taller and healthier than average were also more productive and therefore had better-paying jobs in adulthood, so the direction of the causality is not clear (Lee, 1997). A recruit who enlisted out of state is classified as a mover. There are two hypotheses regarding movers: that they were mostly poor and malnourished (and therefore shorter than average), and moved to another state in the hope of improving their lot; or that moving was costly and therefore movers were also well-nourished (and taller than average) (Craig and Weiss, 1998; Haines, Craig, and Weiss, 2003).

Data for transportation and the disease environment, both important variables, cannot be analyzed at the county level because there are no such data in the 1880 census. We remedy this problem by supplementing this analysis with variables aggregated at the state-level. State infant mortality rates[7] serve as a proxy variable for the disease environment. The effect of infant mortality on height is expected to be negative through the channel of diseases because energy normally channeled into growth is lost to the fight against diseases (Preston and Haines, 1991). The length of railroad lines completed in a state as of June 30, 1880 (measured in 1,000 miles) is used as a proxy for access to transportation. Transportation promotes access

[6] For an analysis of this assumption see Chapter 3.

[7] The number of deaths of infants - that is, children under the age of 1 year -per 1000 births.

not only to markets but also to diseases, so its effect on (rural) height should be negative (Sunder, 2007). Market integration could either lead to a better and more balanced diet, promoting growth because healthy food would become more available and affordable especially in cities, or it could lead to a substitution away from protein- and calcium-rich foods to a carbohydrate-based diet especially for nutrient exporting regions (Komlos, 1987, 1996). To test these hypotheses we estimate regressions on the national and regional level with county-level data (Tables 1.10 and 1.11) and on the national level with county- and state-level data (Table 1.12).

Results from Table 1.10 confirm that the proportion of a given county population living in towns with more than 2,500 inhabitants was negatively correlated with adult height, which is significant only in Model 3 (a ten percentage point increase in the county share of those living in towns was associated with 0.02 in. / 0.1 cm lower heights). However, in all models the proportion of people living in urban areas with more than 25,000 people was negatively associated with stature of almost twice the magnitude of the town category (here a ten percentage point increase in the county share of those living in cities was associated with 0.04 in. / 0.1 cm lower heights). In other words, a high population density brought about by urbanization was correlated with short stature.

Milk cows and pigs per capita were significantly and positively correlated with height confirming the propinquity thesis, whereas wheat per capita and height were not significantly correlated[8] (Table 1.10). Although grain provides energy, in the form of carbohydrates, it contains much less calcium and protein than meat, essential for growth (Waterlow, 1994).

[8] See Baten's (1999) finding that in Bavaria between 1730 and 1880 recruits from wheat-producing regions were shorter than those from dairy regions.

TABLE 1.10
DETERMINANTS OF HEIGHT AT THE COUNTY LEVEL:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Region	(2) Region Const.	(3) Division	N	(4) Region Age (18-20)	N	(5) Region Age (21-50)	N
Age 18	-0.67***	-0.77***	-0.66***	2,139	-0.21**	2,139		
Age 19	-0.55***	-0.64***	-0.55***	2,029	-0.12	2,029		
Age 20	-0.40***	-0.47***	-0.41***	1,506	Ref.	1,506		
Age 21	-0.09***	-0.10**	-0.09**	9,627			-0.09***	9,627
Age 22-50	Ref.	Ref.	Ref.	26,529			Ref.	26,529
Birth Cohorts								
1847-1854	0.49***	0.56***	0.49***	296			0.49***	296
1855-1859	-0.05	-0.06	-0.05	415			-0.05	415
1860-1864	-0.07	-0.08	-0.07	1,121			-0.07	1,121
1865-1869	0.09*	0.11*	0.09*	3,636			0.09*	3,636
1870-1874	Ref.	Ref.	Ref.	9,935			Ref.	9,935
1875-1879	-0.01	-0.01	-0.01	21,608	Ref.	2,602	-0.01	19,006
1880-1884	-0.07	-0.09	-0.08	3,787	-0.14	2,839	0.00	938
1885-1889	0.11	0.12	0.10	720	0.63	34	0.09	696
1890-1894	0.07	0.09	0.07	312	0.02	199	0.09	113
Rural	Ref.	Ref.	Ref.		Ref.		Ref.	
Town	-0.15	-0.17	-0.20*		-0.31		-0.13	
Urban	-0.32***	-0.38***	-0.35***		-0.50***		-0.30***	
Laborer	-0.21***	-0.24***	-0.21***	8,821	-0.33***	1,678	-0.17***	7,143
Semi-skilled	-0.02	-0.02	-0.02	15,304	-0.14	1,299	0.00	14,005
Skilled	-0.12*	-0.14**	-0.12**	8,823	-0.09	1,110	-0.12*	7,713
Farmer	0.32***	0.36***	0.30***	4,498	0.31**	821	0.32***	3,677
Low. w. c.	Ref.	Ref.	Ref.	3,219	Ref.	666	Ref	2,553
Up. w. c.	0.22***	0.25***	0.22***	1,180	-0.20	101	0.27***	1,079
Mover	0.21***	0.24***	0.21***	21,205	0.23***	1,852	0.20***	19,353
Stayer	Ref.	Ref.	Ref.	20,625	Ref.	3,822	Ref.	16,803
Wages	-0.55*	-0.63*	-0.71**		0.35		-0.67***	
Milk cows	0.35***	0.40***	0.31***		0.41		0.34***	
Pigs	0.07***	0.08***	0.05**		0.03		0.08***	
Wheat	-0.18	-0.21	-0.18		-0.33		0.00	
West	0.43***	0.49***		798	0.51**	108	0.42***	690
Midwest	Ref.	Ref.		14,158	Ref	2,057	Ref.	12,101
South	0.19***	0.22***		9,150	0.07	1,215	0.21***	7,935
Northeast	-0.41***	-0.48***		17,720	-0.47***	2,294	-0.41***	15,426
Pacific			0.47***	665				
Mountain			0.34	133				
S. Atlantic			0.03	3,853				
W. S. Cent			0.33***	948				
E. N. Cent			0.01	10,185				
W. N. Cent			Ref.	3,973				
E. S. Cent			0.24***	4,349				
M. Atl.			-0.43***	12,984				
N. England			-0.38***	4,736				
Constant	67.39***	67.10***	67.48***		66.99***		67.38***	
Sigma	2.28***	2.7	2.28***		2.17***		2.30***	
N	41,830	41,830	41,830		5,674		36,156	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Const is constrained. Laborer includes those with unknown occupations. w. c. is white-collar. Skilled is skilled worker. Semi-skilled is semi-skilled worker. S. Atlantic is South Atlantic. W. N. Cent. is West North Central. E. N. Cent. is East North Central. W. S. Cent. is West South Central. E. S. Cent is East South Central. M. Atl. is Middle Atlantic. N. England is New England. Rural is the proportion of county inhabitants living in places with fewer than 2,500, Town with more than 2,500 and fewer than 25,000, and Urban with more than 25,000 inhabitants. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Wheat is measured in 100 bushels. Milk cows, wheat, and pigs are per capita. Wages are annual manufacturing wages per manufacturing worker in $1,000. Railroad miles are miles in a state completed as of June 1st 1880 in 10,000 miles.
Sources: See the text.

Upper-level white-collar workers enjoyed a significant height premium of 0.22 in. (0.6 cm) compared with lower-level white-collar workers, but laborers and skilled workers experienced a significant height penalty, ranging from 0.12 in. (0.3 cm) to 0.21 in. (0.5 cm).

Only the height of semi-skilled workers was not significantly different from that of lower-level white-collar workers. The premium for farmers, 0.30 to 0.32 in. (0.8 cm), supports the propinquity hypothesis (Table 1.10, Models 1 and 3). The premium for upper-level white-collar workers corroborates the findings of Komlos (1987) and Hiermeyer (2008) pertaining to West Point Cadets in that recruits from middle-class families were taller than those from the working-class. Sunder (2007) finds that passport applicants were much taller than average due to the fact that in the 19th-century travel was prohibitively expensive for all but the wealthy.

Our proxy for income, the nominal manufacturing wage per capita, was significantly and negatively associated with stature. This variable picks up the costs of living because income is nominal and therefore positively correlated with costs of living in a county. It is also likely capturing parts of the effects of population density and the degree of industrialization. Our data on those who move out of state confirm the second hypothesis that movers were taller, and are in line with the finding of Haines, Craig, and Weiss (2003) that movers were on average 0.2 in. (0.5 cm) taller than those who remained in the state where they had been born. Variations among regions and divisions are similar to the estimates in Table 1.3.

The results vary by region and are different from the ones found at the national level. With the exception of the West, the more urban dwellers (proportion in cities with more than 25,000 inhabitants) there were in a given county, the shorter the average height of that county's recruits. In the Midwest this pattern applied to towns (proportion living in towns of more than 2,500 people) as well as urban areas, providing further evidence of the negative association between urbanization and height (Table 1.11).

TABLE 1.11
DETERMINANTS OF HEIGHT AT THE COUNTY LEVEL BY CENSUS REGION:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) West	N	(2) Midwest	N	(3) South	N	(4) Northeast	N
Age 18	-0.86	38	-0.52***	830	-0.85***	409	-0.68***	862
Age 19	-0.18	40	-0.42***	673	-0.63***	463	-0.64***	853
Age 20	-0.14	30	-0.38**	554	-0.53***	343	-0.35**	579
Age 21	0.33	180	-0.01	3,415	-0.15*	2,042	-0.15*	3,989
Age 22-50	Ref.	510	Ref.	8,686	Ref.	5,893	Ref.	11,437
Birth Cohorts								
1847-1864	0.63	22						
1865-1879	Ref.	726						
1880-1894	0.68	50						
1847-1854			0.26	64	0.29	77	0.81***	155
1855-1859			-0.26	101	0.05	112	0.03	200
1860-1864			0.03	354	0.00	254	-0.17	493
1865-1869			0.17*	1,215	0.02	796	-0.11	1,554
1870-1874			Ref.	3,225	Ref.	2,226	Ref.	4,270
1875-1879			0.02	7,429	0.00	4,745	-0.02	8,990
1880-1884			-0.13	1,430	-0.11	730	-0.06	1,587
1885-1889			0.25	251	0.04	136	0.03	325
1890-1894			0.33	89	-0.01	74	-0.04	146
Rural	Ref.		Ref.		Ref.		Ref.	
Town	-0.52		-0.42*		-0.50		-0.11	
Urban	-0.37		-0.54***		-0.32		-0.62***	
Laborer	0.62*	130	-0.08	2,857	-0.11	1,997	-0.40***	3,835
Semi-skilled	0.16	292	0.07	4,652	0.26*	3,285	-0.23**	7,075
Skilled	0.29	171	-0.05	2,894	0.19	1,394	-0.35***	4,364
Farmer	0.79	40	0.27**	2,179	0.59***	1,643	0.05	636
Low. w. c.	Ref.	134	Ref.	1,151	Ref.	563	Ref.	1,370
Up. w. c.	1.57***	32	0.17	427	0.33	271	0.09	449
Mover	0.22	313	0.18***	7,701	0.12*	5,187	0.21***	8,001
Stayer	Ref.	485	Ref.	6,457	Ref.	3,963	Ref.	9,719
Wages	-0.11		-0.10*		-0.26		1.40**	
Milk cows p.c.	-0.10		-0.05		0.30		0.56**	
Pigs p.c.	0.39		0.03		0.08		-0.22	
Wheat p.c.	0.30		-0.54***		-1.00*		-0.01	
Mountain	0.06	133						
Pacific	Ref.	665						
Iowa			-0.32	813				
Nebraska			-0.14	167				
MN,SD,ND			Ref.	373				
Kansas			-0.10	551				
Missouri			-0.56***	2,069				
Wisconsin			-0.18	495				
Michigan			-0.61***	1,162				
Illinois			-0.39**	2,244				
Indiana			-0.26	2,373				
Ohio			-0.51***	3,911				
OK,AR					0.68**	206		
Texas					1.15***	569		
Louisiana					0.82***	173		
Kentucky					0.84***	2,458		
Tennessee					1.01***	1,242		
Mississippi					1.04***	185		
Alabama					0.93***	464		
West Virginia					0.93***	304		
Virginia					0.90***	780		
Delaware					-0.04	103		
North Carolina					1.11***	571		
South Carolina					0.86***	381		
DC, Maryland					Ref.	776		
Georgia					0.85***	875		
Florida					0.47	63		
New York							0.04	6,238
Pennsylvania							Ref.	5,455
Vermont							-0.06	227
New Hampshire							-0.28	176
Massachusetts							-0.04	2,823
Connecticut							-0.15	638
Rhode Island							0.13	456
Maine							0.23	416
New Jersey							-0.02	1,291
Constant	67.05***		68.14***		66.61***		66.62***	
Sigma	2.14***		2.26***		2.27***		2.30***	

TABLE 1.11 CONTINUED

N	798	14,158	9,150	17,720

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. w. c. is white-collar. Skilled is skilled worker. Semi-skilled is semi-skilled worker. Rural is the proportion of county inhabitants living in places with fewer than 2,500, Town with more than 2,500 and fewer than 25,000, and Urban with more than 25,000 inhabitants. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Wheat is measured in 100 bushels. p.c. is per capita. Wages are annual manufacturing wages per manufacturing worker in $1,000. MN= Minnesota. SD=South Dakota. ND=North Dakota. OK=Oklahoma. AR=Arkansas.
Sources: See the text.

The average height within a given occupation differed from region to region. While farmers and upper-level white-collar workers were significantly taller in the nationwide regression, farmers were only significantly taller in the South and Midwest and upper-level white-collar workers only in the West. In the South semi-skilled workers were significantly taller, while they were significantly shorter in the Northeast. Skilled workers suffered from a height penalty in the nationwide regression, yet there was no significant effect on the regional level. Laborers, significantly shorter at the national level, were significantly taller than lower-level white-collar workers in the West, yet shorter in the Northeast. With the exception of the West, those recruits who enlisted in a state other than the one in which they were born had a significant height advantage (Table 1.11).

The aggregate variables at the regional level differ somewhat from those at the national level. It is only in the Northeast that milk cows per capita and height were significantly and positively correlated, whereas pigs per capita were not significantly correlated, and it is only in the Midwest and the South that the correlation of wheat production was significant and negative. In the Northeast the annual manufacturing wage per capita was significant and positive, whereas it was significant and negative in the Midwest and in the nationwide regression (Table 1.11).

TABLE 1.12
DETERMINANTS OF HEIGHT AT THE STATE AND COUNTY LEVEL:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Region Age (18-50)	(2) Region Constrained Age (18-50)	(3) Division Age (18-50)	N	(4) Region Age (18-20)	N	(5) Region Age (21-50)	N
Age 18	-0.67***	-0.77***	-0.66***	2,133	-0.21**	2,133		
Age 19	-0.55***	-0.64***	-0.55***	2,026	-0.12	2,026		
Age 20	-0.40***	-0.46***	-0.40***	1,498	Ref.	1,498		
Age 21	-0.09**	-0.11**	-0.09**	9,589			-0.09**	9,589
Age 22-50	Ref.	Ref.	Ref.	26,467			Ref.	26,467
Birth Cohorts								
1847-1854	0.49***	0.56***	0.49***	296			0.49***	296
1855-1859	-0.04	-0.05	-0.04	414			-0.04	414
1860-1864	-0.07	-0.08	-0.07	1,121			-0.07	1,121
1865-1869	0.09*	0.10*	0.09*	3,630			0.09*	3,630
1870-1874	Ref.	Ref.	Ref.	9,914			Ref.	9,914
1875-1879	-0.01	-0.01	-0.01	21,528	0.14*	2,592	-0.01	18,936
1880-1884	-0.08	-0.09	-0.08	3,779	Ref	2,832	-0.01	937
1885-1889	0.11	0.13	0.11	719	0.76*	34	0.10	695
1890-1894	0.07	0.09	0.08	312	0.16	199	0.09	113
Rural	Ref.	Ref.	Ref.		Ref.		Ref.	
Town	-0.17	-0.19	-0.21*		-0.27		-0.15	
Urban	-0.31***	-0.37***	-0.34***		-0.47**		-0.29***	
Infant mortality	-0.02**	-0.02***	-0.02***		-0.02		-0.02***	
Laborer	-0.22***	-0.25***	-0.22***	8,796	-0.35***	1,674	-0.18***	7,122
Semi-skilled	-0.02	-0.03	-0.02	15,262	-0.16	1,295	0.00	13,967
Skilled	-0.12**	-0.14**	-0.12**	8,805	-0.10	1,108	-0.11*	7,697
Farmer	0.31***	0.36***	0.30***	4,490	0.30*	820	0.32***	3,670
Lower w. collar	Ref.	Ref.	Ref.	3,199	Ref.	660	Ref.	2,539
Upper w. collar	0.22***	0.25**	0.22***	1,176	-0.22	101	0.27***	1,075
Mover	0.20***	0.23***	0.21***	21,118	0.23***	1,840	0.19***	16,778
Stayer	Ref.	Ref.	Ref.	20,595	Ref.	3,817	Ref.	19,278
Wages	-0.52**	-0.59**	-0.68***		0.28		-0.63**	
Milk cows p.c.	0.36***	0.41***	0.32***		0.45		0.34***	
Pigs p.c.	0.07***	0.08***	0.05**		0.03		0.08***	
Railroad miles	0.00	0.00	0.00		0.00		0.00	
Wheat p.c.	-0.19	-0.22	-0.19		-0.29		-0.18	
West	0.38***	0.44**		707	0.60*	94	0.35***	613
Midwest	Ref.	Ref.		14,136	Ref.	2,054	Ref.	12,082
South	0.17***	0.19***		9,150	0.10	1,215	0.18***	7,935
Northeast	-0.38***	-0.44***		17,720	-0.42***	2,294	-0.37***	15,426
Pacific			0.44***	649				
Mountain			0.26	58				
South Atlantic			0.04	3,853				
West South C.			0.32***	948				
East North C.			-0.01	10,185				
West North C.			Ref.	3,951				
East South C.			0.24***	4,349				
Middle Atlantic			-0.41***	12,984				
New England			-0.34***	4,736				
Constant	67.61***	67.36***	67.63***		66.98***		67.62***	
Sigma	2.28***	2.70	2.28***		2.17***		2.30***	
N	41,713	41,713	41,713		5,657		36,056	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm). Laborer includes those with unknown occupations. w. collar = white-collar. Skilled is skilled worker. Semi-skilled is semi-skilled worker. North C. = North Central, South C. =South Central. Rural is the proportion of county inhabitants living in places with fewer than 2,500, Town with more than 2,500 and fewer than 25,000, and Urban with more than 25,000 inhabitants. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Wheat is measured in 100 bushels. p.c. is per capita. Wages are annual manufacturing wages per manufacturing worker in $1,000. Infant mortality is measured in deaths per 1,000 births. Railroad miles are miles in a state completed as of June 1st 1880 in 10,000 miles.
Sources: See the text.

The state infant-mortality rates were significantly and negatively associated with stature, confirming the hypothesis that the above-average disease rate in an unhealthy environment that accounted for an above-average infant-mortality rate also accounted for below-average adult heights (Table 1.12). There was no significant correlation between the number of miles of state rail lines and average height, even though railroads facilitated the spread of disease and the trading away of growth-enhancing nutrients. A valid explanation could be technical: that the high level of aggregation fails to capture the county-by-county variation in railroad access. The results from Table 1.10 are robust to the inclusion of state level data (Table 1.12).

1.4 Conclusion

This study of the physical stature of US-born recruits into the Federal Army for the birth cohorts circa 1850-1890 fills a lacuna in the literature. The anthropometric studies that were done on this period tended to be either regionally limited (Ohio, South Carolina) or were limited to the elite segment of the population (West Point Cadets, passport applicants). This is the first study of a national data set based on a large sample of US Army recruits. In addition to estimating the trend for the nation as a whole in this period, the study also examines how and to what degree local nutrients, urbanization, market integration, occupations, and a disease-prone environment affected stature.

This study finds that the decline in physical stature that began in the 1830s continued into the 1850s. The decline in the 1850s was about 0.4 in. (1.0 cm) from 67.64 in. (171.8 cm) in the early 1850s birth cohort to a nadir of 67.26 in. (170.8 cm) in the cohort born during the Civil War and heights remained virtually unchanged until the 1880s, when they started to increase.

Average regional heights ranged from a high of 67.69 in. (171.9 cm) in the South to a low of 66.67 in. (169.3 cm) in the Northeast. Despite the Civil War the South was consistently the tallest region, with no significant changes in stature between the early 1850s and the late 1870s, while the Northeast remained the shortest region just like before the war.

We find that protein and calcium availability were significantly and positively correlated with height both at the national level and in the Northeast similar to findings by Craig and Weiss (1998). The correlation with urbanization (towns as well as cities) was significant and negative both at the national level (controlling for divisions) and in the Midwest and South at the regional level. Infant mortality, used as an indicator for the disease environment, was significantly and negatively associated with height. As for height differences according to occupation, the tallest were upper-level white-collar workers, who could afford better than average food and housing, and farmers, who enjoyed lower relative prices and greater than average proximity to food sources (Komlos, 1987; Lee, 1997)

While this study confirms the conclusions of previous studies concerning the effect of certain established variables on height, it also reveals considerable regional variability. The rapid economic growth that accompanied urbanization, industrialization, and market integration brought 19th-century America many benefits, but they came at a high price: the stagnation in height that translates as stagnation in biological well-being. This study puts the national trend in height on a solid evidential basis. So far trends have mostly been based on extrapolation of local trends derived from Ohio. Our findings show that heights stagnated for a generation after the Civil War in spite of the substantial economic growth especially in the North and the West. Not until the birth cohorts of the 1890s did the benefits of economic growth filter down to affect the biological standard of living of the common people. In contrast, the height of the elite, both men and women, were increasing rapidly beginning with the 1850s. Hence, quite a considerable gulf developed between the common man and the elite segments of the society: In 1850 passport applicants were 0.91 in. (2.3 cm) taller than Army recruits and in 1890 the gap had widened to 1.65 in. (4.2 cm). In 1890 the common man had reached the 1850 level again after decades of stagnation, while the elite continually grew.

References

Data:

Minnesota Population Center. 2004. National Historical Geographic Information System (NHGIS): Pre-release Version 0.1. Minneapolis, MN: University of Minnesota. http://www.nhgis.org

National Archives and Records Administration. 7th and Pennsylvania Ave., NW Washington DC 20408-0001. Microfilm ID M233. Record Group 094. Register of Enlistments in the U.S. Army, 1798-1914. Vol 94 (96%), Vol 96 (100%), Vol 97(10%), Vol 98 (93%), Vol 100 (88%),Vol 102 (100%), Vol 103 (80%), Vol 104 (100%), Vol 105 (100%).

Literature:

A'Hearn, Brian. 1998. "The Antebellum Puzzle Revisited: A New Look at the Physical Stature of Union Army Recruits during the Civil War." In: *The Biological Standard of Living in Comparative Perspective*, ed. John Komlos and Joerg Baten, 250-267. Stuttgart: Franz Steiner.

A'Hearn, Brian. 2004. "A restricted maximum likelihood estimator for truncated height samples." *Economics and Human Biology,* 2: 5-19.

Bateman, Fred. 1968. "Improvement in American Dairy Farming, 1850-1910: A Quantitative Analysis." *The Journal of Economic History,* 28: 255-273.

Baten, Jörg. 1999. "Ernährung und wirtschaftliche Entwicklung in Bayern (1730-1880)." In: *Beiträge zur Wirtschafts-und Sozialgeschichte.* Stuttgart: Steiner Verlag.

Bogin, Barry. 1999. *Patterns of Human Growth*. Cambridge: Cambridge University Press.

Cole, T. J. 2000. "Galton's midparent height revisited." *Annals of Human Biology*, 27 (4): 401-405.

Cole, T. J. 2003. "The secular trend in human physical growth: a biological view." *Economics and Human Biology*, 1: 161-168.

Craig, Lee A., and Thomas Weiss. 1998. "Nutritional Status and Agricultural Surpluses in the Antebellum United States." In: *The Biological Standard of Living in Comparative Perspective*, ed. John Komlos and Joerg Baten, 190-207. Stuttgart: Franz Steiner.

Craig, Lee A., Barry Goodwin, and Thomas Grennes. 2004. "The Effect of Mechanical Refrigeration on Nutrition in the United States." *Social Science History*, 28: 325-336

Cuff, Timothy. 2005. *The Hidden Cost of Economic Development. The Biological Standard of Living in Antebellum Pennsylvania*. Hampshire, UK: Ashgate.

Davis, George B. 1898. *The Military Laws of the United States.* Washington, D.C.: Government Printing Office.

Crawford, Michael J., Mark L. Hayes, and Michael D. Sessions. 1998. "*The Spanish-American War: historical overview and select bibliography*." Naval History Bibliographies; no. 5. Washington DC: Government Printing Office.

Davis, Joseph H. 2004. "An Annual Index of U.S. Industrial Production, 1790-1915." *Quarterly Journal of Economics*, 119: 1177-1215.

Fogel, Robert. 1986. "Nutrition and the Decline in Mortality: Some Preliminary Findings." In: *Long-Term Factors in American Economic Growth,* 439-555. Chicago: University of Chicago Press (for NBER).

Fogel, Robert. 1994. "Economic Growth, Population Theory, and Physiology: the Bearing of Long-term Processes on the Making of Economic Policy." *American Economic Review,* 84: 369–395.

Fogel, Robert. 2004. *The Escape from Hunger and Premature Death, 1700-2100 Europe, America, and the Third World.* Cambridge: Cambridge University Press.

Frisancho, Robert. A. 1990. *Anthropometric Standards for the Assessment of Growth and Nutritional Status.* Ann Arbor: University of Michigan Press.

Gallman, Robert E. 1960. "Commodity Output, 1839-1899." In: *Trends in the American Economy in the Nineteenth Century, Studies in Income and Wealth Vol. 24*, ed. William N. Parker, 13-72. Princeton: Princeton University Press.

Gallman, Robert E.1966. "Gross National Product in the United States, 1834-1909." In: *Output, Employment, and Productivity in the United States after 1800, Studies in Income and Wealth Vol. 30,* ed. Dorothy S. Brady,1-90. New York: Columbia University Press.

Gallman, Robert E. 2000. "Economic Growth and Structural Change in the Long Nineteenth Century," In: *Cambridge Economic History of the United States, Vol. II*, ed. Stanley Engerman and Robert E. Gallman, 1-56. Cambridge: Cambridge University Press.

Haines, Michael, Lee A. Craig, and Thomas Weiss. 2003. "The Short and the Dead: Nutrition, Mortality, and the 'Antebellum Puzzle' in the United States." *Journal of Economic History,* 63: 382-413.

Hiermeyer, Martin. 2008. "*Four Empirical Essays on the Economics of Height.*" PhD diss. University of Munich.

Hughes, Jonathan, and Louis P. Cain. 2002. *American Economic History*. 6th ed. New York: Addison-Wesley.

Johnston, Louis D., and Samuel H. Williamson. 2008. "What Was the U.S. GDP Then?" Measuring Worth. http://www.measuringworth.org/usgdp/ (accessed September 27, 2009).

Komlos, John. 1987. "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America." *The Journal of Economic History,* 47: 897-927.

Komlos, John. 1996. "Anomalies in economic history: Reflections on the antebellum puzzle." *Journal of Economic History, 56: 202-214.*

Komlos, John. 2003. "Access to Food and the Biological Standard of Living: Perspectives on the Nutritional Status of Native Americans." *American Economic Review,* 93: 252-255.

Komlos, John. 2004a. "Improvements in Maximum Likelihood Estimators of Truncated Normal Samples with Prior Knowledge of σ. A Simulation Based Study with Application to Historical Height Samples." *Discussion Paper LMU Munich.*

Komlos, John. 2004b. "How to (and How Not to) Analyze Deficient Height Samples." *Historical Methods,* 37 (4): 160-173.

Komlos, John. 2007. "Anthropometric evidence on economic growth, biological well-being and regional convergence in the Habsburg Monarchy, c. 1850-1910." *Cliometrica*, 1: 211-237.

Komlos, John, and Peter A. Coclanis. 1995. "Nutrition and Economic Development in Post-Reconstruction South Carolina: An Anthropometric Approach." *Social Science History*, 19 (1): 91-115.

Lee, Chulhee. 1997. "Socioeconomic Background, Disease, and Mortality among Union Army Recruits: Implications for Economic and Demographic History." *Explorations in Economic History,* 34: 27-55.

Maloney, Thomas N., and Scott Alan Carson. 2008. "Living Standards in Black and White: Evidence from the heights of Ohio Prison Inmates, 1829-1913.".*Economics and Human Biology,* (6): 237-251.

Margo, Robert, and Richard Steckel. 1983. "Heights of Native Born Northern Whites during the Antebellum Period." *Journal of Economic History,* 43: 167-184.

Preston, Samuel H., and Michael Haines. 1991. *Fatal Years: Child Mortality in the Late Nineteenth-Century America*. Princeton, NJ: Princeton University Press.

Rhode, Paul W. 2002. Gallman's Annual Output Series for the United States, 1834-1909. NBER Working Paper No. W8860.

Sellers, James L. 1927. "The Economic Incidence of the Civil War in the South." *The Mississippi Valley Historical Review*, 14 (2): 179-191.

Smith, Joseph. 1994. *The Spanish-American War: Conflict in the Caribbean and the Pacific 1895-1902.* Singapore: Longman.

Steckel, Richard, and Donald Haurin. 1994. "Health and Nutrition in the American Midwest: Evidence from the Height of Ohio National Guardsmen, 1850-1910." In: *Stature, Living Standards, and Economic Development: Essays in Anthropometric History,* ed. John Komlos, 117-128. Chicago: The University of Chicago Press.

Steckel, Richard. 1995. "Stature and the Standard of Living." *Journal of Economic Literature,* 33 (4): 1903-1940.

Steckel, Richard. 2006. "Health, Nutrition and Physical Well-Being" In: *Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition,* ed. Susan B. Carter, Scott Sigmund Gartner, Michael R. Haines, Alan L. Olmstead, Richard Sutch, and Gavin Wright. Bd 653-654. New York: Cambridge University Press.

Sunder, Marco. 2007. "Passports and Economic Development: An Anthropometric History of the U.S. Elite in the Nineteenth Century." PhD diss. University of Munich.

Tanner, James M. 1978. *Foetus into Man: Physical Growth from Conception to Maturity.* Cambridge: Cambridge University Press.

U.S. Census Bureau. 2002. Geography Division.
http://www.census.gov/geo/www/us_regdiv.pdf (accessed December 2009).

Waterlow, John. 1994. "Summary of Causes and Mechanisms of Linear Growth Retardation." *European Journal of Clinical Nutrition,* 48: (Suppl 1): S210.

Yeager Kujovich, Mary. 1970. "The Refrigerator Car and the Growth of the American Dressed Beef Industry." *Business History Review,* 44 (4): 460-482.

2. Decomposing the Urban American Height Penalty, 1847-1894

ABSTRACT

We analyze trends and determinants of the height of men born in American cities during the second half of the 19^{th}-century. In a sample of 21,704 US Army recruits we find an urban height penalty of between 0.34 in. (0.9 cm) and 0.58 in. (1.5 cm). An increment in urban-population of 100,000 is associated with a height decrease of about 0.31 in. (0.8 cm). We find that urban heights were positively correlated with the extent of the railroad network, the real wage rate in the manufacturing sector, and socio-economic status, while they were negatively correlated with the death rate, and the percentage of the city's population employed in manufacturing. We also find a decline in urban heights after 1855 followed by stagnation until the early 1890s, whereas rural heights stagnated from the late 1840s until 1885. Urban recruits from the Northeast were 0.46 in. (1.2 cm) shorter than urban Midwestern recruits. There is some evidence of a height convergence between large and small cities towards the end of the century and of an inverted U-shaped relationship between height and city size.

2.1 Introduction

Over the course of the 19th-century American cities grew dramatically, their share of the nation's total population having increased from about 6% to 40% (Haines, 2001) but public sanitation, water, and sewage systems were rudimentary throughout much of the period (Preston and Haines, 1991). There was also a shift from home manufacturing and agriculture to factories, where the density of the employee population facilitated the spread of diseases (Costa and Steckel, 1997). It is therefore not surprising that urban death rates were 1.4 times higher than rural ones (Condran and Crimmins-Gardner, 1980; Haines, 2001). Many studies have found a corresponding height penalty insofar as disease encounters decrease the nutritional status of a population (Margo and Steckel, 1983; Steckel and Haurin, 1994; Steckel, 1995; Komlos 1998; Haines, Craig, and Weiss, 2003; Sunder, 2007). Already in the 18th-century urban heights were 0.90 in. (2.3 cm) less than their rural counterparts (Fogel et. al., 1982; Sokoloff and Villaflor, 1982). Even among the free blacks of antebellum Maryland the rural-urban difference was 1.46 in. (3.7 cm) (Komlos, 1992).

In order to clarify the nature of this height penalty at the end of the 19th-century, at the time when sanitary improvements were under way, we estimate time trends in height for urban- and rural-born recruits and investigate height determinants unique to urban areas. While many studies analyze urban penalties, with the exception of Sunder (2007), this is the first study that investigates these city-level determinants of 19th-century urban height. We shall limit our analysis to the 100 largest urban places by population in 1880. At that time the populations of these cities ranged from 19,743 in Springfield, IL, to New York, at 1,206,299 (US Bureau of the Census, 1975). Of these cities 49 were located in the Northeast, 27 in the Midwest, 19 in the South, and 5 in the West.

We begin with an analysis of height trends and levels and of occupational patterns. We then decompose the urban penalty in terms of factors associated with urban height patterns. Key variables include the crude death rate, the connection to transportation networks, the real-wage in the manufacturing sector, the percentage of the population employed in manufacturing (as a proxy for industrialization), and the percentage of foreign-born inhabitants (as a proxy for immigration).

2.2 Data and Methodology

We use a sample of 21,704 urban recruits born between 1847 and 1894 and enlisted in the US Army between 1898 and 1912 (37% of the total sample)[9]. Recruits are classified as urban if they were born in a county that included a city that was listed in 1880 among the nation's 100 largest municipalities[10].

Because the Army had a minimum height requirement of 64 in. (162.6 cm), we carry out our analysis by means of truncated maximum likelihood estimation (TMLE) both with unconstrained and constrained standard deviations. In the case of a constrained estimation, we estimate the coefficients but not the standard deviation, which we assume to be 2.7 in. (6.86 cm) found among contemporary male adults (Frisancho, 1990; Komlos, 2004). We do so because A'Hearn (2004) has shown that under certain circumstances constrained estimates provide a more accurate estimate of the true mean.

[9] Our data are obtained from US Army enlistment records rolls 46 to 68 for the years 1898 - 1912 from the National Archives in Washington, D.C. and from Volumes 11, 12, 18, and 19 of the 1880 10th US Census of Population and Housing (Report on the Social Statistics of the Cities). For a more detailed description of the full sample see Chapter 1.

[10] This limitation to counties of birth is necessary because at the time of enlistment recruits often provided the name of a county and not of a town or city as their place of birth.

TABLE 2.1
DESCRIPTIVE STATISTICS

Variable	μ	σ	Min	Max	N
			Age at Enlistment		
Age 18	0.05	0.21	0.00	1.00	999
Age 19	0.05	0.21	0.00	1.00	1,013
Age 20	0.04	0.18	0.00	1.00	760
Age 21	0.22	0.41	0.00	1.00	4,780
Age 22–50	0.65	0.48	0.00	1.00	14,152
			Birth Cohort		
1847-1854	0.01	0.09	0.00	1.00	171
1855-1859	0.01	0.10	0.00	1.00	231
1860-1864	0.03	0.16	0.00	1.00	585
1865-1869	0.08	0.28	0.00	1.00	1,842
1870-1874	0.24	0.43	0.00	1.00	5,156
1875-1879	0.50	0.50	0.00	1.00	10,763
1880-1884	0.10	0.29	0.00	1.00	2,070
1885-1889	0.03	0.17	0.00	1.00	642
1890-1894	0.01	0.11	0.00	1.00	244
			Region of Birth		
West	0.02	0.14	0.00	1.00	454
Midwest	0.23	0.42	0.00	1.00	4,935
South	0.12	0.33	0.00	1.00	2,678
Northeast	0.63	0.48	0.00	1.00	13,637
			Occupations		
Laborer	0.21	0.41	0.00	1.00	4,582
Semi-skilled	0.42	0.49	0.00	1.00	9,129
Skilled	0.26	0.44	0.00	1.00	5,536
Lower white-collar	0.09	0.28	0.00	1.00	1,890
Upper white-collar	0.03	0.16	0.00	1.00	571
			City Level Variables (10th Census, Chapters 11, 12, 18, and 19)		
City population	336210.10	402352.50	19743.00	1206299.00	21,704
10 largest cities	0.46	0.50	0.00	1.00	9,910
11th-100th cities	0.54	0.50	0.00	1.00	11,794
Death rate per 1,000	22.02	2.52	18.08	35.80	15,272
Railroad lines	7.04	4.79	1.00	21.00	21,704
Real wages	368.73	58.03	215.95	694.86	13,485
Foreign-born	27.59	9.36	1.60	45.00	21,704
Manufacturing	16.02	7.60	1.76	42.68	21,704

Notes: Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. 10 largest cities are the ten largest and Cities 11-100 the 11th to 100th largest by population. Railroad lines are the number of railroad lines touching a city. Real wages are county manufacturing wages divided by county manufacturing workers divided by Haines' (1989) food-price index in $100. Foreign-born is the percentage of the city population born outside of the US. Manufacturing is the percentage of the city population employed in manufacturing.
Sources: See the text.

Birth cohorts comprise quinquennia or decades of birth unless noted otherwise. We also include dummy variables for recruits under the age of 22 at the time of enlistment because one can safely assume that they had not reached their terminal height. To account for spatial variation we include dummy variables for regions of birth.

Because we assume that intergenerational occupational mobility was limited, the recruits' occupations, prior to enlistment, are used as proxies of their parents' socio-economic status. Insofar as parents who earned a higher income could afford better housing and better nourishment for their children, their offspring would become taller (Komlos, 1987; Preston and Haines, 1991; Lee, 1997). At mid-century, height differences according to occupation were about 0.8 - 1.2 in. (2 - 3 cm) (Sokoloff and Villaflor, 1982; Margo and Steckel, 1983).

The real-wage rate prevailing in a county is calculated according to county-level records of manufacturing wages per worker divided by a food-price index constructed by Haines (1989). These wages reflect the purchasing power of city dwellers. Higher real wages translated into better nutrition and housing conditions for urban dwellers and consequently greater stature (Preston and Haines, 1991).

We shall create a subsample of 31 cities for which we have information on death rates. The crude death rate, obtained from the 1880 death registers, is presented as the ratio of deaths per 1,000. The relatively high disease rate of urban environments is assumed to be correlated with death rates that were above and average heights that were below those recorded in rural areas[11] (Costa and Steckel, 1997).

The connection to transportation networks, by which food, among other products, was delivered to urban areas, is proxied by the number of railroad connections of a city. We assume that more connections implied that the quality as well as the quantity of the food supplied was better, and the lower was its relative price; In turn, affordable and nutritious food lead to taller stature in cities than without food imports from rural areas. The conjecture that market integration benefited urban populations complements the hypothesis (Komlos, 1987) that it had negative nutritional consequences for rural populations, by inducing them to substitute grains for meat, and thereby lowering their protein intake. Using geographically weighted regression to account for these spatial effects, Yoo (2009) finds that access to water transportation increased crude death rates in the Midwest but lowered those in the Northeast.

[11] The limitation is, however, that the crude death rate used here depends on the demographic structure of the city. The older the population in a city, the higher the crude death rate irrespective of the disease environment. However, infant mortality, another indicator of the disease environment, is only available at the state level.

The effect of water transportation on height was similar: heights increased in urban areas and decreased in rural ones.

Our proxy for immigration is the foreign-born percentage of the urban population. Because most immigrants were poor upon arrival in the US, the percentage of immigrants in a given city would be correlated with the living conditions there**.** On account of unsanitary living conditions in general and a high disease rate in particular a high percentage of immigrants in a city was likely to be correlated with short stature (Bodnar, 1987). Moreover, since immigrants tended to be shorter than native-born Americans, their children (who may be in the sample) are expected to be shorter as well[12] (Steckel, 1995).

The percentage of the urban population working in the manufacturing sector is a proxy for the degree of industrialization. A high degree of industrialization was correlated with substandard living conditions and therefore with below-average heights. The channel between industrialization and height is the greater intensity of factory work and the higher disease risk in the unsanitary urban environment, relative to small-scale rural manufacturing and agriculture, as well as the low wages earned by urban laborers (Rosen, 1944; Steckel, 1995). Moreover, factory workers were deprived of sunlight and therefore of vitamin D, for bone growth (Holick, 2004; Carson, 2008). This is especially relevant because children who were still growing constituted a considerable share of the manufacturing sector's work force (Goldin and Sokoloff, 1982).

[12] For a more detailed analysis of this relationship see Chapter 3.

2.3 Results

The average height of urban-born recruits declined significantly in the 1855-59 birth cohort reaching a probable all-time low of 66.7 in. (169.4 cm)[13]. This was obviously a cohort that experienced the Civil War as children. Heights fluctuated thereafter within a narrow band of 0.2 in. (0.5 cm) and then began to increase toward the end of the era under consideration. The increase was about 0.4 in. (1.0 cm) signifying that the urban sanitation movement began to have an effect on the nutritional status of the urban population. In contrast, the average height of rural-born recruits was stagnating until the late 1880s, i.e., those who reached adulthood in the early 20th-century, and then also increased by the same amount, 0.4 in. (1.0 cm). The rural population was consistently taller than their urban counterparts throughout the entire period under consideration by between 0.1 (0.3 cm) and 0.9 in. (2.3 cm) (Table 2.2, Figure 2.1). Constrained estimation using the standard deviation of 2.7 in. (6.86 cm) diminishes all of the estimates by about 0.25 in. (0.6 cm) without, however, affecting the trend at all**.**

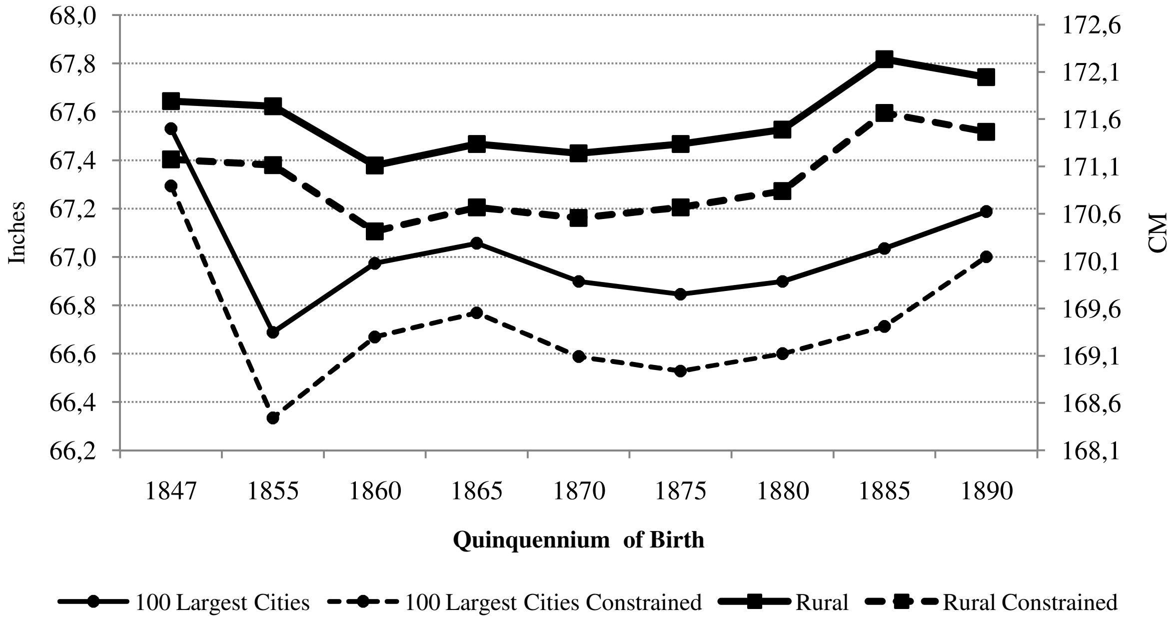
[13] The unusual magnitude of the decline can be explained by sampling error because of the small number of observations in this cohort.

TABLE 2.2
HEIGHT OF US ARMY RECRUITS FROM RURAL AND URBAN COUNTIES:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Rural & Urban (Cities 100)	(2) Rural & Urban (Cities 10)	(3) Urban	N	(4) Rural	N
Age 18	-0.90***	-0.90***	-0.80***	999	-0.93***	1,971
Age 19	-0.69***	-0.70***	-0.70***	1,013	-0.68***	1,676
Age 20	-0.42***	-0.42***	-0.48***	760	-0.38***	1,220
Age 21	-0.17***	-0.17***	-0.16***	4,780	-0.18***	8,679
Age 22-50	Ref.	Ref.	Ref.	14,152	Ref.	22,576
1847-54	0.38***	0.38***	0.60***	171	0.21	210
1855-59	0.03	0.03	-0.23	231	0.20	312
1860-64	-0.01	-0.01	0.05	585	-0.04	824
1865-69	0.08*	0.08*	0.15**	1,842	0.05	2,827
1870-74	Ref.	Ref.	Ref.	5,156	Ref.	7,574
1875-79	0.00	0.01	-0.04	10,763	0.03	17,900
1880-84	0.08	0.08	0.02	2,070	0.10	4,551
1885-89	0.32***	0.33***	0.15	642	0.39***	1,405
1890-94	0.31***	0.32***	0.30	244	0.30**	519
Cities 100	-0.45***			21704		
Cities 10		-0.58***				
Cities 11-100		-0.34***				
Rural	Ref.	Ref.				36,122
Laborer	-0.19***	-0.20***	-0.28***	4,582	-0.14**	7,727
Semi-skilled	-0.02	-0.03	-0.14**	9,129	0.05	12,264
Skilled	-0.11**	-0.12**	-0.25***	5,536	-0.01	6,215
Farmer	0.35***	0.35***			0.40***	6,525
L. w. collar	Ref.	Ref.	Ref.	1,890	Ref.	2,411
U. w. collar	0.19**	0.19**	0.31**	571	0.14	1,015
West	0.17**	0.19**	-0.02	454	0.25***	747
Midwest	Ref.	Ref.	Ref.	4,935	Ref.	14,757
South	0.24***	0.23***	0.10	2,678	0.27***	12,297
Northeast	-0.51***	-0.50***	-0.46***	13,637	-0.57***	8,220
Constant	67.56***	67.57***	67.22***		67.50***	
Sigma	2.30***	2.30***	2.32***		2.29***	
Observations	57,826	57,826	21,704		36,122	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. L. w. collar = lower white-collar. U. w. collar= upper white-collar. Cities 100 means the 100 largest cities (and their counties), Cities 10 the ten largest, and Cities 11-100 the 11th to 100th largest by population in 1880. Rural are those who do not live in one of the 100 largest cities and their counties in 1880.
Sources: See the text.

FIGURE 2.1
NATIONWIDE ESTIMATED HEIGHT OF US-BORN RECRUITS IN RURAL AND URBAN COUNTIES, 1847-1894



Notes: Estimated heights from Table 2.2 weighted with the proportion of white adult males in each region in 1880. Constrained estimates are estimated with the standard deviation set to 2.7 in. (6.86 cm). Urban are those born in one of the 100 largest US cities (and their counties) in 1880 while rural are those born in the rest of the US.
Sources: See the text.

The relationship between urban heights and occupations is analyzed on the national and regional levels and by four size categories using the 100 largest cities, the 10 largest cities (population 1,206,299 - 216,090), the 11th to 50th largest cities (population 160,146 – 35,629), and the 51st-100th largest cities (population 34,555 – 19,743). Heights by occupation indicate that urban laborers both in the nationwide sample as well as in the Northeast were shortest and white-collar workers were the tallest: laborers and craftsmen were shorter by as much as 0.5 in. (1.3 cm) (Table 2.2, Models 1-3; Table 2.3, Models 1 and 2; Table 2.4, Models 1 and 2)[14]. These results confirm that in urban areas there was a considerable height premium for elevated socio-economic status.

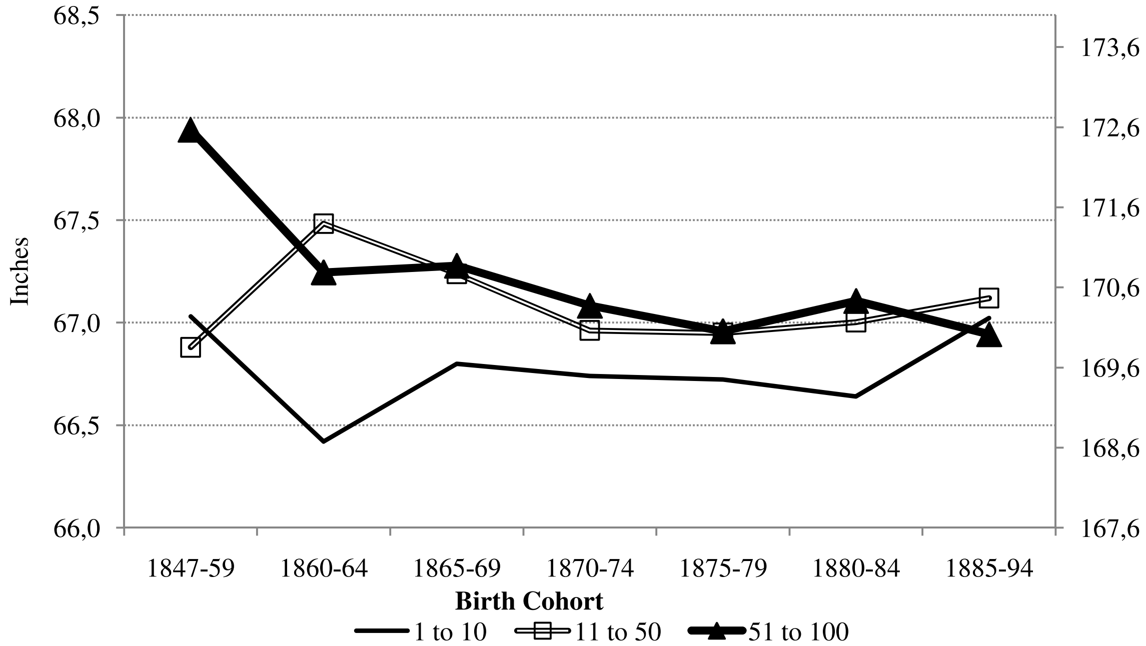
[14] Semi-skilled workers nationwide, in the Northeast, and in the 11th to 50th cities (ranked by size) suffered a height penalty (Table 2.2, Model 3; Table 2.3, Model 2; Table 2.4, Model 1). Urban skilled workers suffered a height penalty at all three of these levels and additionally in the ten largest cities (Table 2.2, Model 3; Table 2.3, Models 1 and 2; Table 2.4, Model 1). Urban upper-level white-collar workers enjoyed a height premium on the national level, in the 51st to 100th cities (ranked by size), and in the urban Midwest (Table 2.2, Model 3; Table 2.3, Model 3; Table 2.4, Model 3).

TABLE 2.3
HEIGHT OF US ARMY RECRUITS BY DIFFERENT CITY SIZES:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Cities 1-10	N	(2) Cities 11-50	N	(3) Cities 51-100	N
Age 18	-0.64***	423	-0.79***	318	-0.82***	278
Age 19	-0.65***	423	-0.69***	347	-0.70***	263
Age 20	-0.37**	314	-0.45***	261	-0.67***	193
Age 21	-0.13*	2,216	-0.15	1,606	-0.17	1,037
Age 22-50	Ref.	6,534	Ref.	4,753	Ref.	3,382
1847-59	0.23	189	-0.11	136	0.90***	100
1860-64	-0.36*	275	0.48**	194	0.18	151
1865-69	0.04	828	0.27**	604	0.21	471
1870-74	Ref.	2,324	Ref.	1,772	Ref.	1,255
1875-79	-0.01	5,032	0.00	3,577	-0.13	2,437
1880-84	-0.07	837	0.04	701	0.02	577
1885-94	0.28*	425	0.18	301	-0.14	162
Laborer	-0.31***	1,888	-0.53***	1,623	0.06	1,172
Semi-skilled	-0.10	4,246	-0.33**	3,063	-0.01	2,085
Skilled	-0.25**	2,504	-0.47***	1,874	0.00	1,345
L. w. collar	Ref.	991	Ref.	548	Ref.	416
U. w. collar	0.24	282	0.19	179	0.47*	136
West	-0.03	321	-0.64	53	0.47*	80
Midwest	Ref.	2,349	Ref.	1,324	Ref.	766
South	-0.17	740	0.12	1,289	0.02	649
Northeast	-0.54***	6,500	-0.39***	4,619	-0.70***	3,658
Constant	67.14***		67.47***		67.28***	
Sigma	2.30***		2.30***		2.34***	
Observations	9,910		7,285		5,153	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. L. w. collar is lower white-collar. U. w. collar is upper white-collar. Cities 1-10 means the ten largest cities by population (and their counties), Cities 11-50 the 11th to 50th, and Cities 51-100 the 51st to 100th largest in 1880.
Sources: See the text.

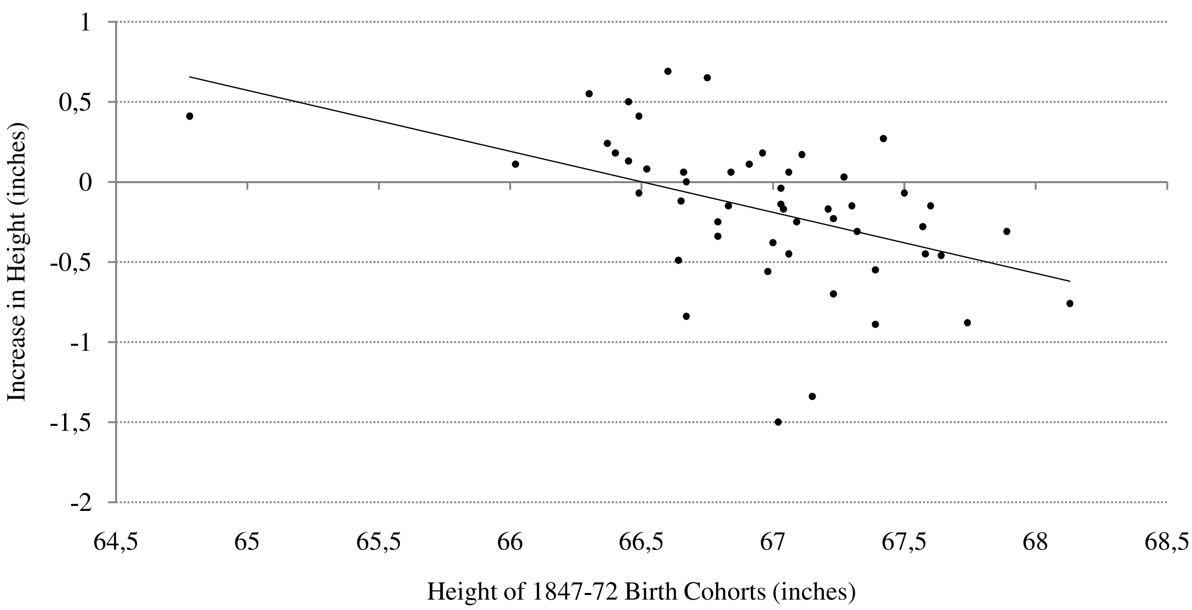
FIGURE 2.2
NATIONWIDE ESTIMATED HEIGHT OF US-BORN RECRUITS IN THE 100 LARGEST URBAN COUNTIES, 1847-1894



Notes: Estimated heights from Table 2.3 weighted with the proportion of white adult males in each region in 1880. 1 to 10 are the 10 largest, 11 to 50 are the 11th- 50th largest, and 51 to 100 are the 51st- 100th largest cities by population and their counties in 1880.
Sources: See the text.

Average heights in the ten largest cities decreased significantly during the Civil War in the first half of the 1860s and recovered significantly between 1885 and 1890 following a U-shaped trend with a long bottom during the reconstruction period (Figure 2.2 and Table 2.3). The trend of heights in the 11th to 50th largest cities increased significantly in the 1860s followed by stagnation. Heights in the next fifty cities declined significantly in the 1850s and then also stagnated. Average heights in large and small cities appear to have converged over time (Figure 2.2). This inference is supported by plotting the change in heights of 54 large cities between the birth cohorts of 1847-72 and 1873-94 by initial height from 1847-72 (Figure 2.3) (Komlos, 2007). Heights in cities where recruits were initially shorter increased more than heights in cities with taller recruits among the 1847-72 birth cohorts.

FIGURE 2.3
CONVERGENCE IN HEIGHT IN LARGE URBAN COUNTIES, 1847-1894



Notes: Estimated heights from truncated regressions for 54 of the 100 largest cities in 1880. Each dot represents the change in height in a city between the birth cohorts of 1847-72 and 1873-94 plotted against the initial height of the 1847-72 cohort. Only cities with at least 30 observations per birth cohort are included.
Sources: See the text.

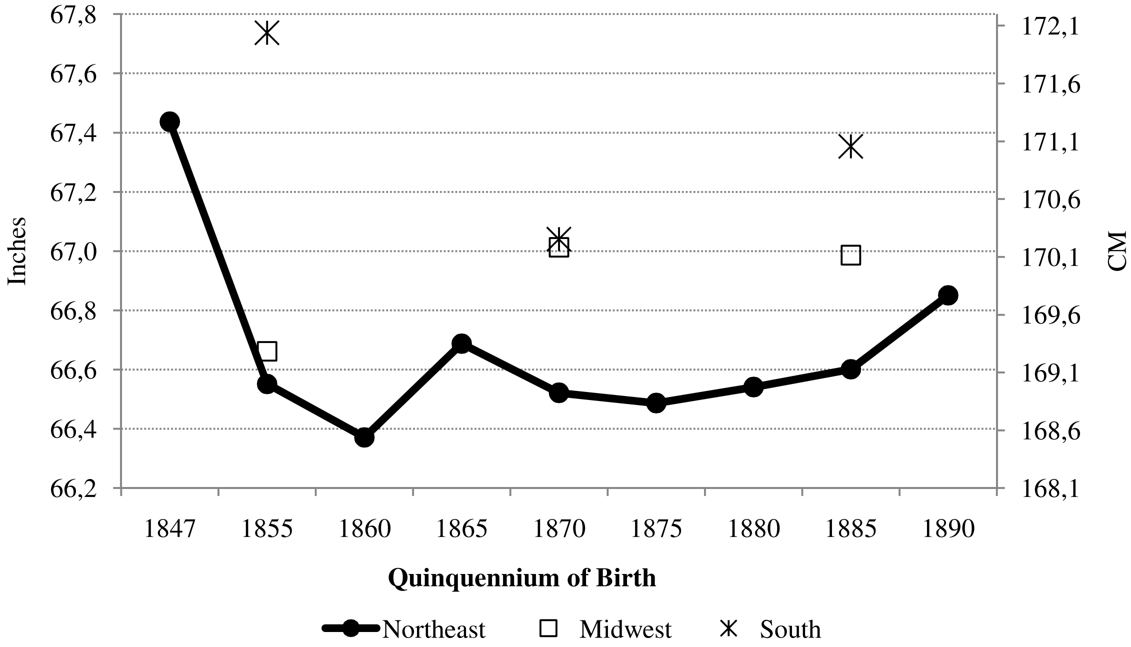
TABLE 2.4
HEIGHT OF US ARMY RECRUITS BY CENSUS REGION:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Northeast Urban	N	(2) Northeast Rural	N	(3) Midwest Urban	N	(4) Midwest Rural	N	(5) South Urban	N	(6) South Rural	N
Age 18	-0.91***	600	-0.78***	474	-0.56***	280	-0.98***	870	-1.10***	93	-1.15***	580
Age 19	-0.63***	626	-0.91***	391	-0.72***	221	-0.59***	700	-1.14***	140	-0.78***	550
Age 20	-0.46***	439	-0.27	254	-0.73***	216	-0.27**	508	-0.26	92	-0.61***	424
Age 21	-0.22***	3,052	-0.14	1,843	-0.07	1,152	-0.17***	3,660	-0.24*	492	-0.21***	2,956
Age 22-50	Ref.	8,920	Ref.	5,258		3,066	Ref.	9,019	Ref.	1,861	Ref.	7,787
1847-54	0.89***	112	0.82***	75								
1855-59	0.00	156	0.27	91								
1860-64	-0.19	373	-0.16	227								
1865-69	0.16	1,121	0.05	751								
1870-74	Ref.	3,300	Ref.	1,768								
1875-79	-0.02	6,777	-0.08	4,017								
1880-84	0.02	1,298	-0.06	921								
1885-89	0.10	352	0.24	261								
1890-94	0.36	148	0.04	109								
1847-64					-0.37	178	0.12	463	0.66***	156	-0.19	471
1865-79					Ref.	3,963	Ref.	11,672	Ref.	2,211	Ref.	9,424
1880-94					-0.01	794	0.18***	2,622	0.29	311	0.19***	2,402
Laborer	-0.40***	2,874	-0.44***	1,943	-0.10	1,062	-0.10	3,078	-0.19	593	-0.09	2,527
Semi-skilled	-0.24***	5,803	-0.24**	3,110	-0.04	1,985	0.09	4,576	-0.02	1,170	0.17	4,265
Skilled	-0.38***	3,520	-0.21	1,799	-0.14	1,286	-0.11	2,626	-0.05	616	0.18	1,614
L. w. collar	Ref.	1,090	Ref.	559	Ref.	471	Ref.	1,062	Ref.	235	Ref.	686
U. w. collar	0.18	353	-0.03	182	0.43*	132	-0.05	423	0.29	64	0.37**	381
Farmer			0.22	645			0.27***	2,996			0.62***	2,836
City pop.	-0.03***				-0.04*				-0.22***			
Constant	67.00***		67.19***		67.22***		67.55***		67.45***		67.69***	
Sigma	2.32***		2.34***		2.30***		2.27***		2.37***		2.28***	
Observations	13,637		8,220		4,935		14,757		2,678		12,297	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. L. w. collar is lower white-collar. U. w. collar is upper white-collar. Urban are those living in one of the 100 largest cities (and their counties). Rural are all those living outside of the 100 largest cities (and their counties) in 1880. City pop. is the population living in cities (in 100,000 people).

Sources: See the text.

FIGURE 2.4
ESTIMATED HEIGHT OF URBAN RECRUITS BY CENSUS REGIONS, 1847-1894

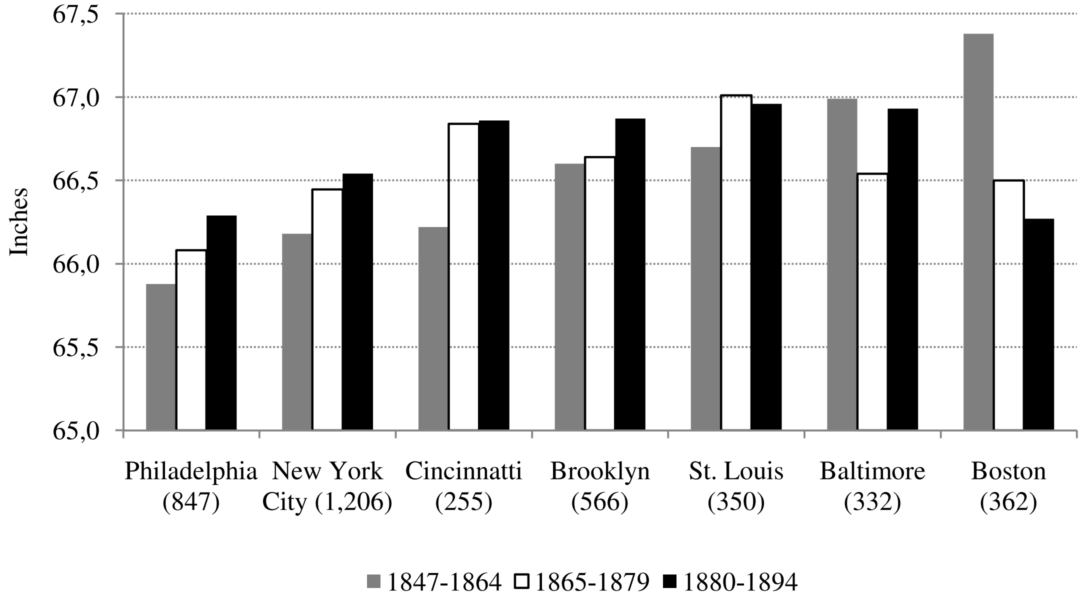


Notes: Estimated heights from Table 2.4. Quinquennia of birth used in Northeast and decades of birth used in Midwest and South.
Sources: Table 2.4.

Spatial analysis indicates that while average height of urban recruits from the Northeast declined significantly in the late 1850s and then stagnated conforming to the national pattern, that of Midwesterners only stagnated, whereas that of Southern recruits, who were tallest, dipped between 1865 and 1879 (Table 2.4 and Figure 2.4).

We also estimate height trends separately in those cities (within the 100 largest cities) with more than 30 observations per birth cohort per city in the sample (Figure 2.5). Heights in all these cities did not change significantly over time with the exception of a decrease in Boston. Height differences among cities were considerable. In the 1865-79 cohort recruits from St. Louis were 0.67 in. (1.7 cm) taller than recruits from Philadelphia and 0.59 in. (1.5 cm) taller than those from New York (Tables 2.5, 2.6, and Figure 2.5). Average heights in the largest cities were shortest while heights in Midwestern cities were tallest. For instance, the tallest recruits were natives of St. Louis, MO, and Cincinnati, OH, the 6^{th} and 8^{th} cities, respectively, in terms of size, while the shortest (born between 1865 and 1879) were from the two largest cities, New York and Philadelphia (Figure 2.5).

FIGURE 2.5
ESTIMATED HEIGHT OF RECRUITS IN SELECTED LARGE URBAN AREAS, 1847-1894



Notes: Estimated heights from Tables 2.5 and 2.6 for each city with at least 30 observations per cohort. City population in 1,000 in parentheses.
Sources: Tables 2.5 and 2.6.

TABLE 2.5
HEIGHT OF US ARMY RECRUITS FROM SELECTED LARGE URBAN AREAS:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) All Cities	N	(2) NYC	N	(3) Philadelphia	N	(4) Brooklyn	N
Age 18	-0.80***	426	-0.46	97	-1.18***	75	-0.85	41
Age 19	-0.66***	452	-0.95***	113	-0.72**	78	-0.88*	42
Age 20	-0.37**	321	-0.50	75	-0.88**	65	-0.09	22
Age 21	-0.19***	2,292	-0.39***	621	-0.23	453	-0.46*	194
Age 22-50	Ref.	6,849	Ref.	1,676	Ref.	1,281	Ref.	527
1847-64	0.01	515	-0.27	118	-0.20	88	-0.04	34
1865-79	Ref.	8,572	Ref.	2,107	Ref.	1,679	Ref.	655
1880-94	0.07	1,253	0.10	357	0.21	185	0.22	137
NYC	-0.35***	2,582						
Philadelphia	-0.42***	1,952						
Brooklyn	-0.08	826						
Boston	-0.26**	1,140						
St. Louis	0.24**	918						
Baltimore	Ref.	586						
Cincinnati	0.11	572						
Lowell	-0.07	437						
Constant	66.75***		66.56***		66.16***		66.75***	
Sigma	2.34***		2.23***		2.52***		2.28***	
Observations	10,340		2,582		1,952		826	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Estimation for cities with at least 30 observations per birth cohort. NYC is New York City, NY.
Sources: See the text.

TABLE 2.6
HEIGHT OF US ARMY RECRUITS FROM SELECTED LARGE URBAN AREAS:
TRUNCATED NORMAL REGRESSION (in inches)

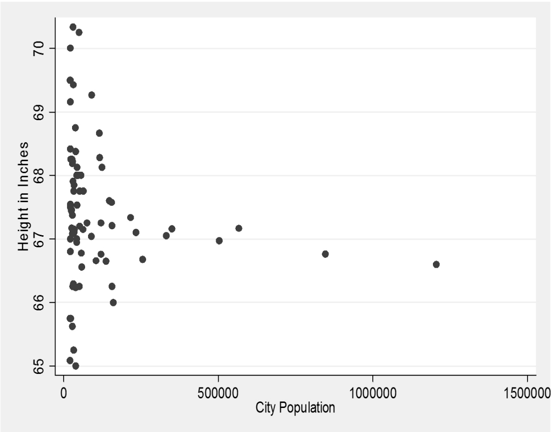
	(1) Boston	N	(2) St. Louis	N	(3) Baltimore	N	(4) Cincinnati	N
Age 18	-0.39	55	-0.66	56	-2.26***	25	-0.89	28
Age 19	-0.27	48	-0.83*	40	-0.43	26	-0.49	30
Age 20	-0.28	30	-0.26	46	0.92*	16	-0.24	17
Age 21	0.23	212	-0.04	219	-0.21	105	0.48*	121
Age 22-50	Ref.	795	Ref.	557	Ref.	414	Ref.	376
1847-64	0.88***	68	-0.30	36	0.45	30	-0.62	48
1865-79	Ref.	948	Ref.	763	Ref.	491	Ref.	459
1880-94	-0.24	124	-0.05	119	0.40	65	0.03	65
Constant	66.47***		67.03***		66.55***		66.74***	
Sigma	2.21***		2.27***		2.37***		2.36***	
Observations	1,140		918		586		572	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Estimation for cities with at least 30 observations per birth cohort.
Sources: See the text.

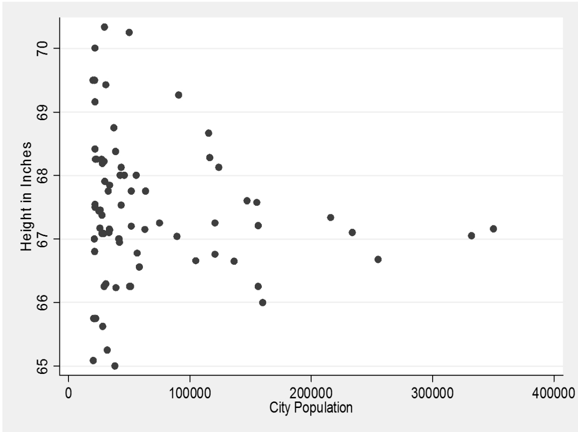
Scatter plots of city size against height exhibit no clear relationship. However, if one excludes the four largest cities (with more than 400,000 inhabitants), there emerges a negative relationship for the 1847-64 and the 1880-94 birth cohorts (Figure 2.6). Estimates from a polynomial regression with height regressed on population in linear, quadratic, and cubic form paint a clearer picture of the relationship (Table 2.7). In the middle of the 19th-century the best place to live in terms of height were small cities, while in the end of the 19th-century it was in larger cities with about 250,000 inhabitants, but not in the largest cities. In the 1847-64 birth cohort the relationship can be described by a downward sloping curve that is flattening out implying that heights decreased with increases in city population, but at a decreasing rate. This relationship is fundamentally different in the 1880-94 birth cohort where there was an inverse U-shaped relationship between height and city size with a maximum height in cities with about 250,000 inhabitants and declining heights thereafter (Figure 2.6). This suggests that this relationship was non-linear and that circumstances in larger cities relative to small cities had improved by the end of the 19th-century. However, recruits from the largest cities remained the shortest.

FIGURE 2.6
SCATTERPLOTS OF HEIGHT AND ESTIMATED HEIGHT BY CITY SIZE

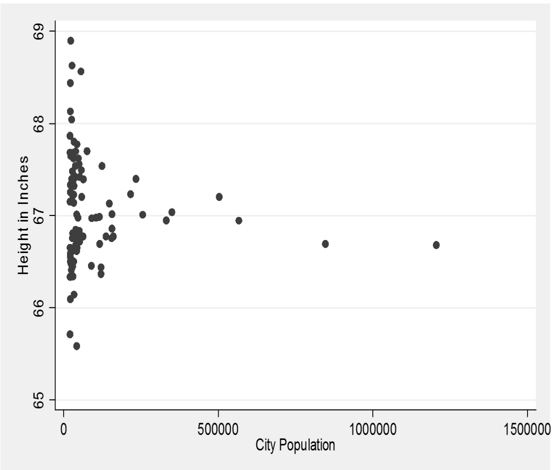
Scatter plot of height by city size for 100 largest urban counties, 1847-64



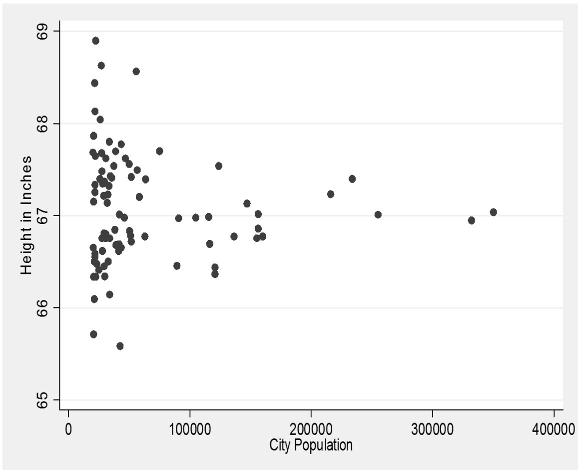
Scatter plot of height by city size for urban counties with cities of up to 400,000 inhabitants, 1847-64



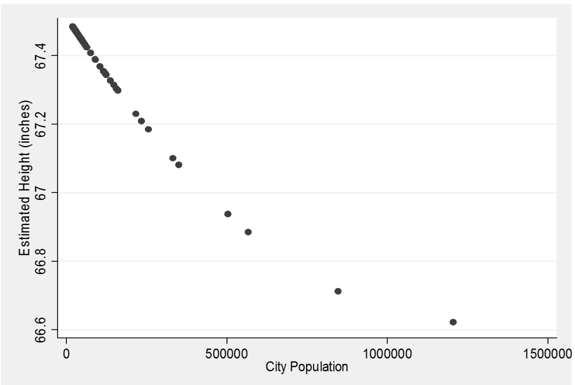
Scatter plot of height by city size for 100 largest urban counties, 1880-94



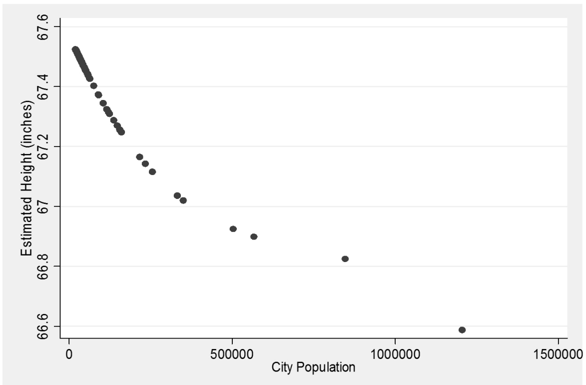
Scatter plot of height by city size for urban counties with cities of up to 400,000 inhabitants, 1880-94



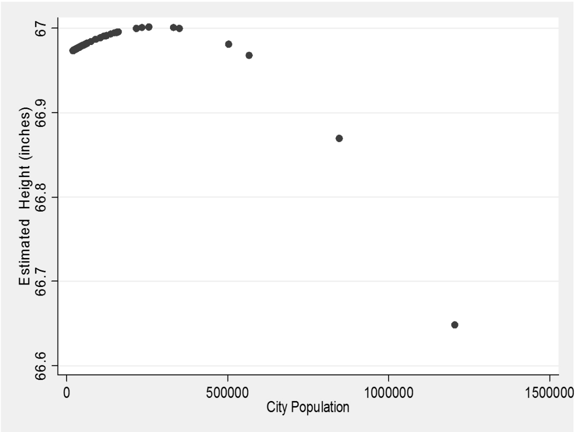
Estimated heights by city size (1847-64), with quadratic population from polynomial regression



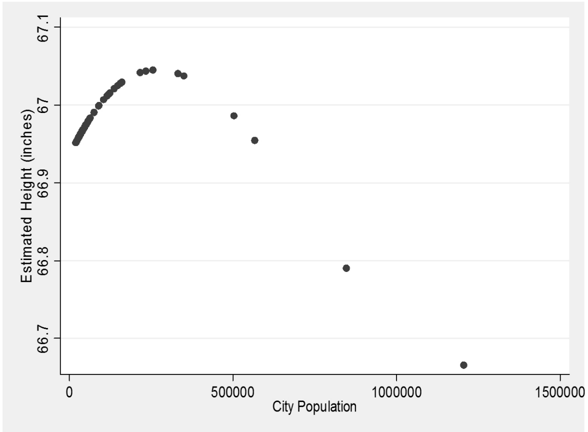
Estimated heights by city size (1847-64), with quadratic and cubic population from polynomial regression



Estimated heights by city size (1880-94),
with quadratic population from polynomial regression



Estimated heights by city size (1880-94),
with quadratic and cubic population from polynomial regression



Notes: Estimated heights (in inches). City population in 1880.
Sources: Table 2.7.

TABLE 2.7
THE RELATIONSHIP BETWEEN HEIGHT AND CITY SIZE
IN LINEAR, QUADRATIC, AND CUBIC FORM:
POLYNOMIAL REGRESSION

	1847-64			1880-94		
	(1) Population Linear	(2) Population Quadratic	(3) Population Cubic	(4) Population Linear	(5) Population Quadratic	(6) Population Cubic
Population	-0.08***	-0.14***	-0.25***	-0.03***	0.02***	0.09***
Population²		5.8e-8***	3.1e-7***		-4.1e-8***	-2.0e-7***
Population³			-1.4e-13**			9.2e-14***
Constant	67.45***	67.51***	67.57***	67.01***	66.97***	66.93***
Observations	1,017	1,017	1,017	3,146	3,146	3,146
Adjusted-R²	0.17	0.17	0.18	0.05	0.06	0.07

Notes: Dependent variable is estimated average height in inches for 54 urban areas from truncated regression for the 1847-64 and 1880-94 birth cohorts. Population is measured in 100,000 people in 1880.
Sources: See the text.

There is evidence of a height penalty of 0.45 in. (1.1 cm) for those born in one of the 100 largest cities relative to the rural population (Table 2.2, Model 1). For instance, the difference of 100 thousand inhabitants between Kansas City, MO (55,785), and that of Buffalo, NY (155,134), translated into a height difference of 0.31 in. (0.8 cm). The height penalty varied considerably depending on the city size; those born in the top ten cities (ranked by size) were on average 0.58 in. (1.5 cm) shorter than those from rural areas - a penalty almost twice that experienced by those born in the next 90 cities: 0.34 in. (0.9 cm) (Table 2.2, Model 2). That city size was negatively correlated with stature is confirmed by numerous studies of other urban categories, and therefore of other urban penalties (Table 2.8).

TABLE 2.8

COMPARISON OF 19th-CENTURY URBAN PENALTIES FROM OTHER STUDIES

Scholar	Year	Sample & birth cohort	Urban penalty
Sunder	2007	Passport applicants, 1790-1899	-0.24 to -0.37 in. (-0.6 to -0.9 cm) (distance to city (of more than 20,000 inhabitants < 20 miles)
Haines, Craig, Weiss	2003	Union Army recruits, 1838-42	-0.99 to -1.4 in. (-2.5 to -3.6 cm) (proportion of county population urban)
Steckel	1995	WWII recruits	-0.47 in. (-1.2 cm) (born in city with more than 500,000 inhabitants)
Margo and Steckel	1983	Union Army recruits, late 1810s-1834	-0.51 in. (-1.3 cm) (born in city of more than 10,000 inhabitants)
Steckel and Haurin	1994	Ohio National Guard, 1850-1910	-0.2 in. (-0.5 cm)

Sources: See References.

TABLE 2.9

CITY-LEVEL DETERMINANTS OF HEIGHT:

TRUNCATED NORMAL REGRESSION (in inches)

	(1)	(2)	(3)	(4)	N	(5)	N	(6)	N
Age 18	-0.80***	-0.80***	-0.80***	-0.80***	999	-0.73***	652	-0.72***	593
Age 19	-0.71***	-0.71***	-0.70***	-0.70***	1,013	-0.66***	686	-0.67***	596
Age20	-0.49***	-0.48***	-0.48***	-0.48***	760	-0.46***	477	-0.41***	441
Age 21	-0.16***	-0.16***	-0.16***	-0.16***	4,780	-0.15**	3,434	-0.13*	3,027
Age 22-50	Ref.	Ref.	Ref.	Ref.	14,152	Ref.	10,013	Ref.	8,826
1847-54	0.61***	0.60***	0.60***	0.61***	171	0.94***	114	0.75***	105
1855-59	-0.23	-0.24	-0.23	-0.23	231	-0.55**	161	-0.52*	132
1860-64	0.04	0.05	0.04	0.04	585	-0.13	417	-0.12	341
1865-69	0.15**	0.15**	0.15**	0.16**	1,842	0.15	1,278	0.11	1,126
1870-74	Ref.	Ref.	Ref.	Ref.	5,156	Ref.	3,616	Ref.	3,208
1875-79	-0.04	-0.04	-0.04	-0.04	10,763	-0.01	7,722	0.00	6,784
1880-84	0.02	0.02	0.02	0.02	2,070	-0.05	1,366	-0.05	1,225
1885-89	0.16	0.15	0.15	0.15	642	0.30**	421	0.12	398
1890-94	0.33*	0.32*	0.31	0.31	244	0.36*	177	0.32	164
Laborer	-0.31***	-0.29***	-0.29***	-0.28***	4,582	-0.39***	3,070	-0.20**	2,769
Semi-skilled	-0.15**	-0.14**	-0.14**	-0.14*	9,129	-0.21**	6,464	-0.05	5,720
Skilled	-0.27***	-0.26***	-0.26***	-0.25***	5,536	-0.30***	3,939	-0.21**	3,404
L. w. collar	Ref.	Ref.	Ref.	Ref.	1,890	Ref.	1,386	Ref.	1,226
U. w. collar	0.30**	0.31**	0.31**	0.31**	571	0.31**	415	0.35**	366
Population	-0.31***								21,704
Death rate						-0.03***			
Railroads		-0.01							
Real wage								0.18***	
Foreign-born			-0.04*						
Manufacturing				-0.08***					
West	-0.03	-0.08	0.02	-0.04	454	-0.05	321	-0.17	321
Midwest	Ref.	Ref.	Ref.	Ref.	4,935	Ref.	3,228	Ref.	3,804
South	0.08	0.03	0.03	0.08	2,678	0.20**	1,899	0.21**	1,564
Northeast	-0.40***	-0.52***	-0.47***	-0.43***	13,637	-0.43***	9,824	-0.41***	7,794
Constant	67.30***	67.33***	67.35***	67.32***		67.73***		66.41***	
Sigma	2.32***	2.32***	2.32***	2.32***		2.32***		2.31***	
Observations	21,704	21,704	21,704	21,704		15,272		13,485	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. L. w. collar is lower white-collar. U. w. collar is upper white-collar. Population is in 100,000. Death rate is deaths per 1,000 city inhabitants in a year. Railroads are the number of railroad lines touching a city. Real wage is the manufacturing wage in a county divided by the number of manufacturing workers divided by Haines' (1989) food price index in $100. Foreign-born is the percentage of the city population that is born outside of the US measured in 10%. Manufacturing is the percentage of the city population employed in manufacturing measured in 10%.
Sources: See the text.

TABLE 2.10
CITY-LEVEL DETERMINANTS OF HEIGHT IN PROPORTIONS AND PER CAPITA VALUES: TRUNCATED NORMAL REGRESSION (in inches)

	(1)	N	(2)	N	(3)	N	(4)	N
Age 18	-0.79***	999	-0.72***	652	-0.68***	593	-0.72***	520
Age 19	-0.70***	1,013	-0.66***	686	-0.66***	596	-0.67***	543
Age 20	-0.49***	760	-0.46***	477	-0.42***	441	-0.41***	385
Age 21	-0.16***	4,780	-0.15**	3,434	-0.12*	3,027	-0.12*	2,666
Age 22-50	Ref.	14,152	Ref.	10,013	Ref.	8,826	Ref.	7,806
1847-54	0.61***	171	0.94***	114	0.68***	105	0.86***	93
1855-59	-0.22	231	-0.55**	161	-0.59**	132	-0.71**	122
1860-64	0.05	585	-0.14	417	-0.09	341	-0.12	308
1865-69	0.15**	1,842	0.14	1,278	0.09	1,126	0.08	1,001
1870-74	Ref.	5,156	Ref.	3,616	Ref.	3,208	Ref.	2,832
1875-79	-0.04	10,763	-0.01	7,722	0.01	6,784	0.01	6,032
1880-84	0.01	2,070	-0.05	1,366	-0.07	1,225	-0.04	1,068
1885-89	0.15	642	0.30**	421	0.11	398	0.20	322
1890-94	0.32*	244	0.36	177	0.36	164	0.32	142
Laborer	-0.29***	4,582	-0.39***	3,070	-0.20**	2,769	-0.27***	2,408
Semi-skilled	-0.14**	9,129	-0.20**	6,464	-0.03	5,720	-0.08	5,065
Skilled	-0.26***	5,536	-0.31***	3,939	-0.21**	3,404	-0.22**	3,014
L. w. collar	Ref.	1,890	Ref.	1,386	Ref.	1,226	Ref.	1,100
U. w. collar	0.31**	571	0.31**	415	0.35**	366	0.34*	334
Rail p.c.	0.22***		0.20***		0.45***		0.44**	
Manufacturing	-0.01*		-0.04		-0.10*		-0.04	
Foreign-born	0.05*		0.05		0.01		0.08	
Death rate			-0.02*				-0.02	
Real wage					0.11**		0.17*	
West	0.02	454	-0.06	321	-0.05	321	-0.15	321
Midwest	Ref.	4,935	Ref.	3,228	Ref.	3,804	Ref.	3,228
South	0.24***	2,678	0.30***	1,899	0.34***	1,564	0.45**	1,189
Northeast	-0.34***	13,637	-0.39***	9,824	-0.23***	7,794	-0.26**	7,182
Constant	66.95***		67.38***		66.28***		66.35***	
Sigma	2.32***		2.32***		2.31***		2.31***	
Observations	21,704		15,272		13,483		11,920	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. L. w. collar is lower white-collar. U. w. collar is upper white-collar. Rail p.c. is the number of railroad lines touching a city per 10,000 inhabitants. Death rate is deaths per 1,000 city inhabitants in a year. Real wages are manufacturing wages in a county divided by the number of manufacturing workers divided by Haines (1989) food price index in $100. Foreign-born is the percentage of the city population born outside of the US measured in 10%. Manufacturing is the percentage of the city population employed in manufacturing measured in 10%.
Sources: See the text.

However, our concern goes beyond the fact that a city's size affected its population's average height to the question of what elements underlie the urban height penalty. We find that the size of the population, death rates, the proportion of the population that was foreign-born, and the proportion of the economy devoted to manufacturing are the factors that were negatively correlated with height. Real manufacturing wages, on the other hand, were positively associated with height[15] (Table 2.9). However, all of these variables are so closely correlated with city size that it renders them insignificant whenever city size is included in the model; only the correlation of city size and height is always significant and negative. To

[15] Proxies for public health such as the number of taps per household or the miles of sewage lines proved to be insignificant in all specifications.

compensate for this effect while also countering multicollinearity, we use proportions and per capita values of variables (Table 2.10).

We find robust positive associations for the real (manufacturing) wage per capita in all specifications. A $100-per-annum (27% of average income) increase in real wages translated into better housing and nutrition, which in turn translated into a height increase of between 0.11 and 0.17 in. (0.3-0.4 cm), between 24% and 38% of the urban penalty[16]. A decrease in the death rate by 10 deaths per 1,000 people (45% of average death rate) was correlated with a height increase of 0.20 in. (0.5 cm) or 49% of the urban penalty: i.e., the worse the disease environment, the lower the population's average height[17]. The percentage of foreign-born residents changes the sign (compared with Table 2.9) and is significant and positive only in Model 1 (Table 2.10). The percentage in manufacturing is significant only in Models 1 and 3, but always negative: a ten percentage point (63% of average) increase in employment in the manufacturing sector yielded a height decrease of 0.01-0.10 in. (0.03-0.3 cm) or between 2 and 22 percent of the urban penalty, confirming that there was a negative association between manufacturing work and height.

The number of railroad connections of a city per 10,000 inhabitants was positively correlated with height; every additional railroad line per 10,000 inhabitants (250% of average) meant a height increase of 0.20 to 0.45 in. (0.5-1.1 cm), between 44 and 100 percent of the urban penalty. The railroad-height correlation therefore supports the theory that railroads, by facilitating the importing of foodstuffs from agricultural regions, led to an improvement in city dwellers' nutrition, because this positive correlation still holds when controlling for death

[16] The urban penalty from Table 2.2, Model 1 for living in one of the 100 largest urban counties is used. Averages from Table 2.1 are used

[17] The death rate ceases being significant when real wage is included. This could be because including the variable real wage greatly reduces the sample size.

rates, real wages, the share of foreign-born, and the percentage in manufacturing that proxy diseases and living conditions.

Evidently, of all the elements considered, it was the size of a city that always had a negative impact on height. However, this effect was indirect, channeled through net nutrition and diseases. On the individual level, superior social status measured by occupations constituted a height advantage roughly equivalent to an additional railroad line or a 100,000-person decrease in the size of the city's population.

2.4 Conclusion

This study finds that recruits born in rural regions were consistently taller than those born in cities. Urban heights declined significantly after 1855 and then stagnated, in the main, whereas rural heights were stagnating until the late 1880s, at which point they began to increase significantly. In the second half of the 19th-century there was an urban height penalty of between 0.58 in. (1.5 cm) in the ten largest cities and 0.34 in. (0.9 cm) in the next ninety cities (ranked by size). This penalty is of a similar magnitude as in other studies. We find evidence that average urban heights converged over time with heights in larger cities approaching those in smaller ones: While in the 1850s and 1860s heights decreased with city size at a decreasing rate, in the late 19th-century we find this relationship to be inversely U-shaped with largest heights in cities of about 250,000 inhabitants. Above-average socio-economic status, in the form of upper-level white-collar occupations, was correlated with above-average height in cities.

However, it was not a city's size itself that mattered but the quality of the environment that correlated with city size. A large number of factors contributed including sanitation, canalization, and running water, rather than the fact that railroad access and height were positively correlated. This is because expansion of the transportation network meant increased market integration, which decreased the price and increased the quality of the food that city dwellers purchased and consumed, and this improvement in their nutrition led to their enjoying a height advantage[18]. Since real wages determined the affordability of food and housing, their level was positively correlated with height, as opposed to death rates, which were negatively correlated with height. Industrialization, too, as measured by the share of the urban population working in the manufacturing sector, was negatively correlated with stature because the working conditions and disease environment in factories compared unfavorably with those of small-scale, rural manufacturing.

An interesting question is how much each of these factors contributed to the height difference between large and small cities and between urban and rural regions: the difference in real wages between the ten largest cities and the next 90 amounts to 8 percent of the height difference between these two groups of cities. The difference between the average number of railroads per capita in the ten largest cities (0.24) and in the next 90 (0.99) amounts to 0.15 in. (0.4 cm), or about 58% of the height penalty between these two groups of cities[19]. The difference between the crude death rate in urban areas (24.7) and rural areas (18.8) accounts for a height difference of 0.18 in. (0.5 cm), or about 40 percent of the urban penalty[20] (Haines, 2001). The difference between the share of the work force in manufacturing nationwide (6%) and in cities (16%) accounts for 18 percent of the urban penalty (U.S. Bureau of the Census, 1975; Lebergott, 1984).

Unlike data from the French and Indian War (1754-63), data from the Revolutionary War (1775-83) reveal an urban height penalty, of 0.9 in. (2.3 cm), which continued not only

---

[18] A similar pattern for water transportation in urban areas has been identified by Yoo (2009).

[19] Using sample averages and coefficients from Table 2.10 in relation to the height penalty from Table 2.2.

[20] Using 1890 values from registration states that reported death rates (Haines, 2001) with coefficients from Table 2.9 in relation to the height penalty from Table 2.2.

through the Civil War but on into the late 19th-century (Fogel et. al., 1982; Sokoloff and Villaflor, 1992). In fact, population density continues to be negatively correlated with height (Komlos and Lauderdale, 2007). Researchers have confirmed that there is an urban penalty in developed economies such as the UK, too, even when they have controlled for socio-economic characteristics (Foster, Chinn, and Rona, 1983; Reading, Raybould, and Jarvis, 1993). The significance of this urban height penalty is that it is correlated with elevated morbidity and mortality risks (Waaler, 1984; Fogel, 1994).

It has been established that the mortality rates of urban and rural populations in the US during the late-19th and early-20th centuries converged (Condran and Crimmins-Gardner, 1978, 1980, 1983). We find some evidence of a parallel convergence in terms of heights; however, the difference between urban and rural heights did not decrease in the second half of the 19th-century but we find that heights in large cities relative to small cities did increase as sanitary improvements began to affect urban living conditions. A growing railroad network that was detrimental for rural heights benefitted heights of urban dwellers because food from rural areas was easily accessible at lower relative prices. In spite of the beginning of a secular trend that was to last till the middle of the next century, the biological standard of living of American men, as proxied by their height had still not reached the level they had in the 18th-century. This is an indication that industrialization even in the New World exerted costs on the population that were hitherto hidden from view. It took a long time indeed before heights again reached their pre-industrial level.

References

Data:

Minnesota Population Center. 2004. National Historical Geographic Information System (NHGIS): Pre-release Version 0.1. Minneapolis, MN: University of Minnesota. http://www.nhgis.org

National Archives and Records Administration. 7th and Pennsylvania Ave., NW, Washington, DC 20408-0001. Microfilm ID M233. Record Group 094. Register of Enlistments in the U.S. Army, 1798-1914. Vol 94 (96%), Vol 96 (100%), Vol 97(10%), Vol 98 (93%), Vol 100 (88%),Vol 102 (100%), Vol 103 (80%), Vol 104 (100%), Vol 105 (100%).

U. S. Bureau of the Census. "1880 Census of Population and Housing, Vol. 11, 12, 18, 19." http://www.census.gov/prod/www/abs/decennial/1880.htm (accessed February 15th, 2010).

U. S. Bureau of the Census. 1975. *Historical Statistics of the United States, Colonial Times to 1970*. Washington, DC: U.S. Government Printing Office.

Literature:

A'Hearn, Brian. 2004. "A restricted maximum likelihood estimator for truncated height samples." *Economics and Human Biology,* 2: 5-19.

Bodnar, John. 1987. *The Transplanted: A History of Immigrants in Urban America.* Bloomington, IN: Indiana University Press.

Carson, Scott Alan. 2008. "Nineteenth Century Black and White US Statures: The Primary Sources of Vitamin D and Their Relationship with Height." CESifo Working Paper Series No. 2497.

Condran, Gretchen A., and Eileen Crimmins-Gardner. 1978. "Public health measures and mortality in U.S. cities in the late nineteenth century." *Human Ecology*, 6 (1): 27-54.

Condran, Gretchen A., and Eileen Crimmins-Gardner. 1980. "Mortality differentials between rural and urban areas of states in the northeastern United States 1890–1900." *Journal of Historical Geography*, 6 (2): 179-202.

Crimmins-Gardner, Eileen M., and Gretchen A. Condran. 1983. "Mortality Variation in U.S. Cities in 1900: A Two-Level Explanation by Cause of Death and Underlying Factors." *Social Science History*, 7 (1): 31-59.

Costa, Dora, and Richard Steckel. 1997. “Long-Term Trends in Health, Welfare, and Economic Growth in the United States.” In: *Health and Welfare during Industrialization,* ed. Richard Steckel and Roderick Floud, 47-90. Cambridge, MA: National Bureau of Economic Research, Inc.

Fogel, Robert W., Stanley L. Engerman, Roderick Floud, Richard H. Steckel, and James Trussell. 1982. “Changes in American and British Stature since the Mid-Eighteenth Century: A Preliminary Report on the Usefulness of Data on Height…” NBER Working Papers 0890, National Bureau of Economic Research, Inc.

Fogel, Robert. 1994. “Economic Growth, Population Theory, and Physiology: the Bearing of Long-term Processes on the Making of Economic Policy.” *American Economic Review,* 84: 369–395.

Foster, J. M., S. Chinn, and R.J. Ronja. 1983. “The relation of height of primary school children to population density.” *International Journal of Epidemiology*, 12: 199-204.

Frisancho, Robert A. 1990. *Anthropometric Standards for the Assessment of Growth and Nutritional Status.* Ann Arbor: University of Michigan Press.

Goldin, Claudia, and Kenneth Sokoloff. 1982. “Women, Children, and Industrialization in the Early Republic: Evidence from the Manufacturing Censuses.” *The Journal of Economic History*, 42: 741-774.

Haines, Michael. 2001. “The Urban Mortality Transition in the United States, 1800-1940.” *Annales de démographie historique*, 101 (1): 33-64.

Haines, Michael. 1989. “A State and Local Consumer Price Index for the United States in 1890.” *Historical Methods*, 22 (3): 97-105.

Haines, Michael, Lee A. Craig, and Thomas Weiss. 2003. “The Short and the Dead: Nutrition, Mortality, and the ‘Antebellum Puzzle’ in the United States.” *Journal of Economic History,* 63: 382-413.

Holick, Michael, 2004. “Sunlight and Vitamin D for Bone Health and Prevention of Autoimmune Diseases, Cancers, and Cardiovascular Diseases.” *American Journal of Clinical Nutrition*, supplement: 1678S-1688S.

Komlos, John. 1987. “The Height and Weight of West Point Cadets: Dietary Change in Antebellum America.” *The Journal of Economic History,* 47: 897-927.

Komlos, John. 1992. “Toward an Anthropometric History of African-Americans: The Case of the Free Blacks in Antebellum Maryland.” In: *Strategic Factors in Nineteenth Century American Economic History: A Volume to Honor Robert W. Fogel,* ed. Claudia Goldin and Hugh Rockoff, 297 - 392. Cambridge, MA: National Bureau of Economic Research, Inc.

Komlos, John. 1998. “Shrinking in a Growing Economy? The Mystery of Physical Stature during the Industrial Revolution.” *The Journal of Economic History,* 58: 779-802.

Komlos, John. 2004. “Improvements in Maximum Likelihood Estimators of Truncated Normal Samples with Prior Knowledge of σ. A Simulation Based Study with Application to Historical Height Samples.” Discussion paper LMU Munich.

Komlos, John. 2007. “Anthropometric evidence on economic growth, biological well-being and regional convergence in the Habsburg Monarchy, c. 1850–1910.” *Cliometrica*, 1 (3): 211-237.

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.

Lebergott, Stanley. 1984. *The Americans, an economic record.* New York City, NY: W.W. Norton.

Lee, Chulhee. 1997. “Socioeconomic Background, Disease, and Mortality among Union Army Recruits: Implications for Economic and Demographic History.” *Explorations in Economic History,* 34: 27-55.

Margo, Robert, and Richard Steckel. 1983. “Heights of Native Born Northern Whites during the Antebellum Period.” *Journal of Economic History,* 43: 167-184.

Preston, Samuel H., and Michael Haines. 1991. *Fatal Years: Child Mortality in the Late Nineteenth-Century America*. Princeton, NJ: Princeton University Press.

Reading, Richard, Simon Raybould, and Stephen Jarvis. 1993. “Deprivation, low birth weight, and children’s height: a comparison between rural and urban areas.” *British Medical Journal*, 307: 1458-1462.

Rosen, George. 1944. “The Medical Aspect of the Controversy over Factory Conditions in New England, 1840-1850.” *Bulletin of the History of Medicine*, 15 (5): 483-497.

Sokoloff, Kenneth, and Georgia Villaflor. 1982. “The Early Achievement of Modern Stature in America.” *Social Science History,* 6 (4): 453-481.

Steckel, Richard, and Donald Haurin. 1994. "Health and Nutrition in the American Midwest: Evidence from the Height of Ohio National Guardsmen, 1850-1910." In: *Stature, Living Standards, and Economic Development: Essays in Anthropometric History,* ed. John Komlos, 117-128. Chicago: The University of Chicago Press.

Steckel, Richard. 1995. "Stature and the Standard of Living." *Journal of Economic Literature,* 33 (4): 1903-1940.

Sunder, Marco. 2007. "Passports and Economic Development: An Anthropometric History of the U.S. Elite in the Nineteenth Century." PhD diss. University of Munich.

Waaler, Hans. 1984. "Height, Weight and Mortality: The Norwegian Experience." *Acta Medica Scandinavica*, Supplement, 679: 1-51.

Yoo, Dong Woo. 2009. "Height and Death in the Antebellum United States: A View through the Lens of Geographically Weighted Regression." Unpublished.

3. Who is Your Daddy and What Does He Do? Stature and Family Background in the US, 1847-1880

ABSTRACT

Using a sample of 2,918 Army recruits that we linked with the digitized 1880 manuscript census, we analyze occupational height premiums, intergenerational occupational mobility, and family-level correlates of height in the US during the second half of the 19^{th}-century. We find that, despite the existence of occupational mobility, the son's occupation prior to enlistment is a reliable proxy variable for the father's occupation, particularly in the case of farmers. When we used the son's and not the father's occupation, height estimates by occupation differed by no more than 0.5% of average height. Using Duncan's Socioeconomic Index one finds that the scores of fathers and sons were positively correlated and that having foreign-born parents lowered the son's socio-economic status. We also find that an individual's height was negatively correlated with living in an urban area, living in the Northeast, and the number of siblings in the household, whereas it was positively correlated with living in the South and having a father who was a farmer. Finally, the Army data reveal that the average height of first-generation Americans caught up with that of those whose parents had been born in the US.

3.1 Introduction

Many sources of height data, such as military-enlistment records, prison records, and passport applications, provide few other vital statistics concerning the individuals measured, much less anything about their backgrounds. Since adult height is the result of net nutrition during periods of growth, researchers in the field of anthropometry seek to learn as much as possible about the circumstances in which the individuals in question matured (Fogel, 1994; Steckel, 1995). In the case of this study, we were able to compensate for the shortcomings of military-recruitment data by linking them to data recorded in the 1880 manuscript census, thanks to the North Atlantic Population Project (NAPP). In order to analyze height data, Costa (1993) and Wilson and Pope (2003) link census records to antebellum muster rolls, and Sunder (2007) links them to 19th-century passport applications. Muster rolls, the database of many height studies, provide only one control for socio-economic status during childhood: the recruit's occupation prior to recruitment. However, his occupation at the time of recruitment most likely reflects his socio-economic status in late adolescence or early adulthood, when he was at the start of his career: a drawback for the researcher. Fortunately the manuscript census provides information on the recruits' parents, including their occupations, providing us with some idea of the circumstances in which the recruits lived during their growth years.

While this study is not the first to link muster rolls and census records in order to study height, it is the first to use data from the second half of the 19th-century to shed light on the family-level correlates of height among the lower and middle classes, primarily. Using a smaller sample of recruits, born in the Northeast during the first half of the 19th-century, Costa (1993) finds height premiums for sons of farmers and for those who had not moved from their county of birth, and height penalties correlated with the number of siblings in the household and with having a father who was poor. Like Haines, Craig, and Weiss (2003), Wilson and

Pope (2003) use data on Federal Army recruits born in the first half of the 19^{th}-century, but they supplement these data with family-level information from the 1850 census. They find negative correlations between height and urbanization, but no significant correlations between height and the number of siblings or with having foreign-born parents. Sunder (2007) analyzes the 19^{th}-century American upper classes by linking passport applicants with family-level information from the 1880 census. He finds the following height premiums: for sons of farmers, between 0.53 in. (1.3 cm) and 0.80 in. (2.0 cm); for sons of professionals, between 0.45 in. (1.1 cm) and 0.64 in. (1.6 cm); for there being servants in the household, between 0.25 in. (0.6 cm) and 0.32 in. (0.8 cm); and he finds a height penalty for having foreign-born parents, between 0.45 in. (1.1 cm) and 0.69 in. (1.8 cm).

After an analysis of how military and census records are linked, we examine the issue of whether a recruit's occupation prior to enlistment was a reliable predictor of his father's occupation, and then present estimates of the error introduced into height estimates by the use of the recruit's, and not his father's, occupation. In the last section we turn our attention to family-level correlates of height.

3.2 Data and Methodology

We have linked the enlistment records of recruits born in the US between 1847 and 1880, and who joined the Army between 1898 and 1912, with the digitized 1880 manuscript census from the North Atlantic Population Project (NAPP)[21], which provides information on their family backgrounds. In the absence of any information on household income, occupation serves as a proxy for the socio-economic status of the household. As for occupations, instead

[21] North Atlantic Population Project and Minnesota Population Center (2008)

of the terms used in our two sources we use those of the Historical International Standard Classification of Occupations (Roberts et al., 2003). The father's occupation, like the son's, is then categorized as one of the following: laborer, semi-skilled worker, skilled worker, lower-level white-collar worker, upper-level white-collar worker, or farmer. (We focus on the occupation of the father since 97% of the women in the linked sample reported housekeeping as an occupation or reported no occupation at all.) High-level occupations on the part of the fathers were positively correlated with household income and consequently with their sons' stature, since the higher the household income the better their housing and nutrition (Komlos, 1987; Preston and Haines, 1991; Lee, 1997). As for the sons of farmers, the proximity to nutrients meant that they could eat better at lower relative prices than could others: hence the sons' above-average stature (Komlos, 1987). We also use Duncan's Socioeconomic Index (SEI), which is constructed from the occupations in the manuscript census and in the enlistment records, as an alternative proxy for socio-economic status. Duncan's SEI, which ranges from 0 to 100, uses income and years of education to predict socio-economic status for occupations in 1950 (Duncan, 1961; Sobek, 1996; Nam and Boyd, 2004).

We can account for the immigration history of the parents by including variables for parental nativity: only father foreign-born, only mother foreign-born, both foreign-born, both native-born, or any parent foreign-born. We use these dummy variables to determine whether the fact of being foreign-born had an effect on the height of one's US-born children. During the second half of the 19th-century Americans were taller than any other nationality (Steckel, 1995), so foreign-born parents would necessarily be shorter than native-born parents[22], and their below-average height would predict their children's, through the intergenerational transmission of their own short stature, unless their children caught up with average American heights. We also have information on the number of siblings living in a household at the time

[22] Unless the tallest from each country immigrated into the US, which is unlikely because the majority of immigrants were poor and socio-economic status was positively correlated with height in other countries, too (Bodnar, 1987; Steckel, 1995).

the census was taken: the more siblings living in a household, the smaller the share of income that could be spent on each child (assuming that all other variables, such as socio-economic status, remain constant). We therefore assume that the height of siblings in a given household was in inverse proportion to their number.

In addition, we use a number of dummy variables to investigate the association between height and age as well as between height and place of birth: we use five- and ten-year birth cohorts to capture changes over time and variables for enlistment between the ages of 18 and 21 to take into account the fact that these recruits had not yet attained their maximal height. To account for spatial variation we include census regions and divisions. We also control for the degree of urbanization in the linked sample by including variables for the following birthplace categories: rural (fewer than 2,500 inhabitants), town (2,500 to 25,000 inhabitants), and city (for places with more than 25,000 inhabitants). In the enlistment records we control for recruits who were born in a county in which was located at least one of the 100 largest cities in 1880. A high population density meant an above-average disease rate and above-average food prices, and consequently below-average stature (Komlos, 1987; Preston and Haines, 1991; Lee, 1997). In order to take the Army's minimum-height requirement of 64 in. (162.6 cm) into account, we estimate heights by means of truncated maximum likelihood estimation instead of ordinary least squares. Some models are estimated with a constrained standard deviation of today's adult population, 2.7 in. (6.86 cm) (Frisancho, 1990; Cole, 2000). The advantage of restricting the standard deviation of height is increased precision and reduced variance; the disadvantage is that it may bring about a trade-off between bias and precision of the estimator. We therefore estimate both with and without constraining the standard deviation of the height distribution (A'Hearn, 2004; Komlos, 2004).

TABLE 3.1
DESCRIPTIVE STATISTICS OF THE LINKED SAMPLE

Variable	μ	σ	Min	Max	N
Height (in.)	67.41	2.05	64.00	76.00	2,918
			Age at Enlistment		
Age	24.20	4.12	18.00	47.00	2,918
Age 18	0.02	0.15	0.00	1.00	68
Age 19	0.04	0.19	0.00	1.00	110
Age 20	0.04	0.19	0.00	1.00	114
Age 21	0.18	0.38	0.00	1.00	522
Age 22-50	0.73	0.45	0.00	1.00	2,148
			Birth Cohort		
1847-69	0.09	0.29	0.00	1.00	277
1870-74	0.29	0.46	0.00	1.00	871
1875-80	0.61	0.49	0.00	1.00	1,814
			Recruits' Occupations Prior to Enlistment		
Laborer	0.18	0.39	0.00	1.00	545
Semi-skilled	0.36	0.48	0.00	1.00	1,055
Skilled	0.24	0.43	0.00	1.00	708
Farmer	0.09	0.29	0.00	1.00	267
Low. w. c.	0.09	0.29	0.00	1.00	279
Up. w. c.	0.04	0.19	0.00	1.00	110
Duncan's SEI	23.01	18.87	4.00	96.00	1,969
			Fathers' Occupations Prior to Enlistment		
Laborer	0.26	0.44	0.00	1.00	762
Semi-skilled	0.19	0.39	0.00	1.00	548
Skilled	0.23	0.42	0.00	1.00	686
Farmer	0.19	0.39	0.00	1.00	554
Low. w. c.	0.03	0.18	0.00	1.00	100
Up. w. c.	0.11	0.31	0.00	1.00	312
Duncan's SEI	24.16	20.51	0.00	93.00	2641
			Region of Birth and Geographic Mobility		
Mover	0.43	0.49	0.00	1.00	1,267
Stayer	0.57	0.49	0.00	1.00	1,695
West	0.03	0.16	0.00	1.00	82
Midwest	0.28	0.45	0.00	1.00	841
South	0.14	0.35	0.00	1.00	421
Northeast	0.55	0.50	0.00	1.00	1,617
E. N. Central	0.22	0.42	0.00	1.00	647
W. N. Central	0.06	0.24	0.00	1.00	184
Middle Atlantic	0.39	0.49	0.00	1.00	1,111
New England	0.15	0.36	0.00	1.00	445
City	0.58	0.49	0.00	1.00	1,701
Urban	0.24	0.43	0.00	1.00	697
Town	0.11	0.31	0.00	1.00	1,903
Rural	0.65	0.48	0.00	1.00	318
			Family Level Variables		
Siblings	2.96	2.01	0.00	12.00	2,918
Father foreign	0.09	0.29	0.00	1.00	263
Mother foreign	0.05	0.22	0.00	1.00	155
Both foreign	0.34	0.47	0.00	1.00	982
Any foreign	0.48	0.50	0.00	1.00	2861
Parents US	0.52	0.50	0.00	1.00	1,518

Notes: Recruits in the linked sample are identified by name, age, state and county of birth. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Duncan's SEI is Duncan's Socioeconomic Index. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. E. N. Central is East North Central. W. N. Central is West North Central. Siblings is the number of siblings. Mother foreign is only the mother foreign-born. Father foreign is only the father foreign-born. Both foreign is both parents foreign-born. Any foreign is any of the parents foreign-born. Parents US is both parents US-born. Urban is being born in a city with more than 25,000 inhabitants, Town in a place with more than 2,500 and fewer than 25,000 inhabitants, Rural in a place with fewer than 2,500 inhabitants, and City in one of the 100 largest urban counties by population in 1880.
Sources: See the text.

3.3 Linkage Process

By means of PASW Statistics 17, we link a sample of 53,198 recruits with about 15.9 million observations from the 1880 manuscript census. To ensure that our results are more accurate than many previous ones, we restrict our data set to those recruits whose first name, last name, state of birth, county of birth, and age in 1880 match data in the census of the same year[23]. As an additional precaution, we also estimate regressions with a larger sample, which we linked by dropping the county-of-birth (but not the state-of-birth) criterion (Tables 3.9 and 3.10).

First, we reduced the census data set to white males born between 1847 and 1880, and then calculated the age of the recruits in 1880 from their age at enlistment and the date of their enlistment as recorded in the military records. We excluded duplicates of those recruits who enlisted more than once, and we eliminated those who could not be identified with sufficient accuracy by their name, age, state, and county of birth. In the linked sample we used information from the manuscript census to eliminate recruits who were foreign-born but who had reported at the time of their enlistment that they were native-born (N=51) and recruits who had claimed to have more than 21 siblings (N=29).

Like all other historical military data, these are not representative of the entire population because they are limited not only to men but almost exclusively to lower- and middle-class ones. Since linking this sample with census data makes it all the less representative, the linkage procedure itself merits attention. When using name, age, state of birth, and county of birth, we have a linkage rate of about 5%, defined as the number of recruits successfully linked with records from the 1880 manuscript census divided by the total number of recruits in our sample of enlistment records. This linkage rate is lower than those found in other studies, such as Sunder's (2007) and Ferrie's (1996) (38 and 19%,

[23] Other studies use phonetic algorithms or allow some leeway regarding self-reported age because of poor numeracy of the recruits thereby trading of accuracy for greater sample size (Steckel, 1983; Ferrie, 1996).

respectively), but when we reduce our linkage criteria to name, age, and state of birth, the rate increases to 23%. There are many possible reasons for these relatively low linkage rates: for instance, a recruit's name may have been misspelled, his age may not have been correctly recorded, or he may have been living elsewhere than his place of birth at the time of the census. Other studies have found that the poor, illiterate, and unskilled were less likely than others' to be correctly recorded in the census, thereby systematically diminishing the probability of their being included in our linked sample (Ferrie, 1996). Since we used the exact age in 1880 calculated from enlistment records to link individuals, those with below-average numeracy skills were also likely to be underrepresented in the linked sample. To estimate which individual characteristics influence the linkage probability, we use a probit model (Table 3.2).

TABLE 3.2
DETERMINANTS OF LINKAGE OF THE CONSCRIPT SAMPLE
WITH THE 1880 MANUSCRIPT CENSUS:
PROBIT REGRESSION

	(1) Matched with Census (1=yes,0=no)	(2) Marginal Effects of Model 1	(3) Matched with Census (1=yes,0=no)	(4) Marginal Effects of Model 3	N
Age	-0.004**	-0.00			
Mover	-0.13***	-0.01	-0.13***	-0.01	27,984
Stayer	Ref.	Ref.	Ref.	Ref.	25,214
Laborer	-0.18***	-0.02	-0.18***	-0.02	10,957
Semi-skilled	-0.12***	-0.01	-0.12***	-0.01	19,849
Skilled	-0.06*	-0.01	-0.07**	-0.01	10,728
Farmer	-0.09**	-0.01	-0.09**	-0.01	6,327
Low. w. c.	Ref.	Ref.	Ref.	Ref.	3,873
Up. w. c.	0.06	0.01	0.05	0.00	1,500
West	0.13**	0.02	0.13**	0.01	1,120
Midwest	Ref.	Ref.	Ref.	Ref.	18,012
South	-0.17***	-0.02	-0.17***	-0.02	13,385
Northeast	0.14***	0.02	0.14***	0.02	20,608
City	0.31***	0.04	0.31***	0.03	20,814
Rural	Ref.	Ref.	Ref.	Ref.	32,384
Birth Cohorts					
1847-54			-0.65***	-0.04	393
1855-59			-0.28***	-0.02	556
1860-64			-0.35***	-0.03	1,435
1865-69			-0.19***	-0.02	4,756
1870-74			Ref.	Ref.	12,981
1875-79			-0.10***	-0.01	29,411
1880			-0.21***	-0.02	3,666
Constant	-1.57***		-1.58***		
Observations	53,198		53,198		
Pseudo-R^2	0.03		0.04		

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Laborer includes those with unknown occupations. Skilled is skilled worker. Semi-skilled is semi-skilled worker. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. City is being born in one of the 100 largest urban counties by population in 1880.
Sources: See the text.

With higher age the probability of having moved away from one's county of birth increases, and therefore the probability of a successful linkage decreases. A recruit's registering in a state other than that of his birth is a measure of his above-average mobility; it also means that he is less likely to be linked than are those who did not move thus: 1 percentage point less[24]. Comparing recruits' linkage rates according to occupation, the probability of being successfully linked is 2 percentage points lower for average laborers and 1 percentage point lower for semi-skilled workers, farmers, and skilled workers compared with lower-level white-collar workers. Regions, too, are a major factor: Southerners are 2 percentage points less likely to be linked while Northeastern and Western recruits are 2 percentage points more likely to be linked than Midwestern recruits. Being born in one of the urban counties among the 100 that were the most populous in 1880 gives a recruit a 3-to-4-percentage-point greater chance of being successfully linked, whereas Wilson and Pope (2003) find it easier to link rural than urban households. The probability of any of the birth cohorts' being linked is between 1 and 4 percentage points below that of the 1870-74 birth cohort (Table 3.2).

This means that the linked sample slightly better represents urban recruits and those who were among the less geographically mobile. In addition, those born in the Northeast and West are overrepresented, whereas the opposite is the case for Southerners. Blue-collar workers and farmers are underrepresented, yet in absolute terms they compose the largest group in the linked sample. These examples of discrepancies indicate how difficult it is to control for the selection bias that arises through the linkage process because the variables used in the selection equation for the determinants of a successful linkage are also used as correlates of stature (Wilson and Pope, 2003).

[24] All interpretation of binary choice models is done by using marginal effects evaluated at the sample mean of all continuous independent variables, whereas for binary independent variables the marginal effect is calculated for a discrete change from 0 to 1.

3.4 Intergenerational Occupational Mobility

This linked sample allows us to gauge the extent of intergenerational (father-son) occupational mobility and to determine whether height patterns differ according to whether it is the occupation of the father or that of the son (prior to recruitment) that we use as a proxy variable for socio-economic status. Often the only proxy provided by military data for determining a recruit's socio-economic status is his prior occupation. As a result, researchers often proceed on the assumption that a recruit's own occupation is a good proxy for his father's occupation and consequently for the recruit's socio-economic background during his childhood. This sample allows us to test this assumption and shed light on the errors that result from using the son's occupation instead of that of the father.

TABLE 3.3
CONDITIONAL PROBABILITIES OF FATHER'S OCCUPATION GIVEN THE SON'S OCCUPATION

	FATHER'S OCCUPATION					
SON'S OCCUPATION	Laborer	Semi-skilled	Skilled	Lower w.c.	Upper w. c.	Farmer
Laborer	***0.32***	0.22	0.21	0.03	0.06	0.17
Semi-skilled	*0.30*	**0.20**	0.23	0.03	0.11	0.13
Skilled	0.22	0.21	***0.32***	0.03	0.10	0.12
Low. w.c.	0.15	0.18	0.21	**0.06**	*0.26*	0.15
Up. w.c.	0.13	0.11	0.19	0.07	**0.20**	*0.30*
Farmer	0.21	0.05	0.07	0.01	0.03	***0.63***

Notes: Probabilities of father's occupation given the son's occupation for the sample linked by name, age, state, and county of birth (N=2,918). The highest probability is in italics. Laborer includes those with unknown occupations. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker.
Sources: See the text.

Analysis of occupational groups reveals that for some occupational groups, such as farmers, the son's occupation was a reasonably good predictor for the father's occupation. For example, 63% of farmers were the sons of farmers, while for skilled workers, laborers, semi-skilled workers, and upper-level white-collar workers the rate was between 20 and 30% and just 6% for lower-level white-collar workers (Table 3.3). These results are, of course, partly a function of the fact that the recruits had only recently entered the workforce and of intergenerational (occupational) mobility which we analyze in the following section.

We also use a probit model to analyze determinants of having the same job as one's father (Table 3.4). Birth-cohort dummies are included to measure changes, if any, in occupational mobility over time. We also include age because the older a recruit the more likely he was to leave his father's occupational category.

TABLE 3.4
DETERMINANTS OF RECRUIT HAVING THE SAME OCCUPATIONAL CATEGORY AS FATHER: PROBIT ESTIMATION

	(1) Y=1 if father and son have same job	Marginal effects from Model 1	(2) Y=1 if father and son have same job	Marginal effects from Model 2	N
Age			-0.01	-0.00	
Age18	-0.11	-0.04			68
Age 19	0.16	0.05			110
Age 20	0.01	0.00			111
Age 21	0.05	0.02			513
Age 22-50	Ref.	Ref.			2,118
1847-69	-0.06	-0.02	0.00	0.00	276
1870-74	Ref.	Ref.	Ref.	Ref.	861
1875-80	-0.14**	-0.05	-0.16**	-0.05	1,781
Son's Occupation					
Laborer	1.03***	0.37	1.02***	0.37	538
Semi-skilled	0.64***	0.21	0.64***	0.21	1,040
Skilled	1.02***	0.37	1.02***	0.36	696
Farmer	1.90***	0.65	1.90***	0.65	265
Low. w. c.	Ref.	Ref.	Ref.	Ref.	273
Up. w. c.	0.69***	0.26	0.69***	0.25	108
Mover	-0.10*	-0.03	-0.09*	-0.03	1,246
Stayer	Ref.	Ref.	Ref.	Ref.	1,672
West	0.11	0.04	0.11	0.04	81
Midwest	Ref.	Ref.	Ref.	Ref.	831
South	-0.01	-0.00	-0.01	-0.00	418
Northeast	0.16**	0.05	0.16**	0.05	1,587
Constant	-1.48***		-1.23***		
Observations	2,918		2,918		
Pseudo-R^2	0.08		0.08		

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Laborer includes those with unknown occupations. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth.
Sources: See the text.

We find that age had no effect on the probability of having the same job as one's father. We also find that over the course of the half century under study there was a significant decrease in this probability: five percentage points less for a recruit born between 1875 and 1880 than for a recruit born between 1870 and 1874 (Table 3.4). This increase in occupational mobility may have been due to the fact that the second Industrial Revolution generated economic changes that were more rapid than those of the first. As for spatial differences, Northeasterners were 5 percentage points more likely than Midwesterners to hold the same job as their fathers, and geographically mobile recruits were 3 percentage points less likely to do so than those who enlisted in their state of birth. These results corroborate the pattern reported in Table 3.3: Farmers were most likely to hold the same jobs as their fathers (by 65 percentage points), followed by laborers and skilled workers (by 37 percentage points), upper-level white-collar workers (by 26 percentage points), and semi-skilled workers (by 21 percentage points) compared with lower-level white-collar workers (Table 3.4, Model 1).

We use Duncan's SEI of fathers and sons to examine the correlation between their SEI scores: an analysis similar to that of intergenerational income inequality or mobility (Becker and Tomes, 1986; Solon, 1992). We include age at enlistment to control for potential work experience (Mincer, 1958). Geographic mobility may have had an impact on SEI, but - since we define a mover simply as a recruit who enlisted elsewhere than in his birth state - we cannot determine whether it was he or his father who made the decision to move. Perhaps movers were more willing than others to take risks, their motivation being to improve their lot; in this case, one would assume that their SEI scores were higher than average. We control for the nativity of the recruits' parents to determine whether it had a negative effect on the recruits' socio-economic status even when we control for the socio-economic status of their fathers. We also include the height of the recruits as an independent variable (Table 3.5, Model 2) to determine whether height was associated with own SEI when controlling for the fathers' SEI. Finally, we test whether a recruit's own or his father's SEI influenced his height (Table 3.5, Models 3 and 4).

TABLE 3.5
INTERGENERATIONAL TRANSMISSION OF SOCIOECONOMIC STATUS (SEI)
AND THE RELATIONSHIP BETWEEN HEIGHT AND SEI:
OLS AND TRUNCATED NORMAL REGRESSION

	(1) SEI of son	(2) SEI of son	N	(3) Height	N	(4) Height	N
SEI of father	0.20***	0.20***				-0.00	
SEI of son				0.00			
Age	0.58***	0.58***					
Mover	1.94**	1.92**	720	0.13	1,203	0.29***	1,523
Stayer	Ref.	Ref.	1,107	Ref.	766	Ref.	1,118
Siblings	-0.36	-0.37		-0.05*		-0.05*	
Mother for.		-3.18*	100	0.23	107	0.04	146
Father for.		-1.80	164	-0.20	180	-0.18	239
Both foreign		-2.23**	592	0.17	638	-0.14	887
Parents US	Ref.	Ref.	971	Ref.	1,044	Ref.	1,369
Any foreign	-2.26**						
Urban	0.74	0.74	427	-0.11	456	-0.34**	633
Town	0.72	0.70	179	0.13	197	-0.23	282
Rural	Ref.	Ref.	1,221	Ref.	1,316	Ref.	1,726
West	6.40**	6.40**	55	0.38	61	0.14	70
Midwest	Ref.	Ref.	528	Ref.	572	Ref.	760
South	-1.08	-1.09	252	0.44**	271	0.38**	369
Northeast	-1.21	-1.20	991	-0.56***	1,064	-0.71***	1,441
Height		0.07					
Age 18				-0.72*	54	-0.31	64
Age 19				-0.51*	78	-0.63**	102
Age 20				-0.82**	78	-0.65**	104
Age 21				-0.04	401	-0.13	486
Age 22- 50				Ref.	1,358	Ref.	1,885
1847 -69				0.18	145	0.16	204
1870 -74				Ref.	549	Ref.	783
1875-80				-0.15	1,275	-0.04	1,654
Father's Occupation							
Laborer				0.20	489		
Semi-skilled				0.04	361		
Skilled				0.08	448		
Farmer				1.04***	425		
Low. w. c.				Ref.	63		
Up. w. c.				0.22	183		
Constant	2.64	2.34		67.10***		67.69***	
Sigma				2.26***		2.30***	
Observations	1,827	1,827		1,969		2,641	
Adjusted R^2	0.07	0.07					

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. SEI is Duncan's Socioeconomic Index. Laborer includes those with unknown occupations. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Siblings is the number of siblings. Mother foreign is only the mother foreign-born. Father foreign is only the father foreign-born. Both foreign is both parents foreign-born. Any foreign is any of the parents is foreign-born. Parents US is both parents US-born. Urban is being born in a city with more than 25,000 inhabitants, Town in a town with more than 2,500 and fewer than 25,000 inhabitants, and Rural in a place with fewer than 2,500 inhabitants.
Sources: See the text.

We find a significant and positive correlation between the SEIs of fathers and sons with a coefficient of 0.2 (the larger the coefficient, the greater the association of the socio-economic status of fathers and sons), suggesting that there was intergenerational mobility (Table 3.5). The older the son at the time of his recruitment, the higher, on average, was his SEI score: for instance, enlisting at 19 rather than at 18 was associated with a 0.58 point (on a scale of 0 to 100) elevation in the SEI score. Geographical mobility, proxied by enlisting outside the state of birth, was associated with a 2-point increase in the SEI (Table 3.5, Models 1 and 2).

Even when we controlled for the father's SEI score, having foreign-born parents translated into a 2.2-point lower score. Having a foreign-born mother but a native-born father was associated with an even greater difference, as much as 3.2 points[25] (Table 3.5, Models 1 and 2): a pattern consistent with the intergenerational persistence of occupations and therefore of socio-economic status. In contrast, we find no significant correlation either between one's height and one's SEI (Table 3.5, Model 2) or between a son's height and his father's SEI (Table 3.5, Models 3 and 4).

3.5 Re-estimating the Occupational Height Premiums

The linked sample allows us to estimate height differentials by socio-economic status using the occupation of the father rather than that of the recruit and to investigate the differentials. When Lantzsch and Schuster (2009) did this, in their study of 19th-century Bavarian conscripts, they found that the tallest were the sons of farmers, upper-level white-collar workers, and public officials and that the shortest were the sons of laborers, blue-collar workers, and apprentices. As for the correlation between the recruit's own occupation and his height, they found the same correlation: the shortest had blue-collar jobs, the tallest white-collar ones.

Our results indicate that using the recruit's, as opposed to his father's, occupation accounts for a certain inaccuracy in estimated heights, but one that is very small; nor does constraining the standard deviation to 2.7 in. (6.86 cm) substantially alter the results. We find

[25] Including the mother's socioeconomic status proved to be insignificant and did not change the results in Table 3.5.

that controlling for the recruit's occupation translates into a significant height penalty for skilled workers, whereas controlling for the father's occupation translates into a significant height premium for farmers' sons (Table 3.6, Models 1 and 2). When both the father's and the son's occupations are considered, being a farmer's son offers the greatest height advantage (Table 3.6, Model 3). Thus those who entered the farming sector, being on average less well nourished and therefore shorter than those born in it, must have lowered the average heights therein. That farmers enjoyed a height premium (an idea substantiated by many studies of the 19^{th}-century US) is in line with Komlos's (1987) propinquity hypothesis, because this height premium remains significant even when we control for the size and socio-economic status of the recruit's family and his parents' birth status (foreign or native) (Table 3.8). It follows that sons of farmers who became upper-level white-collar workers were the tallest and that sons of semi-skilled workers who became skilled workers were the shortest (Tables 3.6 and 3.7). Evidently only the tallest from each occupational category entered white-collar occupations, perhaps because they were also the best educated. Previous studies have failed to link recruits with family-level data; this study fills that gap in showing that coefficients for birth cohorts and regions have identical signs and significance, with only minor differences in magnitude when controlling for the son's rather than the father's occupation (Table 3.6).

TABLE 3.6
COMPARISON OF FATHER'S AND RECRUIT'S OCCUPATIONS
DEPENDENT VARIABLE HEIGHT OF THE RECRUIT:
TRUNCATED NORMAL REGRESSION (in inches)

	(1)	(2)	(3)	N
Age 18	-0.60*	-0.56	-0.55	68
Age 19	-0.60**	-0.55*	-0.58**	108
Age 20	-0.75***	-0.76***	-0.76**	111
Age 21	-0.13	-0.14	-0.13	513
Age 22-50	Ref.	Ref.	Ref.	2,118
Birth Cohort				
1847-69	0.34*	0.34*	0.34*	276
1870-74	Ref.	Ref.	Ref.	861
1875-80	0.00	0.01	0.01	1,781
Son's Occupation				
Laborer	-0.28		-0.33	538
Semi-skilled	-0.21		-0.23	1,040
Skilled	-0.35*		-0.36*	696
Farmer	0.14		-0.15	265
Low. w. c.	Ref.		Ref.	273
Up. w. c.	0.19		0.10	108
Father's Occupation				
Laborer		0.13	0.19	751
Semi-skilled		-0.10	-0.04	539
Skilled		0.04	0.10	672
Farmer		0.72**	0.74**	551
Low. w.c.		Ref.	Ref.	96
Up. w.c.		0.06	0.05	309
Region of Birth				
West	0.17	0.23	0.22	81
Midwest	Ref.	Ref.	Ref.	831
South	0.35**	0.33**	0.32**	418
Northeast	-0.75***	-0.60***	-0.58***	1,587
Constant	67.59***	67.14***	67.33***	
Sigma	2.34***	2.33***	2.33***	
Observations	2,918	2,918	2,918	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Laborer includes those with unknown occupations. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker.
Sources: See the text.

TABLE 3.7
DIFFERENCES IN PREDICTED HEIGHT USING FATHER'S OR SON'S OCCUPATION AS INDEPENDENT VARIABLES

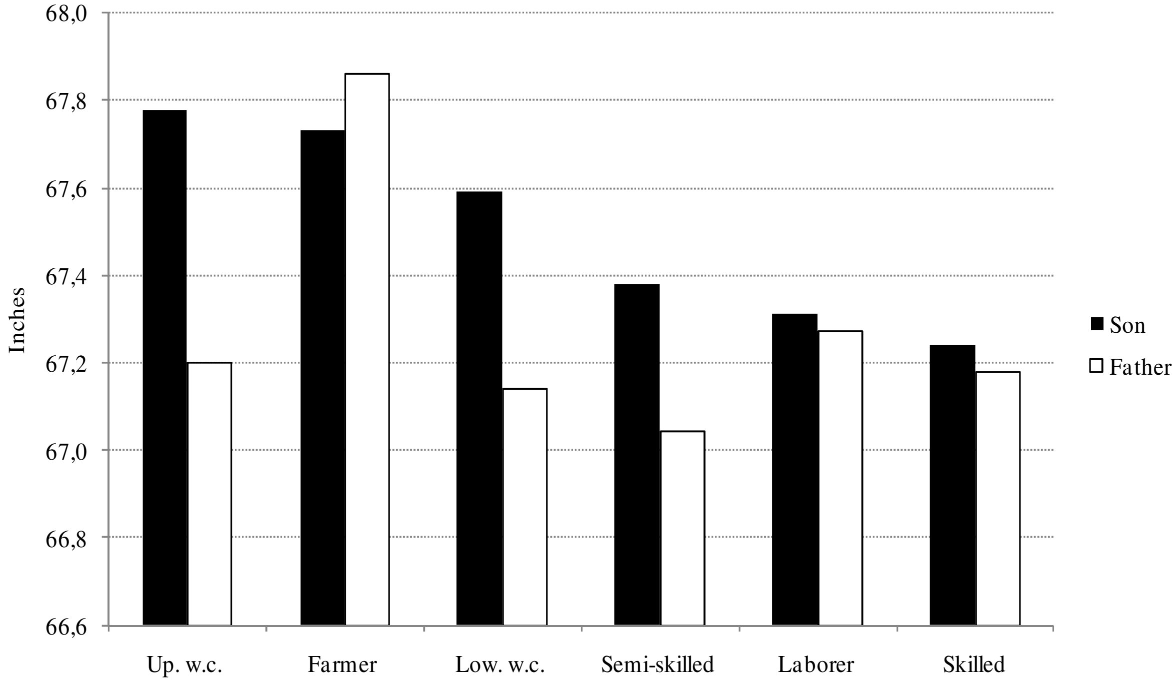
		FATHER'S OCCUPATION						
		Farmer (67.86 in.)	Laborer (67.27 in.)	Up. w. c. (67.20 in.)	Skilled (67.18 in.)	Low. w.c. (67.14 in.)	Semi-skilled (67.04 in.)	Weighted average
SON'S OCCUPATION	Farmer (67.73 in)	**0.13**	-0.46	-0.53	-0.55	-0.59	-0.69	-0.11
	Laborer (67.31 in.)	0.55	**-0.04**	-0.11	-0.13	-0.17	-0.27	-0.01
	Up. w. c. (67.78 in.)	0.08	-0.51	**-0.58**	-0.60	-0.64	-0.74	-0.40
	Skilled (67.24 in.)	0.62	0.03	-0.04	**-0.06**	-0.1	-0.20	0.02
	Low. w. c. (67.59 in.)	0.27	-0.32	-0.39	-0.41	**-0.45**	-0.55	-0.32
	Semi-skilled (67.38 in.)	0.48	-0.11	-0.18	-0.20	-0.24	**-0.34**	-0.11
	μ weighted average							**-0.16**

Notes: Differences in estimated height by occupation for fathers and sons calculated from Table 3.6. All numbers are in inches. Weighted averages are weighted with conditional probabilities from Table 3.3. Laborer includes those with unknown occupations. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker.
Sources: Tables 3.3 and 3.6.

We compare differences in predicted heights by occupation (using the coefficients estimated in Table 3.6), between using the occupation of the father and that of the recruit (Table 3.7 and Figure 3.1). For the two occupations associated with the shortest heights (when the recruit's occupation is used), those of laborers and skilled workers, estimates were virtually identical. While upper-level white-collar workers were taller than farmers (when the recruit's occupation is used), sons of farmers were taller than sons of lower-level white-collar workers. Having an upper-level white-collar father was associated with approximately the same height as having a father who was a lower-level white-collar or skilled worker (Figure 3.1). For recruits who were white-collar workers heights are overestimated by no more than about 0.5% and for semi-skilled workers, farmers, and laborers by even less (Table 3.7). The (weighted) average error when using the son's occupation rather than that of his father is -0.16 in. (-0.4 cm), implying that occupational height premiums are on average overestimated by 0.16 in. (0.4 cm) when the son's, and not the father's, occupation is used (Table 3.7). The largest absolute differences in height when controlling, instead, for the father's occupation are between upper-level white-collar workers whose fathers were semi-skilled workers and skilled workers whose fathers were farmers: -0.74 in. (-1.9 cm) and 0.62 in. (1.6 cm). The two largest (weighted) average differences are overestimations: 0.40 in. (1.0 cm) for upper-level white-collar sons and 0.32 in. (0.8 cm) for lower-level white-collar sons[26] (Table 3.7).

[26] However, these results may not be true for all samples.

FIGURE 3.1
ESTIMATED HEIGHTS BY FATHER'S AND SON'S OCCUPATION



Notes: Estimated heights from Tables 3.6 and 3.7. Son is recruit's occupation prior to enlistment. Father is father's occupation from 1880 manuscript census. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. Laborer includes those with unknown occupations.
Sources: Tables 3.6 and 3.7.

3.6 Family-Level Correlates of Height

Family-level correlates of height reveal that the number of siblings in a household was negatively associated with a recruit's height, whereas foreign-born parents conveyed no height penalty. The number of siblings had a significant and negative association with height at the national level, in rural areas, and in the Midwest, but not in urban areas. The effect was fairly small: an additional child in the household would decrease average height by between 0.05 (0.1 cm) and 0.09 in. (0.2 cm) (Tables 3.8 and 3.9): results similar to Costa's (1993). That there was no association with height if either of the parents was foreign-born confirms Costa's (1993) and Wilson and Pope's (2003) findings for the antebellum period. This suggests that in the US the intergenerational transmission of shorter stature was offset through relatively high living standards (Tables 3.8 and 3.9). Komlos (2008), using data on US Army personnel after World War II, also finds no negative second-generation effects on height. In contrast, among the 19th-century upper classes there was a substantial height penalty, of between 0.47 (1.2 cm) and 0.57 in. (1.4 cm), for having at least one foreign-born parent (Sunder, 2007).

TABLE 3.8
FAMILY LEVEL CORRELATES OF HEIGHT:
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Nation	(2) Nation	N	(3) Rural	N	(4) Urban	N
Age 18	-0.67*	-0.66*	66	-1.03***	39	-0.06	27
Age 19	-0.53*	-0.53*	107	-0.59*	64	-0.40	43
Age 20	-0.75***	-0.75***	109	-0.70**	67	-0.80	42
Age 21	-0.10	-0.10	504	-0.35**	331	0.39	173
Age 22-50	Ref.	Ref.	2,075	Ref.	1,348	Ref.	727
Birth Cohort							
1847-69	0.32*	0.32*	274	0.46**	177	0.04	97
1870-74	Ref.	Ref.	841	Ref.	543	Ref.	298
1875-80	-0.04	-0.05	1,746	0.08	1,129	-0.30	617
Father's Occupation							
Laborer	0.10	0.10	751	0.01	473	0.03	278
Semi-skilled	-0.09	-0.09	539	-0.24	292	0.04	247
Skilled	0.05	0.05	672	-0.17	367	0.23	305
Farmer	0.67**	0.66**	494	0.42	494		
Low. w. c.	Ref.	Ref.	96	Ref.	46	Ref.	50
Up. w. c.	0.07	0.06	309	0.06	177	-0.06	132
Siblings	-0.05*	-0.04*		-0.05*		-0.03	
Mother for.	0.06		154	-0.17	88	0.49	66
Father for.	-0.16		256	-0.17	140	-0.02	116
Both for.	-0.03		972	-0.12	495	0.18	477
Parents US	Ref.	Ref.	1,479	Ref.	1,126	Ref.	353
Any for.		-0.05	1,382				
Urban	-0.28**	-0.27	696			Ref.	696
Town	-0.10	-0.11	316			0.34	316
Rural	Ref.	Ref.	1,849				
West	0.19	0.20	80	0.11	72	0.67	8
Midwest	Ref.	Ref.	811	Ref.	588	Ref.	223
South	0.34**	0.34**	413	0.32*	304	0.49	109
Northeast	-0.53***	-0.53***	1,556	-0.72***	884	-0.12	672
Constant	67.39***	67.40***		67.67***		66.60***	
Sigma	2.31***	2.31***		2.28***		2.33***	
Observations	2,861	2,861		1,849		1,012	

Notes:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Low. w. c. is lower white-collar. Up. w. c. is upper white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. Laborer includes those with unknown occupations. Siblings is the number of siblings. Mother for. is only the mother foreign-born. Father for. is only the father foreign-born. Both for. is both parents foreign-born. Any for. is any of the parents foreign-born. Parents US is both parents US-born. Urban is being born in a city with more than 25,000 inhabitants, Town in a town with more than 2,500 and fewer than 25,000 inhabitants, and Rural in a place with fewer than 2,500 inhabitants.
Sources: See the text.

With the exception of occupational height premiums and penalties, the results for regions and urbanization when we control for family background are similar to the results reported in both Chapter 1, for the full sample without the linkage, and Chapter 2, for the urban subsample. We find a significant urban penalty, of 0.28 in. (0.7 cm), for living in a city with more than 25,000 inhabitants, as opposed to a rural area on the national level (Table 3.8, Model 1). In the Midwest the penalty for living in a town was 0.66 in. (1.7 cm) (Table 3.9, Model 3). These urban penalties are comparable with the results reported in Chapter 2, where we find an urban penalty of 0.58 in. (1.5 cm) for being born in one of the ten largest urban areas in 1880 (population 1,206,299 – 216,090) and a penalty of 0.34 in. (0.9 cm) for being born in one of the next 90 urban areas (population 160,146 – 19,743) as opposed to a rural area[27] (Table 2.2, Model 2).

We find only sons of farmers at the national level (Table 3.8, Models 1 and 2) to be about 0.67 in. (1.7 cm) taller than sons of lower-level white-collar workers; as for the other occupational groups in this sample, there was no significant correlation with stature. As we reported in Chapter 1, there were significant height premiums both for recruits who were farmers prior to their recruitment, of 0.30 in. (0.8 cm), and for upper-level white-collar workers, of 0.22 in. (0.6 cm), and there were significant height penalties both for laborers, of 0.21 in. (0.5 cm), and for skilled workers, of 0.12 in. (0.3 cm), relative to lower-level white-collar workers (Table 1.10, Model 3).

Growing up in the South conveyed a height premium of about 0.34 in. (0.9 cm), whereas growing up in the Northeast was associated with a height penalty of between 0.53 (1.3 cm) and 0.72 in. (1.8 cm), relative to the Midwest (Table 3.8). As for regions within the Midwest, living in the East North Central rather than in the West North Central census division was associated with a height penalty of 0.41 in. (1.0 cm) (Table 3.9). The results reported in Chapter 1 are almost identical: a height premium of 0.29 in. (0.7 cm) for Southerners and a height penalty of 0.73 in. (1.9 cm) for Northeasterners. In Chapter 1 the height penalty for living in the East North Central rather than the West North Central division was reported to be 0.18 in. (0.5 cm) (Table 1.3, Models 1 and 2). In the much larger sample of

[27] The magnitude of the penalties differs because the definition of rural in this study is a place with less than 2,500 inhabitants, whereas it is a county with towns of less than 19, 743 inhabitants in Chapter 2.

those linked only according to name, age, and state of birth the results are similar, but the height premium for farmers at the national level becomes insignificant (Table 3.10, Model 1).

TABLE 3.9
FAMILY LEVEL CORRELATES OF HEIGHT BY REGION,
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Northeast (County)	N	(2) Northeast (State)	N	(3) Midwest (County)	N	(4) Midwest (State)	N
Age 18	-0.73	40	-0.64**	138	-0.38	16	-0.76**	78
Age 19	-0.42	59	-0.68***	199	-0.22	29	-0.38*	110
Age 20	-0.74*	62	-0.75***	192	-0.70	31	-0.31	134
Age 21	-0.16	273	-0.04	1,194	-0.02	154	-0.11	811
Age 22-50	Ref.	1,153	Ref.	4,014	Ref.	601	Ref.	2,531
1847-69	0.23	167	0.14	753	0.72**	60	0.35**	445
1870-74	Ref.	459	Ref.	1,538	Ref.	258	Ref.	935
1875-80	0.06	961	-0.07	3,446	-0.18	513	0.03	2,284
Laborer	-0.17	455	-0.30	1,876	0.21	175	-0.00	811
Semi-skilled	-0.22	402	-0.28	1,233	0.02	100	-0.14	338
Skilled	-0.26	427	-0.24	1,414	0.45	156	-0.13	558
Farmer	0.34	86	-0.07	630	0.63	280	0.02	1,596
Low. w. c.	Ref.	61	Ref.	157	Ref.	18	Ref.	59
Up. w. c.	-0.28	156	0.05	427	0.26	102	0.11	302
Siblings	-0.05		-0.03		-0.09*		-0.03	
Mother for.	0.07	105	-0.18	307	0.11	31	-0.07	116
Father for.	-0.03	154	-0.28**	582	-0.06	69	0.14	317
Parents for.	0.11	726	-0.02	2,428	-0.02	189	-0.08	707
Parents US	Ref.	602	Ref.	2,420	Ref.	542	Ref.	2,524
Urban	-0.14	515	-0.13	1,238	-0.50	99	-0.22	341
Town	0.38	159	0.01	678	-0.66**	124	-0.43***	381
Rural	Ref.	913	Ref.	3,821	Ref.	604	Ref.	2,942
N. England	0.19	454	0.27***	1,318				
M. Atlantic	Ref.	1,133	Ref.	4,419				
East N. C.					-0.41*	647	-0.17*	2,626
West N. C.					Ref.	184	Ref.	1,038
Constant	66.74***		66.97***		67.87***		67.75***	
Sigma	2.41***		2.32***		2.22***		2.25***	
Observations	1,587		5,737		831		3,664	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. County is linked by name, age, state, and county. State is linked by name, age, and state. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. Laborer includes those with unknown occupations. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Siblings is the number of siblings. Mother for. is only the mother foreign-born. Father for. is only the father foreign-born. Parents for. is both parents foreign-born. Parents US is both parents US-born. Urban is being born in a city with more than 25,000 inhabitants, Town in a town with more than 2,500 and fewer than 25,000 inhabitants, and Rural in a place with fewer than 2,500 inhabitants. N. England is New England. M. Atlantic is Middle Atlantic. East N. C. is East North Central. West N. C. is West North Central.
Sources: See the text.

TABLE 3.10
FAMILY LEVEL CORRELATES OF HEIGHT: LINKAGE BY NAME, AGE, AND STATE;
TRUNCATED NORMAL REGRESSION (in inches)

	(1) Nation	N	(2) Rural	N	(3) Urban	N
Age 18	-0.64***	270	-0.73***	211	-0.42	59
Age 19	-0.56***	406	-0.58***	296	-0.48*	110
Age 20	-0.56***	414	-0.57***	312	-0.54	102
Age 21	-0.05	2,562	-0.11	1,973	0.17	589
Age 22-50	Ref.	8,401	Ref.	6,401	Ref.	2,000
1847-69	0.20**	1,504	0.18*	1,154	0.27	350
1870-74	Ref.	3,147	Ref.	2,367	Ref.	780
1875-80	-0.02	7,402	0.03	5,672	-0.18	1,730
Laborer	-0.10	3,332	-0.05	2,481	-0.28	851
Semi-skilled	-0.15	1,690	-0.20	1,017	-0.11	406
Skilled	-0.11	2,246	-0.11	1,371	-0.13	506
Farmer	0.09	3,653	0.10	3,643	0.28	10
Low. w. c.	Ref.	255	Ref.	135	Ref.	120
Up. w. c.	0.13	877	0.16	546	0.06	331
Siblings	-0.03*		-0.04*		-0.01	
Mother for.	-0.10	458	-0.12	291	-0.04	167
Father for.	-0.08	992	-0.08	647	-0.05	345
Parents for.	-0.03	3,290	0.01	1,978	-0.09	1,303
Parents US	Ref.	7,313	Ref.	6,268	Ref.	1,045
Urban	-0.17**	1,705			Ref.	1,705
Town	-0.19**	1,155			-0.01	1,155
Rural	Ref.	9,193				
West	0.01	180	-0.04	165	0.50	15
Midwest	Ref.	3,664	Ref.	2,942	Ref.	722
South	0.31***	2,472	0.32***	2,264	0.13	208
Northeast	-0.74***	5,736	-0.81***	3,821	-0.54***	1,915
Constant	67.60***		67.60***		67.38***	
Sigma	2.33***		2.33***		2.29***	
Observations	12,053		9,193		2,860	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sigma* denotes the estimated standard deviation of heights. Up. w. c. is upper white-collar. Low. w. c. is lower white-collar. Semi-skilled is semi-skilled worker. Skilled is skilled worker. Laborer includes those with unknown occupations. A mover enlisted in a state other than his state of birth and a stayer enlisted in his state of birth. Siblings is the number of siblings. Mother for. is only the mother foreign-born. Father for. is only the father foreign-born. Parents for. is both parents foreign-born. Parents US is both parents US-born. Urban is being born in a city with more than 25,000 inhabitants, Town in a town with more than 2,500 and fewer than 25,000 inhabitants, and Rural in a place with fewer than 2,500 inhabitants.
Sources: See the text.

3.7 Conclusion

We find that occupational mobility was increasing during the period under consideration and that Northeasterners were more likely to have the same occupation as their fathers, whereas geographic mobility lowered this probability. Sons of farmers were most likely to hold the same job as their fathers, followed by laborers, skilled workers, upper-level white-collar workers, and semi-skilled workers relative to lower-level white-collar workers. Using Duncan's Socioeconomic Index (SEI), we find a significant and positive correlation between fathers' and sons' SEI scores, implying mobility.

We find that when controlling for the son's instead of the father's occupation we overestimate the heights of all occupational categories except for that of skilled workers, but only by at most 0.5%, or about 0.40 in. (1.0 cm). In the absence of information on the father's occupation, the bias that results from using the son's occupation is small, and the signs and significance of all other coefficients remain unchanged. This finding will come as good news to researchers who use the son's occupation as a proxy for the father's in anthropometric studies.

Our analysis of family-level correlates of height reveals that the number of siblings in a household and an urban place of birth were negatively associated with height, whereas having a father who was a farmer conveyed a height premium. In the Northeast, family-level correlates had no significant association with height, whereas being born in the South was associated with a height premium. Even when we control for family-level variables, all of the categories with the exception of occupations corroborate the findings described in Chapters 1 and 2. There are only minor differences between the results derived from the large sample of recruits linked by, among other data, state of birth and those from the small sample linked by county of birth. Of particular interest are the results indicating that those with foreign-born parents must have experienced substantial growth: enough to catch up with the average height of those with native-born parents. Evidently living standards in the US during the second half of the 19^{th}-century were sufficiently high that it took only one generation to eliminate the stature discrepancy between newcomers and other Americans.

References

Data:

National Archives and Records Administration. 7th and Pennsylvania Ave., NW, Washington, DC 20408-0001. Microfilm ID M233. Record Group 094. Register of Enlistments in the U.S. Army, 1798-1914. Vol 94 (96%), Vol 96 (100%), Vol 97(10%), Vol 98 (93%), Vol 100 (88%),Vol 102 (100%), Vol 103 (80%), Vol 104 (100%), Vol 105 (100%).

North Atlantic Population Project and Minnesota Population Center. 2008. *NAPP: Complete Count Microdata*. NAPP Version 2.0. Minneapolis, MN: Minnesota Population Center, 2008. http://www.nappdata.org

Literature:

A'Hearn, Brian. 2004. "A restricted maximum likelihood estimator for truncated height samples." *Economics and Human Biology,* 2: 5-19.

Becker, Gary, and Nigel Tomes. 1986. "Human Capital and the Rise and Fall of Families." *Journal of Labor Economics*, 4 (3): S1-39.

Bodnar, John. 1987. *The Transplanted: A History of Immigrants in Urban America.* Bloomington, IN: Indiana University Press.

Costa, Dora. 1993. "Height, Wealth, and Disease among the Native-born in the Rural, Antebellum North." *Social Science History*, 17 (3): 355-383.

Cole, T. J. 2000. "Galton's midparent height revisited." *Annals of Human Biology*, 27 (4): 401-405.

Duncan, Otis D. 1961. "A Socioeconomic Index for All Occupations." In: *Occupations and Social Status,* ed. A. J. Reiss, 109-161. Glencoe, NY: Free Press of Glencoe.

Ferrie, Joseph. 1996. "A New Sample of Males Linked from the Public Use Micro Sample of the 1850 US Federal Census of Population to the 1860 US Federal Census Manuscript Schedules." *Historical Methods,* 29: 141-156.

Fogel, Robert. 1994. "Economic Growth, Population Theory, and Physiology: the Bearing of Long-term Processes on the Making of Economic Policy." *American Economic Review,* 84: 369–395.

Frisancho, Robert A. 1990. *Anthropometric Standards for the Assessment of Growth and Nutritional Status.* Ann Arbor: University of Michigan Press.

Haines, Michael, Lee A. Craig, and Thomas Weiss. 2003. "The Short and the Dead: Nutrition, Mortality, and the 'Antebellum Puzzle' in the United States." *Journal of Economic History,* 63: 382-413.

Komlos, John. 1987. "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America." *The Journal of Economic History,* 47: 897-927.

Komlos, John. 2004. "Improvements in Maximum Likelihood Estimators of Truncated Normal Samples with Prior Knowledge of σ. A Simulation Based Study with Application to Historical Height Samples." *Discussion Paper LMU Munich.*

Komlos, John. 2008. "Stagnation of Heights Among Second-Generation U.S.-Born Army Personnel." *Social Science Quarterly,* 89 (2): 445-455.

Lantzsch, Jana, and Klaus Schuster. 2009. "Socioeconomic status and physical stature in 19th-century Bavaria." *Economics and Human Biology*, 7 (1): 46-54.

Lee, Chulhee. 1997. "Socioeconomic Background, Disease, and Mortality among Union Army Recruits: Implications for Economic and Demographic History." *Explorations in Economic History,* 34: 27-55.

Mincer, Jacob. 1958. "Investment in Human Capital and Personal Income Distribution." *The Journal of Political Economy*, 66 (4): 281-302.

Nam, Charles, and Monica Boyd. 2004. "Occupational Status in 2000; Over a Century of Census-Based Measurement." *Population Research and Policy Review*, 23 (4): 327-358.

Preston, Samuel H., and Michael Haines. 1991. *Fatal Years: Child Mortality in the Late Nineteenth-Century America*. Princeton, NJ: Princeton University Press.

Roberts, Evan, Matthew Woollard, Chad Ronnander, Lisa Y. Dillon, and Gunnar Thorvaldsen. 2003. "Occupational Classification in the North Atlantic Population Project." *Historical Methods,* 36 (2): 89-96.

Sobek, Matthew. 1996. "Work, Status, and Income: Men in the American Occupational Structure since the Late Nineteenth Century." *Social Science History*, 20 (2): 169-207.

Solon, Gary. 1992. "Intergenerational Income Mobility in the United States." *American Economic Review*, 82 (3): 393-408.

Steckel, Richard. 1983. "The economic foundations of East-West migration during the 19th century." *Explorations in Economic History*, 20 (1): 14-36.

Steckel, Richard. 1995. “Stature and the Standard of Living.” *Journal of Economic Literature,* 33 (4): 1903-1940.

Sunder, Marco. 2007. “Passports and Economic Development: An Anthropometric History of the U.S. Elite in the Nineteenth Century.” PhD diss. University of Munich.

Wilson, Sven, and Clayne Pope. 2003. “The Height of Union Army Recruits: Family and Community Influences.” In: *Health and Labor Force Participation over the Life Cycle: Evidence from the Past,* ed. Dora Costa, 113-146. Chicago: The University of Chicago Press.

Lebenslauf

Matthias Zehetmayer

Geburtsdatum: 10. 3. 1983

Geburtsort: München

Ausbildung

1989-1993	Grundschule Lochhausen
1993-1999	Gymnasium Gröbenzell
1999-2002	Ludwigsgymnasium München
2003-2008	Volkswirtschaftslehre (Diplom) LMU München

Beschäftigung

2009 - 2011	Wissenschaftlicher Mitarbeiter am Seminar für Wirtschaftsgeschichte, LMU München