CESifo WORKING PAPERS

8616
2020

October 2020

Nineteenth through early 20th Century Female and Male Statures within the Household

Scott Alan Carson

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 8616*

Nineteenth through early 20th Century Female and Male Statures within the Household

Abstract

When other measures for material conditions are scarce or unreliable, the use of height is now common to evaluate economic conditions during economic development. However, throughout US economic development, height data by gender have been slow to emerge. Throughout the late 19th and early 20th centuries, female and male statures remained constant. Agricultural workers had taller statures than workers in other occupations, and the female agricultural height premium was over twice that of males. For both females and males, individuals with fairer complexions were taller than their darker complexioned counterparts. Gender collectively had the greatest explanatory effect associated with stature, followed by age and nativity. Socioeconomic status and birth period had the smallest collective effects with stature.

JEL-Codes: C100, C400, D100, I100, N300.

Keywords: gender studies, stature by gender, economic transitions.

Scott Alan Carson
University of Texas, Permian Basin
4901 East University
USA – Odessa, TX 79762
Carson_S@utpb.edu

I appreciate comments from John Komlos, Tom Maloney, Lee Carson, and Paul Hodges. Shahil Sharma, Chinuedu Akah, Meekam Okeke, Ryan Keifer, Tiffany Grant, Bryce Harper, Greg Davis, Lee Carson, and Kellye Manning provided research assistance.

I. Introduction

Early resource allocation by gender—both within the household and economy—has received little attention, and measuring individual welfare during economic development using household income. Moreover, wealth is difficult because household income and wealth are shared resources that do not account for how resources are distributed to individuals within the household. When other measures for economic welfare are scarce or unreliable, stature reflects the net cumulative difference between calories consumed, and calories required for work and to withstand the physical environment. A population's average stature is high when calories are adequate relative to calories required for work, to withstand disease insults, and claims by the physical environment and are short when the opposite is true. Nonetheless, because few historical female records survive, most stature findings are for men in military units, which indicates little about the material or biological conditions facing women. Because female and male historical stature data of similar socioeconomic backgrounds is scarce, little is known about their statures compared by demographic, socioeconomic, and regional characteristics. Health and nutrition of US women during the 19^{th} and early 20^{th} centuries also offers insight into inter-family resource allocation, economic conditions, and health within the household (Fogel et al 1978; Komlos, 2012).

Throughout economic development, technological innovations changed the role of women, both within the economy and in the household, which altered gender-based comparative advantage and human-capital (Lunardini, 1997, pp. 95-96, 143-145; Floud et al 2011, pp. 35, 57, and 160; Moehling and Thomasson, 2020, p. 7). For example, technology altered the division of labor and the occupational opportunities available to women (Burnette, 2013, p. 309), and during the early years of US industrialization, textile mills recruited young, unmarried women to leave their parent's homes and farms to board and work in urban textile mills (Bessen, 2015, p. 224; Brand, 2010, p. 156). For the most part, young women were relatively less productive in agriculture and found work in the developing Northeast's urbanized textile industry (Goldin and Sokoloff, 1984; Bessen, 2015, p. 261), and wherever manufacturing spread, women and children's wages increased relative to men.

Nevertheless, not all of the improvements in the status of women relative to men were technological. By the late 19th century, political pressures extended to women's legal and political enfranchisement (Moehling and Thomasson, 2020). Virginia Miner—an early suffrage leader in the movement for Missouri gender equality—tried to vote in an 1872 Saint Louis County election. However, the county Registrar, Reese Happersett, denied her the right to vote because of her gender (Lunardini, 1997, pp. 102-104). With the help of her husband, Miner took her case to the Missouri Supreme Court, which held that women did not have the right to vote, escalating the dispute to the US Supreme Court. In 1874, the United States' Supreme Court upheld the lower court's decision in *Miner vs. Happersett.* Various suffrage movements followed, and by 1920, Carrie Chapman Catt and the National American Suffrage Association (NAWSA)—in combination with women's effort during World War I—contributed to passage of the 19th Amendment, giving women political enfranchisement. Nonetheless, economic, political, and legal integration were slow to follow, and women's material and nutritional welfare were slow to respond.

It is against this backdrop that this study considers three questions regarding women and men's cumulative net nutrition. First, how did female and male statures vary over time by gender? Men were taller than women, and female and male statures remained constant throughout the late 18th and early 20th centuries. Second, how did women and men's statures vary by socioeconomic status? Agricultural workers had taller average statures than workers in other occupations, and the female agricultural height premium was over twice that of males. Third, much has been written about 18th through 20th century stature variation by race, and women and men with fairer complexions were taller than individuals with darker complexions.

II. Health and Stature

A broad spectrum of health conditions are related to stature and skeletal remains, and stature reflects net nutrition among the living, while femur or long bone length reflect height and net nutrition among the dead (Fogel et al. 1978; Steckel and Rose, 2002; Stekel et al 2019). Among early patterns found in stature studies was that average heights decreased during the earliest years of industrialization, patterns known as the early industrial growth puzzle and antebellum paradox (Komlos, 1987; Fogel, 1986, p. 454, Figure 9.1; Steckel, 1994). Health and net nutritional conditions were also related to height variation. For example, anemia is the lack of healthy red blood cells in the circulatory system that leaves an individual tired and weak (Fogel, 1994, p. 370; Bollet and Brown, 2003, pp. 21-23), and anemia in both modern and historical populations is a primary nutritional stress related to iron deficiency (Bothwell, 1995; Papathausiou et al 2019). Anemia is also related to hemoglobin and sickle-cell, therefore, race. Iron deficiency also affects the skeletal system through cribia orbitalis, which are the active lesions localized in the orbital roof. Porotic hyperostosis is the spongy or porous bone tissue located around the cranial vault and reflects poor nutrition (Walker, 1986; Walker et al, 2009; Goodman and Martin, 2002, p. 28; Steckel, Schilli, and Rose, 2002, pp. 67-72). Poor net nutrition is also related to osteoarthritis and degenerative joint disease, which are progressive age related conditions with net nutrition that accounts for how adult stature decreases with age (Denko, 2003, pp. 234-236; Williams et al, 2019, p. 253; Adams and Dolan, 2005).[1]

Height as related to health is linked to mortality risk, and Waaler (1984) and Fogel (1994, pp. 378) illustrate that mortality risk is minimized for average male statures around 73 inches. Height is negatively related to all-source mortalities, which for women and men includes stroke, respiratory, and coronary heart mortalities (Walker et al. 1989; Palmer et al. 1990; Nwasokwa et al. 1997; Song et al. 2003; Yarnell et al., 1992; Davey-Smith et al, 2000, pp. 97-99; Leon et al. 1995). Similar relationships exist between height, stomach, and all source cancers, indicating there is a link between mortality and height. Because stature reflects the cumulative net nutrition available to women from their formative years, understanding 18th through early 20th century gender related stature variation and race throughout life sheds light on cumulative intra-family resource allocation. In addition, poor adolescent and childhood nutrition are related to later life health outcomes (Barker, 1992). For instance, shorter statures in early life are related to cognitive decline and dementia that may start during an adult's early 50s (Stewart, Hardy, and Richards, 2015; Beauchamp et al. 2009; Sundet et al. 2005). In sum, stature is related to net nutrition, cumulative health, and cognitive function in modern and historical populations.

III. Eighteenth through Early 20th Century Female and Male Stature Data

[1] Oral conditions related to health are dental caries, anti-mortem tooth loss, and linear enamel hypoplasia. Dental carries result because of poor oral hygiene but also from diets where carbohydrates are prominent and related to higher rates of dental caries (Ubelaker and Newson, 2002, pp. 356-359; Goodman and Martin, 2002, pp, 25-27, Bereczki et al, 2019, pp. 175-177). Ante mortem tooth loss also occurs when teeth are weakened by poor diets and tooth decay. Linear enamel hypoplasia is the failure of tooth enamel to develop correctly during formative years, is diet related, and is a measure for poor net nutrition related to skeletal development and height (Berecaki et al, 2019; Goodman and Martin, 2002).

Institutions in historical studies that randomly collected statures would have ideally collected height data under randomized controlled conditions. However, during early US economic development, these institutions were yet to develop. In the absence of historically randomized experiments, military and prison records are two sources used to evaluate historical height, and because of the number of male records that survive in military records, they are a primary source of data in stature studies. However, while plentiful, military records have various draw backs, such as being drawn exclusively from men, and individuals in higher socioeconomic groups who were less vulnerable to nutritional variation (Sokoloff and Villaflor, 1982, pp. 456-458; Ellis, 2004, p. 27; Coclanis and Komlos, 1995, p. 93; Meinzer et al, 2019, p. 239). Military records are also disproportionately drawn from individuals of European ancestry, and because women were not the focus of military physical requirements, military records offer no insight into 18th through early 20th century stature variation between genders. Fortunately, because of the size of the 18th through early 20th century US prison data, a sufficient number of females exist to be compared to males.

Prison records are an alternative to military data, and there are advantages to using prison compared to military data. For example, prison resources include both females and males, and because the purpose of military records was violence, prison records are at an advantage to military records in representing the general population (Steckel, 2000; Haines, et al, 2000). Nevertheless, prison records are not beyond reproach, and incarceration reflects material and biological conditions among lower socioeconomic groups, that segment of society most vulnerable to biological change (Ellis, 2004, p. 27; Carson, 2009; Carson, 2012; Sokoloff and Vilaflor, 1982, pp. 456-458; Bereczi et al. 2019, p. 190). Because inmates may have resorted to crime to survive, prison records may represent biological conditions among lower socioeconomic groups. Women also earned and accumulated less income and wealth than men and were unlikely to afford legal counsel at trial. Nevertheless, because prison records contain the greatest number of female statures, they are valuable resources when evaluating 18th through 20th century net nutritional conditions facing women and men.

Data to study 18th through 20th century female and male statures is part of an extensive effort to combine and collate historical heights using prison records (Carson, 2008; Carson, 2009c). The prison sample used in this study is composed of 22 state prisons: Arizona, California's Folsom and San Quinton, Colorado, Idaho, Illinois, Kansas, Kentucky, Maryland, Missouri, Mississippi, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania's East and West, Philadelphia, Tennessee, Texas, and Washington prisons. There are 7,682 females and 300,290 males, and women comprised about 2.5 percent of the US prison sample. In 1837 the Ohio State Prison was the first to construct an annex to house exclusively women, which was followed by New York in 1839, and the early perception of female prisoners was that they were threats to the moral foundations of society. During the earliest years of female incarceration, there were seldom female matrons, and physical and sexual abuse within prison were common (Irwin, 1987; Rafter, 1985).

Between the 1750s and early 1900s, prison enumerators recorded a broad set of personal characteristics, which include gender, birth period, complexion, nativity, decade received, age, and occupations. Because they had legal implications in case an individual escaped and was later recaptured, physical characteristics were recorded in detail. Prison records were recorded at the time an individual was incarcerated; subsequently, prison records represent pre-incarceration conditions and not physical or occupational conditions within prisons. Physical characteristics also helped identify individuals within prisons.

Race is inferred from a complexion variable, and women and men of African descent were recorded as black, dark-black, chocolate, and diverse shades of mulatto. Individuals of European ancestry were recorded as fair, white, light, medium, and dark. These European complexions are supported further because individuals claiming European nativity in US prisons were also recorded with the same fair, white, light, medium, and dark complexions. There were individuals of combined African and European ancestry who were recorded as mulattos. However, in the results that follow, women and men of combined African and European ancestry are referred to as 'mixed-race' (Carson, 2015b). There was also a considerable share of individuals of Mexican ancestry in US prisons (Carson, 2005; Carson, 2007; Carson, 2009, Carson, 2010; Carson, 2015a).

Prison enumerators recorded a broad set of occupations from which socioeconomic status is classified. Men from the clergy, government administrators, and physicians were recorded as white-collar workers. Males who reported their occupations as butchers, carpenters, and blacksmiths are recorded as skilled workers. Female white-collar and skilled workers were scarcer than males, and skilled women were typically in occupations that served the needs of other women (Burnette, 2013; Carson, 2018). For example, skilled female workers include nurses and dress-makers. Farmers, ranchers, and farm laborers are classified as farmers. Male laborers, cooks, and miners are classified as unskilled workers. Female unskilled workers were domestic servants, laborers, and cooks. A final category is included for individuals who recorded no decipherable or illegible occupation at the time of enumeration.

Over the 150 year span of this study, there are caveats when interpreting female and male occupations. Although occupations and job descriptions have changed considerably since the 19th century, there was less 18th and 19th century job displacement because households were typically employed as unskilled workers or in agriculture (Steckel, 1983; Rosenbloom, 2002, p. 88). Modern occupational distributions have also become less segregated along gender lines with technological change (Bleakley and Costa, 2013, pp. 5-10). However, during the 18th through early 20th centuries, because of physical strength requirements, labor market opportunities differed considerably along gender lines (Goldin, 1990; Burnette, 2013, p. 306; Marquez et al. 2019, p. 158).

Table 1, Female-Male Descriptive Statistics

	N	*Frequency*		*N*	*Frequency*
Gender			**Decade Received**		
Females	7,682	2.50	1800s	9	.00
Males	299,414	97.50	1810s	1,061	.35
Birth Decade			1820s	2,736	.89
1750s	91	.03	1830s	3,551	1.16
1760s	199	.06	1840s	4,141	1.35
1770s	417	.14	1850s	6,164	2.01
1780s	1,004	.33	1860s	18,449	6.01
1790s	2,200	.72	1870s	39,896	12.99
1800s	3,675	1.20	1880s	47,874	15.59
1810s	5,709	1.86	1890s	63,302	20.61
1820s	8,678	2.83	1900s	58,121	18.93
1830s	16,057	5.23	1910s	49,416	16.09
1840s	32,323	10.53	1920s	7,848	2.56
1850s	49,842	16.23	1930s	3,579	1.17
1860s	54,853	17.86	1940s	949	.31
1870s	58,871	19.17	**Ages**		
1880s	43,508	14.17	Teens	43,565	14.19
1890s	23,795	7.75	20s	153,623	50.02
1900s	4,702	1.53	30s	65,389	21.29
1910s	1,172	.38	40s	28,281	9.21
Ethnicity			50s	11,658	3.80
Black	58,915	19.18	60s	3,815	1.24
Mexican	3,196	1.04	70s	691	.23
Mulatto	38,832	12.64	80s	74	.02
White	206,153	67.13	**Occupations**		
Nativity			White-Collar & Skilled	93,151	30.33
Europe	19,436	6.33	Farmer	35,262	11.48
Great Britain	16,220	5.28	Unskilled	142,856	46.52
US, Far West	8,614	2.80	No Occupation	35,827	11.67
US, Great Lakes	46,186	15.04	Total	307,096	100.00
US, Middle Atlantic	54,982	17.90			
US, Northeast	5,531	1.80			
US, Plains	36,465	11.87			
US, Southeast	83,675	27.25			

US, Southwest	35,987	11.72

Sources: Arizona State Library, Archives and Public Records, 1700 W. Washington, Phoenix, AZ 85007; Colorado State Archives, 1313 Sherman Street, Room 120, Denver, CO 80203; Idaho State Archives, 2205 Old Penitentiary Road, Boise, Idaho 83712; Illinois State Archives, Margaret Cross Norton Building, Capital Complex, Springfield, IL 62756; Kentucky Department for Libraries and Archives, 300 Coffee Tree Road, Frankfort, KY 40602; Missouri State Archives, 600 West Main Street, Jefferson City, MO 65102; William F. Winter Archives and History Building, 200 North St., Jackson, MS 39201; Montana State Archives, 225 North Roberts, Helena, MT, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, Nebraska, 68501; New Mexico State Records and Archives, 1205 Camino Carlos Rey, Santa Fe, NM 87507Oregon State Archives, 800 Summer Street, Salem, OR 97310; Pennsylvania Historical and Museum Commission, 350 North Street, Harrisburg, PA 17120; Philadelphia City Archives, 3101 Market Street, Philadelphia, PA 19104; Tennessee State Library and Archives, 403 7th Avenue North, Nashville, TN 37243; Texas State Library and Archives Commission, 1201 Brazos St., Austin TX 78701; Utah State Archives, 346 South Rio Grande Street, Salt Lake City, UT 84101; Washington State Archives, 1129 Washington Street Southeast, Olympia, WA 98504.

Whites were predictably the most common racial group; however, women and men of African descent were over represented in US prisons relative to the general public (Table 1; Carson, 2018a; Rafter, 1985; Steckel, 2000, Table 10.1, p. 435; Haines, 2000, Table 8.1, p. 306). Black over-representation in the prison sample may, in part, reflect vagrancy laws enacted during the years immediately after emancipation to prevent former slaves from exiting the labor force (Brands, 2010, p. 156). The most common US nativity was the South. While there were substantial proportions native to the Great Lakes and Middle Atlantic, there were small proportions native to the Far West and Northeast. Individuals from Europe and Great Britain were sizable cohorts in US prisons. Most individuals were born during the 1870s and observed in the 1890s. Whether it was from low income, little wealth, and human capital or because of law enforcement targeting, younger individuals were more likely to be incarcerated in their 20s and 30s (Hirschi and Gottfredson, 1983; Gottfredson and Hischi, 1990; Carson, 2009a; Carson 2018b; Baten and Steckel, 2019; Baten et al, 2014). Low skilled individuals were predictably the most likely to be incarcerated, while farmers were the least likely to be incarcerated. Subsequently, relative to workers in the general population, farmers are underrepresented in the prison sample, while unskilled laborers were over represented (Rosenbloom, 2002, p. 88).

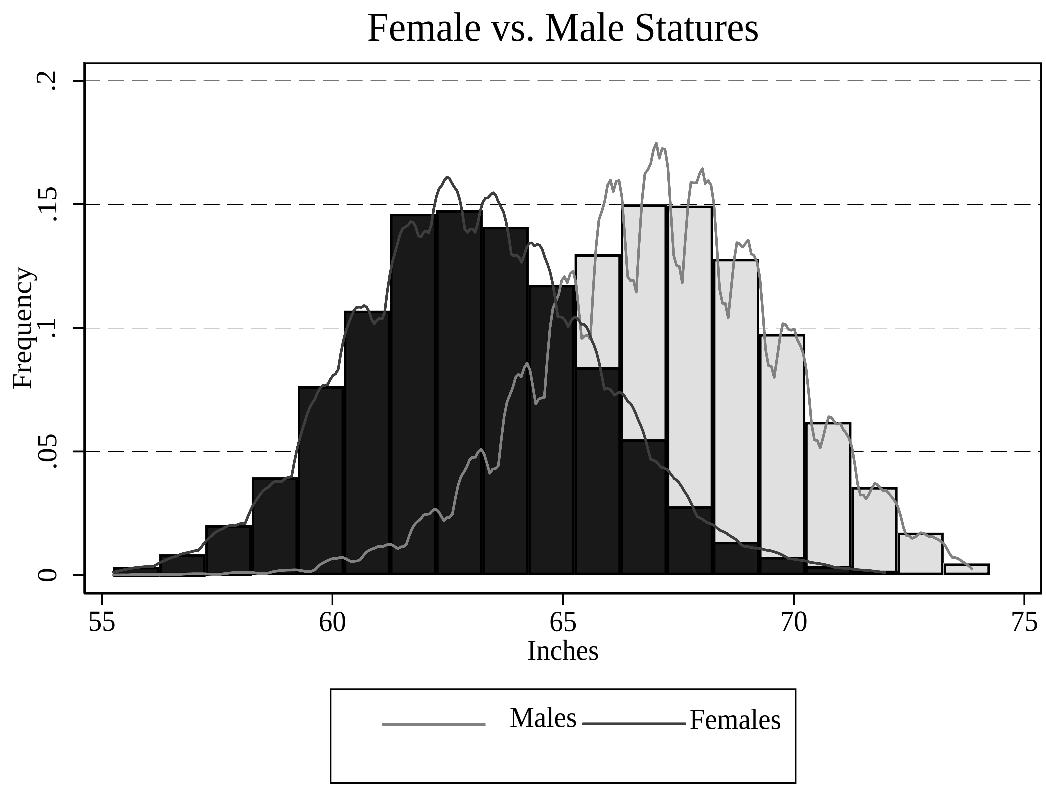

Figure 1, Late 18th through Early 20th Century Women and Men's Height

Source: See Table 1.

Between 1803 and 1946, female average stature was 160.10 centimeters, and male average stature was 170.80 centimeters, indicating males were over 10 centimeters taller than females (Figure 1; Gray and Wolfe, 1980; Frayer and Wolpoff, 1985). However, women's stature standard deviation was greater than men, 7.11 to 6.84 centimeters. Female and male height distributions were also symmetric, indicating they were not affected by a truncation bias present in military samples (Sokoloff and Vilaflour, 1982, p. 456; Komlos and Kim, 1990).

Stature Coefficient of Variations and Gini Coefficients are used to illustrate cumulative net nutrition inequality (Morodi and Baten, 2005). To the extent that stature inequality represents material inequality, the male stature Gini Coefficient was .0223, and the female stature Gini Coefficient was .0244. The male stature Coefficient of Variation was .04006, and the female Coefficient of Variation was .04438; however, statures are genetically determined and are less responsive than other measures for inequality and are interpreted with caution. Subsequently, males were taller than females, whites were taller than blacks, and stature inequality between females and males was similar.

IV. Eighteenth through Early 20th Century Female and Male Statures by Characteristics

Women and men's 18th through 20th century statures are now regressed on demographic characteristics, complexion, age, nativity, birth decade, and socioeconomic status.

$$Centimeters_i = \alpha + \beta_f Female_i + \sum_{c=1}^{3} \beta_c Complexion_i + \sum_{a=1}^{15} \beta_a Age_i + \sum_{n=1}^{8} \beta_n Nativity_i$$

$$+ \sum_{t=1750}^{1910} \beta_t BirthYear_i + \sum_{l=1}^{3} \beta_l Occupation_i + \varepsilon_i$$

A binary female gender variable is included to account for the female-male stature difference (Gray and Wolfe, 1980; Frayer and Wolpoff, 1985; Floud et al, 2011, p. 299). Black, mixed-race, and Mexican race dummy variables are included to account for how stature and net nutrition variation by complexion and race (Steckel, 1979). Annual youth age dummy variables are included to account for female and male adolescent stature growth. Adult decade age dummy variables are included to account for how statures varied in older ages (Carson, 2015b; Williams et al, 2019, p. 253; Goodman and Martin, 2002, p. 44). There are two ways net nutrition is measured over time. Measured by birth year, biological measures reflect how individuals in the same birth cohort experience similar net nutritional conditions throughout life. Measured by current period, stature reflects how various groups experience the same biological conditions for the same period of measurement (Carson, 2019, p. 32). Because stature growth had mostly ceased for women and men in their early 20s, statures are measured by birth year. Occupations reflect socioeconomic status, and five occupation variables are included: white-collar, skilled, farmers, unskilled, and workers without occupations.

Table 2's Model 1 includes both female and male statures. Model 2 includes only female statures, while Model 3 includes only male statures. To compare how net nutritional conditions varied throughout life by race, Models 4 and 5 include only individuals of European and African ancestry.

Table 2, Female-Male Stature Regressions, 1750-1820

	Total	*Female*	*Male*	*White*	*Black*
Intercept	170.54***	161.61***	170.54***	170.57***	168.35***
Gender					
Female	-9.73***			-10.28***	-9.28***
Male	Reference			Reference	Reference
Complexion					
Mexican	-4.99***	-2.04***	-5.01***		
Black	-1.83***	-1.02***	-1.86***		Reference
Mulatto	-1.43***	-1.06***	-1.44***		.437***
White	Reference	Reference	Reference		
Ages					
14	-12.13***	-6.92***	-12.52***	-14.03***	-11.67***
15	-8.19***	-3.24***	-8.53***	-8.52***	-7.81***
16	-5.26***	-2.86***	-5.41***	-5.44***	-5.15***
17	-3.33***	-1.38***	-3.42***	-3.24***	-3.36***
18	-2.17***	-1.20***	-2.20***	-2.00***	-2.44***
19	-1.25***	-.951***	-1.26***	-1.13***	-1.44***
20	-.648***	-.865**	-.640***	-.645***	-.598***
21	-.295***	-.611*	-.289***	-.240***	-.446***
22	-.190***	-.521	-.183***	-.132**	-.241***
23-29s	Reference	Reference	Reference	Reference	Reference
30s	.090***	.660***	.081**	.072*	.172**
40s	-.287***	.030	-.293***	-.213***	-.376***
50s	-.781***	1.25**	-.825***	-.700***	-.944***
60s	-1.52***	.248	-1.56***	-1.45***	-1.62***
70s	-1.99***	-4.76***	-2.01***	-1.78***	-2.34***
80s	-4.21***	-2.21^{-4}	-4.42***	-5.09***	-2.73***
Nativity					
Europe	-2.51***	-4.92***	-2.49***	-2.54***	-1.62***
Britain	-1.58***	-2.57***	-1.55***	-1.59***	-.363
Northeast	Reference	Reference	Reference	Reference	Reference
Far West	.859***	-.848	.890***	.819***	.724*
Great Lakes	1.15***	.659	1.16***	1.14***	1.22***
Middle Atlantic	-.649***	-1.48*	-.624***	-.585***	-.768**
Plains	1.32***	1.18	1.32***	1.50***	.526
Southeast	1.79***	1.02	1.80***	2.02***	1.37***
Southwest	2.98***	1.17	3.03***	2.75***	3.09***
Birth Year					
1750s	.698	-2.60**	.787	-1.44	2.95**
1760s	1.25**	-1.49	1.45***	.892	1.88**
1770s	1.44***	-1.67*	1.78***	1.17***	1.91***
1780s	1.23***	-1.05	1.49***	1.05***	1.47***
1790s	1.09***	-.292	1.15***	1.24***	.801***
1800s	.890***	-1.08**	.969***	1.04***	.575***

1810s	.943***	-.814	.992***	.990***	.693***
1820s	.762***	-1.47***	.826***	.837***	.301
1830s	.265***	-1.49***	.311***	.274***	.060
1840s	.078*	-1.25***	.109**	.091*	-.192*
1850s	.060	-1.56***	.095**	-.084*	.259***
1860s	.224***	-.206	.234***	.110**	.258***
1870s	Reference	Reference	Reference	Reference	Reference
1880s	-.099**	-.281	-.094**	.086	-.261***
1890s	.197***	-.412	.220***	.353***	-.076
1900s	1.15***	1.07	1.18***	1.14***	-.280
1910s	3.32***	4.16**	3.34***	3.08***	4.65
Occupations					
White-Collar & Skilled	.181***	.795***	.154***	.135**	.524***
Farmer	1.48***	4.02***	1.46***	1.48***	1.66***
Unskilled	.349***	.226	.341***	.331***	.863***
No Occupations	Reference	Reference	Reference	Reference	Reference
RMSE	6.55	6.83	6.54	6.44	6.77
R^2	.1359	.0812	.0857	.1119	.1648
N	307,096	7,682	299,414	206,153	87,479

Sources: See Table 1.

Notes: *** Significant at .01; **Significant at .05; * significant at .10.

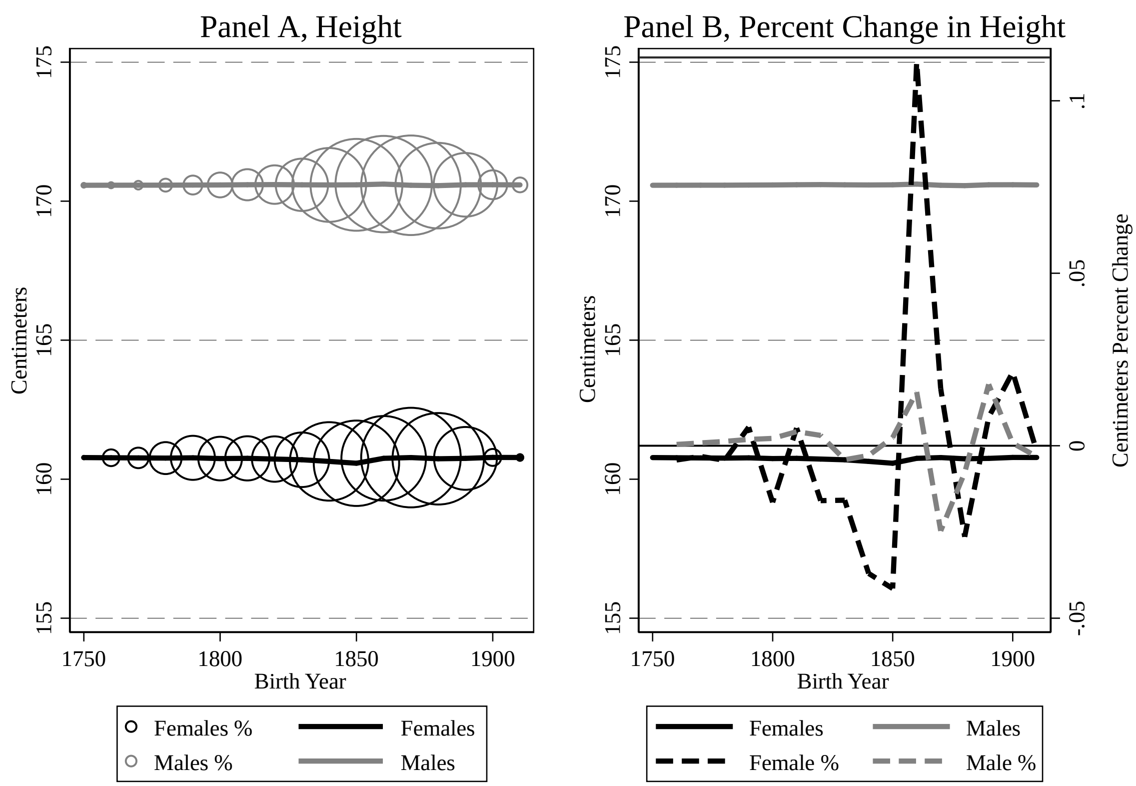

Figure 2, Male vs. Female Stature by Birth Year

Source: See Tables 1 and 2.

Three paths of inquiry are considered when comparing 18th through 20th century female and male stature variation. First, the antebellum paradox is the contradictory result that male statures ironically decreased during the 19th century's second and third quarters at the same time that wages and income monotonically increased (Libergott, 1984; Komlos, 1987; Bogart, 2009). However, this antebellum paradox and early growth puzzle have come under recent criticism that indicates stature variation is the result of selection bias (Bodenhorn, Guinine, and Mroz, 2017). Nevertheless, selection was an important concern in early stature studies, and recent criticisms fail to account for an urbanization penalty across various studies and periods (Komlos, 2019;

Carson, 2008b; Komlos and A'Hearn, 2017; Komlos, 2019; Carson, 2020). Little is known about how women and men's statures in the US compared before the 19th century, and to illustrate how net nutrition varied over time, stature trends in Figure 2 are presented with bubble figures, where circles represent proportional sample size (Carson, 2011; Carson, 2013). Eighteenth through 20th century female and male statures remained approximately constant. Prior to the Civil War, female's stature percent decrease was greater than males and was larger at the end of the antebellum period. Male statures remained mostly constant throughout the 19th through early 20th centuries, and there was little convergence between female and male statures (Figure, 2). Subsequently, males were taller than females, and female antebellum stature percent changes were greater than males, indicating that women experienced greater net cumulative nutritional variation within the economy and the household. Collective stature variation is segregated into choice and non-choice characteristics, and stature variation over time is mostly a non-choice characteristic. The birth-year restricted F-statistic is F(16, 307,049)=48.09, p=.000, indicating that birth years were collectively related for women and men, and birth period had a collective effect on stature variation.

Second, women and men classified as farmers had taller statures and superior net nutrition than workers in other occupations (Atack and Bateman, 1987, pp. 63-64). Moreover, the female farmer stature advantage was over twice that of males, whereas it was small and insignificant for women in other occupations. Two explanations account for taller agricultural worker statures relative to workers in other occupations. Agricultural workers may have been taller because rural agricultural lifestyles created greater access to diets rich in complex carbohydrates and animal proteins, which were associated with low disease burdens because they were in sparsely populated regions where disease is less likely spread (Carson, 2010b; Carson, 2020). Alternatively, farmers and agricultural workers were taller because agricultural occupations required greater strength and size to bear physical routines where size and strength were required (Margo and Steckel, 1992, p. 518; Steckel and Haurin, 1994, p. 122). Because women and men in rural agricultural areas were in close proximity to nutrition rich in animal proteins, farmers and agricultural workers were taller than workers in other occupations, indicating there were biological benefits to both female and male agricultural workers, taller female agricultural workers because there were positive cumulative net nutritional benefits that accrued to agricultural occupations related to rural agricultural lifestyles.

White-collar and skilled workers had taller statures than workers with no listed occupation, and the effect of female white-collar and skilled worker's stature advantage was over five times the male white-collar and skilled advantage. However, unskilled female statures were about the same as women with no occupation, while the male unskilled effect was significant and greater than the male white-collar and skilled stature advantage. The black male white-collar and skilled occupational effect was nearly four times the size as the white male white-collar and skilled effect. The black unskilled stature effect was over twice the magnitude of the white unskilled stature effect. Women and men's statures were collectively related to socioeconomic status, and the occupation restricted F-statistic is $F(3, 307{,}479)=385.89$, indicating there was a collective effect between stature and socioeconomic status.

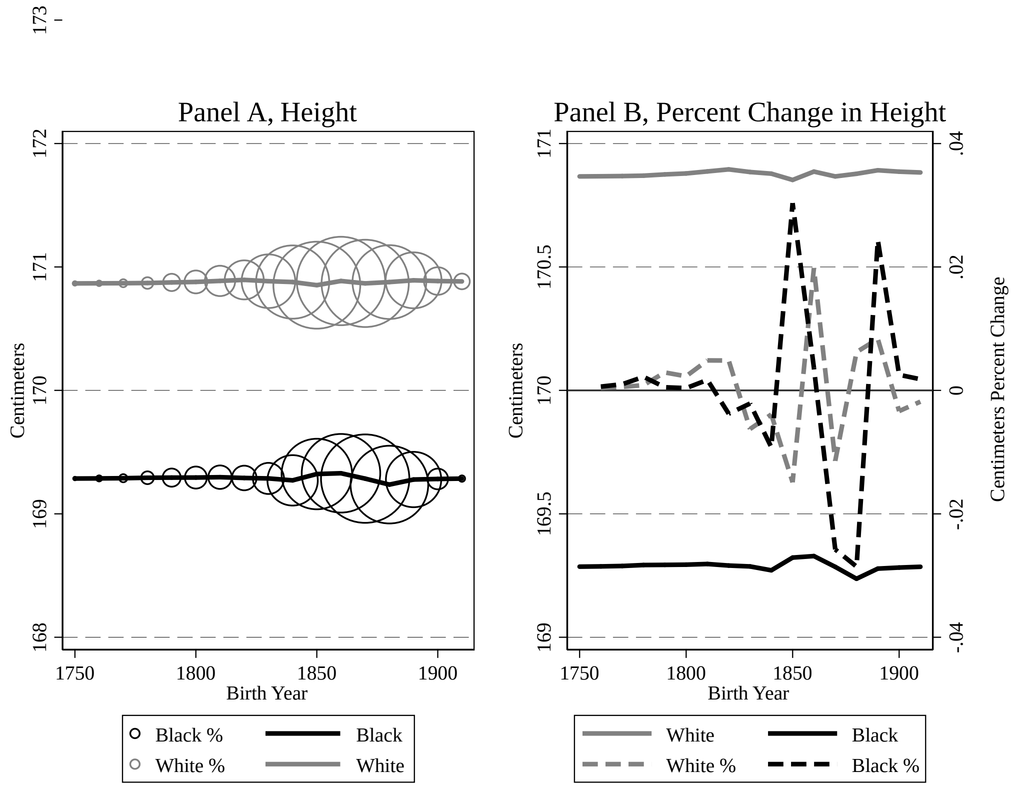

Figure 3, White vs Black Male Stature

Source: See Tables 1 and 2.

Third, height and net nutrition varied by race, and Steckel (1979) was the first to find that individuals with fairer complexions were taller than individuals with darker complexions (Figure 3). Bodenhorn (2002) attributes the stature difference to 19th century social preferences that disproportionately favored individuals with fairer complexions. However, if whites were taller than blacks because of social preferences, whites should have had greater BMIs and heavier weights than workers with darker complexions. However, the opposite is true, and individuals with darker complexions consistently had higher BMIs and heavier weights (Carson, 2009;

Carson, 2012; Carson, 2015).[2] Statures were also collectively related to race, and the race restricted F-statistic is F(3, 307,049), p=.000.

Other patterns are consistent with expectations. Net nutrition varied with respect to macro-nutrients, which reflect regional crop variation and animal husbandry (Carson, 2020). The Northeast and Middle Atlantic were agriculturally productive in dairy but lagged behind other regions in corn, wheat, pork, and beef production (Hilliard, 1972, pp. 135, 156, 166, 94, and 114; Carson, 2020, Atack and Bateman, 1987; Brands, 2010, p. 202). Statures and net nutrition similarly varied regionally by gender, and whites from the Plains and South were taller than blacks. There was little female regional stature variation. Statures were collectively related to nativity, and the nativity restricted F-statistic is F(8, 307,049)=1,414.07, indicating that women and men's statures were collectively related to nativity.

V. Sensitivity Analysis and Collective Marginal Effects

Female and male statures are sensitive to choice and non-choice characteristics. For example, occupations and residence are two characteristics over which individuals exercise considerable control, while gender, race, and age are characteristics individuals have no control. Multiple restriction F-tests assess the statistical significance of a restricted set of variables, and observable gender, race, age, demographic, and socioeconomic variables were collectively related to 18th through 20th century statures. F-statistics do not, however, provide the magnitude for the collective restricted cohorts (Miller, 2005, pp. 37-38). The relative importance of each collective group is the change in the sum of squares regression when a restricted set of variables

[2] Various explanations clarify why individuals with fairer complexions had higher BMIs and weight than whites. For example, with emancipation, freed slaves devoted a higher share do the household wealth compared to whites and the acquisition of food (Higgs, 1977, p. 105); however, black diets included more fat-back pork.

is restricted to illustrate the relative magnitude of a characteristics effect (Miller, 2005, pp. 37-38). SSR_{ur} and SSR_r are unrestricted and restricted sum of squares regression; SSE_{ur} and SSE_r are unrestricted and restricted sum of squared errors. R_r^2 and R_{ur}^2 are restricted and unrestricted coefficients of determination.

Table 3, Female-Male Stature Sensitivity Analysis by Demographic, Socioeconomic Status, and Birth Decade

	Total	*Gender*	*Complexion*	*Ages*	*Nativity*	*Birth Year*	*Occupations*
Intercept	170.54***	170.28***	170.00***	169.79***	171.26***	170.75***	170.84***
Gender							
Female	-9.73***		-10.03***	-9.99***	-9.85***	-9.67***	-9.84***
Male	Reference		Reference	Reference	Reference	Reference	Reference
Complexion							
Mexican	-4.99***	-4.88***		-4.86***	-3.07***	-4.98***	-5.06***
Black	-1.83***	-2.08***		-2.01***	-.883***	-1.80***	-1.88***
Mulatto	-1.43***	-1.63***		-1.65***	-.572***	-1.80***	-1.49***
White	Reference	Reference		Reference	Reference	Reference	Reference
Ages							
14	-12.13***	-12.41***	-12.60***		-12.06***	-12.11***	-12.24***
15	-8.19***	-8.50***	-8.52***		-8.09***	-8.18***	-8.25***
16	-5.26***	-5.59***	-5.46***		-5.11***	-5.25***	-5.28***
17	-3.33***	-3.52***	-3.43***		-3.22***	-3.32***	-3.35***
18	-2.17***	-2.30***	-2.24***		-2.07***	-2.14***	-2.17***
19	-1.25***	-1.33***	-1.29***		-1.21***	-1.24***	-1.26***
20	-.648***	-.722***	-.670***		-.558***	-.627***	-.649***
21	-.295***	-.320***	-.306***		-.224***	-.286***	-.290***
22	-.190***	-.216***	-.209***		-.131**	-.190***	-.186***
23-29s	Reference	Reference	Reference		Reference	Reference	Reference
30s	.090***	.071**	.146***		.063*	.111***	.096***
40s	-.287***	-.266***	-.225***		-.311***	-.197***	-.248***
50s	-.781***	-.681***	-.702***		-.652***	-.601***	-.714***
60s	-1.52***	-1.34***	-1.42***		-1.23***	-1.21***	-1.43***
70s	-1.99***	-1.64***	-1.87***		-1.37***	-1.49***	-1.90***
80s	-4.21***	-3.92***	-3.93***		-3.36***	-3.49***	-4.19***
Nativity							
Europe	-2.51***	-2.49***	-2.41***	2.46***		-2.56***	-2.48***
Britain	-1.58***	-1.65***	-1.43***	-1.55***		-1.54***	-1.61***

Northeast	Reference	Reference	Reference	Reference		Reference	Reference
Far West	.859***	.817***	.827***	.752***		.798***	.977***
Great Lakes	1.15***	1.07***	1.12***	1.10***		1.05***	1.28***
Middle Atlantic	-.649***	-.849***	-.780***	-.720***		-.613***	-.633***
Plains	1.32***	1.20***	1.05***	1.36***		1.30***	1.49***
Southeast	1.79***	1.83***	.913***	1.73***		1.68***	1.89***
Southwest	2.98***	2.96***	1.79***	2.81***		2.86***	3.23***
Birth Year							
1750s	.698	.561	.053	-.505	-1.89**		.763
1760s	1.25**	-.379	.751	.763	-.911*		1.36***
1770s	1.44***	.324	1.07***	1.34***	-.381		1.52***
1780s	1.23***	.135	.809***	1.44***	-.601***		1.34***
1790s	1.09***	.156	.733***	1.14***	-.675***		1.20***
1800s	.890***	.448***	.644***	.878***	-.756***		.960***
1810s	.943***	.692***	.902***	.824***	-.455***		.955***
1820s	.762***	.591***	.823***	.722***	-.448***		.772***
1830s	.265***	.154**	.359***	.367***	-.768***		.283***
1840s	.078*	-.004	.165***	.253***	-.640***		.080*
1850s	.060	.075*	.140***	.121***	-.294***		.040
1860s	.224***	.264***	.236***	.274***	.045		.226***
1870s	Reference	Reference	Reference	Reference	Reference		Reference
1880s	-.099**	-.130***	-.072*	-.137***	.006		-.102**
1890s	.197***	.192***	.292***	-.095*	.495***		.225***
1900s	1.15***	1.27***	1.26***	.638***	1.45***		1.24***
1910s	3.32***	3.45***	3.56***	3.42***	3.67***		3.39***
Occupations							
White-Collar & Skilled	.181***	.502***	.642***	.691***	-.022	.171***	
Farmer	1.48***	1.89***	1.93***	1.86***	1.98***	1.51***	
Unskilled	.349***	.495***	.582***	.673***	.434***	.316***	
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference	

RMSE	6.55	6.72	6.61	6.67	6.68	6.56	6.57
R^2	.1359	.0908	.1214	.1054	.1031	.1338	.1327
N	307,096	307,096	307,096	307,096	307,096	307,096	307,096

Source: See Table 1.

Notes: *** Significant at .01; **Significant at .05; * significant at .10.

$$\%\Delta SSR = \frac{SSR_r - SSR_{ur}}{SSR_u} = \frac{SSE_{ur} - SSE_r}{SST - SSE_{ur}} = \frac{R_r^2 - R_{ur}^2}{R_{ur}^2} = \%\Delta R^2$$

The stature magnitude difference between choice and non-choice characteristics are calculated by comparing restricted and unrestricted percentage changes in R^2. The R^2 percentage reduction when gender is excluded had the greatest reduction of -33.19 percent, followed by nativity at -24.14 percent, and age at -22.44 percent. Race and complexion, while still considerable, had less of a collective effect with stature variation with a -10.67 percent R^2 reduction. Socioeconomic status and birth year had the smallest effects with percent R^2 reductions of -2.36 and -1.55 percent, indicating there were small collective stature effects for socioeconomic status and birth. In sum, after controlling for demographic and socioeconomic effects, gender has the greatest collective explanatory effect with stature variation, followed by age, nativity, race, socioeconomic status, and birth year.

VI. Accounting for the Differences between Structural and Compositional Effects

Female-male stature decompositions are now used to assess how stature differences were attributable to returns to characteristics versus average characteristics. A Blinder-Oaxaca decomposition is a statistical technique used to partition the difference between two dependent variables into characteristic stature returns and average characteristic differences.

Gender

Let S_m and S_f be male and female statures. β_m and β_f are structural sensitivity coefficients that reflect how male and female statures responded to changes in characteristics, whereas X_m and X_f are male and female average characteristic matrices. Because males are genetically taller than females due to genetics and sexual dimorphism, males are classified as the base structure (Gray and Wolfe, 1980; Frayer and Wolpoff, 1985; Floud et al, 2011, p. 299).

$$S_m = \alpha_m + \beta_m X_m \qquad \text{(Equation 1)}$$

and

$$S_f = \alpha_f + \beta_f X_f \qquad \text{(Equation 2)}$$

The male-female stature gap is the difference between Equations 1 and 2.

$$\Delta S = S_m - S_f = \alpha_m + \beta_m X_m - \alpha_f - \beta_f X_f \qquad \text{(Equation 3)}$$

The Oaxaca decomposition is evaluated relative to a counterfactual. Equation 4 is male stature returns observed at female characteristics, while Equation 5 is female stature returns observed at average male characteristics.

$$\beta_m X_f - \beta_m X_f = 0 \qquad \text{(Equation 4)}$$

and

$$\beta_f X_m - \beta_f X_m = 0 \qquad \text{(Equation 5)}$$

Equation 6 is the male-female stature decomposition for male stature returns observed at female characteristics and is constructed by adding Equation 4 to Equation 3. Equation 7 is the male-female stature decomposition for female stature returns observed at male characteristics and constructed by adding Equation 5 to Equation 3.

$$\Delta S = S_m - S_f = \left(\alpha_m - \alpha_f\right) + \left(\beta_m - \beta_f\right) X_f + \beta_m \left(X_m - X_f\right) \qquad \text{(Equation 6)}$$

$$\Delta S = S_m - S_f = \left(\alpha_m - \alpha_f\right) + \left(\beta_m - \beta_f\right) X_f + \beta_m \left(X_m - X_f\right) \qquad \text{(Equation 7)}$$

Table 4, Late Eighteenth through Early 20th Century Female-Male Stature Decompositions

	Structural	**Composition**	**Structural**	**Composition**
Panel A	$(\beta_m - \beta_f)X_m$	$(X_m - X_f)\beta_f$	$(\beta_m - \beta_f)X_f$	$(X_m - X_f)\beta_m$
Levels				
Sum	9.65	1.02	9.73	.930
Total		10.66		10.66
Proportions				
Intercept	.838		.838	
Complexion	-.023	.029	-.040	.046
Ages	-.031	.015	-.051	.036
Nativity	.088	-.005	.083	-4.44^{-4}
Birth Year	.075	.050	.089	-.007
Occupations	-.042	.095	-.004	.013
Sum	.905	.095	.913	.087
Total		1		1
	Structural	**Composition**	**Structural**	**Composition**
Panel B				
Levels	$(\beta_w - \beta_b)X_w$	$(X_w - X_b)\beta_b$	$(\beta_w - \beta_b)X_b$	$(X_w - X_b)\beta_w$
Sum	2.01	-.310	2.23	-.532
Total		1.70		1.70
Proportions				
Intercept	1.31		1.31	
Gender	-.009	.187	-.029	.207
Ages	.029	.210	.029	.210
Nativity	.038	-.594	.190	-.747
Birth Year	.048	.023	.054	.017
Occupations	-.229	-.008	-.236	-2.40^{-4}
Sum	1.18	-.182	1.31	-.313
Total		1		1

Source: See Table 1 and Table 2.

Average male stature was greater than females, and the greatest source of gender-based male stature advantage was in unobserved differences in the intercept, which includes differences in genetics, nutrition, and income (Gray and Wolf, 1980; Frayer and Wolpoff, 1985). Nativity stature returns had the greatest explanatory effect across genders, followed by birth years. However, gender-based compositional effects by nativity were small, and there were large stature return differences by birth year, indicating gender-based nativity returns were greater for males than females.

Complexion

Statures are also decomposed by complexion. Because whites are, on average, taller than blacks, whites are assigned the base structure (Steckel,1979; Carson, 2009).

$$S_w = \alpha_w + \beta_w X_w \qquad \text{(Equation 8)}$$

$$S_b = \alpha_b + \beta_b X_b \qquad \text{(Equation 9)}$$

The white-black stature gap is the difference between Equations 8 and 9.

$$\Delta S = S_w - S_b = \alpha_w + \beta_w X_w - \alpha_b - \beta_b X_b \qquad \text{(Equation 10)}$$

Equation 11 is white stature returns evaluated at black characteristics, and Equation 12 is black stature returns evaluated at average white characteristics.

$$\beta_w X_b - \beta_w X_b = 0 \qquad \text{(Equation 11)}$$

$$\beta_b X_w - \beta_b X_w = 0 \qquad \text{(Equation 12)}$$

Equation 13 is the white-black stature decomposition for white returns to characteristics observed at average black characteristics. Equation 14 is the white-black stature decomposition for black returns to characteristics observed at average black characteristics.

$$\Delta S = S_w - S_b = (\alpha_w - \alpha_b) + (\beta_w - \beta_b) X_b + (X_w - X_b) \beta_w \qquad \text{(Equation 13)}$$

$$\Delta S = S_w - S_b = (\alpha_w - \alpha_b) + (\beta_w - \beta_b) X_w + (X_w - X_b) \beta_b \qquad \text{(Equation 14)}$$

White statures were taller than blacks, and the greatest source of the race-based white stature advantage was in the unobserved intercept differences, which includes differences in genetics, nutrition, and income. Black socioeconomic structural returns were considerably greater than whites, with little difference in compositional returns, indicating gender-based socioeconomic returns were associated with large socioeconomic returns to black social status. Whites, on the other hand, had the greatest stature returns associated with birth year, nativity, and age. Nevertheless, there were large white gender-based differences to compositional effects, indicating the white stature advantage by birth year, nativity, and age were associated more with sample composition and were less causal.

VII. Conclusion

Little work in economics considers historical net nutrition and inequality by gender as development occurred. Household resources are shared resources, which masks how resources were allocated within the household. As a result, during early economic development, average stature may be a better indicator for female material wealth because it reflects how net nutrition accrued to persons within the household and does not mask aggregated household wealth effects.

Women were shorter than men, and black women were shorter than white women. Through the late 18th through early 20th centuries, female and male statures remained constant, and agricultural workers had taller statures than workers in other occupations. The female agricultural stature advantage was over twice that of males. Much has also been written about stature variation by complexion, and fairer complexioned individuals were taller than individuals with darker complexions. One explanation is that late 18th through 20th century social preferences disproportionately favored individuals with fairer complexions because of social preferences. However, individuals with darker complexions had greater BMIs and heavier weights, indicating that 18th and 19th century social preferences are an unlikely explanations for taller statures for individuals with fairer complexions. Moreover, to the degree that stature represents inequality, women's stature inequality was greater than men, indicating that shared resources within the household were distributed less equitably for women than men.

References

Adams, M. A. and P. Dolan. (2005). "Spine Biomechanics." *Journal of Biomechanics*. 38(10), pp. 1972-1983.

Atack, Jeremy and Fred Bateman, (1987). *To Their Own Soil: Agriculture in the Antebellum North.* Ames, Iowa: Iowa State University Press,

Barker, D. (1992). *Fetal and Infant Origins of Adult Disease.* (London: British Medical Journal).

Baten, Joerg, Winny Bierman Jan Luiten van Zanden, Peter Foldvari. (2014). "Personal Security since 1820." *How Was Life? Global Well-being since 1820.* Access the complete publication at: http://dx.doi.org/10.1787/9789264214262-en

Baten, Joerg and Richard Steckel. (2019). "The Developmental Origins of Health and Disease." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 300-324.

Beachamp, Jonathon, David Cesariri, Mangus Joehannesson, Erik Lindquist, and Coren Apicella. (2011). "On the Sources of Height-Intelligence Correlation: New Insights from a Bivariate ACE Model with Assertive Mating." *Behavioral Genetics* 41, pp. 242-252.

Bereczki, Zsolt, Maria Reschler-Nicola, Atonia Marcsik, Nicholas Meinzer and Joerg Baten. (2019). "Growth Disruption in Children: Linear Enamel Hypoplasias." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe.* Cambridge: Cambridge University Press, pp. 175-197.

Bessen, James (2015). *Learning by Doing: The Real Connection between Innovation, Wages, and Wealth.* New Haven: Yale University Press.

Bleakley, Hoyt and Dora Costa. (2013). "Health, Education, and Income in the United States, 1820-2000." National Bureau of Economic Research.

Bodenhorn, Howard. (2002) "Mulatto Advantage: The Biological Consequences of Complexion in Rural Antebellum Virginia." *Journal of Interdisciplinary History* 33, no. 1: 21-46.

Bollet, Alfred Jay and Audrey Brown. (2003). "Anemia." In: Kenneth Kiple (Ed.). *The Cambridge Historical Dictionary of Disease.* Cambridge: Cambridge University Press. pp. 21-26.

Bothwell, Thomas. (1995). "Overview and Mechanisms." *Nutrition Reviews* 53(9). Pp. 237-245.

Brands, H. W. (2010). *American Colossus: the Triumph of Capitalism,1865-1900.* New York: Anchor Books.

Burnette, Joyce (2013). "The Changing Economic Roles of Women." In: Robert Whaples and Randall Parker (Eds.). *Routledge Handbook of Modern Economic History*. Routledge Press: New York. pp. 306-315.

Carson, Scott Alan. (2005). The biological standard of living in 19th-century Mexico and in the American west. Economics and Human Biology 3(3), 405-419.

Carson, Scott Alan. (2007). Mexican body mass index values in the 19th century American west. Economics and Human Biology, 5(1), 37-47.

Carson, Scott Alan. (2008a) "The Effect of Geography and Vitamin D on African-American Stature in the 19th Century: Evidence from Prison Records," *Journal of Economic History,* 68(3), pp. 812-830.

Carson, Scott Alan. (2008b) "Health during Industrialization: Evidence from the 19th Century Pennsylvania State Prison System," *Social Science History*. Volume 32(3). pp. 347-372.

Carson, Scott Alan. (2009a). Racial differences in body-mass indices of men imprisoned in 19th century Texas. *Economics and Human Biology* 7(1), 121-127.

Carson, Scott Alan, (2009b) "The Effects of Demographics, Residence, and Socioeconomic on the Distributions of 19th Century Mexican Biological Living Conditions," *Social Science Journal.* 46(3), pp. 411-426.

Carson, Scott Alan, (2009) "Geography, Insolation and Vitamin D in 19th Century US African-American and White Statures," *Explorations in Economic History.* 46(1), pp. 149-159.

Carson, Scott Alan, (2010a), "Nineteenth Century Mexican Statures in the United States and their Relationship with Insolation and Vitamin D," *Journal of Biosocial Science.* 42, pp. 113-128.

Carson, Scott Alan. (2010b), "Wealth, Inequality, and Insolation Effects across the 19th Century White US Stature Distribution," *Journal Homo of Comparative Human Biology,* 61, pp. 467-478.

Carson, Scott Alan. (2011), "Height of Female Americans in the 19th century and the Antebellum Puzzle," *Economics and Human Biology* 9, pp. 157-164.

Carson, Scott Alan. (2012). Nineteenth century race, body mass, and industrialization: Evidence from American prisons. *Journal of Interdisciplinary History* 42. 371-391.

Carson, Scott Alan. (2013). "Socioeconomic Effects on the Stature of Nineteenth Century US Women." *Feminist Economics* 19(2), pp. 122-143.

Carson, Scott Alan. (2015a). "The Mexican Calorie Allocation among the Working Class in the 19th Century American West." *Essays in Economic and Business History.* 26, pp. 33-50.

Carson, Scott Alan. (2015b). "Biology, Complexion, and Socioeconomic Status: Accounting for 19th Century US BMIs by Race." *Australian Economic History Review*. 55(3), pp. 238-255.

Carson, Scott Alan (2016). "Body Mass Index through Time: Explanations, Evidence, and Future Directions." In: Komlos, John and Inas Kelly (Eds.). *Handbook of Economics and Human Biology*. Oxford: Oxford University Press, pp. 133-151.

Carson, Scott Alan. (2018a). "Black and White Female Body Mass Index Values in the Developing Late 19th and Early 20th Century United States." *Journal of Bioeconomics*, 20(3), pp. 309-330.

Carson, Scott Alan. (2018b). "The Weight of 19th Century Mexicans in the Western United States." *Historical Methods: A Journal of Quantitative and Interdisciplinary History.* 51(1), pp. 1-12.

Carson, Scott Alan (2019). "Late 19th and Early 20th Century Native and Immigrant Body Mass Index Values in the United States." *Economics and Human Biology*, pp. 26-38.

Carson, Scott Alan (2020). "Net Nutrition, Insolation, Mortality, and the Antebellum Paradox." *Journal of Bioeconomics*.

Coclanis, Peter. A., Komlos, John. (1995). Nutrition and economic development in post-reconstruction South Carolina. Social Science History 19(1), 91-115.

Davey-Smith, George, Carole Hart, Mark Upton, David Hole, Charles Gillis, Graham, and Victor Hawtorne. (2000). "Height of Risk of Death among Men and Women: Aetiological Implications of Associations with Cardiorespiratory Disease and Cancer Mortality." *Journal of Epidemiological Community Health* 54, pp. 97-103.

Denko, Charles. (2003). "Osteoarthritis." In: Kenneth Kiple (Editor). *The Cambridge*

Historical Dictionary of Disease. Cambridge: Cambridge University Press. pp. 234-236.

Ellis, Joseph. (2004). His Excellency George Washington. New York: Knopf.

Engeland, Anders, Tone Bjørge, Randi Selmer, and Aage Tverdal. (2003). "Height and Body Mass Index in Relation to Total Mortality." *Epidemiology,* 14(3), pp. 293-299.

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

Fogel, Robert. (1986). "Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings." In: Stanley L Engerman and Robert E Ballman, (Eds.). *Long Term Factors in American Economic Growth.* University of Chicago Press, pp. 439-556.

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(3), pp. 369-395.

Fogel, Robert W., Engerman, Stanley, Trussell, James, Floud, Roderick, Pope, Clayne, Wimmer, Larry. (1978). The economics of mortality in North America, 1650–1910: A description of a research project. Historical Methods: A Journal of Quantitative and Interdisciplinary History, 11(2), 75-108.

Frayer, David, and Milford Wolpoff. (1980). "Sexual Dimorphism." *Annual Review of Anthropolog*y, v. 14, pp. 429-473.

Goldin, Claudia. (1990). *Understanding the Gender Gap: An Economic History of American Women.* New York: Oxford University Press.

Golden, Claudia and Ken Sokoloff. (1984). "The Relative Productivity Hypothesis of Industrialization: The American Case, 1820 to 1850." *Quarterly Journal of Economics,* 99(3), pp. 461- 487.

Goodman, Alan and Debra Martin. (2002). "Health Profiles from Skeletal Remains." In: Richard Steckel and Jerome Rose. *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 11-60.

Gottfedson, Michael, Hirshchi,Travis. (1990). *A General Theory of Crime*. Stanford University Press: Stanford, California.

Gray, J. Patric and Linda Wolfe. (1980). "Height and Sexual Dimorphism of Stature among Human Societies." *American Journal of Physical Anthropolocy*, 53(3), pp. 441-456.

Haines, Michael. (2000). "The White Population of the United States, 1790-1920." In: Michael Haines and Richard Steckel. (Eds.). *A Population History of North America.* Cambridge: Cambridge University Press. pp. 305-369.

Hilliard, Samuel B. (1972). Hog, Meat and Hoecake: Food Supply in the Old South, 1840-1860. Southern Illinois University Press: Carbondale, IL.

Higgs, Robert (1977). *Competition and Coercion: Blacks and the American Economiy, 1865-1914.* Chicago: University of Chicago Press.

Hirshchi, Travis, Gottfredson. Michael. (1983). "Age and the explanation of crime." *American Sociological Review* 89(3), 552-584.

Irwin, John (1987). "Partial Justice." *Journal of Contemporary Crisis.* Review of Partial Justice: Women in State Prison, 1800-1835.

Komlos, John. (1987). The height and weight of West Point cadets: Dietary change in antebellum America. *Journal of Economic History* 47(4), 897-927.

Komlos, John. (2019). "Shrinking in a Growing Economy is not so Puzzling After All." *Economics and Human Biology* 32, pp. 40-55

Komlos, John and JH Kim. (1990). "Estimating Trends in Historical Heights." *Historical Methods*, 23, pp. 116-120.

Komlos, John and Brian A'Hearn. (2017). "Hidden Negative Aspects of Industrialization at the onset of Modern Economic Growth in the U.S." *Structural Change and Economic Dynamics.* 41. 43-52.

Komlos, John and Brian A'Hearn. (2019). "Clarifications of a Puzzle" The Decline in Nutritional Status at the Onset of Modern Economic Growth in the United States." *Journal of Economic History* 79(4). pp. 1129-1153.

Leon David, George Davey-Smith, Martin Shipley and David Strachan. (1995). "Adult height and mortality in London: early life, socioeconomic confounding or shrinkage?" *Journal of Epidemiology and Community Health,* pp. 49, 5– 9.

Lebergott, Stanley. (1984). *The Americans: An Economic Record.* New York: W. W. Norton.

Lunardini, Christine. (1997). *What Every American Should Know About Women's History.* Adams: Holbrook, MA.

Margo, Robert and Richard Steckel (1992). "The Nutrition and Helath of Slaves and Antebellum Southern Whites." In Robert Fogel and Stanley Engerman. *Without Consent of Contract: Conditions of Slave Life and the Transition to Freedom, Technical Papers*. New York: Norton Publishers, pp. 508-521.

Marques, Carina, Vitor Matos, and Nicholas Meinzer. (2018). "Proliferative Periosteal Reactions: Assessment of Trend in Europe over the Past Two Millennia." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorge Baten. *The Backbone of Europe.* Cambridge: Cambridge University Press, pp. 137-174.

Meinzer, Nicholas, Richard Steckel, and Joerg Baten. (2019). "Agricultural Specialization, Urbanization, Workload, and Stature." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 231-252.

Miller, Jane. (2005). *The Chicago Guide to Writing about Multivariate Analysis.* Chicago: University of Chicago Press.

Moehling, Carolyn and Melissa Thomasson (2020). "Votes for Women: An Economic Perspective on Women's Enfranchisement." *Journal of Economic Perspectives.* 34(2), pp. 3-23.

Moradi, Alexander and Joerg Baten (2005). "Inequality in Sub-Saharn Africa: New Data and New Insights from Anthropometrics Estimates." *World Development*, 33(8), pp. 1233-1265.

Murton, Brian (2000). "Famine." In: *In the Cambridge World History of Food.* Cambridge University Press: Cambridge.

Nwasokwa Obi, Maurice Weiss, Clifford Gladstone, and Monty Bodenheimer. (1997). "Higher Prevalence and Greater Severity of Coronary Disease in Short versus Tall Men referred for Coronary Arteriography." *American Heart Journal*,;133:147–52

Palmer Julie R, Rosenberg L, Shapiro S. (1990). "Stature and the Risk of Myocardial Infarction in Women." *American Journal of Epidemiology*, 132 pp 27–32.

Papathanasiou, Anastasia, Nicholas Meinzer, Kimberly Williams, and Clark Spencer Larsen. (2019). "History of Anemia and Related Nutritional Deficiencies: Evidence from Cranial Porosities." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 198-230.

Prince, M. J., Acosta, D. Guerra, M., Huang, Y., Jimenez, I.Z., Rodiriquez, J.J.L . . . Prina, A. M (2018). "Leg Length, Skull Circumstance, and the Incidence of Dementia in Latin America and China: A 10/66 Population-based Cohort Study. *PLoS ONE*, 80, pp. 1-14.

Rafter, Nicole Hahn. (1985). *Partial Justice: Women in the State Prisons, 1800-1835*. Boston: Northeastern University.

Rosenbloom, Joshua. (2002). *Looking for Work, Searching for Workers: American Labor Markets during Industrialization.* Cambridge University Press: Cambridge.

Sokoloff, Kenneth, Villaflor, Georgia. (1982). Early achievement of modern stature in America.

Song, Yun-Mi, George Davey-Smith, and Joohon Sung (2003). "Adult Height and Cause-Specific Mortality: A Large Prospective Study of South Korean Men." *American Journal of Epidemiology* 158(5), pp. 479-485.

Steckel, R., (1979). "Slave Height Profiles from Coastwise Manifests." *Explorations in Economic History* 16: 363-380.

Steckel, Richard (1983). "The Economic Foundations of East-West Migration during the 19th Century." *Exportations in Economic History*. 20, pp. 14-36.

Steckel, Richard. (1994). "Heights and Health in the United States, 1710-1950." In: John Komlos (Ed.). *Stature, Living Standards, and Economic Development Essays in Econometric History*. University of Chicago Press. pp. 25-38.

Steckel, R. H. & Haurin, D. (1994). Health and nutrition in the American Midwest: Evidence from the height of Ohio national guardsman 1850-1910. In: J. Komlos, (Ed.), *Stature, Living Standards and Economic Development*. University Press of Chicago: Chicago, 117-128.

Steckel, Richard and Jerome Rose. (2002). *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press.

Steckel, Richard, Paul Sciulli, and Jerome Rose. (2002). "Health Index and Skeletal Remains." In: Richard Steckel and Jerome Rose. *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 11-60.

Steckel, Richard Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. (2019). *The Backbone of Europe.* Cambridge: Cambridge University Press.

Stewart, R, Hardy, R, and Richards, M. (2015). "Associations between Skeletal Growth in Childhood and Cognitive Function in Mid-Life in a 53-Year Prospective Cohort Study." *PLoS ONE*, 10(4), 1-10.

Sundet, Jon Martin, Kristian Tambs, Jennifer Harris, Per Mangus, and Tore M. Turjussen. (2005). "Resolving the Genetic and Environmental Sources of the Correlation between Height and Intelligence: A Study of Nearly 2,600 Norwegian Male Twin Pains." *Twin Research and Human Genetics*, 8(4), pp. 307-311.

Ubelaker, Douglas and Linda Newson. (2002). "Patterns of Health and Nutrition in Prehistoric and Historic Ecuador." In: Richard Steckel and Jerome Rose (Eds.). *The Backbone of* . *History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 343-377.

Waaler, Hans. (1984). "Height, Weight, and Mortality: The Norwegian Experience." *Acta Medica Scandinavica, Suppliment 679.*

Walker, Phillip. (1986). "Porotic Hyperostosis in a Marine-Dependent California Indian Population." *American Journal of Physical Anthropology, 69*, pp. 345-354.

Walker, Mary, Gerald Shaper, Andrew Phillips, and Derek Cook. (1989). "Short stature, lung function and risk of a heart attack. *International Journal of Epidemiology*;18 (3) : 602–6.

Walker, Phillip, Rhoda Bathurst, Rebecca Richman, Thor Gjerdrum, and Valeried Andrushko. (2009). "The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anemia Hypothesis." *American Journal of Physical Anthropology,* 139, pp. 109-125.

Williams, Kimberly, Nicholas Meinzer, and Clark Spencer Larsen. (2019). "History of Degenerative Joint Disease in People Across Europe: Bioarchaeological Inferences and Lifestyle and Activity from Osteoarthritis and Vertebral Osteophystosis." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 253-299.

Witmer-Backofen, Ursala and Felix Engel. (2019). "The History of European Oral Health: Evidence from Dental Carries and Antebellum Tooth Loss." In: Richard Steckel and Jerome Rose (Eds.). *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 84-136.

Yarnell JGW, Limb E.S., Layzell J.M., and A. Baker (1992). "Height: a Risk Marker for Ischaemic Heart Disease. *European Heart Journal*.13 pp. 1602–1605.