Nineteenth Century Stature and Family Size: Binding Constraint or Productive Labor Force?

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Abstract

The use of height data to measure living standards is now a well-established method in economics. Nevertheless, a neglected area in historical stature studies is the relationship between stature and family size, and statures are documented here to be positively related with family size. The relationship between material inequality and heath is the subject of considerable debate, and there was an inverse relationship between material inequality and stature. The paper also supports a bio-spatial relationship between the environment and stature.

JEL-Code: N30, D10, I10.

Keywords: family economics, stature, wealth, inequality, insolation, vitamin D.

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I. Introduction

The relationship between 19th century stature, household size, and wealth is a neglected area in economic history, and a contributing factor in household fertility decisions was the net benefit associated with larger family sizes (Becker, 1981, p. 96). Until the 20th century, a primary industry in the United States and European societies were associated with agriculture, and given limited physical capital and technology, 19th century farmers typically faced a labor shortage. The net costs of having children was the present value of expected future outlays plus parental time used in the process of rearing children, less the present value of expected monetary returns plus the imputed value of childhood services (Becker, 1976, p. 175). Because in traditional societies mothers and fathers have different biological endowments and human capital, these historical benefits and costs differed from their modern counterparts (Becker, 1981, p. 22; Atack and Bateman, 1987, p. 55). As the primary care-giver, female fertility and child-rearing, in turn, were related to household size and childhood health.

The use of height data to measure living standards is now a well-established method in economics (Fogel, 1994, p. 138; Deaton, 2008; Case and Paxson, 2008). A population's average stature reflects the cumulative interaction between family size, nutrition, disease exposure, work, and the physical environment (Steckel, 1979, pp. 365-367; Tanner, 1962, pp. 1-27). By considering average versus individual stature, genetic differences are mitigated, leaving only the economic and physical environmental influences on stature. When diets, health, and physical environments improve, average stature increases and decreases when diets become less nutritious, disease environments deteriorate, or the physical environment places more stress on the body. Therefore, stature provides considerable insights into understanding historical processes and augments other historical welfare measures.

It is against this backdrop that this study considers the relationship between 19th century stature and family size. Three questions are considered. First, how were 19th century US statures associated with family size? Using a demand for children model, this paper illustrates that 19th century statures were positively related with average household size. Second, how was stature related to average household wealth and inequality? Nineteenth century statures were positively associated with average household wealth and inversely related with wealth inequality. Third, what was the relationship between stature and occupation? After controlling for family size, wealth, and inequality, 19th century rural farmers were taller than workers in other occupations.

II. Fertility, Family Size, and Stature

Fertility and household size have long fallen under the purview of labor economists and economic demographers. However, the relationship between 19th century family size and stature is yet to be considered, and the link between household size and health outcomes is a natural extension of fertility theory. When households were small—because returns to scale were not fully exploited—additional family members increased labor specialization and increased agricultural productivity and household wealth (Becker, 1981, pp. 96-99). On the other hand, when households were large, fixed household resources may have been allocated more meagerly among existing family members. Therefore, there may have been either a positive or negative relationship between household size and stature.

A model is now constructed that frames household decisions to consume market related commodities and children when the number of children also influences household wealth. Assume household heads maximize utility in market related commodities, X, and children, N.

$$U = U(X, N)$$

Typical assumptions regarding first and second order conditions in X and N are maintained.

Nineteenth century household income, y(N), is determined by both agricultural productivity related to household size and property income, V. Household utility and income are, therefore, a function of the number of market related commodities and children. The household full income constraint is

$$y(N) + v = \sum_{i=1}^{n} p_i x_i + \sum_{j=1}^{m} p_N \ N$$

where p_i is the price of the i^{th} market related commodity, and p_N is the price of children. If the optimal values of market goods and children variables are assumed to be an interior solution, the first order utility maximizing conditions for utility maximization in X and N are

$$\frac{\partial U}{\partial X_i} - \lambda p_i = 0$$

and

$$\frac{\partial U}{\partial N} + \lambda (\frac{\partial y}{\partial N} - p_N) = 0$$

Corresponding shadow prices for market related commodities and children are

$$\lambda = \frac{\frac{\partial U}{\partial X}}{p_i} \qquad (1)$$

$$\lambda = \frac{\frac{\partial U}{\partial N}}{(p_N - \frac{\partial y}{\partial N})} \qquad (2)$$

The shadow price for the market related commodity, (1), is straight forward and warrants no further discussion. The shadow price for children, (2), however, deserves further explanation. When the price of children, p_N, increases, traditional demand theory indicates the household has fewer children. However, if mid-19th century US agricultural mechanization was limited and when agricultural productivity related to the number of children increased, it decreased the combined price of having children and the household had more children (Becker, 1981, pp. 96-99; Atack and Bateman, 1987, pp. 49-70). Household size, in turn, was related to individual family member health. Therefore, individual level stature was related with a complex set of personal demographic and occupational characteristics and state-level wealth, inequality, population density, and household size.

III. Nineteenth Century US Prison, Wealth and Demographic Data

To test the relationship between stature, wealth, inequality, population density, and family size, four data sets are constructed: 19th century US prison data, 19th century US state-level average wealth and gini coefficients, a modern state-level solar radiation index, and state population densities and average family size from the 1860 and 1870 US censuses.

Prison Data

The height data used here to assess the relationship between health and observable characteristics is a subset of a much larger 19th century prison sample. All state prison repositories were contacted and available records were acquired and entered into a master data set. These prison records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, Ohio, Oregon, Pennsylvania, and Texas (Table 1). Between 1830 and 1920, prison guards routinely recorded the dates inmates were received, age, complexion, nativity, stature, pre-incarceration occupation, and crime. To take advantage of 1860 and 1870 census wealth and inequality data, the prison data used here is restricted to birth between 1855 and 1874, and only blacks and whites are considered. Inmate enumerators were quite thorough when recording inmate complexion and occupation. For example, enumerators recorded inmates' race in a complexion category. African-Americans were recorded as black, light-black, dark-black, and various shades of mulatto (Komlos and Coclanis, 1997). Whites were recorded as light, medium, dark, fair, and white. This white race scheme is further supported by European inmates incarcerated in US prisoners, who were also recorded as light, medium, dark, fair, and white.[1]

Table 1, Nineteenth Century US State Penitentiaries

	1860		*1870*	
	N	Percent	N	Percent
Arizona			77	2.76
California	840	2.52	1,103	4.14
Colorado	23	3.60	71	4.00
Idaho			14	2.48
Illinois	1,205	5.02	100	5.59
Kansas	92	4.31	136	5.10
Kentucky	1,226	5.27	1,252	6.04
Missouri	1,799	5.09	2,854	5.75
Ohio	3,467	5.07	3,856	5.51
Oregon	130	3.66	108	5.47
Pennsylvania	2,743	4.99	2,752	5.43
Texas	4,655	5.25	6,566	6.01

Source: Numbers include both white and black observations. All state prison repositories were contacted and available records were acquired and entered into a master data set. These prison

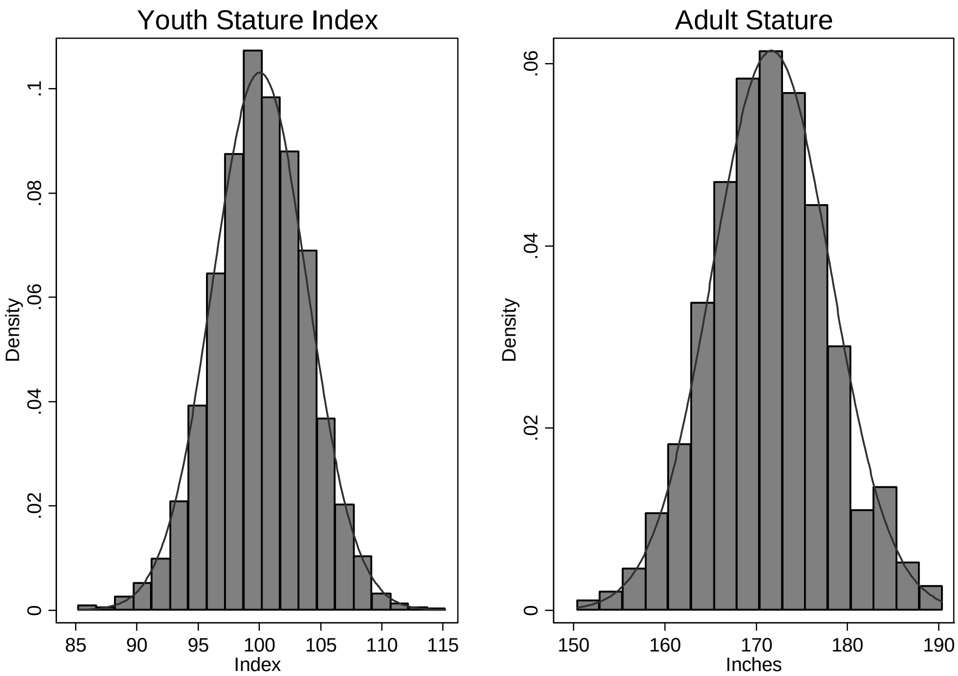
[1] I am currently collecting 19th century Irish prison records. Irish prison enumerators also used light, medium, dark, fresh and sallow to describe white prisoners in prisons from a traditionally white population. To date, no inmate in an Irish prison has been recorded with a complexion consistent with African heritage.

records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Texas, and Washington.

All historical data have various biases, and there is always concern over entry requirements, be it to prison or the military. Physical descriptions were recorded by prison enumerators at the time of incarceration as a means of identification. One common shortfall of military samples is a truncation bias imposed by minimum stature requirements (Fogel et al, 1978, p. 85; Sokoloff and Villaflor, 1982, pp. 459 and 472). Fortunately, prison records do not implicitly suffer from such a constraint and the subsequent truncation bias observed in military samples. However, prison records are not above scrutiny. One potential bias inherent in prison records is that they may be drawn from lower socioeconomic groups, although this bias may itself be an advantage to prison records, because lower socioeconomic groups are more vulnerable to economic change (Bogin, 1991, p. 288; Komlos and Baten, 2004, p. 199).

The shape of the stature distribution is important in stature studies because normally distributed statures allow robust estimation with standard statistical techniques. Because the youth height distribution is itself a function of the age distribution, a youth height index is constructed that standardizes for age to determine youth stature normality. First, each youth age category's average stature is calculated. Second, each observation is then divided by the average stature for the relevant age group (Komlos, 1987, p. 899). Figure 1 demonstrates there were no arbitrary stature truncation points and statures were symmetrically distributed.

Figure 1, National Stature Histograms by Age Group



Source: see Table 1.

Occupations are a reasonable measure for socioeconomic conditions. Enumerators recorded a broad continuum of occupations and defined them narrowly, recording over 200 different occupations, which are classified here into four categories. Workers who were merchants and high skilled workers are classified as white-collar workers; light manufacturing, craft workers, and carpenters are classified as skilled workers; workers in the agricultural sector are classified as farmers; laborers and miners are classified as unskilled workers (Tanner, 1977, p. 346; Ladurie, 1979; Margo and Steckel, 1992; p. 520). Unfortunately, inmate enumerators did not distinguish between farm and common laborers. Since common laborers probably came to maturity under less favorable biological conditions, this potentially overestimates the biological benefits of being a common laborer and underestimates the advantages of being a farm laborer. If there was little movement away from parental occupation, 19th century occupations may also be a good indicator for the occupational environment in which individuals came to maturity (Costa, 1993, p. 367; Margo and Steckel, 1992, p. 520; Wannamethee et al, 1996, pp. 1256-1262; Nyström Peck and Lundberg, 1995, pp. 734-737). Because individuals are able to migrate from their birth state, only inmates incarcerated in their native state are considered here, thereby, eliminating the effects of migration on stature. By having the same prison official record characteristics over much of the period, the consistency of the prison sample creates reliable comparisons across race and time.

Table 2, Nineteen Century US Prison Inmate Demographics and Occupations

Birth Decade	*N*	*%*	$\overline{X}$	*S.D.*	*Occupation*	*N*	*%*	$\overline{X}$	*S.D.*
1850	7,771	22.16	171.04	3.93	White-Collar	2,614	7.45	170.77	6.41
1860	17,677	50.41	171.39	6.87	Skilled	5,624	16.04	170.73	6.49
1870	9,621	27.44	171.12	6.81	Farmer	4,194	11.96	172.88	6.49
Race					Unskilled	21,639	61.70	171.21	7.03
Black	13,125	37.42	170.99	7.22	No Occupation	998	2.85	168.93	6.76
White	21,944	62.57	171.38	6.65	Nativity				
Received					Northeast	na	na		
1870s	3,617	10.31	169.73	7.28	Middle Atlantic	5,495	15.67	169.02	6.44
1880s	11,495	32.78	171.24	7.06	Great Lakes	8,628	24.60	171.60	6.50
1890s	14,678	41.46	171.54	6.63	Plains	4,881	13.92	170.67	6.70
1900s	5,035	14.38	171.43	6.69	Southeast	2,478	7.07	170.52	7.00
1910s	244	.70	171.09	6.34	Southwest	11,298	32.22	172.70	7.11
					Far West	2,289	6.53	169.96	6.32

Source: See Table 1.

Table 2 presents inmate proportions and heights by decade received, race, birth decade, occupations, and nativity. More inmates were incarcerated during the 1870s than the 1860s, and whites were more prominent than blacks, although blacks were over represented in prisons relative to the overall population (Carson, 2008a). Occupations reflect socioeconomic status, and while prison inmates typically come from lower working classes, there were sizable inmate proportions with white-collar and skilled occupations. Many inmates were unskilled, but not abnormally so relative to the overall population. Most inmates in the prison sample were from the Southwest, with significant proportions from Great Lakes, Plains, and Middle Atlantic regions. A concern about the prison data set is that Southern prisons are over represented in the sample, and New England prisoners– one of the principal centers of industrialization and urbanization – were not available. Since Philadelphia probably accounts for a large share of the Pennsylvania sample, it may capture Northeastern industrialization; however, Philadelphia was not Boston or Providence or New York, and makes inferences from the prison data set more likely to represent the rural working class.

US Average Wealth and Wealth Inequality

The 1860 and 1870 federal censuses have been the subject of numerous 19th century wealth studies and provide unique insight into the historical relationship between material conditions, inequality, and health as development occurred. Lee Soltow (1975) uses an 1860 and 1870 US wealth sample to demonstrate that wealth inequality did not start with industrialization and changed little between 1800 and 1940. Atack and Bateman (1981) use 1860 and 1870 census wealth to show that although wealth in the rural North was distributed more equitably than in the South, it was not a classical egalitarian society. Kearl, Pope, and Wimmer (1981) and Pope (1989) use census records to demonstrate that wealth in the Far West was distributed more equitably; however, western wealth accumulation lagged behind that of the East.

Figure 2, 1860 and 1870 US Inequality by State

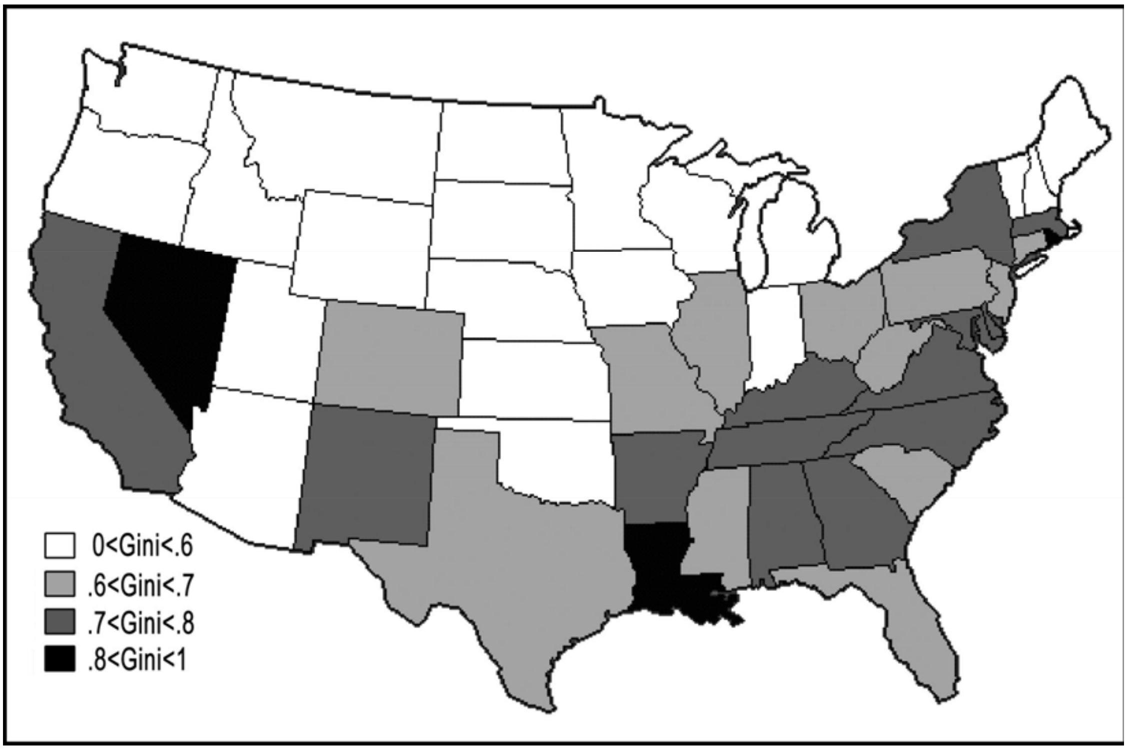
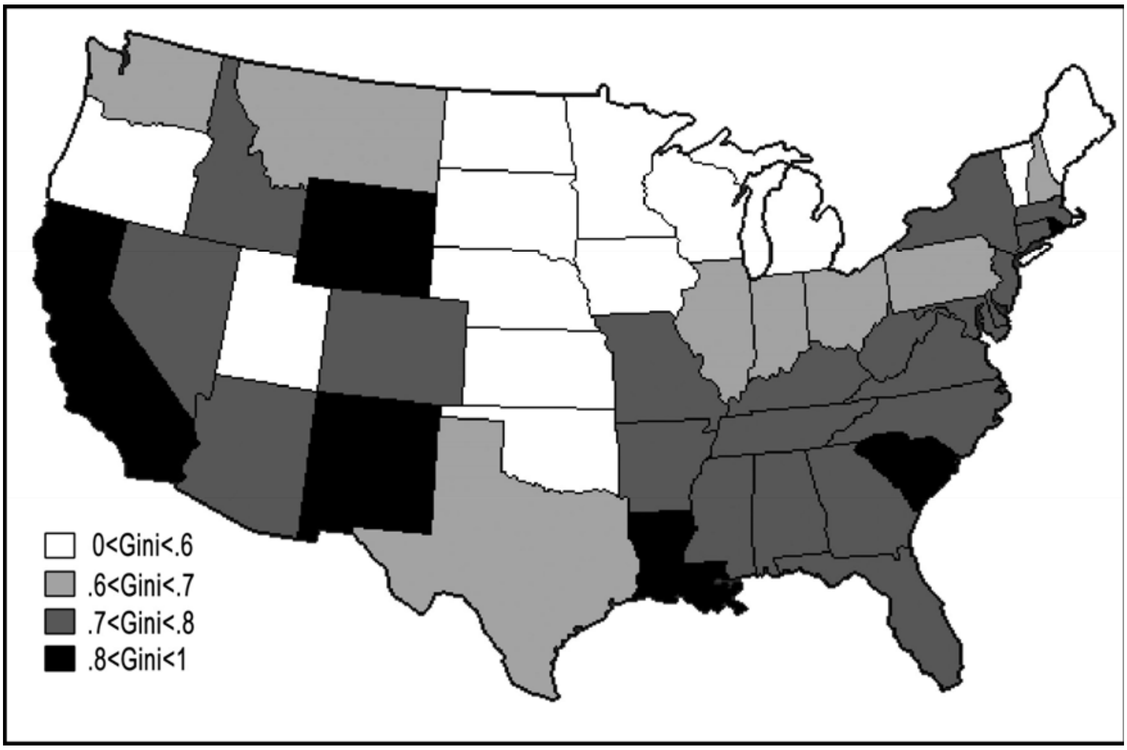


Figure 3, 1870 US Inequality by State



Using the Integrated Public Use Microdata Series, US wealth inequality is considered here for male headed households over the age of 18 (Figures 2 and 3).[2] Eighteen sixty and 1870 total US wealth inequalities were .71606 and .71220, respectively. On the other hand, between 1860 and 1870, average total wealth decreased from $3,289 in 1860 to $3,018 in 1870 (Figures 4 and 5). Northern wealth holdings increased between 1860 and 1870 while maintaining relatively high wealth equality. Nevertheless, it was the North's industrialization that may have threatened Northern biological conditions. In 1860, the South had the highest average wealth and had greater wealth inequality than the North; however, with the end of slavery, average Southern wealth declined considerably while continuing to have high wealth inequality (Saltow, 1975; Easterlin, 1971). Of course, the difference was Southern chattel slavery, and once slaves were freed, southern personal wealth declined.

[2] No upper bound is placed on ages and all US geographic regions are considered.

Figure 4, 1860 US Average State Wealth

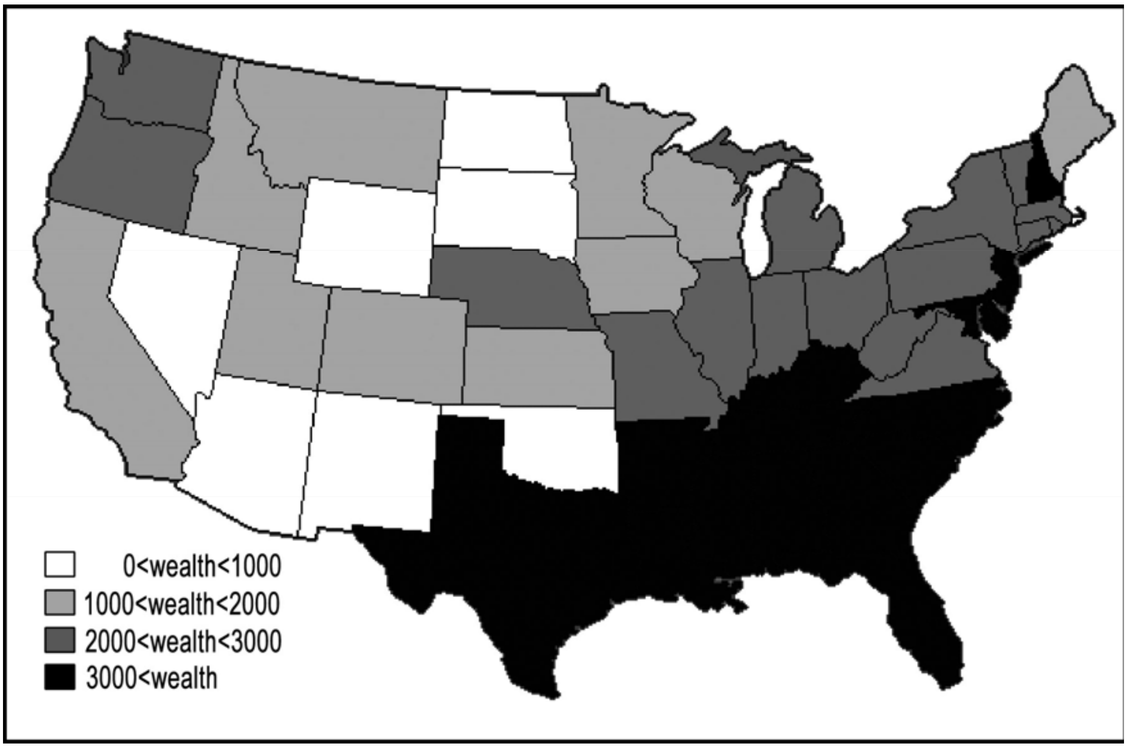
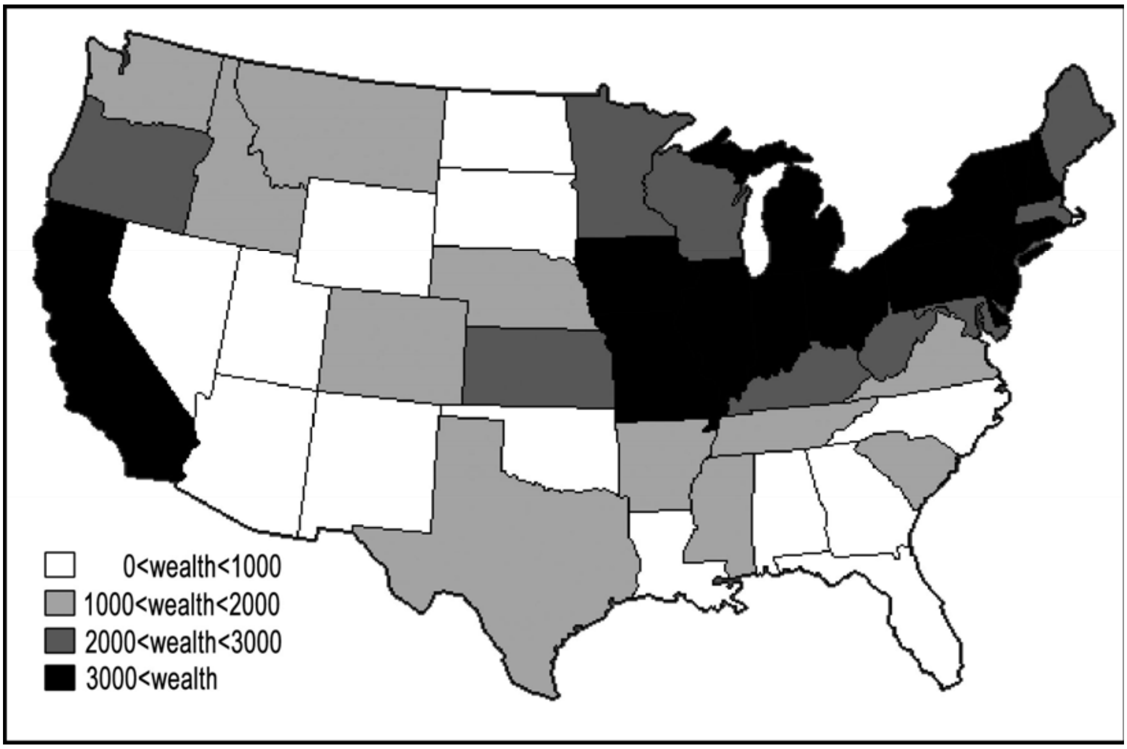


Figure 5, 1870 US Average State Wealth



Solar Radiation

The relationship between stature and wealth is further complicated because in the middle of the 19th century, the South had high wealth accumulation and high wealth inequality, but the South also had greater exposure to sunlight and vitamin D. All else equal, stature is positively related with wealth and may be adversely influenced by wealth inequality, both common characteristics in the antebellum South. Complicating the relationship, the South also had greater exposure to sunlight, which increases vitamin D production, and vitamin D is associated with taller statures. To account for the biological relationship between vitamin D and stature, a state-level insolation index is constructed. Insolation is the incoming solar radiation that reaches the earth, its atmosphere and surface objects, and it is the primary source of vitamin D (Holick, 1981, p. 590). Adult terminal statures have also been linked to vitamin D consumption (Xiong et al, 2005, pp. 228, 230-231; Liu XZ et al., 2003; Ginsburg et al., 1998; Uitterlinden, 2004), indicating that, all else equal, taller statures should be found in geographic locations that receive more insolation. In order of importance, the primary sources of vitamin D in humans are the amount of time exposed to sunlight, skin pigmentation, and nativity. (Holick, 1981, p. 590). Moreover, it is also difficult to interpret insolation's net direct effect on human health, because greater insolation reduces calories required to maintain body temperature and produces more vitamin D, but greater insolation also warms surface temperatures, which may have made disease environments less healthy from water-borne diseases, especially in the South (Steckel, 1992, p. 501).

Because US historical insolation is unavailable, a modern insolation index (1993-2003) is constructed by weighting each state's county insolation centroid relative to the county's proportional square miles in the state. While this index is a rough approximation for historical insolation, it provides sufficient detail to capture state and latitudinal insolation variation and reflects vitamin D production. The US receives, on average, 4.10 hours of direct sunlight per day, and varies by proximity to the equator. Predictably, Southern states have greater insolation than Northern states, and Western states have greater insolation than Eastern states.[3] For example, Wyoming and Ohio are on similar latitudes, but Wyoming receives 4.22 hours of direct sunlight per day, while Ohio receives only 3.66 hours per day. Consequently, new 19th century American data sources introduced here make it possible to assess the various aspects of health, wealth, and inequality.

Family Size

Nineteenth century stature may have also been related to family size; therefore, a measure for state-level family size is required. Ideally individual stature is linked with individual family size. This information is, unfortunately, unavailable. However, average state family size is a reasonable proxy for individual family size, because, given local agricultural and economic

[3] The angle that sunlight strikes the earth's surface influences the amount of energy received at the earth's surface, i.e., geographic locations closer to the equator receive more insolation. However, surface objects in western states received greater amounts of insolation because insolation is also influenced by elevation above sea level and cloud cover. Objects at higher elevations above sea level receive more insolation because there is less atmospheric interference from matter in the atmosphere, such as humidity. Less interference at higher elevations allows more sunlight to penetrate surface objects. The West and Southwest are also the geographic areas within North America with the least amount of cloud cover. However, the insolation index used in the regression models is the net amount of insolation after considering cloud cover because it is based upon recorded surface insolation values and not based on computer models that do not account for cloud cover.

conditions, the efficient average state family size prevailed.[4] Therefore, average state family size is a reasonable approximation for individual family size.

Table 3, Average Family Size by State, 1860 and 1870

	1860			1870		
Blacks	N	Average	S.D.	N	Average	S.D.
Arizona						
California				14	1.43	.85
Colorado				3	1	
Idaho						
Illinois	7	3.29	1.11	293	4.59	2.46
Kansas				214	4.42	2.52
Kentucky	50	2.68	1.88	2,471	5.42	3.06
Missouri	4	4.50	3.51	1,067	4.82	2.95
Ohio	60	5.45	3.11	525	4.81	2.65
Oregon				4	2.5	1.00
Pennsylvania	63	4.48	2.49	717	4.52	2.71
Texas	1	1		2,372	5.78	2.92
	1860			1870		
Whites	N	Average	S.D.	N	Average	S.D.
Arizona				92	2.76	1.69
California				4,861	4.38	2.68
Colorado				369	4.02	2.42
Idaho				104	2.94	2.07
Illinois	3,008	5.02	2.36	25,785	5.60	2.59
Kansas	209	4.31	2.28	3,509	5.15	2.73
Kentucky	4,391	5.45	2.61	11,086	6.18	2.74
Missouri	1,748	5.19	2.62	16,020	5.81	2.71
Ohio	3,967	5.06	2.35	25,923	5.52	2.52
Oregon				887	5.59	2.82
Pennsylvania	4,888	5.00	2.35	33,926	5.45	2.59
Texas	706	5.26	2.70	5,771	6.10	7.80

Source: Integrated Public Use Micro Sample, 1860 and 1870.

Using data from the 1860 and 1870 population censuses, average 1860 and 1870 household sizes are presented in Table 3. Nineteenth century white families were typically

[4] This explanation relies on survivorship studies that posits that if a particular plant size if it is efficient, eventually all plant sizes will adapt this technology and approach the efficient plant size (Stigler, 1958).

larger than black families, and given labor scarcity on agricultural communities, both black and white family sizes increased between 1860 and 1870. Nineteenth century family size varied considerably across the US, and the Midwest grew rapidly and had a young population, while the Northeast grew slowly and had an older population. Moreover, fertility varied by socioeconomic status, and fertility among farmers was higher than non-farmers (Atack and Bateman, 1987, p. 55).

IV. Individual-Level Stature, Wealth, Inequality, and Socioeconomic Status

The timing and extent of stature variation not only reflects the cumulative relationship between diet and disease, but also the distribution of wealth, population density, and family size (Steckel, 1995, p. 1914). We test which of these variables were associated with 19th century US stature.

$$\begin{aligned} \text{Centimeters}_{ijt} = \alpha &+ \sum_{r=1}^{2} \beta_{\text{Race}} \text{Race}_i + \sum_{A=14}^{50s} \beta_{\text{Age},t} \text{Age}_{\text{Age},t} + \beta_{\text{Insol}} \text{Insolation}_j + \beta_{\text{Insol}^2} \text{Insolation}_j^2 \\ &+ \beta_{\text{TW}} \text{Wealth}_{j,t} + \beta_{\text{TW}^2} \text{Wealth}_{j,t}^2 + \beta_{\text{Gini}} \text{Gini}_{j,t} + \beta_{\text{Wealth}\times\text{Gini}} \text{Wealth} \times \text{Gini}_{j,t} + \beta_{1870} 1870 \\ &+ \beta_{\text{Pop}} \text{PopDen}_{j,t} + \beta_{\text{Pop}^2} \text{PopDen}_{j,t}^2 + \sum_{l=1}^{2} \beta_l \text{Occupation}_{i,t} + \beta_f \text{Family Size}_{j,t} + \varepsilon_i \end{aligned}$$

To test the relationship between stature and skin pigmentation, black and mulatto dummy variables are included. Dummy variables are added for the youth ages 14 through 19; adult age dummies are added in 10-year age categories for ages 30 through 50 age groups. To test the stature-vitamin D hypothesis, state-level continuous insolation and insolation squared terms are included. State-level continuous wealth and wealth squared variables are included to assess the relationship between stature and regional wealth levels.[5] State-level gini coefficients, scaled by

[5] The interpretation of total wealth and state level ginis is complicated because household wealth was self-reported in the 1860 and 1870 population censuses. As much as one third of households reported holding zero total wealth,

100, are included to account for 1860 and 1870 state-level wealth inequality. State-level continuous population density and population density squared terms are added to account for the effects of urbanization on stature. Occupation dummy variables are included for white-collar, skilled, farmers, and unskilled occupations. A continuous family size variable is included to test the relationship between stature and family size.

Table 4's, Model 1 presents estimates for stature regressed on age, race, insolation, wealth, inequality, population density, family size, and socioeconomic status. To illustrate how stature relates to demographic, occupation, nativity, migration, and insolation variables, models 2 through 5 omit characteristics to assess their sensitivity with stature in Model 1.

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which undercounts household wealth because, at the limit, households here at least some level of trivial personal wealth. In the absence of a better estimate, it has been customary in census wealth studies to treat these households as holding zero wealth; consequently, households reporting zero total wealth are treated as holding zero wealth when calculating average wealth and state gini coefficients.

Table 4, 1860 and 1870 US Prison Statures, Demographics, Insolation, Wealth Population Density, and Family Size

	Model 1		*Model 2*		*Model 3*		*Model 4*		*Model 5*	
	Unrestricted	S.E.	Insolation Restriction	S.E.	Wealth Restriction	S.E.	Socioeconomic Status Restriction	S.E.	Population Density Restriction	S.E.
Constant	123.49***	15.35	185.49***	2.00	46.39***	11.34	107.44***	14.96	145.51***	5.11
Race										
White	Reference		Reference		Reference		Reference		Reference	
Black	-2.24***	.105	-2.25***	.105	-2.19***	.104	-2.21***	.104	-2.30***	.105
Mulatto	-1.95***	.124	-1.91***	.123	-2.15***	.124	-1.93***	.124	-1.99***	.124
Ages										
14	-12.17***	.700	-12.15***	.699	-12.38***	.699	-12.23***	.696	-12.21***	.695
15	-9.31***	.479	-9.29***	.480	-9.47***	.479	-9.37***	.482	-9.40***	.481
16	-5.16***	.253	-5.12***	.253	-5.20***	.253	-5.14***	.253	-5.23***	.252
17	-3.40***	.189	-3.37***	.189	-3.37***	.191	-3.37***	.189	-3.41***	.190
18	-2.01***	.159	-2.00***	.159	-2.04	.160	-2.01***	.159	-2.04***	.160
19	-1.05***	.147	-1.03***	.147	-1.05	.148	-1.03***	.147	-1.04***	.147
20s	Reference		Reference		Reference				Reference	
30s	-.075	.090	-.060	.090	-.139	.090	-.129	.090	-.111	.090
40s	-.590***	.169	-.582***	.169	-.640***	.169	-.641***	.169	-.602***	.169
50s	-2.01***	.570	-1.92***	.569	-2.06***	.574	-2.05***	.564	-1.98***	.573
Insolation										
Insolation	28.98***	6.99			47.79***	4.90	33.00***	7.00	13.46***	3.00
$Insolation^2$	-2.91***	.773			-4.80***	.525	-3.34***	.774	-1.39***	.379
Wealth Variables										
Total Wealth	-.005***	9.03^{-8}	-.005	6.5^{-4}			-.006***	.001	-.001	8.9^{-4}
Total $Wealth^2$	6.02^{-7}***	9.0^{-7}	7.6^{-7}***	4.9^{-8}			6.4^{-7}***	9.1^{-8}	3.1^{-7}***	8.3^{-8}
Gini coefficient	-.215	.027	-.171***	.026			-.223***	.027	-.120***	.024

Wealth×Gini	.002**	<.01	.001	6.8^{-4}			.002**	8.0^{-4}	-.001	.001
Time										
1860	Reference		Reference		Reference		Reference		Reference	
1870	-.184	.158	.497***	.110	-1.72***	.106	-.239	.160	-.263**	.108
State Population										
Population density	.166***	.017	.094***	.013	.092***	.016	.175***	.017		
Population density^2	-.001***	1.4^{-4}	-.001***	1.4^{-4}	7.9^{-5}***	1.2^{-4}	-.001***	1.4^{-4}***		
Socioeconomic Status										
White-Collar and Skilled	Reference		Reference		Reference		Reference		Reference	
Farmer	1.58***	.122	1.61***	.122	1.69***	.122			1.63***	.122
Unskilled	.605***	.085	.583***	.085	.592***	.085			.594***	.085
Family Size										
Family Size	.786***	.109	.708***	.081	1.68***	.078	.811***	.110	1.06***	.102
N	35,069		35,069		35,069		35,069		35,069	
R^2	.1048		.1032		.0947		.1000		.1014	

Source: See Table 1.

Three general patterns are clear when considering 19th century US statures. First, 19th century statures were taller when household sizes were larger, indicating that additional family members increased labor specialization and agricultural productivity (Edwards and Grossman, 1978, pp. 38-39; Atack and Bateman, 1987, p. 56). The 19th century stature increase with family size indicates additional family members increased household wealth, offsetting increases in additional demands on household resources (Becker, 1981, pp. 97 and 102), and improved 19th century net cumulative health and economic welfare.

Second, consistent with the biological explanation for how stature is associated with insolation, 19th century statures increased in insolation at a decreasing rate, indicating there is a natural threshold to the amount of vitamin D produced internally, and whites in North American latitudes were closer than blacks to the threshold where vitamin D production is curtailed (Holick et al, 1981, pp. 590-591; Jablanski, 2006, p. 62; Holick, 2004a, p. 363; Holick, 2004b, p. 1680S; Carson, forthcoming). The black stature deficit may also be evidence of a previously neglected aspect of slavery's consequences on human biology: the forced migration of Africans to northern climates put blacks in biological environments wherethey were less likely to produce sufficient vitamin D and grow as tall as whites due to higher levels of melanin in their skin (Loomis, 1967, pp. 501-504; Neer, 1979, p. 441).

Third, stature relates with 19th century wealth in at least two ways, and these mechanisms are broadly classified here into the absolute and relative wealth hypotheses. Through the absolute wealth pathway stature increases because wealth directly creates access to nutritious diets and health amenities (Steckel, 1995, p. 1914; Komlos, 1987, pp. 903; Komlos, 1998). The relative wealth-stature pathway hypothesis is that stature decreases with wealth inequality because relative inequality reduces access to beneficial nutrition and health inputs, which forecloses those in lower socioeconomic groups from nutrition and other health inputs (Wilkinson and Pickett, 2006, p. 1775; Subramian and Kawachi, 2004). Both absolute and relative wealth relate with 19th century stature variation, and statures increased in absolute wealth at an increasing rate (Table 4). On the other hand, statures decreased with greater wealth inequality. The positive coefficient for the wealth-inequality interactive term also indicates that absolute wealth effects dominated the relative wealth-stature effects.

Other patterns are consistent with expectations. The degree to which white statures exceed black statures is striking, and this is significant because modern black and white statures are comparable when brought to maturity under similar biological conditions (Eveleth and Tanner, 1976; Tanner, 1977; Steckel, 1995, p. 1910; Barondess et al., 1997, p. 968; Komlos and Baur, 2004, pp. 472-473; Margo and Steckel, 1982, p. 519; Komlos and Lauderdale, 2005; Nelson, et al., 1993, pp. 18-20, Godoy et al., 2005, pp. 472-473). Moreover, compositional effects cannot explain the white-black stature differential, which was due, in part, to whites' access to meat and better nutrition (Margo and Steckel, 1992, pp. 514-515, 517, and 519).

Nineteenth century statures relate to occupations, and farmers were taller than workers in other occupations by about two centimeters (Komlos and Coclanis, 1997, p. 441; Komlos, 1987, p. 902; Steckel and Haurin, 1994, p. 170; Sokoloff and Villaflor, 1982, p. 463; Margo and Steckel, 1983, pp. 171-172; Costa, 1993, p. 367; Komlos and Coclanis, 1997; Komlos, 1987; Steckel, and Haurin, 1994; Margo and Steckel, 1982; Sokoloff and Villaflor, 1982; Carson, 2008b, pp. 822-823). Part of the explanation for taller farmers is related to nutrition, and rural farmers had greater access to nutritious diets. Another part of the farmer stature advantage may have been related to vitamin D. Islam et al. (2007, pp. 383-388) demonstrate that children exposed to more direct sunlight produce more vitamin D, and if there was little movement away from parental occupation, 19th century occupations may also be a good indicator for the occupational environment in which individuals came to maturity (Costa, 1993, p. 367; Margo and Steckel, 1992, p. 520; Wannamethee et al, 1996, pp. 1256-1262; Nyström Peck and Lundberg, 1995, pp. 734-737).

V. Discussion

This study addresses the long-neglected relationship between 19th century stature and household size. Individual stature increased with larger household sizes, indicating that household agricultural productivity added more to wealth than resources additional family members consumed. Statures also relate to average household wealth, and individual statures increased in average state wealth and decreased with inequality. Finally, after controlling for family size, farmers were taller than workers in other occupations. Therefore, individual stature relates with a complex set of demographic, environmental, and wealth characteristics, and the distribution of wealth within a society and within the household was related to 19th century health. However, fertility decisions within 19th century households implicitly increased agricultural productivity more than the costs of having children.

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