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Bones of Contention: The Political Economy of Height Inequality

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Human osteological data provide a rich, still-to-be-mined source of information about the distribution of nutrition and, by extension, the distribution of political power and economic wealth in societies of long ago. On the basis of data we have collected and analyzed on societies ranging from foraging communities to the ancient Egyptian and modern European monarchies, we find that the shift from hunting and gathering to complex fishing techniques and to labor-intensive agriculture opened up inequalities that had discernible effects on human health and stature. But we also find that political institutions intervened decisively in the distribution of resources within societies. Political institutions appear to be shaped not only by economic factors but also by military technology and vulnerability to invasion.

Inequality—its causes and its consequences—has been a longstanding concern in political economy. Yet, aside from some classical contributions, ranging from Aristotle and Machiavelli to Rousseau and Marx, most of what we currently know (or claim to know) about the political economy of inequality is focused on its evolution in the last half-century, mostly in developed countries (Atkinson 1999; Esping-Andersen 1990; Kuznets 1955; Persson and Tabellini 1994, 2000; Williamson, Lindert, and Institute for Research on Poverty 1980).[1] This vexing lack of contemporary research on pre–World War II trends is due largely to the insufficient data on inequality across human communities and over time.

In this article we attempt to narrow this gap. In the first section we explore theoretically the extent to which different political institutional regimes and levels of technological and economic development have affected the distribution of resources and assets in human communities. In a nutshell, we claim that the level of inequality is a function of both economic variables and political institutions. Inequality is low in foraging communities using simple production technologies and with reduced storage capabilities. The introduction of complex fishing techniques and the agricultural revolution open the door to a potentially unequal distribution of assets. Inequality rises with economies of scale in production and/or when capital-intensive military technologies favor the formation of extractive ruling elites.

Although economic and military factors generate much of the potential for inequality, institutions filter those factors through three mechanisms: They establish ownership shares among individuals and groups; they determine the pricing system by maintaining or distorting a competitive market; and they set the level of transfers from asset owners to non-owners. Institutions can in turn be disrupted by changes in production technology and in relative military threat, but they often play an independent role as well.

To test these theoretical propositions about inequality in societies for which there are few reliable sources, we use archaeological and ethnographic data on human heights as a proxy for the level of economic and political inequality. Although economists and anthropologists have begun employing these data to track changes in living standards, the analysis of the distribution of resources within a given community using those observations is in its infancy (see Van Zanden et al. 2013). As we discuss in the second section, human height varies both by genetic factors outside the reach of short-run environmental intervention and by levels of nutrition during the periods of pre- and adolescent growth spurts. According to Eveleth and Tanner (1976, 222), two adult people who would be equally tall under optimal environmental circumstances could be of

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[1] An important theoretical exception is Rogowski and McRae (2008). There are also a few historical studies on income distribution in the United Kingdom and the United States (Lindert 2000; Williamson, Lindert, and Institute for Research on Poverty 1980).

different heights if one was inadequately nourished during the rapid growth periods of childhood and adolescence. Because few human societies have had uniform access to adequate nutrition, we are able to take adult human height as a valuable indirect measure of the distribution of resources within society, particularly before the industrial revolution moved precontemporary societies away from the Malthusian frontier in which they normally lived.

We then examine the extent to which height data for a wide range of societies match certain political and technological covariates. The third section exploits a rich dataset gathered by Franz Boas on Native Americans in the nineteenth century to examine inequality in societies with relatively simple economic and warfare technologies. The fourth section looks at height variance in fully agricultural societies that had very different military technologies and political institutions: from the Zuni Pueblos and the Mayan societies, which had rudimentary technologies of war; to the Mycenaean and Egyptian monarchies, which were governed by elites who relied on bronze weapons and a strong cavalry; and then to late medieval and modern European societies, which relied on plow agriculture and had feudal armies and, later in time, absolutist institutions. The fourth section closes with data from Japan, moving from cross-cultural comparisons to a temporal analysis within the same country. The fifth section reverses treatment and control: Holding constant technologies of war and state institutions, it assesses the impact on inequality of different agricultural systems (in the Midwest agrarian communities and the American South in the middle of the nineteenth century). The sixth section examines the evolution of height variance in the last two centuries. The last section concludes by taking stock of what we have learned from this empirical exercise and compares it to the predictions of the theory.

THEORETICAL EXPECTATIONS

Equality of Conditions: Simple Foraging Communities

According to existing archaeological material, humans lived in hunter-gatherer communities until the Mesolithic era. Relatively unsophisticated production technologies and strong norms of sharing, linked to the need to sustain risk-sharing strategies, led to interpersonal equality of food intake in simple foraging communities (Hawkes 2000). Population density was low (averaging 0.05 people per square mile; Keeley 1988), and communities were dispersed across vast spaces. Within those communities, the inability to store food without it rotting and the need to stay mobile in pursuit of herds undercut asset accumulation and the intergenerational transmission of resources (Smith et al. 2010). Stable political hierarchies were absent or minimal.[2]

Rather than form vertical hierarchies to manage conflict, hunter-gatherer societies tend to split into smaller groups, some of which then move away to exploit other territories (Hirschman 1981). Low-dispersion measures of height and health in foraging societies would constitute corroborating evidence of the equalizing properties of the hunter-gathering political economy.

The Breakdown of Equality: Complex Foraging Communities and Agrarian Societies

The relative economic and political equality of simple foraging societies broke down because two interrelated channels. The first one was strictly economic. The rate of technological innovation differed across individuals and communities, and even when the new production technologies were available to everyone, their application varied across geographical areas. For example, the invention of large boats and fishing equipment such as weirs and nets—resulting in higher productivity rates than simple foragers, higher population densities (around 3.5 persons per mile), some social stratification, and considerable stickiness in the intergenerational transmission of wealth—could only be exploited along a river or a maritime coast.[3] The domestication of plants and animals (jointly with a growing storage capacity) that began around 9000 BC produced even sharper patterns of territorial differentiation, economic specialization, and social stratification across the globe: According to the Ethnographic Atlas, among agricultural societies four out of five have inheritance rules on real property and five out of six have social classes (Boix n.d.). Smith et al. (2010) report a Gini index around 0.4–0.5 for agrarian and pastoral societies versus less than 0.2 among hunter-gatherers for the 21 societies they examined.[4]

A political channel increases inequality as well. As individuals and territories diverge in output and income, the potential for sustained interpersonal and intercommunity conflict rises, particularly when good land becomes scarce.[5] Those producers—fisher folk and

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[2] According to data from the Ethnographic Atlas, a dataset containing social, political, and economic information for almost 1,300 human communities across the world and developed by George P. Murdock, 86% of simple foraging communities are organized at the family, band, or clan level (Boix n.d).

[3] According to the Ethnographic Atlas, more than three-fourths of fishing societies have inheritance rules of some sort compared to one-third among simple hunter-gatherers, and two-thirds have some class structures compared to 12% among simple foragers (Boix n.d.; cf. Gurven et al. 2010; Keely 1998; Kelly 1995).

[4] The literature on the economic determinants of income distribution is substantial and growing, but as Atkinson and Bourguignon (2000, 26) acknowledge, "there is at present no unified economic theory of income distribution." For summaries of these theories, see Kahhat (2007) and Boix (2010).

[5] Our point is not to imply that simple foraging societies are peaceful. On the contrary, violence is very high in stateless societies (Gat 1999; Headland and Reid 1989; Knauft 1987). However, as Kelly (2000, 42–3) notes, violence in pre-state societies "is specific, not generalized, and it does not escalate beyond a sequence of events that encompasses homicide followed by execution of the killer. Typically, a murder is an isolated event with no sequel" and has no fundamental consequences for social inequality or political institutions (Boix n.d.).

farmers who have benefited the most from technological innovation—face the possibility that other, less well-off producers as well as "professional" bandits may systematically raid them and rob them of their crops.[6]

To overcome this permanent threat of conflict (and the attending dissipation of growth), those communities of producers will seek to form state institutions capable of controlling violence and imposing order. On the one hand, they may attempt to defend themselves directly against any would-be predators by spending some fraction of their time setting up a defensive structure, making weapons to deter any potential plunderers, and fighting them. Producers double as rulers. On the other hand, in a scenario modeled by Olson (1993, 2000), individuals with the incentive and capacity to loot the producers in the short run decide instead to protect them against other predators. In exchange for providing protection, these "stationary bandits" extract some permanent rents from producers. In other words, the Neolithic shift to food production and storage increased the transparency of output, making it easier for predators to identify and target producers (Mayshar, Moav, and Neeman 2011). Increased vulnerability to predation created the conditions for protection rackets of various kinds ranging from imperial kingdoms to the fragmented feudal structures of early medieval Europe.

Each of these institutional solutions has different distributional effects. When producers govern themselves, state institutions remain relatively horizontal, there are few transfers of resources across individuals through political mechanisms, and the distribution of income matches the underlying structure of the economy. Of course this does not mean that there is perfect equality of conditions. Differences in the fertility of soil will lead to income heterogeneity.[7] Economies of scale in certain crops such as sugar or cotton, for example, may result in the formation of a system of property that is highly concentrated in a few hands (Engerman and Sokoloff 2002), something we explore in the section "The Impact of Factor Endowment and Production Regimes on Height."[8] By contrast, monarchical regimes have clear tools and incentives for distributing resources to the military class, independently of the type of agricultural system in place. Rent extraction by monarchs and their allies—and therefore inequality—will increase with the power of rulers over their subjects.[9]

Political outcomes depend on the available military technology and its impact on the power ratio between producers and Olsonian bandits.[10] Broadly speaking, the power ratio is more favorable to producers and self-defense is more feasible when military technologies are simple. As long as the production of violence is labor intensive and does not rely on sophisticated weaponry such as chariots, horses, and heavy armor, plunderers have little comparative advantage over producers and can subjugate very few peasants or farmers at a time to extract rents from them.[11] In addition, producers have little incentive to subject themselves to a knightly elite because the opportunity costs of fighting relative to the production of goods and services are still low.

However, once military technologies become more complex, the comparative advantage of would-be predators in the production of violence tends to increase. For example, the domestication of the horse and the invention of flexible two-wheel chariots benefited the pastoralist peoples of the steppes more than the richer agricultural populations of the Near East and resulted in one of the most significant military and population expansions in history: Babylon fell under the attack of the Hurrites, the Aryans conquered Northern India, the Achaeans settled in Greece, and the Hyksos invaded Egypt (Anthony 2010). The introduction of the iron stirrup, which stabilized the horseman and allowed him to engage in mounted shock combat, may have contributed to the creation of a feudal class in Western Europe (Oman 1936; White 1962; for emphasis on cavalry tactics see Bachrach 2001, 196) and in Byzantium (Haldon 1999; Kantorowicz 1956). In addition, more complex technologies increase the opportunity costs of producers and as a result reduce their incentives to wage war directly. At some point, producers may prefer to pay some third party to defend them while devoting themselves fully to production, even if they retain some absolute advantage in war-making. However, because it is difficult for producers to control the "stationary bandit" they accept as a defender, higher opportunity costs generally result in the spread of monarchical or dictatorial institutions.[12]

[6] As long as land is abundant relative to labor, moving to new lands to exploit them with these new technologies is probably cheaper than looting neighbors or relatives. However, conflict and state institutions can also arise under conditions of land abundance. If highly sophisticated weapons are available, a high land/labor ratio may in fact increase the incentives of those bandits to impose a serfdom or slavery system precisely to curtail the exit options of the peasantry (Domar 1970; Hirschman 1981, 250–1). We discuss this possibility in some detail in the section "The Boas Dataset."

[7] The invention and widespread use of the heavy plow in about 1000 AD in Europe conferred a productivity advantage on areas with dense, clay soils, irrespective of other political and economic attributes (Andersen, Jensen, and Skovsgaard 2013). It is also possible that the heavy plow increased gender inequality by increasing the value of brawn in food production, but we leave that question for further research.

[8] Still, it is reasonable to suppose that, beyond a certain threshold, inequality can only be sustained through the threat of violence by those who have more (Boix n.d.).

[9] Even when they have an overwhelming military advantage, warlords will confiscate only to the point where they optimize rents.

[10] We do not model here how the abundance of land and labor may affect the evolution of military technology. They are probably related analytically, in that density leads to more investment in warfare.

[11] A labor-intensive military technology implies that military prowess will be lightly correlated across generations and therefore will leave little traces in relative height. Smith et al. (2010) show that the transmission of hunting skills from fathers to children in foraging societies is low.

[12] Complex war-making technologies may be favorable to producers (and not to looters or bandits) if they are complementary to their technologies of production. Creating and sustaining a powerful navy required an underlying set of skills (as well as capital) that could only be nurtured in trading and commercial cities. That could help explain the cases of democratic classical Athens or republican Venice in late medieval times.

The Industrial Revolution and Democratization

Commerce, the rise of cities, and industrialization gave states new stores of wealth to tax while undermining the military monopoly of the landed elite. Industrialization accelerated from the eighteenth century, resulting in higher incomes overall and, eventually, a more equal distribution of wealth in most cases. In the short run, the higher returns on new production processes increased income disparities. However, as the higher returns in manufacturing industries spread to larger segments of the population and increased the returns to education, the wage gap between skilled and unskilled workers that had initially widened at the beginning of the industrial revolution narrowed again (Kuznets 1955; Williamson 1991). This progressive equalization, at least in opportunities, facilitated a political shift toward mass democracy that in turn reinforced the trend toward equality as liberal institutions invested more in human capital formation and welfare states.

HEIGHT DISPERSION AND INCOME INEQUALITY

Income, Nutrition, and Height

Individual height is determined by both genetic dispositions and environmental factors (intrauterine conditions and the nutritional status and disease environment during childhood).[13] Fogel et al. (1983) show that the mean heights of boys aged 14 to 16 from families of London laborers between 1770 and 1865 were well correlated with the real wages of London artisans. Both Floud, Wachter, and Gregory (1990) and Steckel (1995) provide extensive surveys from the twentieth century that confirm the same association. Based on a sample of the U.S. population with European ancestors in the 1970s and 1980s, Steckel (1995: 1915) shows that income and height are positively correlated, with decreasing marginal returns to income. Individuals with an income of $12,000 (in 1985 US$) are about 10 cm higher than those with an income of $1,000. Similar results have been found for cross-country correlations (Baten and Blum 2012). Cumulative evidence seems to warrant using heights as a proxy for economic development.[14]

Likewise, variance in the heights of individuals within a given society may be used as a proxy for income distribution if we assume that access to food, shelter, and health increases with income and social position. That seems to be particularly true for preindustrial societies, which often lived on the Malthusian frontier. In their examination of the diets of rich and poor households in England from the fifteenth century to the middle of the eighteenth century, Drummond and Wilbraham (1991) find that wealthy individuals had diets rich in meat and fish. Poor households systematically relied on black bread, cheese, and pulses and occasionally on bacon. Fogel (1994) has calculated calorie consumption by decile in France and England by 1790. The French and English top decile consumed 3,672 and 4,329 kcal per day, twice the median intake and three times the consumption of the lowest decile. The bottom 10% of the French labor force lacked the energy for regular work, and the next 10% had enough energy for less than three hours of light work daily. More directly related to this article's empirical strategy, several recent studies—Baten (2000) for Bavarian districts in 1798–1837; Sunder (2003) for Norwegian regions in 1937–97; Baten and Fraunholz (2004) for contemporary Latin America; Moradi and Baten (2005) for contemporary sub-Saharan Africa; and Guntupalli and Baten (2006) for India in 1915–44—have reported a statistically significant cross-country or cross-regional correlation between the coefficient of variation in individual heights and direct measures of income inequality.[15]

The use of height variance as a proxy for income inequality faces three potential problems: reverse causality, selection, and genetic sorting. We discuss them here sequentially. First, height may result in higher earnings rather than the other way around. The positive effect of height has been attributed to its impact on self-esteem, social recognition, or discrimination (Hensley 1993; Magnusson, Rasmussen, and Gyllensten 2006; Wilson 1968) or to its correlation with greater strength and better health (Strauss and Thomas 1998) or with cognitive ability (Case and Paxson 2008). Our results do not depend, however, on showing that individual heights and incomes are related causally in either direction. What matters for our purposes is that we observe higher variance in heights in those societies that have economic, military, and institutional factors that are more conducive to inequality. A correlation between height dispersion and these factors predicting inequality indicates that either a causal relationship exists or that, regardless of the direction of causality, these factors make inequality possible—that is, they allow the marginal effects of height to be positive. The role that contemporary wage-bargaining institutions play in wage formation helps clarify our point. Variance in skills and height distributions is similar across the most advanced economies. Within-country wage compression is positively associated with how centralized wage-setting institutions are (Wallerstein 1999), independently of whether particular wage-setting procedures generate equality or whether wage equality makes centralized bargaining institutions sustainable (Beramendi and Rueda 2012).

[13] According to Silventoinen (2003), 80% of the variation in body height in contemporary Western countries is genetic and about 20% is due to environmental factors.

[14] Africa, which has an extraordinary level of genetic variance, may be the only exception to the income-height correlation (Deaton 2007). For a recent review of this subfield, see Steckel (2009).

[15] Moradi and Baten (2005) and Van Zanden et al. (2013) show the coefficient of covariation and the Gini coefficient of income inequality to be strongly correlated. Moradi and Baten (2005) suggest the following specification: Gini = −33.6 + 20.5 height coefficient of variation.

Height distributions are vulnerable to survivor bias because only survivors into adulthood are included in our samples. A disproportionate number of deaths of poor children, for example, might chop off the bottom end of the height distribution. We are not able to correct in any systematic way for that distortion, but note only that Gini measures of income inequality also measure survivors and therefore suffer from the same problem (see Moradi and Baten 2005; van Zanden et al. 2013). It is thus necessary to interpret any distribution of surviving populations with caution.

Finally, using height variance as a proxy for economic inequality could be suspect if heights are determined overwhelmingly by genetics and if genetically distinct groups in a society coincide perfectly with their economic status. This is not a great concern, at least for populations of similar ethnic background. For example, better nutrition and health care were behind the process of growth and regional convergence in heights in Norway where the genetic pool has remained unchanged in the last two centuries (Sunder 2003). Later in this article we present data on other populations that did not change genetically but whose average height and height variance changed with economic and political conditions: Japan, medieval and modern Poland (especially high-status males and peasants), and African Americans (before and after the Civil War). Over the course of history many populations of warriors have invaded and subjugated different ethnic groups. However, invasions and population movements pose an inference problem in the use of heights data only if neither genetic nor political-economic mixing occurs. Although this situation strikes us as improbable, we remain attentive to this possibility while examining our empirical evidence.[16]

Evidence

Two types of evidence can help us gauge the height of human populations: (1) skeletal remains from human settlements as reported by existing archeological and anthropological research and (2) direct measurement of heights in living individuals, mostly from census data and military records. Data from skeletal remains provide a rare glimpse into the size of prehistoric populations, but suffer from two problems. First, archaeologists and anthropologists rarely find complete skeletons, let alone in the numbers necessary to draw statistically valid inferences about the populations under study. Second, methods to estimate heights from skeletal remains, mainly from the bones of the extremities, are in some cases specific to particular ethnic groups (having been derived from large statistical samples of living people). We have well-tested formulas for some groups (modern whites, blacks, Japanese, and Mesoamericans), but heights—particularly the variance in the distribution—are sensitive to which height estimation formulas are used (Krogman and Işçan 1986). Full height measurements are accurate as far as they go, but are available only beginning in the late eighteenth century (and, exceptionally, in the early eighteenth century for France), and until censuses appeared, they were primarily for military recruits and prison populations.

In our analysis, we use both skeletal and measured height data but, to be conservative, we rely on Franz Boas's data collected for living Native Americans from various tribes in the nineteenth century that approximate the conditions of precontemporary or even premodern societies. We supplement the findings of those data with inferences derived from skeletally estimated height data.

Data on heights from different populations come to us in two formats: (1) complete datasets that report heights for all its individuals and from which we can estimate summary statistics of interest and calculate density distributions and (2) information only of height means and standard deviation of a given population (as a whole or for its different social strata). We discuss the representativeness of our samples when presenting the data. Note, however, that the question of sample representativeness is a less pressing concern in those cases for which we have separate measurements for each economic or social strata.

For the sake of comparison across samples, we focus on two types of measures: primarily the coefficient of variation of each society because it controls for the effect of differential height means and, when this is not feasible, the difference in heights across social strata. In the few cases where we have both measures, the coefficients of variation and the height gap between lower and upper classes are positively correlated. Where possible, we also present and discuss the kernel density distributions of different populations to assess the impact of political and economic factors on inequality.

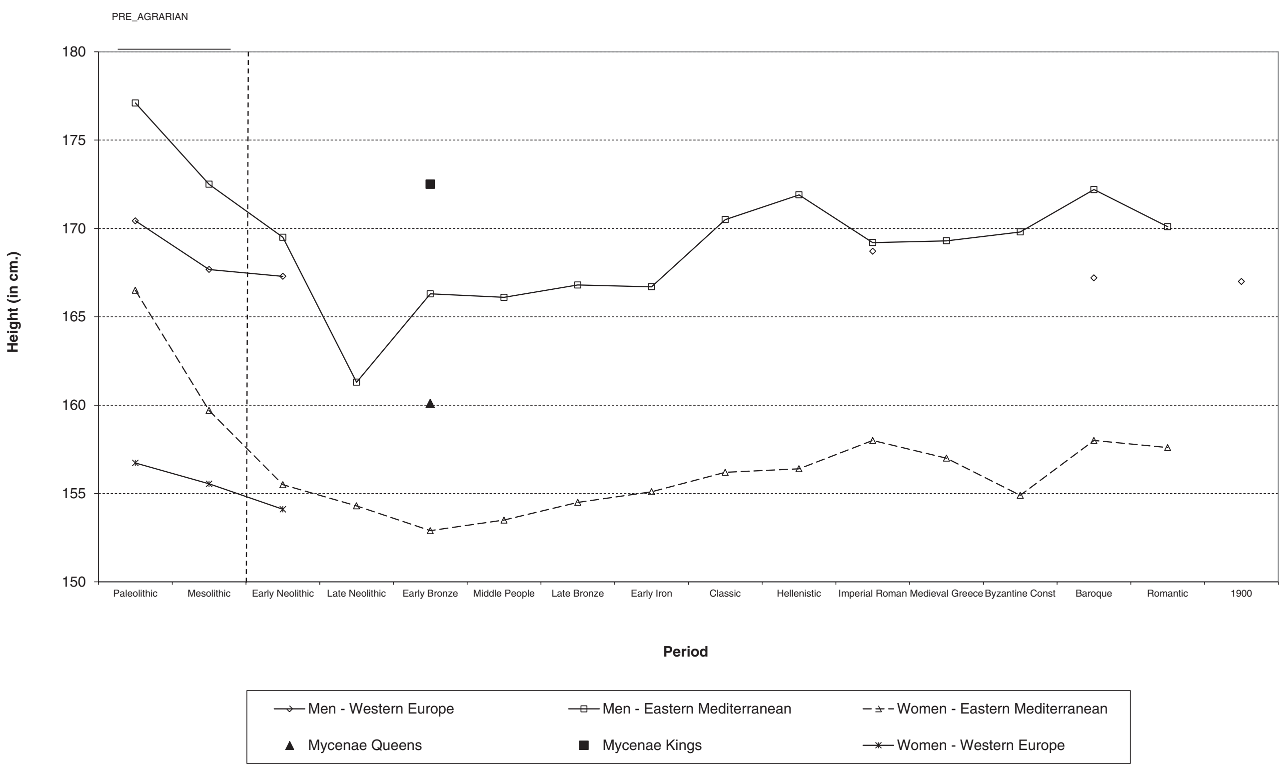
The Evolution of Height

Figure 1 recapitulates succinctly what is known about the evolution of average human height over time. Both men and women were taller in pre-agrarian societies than in agrarian societies. In Paleolithic and Mesolithic sites, femur lengths seem to indicate a height around 175 cm for men and 165 cm for women. These values are in the range of average heights today. Pre-agrarian individuals were tall as a result of their abundant and diverse diet based on scores of plants and animal species, naturally related the use of birth control strategies and low human population densities (Bogin 2001; Gould 1981; Hayden 1981; Hill and Hurtado 1989; Lee 1984). By contrast, agriculturalists tended to rely on a single cereal stable—rice in Asia, wheat in temperate Asia and Europe, and maize in the Americas—supplemented with vegetables and, particularly among wealthy strata, some fish and meat (Scott and Duncan 2000).[17]

[16] We use contemporary height data (in the section "Inequality Today") to examine the possible correlation of genetic heterogeneity and height variance within human communities.

[17] The narrowing of the food base led to growing deficiencies of some essential nutrients. These deficiencies turn up as biological stress in the form of bone lesions due to anemia (porotic hyperostosis),

FIGURE 1. Heights in Western Europe and Eastern Mediterranean



The economic transformation spurred by the industrial revolution had two consequences. In the short run, it led to a decline in average heights as rural dwellers moved to densely crowded, unhealthy urban centers. Transitionally, the opening of markets permitting sales of food for other goods might also have raised the price of food, reducing consumption. In the long run, however, growing per capita incomes and the improvement of public sanitation resulted in better nutrition and health conditions and, eventually, increased heights to the genetic potential—until increased income had no additional effect (Komlos 1989; Steckel 1995).

THE BOAS DATASET: NINETEENTH-CENTURY NATIVE AMERICANS

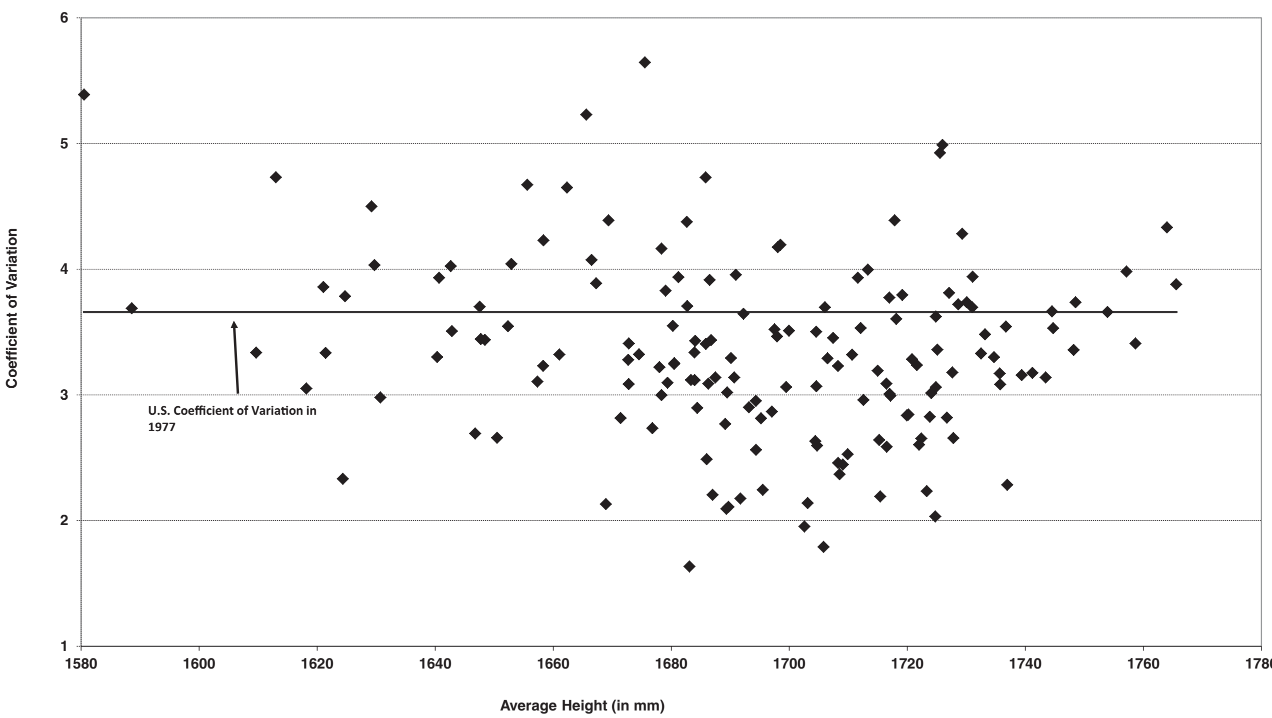
To examine populations with relative simple production technologies and warfare capabilities we exploit an extensive dataset collected by Franz Boas and his research assistants on the age, height, and other anthropometric traits of about 16,000 Native Americans from about 290 tribes, across the continent, in the late nineteenth century. Although Boas did not employ random sampling procedures, the collection of the data was systematic and his coverage of Native American tribes seems to be broad and exhaustive enough to warrant its analysis for our purposes (Jantz 1995; Jantz et al. 1992).

The Boas project took place at a time when most tribes had been in contact with European settlers or at least white governments. Many of those tribes had entered compacts with the American and the Canadian governments that had relocated them into reservation areas; they had already been shocked and in some cases decimated by European diseases, been transformed by the incentives opened to them by trade, and even been affected by the European diet. In an extreme case such as the Sioux, for example, the federal government decided to supply them with a fixed, and quite generous, amount of food after moving them onto reservations (Steckel and Prince 2001). Given that most of the impact of the new settlers seems to have occurred in the 1850s and 1860s, we first examined the height of those cohorts that grew before and after those decades separately. However, because we did not detect any significant deviation in statures across cohorts, we use and report results for the whole dataset formed by all adults older than 18; that is, those born before about 1875.

The average height of the Boas dataset is 168.8 cm for men and 155.9 cm for women. Cross-tribal variance is substantial. The average male height of tribes ranges from a minimum of 160.8 cm (the Wailaki in California) to 175.4 cm (the Cheyenne in the Plains). Average female height goes from 149.7 cm (the Yuki in California) to 163.5 cm (the Sauk in the Northeast). The tallest tribes were taller than their European

incomplete enamel formation in teeth (hypoplasias), loss of bone mass, bone lesions from infections, and stunted growth (Goodman et al. 1988; Ortman 1979; Ortner and Theobald 2000).

FIGURE 2. Native American Man: Average Height and Coefficient of Variation



contemporaries—a similar Boas dataset for European immigrants into the United States shows that the tallest (Slovak men) averaged 168 cm. The shortest native Americans lived in the geographical fringes of the sample: either in the hot Southwest, among the Pueblos, or in the very cold Arctic regions among Eskimos.

To examine intra-tribal inequality, Figures 2 and 3 plot both the average heights and coefficients of variation for Native American communities for which Boas reported more than 10 observations.[18] They also graph the coefficient of variation (CV) of men's and women's height in the United States in 1977: 3.66 for 18-year-old boys, which is similar to egalitarian Iceland's CV (Palsson 1973), and 3.57 for 18-year-old girls (Steckel 1995). Coefficients of variation among Native Americans are also low. About three-fourths of the tribes had a CV lower than 3.66 (and 90% had a CV below 4). Around half of all tribes had a CV of 3.3 or lower.[19] The results for women are very similar. In short, tribes appear to be relatively equal. In both figures, the CV is uncorrelated with average height. This finding suggests that intertribal differences in average height caused either by genetic or environmental factors were not associated with different distributions of wealth.

The Boas data encompass tribes engaged in a wide variety of production practices: from the gathering and hunting practices of the Tahltan in the Canadian subarctic cordillera, the fishing and fur trading villages in the Northwest, and the buffalo hunters in the American Plains to the agricultural sedentary villages of the Zunis in New Mexico. Similarly, these tribes differed in their internal political structure. Some Canadian subarctic tribes had very weak formal institutions at the time of the Boas enterprise: They consisted of very small bands (formed by two or three households) that hunted and gathered over expansive areas, had no overarching chiefdoms, and at most participated in occasional encounters with other bands in the summer. By contrast, the Pueblo Indians relied on a stable political structure, in the hands of warrior-priests who controlled a specific territorial area in a systematic manner with the regular tools (sanctions, force, and executions) of any standard political authority.

To explore the relationship between height inequality and economic and political institutions, Models 1 and 2 in Table 1 estimate the relationship between both mean male height and the CV of male height and two independent variables: type of economy (classified into the four categories of simple foraging, complex foraging, extensive agriculture, and intensive agriculture) and political hierarchy (classified as no authority, clan-based authority, chiefdom, or state). Both covariates are taken from the Ethnographic Atlas. The type of economy is statistically not significant, whereas political hierarchy is positively correlated with mean

[18] Although the goal of exploring the effects of the evolution of political and economic institutions on height would be better served through the temporal analysis of a particular tribe, the cross-section examination of the Boas dataset should give a good approximation of the evolution from pre-agrarian societies to simple, relatively non-stratified agrarian economies (under simple military technologies).

[19] If we are to believe Moradi and Baten's (2005) functional specification, reported in footnote 15, a CV of 3.3 corresponds to a Gini of 34.

FIGURE 3. Native American Women: Average Height and Coefficient of Variation

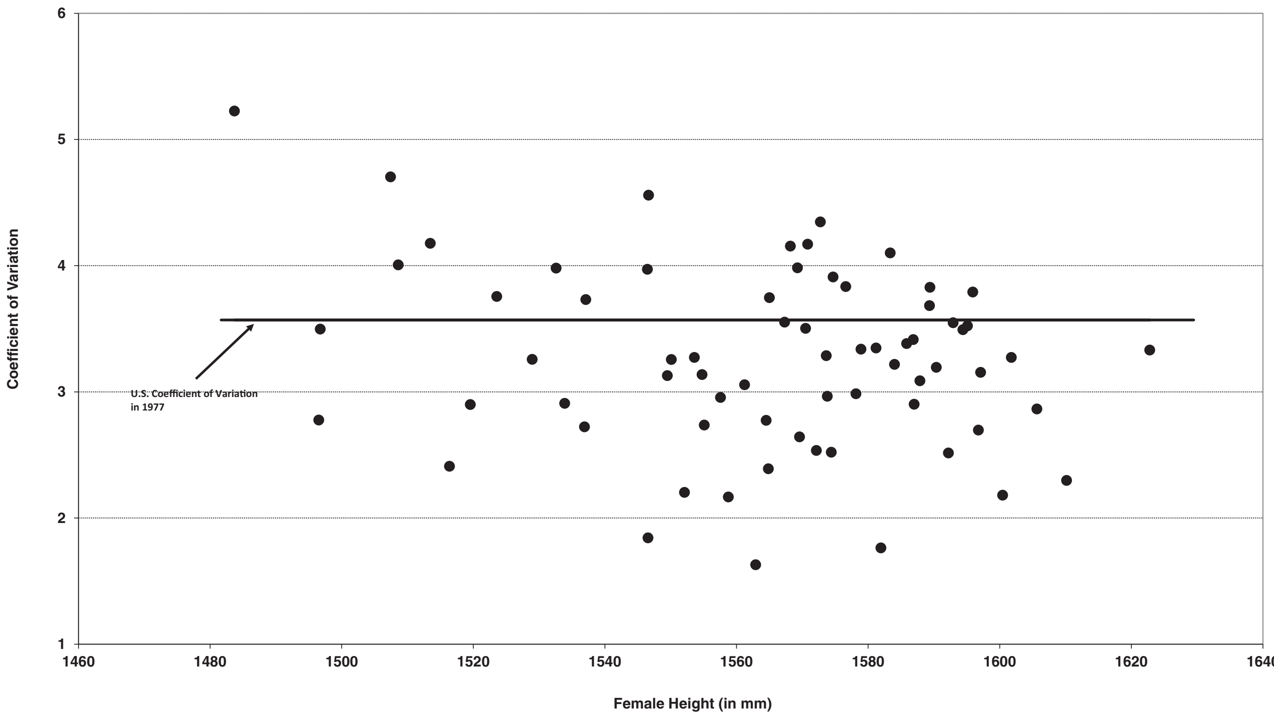


TABLE 1. Covariates of Inequality in North America and the World

	(1)	(2)	(3A) Settlement Pattern	(3B)	(4A) Stratification	(4B)	(5A) Political Hierarchy	(5B)
	Average Male Height	Coeff. of Variation Male Height	World	North Am.	World	North Am.	World	North Am.
Type of economy	2.67	−0.12	0.72***	0.69***	0.28***	0.01	0.44***	0.30***
	(4.13)	(0.08)	(0.05)	(0.09)	(0.05)	(0.07)	(0.04)	(0.07)
Political hierarchy	14.24**	0.02						
	(5.88)	(0.11)						
First cutoff			1.31	2.27	1.54	0.34	0.97	0.25
			(0.19)	(0.23)	(0.20	(0.16)	(0.17)	(0.15)
Second cutoff			1.86	2.37	2.12	1.20	2.01	1.34
			(0.19)	(0.23)	(0.20	(0.18)	(0.17)	(0.16)
Third cutoff			2.13	2.40			3.84	
			(0.19)	(0.23)			(0.19)	
Adj R-squared	0.03	0.00						
LR Chi2			497.4	70.2	219.9	0.03	481.5	20.1
Prob > Chi2			0.00	0.00	0.00	0.85	0.00	0.00
Number of observations	107	107	1163	269	1054	261	1131	266
Estimation model	OLS	OLS	Ordered Probit		Ordered Probit		Ordered Probit	

***p < .01; **p < .05; *p < .10; standard errors in parentheses.

height but not with CV. For the sake of space, Table 1 does not report the (null) results for mean and CV female height. Three additional covariates—the use of horses (coded from the *Handbook of North American Indians*; Sturtevant and Trigger, 1978), the intensity of warfare (taken from Mishkin 1992), and social stratification (from the Atlas)—are not significant either.[20]

[20] Results are available from the authors on request.

To complement the analysis of Models 1 and 2, we look at the association between the type of economy and the following three variables, also taken from the Ethnographic Atlas, through ordered probit models: average size of the group settlement, level of social stratification, and political hierarchy. The estimations are done both for the whole set of observations in the Atlas and for its subsample of North American observations. Size of settlements, which may be taken as a measure of population density and arguably of economic productivity, is well correlated with the type of economy: More complex forms of economic activity lead to more population and larger settlements. The coefficients are very similar for both samples (Columns 3A and 3B). Social stratification (ranging from a no-class system to a society with three differentiated classes) and type of economy are positively and significantly correlated in the world sample but not in North America (Columns 4A and 4B). The results in Column 4B mirror the null result obtained in Column 2 for height variance. Finally, the association between political institutions (as defined earlier) and type of economy is significant in both estimations (Columns 5A and 5B), but is smaller in North America than in the world.[21] In short, in addition to being relatively low, inequality (measured through height variance or through social stratification as coded in the Ethnographic Atlas) cannot be explained by differences in type of economy in North America.[22]

This relative equality in heights and the lack of strongly stratified societies could be the result of the dominant type of warfare in the region.[23] Military technologies remained relatively underdeveloped among Native Americans. Metal weapons were rare or small in size. The introduction of the horse in the sixteenth century certainly resulted in the destruction of many horticultural societies, the expansion of the territorial reach of some of the Plains tribes, and a more elevated status for men (Anthony 1986; Ewers 1955). However, warfare consisted principally of mounted raiding and the use of harrying techniques, mainly to steal horses. No Native American tribe developed the horse-chariot technologies that led to the formation of the kingdoms and empires of the ancient Middle East (McNeil 1981). None established the kind of heavy cavalry that predominated in medieval Europe and that generated a feudal aristocracy (Verbruggen 1997; White 1962).

That is not to say that the development of horse chariots or the stirrup was necessary to establish unequal social relations. Some Native South American populations did use horses to enslave their neighbors (Anthony 1986; Gregson 1969). In West Africa the introduction of large-breed horses in the fourteenth century led to the formation of "cavalry states." Horsemen invaders from the North and the Northeast employed their military superiority to raid the region and to capture men, some of whom they used to reinforce their armies and but most of whom they sold to European and Arab traders. They then reinvested the proceeds of the slave trade to purchase new horses to expand their area of control because it was impossible to breed horses in most of the region due to the presence of the tsetse fly (Goody 1971; Law 1976; Levtzion 1977).[24] Yet North American natives did not develop along those lines: Agriculture was not sufficiently intensive, and the population pool may have been too small to reduce their neighbors to serfdom or to sustain the slave-exporting system of Africa. Finally, firearms, which could have pushed those societies into a new political landscape, were available late and already under the shadow of European conquest.

THE IMPACT OF WAR-MAKING IN AGRARIAN SOCIETIES

Although social stratification and state institutions are more likely to emerge in agrarian economies, their level of complexity varies as a function both of military technologies and of factor endowments and production technologies. This section turns to explore the distributional impact of the first set of factors—that is, the impact of war-making technologies. It compares the Zuni Pueblo and the Mayan city-states—which exemplify agrarian economies with unsophisticated military technologies (like the agrarian tribes of the Boas dataset)—with Mycenae, ancient Egypt, medieval and modern Poland, and absolutist Germany, where warfare implied the use of highly sophisticated weapons—from bronze artifacts to war chariots and heavy cavalry—that resulted in the formation of a powerful military elite and a highly stratified society. Our examination of Japan completes the section by tracing the evolution of heights over time under different institutional and military regimes but a similar geographic and cultural environment.

The Zuni Pueblo

The Zunis, a sedentary people in northwestern New Mexico, represent a simple, relatively nonstratified agrarian political economy. Although Spain tried to conquer and evangelize them in the seventeenth century, an Indian uprising eventually expelled the Spanish from the region in the 1680s. Until the middle of the nineteenth century the Zunis had little contact with external societies and remained politically and economically self-sufficient. Systematic trade and political relationships with the United States only started in the

[21] It is worth mentioning that no Native American society had a state and that only very few are coded in the Ethnographic Atlas as chiefdoms.

[22] Northwestern Pacific societies were a partial exception in terms of inequality. They were rather stratified with a substantial population of slaves. However, they remained territorially very fragmented because their chiefs had no military means to project their power beyond their island or fjord (Ames 1994; Floud, Wachter, and Gregory 1990; Mitchell 1985).

[23] It may be also partially related to a type of agriculture that was relatively unsophisticated, with no plowing technologies and no crops with significant economies of scale.

[24] West African states collapsed once the slave trade was banned in the first third of the nineteenth century (Law 1975; Lloyd 1971).

TABLE 2. Height Distribution in Agrarian Societies with Simple War Technologies

	Years	MEN				WOMEN			
		Obs	Mean	Stand. Dev.	CV	Obs	Mean	Stand. Dev.	CV
A. ZUNI PUEBLOS									
Dolores[a]	600–980	9	162.3	4.8	2.9	10	157.1	4.6	2.9
Hawikku[a]	1400–1680	26	165.1	4.1	2.5	46	153.9	4.1	2.6
S. Cristobal[a]	1350–1680	65	164.3	3.5	2.1	62	152.8	4.9	3.2
New Mex[b]	1890s	62	162.2	4.9	3.0	11	151.3	6.3	4.2
B. MAYAN POPULATIONS									
Jaina[c]	ca. 600	7	160.3	2.4	1.5	12	151.0	4.7	3.1
Copan urban[c]	ca. 825	36	162.8	3.2	2.0	46	155.5	3.9	2.5
Copan rural[c]	ca. 825	9	160.1	2.9	1.8	13	154.9	3.4	2.2

[a] From Steckel and Rose (2002), ch.16.
[b] From Boas project.
[c] Own estimates based on Steckel and Rose (2002).

1880s. This led to a devastating smallpox epidemic in 1892–3 and a move toward livestock cultivation as their main source of livelihood at the turn of the century. In the 1880s the Zuni Pueblos were still governed by a "committee" filled with former warriors who had taken scalps from their enemies. This governing council regulated religious ceremonies, repressed witchcraft activities, coordinated responses to big crises, and resolved inter-town conflicts. All other social relations were left in the hands of families and clans (Ladd 1979).

Panel A of Table 2 displays the mean, standard deviation, and CV of male and female heights in the four periods for which we have data, coming from skeletal remains spanning from AD 600 to AD 1680 and the Boas dataset. The data suggest relative equality. The CV of male height, of 3 or less, is almost a third lower than its value in modern societies. Female heights CVs fluctuate around 3 except in one case.

Mayan Cities

The characterization of precolonial Mayan states has been controversial. Traditionally, Mayan city-states were thought to be highly stratified, theocratic polities (Haviland 1967). More recently, however, several scholars have suggested that the Mayan lived in only mildly stratified cities, with a small priestly and warrior elite, in the middle of a very poor and equal rural economy. From the point of view of our inquiry, the most relevant variable is the kind of military and war-making technologies of Mayan societies. Although the Mayan civilization was not conflict free as some scholars have claimed, its weaponry was clearly underdeveloped and primarily based on chipped-stone spear and dart points (Aoyama 2005; Webster 2000). Mayans had no bronze metallurgy, no wheels, and no domesticated animals, such as the horse, that could be used to engage in the type of large-scale warfare conducted in the Middle East or China.

Table 2, Panel B reports data from a number of Mayan sites during its classical period: Individuals were rather short, even though their statures later dropped even more—by 2 and 5 cm under the Spaniards and by another 2 to 3 cm after Mexican independence. Height variance was quite low: The CV is 2 or less among men (the lowest in all our data) and 2.5 among females in our largest sample (in urban Copan). By area, individuals were shorter and the dispersion was minimal in rural areas—the skeletal remains come from areas with "modest dwellings of perishable materials dispersed in rural areas away from the urban core" and probably belonged to "agricultural laborers and part-time craftspeople" (Steckel and Rose 2002, 289). Urban settlements show more height dispersion, probably reflecting the mix of people—wealthy individuals and their servants and perhaps a class of craftsmen—who lived there. Still, Mayan cities were small. The population of Copan peaked at 27,000 in the ninth century and then fell to a third of that number by AD 1000. Compared with the large polities of Europe that emerged after the military revolution of the Renaissance period, stratification could not have been very extreme, and according to Table 2, it was not.

Mycenae and Ancient Egypt

Although agriculture took root in the Middle East around 9000 BC, the formation of states with a clear hierarchical political structure, a division between a military and religious elite and a mass of subordinate laborers only took place around the late fourth millennium, coinciding with the metal revolution and the use of copper to build short-range weapons, such as maces, axes, swords, helmets, and shields (Yadin 1963). A thousand years later, the introduction of bronze, which was both lighter and sturdier than copper, opened the way to the first big monarchical states in the Middle East (Keegan 2004; McNeil 1981).

TABLE 3. Height Distribution in Agrarian Societies with Complex War Technologies

		MEN					WOMEN				
	Years	Obs	Mean	Stand. Dev.	CV	Height Royals minus Height Commoners	Obs	Mean	Stand. Dev.	CV	Height Royals minus Height Commoners
A. EGYPT											
Mummies[a]	ca 1500 BC	18	166.2	5.5	3.3	+9.2	13	156.2	5.6	3.6	+8.2
Commoners[b]	Dynastic	126	157.0				118	148.0			
B. MYCENAE											
Royal[c]	ca 1700 BC		172.5			+6.4		160.1			+6.6
Commoners[c]	ca 1700 BC		166.1					153.5			
						MEN					
C. 18th CENTURY GERMAN			At 17		At 18		Difference with aristocrats at 17				
Aristocracy[d]	1760–80		164.3		167						
Middle Class[d]	1760–80		159.9		163		−4.4				
Peasants[d]	1790		151.1		–		−13.2				

[a] Smith (1912).
[b] Masali (1972).
[c] Angel (1984).
[d] Komlos (1989).

We report data for Egypt under the New Kingdom and the Middle Bronze Mycenae as representative of ancient agrarian states and complex war-making machines. For Egypt we have direct measurements of mummies for two separate populations: 31 royal mummies (pharaohs and spouses) from the eighteenth to twentieth dynasties of the New Kingdom (1550–1137 BC), x-rayed in the early twentieth century (Smith 1912), and 260 complete skeletons buried in the upper Nile Valley (Asiut, Gebelen, and Aswan) for the Dynastic period (Masali 1972).[25]

The data are reported in Panel A of Table 3. Height differences were substantial in the highly stratified Egyptian polity. Even using a conservative estimate according to which royal mummies shrank 8 cm, pharaohs averaged 166 cm and were about 9 cm taller than common males. Women belonging to the royal family averaged 156 cm or about 8 cm taller than the average common female.[26] Because we do not have data on the shares of aristocratic and nonaristocratic population and given that Masali does not report the standard deviation for commoners, we cannot estimate the true CV for all the Egyptian population. Even assuming, however, a standard deviation of 6 for commoners (a number on the upper range of all the data we have), the median pharaoh would be in the 95th percentile of the commoners' population.

Mycenae, which had a powerful militarized monarchy with a Homeric aristocracy in the Middle Bronze period (around 1800–1700 BC), reveals a similar pattern. Differences in height were remarkable. Whereas the estimated stature of kings and males buried in kings' tombs was 172.5 cm, commoners averaged 166.1 cm or 6.4 cm less (Angel 1984). Among women, the upper strata averaged 160.1 cm and the commoners 153.5 (Table 3, Section B). As Angel (1984) points out, these differences cannot be attributed to ethnic origin because the royalty "show[s] the same striking diversity of morphology (and implied origins) as the general population, then in the process of absorbing Indo-Europeans and other settlers, including some from Africa." Instead, "the 4 percent increase in stature and in pelvic depth and the 30 percent increase in skull base height in the royalty, their thicker and more rounded long bones, and the five-fold improvement in their dental health all show nutritional improvement that must involve more meat protein than the average citizen got" (Angel 1984, 66).

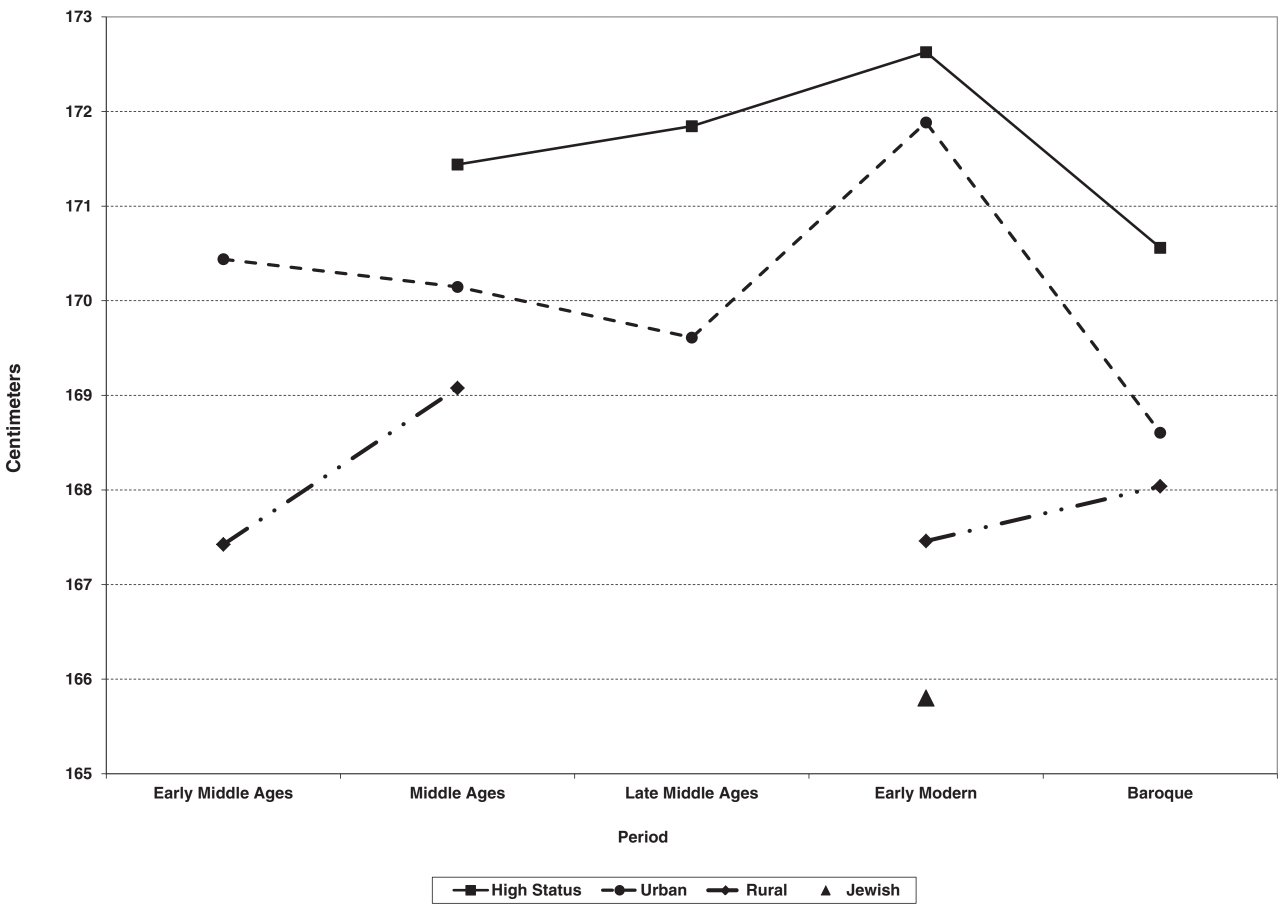
Medieval and Modern Europe

Medieval European societies offer us a picture of preindustrial societies characterized by a rural economy (about 90% of the population lived in the countryside) and feudal institutions with a thin rural nobility, an overwhelming population of farmers and laborers, and the clergy itself reproducing the hierarchically constructed structure of nobles and peasants (Duby 1968). With the expansion of commerce and the invention of

[25] We have no clear information on the social status of commoners. Notice, however, that if they belonged to the nonroyal upper strata, this would strengthen our claims on inequality in Egypt even more because lower status individuals were probably shorter.

[26] Comparisons of these complete skeletons with heights taken from living individuals have to be made with care because soft tissue shrinks with mummification. Their average height loss, depending on the pharaoh's level of activity and therefore the amount of soft tissue, may have reached up to 10 cm, of which 6 to 7.5 cm would come from the spine and the rest from soles and knees. Skeletons also shrink about 10 cm as a result of the loss of all soft tissue (personal communication from Rose Drew).

FIGURE 4A. Male Heights in Poland, 11th to 18th Centuries



the cannon, Europe moved from the feudal order to a system of sovereign states with strong royal dynasties that often co-opted the old nobility within absolutist institutions. In the West, feudalism gave way to a more modern agrarian system, based on the recognition of the Roman concept of absolute property rights, money-based transactions, and the emergence of a free class of farmers. In Eastern Europe, despite or perhaps because of greater land/labor ratios, the nobility successfully engineered a second feudal revolution and reestablished serfdom in the sixteenth and seventeenth centuries (Anderson 1974; Domar 1970).

Extensive data from Poland—gathered from 53 cemeteries, encompassing 3,000 individuals, and spanning the tenth to the nineteenth centuries—can help us assess the evolution of inequality over time in feudal countries with some detail. Figures 4A and 4B show the evolution of male and female heights in Poland from the central centuries of the Middle Ages (tenth to fourteenth centuries) to the Baroque period (mid-seventeenth century). For each period they distinguish between high-status, rural, urban, and Jewish cemeteries. Until the population crisis of the fourteenth century, we observe some systematic but small differences between social segments. High-status males and urban dwellers men were 3 cm taller than rural populations. Among women there were no significant differences; in fact, and against our expectations, rural women were 1.5 cm taller than high-status females up until the fourteenth century. After the Black Plague and especially the reintroduction of serfdom in the sixteenth century, height differences across classes increased dramatically. High-status men were 5 cm taller and high-status women were 2 cm taller than peasant folk. The difference with Jewish populations is even larger—the latter were 7 and 5 cm shorter, respectively—probably reflecting their extreme poverty (even though we cannot exclude genetically determined differences at work there). Differences in height due to income and nutrition were essentially interclass. Rural communities, for which we have individualized data, appeared to be relatively homogeneous: The CV of male heights in the cemetery of Ostrow Lednicki (fourteenth to the seventeenth centuries) is 3.3.

Late-eighteenth-century Germany seems to tell a similar story (Table 3, Panel C). Based on conscription data, Komlos reports that from the 1760s to the 1790s German aristocrats at age 17 averaged 164.3 cm, compared to 159.9 for middle-class recruits and 151.1 for German peasants. Although this gap probably closed as the peasants experienced some delayed

FIGURE 4B. Female Heights in Poland, 11th to 18th Centuries

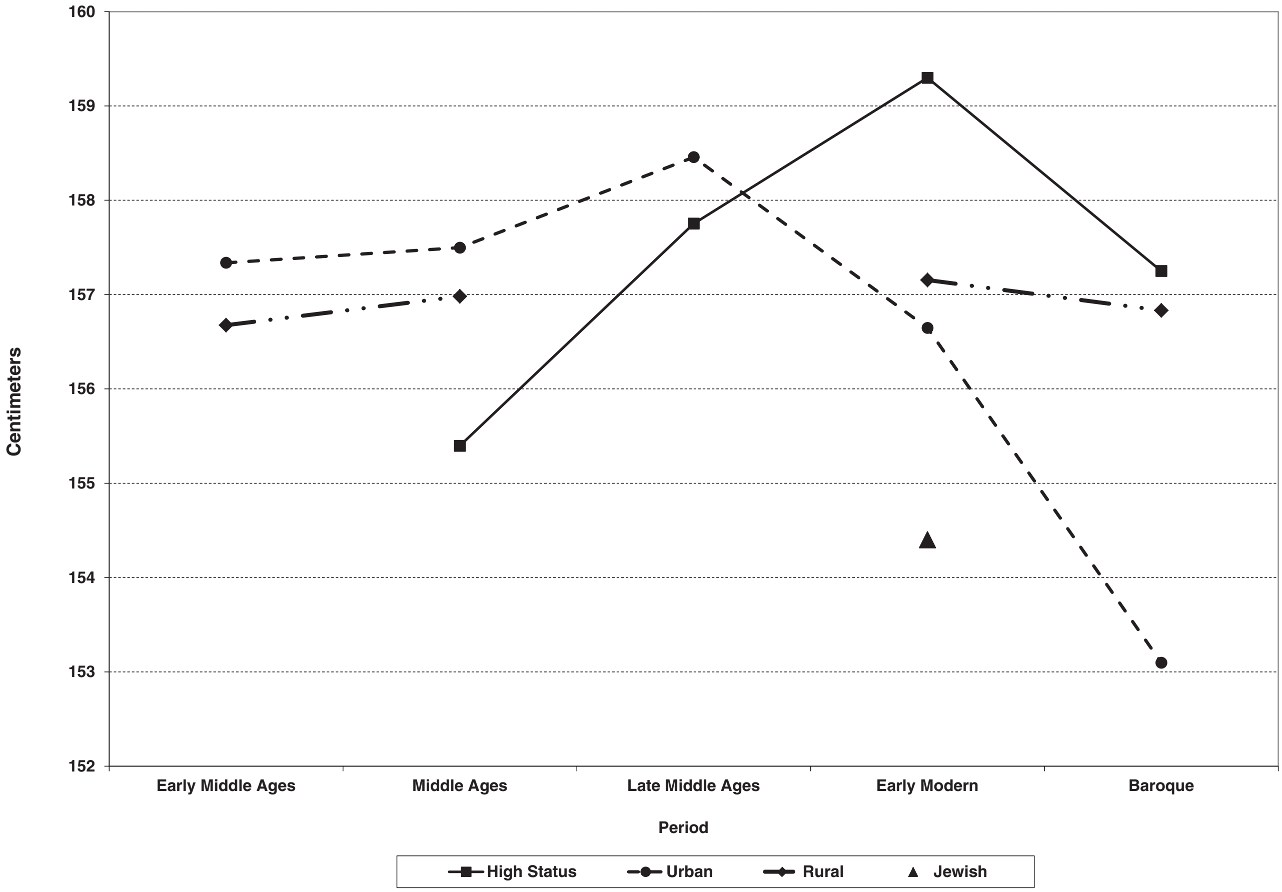


FIGURE 5A. Distribution of Male Heights in Agrarian Economies

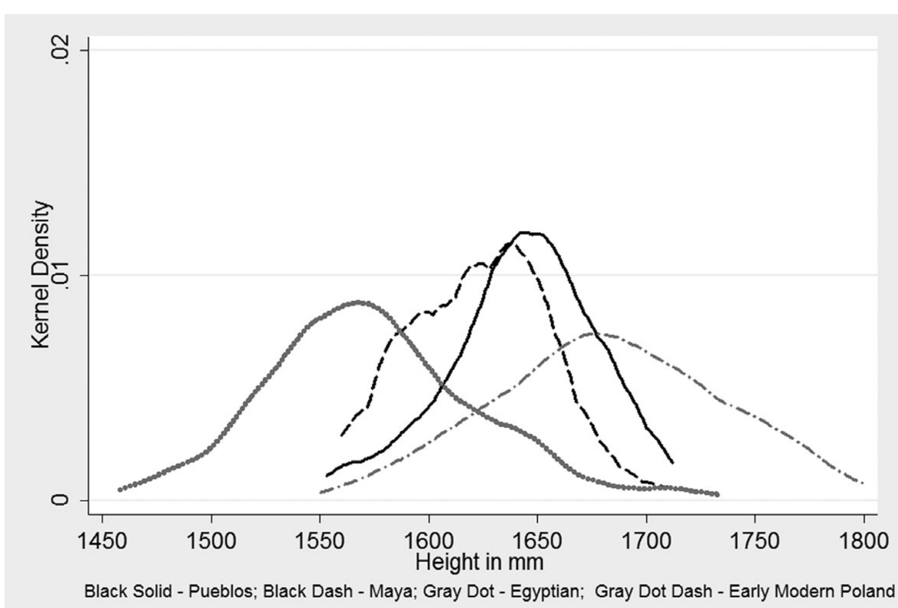
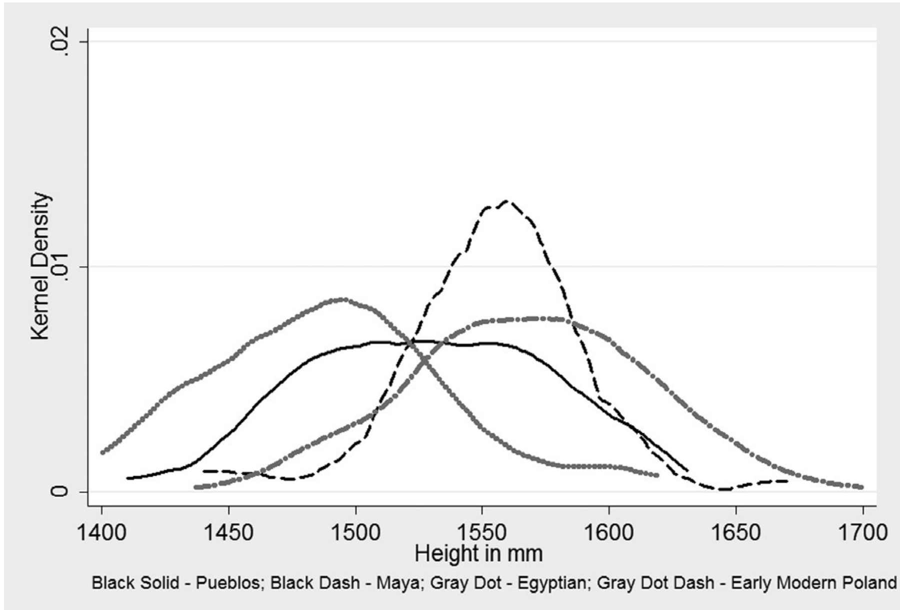


FIGURE 5B. Distribution of Female Heights in Agrarian Economies



growth (Komlos 1989: 94), research shows that stunting during adolescence is never fully overcome afterward (Case and Paxson 2008).[27]

Figures 5A and 5B summarize our discussion by comparing the kernel density distributions of male and female heights in two simple-warfare societies (the Zunis and the Maya) and two complex-warfare cases (Egypt and Poland).[28] Particularly for males, the variance in heights is much higher in the latter two and seems to corroborate our theory about the differential impact of politics and warfare.

The differences in height inequality match the direct—although very scarce—data we have on income inequality in both feudal and absolutist or despotic monarchies. Goldsmith (1987) reports that, at the death of Augustus (14 AD), the top 1/10,000 households of the Roman Empire received 1% percent of all income. (For comparison, the British royal family received 0.2% of all income in 1979–80.) In Mughal India around 1600 AD, they received 5% of all income. The annual income of the Indian emperor was the equivalent of the wage of about 650,000 unskilled workers. Milanovic, Lindert, and Williamson (2011) examine the level of inequality in 28 preindustrial societies and, by comparing it with the theoretically maximum feasible inequality, compute the actual level of rent extraction by the elite. According to their estimations, income transfers to elites were extremely high in monarchical societies: Elites captured more than two-thirds of all the resources available once we exclude the total sum of the minimum subsistence wage for all the population. By contrast, the level of "rent extraction" is estimated to be from one-third to two-fifths in today's advanced economies.

Japan

Table 4 displays height data for people living on the Japanese islands from 850 BC to the nineteenth century, calculated from bone measurements, using the Fujii method of calculation that is derived from Japanese populations.[29] The early hunter-gatherer population (the Jomon people, who lived in Japan from at least 4000 BC and probably earlier) were more evenly sized (with a male CV of 2.70) than the agricultural Yayoi who supplanted them in the fourth century BC (with a male CV of 3.56; Matsushita 1994; Yamada 2003). Because some of the Yayoi may have been of different genetic stock, one may take this as suggestive but not conclusive evidence for the effects of sedentary agriculture on intra-male inequality (Yamada 1997).

[27] Data for early-nineteenth-century Britain confirm a similar significant gap across social strata. For boys at age 15, the London poor averaged 147 cm, whereas the English gentry boys attending the Sandhurst Military Academy were already 163 cm tall (Floud, Wachter, and Gregory 1990).

[28] Using Stata's procedure kdensity, we were able to estimate kernel densities directly for Zunis and Maya because we have individual data. For Egypt, we assigned the following percentage to each segment of the population: 5% of royal-aristocratic stock and 95% of commoners. For the commoners, we randomly generated a distribution of individuals with a hypothetical standard deviation (Masali [1972] does not report the actual one) equal to a very low CV of 3 (to stack our deck against finding inequality). For Poland we assigned, in line with the historical data available, the following proportion to each social segment: 10% nobility, 5% cities, 10% small towns, 10% Jewish, and 65% rural non-Jewish. For each strata, we randomly generated a distribution of individuals with a standard deviation corresponding to a CV of 3—again stacking the results toward height compression within each group.

[29] The Fuijii method estimates height from femur length based on a particular femur-to-height ratio that is greater than the ratios employed for Caucasian populations (Nakanishi and Nethery 1999).

TABLE 4. Height in Japan

		MEN				WOMEN			
Era	Time Period	Obs	Mean	Std. Dev.	CV	Obs	Mean	Std. Dev.	CV
Jomon	To 300 BC	87	158.2	4.3	2.7	91	148.2	4.2	2.8
Yayoi	300 BC–AD 250	151	160.8	5.7	3.6	105	150.4	5.0	3.3
Kofun	3th –7th cent.	48	161.6	4.5	2.8	21	150.1	4.8	3.2
Medieval	13th –16th cent.	20	158.1	5.5	3.5	29	146.1	4.0	2.7
Togukawa-Shogun	1603–1868	4	155.5	4.4	2.8				
Togukawa-Edo	1603–1868	36	157.2	4.9	3.1	31	146.2	4.1	2.8

Note: Formula employed to calculate height: Fujii method.
Sources: See text.

Intra-male height dispersion appears to have grown in later centuries as agriculture became more labor intensive and as society became disrupted by warfare, although our data do not allow us to weight these factors. The Kofun period (third century BC to the seventh century AD) is named after the grave tumuli (*kofun*) in which the upper classes were buried. For that era we have only height data estimated from people buried in these mounds, without commoners as a baseline for comparison. Yet it is noteworthy, given that this is a high-status group, that the Kofun people are the tallest of the Japanese sample and have the lowest intra-male dispersion after the Jomon.

Commoner and low-ranking warrior families from the war-wracked medieval period (thirteenth to sixteenth centuries) had greater height dispersion than in most other periods in Japanese history, although not as great as in medieval Europe (Hiramoto 1972, 222; Nakahashi and Nagai 1985). Unlike the stable and stratified Tokugawa social order that followed it, medieval Japan was plagued by endemic civil war, political upheaval, and upward social mobility whereby many rural families became part of the warrior class.

We expected more evidence of nutritional variation between the Tokugawa shogun and Edo commoners (seventeenth to nineteenth centuries), but find that the shogun for whom we have available data were surprisingly short. Three of the four shogun for whom there are height data—Tokugawa Iyenobu (1662–1712; 162 cm), Iyeshige (1711–61; 153 cm), Iyeyoshi (1793–1853; 153 cm), and Iyemochi (1846–66; 154 cm)—were shorter than the average height of 157 cm for commoners in the Edo period. Either commoners were adequately nourished, or as some scholars have suggested, the Buddhist strictures of the Tokugawa family prevented the shoguns from consuming sufficient quantities of protein (Matsushita 1994; Suzuki 1985). It is also likely that the shoguns strengthened their genetic "tether" by assortive mating.

THE IMPACT OF FACTOR ENDOWMENT AND PRODUCTION REGIMES ON HEIGHT

We now turn to the impact of inequality of different factor endowments and production regimes under similar military and institutional structures by looking at the nineteenth-century United States. Midwestern societies (Ohio and several cities by the Great Lakes) approximated economies of relatively equal farmers with democratic institutions. The American South had a very stratified society with a large population of slaves.

Midwest Farming Economies

Table 5A presents average heights for Ohio guardsmen by their occupations and decade of enrollment—estimated using the data gathered by Steckel and Haurin (1994). Although some cohort CVs are high, what is remarkable is that height differences across occupations were low: The largest gap in average heights was 2.2 cm. The small occupational differences observed in the heights of the Ohio National Guard are in line with results for American data in other time periods. Union troops in the Civil War who were farmers were only 1.4 cm taller than laborers.

Table 5B reports height statistics for two North American communities in the Great Lakes in the 1840s: the middle-class city of Belleville and the skeletal remains of the cemetery of the poorhouse of Highland Park (taken from Steckel and Rose 2002). Differences in mean heights are very small—a maximum of 1.7 cm for men. The CV of the two populations together is 3.36 for men and 3.64 for women, which are lower than the U.S. CV in 1977.

Slave Economies

Table 5C reports height statistics for white elites and black slaves in the antebellum American South and for free African Americans after the Civil War (also taken from Steckel and Rose 2002). Male slaves were 4 cm shorter than southern white men (and 6 cm shorter than Ohio national guards). Enslaved women were 6.5 cm shorter than white women. This wider gap in heights for females was likely related to investment decisions made by their owners as a function of their specialization.[30] Male free blacks (measured in 1888)

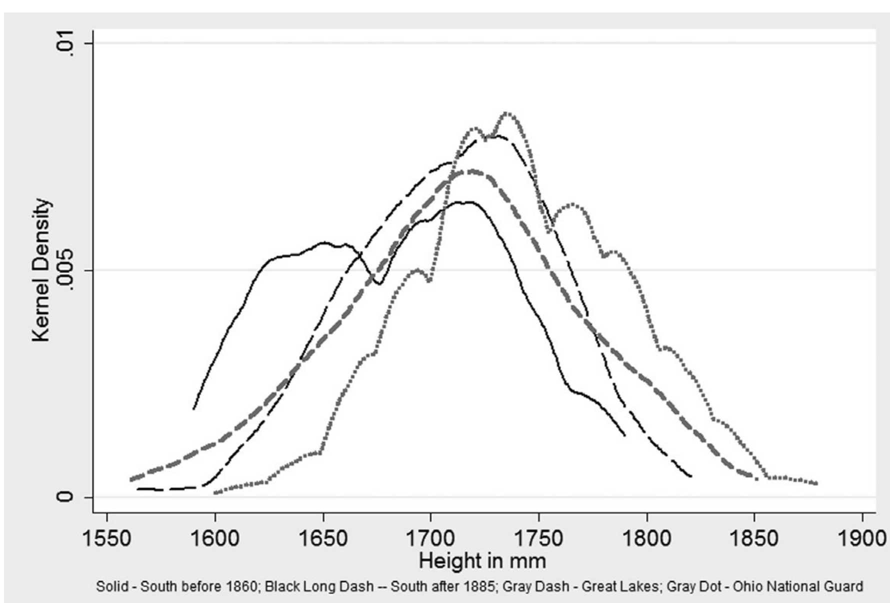
[30] Researchers who have gathered information on average heights for North American slaves have noticed that they were relatively

TABLE 5. Production Regimes And Height Inequality in Mid-Nineteenth Century United States

	Men				Women			
	Number	Mean	St.Dev.	CV	Number	Mean	St.Dev.	CV
A. OHIO RECRUITS								
Occupation								
Laborer	630	173.28	6.58	3.80				
Other	2,036	173.66	6.20	3.57				
Skilled Worker	1,107	174.04	5.97	3.43				
Clerical Worker	418	174.07	5.72	3.28				
Farmer	406	174.70	6.53	3.74				
Professional	438	175.51	6.38	3.63				
Enrolled 1870–9	694	173.77	6.87	3.95				
Enrolled 1880–9	725	174.51	5.39	3.09				
Enrolled 1890–9	3,039	174.49	5.58	3.20				
B. GREAT LAKES								
Belleville	122	172.03	5.24	3.05	91	160.22	5.60	3.50
Highland Park	91	170.33	6.27	3.68	61	160.44	6.19	3.86
All	213	171.30	5.75	3.36	152	160.30	5.83	3.64
C. AMERICAN SOUTH								
White Elites	7	170.79	4.51	2.64	3	165.73	2.32	1.40
Black Slaves	17	167.94	5.60	3.34	18	159.14	6.43	4.04
Total Antebellum	24	168.62	5.45	3.23	21	160.10	6.43	4.02
Free Blacks	95	171.12	4.71	2.75	84	159.32	4.62	2.90

Sources: Ohio: Steckel and Haurin (1994). Panels B & C: Steckle and Rose (2002).

FIGURE 6A. Distribution of Male Heights in 19th-Century United States

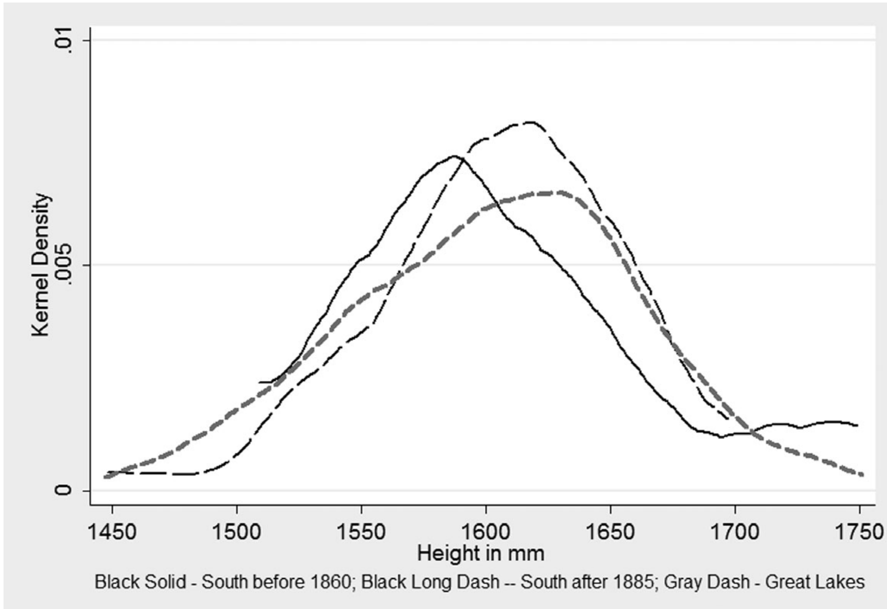


caught up very quickly with whites. This catch-up did not occur, however, among black women.

Figures 6A and 6B represent the kernel density distributions of the male and female populations of the Midwest (Belleville and the poor house together and, for males only, Ohio National Guard individuals) and of the American South (whites and slaves before 1860 and whites and free blacks after 1880). Midwest distributions approach the pattern of a normal distribution

tall, with a mean of 166 cm at age 18, and therefore almost as tall as members of the European upper classes. Black slaves in Trinidad were shorter: Men and women averaged 164 and 155 cm, respectively (Friedman 1982).

FIGURE 6B. Distribution of Female Heights in 19th-Century United States



(with a higher mean for Ohio men). The distribution of South Carolina men is clearly bimodal in the antebellum era, but normalizes after the war.[31]

INEQUALITY TODAY

Height may not be as strong a proxy for inequality in the contemporary period, at least for societies in which calories are not in short supply for even the least well off. The quality of calories is likely to vary, however, and income inequalities in advanced countries today are likely to be evidenced in other kinds of health issues, such as longevity, infant mortality, and proneness to particular kinds of diseases (Allen 2003; Hoffman et al. 2002). We leave further exploration of these differences to future work.

Because caloric abundance is a relatively recent phenomenon and because there is still variation across regions of the world in access to adequate nutrition, we explore the evolution of within-group height variance in contemporary societies from 1800 by plotting male and female CV and average height in Figures 7A and 7B. Average height is taken as a proxy for development, in line with the existing literature. We draw our data from the several hundred articles listed in van Zanden et al. (2013); it includes more than 1,000 data points for male populations and close to 350 for female populations. Both figures display the individual observations, one for each population, and the fitted regression line with 95% confidence intervals. The CV declines by about 0.75 points for the full range of heights for both men and women. The variance in CV also decreases with height: Shorter societies include very unequal and relatively equal distributions; taller societies are more homogeneous. These results are consistent with the proposition that economic development and modernization result in more equality, although we acknowledge that these findings could also reflect the declining measurability in the modern era of inequality through height data alone.

Table 6 reports the results of regressing the CV on average height and on genetic diversity. We measure generic heterogeneity using the Ashraf-Galor index of migratory distance from East Africa. The index captures the “serial founder” hypothesis according to which, as humankind expanded over the world out of Africa, the new groups that formed carried with them a fraction of the genetic diversity of their original groups. As pointed out in Ashraf and Galor (2013), migratory distance or distance with respect to East Africa (Addis Ababa) alone explains 86% of the cross-group variation in within-group genetic diversity. As shown in Table 6, migratory distance is statistically significant for males but not for females. The effect is small from a substantive point of view: A change of one standard deviation in migratory distance changes the male CV by 0.12—or a tenth of the CV standard deviation. Average height, which is not correlated with migratory distance, continues to be negatively correlated with CV: An increase of one standard deviation in height leads to a decline of almost half the standard deviation of the CV. This result strengthens our confidence in the effects of development on height equality even controlling for genetic endowment.

CONCLUSIONS

This article has laid out in broad brush strokes a theoretical framework about the effects of economic,

[31] The CV for antebellum men is 3.3 and for antebellum women is 4.01.

FIGURE 7A. Evolution of Male Heights and Coefficient of Variations since 1800

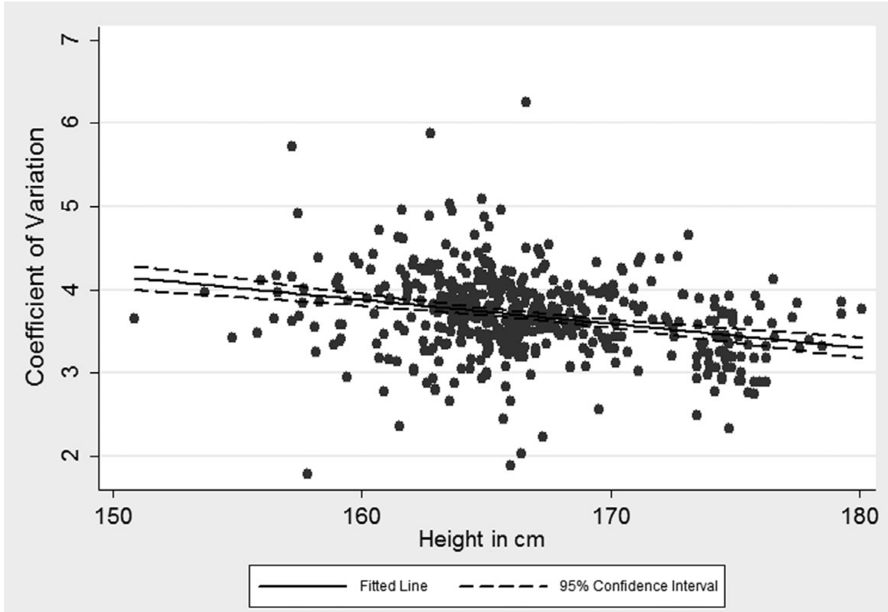
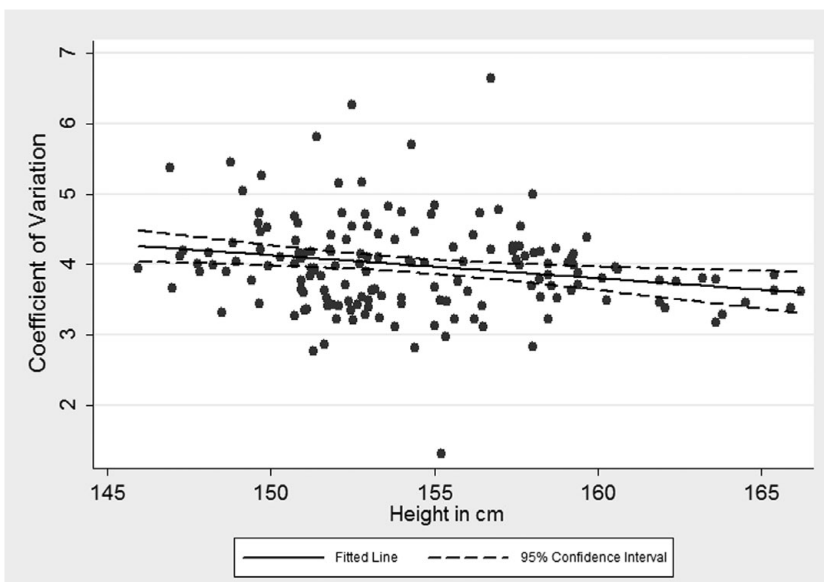


FIGURE 7B. Evolution of Female Heights and Coefficient of Variations since 1800.



Sources. The observations correspond to measurements of populations reported in the scientific publications employed by van Zanden et al. (2013).

military, and institutional factors on income equality and offers a new array of data for testing that framework. Human osteological data provide a potentially rich source of knowledge about times and places beyond the reach of more conventional tools of social science inquiry. However, the data are incomplete in several respects that are important for checking our theoretical propositions: We lack reliable time-series data for most populations, and even for the purposes of cross-sectional analysis, we do not have representative samples of all of the analytical categories that we would like to test.

Nevertheless, the scholarly community has begun to assemble a sufficient wealth of data from various times and places to increase our confidence and, even if imperfectly, our findings tend to fit well with our theoretical expectations overall. In an admittedly incomplete way, we are able to hold constant the economic,

TABLE 6. Within-Group Height Variance, Development, and Genetic Endowment

	(1) Men	(2) Men	(3) Women	(4) Women
Constant	8.732***	8.455***	6.744***	6.655***
	(0.414)	(0.412)	(0.456)	(0.459)
Average height	−0.031***	−0.030***	−0.019***	−0.018***
	(0.002)	(0.002)	(0.003)	(0.003)
Migratory distance		0.018***		0.007
		(0.003)		(0.005)
No. Observations	998	998	314	314
R2	0.135	0.158	0.111	0.117
Estimation	OLS	OLS	OLS	OLS

Notes: The observations correspond to measurements of populations reported in the scientific publications employed by van Zanden et al (2013). The index of migratory distance from East Africa corresponds to the great circle distance from Addis Ababa (Ethiopia) to each country's modern capital city along a land-restricted path forced through one or more intercontinental waypoint (Cairo, Istanbul, Phnom Penh, Anadyr and Prince Rupert) through which migrants had to travel. Distances are calculated using the Haversine formula and are measured in units of 1,000 km. The geographical coordinates of the intercontinental waypoints are from Ramachandran et al. (2005), whereas those of the modern capital cities are from the CIA's World Factbook.
***p < .01; **p < .05; *p < .10; standard errors in parentheses.

military, and institutional features in various times and places to understand to some extent the scope conditions for each. The shift of hunter-gather societies to complex fishing and sedentary agriculture often introduced inequalities severe enough to affect the distribution of human health and stature, as scholars have long thought. Although we do not have as much time-series evidence as we would like, we also find that inequality reflected, at least to some degree, factor endowments and corresponding production regimes. Temperate areas specializing in wheat production developed relatively egalitarian farming communities, at least in the Western hemisphere, compared to areas that grew crops with strong economies of scale (cf. Engerman and Sokoloff 2002).

Our evidence corroborates the expectation that the distribution of wealth tends to follow factor endowments, but institutional form and military position can countervail economic factors in significant ways. This rejection of economic determinism is important. Stationary bandits made use of changes in factors of production to their own advantage, as when the Ancien Regime French monarchy continued to live well by shifting its tax base from the landed to the urban elite. In behavior typical of rulers with minimal accountability, French monarchs were able to bestow land and offices on favorites, manipulate markets, and arbitrarily redirect profits to themselves and others from those who worked the land. Rulers and aristocrats in large, centralized states were typically able to command the resources that made their offspring physically taller than commoners, even when they had come from the same genetic stock. By contrast, the Zuni Pueblos and mid-nineteenth-century American Midwest offer examples in which relatively egalitarian societies constrained the transfer of resources to political leaders.

A wealth of yet untapped osteological data present further opportunities for examining our claims and for refining or challenging the theoretical propositions we have put forward. For simplicity, we categorized hierarchical systems of government as "monarchical," but examining human remains and records about height and health may make it possible to judge the separate effects of dictatorial from oligarchical rule. Were the absolutist monarchs who fielded mass armies in early modern Europe more generous to the peasantry on whose manual labor they relied than the feudal lords who fought in heavy armor on horseback in medieval times? Even more controversially, inequality as a result of merit versus rents is hard to distinguish in the relationship between the sexes. Did sexual dimorphism (the difference in male and female stature) expand from hunter-gather to sedentary agricultural societies because of efficiency-driven shifts in the household division of labor, or did it reflect a drop in female bargaining power as females lost independent access to food (Blaffer-Hrdy 1990; Kuhn and Stiner 2006)? We have only scratched the surface and invite the scholarly community to join our endeavor on this new empirical frontier.

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