Why are you tall while others are short? Agricultural production and other proximate determinants of global heights

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Abstract:

We analyze the proximate determinants of the biological standard of living from a global perspective, namely, high-quality nutrition and the disease environment during the 19th and 20th centuries. Until the mid-20th century, the local availability of cattle, meat, and milk per capita and the local disease environment mainly determined the stature of the population - and, by implication, how long they lived and how healthy they were. During the late 20th century, the trade of agricultural products and health-promoting technologies increased in relative importance; hence, the local availabilities became less decisive in explaining height differences.

Introduction

Federico (2005) describes agricultural development over the last two centuries as an outstanding success story. Agriculture has succeeded in feeding a growing population, producing a variety of products at falling prices, and enabling, through efficiency gains, many members of the agricultural labor force to be active in other sectors. By analyzing the increasing inputs to agricultural production, such as physical and human capital, the substitution of labor with machinery, and the growing efficiency due to technological and technical advances, Federico finds that the productivity increase in agriculture was even greater than that in manufacturing.

However, for the agricultural development to truly be considered a success – at least from a welfare-based perspective – the impact of agricultural production on consumption must first be determined. While production and productivity may have grown, the welfare outcome is less clear, especially in poorer world regions (Clark 2007). Apart from this significant inequality issue, losses of perishable products during transport and storage are also crucial factors when assessing global nutrition and welfare trends. Therefore, this study assesses the outcome of the aforementioned success story and its relevance to human nutrition using anthropometric methods (Fogel et al. 1982, Steckel 2009, Komlos and Baten 2004, Floud, Fogel, Harris and Wong, Hatton 2013).

We examine these topics using average male height as a metric proxy for health and net nutritional status, which could be partially determined by a set of production indicators as proxies for the production of high-quality foodstuffs. In addition, infant mortality is used as a proxy for health, and several control variables are taken into consideration. The impact of animal protein and calcium on anthropometric values has been described in terms of a bottleneck (Baten 2009) – the concept implying that producing animal protein is expensive, particularly in densely populated areas. The historical record indicates that humans have always required large quantities of protein, in particular animal protein, such as milk and meat, to obtain micronutrients, such as calcium, and to generate antibodies and essential amino acids deficient in plant proteins. These externally provided nutrients help to fight infectious diseases and eventually lead to taller final adult body

height (Grigg 1995, Baten 1999). De Beer's (2012) meta-analysis of clinical studies reveals that the most likely effect of dairy products supplementation is 0.4 cm per annum additional growth per approx. 245 ml of milk daily. Milk seems to have a greater effect on growth than other dairy products.[1] Conversely, if nutritional intake is insufficient or if factors such as disease or hard labor divert energy, body growth is severely retarded, and the body cannot fully compensate for growth deceleration if conditions do not improve markedly later in childhood or adolescence (Steckel 1995, Blum 2011, 2013a).

The interactions between stature, nutrition and health have been investigated by a number of country case studies, including the U.S. and the Habsburg Empire (Komlos 1985, 1987, Haines, Craig and Weiss 2003). In this study, however, we use a large panel dataset to assess the relationship between nutritional standards, mortality and height among 156 countries during the 19th and 20th centuries.

Crafts (2002) and, more recently Prados de la Escosura (2010) have calculated historical Human Development Indices, as they argued that income should be complemented by other components such as longevity and education. Prados de la Escosura found that the "Rest" as he defines it (the pre-1994 non-OECD members) caught up during its demographic transition phase between WWII and about 1970. After 1970, in spite of rising education, convergence in HDI overall and longevity in particular vanished according to his estimates.

Similar to these authors, we depart for the health-related aspects of the standard of living from the health production function literature (Preston 1975, Easterlin 1999, Hatton 2013). The health production describes the relationship between income and health as a concave function (HPF$_1$ in Figure 1, see Preston 1975). As income grows from Y$_1$ to Y$_2$ and finally Y$_4$, health also improves, but the marginal increase of health becomes smaller with each unit of income. Easterlin (1999) argues that most of the health improvement during the 20th century was caused by the

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[1] In addition, lower initial height-for-age and belonging to the 10-19 age group increased height effects in food supplementation studies.

improving disease environment, represented in the figure by the shift from HPF_1 to HPF_2. At the same level of income, a better disease environment results in higher health values.

Hatton (2013) explains that most of the health production function literature interprets income in terms of food consumption, without considering the composition. Hence an alternative interpretation of the shift from HPF_1 to HPF_2 could also be different agricultural specializations. Countries specialized in dairy farming, for example, might have followed HPF_1, whereas countries in which only starches were produced might have followed HPF_2 – especially during the 19th and early 20th centuries, when transport technology did not allow protein trade to the same degree as it did later.

[FIGURE 1 HERE]

1. The development of agricultural output

During the 19th and 20th centuries, world agricultural production experienced significant increases due to growing inputs, technological improvements, and a series of institutional changes, such as market reforms, property rights and the role of policy makers (Federico 2005). However, these increases were not uniform around the globe. In most countries for which evidence is available, the total agricultural output has increased during the past two centuries as indicated by growth rates ranging from 0.5 to 0.6 % in Austria, Belgium and Spain to 3 % and 8.7 % in the U.S. and Australia, respectively. While agricultural production in (today's) OECD countries increased 2.4 times between 1800 and 1870 (Federico 2005), anthropometric evidence suggests that per-capita nutrition did not necessarily improve (Steckel 1995, Komlos 1998). Some authors report that during the early and mid-19th century, nutritional standards stagnated or even worsened in some parts of the world and that average height, in many cases, did not begin to increase until the late 19th century (Zehetmayer 2011).

For post-1870 periods, agricultural output data are more abundant, thus allowing for comparisons between and among time-periods and world regions. The growth rates presented in

Table 1 indicate that agriculture grew faster between 1870 and 1913 as a result of decades without major shocks and rapid economic development, in general. Conversely, the war and inter-war period of 1913 to 1938 prevented the continuation of this positive pre-war development. Only Latin America was left almost unscathed during the 1913 to 1938 period, which is reflected by impressive growth rates during both of the aforementioned periods (Federico 2005, Maddison 2001). In Eastern Europe, Asia and the Western settlements, populations grew faster than agricultural output, which is indicated by bolded characters in Table 1. This indicates a substantial pressure on available food resources, which typically are only partially offset by food imports. In Asia and Oceania, population pressures on food resources continued until the 1950s. After 1960, this food pressure became most catastrophic in Africa, where the population grew much more than the agricultural output and net imports could not be financed by export revenues. This also occurred, though not to the same severe degree, in the Soviet Union and its successor states. Federico (2005), citing WTO estimates, reports – for the whole world – an average total annual growth rate of 2.3 % between 1950 and 2000. This growth rate enabled a tripling of world agricultural output, whereas the world population increased only by a factor of 2.4. This indicates that both total and per-capita productions grew at an impressive pace, potentially leading to superior nutritional standards (Table 2).

[TABLE 1 AND 2, AND FIGURE 2 HERE]

In addition to the mere increase in the quantities produced, a significant change in the *composition* of food production is observable, especially regarding the pre-WWI period. While both the output of crops and livestock increased, rising production capacities also allowed moving from producing low-quality foodstuffs toward more expensive, high-quality foodstuffs, as indicated by the livestock-crop ratio (Figure 2). While this development reflects increasing production capabilities, it also indicates a change in purchasing power of consumers in many of the rapidly developing countries. Furthermore, though output levels continued to increase during the second

half of the 20th century, there was no clear trend evident in the livestock-crops ratio (Federico 2005).

However, Tables 1 and 2 also indicate that growth rates differed among world regions and periods. As openness to trade and the technological possibilities to store and transport foodstuffs changed, differences between production and consumption were not necessarily equal to the development of nutrition among world regions and over time (Salvatore 2004b).

3. Methodology and data

Data used in this study include Baten and Blum's (2012a) average male height compilations from 156 countries and span the 19th and 20th centuries (Table 3). All country estimates are organized by birth decades, and the panel of height estimates is analyzed using a set of explanatory variables.

Two questions must be addressed regarding this study. How comparable were different height samples for the various countries included in this database? How substantial were the various selectivities of the measured individuals? First, some typically biased samples – such as samples of students – were not included in the national height estimates considered in our study. In general, preference was given to military conscript samples and systematic anthropological measurements. The military conscript samples became available after the concept of general conscription in the French revolutionary and Napoleonic armies spread throughout continental Europe around 1800. Typically, every male of a certain age was measured and medically examined (thereafter, the lot determined who joined the army). The files, to the extent that they survived, recorded everyone's height, except for the small share of illegal emigrants (clergymen were also exempt). Hence, height estimates based on this system are more representative than volunteer armies. Anthropological measurements, which were conducted in many developing countries beginning in the 1970s and 1980s, were also a very comprehensive source with little underlying selectivity. However, the

earliest anthropological measurements of the late 19th century were sometimes more difficult to use because they were often quite localized. Only if a country was documented by a large number of regional measurements (representing the various regions) could representativeness for national means be assumed.[2] For some countries and periods, only samples of prisoners, slaves and volunteer soldiers were available. In those cases, selectivities were slightly more difficult to assess. However, for most of the countries, several sources were available, and hence, a comparison of height trends and levels recorded in different contexts was possible. Baten and Blum (2012a) also ensured that no substantial regional biases were present in the height series that was ultimately selected for a specific country (especially in large countries where regional height differences can be substantial). One obvious problem in volunteer armies and prison samples is the dependence on the opportunity costs as determined by the labor market. The preferred strategy in this case was to assess height samples that were recorded for only one year (or for a short span of time, such as the U.S. Civil War 1861-65) and that contained different age groups. This allowed to keep the labor market conditions constant at the time of recruitment so that height, when organized by birth cohort, could be analyzed. A number of recent studies also have used the basic numeracy of sampled individuals in comparison with census-based numeracy estimates to assess potential sample selectivity bias (firstly done in Stegl and Baten 2009).[3]

In order to assess how large the problem of sample selection bias might be potentially, we also did a robustness test using a puristic strategy and repeated the regressions of table 6 (discussed below) with only those observations which stemmed either from (a) conscript armies in which male invividuals were measured in a representative way or (b) from Demographic and Health Surveys or anthropological surveys in which the invividuals were measured without social composition bias or potential labour-market-based sample selection biases. As a small minority of the samples falling under category (b) might

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[2] The very earliest anthropological data could sometimes not be used as anthropologists sometimes intended to find certain extremes (such as "the tallest African tribe," etc.).
[3] For additional information on the height data set, see Appendix B.

not be regionally representative for the whole country, we identified for each country those

studies which could potentially suffer from regional or urban-rural bias. This puristic

exercise resulted in dropping 73 of the 604 country-birth decade observations which were

previously included in column 2 of Table 6. Calculating the share of observations which

might be considered suspicious by some sceptic readers results only in a loss of between 9.1

and 12.1 percent of our overall sample. Conversely, around 90 percent of our observations

are based on either representative military conscription or anthropological surveys. We

assessed the remaining 10 percent further and would argue that they are mostly unaffected

by sample selection bias, except perhaps for a small minority of cases, which we cannot

clearly identify based on the information available to us in the – especially older –

anthropological survey reports.

[TABLE 3 AND 4 HERE]

The main result is that the estimation using the reduced sample yields virtually identical

results (Table C.3). None of the coefficients deviates by more than 10 percent. The cattle factor

might be slightly larger and the GDP effect slightly less important, but the size categories and levels

of significance are very close to being identical.[4]

One important question to address regards catch-up growth. That is, if an epidemic disease

retards the growth of a child only temporarily (or if there is a temporary famine), catch-up growth

later in childhood or adolescence will bring the stature to almost the same level as if the temporary

retardation had not happened. For example, the famine in Rotterdam 1944/45 was famous in this

respect. When the German troops retreated during WWII, they isolated Rotterdam from any food

imports for a number of months. While the population suffered from a terrible famine, Dutch

anthropologists determined later that due to catch-up growth, this did not leave a permanent mark

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[4] For a similar robustness test on the minimum number of cases per country and birth decade, see Appendix C.

on the part of the population that were children during the time of the famine. However, if bad conditions would have remained, permanent stunting would have been the effect, as in many other countries and periods.

Data on lactose tolerance, which will later be used in the analysis as an instrumental variable, are compiled from Ingram et al. (2009) and Flatz (1995). Ingram et al. (2009) performed an interesting compilation research on lactose tolerance, compiling almost 450 studies on countries and regions within countries. Almost all of these studies relied on the experiment and addressed the following question. Did the consumption of a typical amount of milk contribute to small increases in blood glucose levels and in breath hydrogen levels? The typical samples ranged between 10 and 99, as samples larger than 100 were rare. Ingram et al. also carefully investigated and recorded whether sufficient context information was provided in the original studies. They determined that extreme lactose tolerance or intolerance is exceptionally rare as, typical values ranged between 30 and 70 % for the majority of the world regions. The only large areas with very low tolerance (< 10%) are Southeast Asia (including South China) and the South Angola-Namibia-Botswana region. Interestingly, the latter region has a large amount of cattle per capita. Northwestern Europe and the Senegal-Mali region in West Africa had high numbers of lactose-tolerant individuals. Smaller regions with lactose digesters were situated in Pakistan/Northwest India, Saudi-Arabia and East Africa. In general, areas suitable for raising cattle demonstrated increased lactose tolerance (except with respect to Angola-Namibia-Botswana).

The other variables included are derived from standard sources (Table 4). Information on cattle, milk and meat are taken from Mitchell (1980, 1982, 1983), World Bank Development Indicators, Federico (2005) and Hübner (several years). Infant mortality is compiled using Collver (1965), Mitchell (1980, 1982, 1983) and Chesnais (1986). Mountainous terrain and civil war data are taken from Collier and Hoeffler (2004) and the correlates of the war database (initiated by Singer and Small 1972 and regularly updated), respectively. Civil war is coded as a dichotomous variable adopting the value 1 if a country experienced a civil war during a ten-year period. The database only contains

information on those conflicts that caused at least 1,000 battle-related deaths (of all participants) per conflict year.[5] The democracy index is taken from the Polity IV Project (Marshall and Jaggers 2008; averages for the countries have been included).

One important methodological decision was to use proximate determinants of height in this study rather than underlying factors. Proximate variables allow circumventing the lack of reliable purchasing power based on production/productivity statistics for large parts of the world during the 19th and 20th centuries. Many inputs to human welfare were not traded officially but were distributed informally in the form of subsistence farming, intra-household transfers, or black markets. Other goods and services were provided through public goods, such as infant-nutrition programs and public hospitals. Another set of obstacles that economic historians must address are similar to those of contemporary development economists. Even if accurate production statistics are available, the international comparability may be limited due to different baskets of goods, different price indices (e.g., Laspeyres vs. Paasche) or the change in the quality of the goods and services (Nafziger 2012). We address these shortcomings by using outcome-oriented measures.

Similar to average height, proximate determinants can also capture the outcome of economic activities, such as agricultural production and health status, but they do not allow for the direct measuring of nutrition quality or the disease environment. We take into account that the prices of goods and services in two different places at two different points in time may differ, especially if someone applies exchange rates to convert production values in a common currency, as the utility these goods and services provide is independent of time and space. Given this, the regression analyses as performed in this study rely on a number of proximate variables to measure animal protein consumption (cattle, meat and milk availability), biological living standards (average male height) and infant mortality rate (disease environment).

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[5] The codebook is available at http://www.correlatesofwar.org/COW2%20Data/WarData_NEW/WarList_NEW.html (last access, January 16th, 2013).

[FIGURE 3 HERE]

In Figure 3, which was drawn using some interpolation, the results of Baten and Blum (2012a) are shown (in Appendix A, a Figure without interpolation is included). In general, four different types of countries can be identified. First, during the entire period under observation, Anglo-Saxon settlements were characterized by superior biological living standards. Moreover, after the 1880s, Western Europe, Eastern Europe and Central Asia experienced a substantial upward trend. However, after the foundation of the Soviet Union, discrepancies increased between the West and the East with respect to height (Mironov 2012). Conversely, Latin American and Middle Eastern populations were relatively tall during the 19th century, but they then fell behind in relative terms in the 20th century (Salvatore 2004a).

In addition, East Asia and sub-Saharan Africa remained consistent with the world average during the period under observation, with the exception of East Asia during the late 19th century. Sub-Saharan Africa is the only world region to experience a decline in average heights in absolute terms (Moradi 2005). Finally, the data show that South and Southeast Asia experienced no clear trend in the 19th century, while in the 20th century, Southeast Asia's average height increased constantly, eventually reaching South Asia's average height in the 1980s. South Asia, however, is still characterized by stagnating stature (Brennan, McDonald and Shlomowitz 1994a, 1994b, 1997, 2000, Guntupalli and Baten 2006, Baten, Stegl and van der Eng 2013), a finding that actually corresponds quite well with the population pressure on the agricultural resources that we identified herein (Tables 1 and 2). The pressure on Africa in the late 20th century is visible in both data sets as are the food scarcities in Asia and other world regions during the WWII era.

It is remarkable that some countries have a reputation for a bad disease environment and yet still display tall heights. People are sometimes tall in countries and regions with problematic disease environments – such as the U.S. American South or the African Sahel zone region. The inhabitants of the Southern states, for example, were taller than the Northerners before the Civil War, whereas

our perception of disease environments suggests that warmer climates, in general, and malaria-infected river deltas, in particular, were less healthy than the Northern climates. Similarly, the disease environment of the Sahel zone was most likely quite adverse, compared to European countries, though our knowledge is limited for early periods. However, it seems that, to a certain degree, good local protein availability counter-balances problematic disease environments. For example, values of cattle per capita were extremely high in the Sahel zone, and the population was apparently able to create antibodies. Nevertheless, climatic vulnerability was also high, and even small reductions in rainfall resulted in famine, conflict and death. In the southern U.S., similar compensation phenomena due to protein availability most likely occurred. It is worth noting, however, that the income of the white population in the Southern states was also very high.

4. Regression analysis: baseline estimates

In the following analysis, we focus on proximate determinants: protein availability, disease environment and altitude.[6] In contrast, factors such as productivity, institutional design, income, education, trade, religion and similar variables are considered underlying causes that may determine or contribute to the proximate causes - disease environment and the consumption of high quality foodstuffs. We did not include the underlying but proximate determinants in our analysis. Only civil war, GDP and democracy were included as indirect determinants because we wanted to control for the exceptional situation of civil war, for the potential omitted variable of GDP and for the inequality effects of political autocracy.

We use panel data composed exclusively of actual observations (no interpolations) and check for the existence of unit root problems by considering the residuals of our regression by means of the Fisher test (Maddala and Wu 1999). This results in a chi-square (112) value of 289.98 and a p-value of 0.00. As the null hypothesis of the Fisher test is formulated in such a way that the series is non-stationary, we conclude that there is no unit-root problem. As we also take potential

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[6] The very first (approximately 3) years of life constitute the most important growth period. Therefore, all variables are arranged by birth decades as they capture influences on height around that crucial time.

serial correlation seriously, we cluster standard errors at the country level in every specification.

We include a range of variables to control for the availability of animal protein per capita (Baten 1999, 2009). In a bivariate graphical analysis of the cross-section of the 1900 birth decade, cattle per capita suggests a positive correlation (Figure 4), though there are three modest deviations - Argentina, and to a lesser extent Cuba and Madagascar - as indicated in the lower right of the Figure. Argentina's population may have been deprived of animal protein because the country exported a significant portion of its cattle products, and Cuba and Madagascar displayed similar behaviors, at least during the early 20th century (Salvatore 2004b).[7]

The per capita availability of livestock is a useful protein-related indicator as cattle accounts for a large share of the meat and milk supplies. Accordingly, the effect of cattle per capita is positive and statistically significant (Table 5, Column 1).

[FIGURE 4, TABLE 5 HERE]

This protein indicator is available for a large number of observations, but because it does not account for productivity per animal, we developed a second Model that replaces cattle per capita with the annual output of meat per capita and a third Model that permits us to estimate the amount of milk per capita. As a result, we were able to determine that animal-protein availability has a positive impact on height, as the coefficient's level is consistently significant. We include the infant mortality rates to control for disease environment, and the results confirm our expectations. That is, a problematic disease environment is associated with shorter people, as the one-standard-deviation effect is approximately twice that of the protein effect.

Both protein and disease environment are significant and display the expected signs when assessed separately (Table 5, Columns 4 and 5). The R-squares, however, are somewhat larger in the case of the regression where the only variable is the disease environment. These data should be

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[7] We experimented with cattle trade share data that may have helped to clarify this issue, but as the data were scanty, the results were not decisive and were therefore not presented.

interpreted with caution because just as average income is only a rough indicator of a population's well-being, cattle per capita is only a rough indicator of protein availability as, due to the pressure of the export market, much of the meat may, in fact, not end up in local markets. Perhaps even more importantly, the output of protein per animal varies.

One factor that is particularly difficult to measure is inequality. Hence, we only include the political variables that may have redistributive effects. In addition, it has been argued that the anthropometric welfare indicator, human stature, by itself is already more sensitive to inequality as heights of the poorer strata tend to be more vulnerable during difficult times (Blum 2013a). Do the findings suggest that the biological standard of living in countries run by non-democratic governments tends to be lower than that of similarly wealthy countries? While the coefficient is positive, the degree is insignificant, thus suggesting that the answer is 'no' (Table 5, Column 2). The same conclusion holds with respect to civil war, at least when all other variables are included.

The proportion of mountainous areas in a given region has been hypothesized to have a direct effect, in anthropological studies, on height, though a consensus has yet to be reached.[8] For example, Harrison and Schmidt (1989) argue that humans who live at high altitudes (such as the Peruvians in the Andes) tend to be relatively short, thus contradicting previous studies of the Alps, the Scottish Highlands and the French Jura. If Harrison and Schmidt are correct, this effect could be, in part, because the disease environment in such regions benefits from underpopulation. In addition, high-altitude Europeans, in particular, benefit from their proximity to protein production (Baten 1999). Having controlled for protein proximity and disease effect, we side with Harrison and Schmidt, although the effect is minimal. Because mountain dwellers in less developed countries are relatively poor and mountains reduce agricultural productivity and raise infrastructure costs, economic variables likely contribute to this pattern.

If we use standardized coefficients rather than conventional coefficients, the results are

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[8] A similar geographic factor which has received some attention is the insolation effect (working via vitamin D production in the human body). The literature finding positive effects has mainly focused on single countries so far. Studying it for a number of countries would be a desideratum for the future.

confirmed (Table 6). Standardized coefficients allow us to compare the magnitude of impact of the independent variables on the dependent variable. The results presented in Table 6 suggest that the effect of disease environment, measured by the infant mortality rate, is greater than the effect of cattle per capita, thereby suggesting that the former variable is somewhat more important, at least for the period and countries for which both variables can be observed.

We were also curious whether GDP per capita, as an indicator of the general production capacity of a country, would replace or minimize any positive impacts of protein availability and disease environment. A priori, we expected a lower GDP replacement effect for disease environment given that higher income cannot buy better health (at least not until the medical technology revolutions of the early 20th century). Nonetheless, we would have expected that the GDP could have replaced a substantial part of the protein effect, as proxied by cattle per capita. In Table 6, Models (4) and (5), GDP per capita was included, in one specification, jointly with cattle per capita, and in another, jointly with infant mortality, our disease indicator. In both cases, while the GDP has a positive sign and becomes statistically significant, it does not lead to the insignificance of cattle per capita or infant mortality. Interestingly, the size of the latter declines by approximately 50 %, whereas the size of the cattle coefficient declines only by approximately 30 %, and the adjusted R-square increases modestly in the case of the cattle-GDP combination (from 0.45 to 0.53). Especially during the 20th century, countries with a higher GDP had lower infant mortality and better anthropometric values. A high GDP per capita in combination with a low cattle per capita would impact cattle imports if exporters were available, given the transport technology restraints. A low GDP and a high cattle per capita should provide incentives to become a protein-exporting country. In contrast, however, the adjusted R-square does not increase if the disease environment is complemented by a GDP per capita variable.[9] We emphasize that we are not arguing for a specific direction of causality when we include GDP, as it might well be that height influences GDP. The inclusion of this variable is only intended to avoid a potential omitted variable bias. We conclude

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[9] Unfortunately, it is not possible to estimate a more general model including all these variables as the number of cases would become too small.

that while GDP per capita adds some explanatory power (and controls for food imports and exports), it does not completely replace the effect of local protein availability and local disease environment.

5. Endogeneity

In principle, we could imagine a problem of reverse causality. In other words, rather than higher local cattle per capita figures resulting in increased height, it may be that people who are financially better-off (and, hence, probably also physically stronger) may be able to maintain a larger number of cattle due to superior productivity. Instrumental variable (IV) techniques allow circumventing this problem, providing a suitable instrument can be found. In addition, IV techniques can serve a second function, namely, to reduce measurement error as cattle per capita is a rough proxy for milk consumption per capita, and thus includes a substantial amount of measurement error. Therefore, applying IV techniques mitigates the severity of the problem.

An attractive instrumental variable is lactose tolerance. Because lactose tolerance is genetic and, hence, generally exogenous during the period under study, the lactose tolerance variable allows us to conduct an endogeneity test of the protein-availability variable. Data on lactose tolerance are taken from Ingram et al. (2009) and Flatz (1995). The data reflect the portion of a population (in %) that does benefit from lactose tolerance. In some countries, cattle stock and milk production go hand-in-hand, while in other countries, the focus is mainly on meat production. Therefore, the idea behind this variable is to separate the ability to digest milk (or the lactose in milk) and the availability of cattle. In general, the prevalence of lactose tolerance leads to a higher consumption of cow milk compared to estimates based on purchasing power as many people voluntarily renounce cow milk. Children without this limitation have more time to consume milk without being affected by side effects and are therefore able to access the benefits of milk consumption for a longer period of time. While children usually lose lactose tolerance after the weaning phase, Sahi (1994) contends that the period until a child becomes intolerant to lactose can vary considerably

between populations.

One of the major challenges in any instrumental variable approach is the requirement of the exclusion restriction, which implies that the instrumental variable does not have a direct influence on the ultimate dependent variable except via the instrumental variable. However, in the case of lactose tolerance, it is clear that any effect on height requires a certain amount of milk production; otherwise, an effect cannot be imagined. Hence, in this case, the exclusion restriction is not violated.

When instrumenting cattle per capita with lactose tolerance, we obtain a significantly positive coefficient, one that is even larger than the aforementioned cattle coefficients (Table 7), thus indicating that the IV result is most likely estimated with less measurement error. The first stage results indicate that lactose tolerance could be an instrument for the potentially endogenous variable cattle per capita. However, with an F-statistic of less than 10, it is a weak instrument and therefore requires a limited information maximum likelihood (LIML) estimation technique. The results of this estimation approach are identical to the IV estimates.

[TABLE 6, 7 AND 8 HERE]

The coefficients of disease environment and GDP are insignificant in the regressions. It should not be concluded from this result that the disease environment and production capacity are less relevant.[10]

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[10] In the case of the GDP, we stressed that it is included herein, though we do not argue for one direction of causality. We would prefer instrumenting also infant mortality; however, unfortunately, an instrumental variable for infant mortality for such an early period is not available, because it is also not strongly exogenous, even if is has a reputation for being more exogenous than child mortality (which is more nutrition-related). A large part of infant mortality in contrast is related to hygienice and breast-feeding behaviour, as well as the disease environment. As we cannot instrument infant mortality, we will not interpret this part of the analysis as causal. For example, we would not interpret the insignificance of infant mortality once protein proximity is instrumented. As we consider the assessment of the proximity effect as the more relevant contribution of this article, we decided to use this IV regression, even if only one of the two variables could be instrumented.

6. Early and late developments

Due to a sufficient number of observations, we were able to distinguish an early (1870 to 1949) and a late (1950 to 1989) period (Table 9).[11] We expect to find a decline in the importance of local protein production and health advantages during the late period due to technological developments, such as refrigeration and other storage methods, that permit an expansion of the international market in both foodstuffs and medical materials.

We find that between 1870 and 1949 both the country-specific output of protein and our disease proxy had fairly large coefficients, thus indicating that the effect was greater for that period than it was between 1950 and 1989, when, in fact, the coefficients for disease and protein had diminished (Table 8, Column 3).

When comparing standard deviation (SD) effects, we find that one SD during the early period (SD=1.10) accounts for an additional 1.51 cm in height, whereas for the latter period, with a standard deviation for cattle of 1.04, the effect is only 0.63. We interpret this change as a gradual change from protein proximity to income and other factors (such as public health) over time as determinants of biological welfare. As a caveat to our argument that the explanatory share of protein availability declined, we note that protein sources may also have changed substantially as, for example, the composition of types of meat may have changed.

7. A lower-bound estimate of the effects of food behavior, intergenerational effects, culture, and other currently unobservable factors

We also include a full set of birth-decade and world region dummies in most of the aforementioned regressions. The comparison of the world region dummies in regressions with and without explanatory variables permits us to estimate the size of various unobservable characteristics. While the early generations of anthropologists firmly believed in the existence of races (a term later replaced by genetic potential), there is, today, a consensus among leaders in the field that height

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[11] As for the early period, 1810-70, there were an insufficient number of countries providing all of the explanatory variables to permit accurate analysis.

potential is primarily a function of environmental factors (Bogin 1988).

Second, human preferences and behaviors related to food may play a role, especially in rich industrial societies where the consumption of red meat and other protein-rich foodstuffs seems to have stagnated or declined. Food taboos, however, also exist in poor countries and have supposedly caused some ethnicities and religious groups to consume less protein than they otherwise would have. Two of the most famous religious taboos include the Hindu's ban on beef and the Muslim's ban on pork. However, the question is whether these taboos would have a substantial effect given that substitution of other protein sources may be possible. However, recent evidence has shown that the influences are limited and should only be taken into account if countries with strongly opposed dietary patterns are being compared (Blum 2013b).

The third possible factor is that of intergenerational size limits. In this regard, Cole (2003) has argued that Japanese height levels could not quickly catch up with Western height levels because of a biological check mechanism on the size of a baby relative to that of the mother. In other words, the body prevents the fetus from growing too large if the birth channel of the mother is not as large. Another intergenerational factor may be dietary habits. For example, dietary habits of migrants may persist in a second generation even after moving to a new environment with different relative prices. Accordingly, the offspring of those who have migrated from low-protein to high-protein regions may continue to eat the low-protein dishes favored by their parents.

[TABLE 9 HERE]

These and some other potential unobservable factors should be reflected in the regressions of world region dummy variables after the effect of observable explanatory variables has been removed. Therefore, we compare two such sets of regressions, one with and the other without explanatory variables controlling for environmental factors. While Western Europe is the constant, among the other world regions, there is a sharp decline in the coefficients that capture world region

specific effects when all explanatory variables are included. For example, when differences in cattle per capita and similar factors are not controlled, the average height of East Asians is lower by 8.2 cm, but when these factors are controlled, the difference is only 4 cm. We should note that because measurement error produces a downward bias to coefficient size, the shrinkage of the coefficient may yield a lower-bound estimate of the effect of explanatory variables. Similarly, the coefficients of Latin America, South Asia and Africa decreased by approximately 50%, while the decrease in the coefficient of Southeast Asia was somewhat less. When explanatory variables are controlled, the Middle East and Eastern European coefficients diminished to the point of insignificance. The region comprising North America, Australia and New Zealand was characterized by a positive coefficient relative to that of Western Europe.

8. Conclusion

During the 19th and 20th centuries, agriculture in many countries succeeded in feeding a growing population better than it had in earlier times, and its efficiency gains enabled large parts of a formerly agricultural labor force to be active in other sectors. However, before we agree to this broadly accepted judgment, the findings presented in this study must be considered. The analysis in this paper links agricultural production levels and human consumption on a global scale during the past two centuries.

We use average height from a global panel of countries as a proxy for human well-being, which allows us to investigate welfare from a nutritional perspective. We also consider the remarkable differences in world regions as height has not increased substantially in all countries. For example, Europeans are tall today while South Asians remain short. We confirm that the major determinants of biological well-being and, hence, height are the quality of nutrition and the disease environment, whereas geography is a minor determinant. As animal protein production plays a crucial role in determining human health and welfare, economies that were able to invest in a high

share of cattle and dairying achieved the most advanced levels of welfare and development. In addition, we find that lactose tolerance influences biological living standards through milk consumption, a somewhat neglected issue in the anthropometric literature. Moreover, our results suggest that influences other than environmental ones play only a small role in the determination of average height. The size of world region coefficients decrease significantly when including variables that capture environmental factors, such as diseases, quality of nutrition and political and geographical variables. A series of robustness tests, such as IV regressions where lactose tolerance is used as an instrument for cattle availability, confirms these findings.

In addition, the results presented in this study may contribute to understanding the wider development of living standards during the past two centuries. Until the mid-20th century, the local availability of cattle per capita and the disease environment mainly determined the stature of the population. During the late 20th century, trade increased and other factors became more important. This also implied that the local protein availability was crucial for the health and life expectancy of early populations. Robert F. Fogel (1993) stressed, in his lecture to the Nobel Prize committee, that a height gap of 17.5 cm for modern Norwegian males in the 1960s and 1970s meant a higher probability of dying in the following period of not less than 71%, clearly a significant amount. He based his work on Waaler (1984), who measured several thousands of Norwegians and followed them in a longitudinal study. Norway had one of the populations with the best nutrition in the late 20th century. Baten and Komlos (1998) estimated that one additional centimeter in height equals approximately 1.2 years additional life expectancy, with only a negligible coefficient change over time among the birth cohorts of 1860, 1900 and 1950, i.e., the latter being adults in the 1970s to the present. Hence, 1 cm is clearly a meaningful amount as living 1.2 years, more or less, is a substantial asset in the quality-of-life portfolio.

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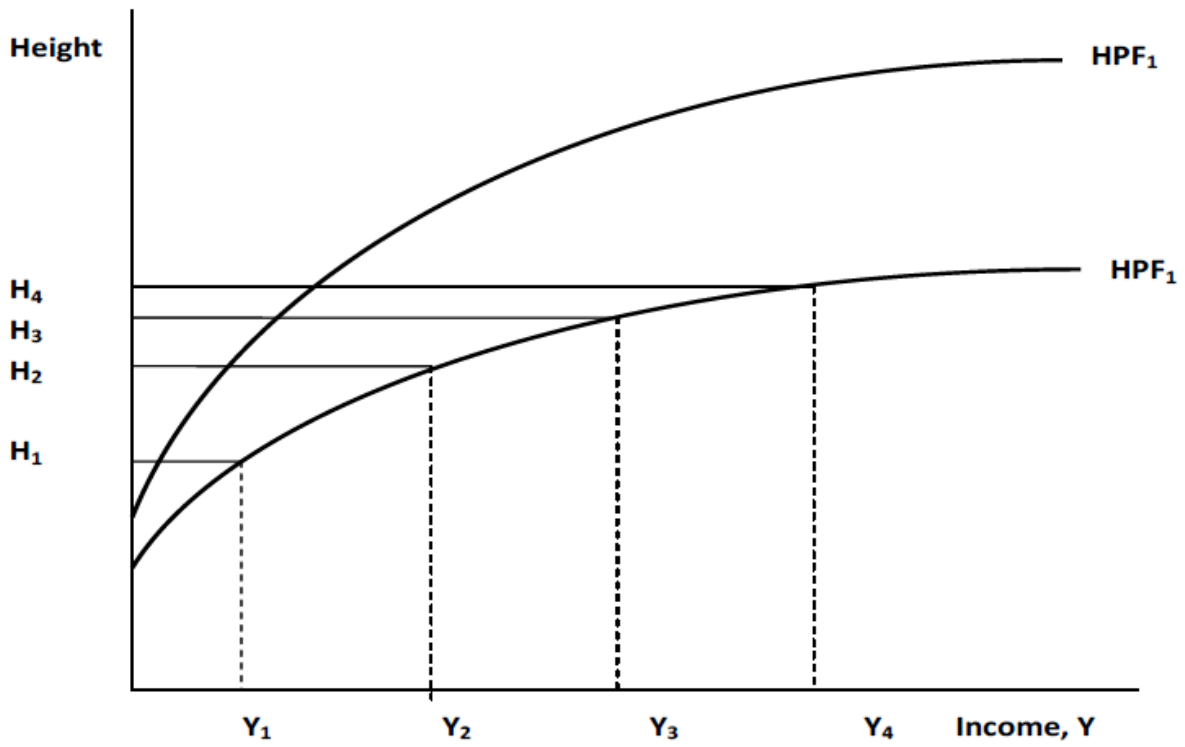
Figure 1. *The health production function.*
Source: *Hatton (2013).*
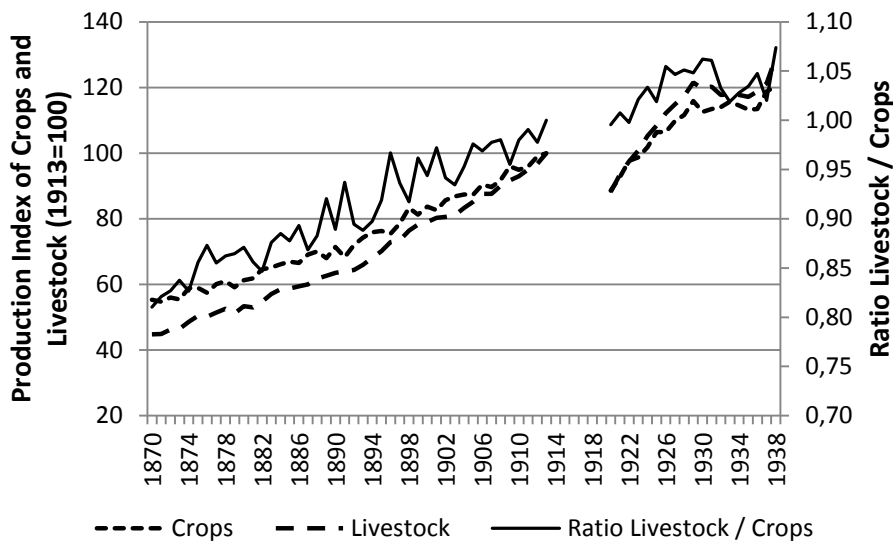
Figure 2. *Production levels of crops and livestock and the composition of production.*
Data source: *Federico (2004, 2005).*
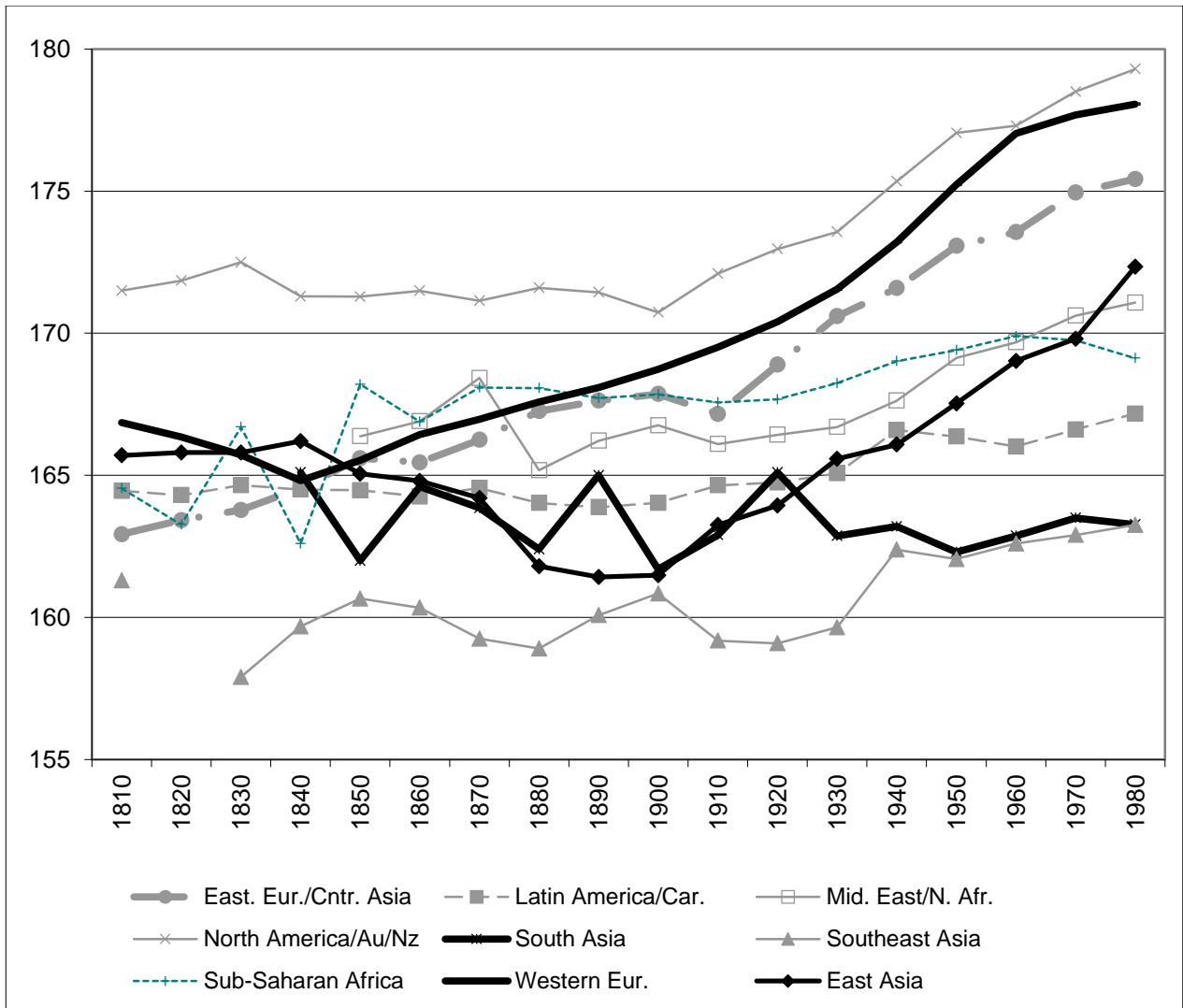
Figure 3. *Height trend by world region (using interpolations, weighted by population size).*
Notes: *Migrant heights are included (but account only for 0.7% of the sample).* Source: *Baten and Blum (2012a). See ther Tables 1 and 9 for data coverage by country.* Note: *The standard world region classification has been used. The only exception is a group of 4 former British settler colonies (US, Canada, Australia & New Zealand) as they experienced a great share of Western European settlers and are characterized by land abundance which allowed superior nutrition and eventually qualified them to become food exporters in the first wave of globalization (Baten and Blum 2012b).*
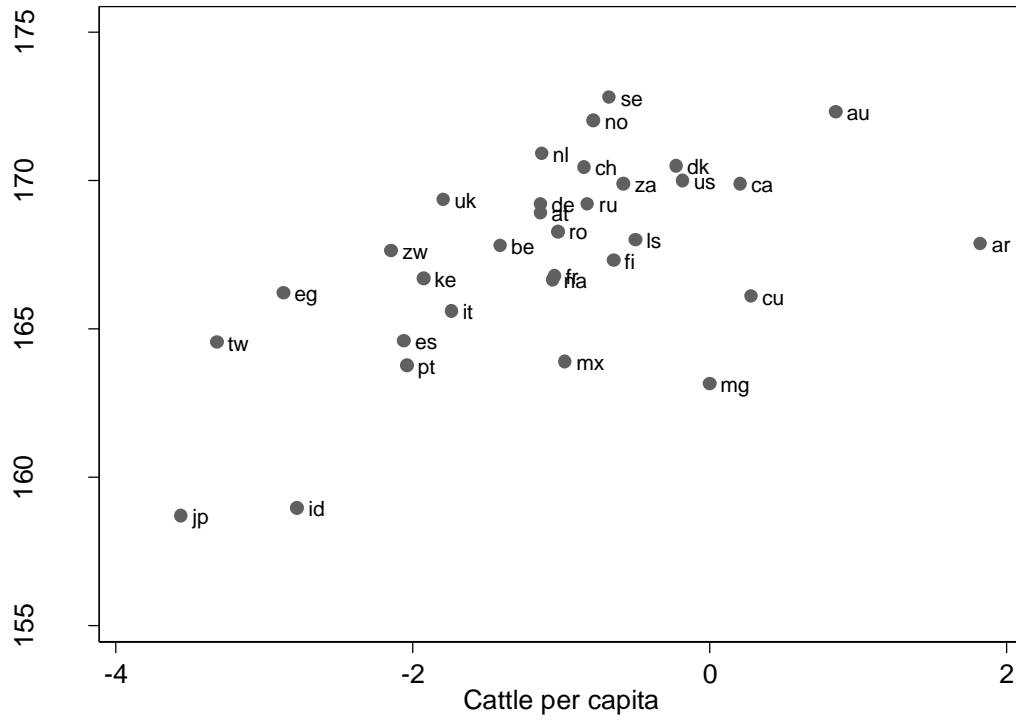
Figure 4. *Correlation between (ln) cattle per capita and height in 1900*
Source: see text. Country abbreviations are ISO-2-character abbreviations (see table 3).

Table 1. *Rates of change in gross agricultural output and population growth, 1870-1938*

	1870-1938	1870-1913	1913-1938	1870-1938	1870-1913	1913-1938
	Agric.O.	Agric.O.	Agric.O.	Pop.	Pop.	Pop.
North Western Europe	0.97	1.02	1.50	0.62	0.84	0.29
Southern Europe	0.89	0.81	1.19	0.69	0.67	0.76
Eastern Europe	1.67	2.13	**0.36°**	0.96	1.20	0.59
Asia	0.97	1.11	**0.58**	0.70	0.60	0.89
South America	3.80	4.43	3.05	2.48	2.64	2.33
Western Settlement	**1.37**	2.20	**0.74**	1.83	2.13	1.40
World	1.31	1.56	**0.67**	0.85	0.85	0.88

Note: Bold are cases, in which agricultural output grew less than population. Northwestern Europe: UK, France Sweden, Denmark, Belgium, the Netherlands, Germany, Finland, Switzerland. Southern Europe: Italy, Greece, Spain, Portugal. Eastern Europe: Austria-Hungary and Russia. Asia: Japan, India, Indonesia. Western Settlement: Canada, Australia, USA. South America: Argentina, Uruguay, Chile. ° not significantly different from zero. Source: Federico (2004, 2005). Maddison (2001), for the population growth figures.

Table 2. *Rate of change in gross agricultural output and population growth, 1938-2000*

	1936/38-1948/52	1948/52-1958/60	1961-2000	1935-1950	1950-1960	1960-2000
	Agric.O.	Agric.O.	Agric.O.	Pop.	Pop.	Pop.
Africa	1.72	3.10	**2.25**	1.10	2.43	2.69
North Central America	2.63	**1.40**	1.77	1.56	2.27	1.51
South America	1.68	3.13	2.92	2.30	2.99	2.19
Asia (excluding China)	**0.31**	3.64		0.73	2.17	
Asia (including China)			3.54			1.91
Western Europe	0.56	2.55	0.91	0.49	0.77	0.46
Oceania	**0.81**	2.85	1.68	1.47	2.52	1.53
USSR/successor states			**-1.94°**	0.00	1.96	0.79

Note: Bold are cases, in which agricultural output grew less than population. Column (1): from prewar (1936-38) to 1948-52 - compound rates. Column (2): from 1948-52 to 1958-60 - compound rates. Column (c): 1961-2000. ° not significantly different from zero. Population for Oceania refers to Australia and New Zealand. Source: Federico (2005) based on FAO Statistical Database. Maddison (2001), for the population growth figures.

Table 3. *Number of birth decades documented by country*

Country	N	Country	N	Country	N
Afghanistan (af)	3	Germany (de)	18	Norway (no)	18
Albania (al)	3	Ghana (gh)	13	Oman (om)	0
Algeria (dz)	3	Greece (gr)	10	Pakistan (pk)	8
Angola (ao)	7	Guatemala (gt)	8	Palestinian Territory (ps)	0
Argentina (ar)	15	Guinea (gn)	10	Panama (pa)	1
Armenia (am)	9	Guinea-Bissau (gw)	8	Papua New Guinea (pg)	5
Australia (au)	10	Guyana (gy)	5	Paraguay (py)	2
Austria (at)	14	Haiti (ht)	6	Peru (pe)	14
Azerbaijan (az)	6	Honduras (hn)	4	Philippines (ph)	8
Bahrain (bh)	0	Hong Kong (hk)	2	Poland (pl)	12
Bangladesh (bd)	7	Hungary (hu)	11	Portugal (pt)	18
Belarus (by)	3	India (in)	14	Puerto Rico (pr)	5
Belgium (be)	10	Indonesia (id)	16	Qatar (qa)	0
Benin (bj)	8	Iran (ir)	11	Reunion (re)	0
Bolivia (bo)	8	Iraq (iq)	4	Romania (ro)	7
Bosnia and Herzegovina (ba)	0	Ireland (ei)	14	Russian Federation (ru)	18
Botswana (bw)	2	Israel (il)	4	Rwanda (rw)	7
Brazil (br)	18	Italy (it)	18	Saudi Arabia (sa)	4
Bulgaria (bg)	4	Jamaica (jm)	6	Senegal (sn)	13
Burkina Faso (bf)	16	Japan (jp)	11	Serbia and Montenegro (cs)	5
Burundi (bi)	2	Jordan (jo)	5	Sierra Leone (sl)	8
Cambodia (kh)	14	Kazakhstan (kz)	11	Singapore (sg)	1
Cameroon (cm)	13	Kenya (ke)	9	Slovakia (sk)	7
Canada (ca)	18	Korea (North) (kp)	9	Slovenia (si)	4
Cape Verde (cv)	0	Korea (South) (kr)	9	Somalia (so)	6
Central African Republic (cf)	8	Kuwait (kw)	0	South Africa (za)	10
Chad (td)	10	Kyrgyzstan (kg)	9	Spain (es)	16
Chile (cl)	2	Laos (la)	11	Sri Lanka (lk)	3
China (cn)	18	Latvia (lv)	5	Sudan (sd)	7
Colombia (co)	12	Lebanon (lb)	5	Swaziland (sz)	5
Comoros (km)	3	Lesotho (ls)	5	Sweden (se)	16
Congo (cg)	10	Liberia (lr)	7	Switzerland (ch)	9
Costa Rica (cr)	2	Libya (ly)	2	Syria (sy)	5
Cote D'Ivoire (Ivory Coast) (ci)	13	Lithuania (lt)	2	Taiwan (tw)	13
Croatia (Hrvatska) (hr)	12	Macedonia (mk)	4	Tajikistan (tj)	6
Cuba (cu)	7	Madagascar (mg)	8	Tanzania (tz)	11
Cyprus (cy)	4	Malawi (mw)	8	Thailand (th)	8
Czech Republic (cz)	16	Malaysia (my)	6	Togo (tg)	7
Democratic Republic of the Congo (cd)	11	Mali (ml)	12	Trinidad and Tobago (tt)	1
Denmark (dk)	16	Mauritania (mr)	4	Tunisia (tn)	2
Djibouti (dj)	0	Mauritius (mu)	0	Turkey (tr)	13
		Mayotte, Saint Helena, West Sahara (ytsheh)	0		
Dominican Republic (do)	4			Turkmenistan (tm)	3
East Timor (tp)	1	Mexico (mx)	17	Uganda (ug)	10
Ecuador (ec)	0	Moldova (md)	5	Ukraine (ua)	6
Egypt (eg)	12	Mongolia (mn)	2	United Arab Emirates (ae)	0
El Salvador (sv)	0	Morocco (ma)	6	United Kingdom (uk)	18
Equatorial Guinea (gq)	1	Mozambique (mz)	10	United States (us)	17
Eritrea (er)	3	Myanmar (mm)	9	Uruguay (uy)	2
Estonia (ee)	8	Namibia (na)	7	Uzbekistan (uz)	8
Ethiopia (et)	10	Nepal (np)	8	Venezuela (ve)	6

Finland (fi)	13	Netherlands (nl)	18	Viet Nam (vn)	12
France (fr)	18	New Zealand (Aotearoa) (nz)	5	Yemen (ye)	6
Gabon (ga)	7	Nicaragua (ni)	4	Zambia (zm)	5
Gambia (gm)	1	Niger (ne)	11	Zimbabwe (zw)	6
Georgia (ge)	3	Nigeria (ng)	12		

Note: Migrant heights (unadjusted) were included on the following countries in this Table, but not in the following Tables and Figures, except where noted (in parentheses the number of birth decades: Algeria (2), Armenia(1), Bangladesh (4), Croatia (Hrvatska) (1), Czech Republic (1), India (6), Israel (1), Korea (North) (6), Malawi (1), Mozambique (1), Pakistan (1), Poland (2), Romania (1).

Table 4. *Descriptive statistics (cases included as in Model 1 of Table 5, except milk and meat)*

Variable	N	Mean	Std.dev.	Min.	Max.
Height	417	169.45	4.60	156.00	182.30
Cattle (p.c.)	417	0.62	0.91	0.01	8.49
Cattle (p.c., ln)	417	-1.03	1.07	-4.93	2.14
Infant mortality (p.c.)	417	116.85	63.63	5.80	316.10
Infant mortality (p.c., ln)	417	4.55	0.75	1.76	5.76
Democracy	414	6.21	3.84	0	10
Mountain share	417	17.38	19.09	0	82.2
Civil war	417	0.04	0.20	0	1
Meat (p.c.)	212	37.87	42.83	0.79	288.28
Meat (p.c., ln)	212	3.15	1.02	-0.23	5.66
Milk (p.c.)	192	291.78	343.51	0.17	2827.86
Milk (p.c., ln)	192	4.87	1.63	-1.76	7.95
Lactose tolerance	296	0.59	0.31	0	1
Eastern Europe/ Central Asia	417	0.06	0.24	0	1
Latin America/Caribbean	417	0.17	0.38	0	1
Middle East/North Africa	417	0.04	0.19	0	1
North America, Australia, New Zealand	417	0.08	0.27	0	1
Sub-Saharan Africa	417	0.18	0.39	0	1
East Asia	417	0.05	0.21	0	1
South Asia	417	0.01	0.05	0	1
Southeast Asia	417	0.02	0.15	0	1

Note: "East. Eur./Cntr. Asia"= Eastern Europe and formerly members of the Soviet Union. Democracy is a time-invariant variable here that takes the average of all available democracy values for a given country (otherwise the number of cases would be severly reduced by missing values of this variable that is not really of central importance here).

Table 5. *Determinants of height (panel models, clustered by country)*

	(1)	(2)	(3)	(4)	(5)
Main expl. var.	cattle	meat	milk	cattle only	mortality only
Cattle (ln, p.c.)	0.47*			0.82***	
	(0.079)			(0.001)	
Infant mortality (ln)	-1.65***	-1.46***	-1.36***		-1.99***
	(0.000)	(0.001)	(0.002)		(0.000)
Mountains	-0.03**	-0.06**	-0.07***		
	(0.019)	(0.028)	(0.005)		
Civil war	0.25				
	(0.448)				
Meat (ln, p.c.)		0.51**			
		(0.032)			
Milk (ln, p.c.)			0.37**		
			(0.045)		
Democracy		0.40***			
		(0.007)			
Time Fixed Effects	YES	YES	YES	YES	YES
World region-fixed effects	YES	NO	NO	NO	NO
Constant	171.95	179.81	178.90	161.81	174.61
Observations	417	219	200	604	551
Number of countries	77	58	53	103	106
R-squared (within)	0.92	0.88	0.9	0.82	0.91
R-squared (overall)	0.73	0.6	0.62	0.29	0.45

Note: robust p-values in brackets based standard errors are clustered by country to avoid potential consequences of serial correlation, and to provide heteroskedasticity-robust and cluster-robust estimates, see Cameron/Trivedi (2009), p. 85. *, **, *** refer to significance levels of 1, 5, and 10 percent. Estimates are random effects panel estimates. Fixed effects estimates are not plausible for such a long time frame, as it seems unlikely that country effects remain unchanged for two centuries, which is an assumption required for fixed effects estimation. For data characteristics see Table 5. Dummies for all potential biases such as data set based on prison registers, volunteer army etc. included (see Baten and Blum 2012a). The relatively high R-square values are partly caused by the time and region fixed effects dummies, and hence should not be interpreted as explanatory power. Constants are all significant at 1 percent level.

Table 6. *Determinants of height (BETA coefficients)*

	(1)	(2)	(3)	(4)	(5)
	cattle	cattle only	mortality only	cattle & GDP	mort. & GDP
Cattle (ln, p.c.)	1.10***	1.21***		0.89***	
	(0.000)	(0.000)		(0.000)	
Infant mortality (ln)	-1.79***		-2.92***		-2.06***
	(0.000)		(0.000)		(0.000)
GDP/c (ln)				1.79***	1.26***
				(0.000)	(0.000)
Mountains	-0.03***				
	(0.000)				
Civil war	-0.97				
	(0.114)				
Time Fixed Effects	YES	YES	YES	YES	YES
World region-fixed effects	YES	NO	NO	NO	NO
Constant	183.55	165.05	180.72	151.91	167.15
Observations	417	604	551	455	466
Adj. R-squared	0.74	0.45	0.56	0.53	0.56

Note: see notes to Table 5. The relatively high R-square values are partly caused by the time and region fixed effects dummies, and hence should not be interpreted as explanatory power. Constants are all significant at 1 percent level.

Table 7. *Determinants of height - Cattle instrumented with lactose intolerance*

Estimation technique	2SLS	LIML	LIML
First Stage			
Lactose tolerance	0.93		
	(0.058)		
Robust F	3.548		
	(0.066)		
Second Stage			
Cattle (ln)	3.91**	3.91**	5.40*
	(0.041)	(0.041)	(0.061)
Infant mortality (ln)	0.37	0.37	-0.18
	(0.677)	(0.677)	(0.867)
GDP/c (ln)			-2.68
			(0.239)
Mountain share	-0.04**	-0.04**	-0.03
	(0.041)	(0.041)	(0.146)
Time-fixed effects	YES	YES	YES
Region-fixed effects	YES	YES	YES
Constant	169.03	169.03	193.78
Observations	296	296	268
R-squared	0.69	0.69	0.66

Note: robust p-values in brackets based standard errors are clustered by country. *, **, *** refer to significance levels of 1, 5, and 10%. Dummies for all potential biases such as data set based on prison registers, volunteer army etc. included (see Baten and Blum 2012a). The relatively high R-square values are partly caused by the time and region fixed effects dummies, and hence should not be interpreted as explanatory power. As a caveat, we would like to note that lactose intolerance IV is cross-sectional in nature. Remember, however, that the cross-sectional component is much more important than the time series component (we have a typical large N – small T sample). In the very long run, lactose intolerance can be endogenous, but two centuries are not long-run for this type of effect. Constants are all significant at 1 percent level.

Table 8. *Determinants of height, early and late periods*

	(1)	(2)	(3)	(4)	(5)
Period	overall	early	early	late	late
Cattle (ln)	1.10***	1.37**	0.92**	0.61	0.75*
	(0.003)	(0.033)	(0.041)	(0.156)	(0.061)
Infant mortality (ln)	-1.80**	-3.37**	-5.54***	-1.19	-1.73
	(0.021)	(0.013)	(0.000)	(0.145)	(0.122)
Mountain share	-0.03**	-0.01	-0.03	-0.05***	-0.06***
	(0.030)	(0.651)	(0.307)	(0.002)	(0.008)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	No	Yes	No
Constant	183.53	187.38	196.53	182.24	179.94
Observations	417	175	175	190	190
Adj. R-sq.	0.74	0.68	0.53	0.78	0.58

Note: robust p-values in brackets based standard errors are clustered by country. *, **, *** refer to significance levels of 1, 5, and 10%. Dummies for all potential biases such as data set based on prison registers, volunteer army etc. included (see Baten and Blum 2012a). Constants are all significant at 1 percent level.

Table 9. *World region dummies - Lower-bound estimates of the effects of food behaviour, intergenerational effects, culture, and other unobservable factors*

	Effects of genetics etc. (regr. with explan. var.)	Overall region effect (without expl. var.)
East Asia	-3.97***	-8.22***
	(0.001)	(0.000)
East. Eur./Cntr. Asia	0.15	-0.98*
	(0.778)	(0.051)
Latin America/Car.	-4.44***	-8.33***
	(0.000)	(0.000)
Mid. East/N. Afr.	-0.98	-5.98***
	(0.227)	(0.000)
North America/Au/Nz	1.84***	2.71***
	(0.000)	(0.000)
South Asia	-3.83***	-7.16***
	(0.000)	(0.000)
Southeast Asia	-7.54***	-13.11***
	(0.000)	(0.000)
Subsaharan Africa	-2.20**	-5.60***
	(0.010)	(0.000)
Western Eur.	Reference	Reference

Note: robust p-values in brackets. *, **, *** refer to significance levels of 1, 5, and 10%. Included explanatory variables are cattle, infant mortality, mountain, civil war, lactose, birth decade. OLS estimation. "East. Eur./Cntr. Asia"= Eastern Europe and formerly members of the Soviet Union.

Appendix A: Height Trend without Interpolation (Internet Appendix)

In Figure A.1, we present the height estimates by world region without using any interpolations. However, the world region estimates using only recorded measurements may be biased if samples are not random for the region in question, that is, if there were variations in the amount of reliable data available for each country in that region. To compensate for any such missing values, we applied the best possible interpolation strategy such that, wherever possible, we identified a benchmark level estimate for each country to obtain levels that are close to the true height values being interpolated for a specific country. We then used the variation over time of nearby countries with similar characteristics. Linear interpolation was avoided because doing so may obscure certain fluctuations such as the declines that occurred in certain countries during the second half of the 19th century. Instead, we opted for backward- and forward-projection techniques, using the country-specific benchmark years and obtaining the changes between the benchmark and the estimated decades from a similar neighboring country. For example, because the change from the 1870s to the 1880s in Iraq is similar to the change in Iran over the same period, one could draw a conclusion from the results of a linear interpolation for Iraq for the same period, 1870s to 1880s. Using the height level of the 1870 Iraq benchmark guarantees its accuracy. (The interpolated values are represented by the white cells in Table B.1, with the exception of the Middle East 1810-49 and South Asia 1810-29, for which no reasonable interpolation was possible.) The correlation between world region trends based exclusively on real-height values and the series that includes interpolations is quite close (Figure 3 in the main text).
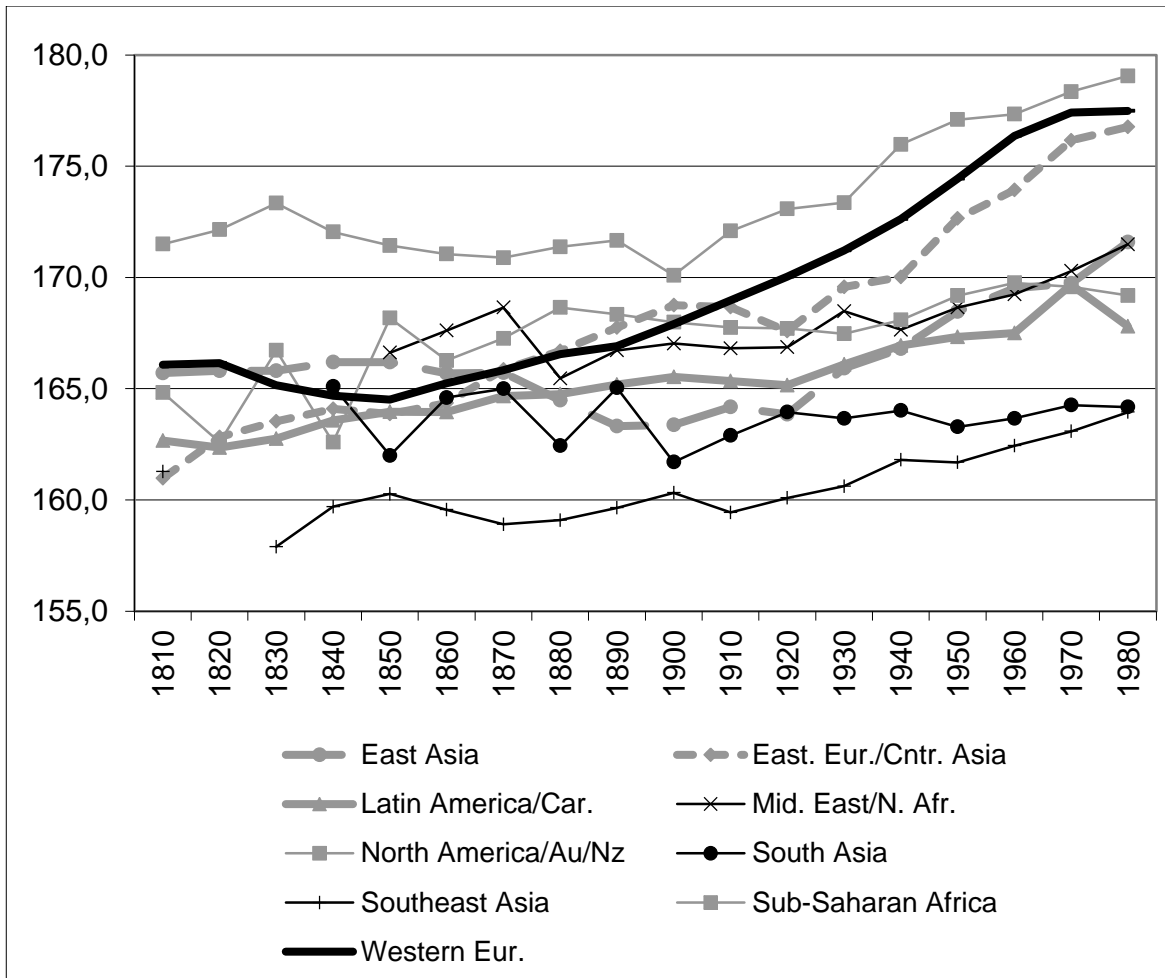
Figure A.1. *Height trend by world region (no interpolations, weighted by population size)*
Note: *Migrant heights are included.* Source: *Baten and Blum (2012a). See Tables B.1 for data coverage by country.* Note: *The standard world region classification has been used. The only exception is a group of 4 former British settlement colonies (US, Canada, Australia & New Zealand) as they experienced a great share of Western European settlers and are characterized by land abundance, which led to superior nutrition and eventually qualified them to become food exporters in the first wave of globalization (Baten and Blum 2012b).*

Appendix B: Data quality and biases (Internet Appendix)

How can we estimate the world height trend over a period spanning nearly two centuries? To compensate for the fact that until the middle of the twentieth century data are scarce for countries where poverty and illiteracy prevailed, we solicited a large number of recent anthropological measurements, with the aim of representing 164 countries, but were obliged to exclude eight for lack of evidence (Table B.1).[12] Needless to say, in some cases only a few birth decades are documented, and certain height estimates are somewhat weaker than others. But we have been as accurate as possible under the circumstances, recording height by province whenever possible, and adjusting our calculations to take into account any modifications of national borders. Only certain combinations of countries and birth decades are sufficiently well documented to contribute to our estimates for world regions and half centuries; for instance, no evidence is available for the Middle East and North Africa in the early 19th century, in large part because of the absence of precise height measurements in Ottoman Empire military data.[13] In most other world regions, however, army data were available for the early 19th century. The year 1950 marks a turning-point in that from that moment on population censuses, health surveys, and similar sources include data on women -- in fact, considerably more than on men -- because institutions other than the military, particularly those related to the health sciences, begin to take interest in them. The fact that there is a correlation, if not a simple one, between male and female heights is by now beyond dispute (Baten and Blum 2010) and it justifies our substituting one set for another when need be. Objections to this strategy might be raised by those who accept the female- resiliency hypothesis, which holds that for biological reasons the average height of a given female population is more resistant to adverse conditions than is that of their male counterparts. Some evidence of small pre-historic samples supported this hypothesis. However, drawing on the largest height sample available to date, Guntupalli (2005) has gone far to disprove this hypothesis for the last two centuries. Since the vast

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[12] Bahrain, Cape Verde, Djibouti, the Palestinian Territory, Qatar, Reunion, the United Arab Emirates, and finally the trio Mayotte, Saint Helena, and Western Sahara (aggregated as in Maddison 2001).

[13] Instead of exact measurements the Ottoman army categorized each recruit as small, medium, or large as well as barefaced or bearded.

majority of historical height estimates are for males, we transform all estimates into male equivalents, estimating specific regression equations for each world region in order to account for potential differences (Table B.2).

How could heights of individuals of age 18 to 22 (i.e.,.adolescents) be adjusted in order to be comparable to final height? It is reasonable to assume that a teen-age conscript, for example, from a malnourished population has yet to reach his maximal height. In such a case we calculate what his final height will be by applying the method presented in Baten and Komlos (1998).[14] Migrants, evidently not representative of the population into which they were born, are another potential source of bias; in some cases, the possession of skills and money motivate a person to migrate (Stolz and Baten 2010, Humphries and Leunig 2009). Such an ambiguous situation obliged us to generate reasonable adjustments. For example, if we could determine (thanks to data permitting us to compare the average height of migrants with the average height of the source population) the height selectivity of migrants from country A to country B, and if country C was very similar to country A in terms of development, then we adjusted the migrant height of country C by the same centimeter differential as country A migrants displayed, compared to the stayers of this country. However, this adjustment was necessary for only a small fraction of our sample, specifically, a mere 0.7%, out of the 1.5% of our sample observations based on migrant heights.

We have taken great care to identify all the biases that may have been generated by the institutional context -- enlistment in the military, incarceration in prisons, and sale in the slave trade, chiefly -- in which heights were recorded.[15] Voluntary soldier samples were included only if satisfactory statistical methods had been used to eliminate the height bias of truncated samples. As for other potential biases, one way to estimate their possible effect is to regress stature on a full set

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[14] See the notes to Table 1 in the work cited. The authors suggest the following adjustments, derived from Mackeprang's 19th-century-growth studies, for societies in which males in their teens and twenties have yet to achieve their maximal height (as a rule, above 170 cm). Those who were 18 years of age were estimated to have 2.4 cm to go; those age 19 1.7 cm, those age 20 0.9 cm, those age 21 0.4, and finally those age 22 only 0.1 cm. Clearly these estimates are not valid for all populations, since growth in late adolescence is largely a function of the individual's environment, but without such simplification comparison of heights in this age group would be impossible. Moreover, the results presented in Table B.1 of the appendix indicate that these estimates are generally valid.

[15] We also did our best to rid our data set of social, ethnic, and regional biases. On migrant height bias, see Baten and Blum 2010.

of birth decade and country dummy variables.

As for those institutional contexts that are specific to certain world regions and time periods, we have included them in a series of bias-analysis regressions, each designed to expose a potential bias typical of a given region or time period. For example, we had to rely on prison samples for Latin America and North America in the 19th century, whereas for most European countries we could obtain conscript samples, which as a rule entail a broader portion of the social spectrum; and anthropological samples were virtually our sole source for certain world regions.[16]

Self-reported heights are particularly prevalent in industrial countries in the later 20th century. Since, according to a number of studies, male respondents tend to overestimate their own height, we have adopted the corrective recently proposed by Hatton and Bray (2010), and will test its accuracy.

When we regress human stature on a full set of country and birth-decade dummies and on those potential-bias variables, the coefficients of the latter turn out to be insignificant (Table B.3). The coefficients are also small in most cases, with the exception of the slave coefficient. But not only is the negative coefficient for slaves (our slave data being limited to early-19th-century Africa) statistically insignificant; the only comparison group consists of military recruits. Thus it may very well be in this special case of slaves that an insufficient amount of data, for the purposes of comparisons, accounts for the large coefficient. For other anthropometric studies, it is a very important result that prisoners and voluntary soldiers did not differ significantly from other height sources, because this had been an issue in many earlier studies.

In the interest of accuracy we also assessed the possible biases of aggregate age, late-adolescent growth, self-reported heights, and migrants with and without adjustment (Table B.4). We found these potential biases to be insignificant, with the possible exception of positive coefficients for migrants, underlining the need not only to exclude unadjusted heights but also, by means of

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[16] The cutoff criterion for including a world region and a half century was 10% with one notable exception: that of "aggregated ages," for which we had to estimate the birth decade in which the majority of measured individuals were born; in this case we raised the level to 30%.

dummy variables, to control for any and all other potential biases.[17]

Additional references

Guntupalli, A. (2005). Essays on Indian Anthropometric Development. Ph.D. disseration Dissertation, Univ. Tuebingen.

Humpries, J. and T. Leunig (2009). Was Dick Whittington taller than those he left behind? Anthropometric measures, migration and the quality of life in early nineteenth century London?. *Explorations in Economic History 46*. 120-131.

Koepke, N. and Joerg Baten (2008). Agricultural specialization and height in ancient and medieval Europe," *Explorations in Economic History* 45, 127-146.

Table B.1. *World regions, individual countries, and birth decades: coverage of the data set (yellow indicates that real data was available and was accepted)*

Co	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980
Cn	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Hk												█	█		█	█	█	█
jp							█	█	█	█	█	█	█		█	█	█	█
kp							█	█	█				█	█	█	█	█	█
kr							█	█	█				█	█	█	█	█	█
mn											█	█			█	█	█	█
tw					█	█	█	█	█				█	█	█	█	█	
al							█	█	█	█			█	█			█	█
am					█	█				█				█		█	█	█
az																█	█	█
ba																		
bg							█					█	█					
by				█	█				█								█	
cs					█		█	█							█	█		
cz	█	█	█	█	█	█	█								█	█	█	█
ee						█	█	█							█	█	█	█
ge																		
hr	█	█	█	█	█						█			█	█	█		
hu	█	█	█										█	█	█	█	█	
kg																		
kz				█	█		█	█						█	█			
lt												█	█					
lv						█	█	█	█			█						
md														█	█	█	█	█
mk								█										
pl		█	█	█	█	█	█		█		█	█		█	█		█	
ro	█	█	█	█	█	█	█	█	█		█			█	█	█	█	█
ru	█	█	█	█	█	█	█	█	█	█	█			█	█	█		
si						█	█	█	█			█	█		█	█	█	█
sk					█	█	█	█				█	█		█	█		
tj							█	█	█		█							
tm						█	█	█	█	█	█							
ua			█	█	█		█	█										

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[17] We also created dummy variables for the rare cases that we encountered of significant regional, ethnic, and social selectivity (e.g., workers in South Africa), and include those dummies in our regressions below. By "significant" we mean evidence (derived from more or less contemporary studies) of a one-centimetre (or greater) deviation from the national mean.
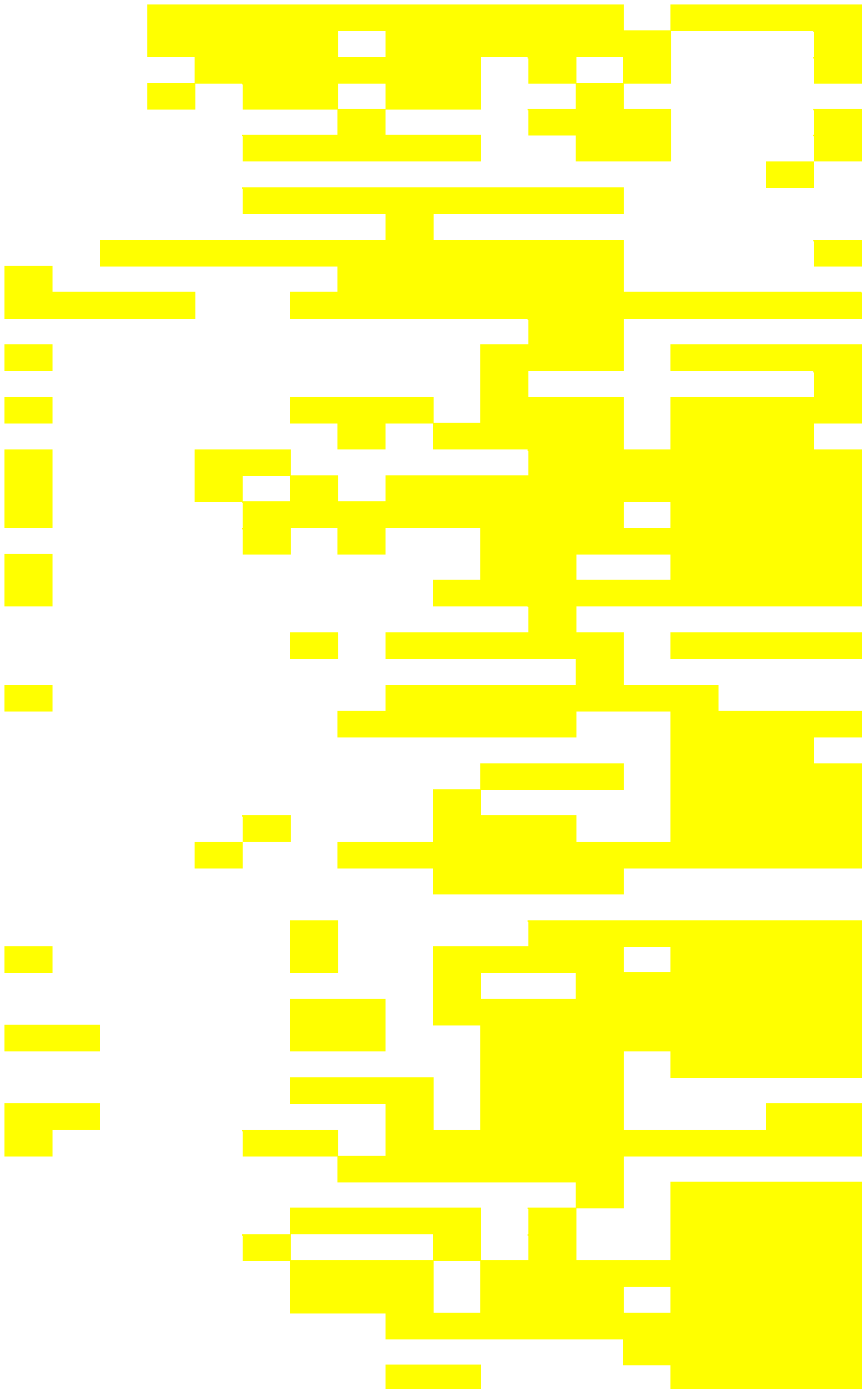
Note: Migrant heights (unadjusted), with the number of birth decades in parentheses, in the following countries: Algeria (2), Armenia(1), Bangladesh (4), Croatia (Hrvatska) (1), Czech Republic (1), India (6), Israel (1), Korea (North) (6), Malawi (1), Mozambique (1), Pakistan (1), Poland (2), Romania (1). Sources: see Baten and Blum 2010, Data Appendix

Table B.2. *How to estimate male heights on the basis of female height by world region*

	Americas	Asia (exc. SE)	Europe	SE Asia/Pacific	Sub-Sah Africa
Female	1.05***	0.94***	0.97***	1.02***	1.11***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	3.63	20.53	16.53*	6.59	-6.72
	(0.740)	(0.370)	(0.061)	(0.370)	(0.120)
Observations	45	13	22	36	38
R-squared	0.88	0.87	0.88	0.92	0.97

Robust standard errors in brackets. *, **, *** refer to significance levels of 1, 5, and 10 percent. Sources: see Data Appendix

Those regressions are based on the data provided in Gustafson and Lindenfors' (2004), a data set on male and female height, which is currently the standard anthropological data set for this kind of question. For Africa, we relied on the estimates of Moradi (2009b).

Table B.3. *Potential biases caused by the institutional context of measurement*

	(1)	(2)	(3)	(4)
Voluntary soldiers	-0.31			
	(0.28)			
Women		0.31		
		(0.47)		
Prisoners			0.82	
			(0.21)	
Slaves				-2.45
				(0.44)
Time-fixed effects	YES	YES	YES	YES
Country-fixed effects	YES	YES	YES	YES
Constant	166.63***	165.04***	163.03***	162.95***
	(0)	(0)	(0)	(0.000010)
N	91	401	416	67
R-square	0.79	0.83	0.90	0.96

Note: Robust standard errors in brackets. *, **, *** refer to significance levels of 1, 5, and 10%. The other constant refers to all other observations in which the potential bias does not appear.

Table B.4. *Other potential biases caused by the institutional context of measurement*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Aggregated age	0.13							
	(0.61)							
Age 18		0.84						
		(0.16)						
Age 19			-0.64					
			(0.26)					
Age 20				-0.84				
				(0.13)				
Age 21					-0.08			
					(0.92)			
Self-reported						0.52		
						(0.19)		
Migrant (unadj.)							2.13	
							(0.15)	
Migrant (adj.)								1.23
								(0.21)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Constant	161.86***	168.60***	164.92***	175.32***	167.49***	165.70***	177.25***	166.10***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	1401	396	121	127	121	63	66	66
R-square	0.81	0.89	0.78	0.94	0.79	0.83	0.96	0.94

Standard errors in brackets. *, **, *** refer to significance levels of 1, 5, and 10% . Sources: see Data Appendix

Appendix C: Does autocorrelation-consistent estimation make a difference?

In the main regressions, we clustered at the country-level, hence autocorrelation would not be a problem. In addition, in most estimations also decade fixed effects were included. Nevertheless, we were curious whether results would change if we adjust for autocorrelation. Hence we also include versions of tables 5 and 6 based on GLS-estimation with an AR(1) term here. The results are qualitatively unchanged: the same indications of significance (except for democracy) and economically substantive coefficients. The coefficient of cattle in Table C.1 is even larger, but the infant mortality coefficients show higher volatility (this method comes at a cost – the estimation reduces the number of cases) In table C.2 regular coefficients are presented instead of BETA coefficients.

Table C.1. *GLS-version of table 5*

	(1)	(2)	(3)	(4)	(5)
Main expl. var.	cattle	meat	milk	cattle only	mortality only
Cattle (log, p.c.)	0.82***			0.88***	
	(0.000)			(0.000)	
Infant mortality	-1.73***	-2.37***	-2.51***		-3.27***
	(0.000)	(0.000)	(0.000)		(0.000)
Mountains	-0.04***	-0.07***	-0.09***		
	(0.000)	(0.000)	(0.000)		
Civil war	-0.04				
	(0.896)				
Meat (log, p.c.)		1.52***			
		(0.000)			
Milk (log, p.c.)			1.03***		
			(0.000)		
Democracy		0.08			
		(0.348)			
World region-fixed effects	YES	NO	NO	NO	NO
Constant	182.84***	176.56***	179.33***	170.05***	183.68***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	411	213	192	584	537

Table C.2. *GLS-version of table 6 (regular coefficients instead of BETA coefficients shown)*

	(1)	(2)	(3)	(4)	(5)
	cattle	cattle only	mortality only	cattle & GDP	mort. & GDP
Cattle (log, p.c.)	0.60***	0.88***		0.59***	
	(0.003)	(0.000)		(0.001)	
Infant mortality	-3.39***		-3.27***		-2.13***
	(0.000)		(0.000)		(0.000)
Ln GDP/c				2.75***	1.23***
				(0.000)	(0.000)
Mountains	-0.04***				

	(0.000)				
Civil war	-0.30				
	(0.358)				
Time Fixed Effects	YES	YES	YES	YES	YES
World region-fixed effects	YES	NO	NO	NO	NO
Constant	187.19***	170.05***	183.68***	149.05***	169.30***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	411	584	537	447	453

Table C.3. *Conscript army-Anthropological report-only version of table 6 (excluding prisoners, volunteer soldier army samples etc.)*

	(1)	(2)	(3)	(4)	(5)
	cattle	cattle only	mortality only	cattle & GDP	mort. & GDP
Cattle (log, p.c.)	1.20***	1.27***		0.98***	
	(0.000)	(0.000)		(0.000)	
Infant mortality	-2.08***		-2.75***		-1.94***
	(0.000)		(0.000)		(0.000)
Ln GDP/c				1.65***	1.12***
				(0.000)	(0.001)
Mountains	-0.03***				
	(0.000)				
Civil war	-0.89				
	(0.149)				
Time Fixed Effects	YES	YES	YES	YES	YES
World region-fixed effects	YES	NO	NO	NO	NO
Constant	179.83***	165.04***	177.09***	153.46***	167.54***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	379	531	486	407	421
Adj. R-squared	0.75	0.47	0.57	0.55	0.57
Percent excluded	9.1	12.1	11.8	10.5	9.7
Original observations	471	604	551	455	466

Using such a global sample as we do here comes clearly at a cost. We had to integrate samples of very different institutional contexts in order to reach this unusual global coverage. In the cases in which we could average height estimates based on different institutional contexts, this might even be an advantage, because different selectivities might cancel each other out. For example, where we averaged an estimate based on prisoners (adjusted for social composition) and an estimate based on volunteer army soldiers (which was of course adjusted for minimum height requirement and for social composition), the resulting average was probably closer to the true value compared to the situation in which we could take height estimates based on one source only. However, not for all countries such a multiple-institutional context strategy was possible.

On the other hand, sceptics of anthropometric research often forget that most sources used in this field are actually not suspicious to be potentially influenced by sample selection bias.

In order to assess how large the potential problem of sample selection bias might be, we take a puristic strategy and repeat the regressions of table 6 with only those observations which stem either from (a) conscript armies in which male inviduals were measured in a representative way or (b) from Demographic and Health Surveys or anthropological surveys in which the inviduals were measured without social composition bias or potential labour-market-based sample selection biases. As a small minority of the samples falling under category (b) might not be regionally representative for the whole country, we identified for each country those studies which could potentially suffer from regional or urban-rural bias. This puristic exercise resulted in dropping 73 of the 604 country-birth decade observations which were previously included in column 2 of Table 6. Calculating the share of observations which might be considered suspicious by some sceptic readers results only in a loss of between 9.1 and 12.1 percent of our overall sample. Conversely, around 90 percent of our observations are based on either representative military conscription or anthropological surveys. We assessed the remaining 10 percent further and would argue that they are mostly unaffected by sample selection bias, except perhaps for a small minority of cases, which we cannot clearly identify based on the information available to us in the – especially older – anthropological survey reports.

In order to convince readers who might have a sceptic attitude to multi-country anthropometric studies, we think that this puristic experiment is worthwhile, even if it gives us only a maximum estimate of potential sample selection bias.

The main result is that the estimation using the reduced sample yields virtually identical results (Table C.3). None of the coefficients deviates by more than 10 percent. The cattle factor might be slightly larger and the GDP effect slightly less important, but the size categories and levels of significance are very close to being identical.

Finally, we also excluded observations of only modestly sized N. Also in the main regression tables, we did not include really small numbers of cases (such as less than 30). In the "quite small" range of 30-50 observations, we included only 4 observations which were important for the regional balance of our sample, but did not have any effect on the results. As long as samples are not socially or regionally biased, a sample size of 30-50 observations per birth decade can already be modestly informative (and many anthropological studies that focus on the period studied here are based on this size group). In Table C.4 we went a step further and excluded all observations below 200 observations per birth decade and country. As a result, the coefficients remained almost unchanged. For example, the cattle BETA coefficient changed only from 0.89 to 0.94 in column 4, from 1.21 to 1.24 in column 2 and not at all in column 1. From the second-but-lowest line we can see that only around 3 percent of our country-decade observations fall into the below-200 range. As a caveat, we should note that sometimes the information about sample sizes is not very precise in the original sources that we used. Sometimes N is only reported for the whole data set, and not for each birth decade, for example. In other cases, it is noted that, for example, all 19-year-olds of the whole country are considered, and no particular number is reported (but obviously in countries of substantial size, it is above 200).

As a result of these robustness check, we can concluded that it is highly unlikely that small-sample-bias, outliers based on small samples or sample selectivity biases have a substantial effect on our results.

Table C.4. *Regression excluding observations with less than 200 individual heights per birth decade and country (version of table 6)*

	(1)	(2)	(3)	(4)	(5)
	cattle	cattle only	mortality only	cattle & GDP	mort. & GDP
Cattle (log, p.c.)	1.10***	1.24***		0.94***	

	(0.000)	(0.000)		(0.000)	
Infant mortality	-1.82***		-2.82***		-2.03***
	(0.000)		(0.000)		(0.000)
Ln GDP/c				1.56***	1.14***
				(0.000)	(0.001)
Mountains	-0.02***				
	(0.000)				
Civil war	-1.04*				
	(0.078)				
Time Fixed Effects	YES	YES	YES	YES	YES
World region-fixed effects	YES	NO	NO	NO	NO
Constant	183.68***	165.63***	180.63***	153.93***	168.07***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	398	585	532	442	453
Adj. R-squared	0.76	0.47	0.58	0.54	0.56
Percent excluded	4.6	3.1	3.4	2.9	2.8
Original observations	471	604	551	455	466

Appendix D (online appendix): A selective review of the literature on individual countries and regions

We begin with a selective description of the more prominent studies on which our height data set is based. Due to the existence of a considerable body of scholarly work, long-term time series are available for a considerable number of countries around the world; however, in other cases, the documentation is limited to one or two benchmark years. In addition, while data used in the majority of articles pertain to national averages, the geographical distribution of resources and the distribution of resources within a society as a whole also plays a role (Steckel 1983, 1995, Carson 2009, Blum 2013c, 2013d). Though data availability varies among world regions, it is safe to say that in the past decade there has been an overall increase in data availability. Furthermore, while western Europe and European settlements have been the object of numerous studies, as our long list of references attests, other world regions have been subject to far fewer studies (e.g., Floud, Wachter and Gregory 1990, Floud 1994, Baten and Komlos 1998, Steckel and Floud 1997). Accordingly, the U.S. is particularly well researched with the latest addition to the large body of literature being presented by Zehetmayer (2011), who found that U.S. stature continued to decline during the Civil War by approximately one cm and stagnated for an extended period of time before starting to increase during the late 1880s. Southern Europe has also been added to the data set (A'Hearn 2003, Peracchi 2008, Martínez-Carrión 1994), which was then followed by Garcia and Quintana-Domeque (2007) and Hatton and Bray (2010) who even further extend the European data set. Beyond that, Whitwell, de Souza and Nicholas (1997) have documented Australia and Federico (2003) has reported that in Italy, during the second half of the 19th century, growth in agricultural production led, contrary to the standard series of national accounts, to an increased food intake and, eventually, to increases in physical stature.

Eastern Europe and central Asia have undergone a thorough anthropometric examination by Mironov (1999, 2004, 2012) due to a combination of archival and contemporary anthropological data (see, also, Mironov and A'Hearn 2008, Komlos 1999). Mironov's estimates of Russian and

various other eastern European height trends provide a valuable overview of this world region, even if Wheatcroft (1999) offers a different interpretation. As for central Asia, we can draw on the demographic and health surveys (DHS) conducted since the 1980s and onward as these surveys allow us to cover birth decades after the 1940s. Furthermore, due to anthropologists, we have data for the birth period 1960 to 1989 in eastern Europe (e.g., Bielicki and Hulanicka 1998, Vignerova and Blaha 1998), and among Komlos' many studies, there are several on east-central Europe, regions that once composed the Habsburg Empire (Komlos 1985, 1989, 2007).[18]

Pre-1950 Latin America data on Argentina and Colombia have been provided by Salvatore (1998, 2004a), Salvatore and Baten (1998), López-Alonso and Condey (2003), Meisel and Vega (2004, 2005), Carson (2005, 2008), and recently by Baten and Carson (2010).[19]

Asia, the Middle East and North Africa are only modestly documented. We have access to Indian height data not only for the early 20th century (Guntupalli and Baten 2006) but also for birth cohorts dating as far back as the early 19th century (Brennan, McDonald and Shlomowitz 1994a, 1994b, 1997, 2000). Although the latter studies are based on labor-migrant heights, and hence, they are not necessarily a representative sample of India, the authors offer persuasive arguments that these heights were equivalent to those of the population as a whole. For Japan, we turn to Mosk (1996), Bassino (2006), Shay (1994) and Honda (1997) and for China, to Morgan (2009); Baten and Hira (2008); and Baten, Ma, Morgan and Wang (2010). The latest of several studies of the two Koreas is one of North Korea by Pak, Schwekendiek and Kim (2011). As for Southeast Asia, little evidence on this region is available (Vietnam: Bassino and Coclanis 2008; Indonesia: van der Eng 1995, Baten, Stegl and van der Eng 2013; the Philippines: Murray 2002). The late 19th and early 20th centuries of the Middle East and North Africa have been documented in Stegl and Baten (2009).[20]

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[18] Kopczyński (2006) has done likewise for Poland.

[19] Brazil, Peru, and Argentina have been studied by Baten, Pelger, and Twrdek (2009) and Twrdek and Manzel (2010). In addition, there is scattered information regarding the Indian populations in these and other countries (Bogin and Keep 1998).

[20] Data from the Demographic and Health Surveys (DHS) program allow a trend estimate for Turkey and Egypt during

African height data on freed slaves and military recruits permit a rough estimate for the early

19th century (Eltis 1982, Austin, Baten and van Leeuwen 2012). Eltis (1982) has argued that

the height discrepancy between freed slaves and others was negligible because height was

not an important pricing criterion, and though slave heights varied from region to region,

regional prices did not reflect this variation. Furthermore, any height differences among

freed slaves were diminished by Africa's own demand for the strongest (and, thus,

presumably the tallest) workers available because Africa itself was a labor-scarce world

region. There is also no evidence that the slave market established anything similar to the

military's minimum-height requirement. A comparison of height data for soldiers and slaves

indicate that the latter do not suffer from significant bias (Austin, Baten and van Leeuwen

2012). For Africa, during the period 1890 to 1930, a large number of anthropological studies

are available. For example, there are older studies regarding one of two major Kenyan

peoples, the Kikuyu and the Massai (Orr and Gilks 1931), as well as more recent studies

(Moradi and Baten 2005, Moradi 2009a, 2009b, Austin, Baten and Moradi 2013).[21]

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the period 1950 to 89, while the 1970s and 1980s have been the object of a number of anthropological studies.
[21] The problem of potential survivor bias in the African DHS data sets, which span the years 1945-89, has been resolved by Moradi (2005).

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