Joerg Baten*

"Global Height Trends in Industrial and Developing Countries, 1810-1984: An Overview "

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* University of Tuebingen and CESifo, address: Dept. of Economics, Mohlstr. 36, 72074 Tuebingen, University of Tuebingen and CESifo, joerg.baten@uni-tuebingen.de

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Abstract

This short article is based on a large data set project that aims at collecting heights for 165 countries around the world between 1810 and 1984, for five year birth cohorts. Where no reliable data is available, interpolations and estimations are used. As far as possible, interpolations are not linear, but use the growth rates of similar countries. We keep the level of height as close as possible to a real measurement level in each country. We find that a surprising amount of height information is available by now (although Africa in the 19th century and many other poor countries are poorly documented). This is especially true if anthropological surveys are included, which are somewhat less exact in describing the birth cohort. In general, our interpolation strategy yields plausible results, even if it can be only a first step that needs to be augmented with additional and more precise data.

We find that the anthropometric divergence between rich and poor countries started around 1880, right in the middle of the first globalization period. However, height differences between rich and poor did not diminish in the deglobalization period 1914-1945. Whether correlation equals causality, needs to be assessed in later studies.

In the final section, we compare GDP and height data and find that GDP explains a substantial part of height differences and development, but proximity to protein production, inequality and other factors also play a decisive role. Especially the deviations of the income-height relationship will allow to tell a fascinating global economic history, once the database is augmented and corrected.

Introduction

This paper is the very first - and preliminary - Beta version of a study on world height trends. 165 countries are taken into account (those with more than 400,000 inhabitants), although some are only documented by one or two height estimates and a minority is completely undocumented yet (in which case heights of the most similar neighbouring country or countries were taken as approximations). The idea of this project is that subsequently additional information is entered to improve this database of world-wide height estimates over the next months and years.

Human stature is now a well-established indicator for the biological standard of living, as it is typically correlated with health, longevity, and nutritional quality. Only few exceptions come to mind, such as the Japanese who consumed very little protein before the economic boom of the 1960s and had short statures. But the Japanese achieved relatively high longevity values by investing in personal hygiene and health-related education.

A large number of studies have been conducted on heights around the world, but no attempt has yet been made to compile and standardize all available sources, and to interpolate the missing values with reasonable assumptions. This study is a first step to this ambitious goal. It is clear that a lot of gaps exist, especially on less developed countries before the 1950s. The series on individual countries will clearly contain a fair bit of measurement error, even when measurements are available and can be based on sufficient numbers of cases: often the regional and social composition of height samples cannot be perfectly assessed for being representative or not (and then perhaps adjusted). The basic strategy to cope with this is to collect data for a large number of countries. Hence measurement errors will cancel out on a global scale. And even trends for world regions can be reliable (especially for those for which sufficient independent measurements are available).

Such a work can also be important for further data collection efforts, as it is helpful to have a realistic range to compare new height estimates to (for example, if the conversion of

historical measures is ambiguous). This compilation will in the long run help to approach some of the most important questions in economics: When did the divergence between today's rich and poor countries begin? Did globalisation cause this global inequality of countries? For example, was the divergence movement particularly fast when international markets integrated in the 1850-1913 period, and did it come to a stop when globalisation broke down 1914-45 (O'Rourke and Williamson 1999)?

Our approach can provide additional insights to this debate, as heights are not fully correlated with national incomes or real wages that had been used to assess these questions before. For example, heights are also influenced by the availability of non-traded food stuffs (such as milk, meat of low quality, and offals) and health resources. When globalisation boomed, the New World food exporting economies could, for example, have lost some of their initial height advantage.

World height trends

How can we estimate roughly a world height trend over the period 1810-1980? As always in global comparisons, we know some series for some individual countries, and we know little for other countries. Especially the poor and less literate countries tend to be poorly documented for the period before the middle of the 20th century. After about 1950, the availability of sources changes dramatically, because the Demographic and Health surveys and similar sources provide a large amount of height data on women born between the 1950s and 1980s. After the early 1980s, there is again a shift, as adult heights are no longer available. Some preliminary estimates might be possible by comparing children's height to standard growth curves 1980-2005. For this, we have to assume – or test as far as possible - a roughly similar distribution of nutrition and medical resources between children and adults. Then we can estimate how tall those children would have been as adults, using the standard

growth charts. In this study, we only used this approach for the Near Eastern countries on which other sources were particularly scarce.

Male and female heights

For the 1950-1984 period, much more data is available on women than on men, whereas for most of the previous period the opposite is the case. The reason is the demographic and health interest in mothers, and in female behaviour in general. Certainly, male and female heights are not perfectly correlated, but to a certain extent they are related (Baten and Murray 1999, Moradi and Guntupalli 2006). Hence we would like to estimate this relationship between male and female height. If we dare the assumption that height trends were broadly similar, this allows to transform female heights into male height equivalents or vice versa, where heights for only one of the genders are available. As most historical height estimates are for males, we mostly transform into male equivalents. The source for this estimate is Juergens et al.'s (1990) height data (mostly for late 20th century samples, all data in cm):

$$\text{Male height} = 24.9879 + 0.9175 * \text{female height}$$

(Adj. R-square is 0.91, p-value of the female height coefficient 0.00, of the constant 0.03, N=20). Slight deviations include relatively taller women in Southeast Asia and North Africa (adding a dummy for those two increase the adjusted R-square to 0.94, and the formula is then 28.969 + 0.8946 * female height – 3.4242 * NorthAfrica/SouthEastAsia, all p-values 0.00).

We can therefore in principle express heights as male equivalents, but it might be important to countercheck the time-invariance property of this relationship by looking at samples of the 19th century. A refinement of this estimation strategy would be to take gender discrimination proxies (such as relative life expectancies, relative child mortality age 2-5 etc.) into account.

Individual world regions

For some countries, we have to use linear interpolation. Another possibility is to use the time variation of other, nearby countries with similar characteristics. Further studies will hopefully fill the gaps and necessary interpolations in the future with real data. We refer to today's borders of countries wherever possible to allow long-run comparisons, following the Maddison (2001) strategy.

Industrial countries have been assessed by many studies cited in the long list of references. There are even some survey pieces on this group (among others, Floud 1994, Baten and Komlos 1998, Steckel and Floud 1997). We took care to adjust heights of still growing individuals to their most likely adult height level, following the method explained in Baten and Komlos (1998, notes to table 1). For example, an 18-year-old conscript in a population that was shorter than 170 cm certainly had some remaining growth to expect.

For **Eastern Europe and Central Asia**, Mironov (1999, 2004) has done extremely important anthropometric work, both with archival and contemporary anthropological data. His Russian height trend and the height levels reported for many regions in Eastern Europe provide a good picture for this world region. For the 1950-80 period, DHS surveys are available for several central Asian countries, and the 1960s to 1980s are well-documented by anthropological work (for example, Bielicki and Hulanicka 1998, Vignerova and Blaha 1998, see the references for a more complete list). Komlos (1985, 1989, 2006) has, among so many other countries studied by him, provided data on Southeastern Europe (the parts of the Habsburg Monarchy). Poland was recently documented in Kopczynski (2006). The Russian military-statistical handbook provided additional data on the early 19th century (Russia 1871, Woenno-Statistitscheskii Sbornik).

For **Latin America** before 1950, we have studies on Argentina to approximate the wider Southern Cone (Argentina, Chile, Uruguay, Paraguay), and studies on Mexico and Colombia for the Northern part (see Salvatore and Baten 1998, López-Alonso and Porras

2003, Meisel and Vega 2004a, 2004b). We recently collected a small sample from several Peruvian military sources (thanks to Güde Hansen for visiting the National Archive in Lima).

The Peruvian height series, even if based only on a small number of observations, fits very well to what we know so far about the other Latin American countries that do not belong to the Southern cone: There was an upward movement in the late 19th and 20th century, albeit from a very low level. The Peruvian data suggest a decline around mid-19th century, similar to what we observe in the U.S. and most European countries, which is therefore also not unplausible.

López-Alonso et al. (2003) arrived at about 161 cm for Mexican recruits and height estimates based on skeleton samples in the mid-18th century. The skeleton samples were mostly from central Mexico, and they reported also the difference to the taller North Mexican height, hence we adjust this figure to approximately 163 cm for the late 18th century. In Mexico of the 1840s heights were around 165 cm (Carson 2005). Moreover there is some scattered evidence for these and other countries on American Indians (see Bogin and Keep 1998).

For **Asia, the Middle East and North Africa**, the Japanese and Indian cases are relatively well-documented, Indian height data going back to the birth cohorts of the early 19th century (see Brennan, McDonald, and Shlomowitz 1994a, 1994b, 1997, 2000, BMS for short. On the early 20th century, see Guntupalli and Baten 2006, on Japan Mosk 1996, Bassino 2006, Shay 1994, Honda 1997). However, Indian height data until 1900 rest on the assumption that labour migrants had similar heights as the general population, for which BMS found convincing arguments. For China, the same assumption applies to the growth rates, whereas the level can be adjusted accordingly. Morgan 2006 did recently a remarkable study, tracing Chinese heights in Australian migrant sources, and offering overlapping evidence that allows to adjust migrant heights to the underlying home population. Indonesian, Thai, and Vietnamese data is available to a certain extent (Vietnam: Bassino and Coclanis 2005;

Indonesia: van der Eng 1995). For the Philippines there is a study by Murray (2002). The Middle East and North Africa of the late 19th/early 20th century has been documented by an astonishing number of anthropological studies that were compiled by Field (1956, we are running a separate project on heights in the Islamic world). For Turkey and Egypt 1950-80, DHS data allow a trend estimate for this region, and the 1970/80s has been documented by a number of anthropological studies.

African heights are available for the 1945-1984 period, Moradi (2005) clarified how to use those data sets, given potential survivor bias. For the early 19th century, heights can be approximated to a certain extent with data on freed slaves. Eltis (1982) has strongly argued that the bias between freed slaves and the underlying populations was small or negligible. He argued, for example, that there were no slave price differences observed between regions with tall and short slaves. This should have been the case if height was a prominent selection criterion. Moreover, by the 19th century physically strong (and tall) Africans were also demanded in colonial Africa's plantations. Finally he observed that height distributions from all regions were quite normal. If there would have been something like a minimum height requirement of slaves, those from the regions of shorter stature should have displayed some shortfall.

Eltis described the African regions from which the slaves embarked in certain ports originated. For example, he found that freed slaves embarked in the ports of Senegambia represent the semiarid Sahel zone countries.

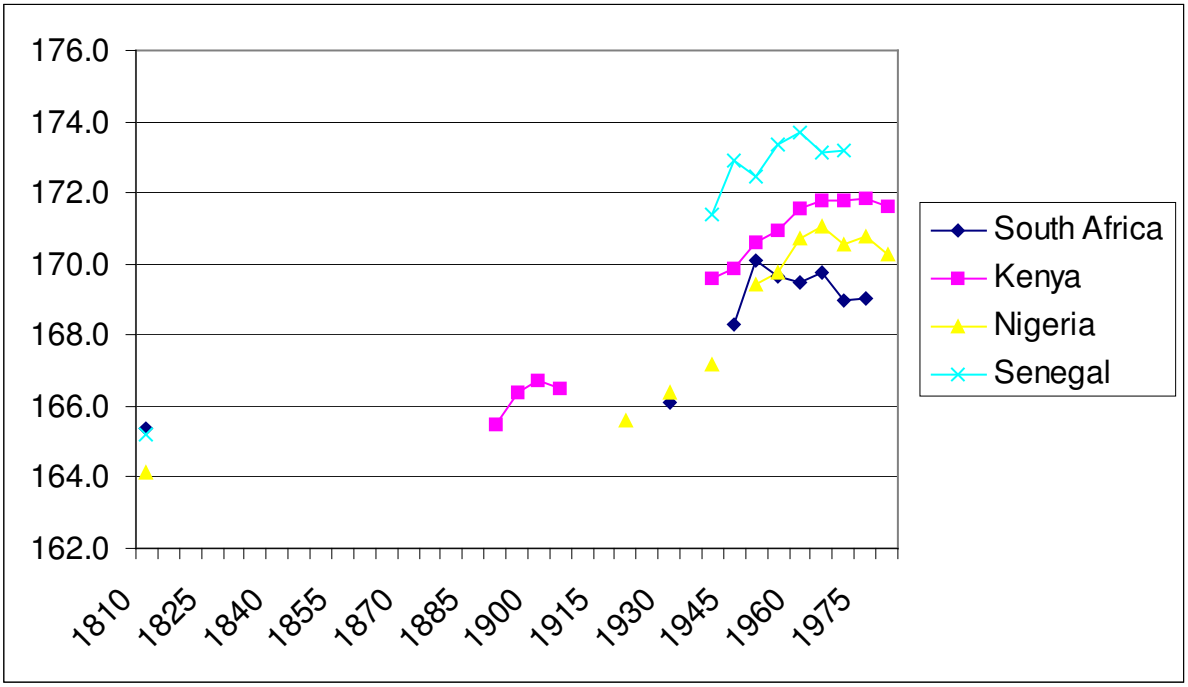

Figure 1: Heights in Africa.

Finally, for the late 19th and early 20th century some anthropological studies are available. For Kenya and Nigeria, for example, some data on the 1890-1930 period is available (Figure 1). For Kenya, the Orr and Gilks (1931) study focused on Kenyan Kikuyu and Massai, which were born after the early 1890s (thanks to Alexander Moradi for providing this data). No matter whether we look at Kikuyus alone or create an index of both ethnicities, there was a strong height increase up to the late 1960s. Afterwards Kenyan heights started to stagnate (see also Moradi 2005). Nigerian heights are available since the 1920s, and display a similar height increase, and a stagnation thereafter. Heights in Senegal were substantially higher. Finally, the South African height development has been documented by Crayen (2006). Given the similarity of the Kenyan and Nigerian height series, we estimate an African trend for the post-1890 period (which we adjust for height levels using post-1950 data). It is obvious that African historical heights are a particular desideratum.

The very first estimates of a world height trend 1810-1984

Figure 2 has the very first estimates of a world height trend 1870-1984, Beta-Version 1.0, and a number of world region trends for the 1810-1984 period. Those are arithmetic averages of 165 countries, often with very bold interpolations. Further versions of this paper should also compare weighted averages (although China and India then dominate the global series). But the result looks relatively plausible, comparing the individual world regions with the existing available literature for individual countries.

In general, we can distinguish four groups of world regions.

(1) The industrial countries and those Eastern European and central Asian countries that were socialist at some point in time had a strong upward trend after the 1880s. It is remarkable, however, that after the First World War (when the Soviet Union was created), the differential between those two winner groups increased (Komlos 1999; Mironov 2006).

(2) In contrast, the Latin American countries and those in the Near East and North Africa started at relatively high levels in the 19th century, but had only a modest height growth during the 20th century (Salvatore 2005)

(3) East Asia and Sub Saharan Africa started on a relatively low level in the 19th century, and ended up not far from the global average. Remarkably, Africa is the only world region with a consistent height decline over the last two decades. (Moradi 2005)

(4) Finally, two world regions that started low and ended on a low level are South and Southeast Asia. Especially the former had almost no upward trend since the late 19th century, whereas Southeast Asia started at lower height levels which subsequently increased somewhat (Brennan/McDonald/Shlomowitz 1994a, 1994b, 1997, 2000, Guntupalli/Baten 2006). The lacking protein (and milk in particular) might have played a special role, whereas in East Asia there was a growing consumption in Northern and Eastern China and South Korea, for example.

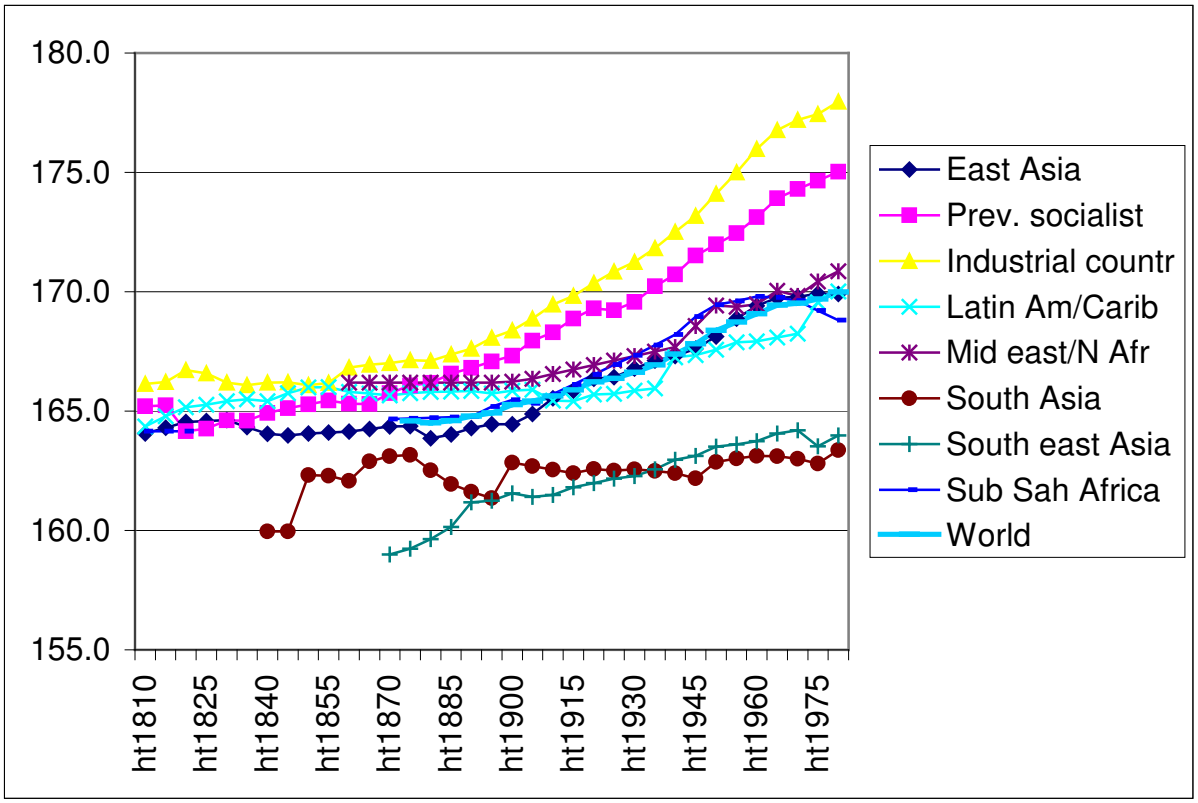

Figure 2: Preliminary height trend estimates for all world regions.

Notes: "Prev. socialist“ are those countries which Eastern Europe and central Asia which were socialist at some point in time.

How closely is height influenced by GDP?

A somewhat preliminary analysis can be performed on the relationship between purchasing power and height. Originally, the literature had assumed a close correspondence between those two variables (Fogel et al. 1982). In the literature of the past two decades, some important deviations between height and GDP were found. Even between height and real wages for unskilled labour such deviations existed, which presumably was not caused by increasing inequality (among many others, see the pioneers Margo and Steckel 1983, Komlos 1996). However, even within the group of industrial countries (today), there was a strong focus on two important cases, the UK and the United States of America. In many other countries, the relation between real wages and heights was actually much closer (Baten 2000).

Our new data set allows a much broader view on the global economy, even if the results are somewhat preliminary, given the "work in process" character of the data set.

In a simple scattergram, there is some positive correlation between real GDP per capita and height. In general, there is only a modest number of cases between 155 and 160 cm (mostly in central America and South East Asia), and a limited number of heights above 180 cm. The most solid block of observations is between 160 and 172 cm, indicating that those values were typical in the past two centuries. The deviation to the lower right is Japan, but for the Japanese values alone there was also a positive correlation between GDP and height over time. Deviations on the upper left include some East European, Caribbean, and North African countries. In the 1925-49, also some East Asian miracles (Taiwan, South Korea) had higher height levels than expected, before their GDP grew in the subsequent period (Figure 4).

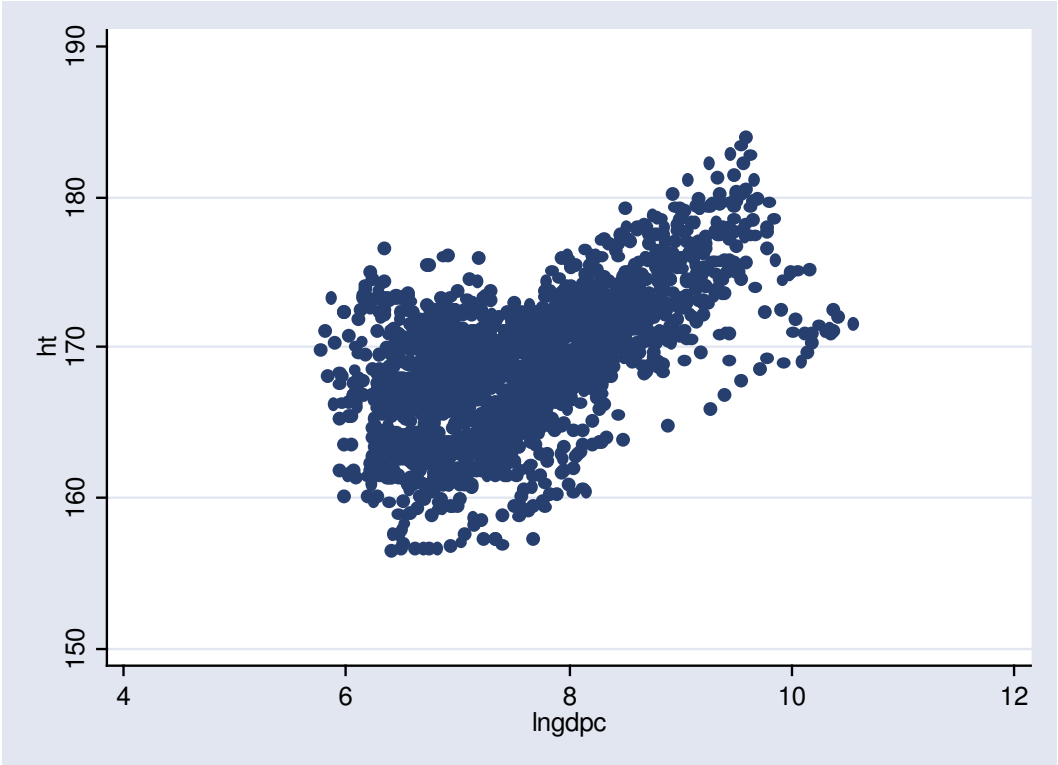

Figure 3: Height and Log GDP per capita, all periods

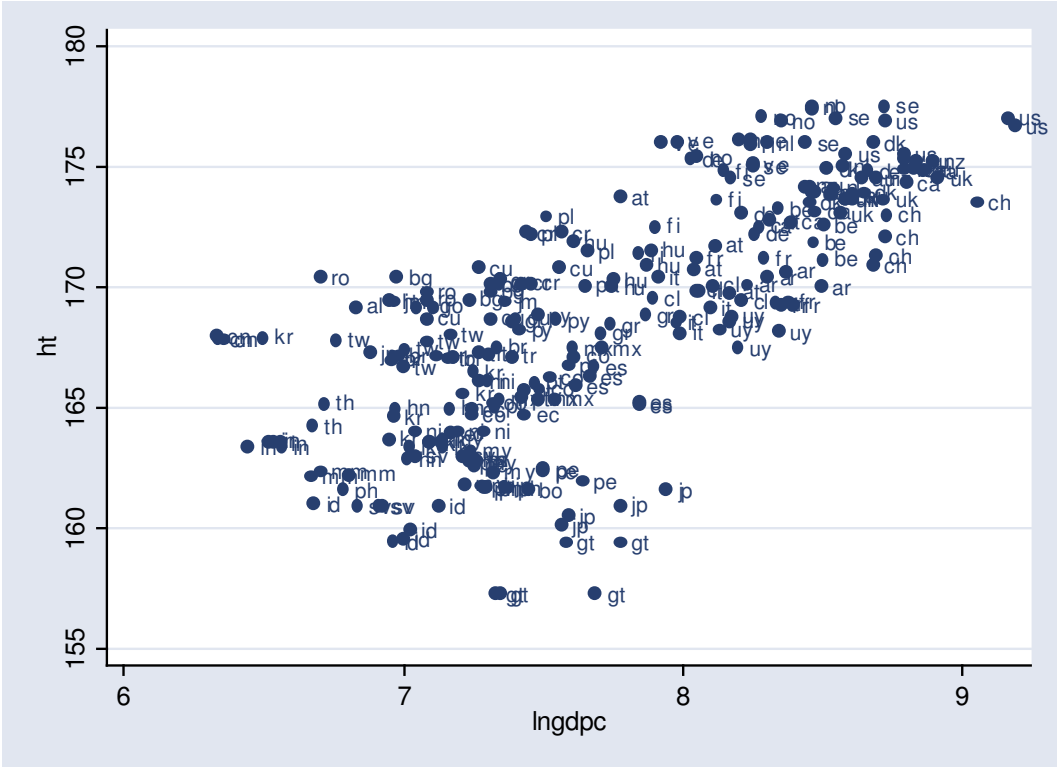

Figure: Height and Log GDP per capita, period 1925-1949

Note: multiple entries per country represent various birth quinquennials

Table 1: Determinants of height: (1) not controlling for GDP/c, (2) controlling for GDP/c, (3) as (1), but same cases as (2).

Regr. No.	Coeff. (1)	P-val. (1)	Coeff. (2)	P-val. (2)	Coeff.(3)	P-val.(3)
Ln GDPC			1.77	0.00		
Democracy	0.27	0.01	0.08	0.44	0.22	0.04
%Mountain	-0.02	0.10	-0.03	0.04	-0.04	0.00
d181024	-6.06	0.00	-3.25	0.00	-6.63	0.00
d182549	-5.91	0.00	-4.97	0.00	-8.86	0.00
d185074	-5.59	0.00	-4.47	0.00	-7.48	0.00
d187599	-5.24	0.00	-4.33	0.00	-6.90	0.00
d190024	-4.32	0.00	-2.72	0.00	-4.80	0.00
d192549	-2.77	0.00	-1.45	0.00	-3.01	0.00

d195074	-0.65	0.00	0.08	0.54	-0.57	0.00
Caribbean	0.71	0.61	-0.12	0.94	0.92	0.59
East Asia	0.54	0.69	0.78	0.58	1.60	0.27
Eastern Eur/CA	1.53	0.10	1.36	0.21	4.07	0.00
Industrial Countr	1.71	0.09	1.05	0.34	3.62	0.00
Latin America	-0.42	0.60	-2.57	0.00	-0.74	0.38
Middle East/NA	1.24	0.09	-1.50	0.06	0.99	0.21
South Asia	-4.44	0.00	-5.20	0.00	-5.29	0.00
South East Asia	-4.57	0.00	-4.42	0.00	-3.67	0.00
Constant	169.83	0.00	157.25	0.00	169.88	0.00
N	4655		1611		1611	
Adj. R-sq	0.51		0.55			

Random Effects Estimates. Constant: born 1975-99 in Sub Saharan Africa

P-values in italics, shading indicates significance at 10% level

In Table 1, we assess some determinants of heights, such as real national income (in 1990 Geary Khamis $, from Maddison 2001), political system, elevation, and a set of period and world region dummies. Omitted variables are here the proximity to protein production, relative prices of high-quality food, the disease environment, inequality, generation transmission effects (for example, short Japanese mothers might have shorter children), or dietary customs (in Northern Europe and the Netherlands, people still drink more milk than in Italy, although the latter could afford more today), and other variables. We also need to consider whether either GDP or height estimates contain such an amount of bias that this could act as an omitted variable.

The economic theory behind national income as a height determinant is probably clear: more income can usually buy more nutritional quality, and in the 20th century more health. Democracy was inserted to see the possible effect of political participation: could it be

that rich non-democratic governments (for example, in oil-producing countries) generate a lower standard of living for the population? We actually find that there was a positive effect of democracy on heights (model 1 and 3), but only as long as GDP per capita was not taken into consideration. In model 2, which controls for Log GDP per capita, democracy becomes insignificant. We conclude that democracy and the more liberal institutional structure that is usually correlated with it rather creates growth-promoting effects, and national income captures this effect in our regressions.

Another variable that is not a standard determinant of height is the percentage of mountainous terrain. We included it as in previous studies those regions within Europe often featured taller populations compared with lowlanders nearby (such as the Alps, Scottish highlands, the French Jura, the northern Caucasus). The disease environment might be more favourable in sparsely populated mountain regions. I argued in previous studies that it was the proximity to protein that allowed those European mountain dwellers to acquire better nutritional status, which is plausible as the same applies to other (non-mountainous) dairying intensive regions such as the continental North Sea coast (Baten 1999). In contrast, anthropological studies on LDCs argued that humans in mountainous areas are generally shorter (such as Peruvians in the Andes), but this might of course be caused by economic variables as well. In the regressions above, the results on a global scale indicate that a higher share of mountainous terrain leads to lower heights, even controlling for purchasing power.

One important result of the regressions above is the consistent influence of GDP per capita on height. Given that two of the 165 countries experienced deviations between income and height/life expectancy development in the mid-19th century (the UK and the U.S.), it sometimes seemed in the literature as if the correlation between income and height was weak. We find that GDP per capita is actually a strong predictor of height, even after including period and world region dummies (and also when we perform cross-sections below to avoid trend correlation and unit root problems). It is also interesting to consider the differences in

period and world region dummies if income is taken into account, as opposed to not including GDP in the regression. The third regression includes only those cases that were also included in the second regression, therefore we will mainly compare those two. But the results are broadly similar for the first and third regression.

First, when we take GDP into account, the period dummies are all much smaller. Those measure the difference of a certain period with the constant that represents the last period (1975-84). For example, after controlling for income the coefficient for the 1900-1924 period shrinks from 4.8 cm to only 2.7 cm. In other words, about half the height increase vanishes once controlling for GDP. The difference between 1950-74 and the last period even gets insignificant – all of that height difference can be explained by GDP. But still, many of the period coefficients are statistically significant, so GDP alone cannot explain the height development. Between 1825 and 1874, people were between 4 and 5 cm shorter than we would expect them be based on GDP estimates. (But not 8 or 9 cm without controlling for income.)

The world region coefficients are equally interesting. While the insignificance between the Caribbean heights and the constant (representing Sub Saharan Africa) might be not as astonishing, the insignificance of the "East Asia" coefficient is quite apparent. We find that heights in China, Korea etc. were not significantly different from African heights. In Eastern Europe and Central Asia (the parts of the previous Soviet Union such as Kazakhstan etc), the coefficient switches to insignificance once GDP is taken into account – and the same applies to Industrial countries! African heights are not different from those in industrial and (at some point) socialist countries, once the income differential is taken in to account. This confirms results about individuals of African origin the U.S. whose heights were not different, if income and education was on the same level (Cuff 1998).

In contrast, the Latin America and the Middle East/North Africa differential to Africa is characterised by the opposite. Those world regions do not have significantly different

heights from Africa as long as GDP is not considered. But once it is, given the much higher GDP in many countries of Latin America and the Middle East regions, heights are much shorter than we would expect. This fits well with the high income inequality in Latin America and the oil producers of the Middle East and North Africa, which might have had a detrimental influence on heights. In contrast, the disease environment should be equally bad or even slightly better than in Africa.

Regions of the world that were significantly shorter than Africa were South Asia and South East Asia. Here the disease environment could play a role, but more likely it is the lack of protein in those two regions of the world. For example, within India there were quite high levels of height in those regions that had relatively high values of protein (such as the Punjab and Haryana within India, see Guntupalli/Baten 2006). A next step would be to generate approximations for this variable on a global level to see whether the world regions dummies would decrease in size.

We also assessed the sensitivity of height to GDP in different periods (Table 2). Those are the Adjusted R-Squares from regressions of height on Log GDP (Height = $ß_1$ + $ß_2$LogGDP + e). For the earliest two periods, the number of observations is insufficient (two few GDP estimates), but in the late 19th century there is already a remarkable correlation of the two variables. Interestingly, for the 1950-74 period with the highest number of cases it is actually quite low, partly because oil producers had particular high GDP in this period, and low heights, and also Japanese heights only converged late to their expected level. In contrast, Western African countries specialized on cattle production had relatively tall populations, relative to their low GDP, which changed somewhat in the following period when African heights declined (Moradi 2005).

Table 2: Correlations of height and GDP in different periods

Quarter Cent	Adj-R-sq	N
1850	0.20	124
1875	0.48	130
1900	0.40	212
1925	0.53	248
1950	0.25	683
1975	0.42	546

Conclusion

This study was a first step to introduce a new data set on global height trends, and height trends by world region. Constructive criticism, and especially references to additional data (or data sets in email attachments…) are warmly welcome. The data appendix will be made available in a few months and updated subsequently, so that the interpolation decisions become transparent in detail (whereas the data section above online describes the most important sources). Most of the sources are listed below, hence the references are longer than the paper itself (but they might not yet be complete, please do not take it as an insult if I forgot to cite your paper in this preliminary version, but let me know…).

We find that most of the anthropometric divergence between today's industrial and developing countries took place after the 1880s. The Eastern European and Central Asian countries also experienced some height increase 1880-1917 (before they became socialist in two major waves). The height increase continued later, although they achieved slightly lower levels and growth rates than the Western industrial countries. Latin American and the Near East/North Africa region had impressive levels until 1880, but only modest growth thereafter. South Asia had a disappointing development, and also South East Asia grew only modest. Africa did not perform as bad as perhaps expected in the 1900-1965 period, but had a terrible height decline since then.

Analysing the GDP and height relationship, we find it to be quite strong, but it is does not explain more than 20-50% of the variation. Some important deviations remain, which might be partially caused by protein availability, generation transmission effects, dietary customs, and other factors.

Finally, did globalization cause this global height inequality of countries? For example, was the divergence movement particularly fast when international markets integrated in the 1850-1913 period, and did it come to a stop when globalization broke down 1914-45 (O'Rourke and Williamson 1999)? We find that the latter was not the case, divergence in height was strong in the 1914-45 period. However, the timing supports a view that the height divergence started in the middle of "first era of globaliation", around 1880. Whether correlation is causality here, needs to be assessed in further studies.

References

Most of the references refer to the data used in the underlying global data set. This is highly preliminary!! But please mail me suggestions for additions! The exact correspondence between references and individual height estimates used in this study are explained in a separate appendix that will be made available to the reader over the next months.

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