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Anthropometric Trends in Southern China, 1830-1864

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Anthropometric Trends in Southern China, 1830-1864

Abstract

Anthropometric indicators can shed light on the "Great Divergence" debate on the timing of the welfare development in China and Europe. We mobilize two new data sets of Southern Chinese contract migrants who were sent to Suriname and Indonesia, and thus supplement the limited existing evidence on early to mid-19th century China. The Southern Chinese were about as tall as Southern Europeans during the early and mid-19th century, but notably shorter than Northwestern Europeans. Height development was stagnant or slightly downward over the period under study, which fits into the pattern of real wage developments at that time.

JEL: O40, N15, IN35, I31

Keywords: heights, China

Almost no debate in recent economic history has stirred up as much controversy as the "Great Divergence" debate about the timing of the European lead in average incomes and living standards. While it is clear that China was the global technological leader in the Middle Ages, the East Asian giant had fallen back by the late 19th and early 20th century. By then, it was clearly poorer than Europe and the former European settlements in the New World. The question is, when this divergence started. Pomeranz argued that no substantial welfare divergence had taken place before the early 19th century between China's and Europe's most advanced regions, the lower Yangzi and England.[1] Only then England and other European regions could leave the Malthusian cul-de-sac and make full use of their coal resources, food and raw material imports from the Americas, according to Pomeranz's main argument. In contrast, Maddison argued that already in the 14th century Europe (and England) overtook China in terms of GDP per capita, and the differences have been persistent ever since.[2] The 19th and early 20th century saw a widening of those level differences which had already appeared much earlier. Maddison draws the political and ethical conclusion that this timing suggests a stronger responsibility of China herself and her government for the welfare divergence, whereas the Pomeranz view could have attributed more responsibility to the European imperialism in the 19th century. Maddison's argument suggests that economic history has substantial relevance in judging responsibilities for today's welfare differences.

It is clear that such widely differing statements about the timing of the "Great Divergence" can only emerge when the data source situation is weak.[3] Are there also conceptual differences underlying the different positions? Maddison's strategy of measuring GDP can be assumed to weigh more strongly urban trade and industry, and assign less weight to agriculture.[4] Sometimes the urban share is even used as a proxy for national income, even if it is clear that many components of welfare (such as health, life expectancy, and nutritional

[1] Pomeranz, *Great Divergence*.
[2] Maddison, *World Economy*, p. 44.
[3] Ma, *Growth*.
[4] Koepke and Baten, *Agricultural*.

quality) were typically worse in large urban environments (the "urban penalty").[5] Pomeranz argued that the Lower Yangzi was equal or even ahead of England in agricultural productivity, whereas in some parts of manufacturing productivity England might have been leading.[6] This might imply that nutrition should have been better in the Lower Yangzi than in England during the late 18th and early 19th centuries. Nutrition is therefore a core issue of the debate.

How can we measure the quality of nutrition during this period, and its development over the first decades of the "Great Divergence", i.e. between the early and mid-19th century? One such approach could be the use of anthropometric indices, especially the comparison of human stature. Anthropologists and human biologists have found that adult height is mainly determined by the quality of nutrition and the disease environment during early childhood. In general anthropometric history is by now a well-accepted tool for shedding light on questions that are otherwise difficult to answer. Moreover, the biological components of welfare are interesting in themselves: stature differences have been found to be typically correlated with health and life expectancy. This has allowed anthropometrics to make important contributions to crucial debates in economic history, such as the standard of living debate or the resolution of important puzzles like the antebellum puzzle and the early industrial growth puzzle.[7]

Studies on Chinese anthropometric history before the 20th century are rare. Stephen Morgan has recently made a big step forward by using a data set of Chinese migrants to Australia in order to study trends in the 19th century.[8] Carson provided an additional study on Chinese prisoners in American jails, which confirmed the stagnant or slightly downward trend.[9] Murray investigated the heights of 150 return migrants from the U.S. and found them

[5] Srzeter and Mooney, *Urbanisation*.
[6] Pomeranz , *Great Divergence*, pp. 45, 216-18.
[7] Komlos, *Stature*; Komlos, *Shrinking*; Steckel and Floud, *Health*.
[8] Morgan, *Economic Growth*; Morgan, *Stature*.
[9] Carson, *Biological*.

to be surprisingly tall.[10] Murray's main hypothesis is that their tall height might have been caused partially by selectivity of return migrants, and partially by the fact that those return migrants were born in earlier periods than the Chinese of subsequent birth cohorts.

It can be concluded that past studies of Chinese height have used records of Chinese who had migrated to Western high-income societies (by the standard of the time), which had a relatively good supply of food, especially animal protein. An issue for height studies is whether the share of Chinese who migrated to these countries in their late teens or early twenties could have experienced some catch-up growth in this more growth-conducive environment. Were this the case their height estimates would approach the upper-bound estimate for Chinese height at the time. Our study of Chinese migration to Indonesia and Suriname makes a major contribution to the literature: it presents the first samples of Chinese who did not migrate to countries with substantially better nutrition. Heights in Indonesia varied around 158-163 cm during the 1890s and 1900s,[11] whereas the white native-born Australians were the tallest nation in the world at the time, and the Americans were not much shorter.[12] Moreover, especially the travel cost to Indonesia was lower than to the U.S. and Australia. Hence we might provide heights of slightly poorer strata of Chinese society, whereas the earlier studies might have reflected a segment of higher purchasing power.

2. Why are heights of 19th century Chinese important? The context of the "Great Divergence" debate

Most economists have traditionally viewed Europe as having achieved a much higher living standard by the 18th century, compared to China. Famous scholars such as Adam Smith

[10] Murray, *Stature*.
[11] Van der Eng, *Inventory*.
[12] Steckel and Floud, *Health*, p. 424.

argued that Chinese labourers were poorer even than the poorest workers of Europe.[13] Malthus and more recently Landes have interpreted this as a demographic response to the particular agricultural situation in China, which required a strong central power.[14] This central power typically tried to maximize population growth, thereby producing economic stagnation in the long run. The view of a stagnating China was challenged by the so-called "California school," which argued that the welfare of China's most advanced regions (in the lower Yangzi) was comparable to the one of England in the 18th and the first decades of the 19th century.[15] Pomeranz argued that the institutional framework in China's Lower Yangzi region was similarly supportive or problematic as in England in the early modern period. In contrast, especially Brenner and Isett argued that Lower Yangzi institutions were not as favourable.[16] Especially the much lower reliance on market-based property right, compared to England, could have made the "Malthusian" problems of the mid and late 19th century more difficult to avoid in the Chinese case.

The debate about the underlying forces of the Great Divergence cannot be solved here, but this study contributes to the question whether welfare differences already existed between China and Europe during the early 19th century. Hence the crucial question for our study is how the differences of the standard of living between the two geographical areas (and their subregions) were measured by previous authors who debated the issue. Most of the data of the first set of studies takes national income, capital stock, and productivity measures as well as consumption of certain luxury goods as yard sticks.[17] Given the variety of different estimates and luxury items (and the difficult source situation), a full consensus has not been reached yet using those indicators. Another approach has been taken by Allen et al. who made a very comprehensive attempt to measure real wages for different European and Chinese cities and

[13] Smith, *Wealth.*
[14] Malthus, *Principle*; Landes, *Wealth.*
[15] Pomeranz, *Great Divergence*.
[16] Brenner and Isett, *England's Divergence*.
[17] Pomeranz, *Standard*.

rural areas.[18] This team of authors finds that especially London and Amsterdam were clearly ahead of Beijing and other large Chinese cities already in the 18th century, but that Central and Southern Europe did not earn higher wages than the Chinese. Only in the 19th century, did central European cities overtake the Chinese ones. Another core strategy to measure living standards was to measure life expectancy. Lee et al. supported this argument by providing life expectancies of 26-29 and higher for Liaoning, Anhui, and Beijing.[19] However, there is some debate about the counting method, especially of female infant deaths. Huang criticized Lee et al. for their interpretation of female infanticide as a special Chinese custom of postnatal abortion.[20] If one would include the dead infants in the regular mortality record, Huang argues, the life expectancy of females at birth would decline from 29 to around 22 years. This would be substantially lower than English values.[21] While the Chinese infanticide might be seen as "preventive" check rather than famine-induced mortality, for the comparison of life expectancies as welfare measure, many scholars would probably agree that those killed girls should be included. But currently Chinese data quality seems not to be sufficient to construct good estimates of female infanticide rates.[22] Whether one treats the infanticide especially of young female Chinese as postnatal abortion ("allowed" by cultural attitudes), or assigns this part of the population their own weight in the welfare measures, is probably a normative decision which cannot be taken on the basis of scholarly arguments only. Providing anthropometric welfare indices for the surviving population can shed light in such a situation in which it is difficult to determine the biological welfare based on other measures. Hence the comparison of height data can complement the record of the "biological standard of living" in China and Europe.

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[18] Allen, et al., *Wages*.
[19] Lee and Camphell, *Living Standards.*
[20] Huang, *Development.*
[21] Also in less-developed parts of Europe infanticide by neglect was also quite well-known. Among many others, Baten, *Ernaehrung*, discussed the abnormally high infant mortality in Bavaria, which was partly caused by the absence of breast-feeding of the infants, and partly by the use of "care-takers" (who in reality killed by neglect).
[22] Lee et al. *Positive Checks*: 598.

3. Data

This study aims at mobilizing two new data sets of Chinese contract migrants. It will supplement the existing limited evidence on the anthropometric history of early to mid-19th century China. One of the data sets consists of only 159 Chinese who were brought to Suriname, after discarding two females and all those younger than 23 (nobody older than 50 had to be discarded, as the oldest person was 42).

We also discarded those born outside of China (British Guyana and Indonesia), as well as those who were ethnically Chinese but not born in China. Clearly, the Suriname sample is small, hence we will use it only for comparison purposes, and conclusions are tentative at best. The individuals remaining in the sample were measured when they were brought to the Dutch colony of Suriname (North of Brazil) as labour migrants. Their places of birth were predominantly in the Guangdong (Canton) province.

As to the quality of measurement, among the 159 cases measured in the first sample, most are reported accurately to the millimeter. However, full centimeters are somewhat overrepresented (31% in spite of the expected 10%). If we look at the distribution of our sample, it looks quite normal (Figure 1, rounded down to full cm). There is no minimum height requirement visible, as it is the case with some military samples that have been analysed for other countries (and which would need special treatment). Heaping on multiples of 5 is quite limited. However, there is modest heaping on heights starting with even centimeters in the mid-range of the sample.

This first sample of contract workers sent to Suriname is relatively small, and certainly no wide-ranging conclusions can be built on it alone. However, four out of the five samples reported by Murray for 19th century China are of the same size or smaller (and all have unclear years of birth, since anthropologists often did not report height by birth year or by

age).[23] Given the scarcity of anthropometric information about Chinese living standards in the period before 1900, we believe that this first sample is still an important small piece of information, especially in combination with the other studies mentioned above, this being all the more so since, firstly, migrant height data sets automatically raise the suspicion that migrant heights could be determined by labour market conditions in both the country of origin and the immigration country. The institutions which coordinate the migration process could also play a role here. We will turn to the literature on the height selectivity of contract workers and other migrants below. For the moment, we argue merely that it is important to obtain migrant data from different immigration countries in order to compare height trends and levels. Secondly, the migrants to Suriname arrived there within a relatively short time span, between 1862 and 1888. Moreover, 77% arrived in the years 1872 and 1873. Hence, long-term changes in labour-market conditions are not likely to have influenced Chinese migrant heights. Thirdly, we find that our height estimates do not fluctuate strongly, which could be a signal that selectivity biases did not change to a large extent.
But clearly, the data set is very small and only useful to counter-check other results which are based on a larger data set.

Our second data set is in fact much larger (12,678 observations) and was collected by the anthropologist Bernhard Hagen in the 1880s.[24] Fortunately, he reported the ages so that the approximate birth years can be calculated. Hagen published his study in the highly renowned "Royal Netherlands Academy of Arts and Sciences in Amsterdam" series. Hagen measured no less than 15,722 Chinese males who had migrated to Indonesia. Those contract workers went in particularly large numbers during the 1880s and 1890s (the numbers in East Sumatra increased from 15,500 to 59,038).[25] Occupations are not known for both our samples, but Hagen mentions that most of the emigrants came from an agricultural background, as is

[23] Murray, *Stature*.
[24] Murray found it cited in another anthropological study of the 1920s.
[25] Breman, *Taming*, p. 60.

also typical for most samples of people who were brought to tropical plantations as contract workers.[26] We discarded all those above 50 and below 23 years of age in order to make sure that there was no residual growth: below the age of 23, there was still substantial growth, namely of 1.7 cm from age 20 to age 21; 0.2 cm from age 21 to 22; 0.5 cm from age 22 to 23, and virtually no growth beyond that. Hence, we could base our estimates on N=12,678 observations. Hagen reported a smaller sample of some 383 cases individually as an appendix to his study.[27] It shows that he measured and reported heights down to fractions of a centimetre, i.e. more precise than the German recruitment offices report today (they only report nearest centimetres, thanks to John Komlos for the friendly information).[28]

Fortunately, the Southern Chinese in the second data set came from the same province (Guangdong) as those in the first, which makes the two samples comparable. The Chinese males in the second sample had moved to the tobacco plantations of Indonesia, leaving a country of quite modest nutritional circumstances behind and moving to another situation with similar conditions (on the details, see below); hence, catch-up growth might have been relatively unimportant.

When were the migrants measured? Hagen had already measured 1,000 Chinese for a publication in 1884 (about 7% of the total), and collected the remaining heights afterwards. He reports that he finished his main study in 1888. It is clear that the analysis of such large data sets took quite a while, and Hagen does not mention support from any institute. He thus had to calculate most of the averages himself, which was quite a time-consuming task in the late 19th century. Therefore, it is very likely that the bulk of the observations were measured in 1885 and 1886, with some perhaps in 1887. Hagen reported both heights by five-year-age groups and (averaged) heights by single-year age.[29] The birth year measurement error is likely

[26] Hagen, *Anthropologische*.
[27] Hagen, *Anthropologische*. Only a minority of those were Chinese, most came from Indonesia.
[28] From this degree of exactness, it should also be clear that Hagen did not measure heights with shoes, as this would have invalidated all his efforts.
[29] Hagen, *Anthropologische*.

not to be large if we deduct the age from 1885 or 1886. Five-year birth cohorts are also recommendable in the presence of age-heaping (preference for age multiples of five).

Two potential biases could still affect the oldest cohorts, since those aged 45-49 and those aged 50 (25 persons were age 50) might have already started to shrink, although modern longitudinal studies find this effect to be relatively modest (less than half a centimetre up to the age of 50). Some historical studies on Indian heights also arrive at low shrinking degrees in cross-sections.[30] This would produce a downward bias among the earliest cohorts. What is more, those whose age is given as exactly 50 rounded their age with greater likelihood, and it has been argued that rounding one's age is associated with lower education and lower social status.[31] However, a small upward bias might counterbalance such effects to a certain extent: with regard to the oldest Chinese emigrants, the plantation owners might have been somewhat more selective, and although detailed studies find that this concerned mainly chest circumference, the possibility cannot be fully excluded that such selectivity applied to height as well. Still, we do not know exactly when the sampled Chinese arrived in Indonesia. It is therefore not unlikely that some came already one or two decades earlier, making this second bias less likely. In conclusion, the first bias might make the first cohorts look slightly shorter than they actually were.

4. Results

Before discussing additional potential selectivities and biases in the following section, we first discuss the main results of our height trends. We find that the level of heights is between 161 and 164 cm (Table 1). Similarly, the first Suriname quinquennial has only 17 observations. However, between 1835-39 and 1845-49, for which we have more stature measurements, we observe a downward trend in the first sample. The second sample (migrants to Indonesia) is also characterised by a stagnating trend, or an even slight downward movement. Heights

[30] Guntupalli and Baten, *Development*, Appendix.
[31] Crayen and Baten, *Numeracy*.

declined among the migrants to Indonesia from 162.6 to 161.5 cm between 1835 and 1864, or by 1.1 cm. The statistical significance of the Indonesian height difference cannot be assessed, as data is only available as aggregates. But in other height studies, differences of this size have always been statistically significant, even with much smaller sample sizes. Both samples have similar levels, although the sample of migrants to Suriname is based on a very small sample size. Nevertheless, it is available on individual level, so we can test tentatively the significance of the downward movement. We find that Southern Chinese born during 1845-49 were significantly shorter than those born a decade earlier (Table 2). The similar movement (first upward, then downward) of both series increases its plausibility (see Figure 2). We would tend to formulate our results cautiously and speak of a "stagnation or slight downward trend" of Southern Chinese heights in the period of 1835-64.

How do our data compare to prison samples of Chinese who were incarcerated in Australia and the U.S.? We would expect that Chinese who went to countries with better diets in their late teenage years and early 20s might have benefitted from these more nutritious diets. Moreover, the plantations in Southeast Asia had a bad reputation due to the high mortality and terrible punishment of the workers (especially in the early years).[32] Chinese who were better more skilled (and perhaps taller) and had the choice might have preferred Australia and America. Hence, a slightly higher height level of migrants to Australia is to be expected, compared to migrants to Indonesia. On the other hand, the Australian and U.S. prisoners might come from lower income strata, compared to the average migrant. However, both Morgan and Carson emphasized that their prison samples are relatively representative of the underlying migrant population.[33] Moreover, studies directly comparing prison samples with the total population showed that prisoners tended to be equal or even slightly taller than the general population.[34] We find indeed that the prisoners in the U.S. and Australia were

[32] Breman, *Taming*; but see the different view of Houben and Lindblad, *Coolie Labour*.
[33] Morgan, *Stature*; Carson, *Biological*.
[34] see Baten, *Ernaehrung*, even if admittedly the prison selectivity might have been different in those countries.

taller (by around 1.5 cm on average, see Table 1). Hence the Indonesian and Suriname samples probably form a lower bound estimate for Southern Chinese heights, whereas the U.S. and Australia prisoners form an upper bound estimate.

If we compare those heights with selected European and Indian height studies, we find that the Chinese born in this period had about the same height as Southern Europeans (Figure 2; here, we rely on the study by A'Hearn on Northern Italians. From studies of cohorts born later in the century, we can estimate that Southern Italians and Spaniards were even shorter).[35] Indian contract workers brought to Fiji were similarly short as the Southern Chinese. The Chinese actually shared their stagnating or slightly declining height development with the European populations up to the 1850s. However, already during the 1860s, the European values started to trend upwards and increased especially after 1880, when the "Great Divergence of Heights" began.[36]

5. Discussion: Selectivity issues of migrant heights

What was the situation in the regions of origin and the target region, and the organisation of migration? The regions of origin were highly concentrated near Canton in the South of China, and it was a male migration of Chinese aged mostly between 18-40. The intention of most Chinese was to earn money abroad and then to return to their home districts. In general, the area around Guangdong was quite poor during the mid- to late 19th century, for several reasons: the Opium wars, import competition on domestic textile production, the destabilized dual currency system, and, most catastrophically, the Taiping and Red Turban rebellions which destructed the Eastern and Southern economies and produced famine and excessive repression by the government.[37] Many villages near Canton were entirely devastated during the retaliation phase, and a number of Southern Chinese emigrated as members of secret

[35] A'Hearn, *Anthropometric*.
[36] Baten, *Global*.
[37] Wakeman, *Strangers,* pp.139-148, 180.

societies to flee punishment.[38] During the 1880s, the Chinese workers came again in larger numbers, as the famine in their home land drove them out of the country.[39]

The organisation of Chinese emigration was characterised by different schemes.[40] One method used for Australian migration during the 1850s and 1860s was the "credit ticket" trade. Chinese merchants in the destination countries sold medium-term contracts to Chinese emigrants in shops in Canton and Hongkong, which granted the passage against contract labour in the destination countries. As securities, often agricultural land was named as collateral. Especially for emigration to the Australian gold fields, this contract model was applied, suggesting that many of the migrants had families owning some land. This confirms our view that heights of the migrants to Australia provide an upper-bound estimate of Southern Chinese heights.[41] Other contract models in Asian migration were based on direct recruitment activities by large plantation owners or their agents.[42] This direct model might imply slightly more average or even negative selectivity, as also Chinese from non-landed families were able to migrate within this scheme, if they were healthy enough.[43]

There might have been a different selectivity depending on whether the migrants went to poor or rich countries (especially in terms of nutrition). The latter could experience catch-up growth if they moved as children or young adults. Such migrants may have benefited from the improved nutrition after migration, so that their heights might not have been fully representative of their places of birth. From the viewpoint of anthropometrics, it is thus advantageous to have samples of migrants who moved from a country of modest nutrition to another with somewhat similar conditions (such as Indonesia and Suriname), because the above-mentioned effect would not be as strong in this case. We can indeed assume that the

[38] Morgan, *Stature*; Cronin, *Colonial Casualties*, p.9; Cai, *Chinese*, p. 133.
[39] see Breman, *Taming*, p. 51.
[40] Morgan, *Stature*; Cronin, *Colonial Casualties, p.9-10.*
[41] Morgan, *Stature*.
[42] A somewhat similar system of contract work was installed by the British, who hired Indian workers for the tropical plantations in Fiji, Mauritius, and similar places. Brennan et al. carefully evaluated the degree of height selection involved, and found that the recruitment officers did not consider height an important variable, but rather took chest circumference as the crucial criterion, see Brennan et al., *Trends*.
[43] Brennan et al., *Trends*.

nutritional situation in Southern China, Indonesia, and Suriname was similar, because heights were at similar levels around 1900.[44]

Was there a special mortality bias among the Chinese contract labourers in the Dutch tobacco plantations of Sumatra, where most of them were measured? During the 1980s and 1990s, there was a considerable debate about the living conditions in those plantations, initiated by the sociologist Breman, who argued that the living conditions were terrible and mortality rates of migrant workers were extremely high.[45] If that was the case, the shorter and weaker workers represented a high percentage in the mortality rate. Hence they might have been absent from the South Chinese worker population before Hagen could measure them.[46] The workers on those plantations were terribly treated. The work load was very heavy, and nutrition quite poor. The diet consisted mainly of rice, growing vegetables was not allowed, and meat was served and consumed only on very special occasions.[47] Hence, the diet was probably similar and not much better than the one in Southern China during the mid-19th century crisis years. Breman emphasized that – apart from heavy workload -- the major causes of death were (1) the fatalities on board of the ships which brought the workers from South China to Sumatra, (2) malaria, (3) contagious disease, and (4) infected wounds on legs and feet that were not adequately treated.[48] The rate of mortality for those reasons was not significantly determined by the nutritional situation of the workers. Hence the total upward bias of heights might be limited for the plantation workers. Apart from the plantatations, Breman observed particularly high mortality rates in mining, but Hagen did not measure mining workers, hence there should not be a bias from this side.[49] Moreover, Houben and Lindblad argued that Breman overstated his case.[50] Living conditions during the

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[44] Baten, *Global*.
[45] Breman, *Taming.*
[46] Hagen, *Anthropologische*.
[47] Breman, *Taming*, pp. 115-7.
[48] Breman, *Taming*, p.58.
[49] Breman, *Taming*, p.202.
[50] At least after 1900, mortality rates decline to levels that were actually more favourable than in densely populated Java, see Houben and Lindblad, *Coolie Labour* p.54.

establishment of the estates were indeed bad, and official mortality statistics might have underreported total mortality, but they improved as medical experience with the local disease environment accumulated. If so, this may have further eliminated any potential upward bias in the Indonesian migrant data.

In conclusion, our samples are certainly to some degree influenced by the situation in the region of origin and the target countries. However, it turned out that they complement the existing studies of Morgan and Carson quite well by providing a lower bound estimate of Southern Chinese height, whereas migrants to the U.S. and Australia might represent an upper bound estimate.

Are the height levels of European and Chinese populations informative for welfare analyses of the 19th and early 20th century? Or did perhaps genetic height potentials determine the lower height of the Chinese, so that we underestimate the true nutritional quality in China? First, we clearly have to distinguish between individual genetic height maxima (which exist undoubtedly and result in individual heights above or below the population mean), and population height maxima. The latter were called "racial characteristics" by anthropologists of the early 20th century. Many anthropologists even today would argue that those different maxima exist, whereas others argue that they do not.[51] The recent literature shows that the better we can measure the determinants of height in recent research, the less room remains for different population height maxima. We will provide a number of examples from many countries, before returning to the China-Europe comparison below. For example, anthropologists were traditionally convinced that people in Northeastern France were of "Germanic" origin, whereas those in Southwestern France had more "Romanic" genes and were hence shorter for genetic reasons. However, if the local milk supply (which influences the local consumption) and real wages are taken into consideration, the residual map of 19th century French heights, shows almost entirely random values, with no advantage for the

[51] see Bogin, *Patterns*.

Northeast.[52] This finding of insignificant racial differences if nutritional quality is considered, is also true for 20th century populations such as the African Massai or the Tutsi, who consumed relative protein- and calcium-rich diets of milk and blood, hence their impressive height even at modest income levels.[53]

But the Japanese are clearly an exception here. They are still relatively short today, even in spite of their high income. Clearly, the Japanese have gained enormously in height since the 19th century. But we have to admit that for today's situation, nutritional habits, lactose intolerance, and intergenerational effects might play a role. Even if it is quite fashionable among Japanese, South Koreans and Chinese today to consume cow milk, the per capita consumption is still much smaller than in the Netherlands or Scandinavia, where past economic circumstances have generated today's consumption habits. But it is remarkable that East Asian consumption (and height) has grown considerably over the past decades. Intergenerational effects of height might also play a role. A biological mechanism prevents short mothers to give birth to very large children (due to the size of the birth canal). Hence the Japanese, for example, might still remain relatively short for another generation or two, in spite of their relatively high income and good consumption possibilities. This might be caused by the extremely protein-scarce nutrition of the 19th and early 20th century, but has effects until today. On the other hand, the average height of the birth cohort of 1972 in urban Northern China was 173.6 cm at age 19, which is only 2.2 cm shorter than the U.S. average in the 1980s (175.8 cm).[54] Since then, after the economic boom of the 1980s, the Chinese have probably grown considerably, so today, differences would be small. One can speculate that if the Chinese had the same income as Americans, they would probably have similar heights. On the other hand, the shorter height of Chinese during the 19th and early 20th century was

[52] Baten, *Kartographische Residuenanalyse*.
[53] Bogin, *Patterns*.
[54] Morgan, *Biological Indicators*.

probably more determined by the low quality of nutrition and the disease environment, rather than by racial height maxima.[55]

Another way of studying the potential role of different "racial" height maxima is to compare the height of elite groups and the poor population in Less Developed Countries.[56] For example, Habicht et al. argued that the height difference between rich and poor Nigerians was very large, much larger than the difference between the Nigerian elite and the U.S. population.[57] The same applies in Ghana[58], Egypt, Haiti, and Togo.[59]

Finally, migrants provide additional evidence about the role of genetic height maxima. When Guatemalan children during the civil war were brought to the U.S. and exposed to a protein-rich U.S. diet, Bogin followed their height development. Within a few years after migration, the children were much taller than their compatriots who stayed at home.[60] They did not entirely reach the U.S. average (perhaps due to nutritional and disease insults during their early years), but came quite close to it. Of course, this does not happen to all migrant children, especially if they come with their parents who might keep their traditional diet and do not adopt the target country cuisine.

Could lactose intolerance have kept the Chinese short? Lactose intolerance means that people have digestive problems when drinking large quantities of milk after the age of 5–7 Especially East Asians (east of Tibet and Rajasthan), Native Americans and some African people suffer from lactose intolerance.[61] Yet even lactose intolerant people can digest modified milk such as Kefir, Lassi and similar products. Moreover, all people can drink about one cup of milk per day if they train their intestinal bacteria to live in a milk environment.

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[55] Nutritional habits, lactose intolerance, and intergenerational effects seem to play a large role especially at high income levels. For most of the 19th and early 20th century, the populations were quite poor compared to today, and the quality of nutrition was so low that most people would have be willing to consume some additional grams of protein.
[56] Moradi and Baten, *Inequality*.
[57] Habicht et al., *Height*, pp. 611-615.
[58] Fiawoo, *Physical Growth*; Eksmyr, *Anthropometry*, pp. 59, 157-163, 159.
[59] Graitcer and Gentry, *Measuring*, pp. 297-9.
[60] Bogin, *Patterns*.
[61] Mace et al.,*Testing*.

Could the lower height of the Chinese be caused by the fact that they used other protein sources, such as soybeans, which might not have had the same impact in height, but were healthy enough to generate high life expectancies for the Chinese? This question cannot be fully answered, and remains a caveat in our analysis. Clearly, vegetables, grains, and especially soybeans contain also protein, but it seems as if especially the amount of animal protein per capita was crucial for life expectancies in 19th and early 20th century societies, which is also mirrored in the anthropometric record.[62] Certainly it was possible to reach a high life expectancy with a very good education and hygienic behaviour, as the life expectancies of the Japanese during the early 20th centuries showed. But the input of high-quality animal proteins allowed the populations in the past to fight more easily the terrible disease environment of the time by generating antibodies.[63] Especially the consumption of milk seems to have played a crucial role, perhaps not only due to its protein, but also calcium and vitamin content.[64] It is clear that we cannot apply today's protein requirements to the 19th century, when the disease environment was much harsher and required much more high-quality protein. We conclude that genetic height potentials seem of relatively small importance, if the quality of nutrition can be measured accurately, even today.

6. Conclusion

This study has focused on the decisive period when economic development in China probably began to deviate from that of Europe, between the 1830s and the 1860s. This was a period of declining real wages in China, mainly because grain prices were rising quickly and reached their peak in the 1850s, exactly the period for which we observe very low heights.[65] We have offered evidence from two samples of Chinese migrants, claiming that it is of great

[62] Baten and Komlos, *Height*; Alter and Oris, *Life conditions*; Alter, *Height*; Costa, *Height*.
[63] Bogin, *Patterns*, pp. 132-33.
[64] Baten, *Ernaehrung*.
[65] Allen et al., *Wages*.

importance to study data sets from different institutional contexts and different immigration countries.

The range of average Southern Chinese heights in the 19th century appears to have been relatively stable, around 161-164 cm for males. This puts China into a similar height category as Southern Europe during the mid 19th century. However, the Chinese were indeed clearly shorter than the British or other Northwestern Europeans, or the inhabitants of former European settler colonies (like the U.S., Australia etc.). Hence, a first important result is that the level of height in Southern China, as well as in Southern Europe, was clearly below the English level. This confirms the results of Allen et al. who studied real wage levels.[66] Similar to them, our study takes also a middle position in the "Great Divergence" debate, as we find a poorer anthropometric record for Southern China, but also for Southern Europe, compared to England.

What can we say about time trends of height? Both China and Southern Europe showed also relatively slow economic development in the 19th century. In contrast, Northwestern Europeans and later Central and Northern Europe experienced dramatic industrial development. And what happened after our study period? In the first half of the 20th century, Southern Europe also experienced a strong upward trend in height. Today, young Italians and Spaniards are not much shorter than young Americans. The Chinese, in contrast, remained on a more modest height level for a long period. Only about three decades ago, Chinese heights began to converge strongly to Western levels. We reported above that young Northern Chinese urbanites are today probably only marginally shorter than the American average, whereas the rural und less educated Chinese are still remarkably shorter.[67]

[66] Allen et al., *Wages*.
[67] Morgan, *Biological*.

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Table 1: Heights of Southeastern Chinese contract workers brought to Suriname and Indonesia (males, age 23-50)

Birth quinquennial	Migr. to Suri.	N	Migr. to Indon.	N	Prison Australia	Prison U.S.
1830-34	162.1	17	160.3	25	164.5*	163.8*
1835-39	163.7	43	162.6	129		
1840-44	162.1	63	162.3	884	163.9*	164.2*
1845-49	161.1	36	162.3	2046		
1850-54			162.3	3337	163.9*	163.4*
1855-59			162.1	4354		
1860-64			161.5	1928	163.0*	163.5*
Sum (N)		159		12678	1492	1463

Source: see Figure 1 for Suriname migrants, and Hagen, *Anthropologische*, for those to Indonesia.

* The prison samples refer to birth decades, not 5-year-birth cohorts. The sums of the prison samples refer to totals of the respective studies, which include those born before 1830 or after 1864.

Table 2: Regression of height of Suriname migrants on five-year-birth group dummy variables, 1830-1849

Birth cohort dummies	Coeff.
	(p-value)
born 1830-34	-1.57
	(0.34)
born 1840-44	-1.84
	(0.11)
born 1845-49	-2.61**
	(0.045)
Constant	163.70***
	(0)
Observations	159
R-squared	0.03

Notes: P-values in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The constant refers to a Chinese who was born in 1835-39.

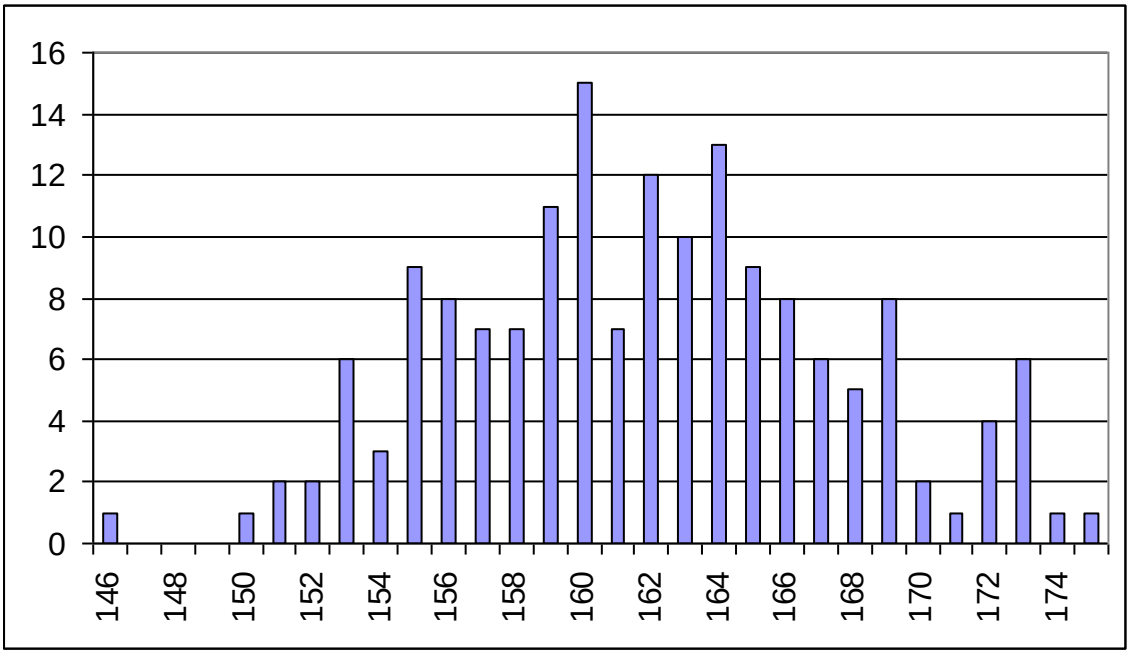

Figure 1: Distribution of male heights of Chinese migrants to Suriname, rounded to next lower centimeter, age 23-50.

Source: Historical Database of Suriname, assembled by Maurits Hassankhan (University of Suriname) and Sandew Hira (Amrit Consultancy), based on the following orignial sources: National Archives of Suriname, immigration registers: 1.China 1864/1871 no. C1- C966; 2. China 1864/1871 no. C967-C1080; 3. Register China 1880 4. Register Barbados and China 1879 no 386D.

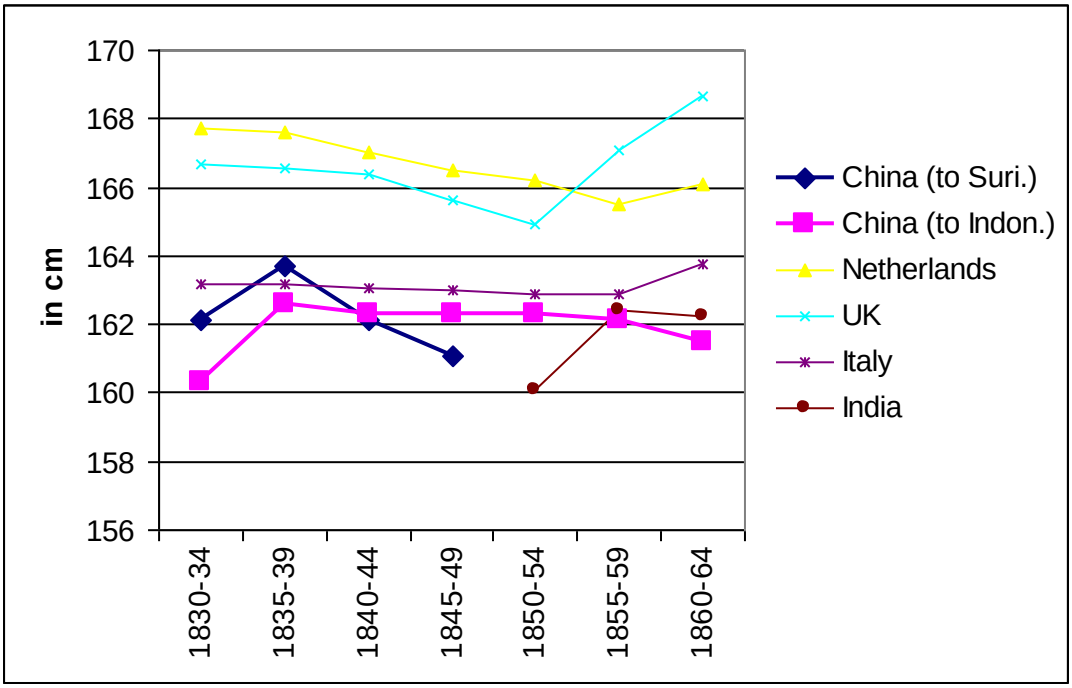

Figure 2: Chinese (Guangdong), Indian, and European heights in the early to the mid-19th century

Source: Brennan et al., *Trends*, Drukker and Tassenaar, *Case*, Komlos, *Stature*; Komlos, *Shrinking*; Harris, *Health*; A'Hearn; *Anthropometric;* on Guangdong migrants, see Figure 1 and Table 1.