**Working Paper Version, forthcoming in “Economics and Human Biology” 2019**

# Height Development of Men and Women from China, South Korea, and Taiwan during the Rapid Economic Transformation Period of the 1960s to 1980s

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**Keywords:** anthropometry; East Asia; East Asian Social Survey (EASS); economic development; education; gender inequality; living conditions

**JEL Codes:** I3, N3, N9, O1

## Highlights

- Height increased dramatically in East Asia from 1960 to 1989.
- Height inequality according to gender partially increased in the 1980s.
- Education played a key role and can be used to mitigate gender differences.

## Abstract

We study height trends among Chinese, South Korean, and Taiwanese groups during the rapid economic growth period of the 1960s to the 1980s. Heights rose strongly as income grew. Did rapid income growth also cause a decline in gender inequality? Or did it rise because the gains were unevenly distributed? Gender inequality is particularly interesting given the traditionally strong son preference in the region. For mainland China, we find that gender inequality was relatively modest in the pre-reform period (before the 1980s). Especially in comparison to the early 20th century, female heights grew faster than male heights. In contrast, the 1980s transition period to an economic system with market elements was characterized by increasing gender inequality in China. This was the case to an even greater extent in South Korea, where gender dimorphism noticeably increased during the 1980s, paralleling a similar increase in sex-selective abortions. Moreover, we also study other inequality patterns in the three countries, focusing on socioeconomic, regional, and educational differences between groups.

## 1. Introduction

The most dramatic shift in the world economy during the second half of the 20th century was the rise of East Asia. Soon after Japan reached the top of world income rankings, South Korea, Taiwan, and China emerged as economic powerhouses. All three countries moved from less than 10% of the U.S. GDP per capita to much higher levels (Table 1). In light of such dramatic changes, it is important to determine whether or not all population groups benefitted equally or if some fell back in relative terms.

Anthropometric research over the past decades has provided the welfare indicator “human stature,” which facilitates the measurement of health development by social and regional groups as well as by gender (Ruff, 2002). This indicator is particularly sensitive to the quality of nutrition and healthcare during the first years of life, although biological factors (and genetic factors in particular) must also be taken into account, at least at the individual level (Komlos, 1985; Steckel, 2009). Even small differences in the quality and quantity of nutrition (DeRose et al., 2000) or healthcare provided (Timaeus et al., 1998) to male offspring, as opposed to female offspring, may influence biosocial wellbeing ratios.

In this study, we trace the height development patterns of men and women from China, Taiwan and South Korea during the rapid economic transformation of the 1960s to the 1980s (Morgan, 1998, 2000). Did females benefit to the same degree from the vast improvements in welfare? Alternatively, did the strong “son bias” (defined as a substantial preference for male children) lead to redistribution in favor of male children? In addition to this focus on gender inequality, we will address inequalities by region, income, and educational status. Our results on gender inequality are of particularly high value, given that such an analysis, utilizing human height data on East Asians, has never been made from a comparative perspective before.[1]

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[1] For a country study on, e.g., South Korea, see Pak (2011).

Son preference is observable in many countries worldwide (DeRose et al., 2000), and it is traditionally strong in China, South Korea, and Taiwan but not in North Korea (Goodkind, 1999). For many centuries, the Confucian culture of the region has emphasized a patrilineal family system in which only male offspring were eligible to continue the bloodline and perform ancestral rites. Perhaps even more importantly, sons had a high traditional economic value for the family, as it was their role to provide resources for their parents in old age (Yu et al., 1990). Married daughters, on the other hand, literally left the household as they were included in the household registration system of their in-laws, while also living with their parents-in-law for the rest of their lives. Hence, early childhood “investments” in sons provided financial security for old age. Moreover, after a son’s marriage, his parents obtained a daughter-in-law who would take care of them in old age. This family system resulted in a society with one of the highest gender inequalities in the world. This was particularly extreme in the period prior to the beginning of our study, namely the early 20th century, which can be seen as the “status quo ante” before our study begins (Kazuko, 1978). But even in the 1980s, China, South Korea, and Taiwan were still (or perhaps again) found to have the world's highest male-to-female sex ratios at birth (Goodkind, 1999; Schwekendiek, 2016b). This is also visible in Figure 1 for the case of South Korea from 1980 to 2005.

After the declaration of the People’s Republic of China in 1949, the government initiated measures to reduce gender inequality, although the outcomes remain questionable to this day. On the one hand, equal rights for women were included in the Constitution of 1954, as the government promoted equal pay and equal opportunity. The government also introduced maternity leave and daycare (Li, 2000). On the other hand, during the Mao period, males still had significantly higher wages than females. The official policy of equal opportunity implied that women could work full time, but in reality, this often generated the double burden of both household work and wage labor (Du and Dong 2009). Hence, an important empirical question remains, and this will be our basic research question (1): how did gender inequality develop during the 1960s and 1970s? We address this issue by examining the relative development of height among men and women. For example, after Mao's reforms resulted in a food crisis during the 1960s, local witnesses reported extreme forms of neglect of girls, as "families tried to pool their [food] rations and often the husband would rule that any female children should be allowed to die first since if they lived they would later be given in marriage to another family" (Becker, 1996). This example strikingly illustrates that vital resources traditionally tend to be allocated to male offspring in China, especially when the economy is not faring well.

We will also assess – as our basic research question (2) – whether or not the market reforms in China after 1978 (effective since the 1980s) led to a reduction in the traditional son bias, or if perhaps, the erosion of gender equality policies was associated with more inequality during the 1980s. As mentioned above, the prototype of the “new entrepreneur” of the 1980s was most often a male (Wu, 2009). Short et al. (2001) concluded that even in the early 1990s, despite the government's one-child policy which was implemented in 1980, which generally lowered the child-rearing and caring costs of households, preschool sons continued to receive more care from their parents than their female counterparts.[2]

South Korea and Taiwan are interesting comparative cases in East Asia. In a pioneering study on the biological standard of living in South Korea, Gill (1998) concluded that the final height of women was delayed (relative to men) in the dire post-Korean War years of the 1950s

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[2] Song and Burgard (2008) compared height trends in the Philippines, where son preference is low, with those in son-biased China. They concluded that Chinese male children had an extra growth advantage over female children relative to the height gap in the Philippines during the 1990s. They also found that the gap in gender dimorphism was more pronounced in rural than urban areas of China.

and 1960s due to "discrimination against women in traditional Korean families [so that] Korean women often consumed fewer nutrients than males relative to their needs." In conducting a comparative study on heights in North Korea (where son preference is low) and South Korea (with a  high son bias), Pak (2011) found that gender dimorphism among cohorts born in the 1950s versus those born in the 1980s did not increase over the two periods observed in North Korea, whereas males showed a pronounced advantage in growth over females in South Korea during the same period, which tentatively suggests that gender equality declined. In the 1980s, son bias was still high but declined notably after this decade. For instance, the share of parents preferring a son for economic reasons, such as old age support, has declined in South Korea from 26.0% in the 1980s to 2.6% in 2003 (Chun and Das Gupta, 2009).

Hence, we will also study the development of gender inequality in height in South Korea and Taiwan, which became market economies much earlier than the mainland of the People's Republic. Our basic question (3) will be whether the South Koreans and Taiwanese moved to higher gender equality earlier, because the rapid income growth during the 1960s and 1970s might have already allowed the allocation of resources to girls in a more equal way. Did gender equality gain further momentum during the liberalization phase of the 1980s? Or was the transformation phase of the 1980s characterized by higher gender inequality in South Korea and Taiwan?

Taiwan has not undergone changes as extreme as China and South Korea did during the second half of the 20th century, as it was spared macroeconomic shocks such as the food crisis under Mao or the Korean War. We can therefore reasonably expect that gender dimorphism improved there earlier and in a more steady fashion, and we assess this below.

To study these basic questions, we utilize a new dataset that allows for the systematic comparison of female and male heights in the three countries of China, South Korea, and Taiwan. The East Asian Social Survey (EASS) recorded heights in their 2010 wave (EASS 2010 hereafter), which is discussed in the next section. Earlier studies on heights in East Asia provided many important insights by broadly and descriptively investigating anthropometric trends in China, Korea, and Japan (Gill, 1998; Lin et al., 2004; Morgan, 2000; Mosk, 1996; Schwekendiek, 2016a; Schwekendiek and Jun, 2010) but did not differentiate by gender, regional, or educational group in great detail.

Using anthropometric information to study gender inequality results in some methodological challenges that we resolve in this article. A variety of different measures has been used to trace the gender inequality of height (Gray and Wolfe, 1980; Costa-Font and Gil, 2008; Guntupalli and Baten, 2009). Each measure shows slightly different trends. In order to report gender inequality in a consistent way, we systematically compare gender inequality of height with other gender inequality indices (in section 4) and suggest a formula that can serve as a standard measure for this important dimension of human welfare.

The impact of a rapid shift in income, as occurred in East Asia between the 1960s and 1980s (Table 1), is not limited to gender issues but extends to a plethora of socioeconomic variables. Hence, we address inequalities between large urban agglomerations and rural areas; we investigate the role of education, as it is one of the instruments by which the government intentionally reduces gender inequality (United Nations, 2012); and we determine how household income impacts height.

The cohorts between the 1960s and 1980s are highly relevant, as they are the ones that currently fill the labor market in East Asia. Individuals born in the 1980s are now in their thirties, whereas those born in the 1970s and 1960s are now in their forties and fifties. Moreover, given the high life expectancy of East Asians, these cohorts will be major players in the local society and the economy for many decades to come; either as producers or consumers.

## 2. Data

Thus far, an overlooked source of height data is the East Asian Social Survey (EASS). EASS was initiated in 2003 by various higher education institutions in China, South Korea, Taiwan, and Japan. The 2010 wave included heights for the former three countries. That is, information on Japanese heights was collected but not made available later (Table 2). Other EASS waves did not include height data.

The EASS was the only source of height information for the three countries formatted in a directly comparable way, whereas other sources such as the “Chinese Health and Nutrition Surveys” (CHNS) were in country-specific formats and thus could not be directly compared to sources from the other countries. For example, the CHNS only recorded information on nine provinces in 2009 and 12 provinces in 2011, whereas the EASS studied here recorded heights for all 31 Chinese provinces and autonomous regions (excluding Hong Kong). The EASS also included all regional units of Taiwan and South Korea.

A possible disadvantage of the EASS data is that all heights were self-reported. However, in section 3, we systematically compare self-reported versus measured heights and suggest an adjustment method. We also develop a weighting procedure to make the EASS data representative for China, given the considerable regional differences among the world's most populated nation and an oversampling of well-educated Chinese, as we observe below (Morgan, 2000, EASS 2010).

The sampling was carried out as follows. In the case of the China survey, the aim was to include all addresses in the country. In the first step, counties were selected randomly but with regional weights for GDP, education, population density, and urban population in proportion. In step two, village committees within the selected counties were contacted. The village committees created lists of individuals that were chosen in step 3 as an individual random sample of households. Within the households, Kish grids were used, which apply a pre-assigned table of random numbers in order to select members within the family. This selection procedure is a standard one in international surveys. For example, the UN multiple indicator cluster surveys are also based on random multistage sampling procedures (United Nations Children's Fund, 2015). These procedures were similar for Taiwan and South Korea (Table 2).[3]

In the EASS (2010), a large set of variables was collected, and only those we considered to be the most relevant were included. We also investigated gender inequalities in particular and included information on education, income groups, and regions in the dataset.

Education is differentiated by the following: no formal education, primary schooling, junior high school, high school, junior college, and university/graduate school education. In a careful assessment of the representativeness of the data, we found that the latter three categories were over-represented, especially in China. Hence, we created educational sampling weights by comparing the sample with underlying official census data in order to make our analysis representative for the whole nation (see Appendix Table A.1).

Income was coded on a five-point Likert scale, ranging from "far below average," "below average," "average," "above average," and "far above average." We combined the first and last two categories into "below average income" and "above average income" groups and preserved the "average" category, as otherwise some categories would be represented by too few (or no) cases, making cross-country or even within-country comparisons meaningless.

As for regional units, we differentiated among three metropolitan provinces, namely, Beijing, Shanghai, and Tianjin (Tianjin as a separate province), and three other regions (East, West, North/Northeast China, see Appendix Table A.7). Counties with high population numbers

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[3] Heights are “heaped,” i.e., round numbers are mentioned more often. Schneeweiss et al. (2010) carefully studied heaping in height values and concluded that this phenomenon does not systematically lead to bias in heights. (See Appendix E for more detail.)

had a higher likelihood of being included. This might have partially caused an over-representation of the capital, Beijing. Another source of bias is the response rate of 72%; the remaining 28% non-responders were more highly concentrated in the West and less educated. It was necessary to create a weight variable to make the estimates representative for the large Chinese population (see Appendix Table A.2). Hence, we took regional and educational biases into account and used this weight variable to compensate. Note that we did not create a weight variable for South Korea and Taiwan, given their rather small geographic and demographic sizes compared to China. Moreover, the regional and educational distributions in EASS 2010 were found to follow the census distributions very closely. For example, 25% of the South Korean population lived in the Seoul/Incheon region in 2010, constituting 26% in EASS (see Table Appendix A.4a, and City Population, 2019, from which we took the 2010 census). Further, 45% of Taiwanese lived in the Taipei/Taiwan-North region, according to the 2011 census, and constituted 45% of the EASS (City Population, 2019; we took the estimate for 2011; Table Appendix A.4a).[4]

Unfortunately, no data on internal migration were collected in EASS 2010. We must therefore assume that migration had only a modest impact on our analysis, e.g. on gender inequality or the interaction of paternal and maternal education on the respondent's height.

## 3. Adjustment strategy for self-reported heights in China, South Korea, and Taiwan

In general, people tend to overestimate their height when asked to self-report. Hatton and Bray (2010) provided a recent survey on this behavior. For Western Europe, self-reported height has served as the primary source of internationally comparable data for the second half of the 20th

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[4] In addition, own education was 11.9 years in South Korea (18+ population in South Korea Census, 2010), whereas in the EASS, it was 11.8 years (UNDP, 2018).

century (Garcia and Quintana-Domeque, 2005). Although previous studies do acknowledge that self-reported heights have the disadvantage of often being slightly upwardly biased, especially for older males, Hatton and Bray (2010) suggested that this disadvantage is only minor. The disadvantage of including data with self-reporting bias is indeed small compared to basing one's analysis on only one type of data, without any possibility for comparison.

Studies that have systematically compared self-reported to measured heights found that the average upward bias in self-reporting is less than 1 cm for adult men. The bias across given social groups in a sample (e.g., between high and low educational status) is even less severe, as it often cancels out on average. Hatton and Bray (2010) find an upward bias of only 0.4-0.9 cm in samples from Sweden, the UK, France, and the US.

Earlier studies on East Asia have confirmed a self-reporting bias of this order of magnitude. South Koreans over-reported their heights by up to 0.5 cm (Bae et al., 2010), whereas Chinese overestimated their heights by around 1 cm (Lu et al., 2016). Hence, the bias is not severe in the case of Chinese, and even less so for South Koreans (for anecdotal evidence, see Appendix C).

To investigate this issue further, we compared self-reported heights from EASS 2010 with two external datasets utilizing directly-measured heights of East Asians. First, the China Health and Nutrition Survey (CHNS) was created in order to allow comprehensive health studies based on microdata. While this sample did not include all provinces in China, the most recent waves also included Beijing and other large cities, allowing us to tentatively compare self-reported and measured heights. We used the 2011 wave (CHNS 2011), which included similar birth cohorts as in our EASS 2010 dataset. Second, the NCDRisk group compiled nearly all anthropometric studies worldwide since the 1950s (and a small number of mostly Scandinavian ones before 1950) that were obtainable and not self-reported (NCDRisk, 2016). They also included East Asian samples, such as data from the China Health and Nutrition Survey (CHNS, all following dataset references as cited in NCDRisk), provincial samples from the Sino-MONICA series (for example, the 1988 Sino-MONICA Sichuan sample), and samples taken for various health analysis purposes including height, such as the Beijing Pediatric Eye Study. They often included ages up to 64 years for China, and hence, a modest amount of height underestimation due to shrinking, relative to our target age group of 21-50, cannot be avoided. For South Korea, the NCDRisk study included the 1986 INTERSALT urban community sample (which naturally has an urban bias). From 1998 to 2013, they only included various waves of the (relatively unbiased) Korean National Health Insurance and the KNHANES datasets. For Taiwan, the study relied mostly on the 1985 INTERSALT urban community sample, followed by the 1993 to 2008 Nutrition and Health Surveys and some other samples. Overall, the measured datasets are not without potential biases.[5] This again confirms how crucial it is to mobilize various datasets in order to verify the main results.

To compare measured with self-reported heights by birth decade and country, we created a small panel dataset of East Asian male heights by birth decade (1960s to 1980s) and country. The correlation coefficient was as large as 0.95, although the sample was small (p=0.00, N=9). Moreover, in Appendix Figure A.1, we report differences between self-reported heights in China, South Korea, and Taiwan for men and women using heights from our dataset and the NCDRisk dataset and by limiting the comparison to the period 1960 to 1989. We were able to confirm the results of earlier studies in which China had a slightly stronger self-reporting bias than South Korea, although both were not too large. Chinese males overestimated their heights by around 1.35 cm, whereas their female counterparts did so to a slightly greater degree (some

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[5] This is true, even if urban location and age structure is controlled for in some studies. Sometimes, these variables are collinear with others, and hence, a perfect adjustment is technically not possible.

by 1.6 cm). One should bear in mind that some of the differences were not necessarily caused by self-reporting in the EASS but were due to the inclusion of older (and already shrinking) individuals in the Chinese NCDRisk sample of measured heights. Taiwanese and South Korean males only overestimated their heights by some 0.4 and 0.7 cm, respectively. Among Taiwanese and South Korean females, the bias was negligible (some 0.2 cm). Generally then, the Chinese bias was not alarmingly large (and might be partly explained by the finding that older and already shrinking individuals were included in the measured data), whereas the self-reporting biases in the cases of South Korea and Taiwan were negligible. We also compared our main trend result below, using self-reported and measured heights (see Appendix F).

We can conclude that while self-reported heights were usually overestimated, intergroup differences were only affected to a small extent, and some of the main results that we replicated with various samples were robust across the different samples. In order to make the levels more comparable with other studies, we systematically adjusted the self-reported heights, below, in terms of gender and country.

## 4. How can heights be used to analyze gender equality?

Gray and Wolfe (1980), Costa-Font and Gil (2008), and Guntupalli and Baten (2009) used three different measures to trace gender inequality of height. Each measure shows slightly different trends. To report gender inequality in a consistent way, in this section, we compare gender inequality of height systematically with other gender inequality indices and suggest a formula that can serve as a standard measure. The challenging issue is that height inequality by gender cannot be analyzed simply by comparing the average heights of both genders, as there are also biological factors at work. Even if male height were found to increase more rapidly than female height, this would not necessarily imply an increase in gender inequality. Indeed, anthropologists have found that the height gap between males and females tends to increase when height levels improve (Gray and Wolfe, 1980). Hence, it has been suggested to deflate the gap by average male height (Guntupalli and Baten, 2009). However, since large new datasets have become available (NCD Risk Factor Collaboration, 2016), we know that even this deflated dimorphism ratio increases as average height rises. In other words, the gender height gap accelerates relative to average height. Hence, in this study, we develop a new method based on the large international NCDRisk sample to measure gender inequality based on height data.

Until recently, global anthropological research on the height gap between males and females was based on heterogenous samples, with not much attention paid to statistical representativeness. Eveleth and Tanner (1990) reported a variety of such questionable samples that covered nearly all world regions. For example, hunter-gatherer populations were overrepresented. In contrast, data collected from the NCDrisk group (NCD Risk Factor Collaboration, 2016) encompassed both female and male heights from almost all countries. Although the evidence was sometimes potentially biased by an over-representation of individual (often urban) communities or by the composition effects of different sources, most of the country samples were shown to be representative of their underlying populations. As a result, the ratio of the gender-height gap relative to average height could be systematically studied.

One methodological challenge is that many developing countries have both low height averages and a large gender gap. Hence, it would be ideal to select a sample of countries with relatively average or “typical” gender inequality and then estimate “height gap-to-average” relationships. A suitable gender inequality index would be the residual from this formula, that is, numerically positive deviations to the upper left of a regression line would indicate higher gender inequality and numerically negative deviations to the lower right would indicate lower gender inequality.

Currently, the most widely accepted measure of gender inequality is the Gender Development Index (GDI). The GDI was calculated for 20 countries in the 20th century by

Carmichael et al. (2014). We took the middle group consisting of nine countries and estimated the height gap as an average relationship (Appendix Table A.3, Appendix Figure A.3, Appendix Table A.4). The R-squared values were very high, and the coefficient was consistent regardless of the inclusion of China. We used the formula without China in order not to predetermine the results, given that China is one of the main countries of interest. The resulting formula for gender inequality of height, based on the regression result, is as follows:

$$GI_{\underline{h}} = H_m - H_f - (-33.75 + 0.276 * H_{mf}) \qquad (1)$$

where $H_m$ and $H_f$ are the height values for males and females, respectively, $H_{mf}$ is the average height of both genders, and $GI_h$ represents gender inequality of height.

In a recent paper, Baten (2018) evaluated this new measure by comparing it with relative life expectancies of both genders worldwide since 1890. In addition, that study compared the measure with the GDI for all countries since 1995 as well as for 14 (later 20) well-documented countries since 1900 (Carmichael et al., 2014). The gender inequality of height measure was shown to be consistently associated with all of these measures, as evidenced by simple Pearson correlation coefficients as well as by country-fixed effect regressions that control for country-specific unobservable factors. The correlation between the measures was observable for all world regions and periods of the 20th century, except for Western Europe and North America over the last four decades (when nutritional quality became sufficiently independent of income). As an example, we compared the new measure of gender height inequality to gender differences in life expectancy of other Asian countries during the 1960s (Figure 2).[6] Bangladesh, India, Nepal, and Pakistan have some of the highest gender inequalities in Asia, and this corresponds to

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[6] Gender research on relative life expectancies has shown that female life expectancy tends to be higher even in gender-unequal societies with strong son biases because males consume more cigarettes and alcohol and engage in unhealthy behaviors, biological factors aside.

the worst relative values of gender-specific life expectancy as well as high gender height inequality. Upon considering the values of China and South Korea (note that the life expectancy of Taiwanese was not available by gender), we observe that South Korea held a generally upper-middle position within Asia (clearly topped by Singapore and Bhutan) in this index, whereas China performed slightly better in gender inequality of height than in gender inequality of life expectancy. It should also be noted that gender inequality of height reflects investment during the first years of life, whereas gender inequality of life expectancy reflects inequality over an entire lifetime. In Appendix D, we also compare this measure with the simple ratio of male-to-female height, and find that both yield quite similar trend estimates (but our new measure is more closely correlated with other gender inequality indicators).

## 5. Analysis

Although we primarily focus on the birth decades of the 1960s to the 1980s, we also included the heights of all individuals born from the 1910s to the 1950s in an exploratory analysis of the ‘status quo ante’. Needless to say, the final heights of individuals aged 51 to 90 years were affected by shrinking (for a further discussion, see Appendices A and B). Moreover, survivor bias results from the phenomenon that more educated and taller individuals live longer (although there is also evidence against this claim; see Guntupalli and Baten, 2006). Mean height trends were grouped by birth decade and stratified by sex (Figure 3). Subsample sizes are reported in the notes below the graph. As mentioned above, this analysis requires a caveat, as individuals tend to shrink noticeably at higher ages. We cannot directly compare height levels of individuals born in the 1910s to those born in the 1990s in order to infer how the biological standard of living has evolved. However, we may broadly compare the mean height levels of East Asians in each decade to each other in order to investigate when the biological living standard relatively improved or worsened. Again, this finding is based on the assumption that shrinking rates, as well as survival rates, were similar among all samples.

One of our most striking findings is that South Korean men and women born in the 1910s to the 1930s were not really different from their Chinese and Taiwanese counterparts (Figure 3; see also Appendix Figure A.6, including confidence intervals). However, male South Korean cohorts consistently became the tallest after WWII. Contemporary South Korean men in their 30s (i.e., those born in the 1980s) are now the tallest in East Asia, a result also observed in earlier studies (Lin et al., 2004; Schwekendiek, 2016a). One could object that South Koreans should be compared with North and Northeastern Chinese, given that their diet might be more similar. For example, Northern Chinese were reported as having traditionally consumed more wheat (Morgan, 1998), as South Koreans increasingly did after the Korean War, thanks to subsidized wheat imports from the U.S. (Schwekendiek, 2016b), whereas Southern Chinese had a predominantly rice-based diet. However, even if we compare rural South Korean males with Northern/Northeastern Chinese males, we observed average differences of 1.2, 1.7, and 3.8 cm in the 1960s, 1970s, and 1980s, respectively (Table 3).

Strikingly, the contemporary height gap between Taiwanese and Chinese men (i.e., two groups of Chinese people) was not huge, considering contemporary Taiwan's GDP per capita relative to China's (Table 1). However, if we compare Taiwanese males with Chinese born in the Southeastern provinces of Fujian and Guangdong, we observed average height differences of 1.9, 1.4, and 3.1 in the 1960s, 1970s, and 1980s, respectively, in favor of Taiwanese; which was quite a notable difference. Interestingly, both in the comparison of South Korea with North/Northeastern China, as well as in the comparison of Taiwan with the Fujian/Guangdong region of China, we observe a widening height gap in the last birth decade of the 1980s.

Next, we apply the aforementioned gender equality indicator to China, South Korea, and Taiwan. Gender inequality was initially quite high in South Korea, Taiwan, and China during the

1910s –1930s and 1940s (Figure 4). The slightly lower values in the earliest period in China might be due to low sample sizes. However, gender inequality declined dramatically in China and Taiwan between the 1940s and 1950s, and remained low in China until the 1970s. We observe a substantial increase in gender inequality in South Korea as well as a modest though still noticeable upswing in China during the transition and liberalization period of the 1980s. Upon disaggregation by region, we find that areas outside Seoul showed the strongest increases in the case of South Korea (Figure 5). In nonmetropolitan China, the Eastern region showed the greatest increase in inequality after previously experiencing very low gender inequality. Demographic data measuring gender equality according to sex-selective abortions corroborate this increase in gender height inequality in South Korea (Figure 1), the only differences being that sex ratios at birth are prenatal biosocial indicators of gender equality as opposed to relative heights indicating postnatal discrimination.

As noted above, aside from changes in gender values, rapid economic changes might also have affected a plethora of further socioeconomic variables. Thus, our discussion now shifts to height differences by region, education, and household income, all of which were included in EASS 2010.

Regarding regional classifications, we first study differences of residence in the metropolises of each nation (i.e., Beijing, Shanghai, Tianjin, Seoul, and Taipei). Many people worldwide prefer to live in large cities and the capitals of their nations since they are deemed to be safer, more developed, and offer better networking opportunities.[7] While South Korea has not

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[7] In addition, as East Asian nations have traditionally placed a strong emphasis on education in order to pass the highly competitive Confucian state examinations that granted them nobility status, families tend to favor living in the capital for its better education opportunities, including private cram schools and top universities (Baten and Sohn, 2017).

limited intra-migration historically (Schwekendiek, 2016b), China has heavily restricted it (Chan and Zhang, 1999); although many Chinese who come to study in large cities end up staying. Furthermore, we defined the “West region” as the 12 Western provinces that were identified by the 2010 development plan as needing specific development efforts. We included the “North” and “North-East” regions as well, which had different nutritional styles. We defined the "East region" as the whole Eastern coast and inland regions insofar as they were not included in the Western Development Plan (see Appendix Table A.7 for the list of regions). For South Korea, Seoul and the capital region were distinguished from the Southwestern and Southeastern regions of the peninsula. We divided Taiwan into Taipei and the surrounding Northern region, a Central region, and the Southern region.

Next, we can assess the effect of relative household income, which is undoubtedly one of the advantages of EASS 2010 relative to other surveys. In most other height datasets (such as the frequently used Demographic and Health Surveys), income is not directly included and has to be estimated based on possession of televisions, refrigerators, and other items. Obviously, this method only allows an indirect assessment of the relationship of height with income, and potential biases exist. In contrast, EASS 2010 included a direct question about income in five mutually exclusive and closed-ended response categories (which we combined into three categories, as discussed above). Whereas people commonly do not want to disclose their exact nominal income for various reasons, respondents are more willing to provide relative information on their household income. Not surprisingly, the total sample size decreased only by three respondents in the case of China, seven respondents in the case of South Korea, and four respondents in the case of Taiwan due to missing information for this question.

The last set of variables is related to educational status. The availability of this information and its level of detail is another substantial advantage of the EASS 2010 dataset, as the education levels of mothers and fathers were recorded in great detail. This is very relevant information, as parental education levels could influence the healthcare and nutritional quality that the respondents received (proxied by his or her final height). In EASS 2010, respondents were asked to specify the years of schooling their fathers and mothers actually received numerically, and the data were utilized in the regression analysis.

## 6. Regression results for regional, educational, and gender inequality

In this section, we examine the relationship between height in the three East Asian countries as well as various potential correlates of height. Causal language is not used since causality cannot be directly assessed except for the birth decadal indicator variables, for which the direction of causality is clear. In contrast, education, income, and choice of residence can also be influenced by height, although the other direction of causality probably accounts for the larger part of the relationship. In particular, we assess the multiple relationships using the following econometric equation:

$$\text{Height}_{it} = ß1 + ß2 \text{ birth period}_t + ß3 \text{ educ\_m}_i + ß4 \text{ educ\_f}_i + ß5 \text{ inc\_below}_i + ß6 \text{ inc\_above}_i + ß7 \text{ region}_i + u_{it}$$

where $\text{Height}_{it}$ refers to individual i born in decade t, which was either the 1960s, 1970s, or 1980s, and $u_{it}$ pertains to the stochastic error term. We perform all regressions by country and sex separately (except where we include interaction terms). Educ_m (Educ_f) is the mother's (father's) education, and inc_below (inc_above) is income below (above) the average income group.

Among Chinese males, the time dummies indicate a substantial height difference among those born in the 1970s and 1980s relative to the reference category of the 1960s (Table 4). The 1980s coefficient for China is modest in comparison to that of South Korea, where average height growth was as large as 3.76 cm between the 1960s and 1980s for males. This difference is consistent even when controlling for education and other factors. In Taiwan, height development over time was also dynamic for males. The similarity between male and female height development was greatest in Taiwan, whereas South Korean female stature did not gain as much momentum as male heights during the 1980s, as already discussed above (Table 5). South Korean women experienced the world's largest improvement in height over the last century, rising by nearly 20 cm during the 20th century (NCD Risk Factor Collaboration, 2016). We find that this increase in the height of South Korean women was much less pronounced between the 1970s and 1980s. The sharpest increase in South Korean female height took place before the 1970s, according to this observation (and earlier data by NCDRisk Factor Collaboration, 2016).

Moreover, the coefficients for the father’s and mother’s levels of schooling are mostly positive in all countries and for both genders, although only some show statistical significance. The largest coefficients are for “college and higher” completion in China, both for maternal and paternal education levels, and for female and male heights as the dependent variable. This is a remarkable finding for two reasons. First, educational premia were limited or nonexistent in China before the reform period took effect in the 1980s (Fang et al. 2012, Fleischer and Wang 2005). It seems that parental education indirectly impacted the heights of their offspring via health education. Second, contrary to the common belief of China being a country with high educational zeal, under-education was a problem in the past. For instance, even after the schooling law of 1986, it took concerted efforts to get children to attend school regularly (Fang et al. 2012).

Maternal education shows a strong effect on the development of female heights. For example, six of the coefficients for maternal education are significant for female heights but slightly fewer (four coefficients) significant for male heights. Moreover, lower school completion levels have a significant effect on Taiwanese women, as indicated by a relatively large coefficient for "primary schooling" relative to the constant, which was “no formal schooling.” This is consistent with the theory that maternal education substantially mitigates son bias (Baten, 2018). In other words, better educated mothers were probably less severely affected by son bias, whereas less educated ones allocated more food and medical resources to their male offspring. In general, it is safe to say that education was substantially and positively correlated to height.

In South Korea, education coefficients are less often statistically significant compared to China or Taiwan. However, the coefficient of lower-than-average income is larger (and significant) in the case of South Korea. In China, the male above-average income group is substantially taller than the male average income group (1.6 cm). In contrast, male Chinese who claimed to have a below average income were shorter (0.8 cm). This income effect is not confirmed by their female counterparts (Table 5). Explanations are only speculative at this point, as we cannot yet quantify their relative importance. One explanation might be female buffering, as women’s bodies have been shown to be less sensitive to less optimal nutrition (Guntupalli and Baten, 2009). This phenomenon is explained by evolutionary theories asserting that women are more critical for repopulation following nutritional disasters, and hence, female bodies are biologically built to be more resilient to adverse circumstances. Another potential explanation of the slightly lower female coefficients might be the less favorable allocation of high-quality food to females in middle-income groups, as the gains in status that motivate son preference might be strongest in this group. Lastly, height might simply be less valued for females in this status group, and marriage behavior could cause an assignment to the average income group.[8]

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[8] An unusual pattern was found in another East Asian country, namely Japan (which does not imply that it was necessarily similar in China, Taiwan, or South Korea): marriage sorting into

It is also notable that the number of significant coefficients is larger for differences between average and below average incomes, relative to differences between average and above average incomes. A higher income is usually spent on goods other than on high-quality nutrition and medical resources, according to Engel's law (Baten, 2018). The exception is Chinese males born into higher-income families, who reported taller heights, which likely indicates more high-quality protein consumption between the 1960s and the 1980s. While we have only the income data of the respondent (and not parental income), we may assume a substantial correlation between parental and own income, even though the complexities of Chinese history might have mitigated this correlation.

Lastly, residence patterns show interesting differences between the three East Asian nations and between the sexes. Residence in the large cities of Beijing and Shanghai was associated with a large height difference relative to the reference category, namely, the 12 Western provinces. Indeed, migration to Beijing was strongly regulated and negligible before the 1980s (Chan and Zhang, 1999). Beijing is a much more exclusive place for contemporary adults who were born during the 1960s, 1970s, and 1980s. These people partly originated from families who had lived in Beijing for generations, being influenced by the attractiveness of the city for competitive immigrants in earlier centuries.

Clearly, China shows the largest height differences according to region of the country. However, the sheer size of China might have caused this result. Hence, heights in Beijing and Shanghai should not be compared to those in all of China but instead to the surrounding region (Table 3). Relative to its surroundings, Beijing "only" had a 2.0 to 2.5 cm advantage, whereas males in Shanghai were between 1.9 and 6.6 cm taller. Although this extreme value might be an

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income groups also happened for males marrying into richer families, but traditionally, this type of marriage was much less frequent in East Asia, see Yamamura and Tsutsui, 2017.

overestimation resulting from a modest number of cases, Shanghai still shows an average 3.9 cm height advantage compared to Eastern China. Over time, we observe a modest convergence of the rural population relative to these metropolises. Males in Seoul were also taller than males in the rest of the country (though not significantly), whereas inhabitants of Taipei and its surrounding region did not display a height gap. Again, the differences among females were substantially smaller, although females in Beijing had a substantial height advantage (relative to the rural reference category) compared to those in Seoul or Taipei.

The large anthropometric gaps in China between rural places and metropolises are well known. For instance, a previous study found that China has the world's largest gap in rural-urban stunting of height among preschool children, measured in 92 countries around the year 2000 (Guntupalli and Schwekendiek, 2009). Another study based on schoolchildren and adolescents found height differences up to 10 cm across regions in contemporary China (Morgan, 2000). While these studies were based on individuals who were still growing, the current study based on final heights demonstrated that differences in biological living standards between rural places and metropolises were substantial.

We also find that urban residence, after controlling for metropolitan region, was surprisingly negative, although only significant in the case of South Korea. Urban life also has its disadvantages, such as pollution and having easier access to cheaper low-quality nutrients such as fast food (Popkin, 2009).

We also use a “horserace” regression to test whether maternal or paternal education level mattered more for heights of females and males (Table 6). To reduce the number of coefficients, we simplify the education variable to the number of school years (zero for no schooling, followed by steps of 3, 6, and 9 years recorded for intermediate levels before each year of education was counted beyond that). Maternal coefficients are found to be significant in two models, while paternal education coefficients are found significant in only one regression. Of the six models, Taiwanese females are the only ones for which the education level of the father mattered more than that of the mother. In studies on other countries, maternal education levels showed a stronger influence, as mothers typically make more decisions within the household (Baten and Böhm, 2010). Their education levels possibly matter the most since they generally allocate food and medical resources to children. Why this effect was not as strong in the case of Taiwan requires further exploration. For South Korea, the effect of education is smaller and not statistically significant.[9]

## 8. Conclusion

This research investigated how the heights of Chinese, South Koreans, and Taiwanese developed during the rapid growth period of the 1960s to the 1980s, with special attention paid to socioeconomic, regional, and educational differences among groups as well as to gender-specific gains in height, given strong son preference in the region due to Confucianism. We find that gender inequality in mainland China was relatively modest in the pre-reform period (before 1978). In particular, in comparison to the early 20th century, female heights developed better than male heights. In contrast, the transition period to an economic system with market elements during the 1980s was characterized by increasing gender inequality in China. In South Korea, gender inequality has increased even more (Pak, 2011).

This gender height inequality moved in parallel to sex-selective abortions in South Korea, which was another manifestation of son bias (Chun and Das Gupta, 2009). In the late

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[9] Lastly, we studied the interaction effects between gender and education as well as between income and education. However, these interactions did not turn out to be statistically significant (Table Appendix A.5). We also assess whether or not the results would differ if we excluded the Muslim minority (data were gathered in EASS 2010), and they did not (Appendix Table A.6).

1980s and early 1990s, South Koreans aborted a much higher number of female fetuses than male ones. However, during the later 1990s, the number of sex-selective abortions was reduced by legislation. During the entire 20th century, however, South Korean women benefited greatly from declining gender inequality at one of the fastest rates worldwide. In Taiwan, which did not participate in the “son bias reappearance” of the 1980s, gender inequality also followed a positive trend.

In order to study gender inequality of height, we developed a formula that accounts for the empirical fact that the height gap between males and females increases with average height, but not exactly proportionally. We also studied height inequalities by region of residence, education level, and income. Regional differences in China were large, especially between Western China and the booming metropolises of Shanghai and Beijing. However, the record of Beijing was more difficult to evaluate; while its inhabitants were strikingly taller than the Chinese average, they were only modestly taller than Chinese residing in the North and Northwest. In contrast, Shanghai residents were much taller than the inhabitants of their surrounding regions (by 3.9 cm).

Lastly, the education level of the parents had a strong effect on height, even in a period and region (mainland China) in which skill premia were low. However, there were other causal channels from parental, and especially maternal, education to children’s height (via health-knowledge acquisition, for example). Income effects on height were modest and not always significant. The strongest effects of income differences were observed in South Korea, whereas educational effects were not very strong.

## Acknowledgements

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2018S1A6A3A01023515). We also acknowledge support by the Deutsche Forschungsgemeinschaft (German Research Foundation) and the SFB 1070 ResourceCultures at the University of Tuebingen. Documentation materials and raw datasets regarding the East Asian Social Survey of 2010 (EASS 2010) were acquired from the Survey Research Center hosted at the Academy of East Asian Studies of Sungkyunkwan University as well as the Interuniversity Consortium for Political and Social Research hosted at the Institute for Social Research of the University of Michigan. This research also utilized data from the China Health and Nutrition Survey (CHNS). We thank the National Institute of Nutrition and Food Safety, China Center for Disease Control and Prevention, Carolina Population Center (5 R24 HD050924), University of North Carolina at Chapel Hill-NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700), and Fogarty International Center-NIH for financial support for the CHNS data collection and analysis files from the 1989 to 2011 and future surveys, as well as the China-Japan Friendship Hospital-Ministry of Health for support for CHNS 2009. We are grateful to the Tuebingen economic history group for their general feedback, especially to Laura Maravall and Elisabeth Kempter. A final thanks to the editor, Inas Kelly, three anonymous referees and to Stephen Morgan and Tom Keywood for their valuable comments to improve this manuscript.

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# Tables and figures

## Table 1: GDP per capita in East Asia and the U.S., 1820-2010

| Year | Selected countries or territories | | | | |
|---|---|---|---|---|---|
| | United States | China | Japan | South Korea | Taiwan |
| 1820 | 2,080 | 741 | | 477 | 907 |
| 1870 | 3,736 | 751 | 985 | 480 | 907 |
| 1913 | 8,101 | 881 | 1,852 | 690 | 1,207 |
| 1950 | 15,241 | 757 | 2,519 | 1,122 | 1,393 |
| 2001 | 45,878 | 4,400 | 33,086 | 23,412 | 30,780 |
| 2010 | 49,267 | 9,475 | 35,477 | 32,325 | 37,804 |

Source: Maddison Project Database 2018, under: https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2018 (accessed January 3, 2019).

## Table 2: Overview on EASS 2010 in China, South Korea, and Taiwan

| Country or territory: | China | South Korea | Taiwan |
|---|---|---|---|
| Date of survey: | July to December 2010 | June to August 2010 | July 2011 to April 2012 |
| Institute: | Renmin University of China | Sungkyunkwan University | Academia Sinica |
| Sample size: | 3,866 | 1,576 | 2,199 |
| Sampling: | Multiple stage random sampling initially drawing on addresses | Multiple stage random sampling initially drawing on household registries | Multiple stage random sampling initially drawing on individual population registries |
| Method of interview: | Face-to-face | Face-to-face | Face-to-face |
| Language of interview: | Chinese | Korean | Chinese & Fukien dialect & Hakka dialect |

Source: Data were compiled by the authors from the codebooks, documentation, and questionnaires of EASS (2010). Japan was dropped, as heights were not included in the final EASS 2010 files.

## Table 3: Comparisons of male heights from Beijing, Taiwan, and other places with adjacent (mainland Chinese) provinces

| | South Korea | China North/North East | |
|---|---|---|---|
| Birth decade | Mean | Mean | Difference |
| 1960 | 170.84 | 169.66 | 1.18 |
| 1970 | 172.62 | 170.88 | 1.74 |
| 1980 | 175.13 | 171.32 | 3.81 |
| total | 172.81 | 170.51 | 2.30 |

| | Taiwan | Fujian and Guangdong | |
|---|---|---|---|
| Birth decade | Mean | Mean | Difference |
| 1960 | 169.43 | 167.48 | 1.95 |
| 1970 | 171.36 | 169.99 | 1.36 |
| 1980 | 172.52 | 169.44 | 3.08 |
| total | 171.14 | 168.77 | 2.36 |

| | Beijing | China North/North East | |
|---|---|---|---|
| Birth decade | Mean | Mean | Difference |
| 1960 | 172.15 | 169.66 | 2.50 |
| 1970 | 173.31 | 170.88 | 2.44 |
| 1980 | 173.28 | 171.32 | 1.96 |
| total | 172.91 | 170.51 | 2.39 |

| | Shanghai | China-East | |
|---|---|---|---|
| Birth decade | Mean | Mean | Difference |
| 1960 | 171.24 | 167.92 | 3.32 |
| 1970 | 175.30 | 168.69 | 6.61 |
| 1980 | 172.63 | 170.73 | 1.90 |
| total | 172.73 | 168.87 | 3.85 |

Notes: We calculated average male heights from the EASS 2010 for the birth decades reported in the table above (implying ages 21-50). We adjusted for self-reporting bias and used regional and educational weights for China.

## Table 4: Regressions of height of men

| | Schooling of father | | | Schooling of mother | | |
|---|---|---|---|---|---|---|
| | China | South Korea | Taiwan | China | South Korea | Taiwan |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Born 1970s | 0.90* | 1.59*** | 1.51** | 0.86* | 1.60*** | 1.33** |
| | (0.050) | (0.008) | (0.014) | (0.069) | (0.007) | (0.043) |
| Born 1980s | 1.67*** | 3.76*** | 2.39*** | 1.68*** | 3.42*** | 1.87** |
| | (0.003) | (0.000) | (0.001) | (0.003) | (0.000) | (0.015) |
| Primary schooling | 0.26 | -0.49 | 1.45 | 0.40 | -0.59 | 0.96 |
| | (0.603) | (0.541) | (0.110) | (0.391) | (0.371) | (0.192) |
| Junior high | 0.77 | 1.15 | 2.06* | 0.55 | 0.48 | 0.61 |
| | (0.214) | (0.203) | (0.051) | (0.409) | (0.562) | (0.500) |
| High school | 0.47 | 1.06 | 2.29** | 1.10 | 1.60** | 3.51*** |
| | (0.517) | (0.212) | (0.022) | (0.278) | (0.041) | (0.000) |
| College and higher | 3.97*** | 0.91 | 3.10*** | 4.74*** | 0.06 | 2.44** |
| | (0.000) | (0.347) | (0.004) | (0.000) | (0.956) | (0.023) |
| Income above average | 1.59** | 0.16 | -0.16 | 1.58** | 0.31 | -0.09 |
| | (0.020) | (0.793) | (0.839) | (0.019) | (0.620) | (0.912) |
| Income below average | -0.75* | -1.30** | -0.74 | -0.80* | -1.24** | -0.73 |
| | (0.084) | (0.016) | (0.225) | (0.068) | (0.021) | (0.220) |
| Urban | -0.13 | -1.26*** | -0.47 | -0.21 | -1.25** | -0.44 |
| | (0.802) | (0.009) | (0.378) | (0.670) | (0.011) | (0.403) |
| China: Beijing | 5.44*** | | | 5.57*** | | |
| | (0.000) | | | (0.000) | | |
| China: Tianjin | 2.40** | | | 2.43** | | |
| | (0.021) | | | (0.024) | | |
| China: Shanghai | 4.79*** | | | 4.69*** | | |
| | (0.000) | | | (0.000) | | |
| China northeast | 3.81*** | | | 3.78*** | | |
| | (0.000) | | | (0.000) | | |
| China East | 2.32*** | | | 2.31*** | | |
| | (0.000) | | | (0.000) | | |
| South Korea: Seoul | | 0.61 | | | 0.58 | |
| | | (0.376) | | | (0.392) | |
| South Korea Southwest | | 0.59 | | | 0.51 | |
| | | (0.299) | | | (0.373) | |
| Taiwan: Taipei/North | | | -0.10 | | | -0.16 |
| | | | (0.860) | | | (0.788) |
| Taiwan center | | | -1.09 | | | -1.12 |
| | | | (0.121) | | | (0.107) |
| Constant | 165.72*** | 171.08*** | 168.65*** | 165.87*** | 171.44*** | 169.35*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| | | | | 0 | 0 | 0 |
| Observations | 1,019 | 461 | 570 | 1,019 | 461 | 570 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Adjusted R-squared | 0.105 | 0.128 | 0.052 | 0.101 | 0.136 | 0.069 |

Notes: Dependent variable is final height. The constant refers to no schooling, born in the 1960s, with an average income, and residing in a rural area. For China in columns 1 & 2, "West" represents the reference category. For South Korea, the constant refers to the Southeast region, for Taiwan it refers to the South region. We adjusted for self-reporting bias and used regional and educational weights for China.

**Table 5: Regressions of heights of women**

| | Schooling of father | | | Schooling of mother | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | China | South Korea | Taiwan | China | South Korea | Taiwan |
| Born 1970s | 0.45 | 1.92*** | 0.85 | 0.37 | 1.83*** | 0.56 |
| | (0.241) | (0.000) | (0.119) | (0.327) | (0.001) | (0.307) |
| Born 1980s | 1.09** | 2.04*** | 2.25*** | 0.87* | 1.73*** | 2.10*** |
| | (0.024) | (0.000) | (0.000) | (0.074) | (0.007) | (0.001) |
| Primary schooling | -0.15 | 0.16 | 0.20 | 0.44 | -0.44 | 1.58*** |
| | (0.733) | (0.852) | (0.780) | (0.285) | (0.542) | (0.009) |
| Junior high | 0.30 | 0.40 | 0.62 | 1.14** | -0.07 | 0.89 |
| | (0.517) | (0.652) | (0.447) | (0.027) | (0.933) | (0.246) |
| High school | 0.98* | 0.51 | 0.79 | 1.84*** | 0.69 | 2.18*** |
| | (0.093) | (0.540) | (0.377) | (0.006) | (0.401) | (0.006) |
| College and higher | 2.03** | 1.55* | 2.96*** | 4.22*** | 2.01 | 2.53** |
| | (0.046) | (0.095) | (0.001) | (0.000) | (0.136) | (0.010) |
| Income above average | 0.22 | 0.41 | 0.91 | 0.09 | 0.45 | 0.85 |
| | (0.708) | (0.466) | (0.231) | (0.867) | (0.413) | (0.266) |
| Income below average | -0.11 | -0.77 | -0.42 | -0.11 | -0.77 | -0.60 |
| | (0.767) | (0.136) | (0.457) | (0.759) | (0.132) | (0.267) |
| Urban | -0.53 | -0.18 | -0.30 | -0.69 | -0.18 | -0.19 |
| | (0.201) | (0.703) | (0.510) | (0.107) | (0.701) | (0.677) |
| China: Beijing | 2.48*** | | | 2.16** | | |
| | (0.004) | | | (0.013) | | |
| China: Tianjin | 4.24*** | | | 3.87*** | | |
| | (0.000) | | | (0.000) | | |
| China: Shanghai | 4.34*** | | | 4.21*** | | |
| | (0.000) | | | (0.000) | | |
| China Northeast | 3.44*** | | | 3.32*** | | |
| | (0.000) | | | (0.000) | | |
| China East | 2.05*** | | | 2.01*** | | |
| | (0.000) | | | (0.000) | | |
| South Korea: Seoul | | -0.12 | | | -0.05 | |
| | | (0.855) | | | (0.944) | |
| South Korea Southwest | | -0.29 | | | -0.24 | |
| | | (0.597) | | | (0.656) | |
| Taiwan: Taipei/North | | | -0.26 | | | -0.21 |
| | | | (0.637) | | | (0.705) |
| Taiwan center | | | 1.24** | | | 1.27** |
| | | | (0.031) | | | (0.029) |
| Constant | 155.82*** | 158.78*** | 157.28*** | 155.75*** | 159.26*** | 156.88*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| Observations | 1,188 | 518 | 590 | 1,188 | 518 | 590 |
| Adjusted R-squared | 0.063 | 0.039 | 0.079 | 0.067 | 0.043 | 0.068 |

Notes: Dependent variable is final height. The constant refers to no schooling, born in the 1960s, with an average income, and residing in a rural area. For China in columns 1 & 2, “West” represents the reference category. For South Korea, the constant refers to the Southeast region, for Taiwan it refers to the South region. We adjusted for self-reporting bias and used regional and educational weights for China.

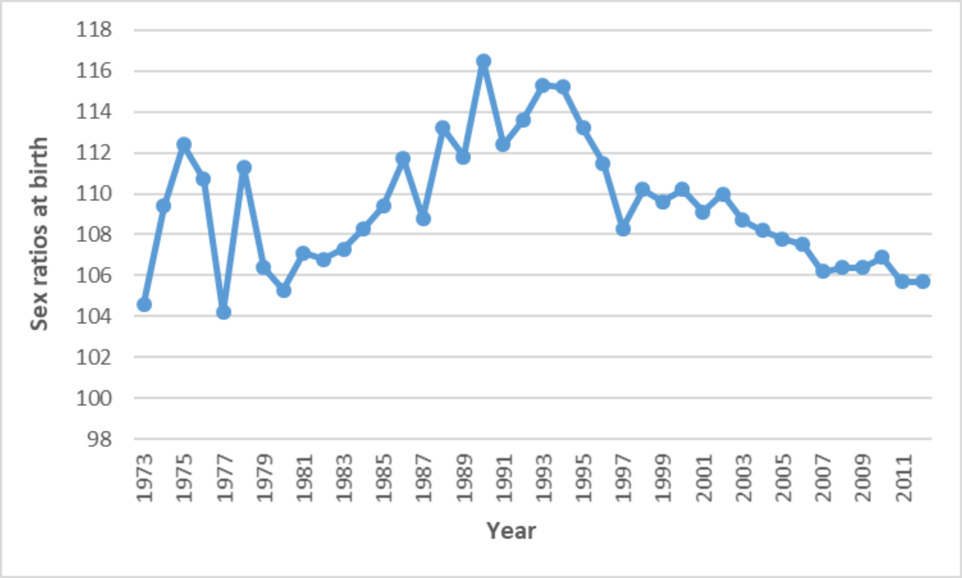
## Table 6: Regressions of heights of men and women: A comparison of the relevance of father's and mother's heights.

| | Male heights | | | Female heights | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | China | South Korea | Taiwan | China | South Korea | Taiwan |
| Born 1970s | 0.68 | 1.48** | 1.05 | 0.37 | 1.76*** | 0.82 |
| | (0.157) | (0.014) | (0.121) | (0.346) | (0.001) | (0.140) |
| Born 1980s | 1.49*** | 3.62*** | 1.65** | 0.71 | 1.82*** | 1.62** |
| | (0.009) | (0.000) | (0.050) | (0.160) | (0.004) | (0.011) |
| Income above average | 1.78*** | 0.16 | -0.13 | -0.11 | 0.44 | 0.85 |
| | (0.008) | (0.798) | (0.866) | (0.842) | (0.428) | (0.288) |
| Income below average | -0.76* | -1.23** | -0.76 | -0.01 | -0.77 | -0.24 |
| | (0.087) | (0.023) | (0.234) | (0.974) | (0.133) | (0.677) |
| Years educ. of father | 0.06 | 0.04 | 0.10 | 0.03 | 0.07 | 0.19** |
| | (0.371) | (0.560) | (0.256) | (0.508) | (0.357) | (0.016) |
| Years educ. of mother | 0.07 | 0.08 | 0.16* | 0.13** | 0.05 | 0.04 |
| | (0.361) | (0.320) | (0.070) | (0.014) | (0.532) | (0.546) |
| Urban | -0.24 | -1.25*** | -0.50 | -0.83* | -0.16 | -0.14 |
| | (0.633) | (0.010) | (0.357) | (0.063) | (0.738) | (0.768) |
| China: Beijing | 5.65*** | | | 2.06** | | |
| | (0.000) | | | (0.019) | | |
| China: Tianjin | 2.50** | | | 3.72*** | | |
| | (0.026) | | | (0.001) | | |
| China: Shanghai | 5.44*** | | | 4.18*** | | |
| | (0.000) | | | (0.000) | | |
| China Northeast | 3.81*** | | | 3.14*** | | |
| | (0.000) | | | (0.000) | | |
| China East | 2.36*** | | | 1.84*** | | |
| | (0.000) | | | (0.000) | | |
| South Korea: Seoul | | 0.56 | | | -0.10 | |
| | | (0.415) | | | (0.881) | |
| South Korea Southwest | | 0.52 | | | -0.27 | |
| | | (0.361) | | | (0.621) | |
| Taiwan: Taipei/North | | | -0.32 | | | 0.03 |
| | | | (0.608) | | | (0.958) |
| Taiwan center | | | -1.03 | | | 1.13* |
| | | | (0.157) | | | (0.060) |
| Constant | 165.67*** | 170.75*** | 168.89*** | 155.69*** | 158.35*** | 156.14*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Observations | 991 | 461 | 540 | 1128 | 518 | 549 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Adjusted R-squared | 0.101 | 0.125 | 0.060 | 0.061 | 0.044 | 0.068 |

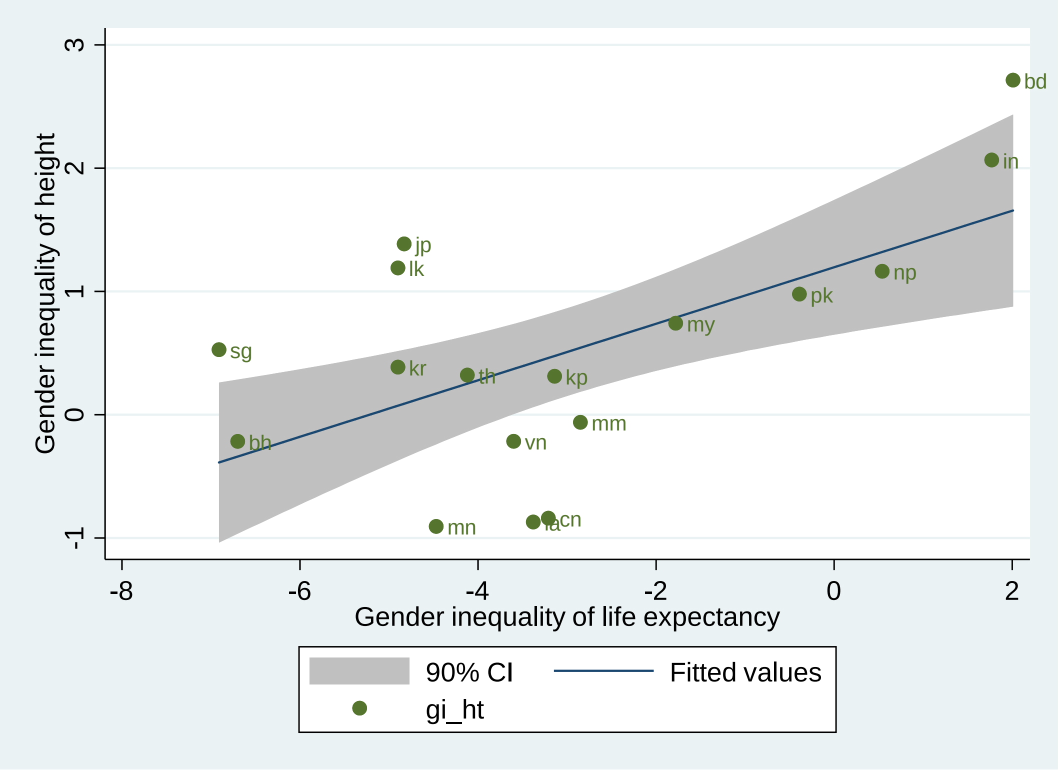
Notes: Dependent variable is height. The constant refers to individuals born in the 1960s, with an average income, and residing in a rural area. For China in columns 1 & 2, “West” represents the reference category. For South Korea, the constant refers to the Southeast region, for Taiwan it refers to the South region. We adjusted for self-reporting bias and used regional and educational weights for China.

**Figure 1: Historical trends in sex ratios at birth in South Korea as a biosocial indicator of pre-natal gender discrimination**



Notes: Sex ratio at birth pertains to the number of males born alive per 100 females born alive.
Source: Korean Bureau of Statistics (2013); Chun and Das Gupta (2009).

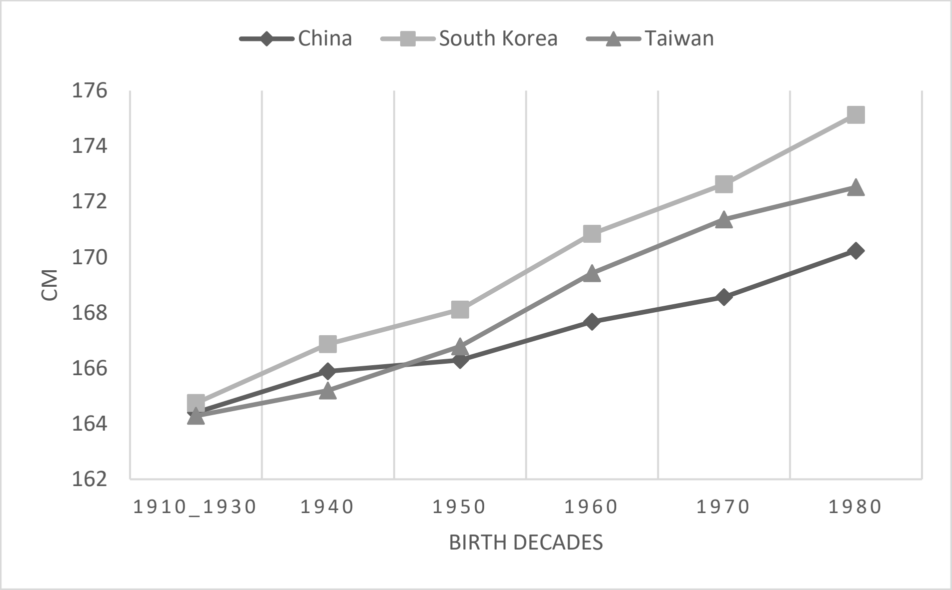
**Figure 2: Gender inequality of life expectancy and of height in Asia (birth decade of 1960s)**



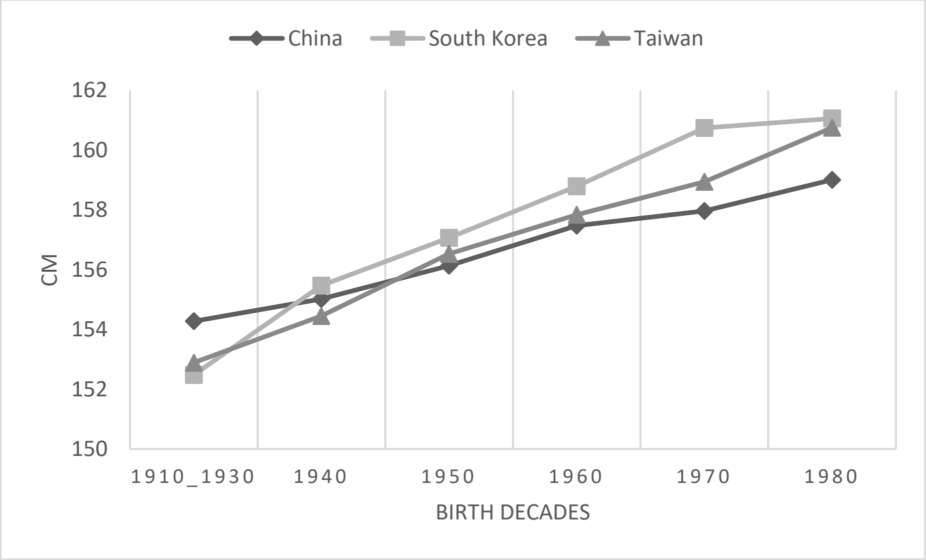
Sources: On life expectancies: Clio-Infra.eu; on heights: China and South Korea based on EASS 2010 (adjusted for self-reporting and using regional and educational weights). All other height inequality estimates are based on NCDRisk (2016) data. Philippines and Papua-New Guinea were excluded due to measurement error, see Baten (2018). The two-letter abbreviations follow IOS-2-standard (kr for South Korea etc.)

## Figure 3: Heights by birth decade in China, South Korea, and Taiwan (not accounting for shrinking above age 50, which applies mainly from 1910s to 1950s)

Panel A Males

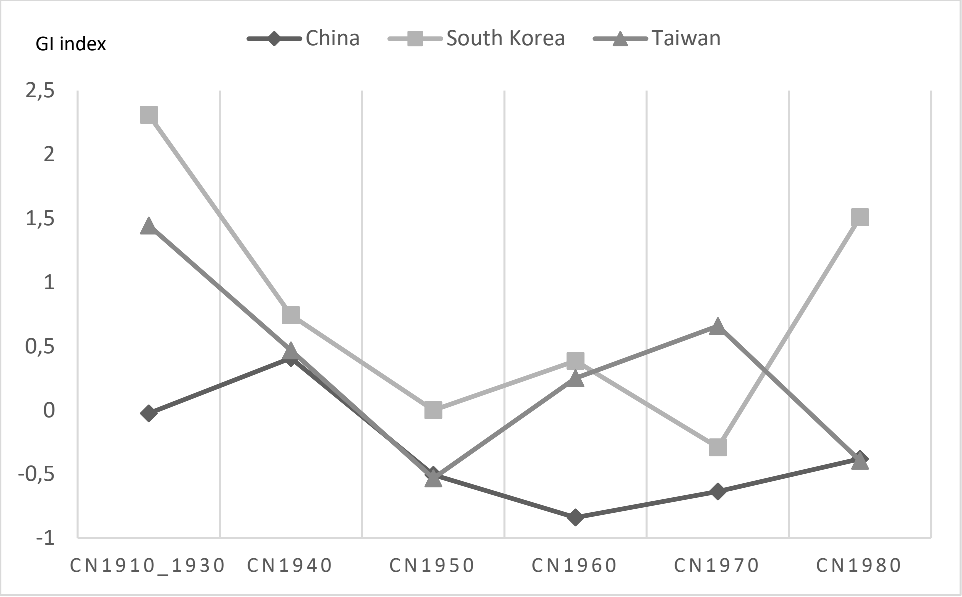


Panel B Females



Notes: For the sake of intercountry comparability, height trends are plotted under the assumption of uniform shrinking rates. The actual final height of cohorts born in the early to mid-20th century is thus noticeably higher. We adjusted for self-reporting bias and used regional and educational weights for China. Subsample sizes for males born in the 1910s-1930s, 1940s, 1950s, 1960s, 1970s, and 1980s are as follows: 156, 242, 396, 418, 358, and 243 for China; 61, 75, 113, 153, 165, and 143 for Korea; as well as 95, 124, 198, 186, 192, and 186 for Taiwan, respectively. Conversely, subsample sizes for females born in the 1910s-1930s, 1940s, 1950s, 1960s, 1970s, and 1980s consist of the following number of individuals: 160, 243, 357, 495, 412, and 281 for China; 87, 72, 100, 196, 201, and 121 for Korea; as well as 82, 125, 199, 211, 182, and 183 for Taiwan, respectively. Source: Authors' calculation based on EASS 2010.

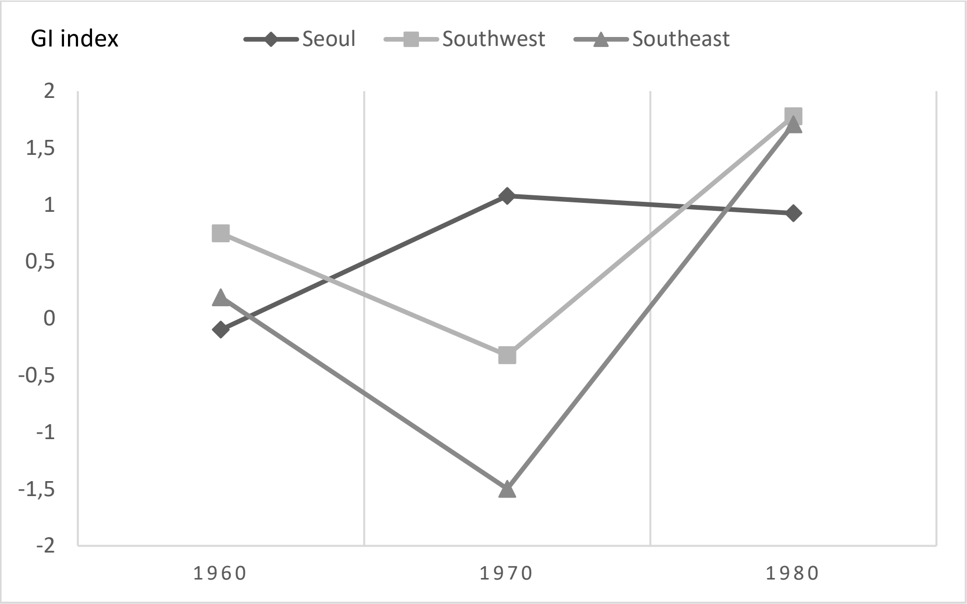
## Figure 4: Gender inequality in China, South Korea, and Taiwan



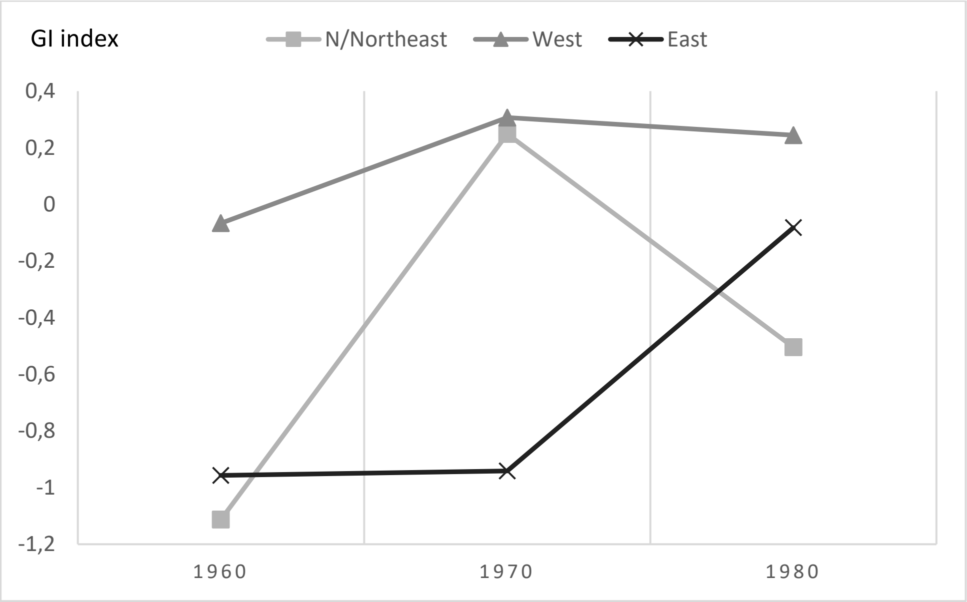
Source: EASS 2010.
Notes: We adjusted for self-reporting bias and used regional and educational weights for China. “GI index” is the gender inequality index explained in the text.

## Figure 5: Gender inequality in the regions of South Korea and China

Panel A: South Korea



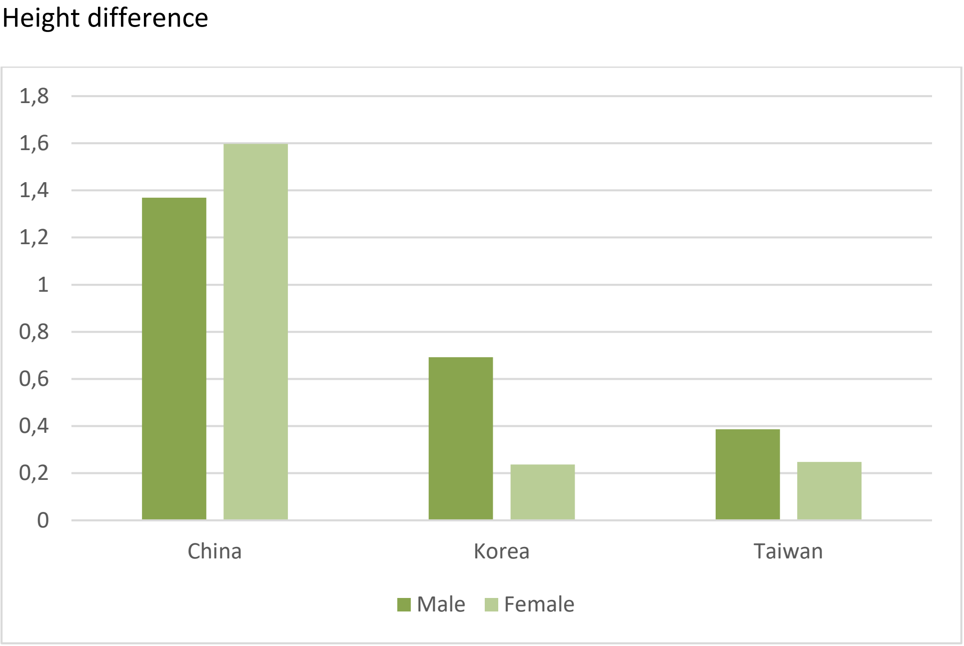
Panel B: China



Notes: Metropoles are excluded. We adjusted for self-reporting bias. “GI index” is the gender inequality index explained in the text.

# Appendix A: Figures and Tables (online only)

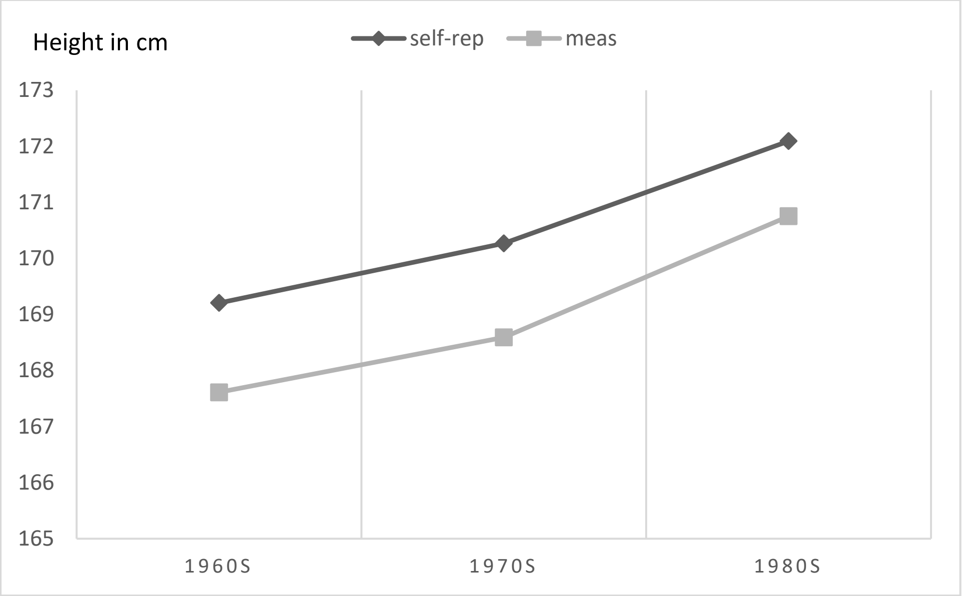
## Appendix Figure A.1: Differences between self-reported and measured height (NCD-Risk estimates) in East Asian countries by sex



Notes: The left darker bar represents height differences between self-reported and measured height for males, the right lighter bar for females.

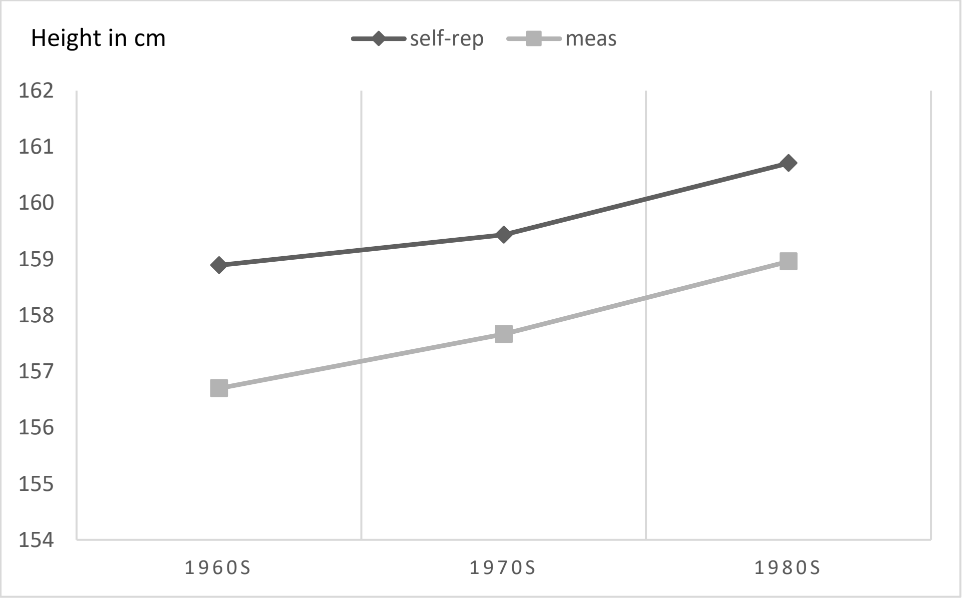
## Appendix Figure A.2: Comparison of (a) self-reported and (b) measured heights (based on the China Health and Nutrition Survey

Panel A: Heights of men



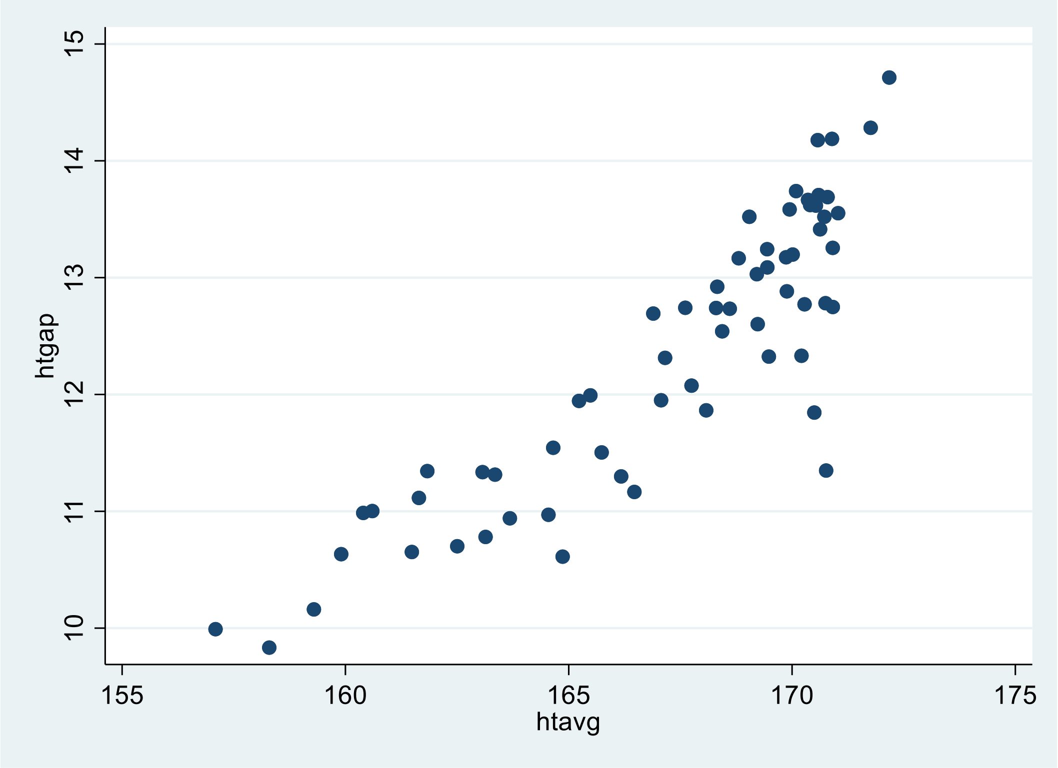
Abbreviations: “self-rep.” = self-reported; “meas.” = measured heights

Panel B: Heights of women



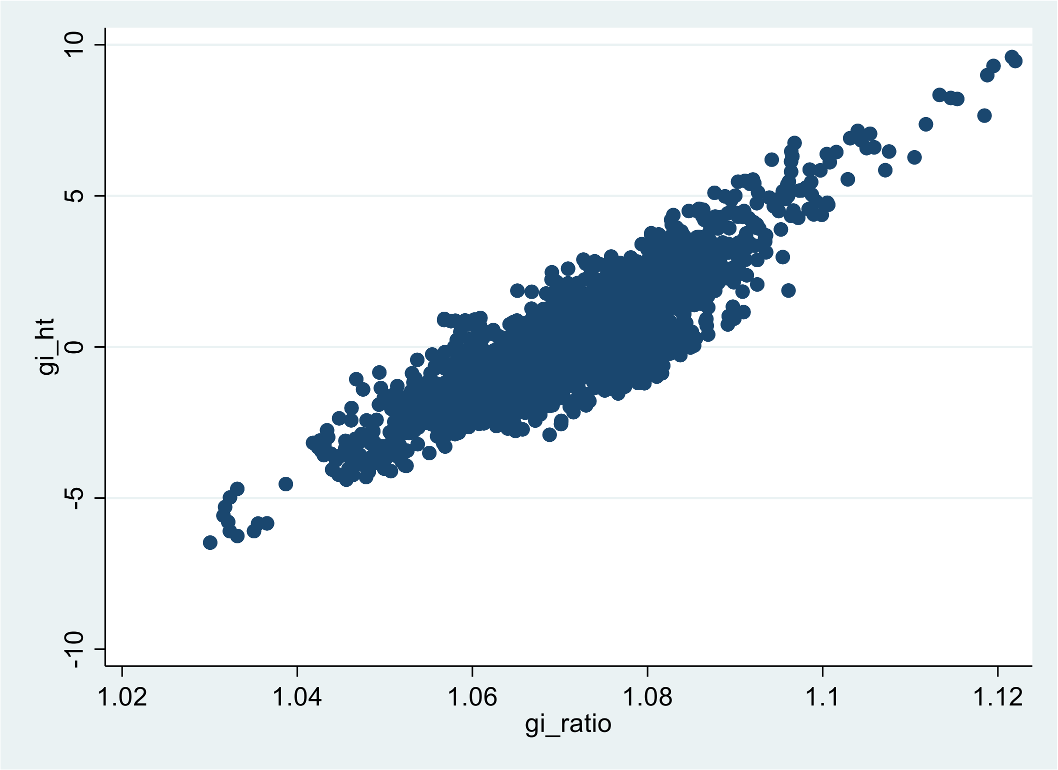
Notes: Lines show the heights of self-reported (EASS 2010) height averages and measured (China Health and Nutrition Survey) data, by birth decades, including ages 21-50.

### Appendix Figure A.3: Relationship between height average and height gap.



Notes: Birth decade 1990 for China, Thailand, France, Russia, United States, Poland, United Kingdom, Canada, and Spain.

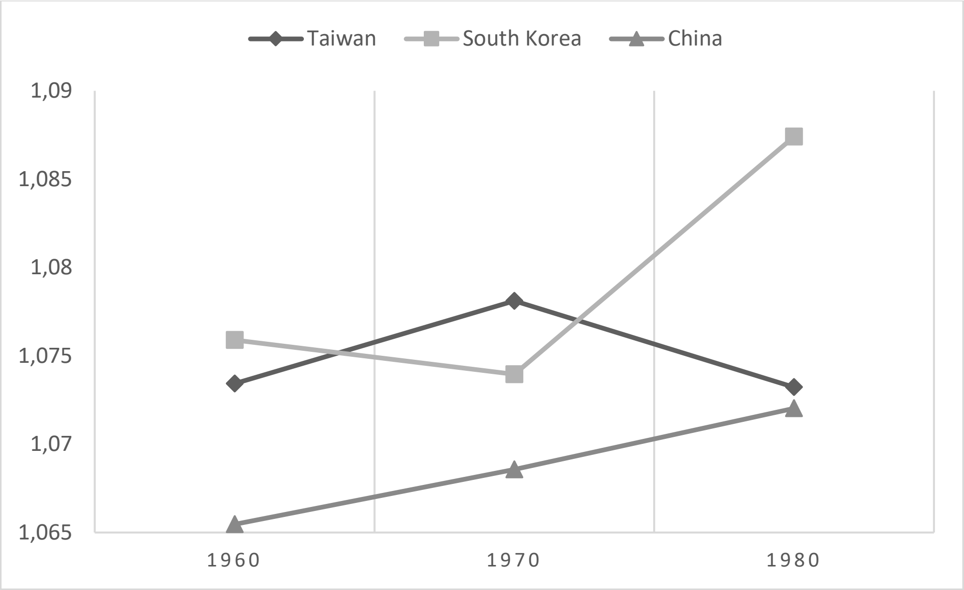
### Appendix Figure A.4: Comparing our new measure of height inequality with the ratio of male-to-female height



Notes: Correlation: 0.8563, p=0.000, N=2178.

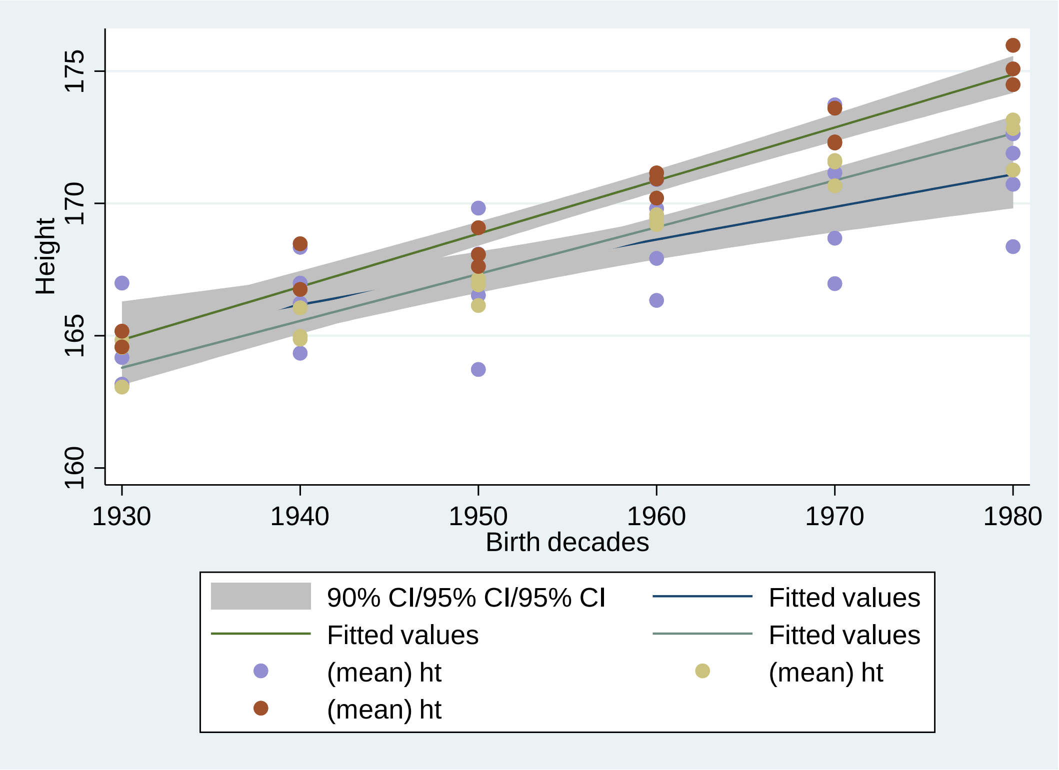
### Appendix Figure A.5: Trends in gender inequality obtained with the ratio of male-to-female height

Height ratio



Notes: This figure uses the simple ratio between male and female height as an inequality indicator.

## Appendix Figure A.6: Trends in male height, with confidence intervals based on regions



Notes: The trend estimates and scatters are based on regions of the countries: For Taiwan and South Korea, all three regions, for China we needed to aggregate Beijing, Tianjin, and Shanghai into a "metro" region, resulting in four regions (West, East, North-Northeast, metro). The line and color ending high in the 1980s is South Korea, the line and color ending low in the 1980s is China, and Taiwan in the middle. Self-reporting adjustment, but no regional/educational adjustment, as the regional adjustment does not make sense for a regional disaggregation.

## Appendix Table A.1: Educational shares: (a) observations in our sample and (b) in the Chinese census of 2010. Educational weights to counterbalance over-sampling

| Classification in EASS 2010 | DE-GREE | Freq. | % in EASS 2010 | % in Census 2010 | Classification in Census 2010 | Weights |
|---|---|---|---|---|---|---|
| No formal schooling | 0 | 550 | 14.2 | 11.5 | No schooling or n.a. | 0.81 |
| Elementary | 1 | 871 | 22.6 | 26.8 | Primary | 1.19 |
| Junior high | 2 | 1,160 | 30.0 | 38.8 | Junior secondary | 1.29 |
| High school | 3 | 681 | 17.6 | 14.0 | Senior secondary | 0.80 |
| Junior college | 4 | 313 | 8.1 | 8.9 | College and higher | 0.58 |
| University | 5 | 256 | 6.6 | | Included above | |
| Graduate school | 6 | 31 | 0.8 | | Included above | |

**Appendix Table A.2: Regional shares: (a) observations in our EASS 2010 sample and (b) in the Chinese census of 2010. Regional weights to counterbalance over-sampling**

| Prov.No. | *Province* | *Survey* | *Census* | | *Weights* |
|---|---|---|---|---|---|
| | | share, % | in 10,000s of people | share, % | |
| 11 | Beijing | 4.7 | 1961.2 | 1.4 | 0.3 |
| 12 | Tianjin | 3.3 | 1293.8 | 0.9 | 0.3 |
| 13 | Hebei | 2.3 | 7185.4 | 5.2 | 2.3 |
| 14 | Shanxi | 2.4 | 3571.2 | 2.6 | 1.1 |
| 15 | Neimenggu | 1.1 | 2470.6 | 1.8 | 1.6 |
| 21 | Liaoning | 3.4 | 4374.6 | 3.2 | 0.9 |
| 22 | Jilin | 3.8 | 2746.2 | 2.0 | 0.5 |
| 23 | Heilongjiang | 4.7 | 3831.2 | 2.8 | 0.6 |
| 31 | Shanghai | 4.4 | 2301.9 | 1.7 | 0.4 |
| 32 | Jiangsu | 4.2 | 7866.0 | 5.7 | 1.4 |
| 33 | Zhejiang | 4.6 | 5442.7 | 4.0 | 0.9 |
| 34 | Anhui | 3.7 | 5950.1 | 4.3 | 1.2 |
| 35 | Fujian | 2.6 | 3689.4 | 2.7 | 1.0 |
| 36 | Jiangxi | 4 | 4456.7 | 3.3 | 0.8 |
| 37 | Shandong | 5.3 | 9579.3 | 7.0 | 1.3 |
| 41 | Henan | 5.6 | 9402.4 | 6.9 | 1.2 |
| 42 | Hubei | 5.5 | 5723.8 | 4.2 | 0.8 |
| 43 | Hunnan | 4.2 | 6568.4 | 4.8 | 1.1 |
| 44 | Guangdong | 4.4 | 10430.3 | 7.6 | 1.7 |
| 45 | Guangxi | 2.8 | 4602.7 | 3.4 | 1.2 |
| 46 | Hainan | 0.9 | 867.2 | 0.6 | 0.7 |
| 50 | Chongqing | 2 | 2884.6 | 2.1 | 1.1 |
| 51 | Sichuan | 5.1 | 8041.8 | 5.9 | 1.2 |
| 52 | Guizhou | 2.4 | 3474.6 | 2.5 | 1.1 |
| 53 | Yunnan | 3.3 | 4596.6 | 3.4 | 1.0 |
| 54 | Xizang | 1 | 300.2 | 0.2 | 0.2 |
| 61 | Shanxi | 3.6 | 3732.7 | 2.7 | 0.8 |
| 62 | Gansu | 1.6 | 2557.5 | 1.9 | 1.2 |
| 63 | Qinghai | 1 | 562.7 | 0.4 | 0.4 |
| 64 | Ningxia | 0.9 | 630.1 | 0.5 | 0.5 |
| 65 | Xinjiang | 1.1 | 2181.3 | 1.6 | 1.4 |

## Appendix Table A.3: Gender development index for 2000

| Country | Gender development index |
|---|---|
| Egypt | 57 |
| India | 59 |
| Turkey | 60 |
| Kenya | 64 |
| Indonesia | 66 |
| Brazil | 70 |
| Italy | 70 |
| Japan | 70 |
| Mexico | 71 |
| China | 71 |
| Thailand | 71 |
| France | 73 |
| Russia | 73 |
| United States | 74 |
| Poland | 76 |
| United Kingdom | 76 |
| Canada | 77 |
| Spain | 77 |
| Australia | 78 |
| Argentina | 79 |
| Germany | 80 |
| South Africa | 81 |
| Netherlands | 83 |
| Sweden | 91 |

Notes: The highlighted countries included in the regressions (see Table A.4).

## Appendix Table A.4: Regressions of height gap between genders based on average heights

| | (1) | (2) |
|---|---|---|
| Countries excl.? | None | China |
| Height average | 0.276*** | 0.273*** |
| | (0.000) | (0.000) |
| Constant | -33.748*** | -33.314*** |
| | (0.000) | (0.000) |
| | | |
| Observations | 63 | 56 |
| Adjusted R-squared | 0.779 | 0.748 |

Notes: The first regression includes all nine countries (various birth decades since the 1930s), the second excludes China.

Table A.4a: Descriptive statistics for the explanatory variables used in the regression analyses

**Panel A: males**

| | China | | South Korea | | Taiwan | |
|---|---|---|---|---|---|---|
| **Variables** | **Mean** | **Std.Dev.** | **Mean** | **Std.Dev.** | **Mean** | **Std.Dev.** |
| Born 1960s | 0.395 | 0.489 | 0.312 | 0.464 | 0.290 | 0.454 |
| Born 1970s | 0.346 | 0.476 | 0.337 | 0.473 | 0.298 | 0.458 |
| Born 1980s | 0.209 | 0.407 | 0.292 | 0.455 | 0.312 | 0.464 |
| No schooling father | 0.334 | 0.472 | 0.124 | 0.330 | 0.113 | 0.317 |
| Primary schooooling father | 0.347 | 0.476 | 0.222 | 0.416 | 0.324 | 0.469 |
| Junior high father | 0.175 | 0.380 | 0.178 | 0.383 | 0.150 | 0.358 |
| High school father | 0.111 | 0.314 | 0.292 | 0.455 | 0.240 | 0.427 |
| College father | 0.033 | 0.180 | 0.184 | 0.388 | 0.172 | 0.378 |
| No schooling mother | 0.536 | 0.499 | 0.149 | 0.356 | 0.202 | 0.402 |
| Primary schooling mother | 0.280 | 0.449 | 0.341 | 0.474 | 0.310 | 0.463 |
| Junior high mother | 0.107 | 0.309 | 0.155 | 0.362 | 0.146 | 0.353 |
| High school mother | 0.062 | 0.242 | 0.267 | 0.443 | 0.234 | 0.423 |
| College mother | 0.015 | 0.120 | 0.088 | 0.283 | 0.108 | 0.311 |
| Years of educ. father | 5.699 | 4.293 | 9.180 | 4.955 | 9.282 | 4.441 |
| Years of educ. mother | 3.753 | 4.191 | 7.859 | 4.630 | 7.948 | 4.750 |
| Income above average | 0.102 | 0.303 | 0.224 | 0.418 | 0.102 | 0.303 |
| Income below average | 0.401 | 0.490 | 0.371 | 0.484 | 0.213 | 0.410 |
| Urban | 0.160 | 0.366 | 0.424 | 0.495 | 0.367 | 0.482 |
| China: Beijing | 0.012 | 0.107 | | | | |
| China: Tianjin | 0.006 | 0.074 | | | | |
| China: Shanghai | 0.011 | 0.104 | | | | |
| China northeast | 0.143 | 0.350 | | | | |
| China east | 0.547 | 0.498 | | | | |
| China west | 0.282 | 0.450 | | | | |
| South Korea: Seoul | | | 0.253 | 0.435 | | |
| South Korea southwest | | | 0.486 | 0.500 | | |

| | | | | |
|---|---|---|---|---|
| South Korea southeast | 0.261 | 0.440 | | |
| Taiwan:  Taipeh/North | | | 0.453 | 0.498 |
| Taiwan centre | | | 0.246 | 0.431 |
| Taiwan south | | | 0.301 | 0.459 |

Notes: Table reports the fractions (between 0 and 1) for most of the variables, except for the years of education of father and mother, for whom the years are reported. For example, 0.395 or 39.5% of the male height observations were born in the 1960s. Abbreviation “Std.dev.” is the standard deviation of the variable. Number of cases is the same as in the regression Tables (Table 4 and Table 5).

**Panel B: females**

| | China | | South Korea | | Taiwan | |
|---|---|---|---|---|---|---|
| **Variables** | **Mean** | **Std.Dev.** | **Mean** | **Std.Dev.** | **Mean** | **Std.Dev.** |
| Born 1960s | 0.400 | 0.490 | 0.350 | 0.477 | 0.337 | 0.473 |
| Born 1970s | 0.343 | 0.475 | 0.359 | 0.480 | 0.289 | 0.453 |
| Born 1980s | 0.221 | 0.415 | 0.216 | 0.412 | 0.303 | 0.460 |
| No schooling father | 0.362 | 0.481 | 0.114 | 0.318 | 0.148 | 0.356 |
| Primary schooooling father | 0.301 | 0.459 | 0.209 | 0.407 | 0.334 | 0.472 |
| Junior high father | 0.191 | 0.393 | 0.204 | 0.403 | 0.173 | 0.379 |
| High school father | 0.111 | 0.314 | 0.309 | 0.462 | 0.175 | 0.380 |
| College father | 0.035 | 0.184 | 0.164 | 0.371 | 0.170 | 0.376 |
| No schooling mother | 0.537 | 0.499 | 0.150 | 0.357 | 0.211 | 0.408 |
| Primary schooling mother | 0.245 | 0.430 | 0.309 | 0.462 | 0.390 | 0.488 |
| Junior high mother | 0.153 | 0.360 | 0.218 | 0.413 | 0.156 | 0.363 |
| High school mother | 0.054 | 0.227 | 0.264 | 0.441 | 0.161 | 0.368 |
| College mother | 0.010 | 0.099 | 0.059 | 0.236 | 0.083 | 0.276 |
| Years of educ. father | 5.676 | 4.420 | 9.211 | 4.698 | 8.850 | 4.459 |
| Years of educ. mother | 3.772 | 4.181 | 7.714 | 4.503 | 7.174 | 4.512 |
| Income above average | 0.083 | 0.276 | 0.198 | 0.399 | 0.081 | 0.273 |
| Income below average | 0.385 | 0.487 | 0.354 | 0.479 | 0.222 | 0.416 |
| Urban | 0.152 | 0.359 | 0.420 | 0.494 | 0.343 | 0.475 |
| China: Beijing | 0.013 | 0.113 | | | | |
| China: Tianjin | 0.006 | 0.077 | | | | |
| China: Shanghai | 0.008 | 0.088 | | | | |
| China northeast | 0.133 | 0.340 | | | | |
| China east | 0.555 | 0.497 | | | | |
| China west | 0.285 | 0.451 | | | | |
| South Korea: Seoul | | | 0.264 | 0.441 | | |
| South Korea southwest | | | 0.459 | 0.499 | | |
| South Korea southeast | | | 0.277 | 0.448 | | |

| | | |
|---|---|---|
| Taiwan:  Taipeh/North | 0.445 | 0.497 |
| Taiwan centre | 0.261 | 0.439 |
| Taiwan south | 0.295 | 0.456 |

Notes: Table reports the fractions (between 0 and 1) for most of the variables, except for the years of education of father and mother, for whom the years are reported. For example, 0.400 or 40.0% of the female height observations were born in the 1960s. Abbreviation “Std.dev.” is the standard deviation of the variable. Number of cases is the same as in the regression Tables (Table 4 and Table 5).

## Appendix Table A.5: Regressions with interaction terms, pooling heights of men and women

| | China<br>(1) | South Korea<br>(2) | Taiwan<br>(3) |
|---|---|---|---|
| Born 1970s | 0.48 | 1.62*** | 0.94** |
| | (0.116) | (0.000) | (0.029) |
| Born 1980s | 1.03*** | 2.70*** | 1.63*** |
| | (0.006) | (0.000) | (0.002) |
| Educ. parents * female | -0.06 | -0.06 | -0.03 |
| | (0.375) | (0.390) | (0.694) |
| Educ * higher income | 0.08 | 0.01 | 0.15 |
| | (0.306) | (0.886) | (0.136) |
| Educ. parents (years) | 0.13* | 0.15** | 0.15 |
| | (0.095) | (0.049) | (0.157) |
| High income than aver. | 0.16 | 0.97 | -0.52 |
| | (0.706) | (0.178) | (0.521) |
| Female | -10.35*** | -12.07*** | -11.63*** |
| | (0.000) | (0.000) | (0.000) |
| Urban | -0.47 | -0.65* | -0.30 |
| | (0.159) | (0.054) | (0.408) |
| China: Beijing | 3.68*** | | |
| | (0.000) | | |
| China: Tianjin | 3.26*** | | |
| | (0.000) | | |
| China: Shanghai | 4.71*** | | |
| | (0.000) | | |
| China Northeast | 3.47*** | | |
| | (0.000) | | |
| China East | 2.12*** | | |
| | (0.000) | | |
| South Korea: Seoul | | 0.21 | |
| | | (0.650) | |
| South Korea Southwest | | 0.08 | |
| | | (0.829) | |
| Taiwan: Taipei/North | | | -0.14 |
| | | | (0.746) |
| Taiwan center | | | 0.08 |
| | | | (0.860) |
| Constant | 165.62*** | 169.67*** | 168.65*** |
| | (0.000) | (0.000) | (0.000) |
| | | | |
| Observations | 2,119 | 979 | 1,089 |
| Adjusted R-squared | 0.514 | 0.629 | 0.550 |

Notes: The constant refers to somebody born in the 1970s, with an average income, and residing in a rural area. For China in columns 1 & 2, West represents the reference category. For South Korea, the constant refers to the South-East region, for Taiwan it refers to the South region. We adjusted for self-reporting bias and used regional and educational weights for China.

Appendix Table A.6: Replicating Tables 4 and 5 (first column) without the Islamic religious minority

| | (1) | (2) |
|---|---|---|
| **Gender:** | **Males** | **Females** |
| Born 1970s | 0.88* | 0.49 |
| | (0.061) | (0.212) |
| Born 1980s | 1.69*** | 0.97* |
| | (0.003) | (0.051) |
| Primary school father | 0.27 | -0.10 |
| | (0.592) | (0.821) |
| Junior high school father | 0.78 | 0.35 |
| | (0.221) | (0.468) |
| High school father | 0.48 | 1.05* |
| | (0.507) | (0.077) |
| College father | 3.99*** | 2.11** |
| | (0.000) | (0.046) |
| Income above average | 1.62** | 0.18 |
| | (0.021) | (0.753) |
| Income below average | -0.74* | -0.18 |
| | (0.093) | (0.613) |
| Urban | -0.12 | -0.48 |
| | (0.812) | (0.259) |
| China: Beijing | 5.27*** | 2.40*** |
| | (0.000) | (0.007) |
| China: Tianjin | 2.39** | 4.38*** |
| | (0.023) | (0.000) |
| China: Shanghai | 4.78*** | 4.45*** |
| | (0.000) | (0.000) |
| China Northeast | 3.80*** | 3.57*** |
| | (0.000) | (0.000) |
| China East | 2.29*** | 2.14*** |
| | (0.000) | (0.000) |
| Constant | 165.70*** | 155.70*** |
| | (0.000) | (0.000) |
| Observations | 991 | 1,151 |
| Adjusted R-squared | 0.104 | 0.065 |

Notes: The constant refers to no schooling, born in the 1960s, with an average income, and residing in a rural area. For China, West represents the reference category.

## Appendix Table A.7: Regional re-classifications for China, South Korea, and Taiwan

| Country | Province | Regional Classification |
|---|---|---|
| China | Beijing | Beijing |
| China | Tianjin | Tianjin |
| China | Shanghai | Shanghai |
| China | Hebei | East |
| China | Shanxi | North/Northeast |
| China | Neimenggu | North/Northeast |
| China | Liaoning | North/Northeast |
| China | Jilin | North/Northeast |
| China | Heilongjiang | North/Northeast |
| China | Jiangsu | East |
| China | Zhejiang | East |
| China | Anhui | East |
| China | Fujian | East |
| China | Jiangxi | East |
| China | Shandong | East |
| China | Henan | East |
| China | Hubei | East |
| China | Hunnan | North/Northeast |
| China | Guangdong | East |
| China | Guangxi | West |
| China | Hainan | East |
| China | Chongqing | West |
| China | Sichuan | West |
| China | Guizhou | West |
| China | Yunnan | West |
| China | Xizang | West |
| China | Shaanxi | North/Northeast |
| China | Gansu | West |
| China | Qinghai | West |
| China | Ningxia | West |
| China | Xinjiang | West |
| | | |
| South Korea | Seoul Metropolitan City | Seoul region |
| South Korea | Incheon Metropolitan City | Seoul Region |
| South Korea | Daejeon Metropolitan City | Southwest |
| South Korea | Busan Metropolitan City | Southeast |
| South Korea | Ulsan Metropolitan City | Southeast |
| South Korea | Deagu Metropolitan City | Southeast |
| South Korea | Gwangju Metropolitan City | Southwest |

| | | |
|---|---|---|
| South Korea | Gyeonggi Province | Southwest |
| South Korea | Gangwon Province' | Southeast |
| South Korea | Chungcheong Province | Southwest |
| South Korea | Gyeongsang Province | Southeast |
| South Korea | Jeolla Province | Southwest |
| South Korea | Jeju-do | Southwest |
| | | |
| Taiwan | Keelung city | Taipeh and Northern Taiwan |
| Taiwan | Taipei city | Taipeh and Northern Taiwan |
| Taiwan | New Taipei city | Taipeh and Northern Taiwan |
| Taiwan | Taoyuan county | Taipeh and Northern Taiwan |
| Taiwan | Hsinchu city | Taipeh and Northern Taiwan |
| Taiwan | Hsinchu county | Taipeh and Northern Taiwan |
| Taiwan | Miaoli county | Central Taiwan |
| Taiwan | Taichung city | Central Taiwan |
| Taiwan | Taichung county | Central Taiwan |
| Taiwan | Nantou county | Central Taiwan |
| Taiwan | Changhua county | Central Taiwan |
| Taiwan | Yunlin county | Central Taiwan |
| Taiwan | Chiayi city | Southern Taiwan |
| Taiwan | Chiayi county | Southern Taiwan |
| Taiwan | Tainan city | Southern Taiwan |
| Taiwan | Tainan county | Southern Taiwan |
| Taiwan | Kaohsiung city | Southern Taiwan |
| Taiwan | Kaohsiung county | Southern Taiwan |
| Taiwan | Pingtung country | Southern Taiwan |
| Taiwan | Ilan country | Taipeh and Northern Taiwan |
| Taiwan | Hualien county | Southern Taiwan |
| Taiwan | Taitung county | Central Taiwan |

## Appendix B: Comments on data processing and analysis

As our study focused on the period from the 1960s to 1980s and the year of measurement was 2010, the age range of this study is 21 to 50 years. This avoids including older teenagers who might have experienced growth at later ages than usual.[10] For a discussion of height-age profiles in earlier periods, see Choi and Schwekendiek, 2009; Pak et al., 2011; Schwekendiek and Jun, 2010. We did not include respondents born in the 1990s, as this would have resulted in too low a sample size.

On the other hand, final height is negatively impacted by shrinking due to old age. Yet, individuals shrink very modestly during this period, if at all, until 50 years of age; still quite moderately until the age of 60 years, and more thereafter (earlier studies by Chandler and Bock, 1991 arrived at faster shrinking rates, but they studied rural West-Australian populations of European origin born in the 1960s in which shrinking was fast, perhaps due to the lifestyle of hard labor common in rural Western Australia).

A recent study by Huang et al. (2013) on Chinese shrinking suggests that shrinking depends on socioeconomic variables. Poorer and less educated Chinese tended to shrink more at higher ages. They also found that shrinking was negligible before the age of 50. Given that we focus on the birth decades of the 1960s to the 1980s, we avoided potential shrinking effects; except in Figures 2 and 3, where we explicitly discuss the problem.

As no information on the birth date of the respondents was included in EASS 2010, we estimated birth decades indirectly, based on the respondent’s current reported age in years and the year of the interview (2010 minus current age in the cases of China and South Korea, as well

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[10] See also the older study by Sinclair and Dangerfield, 1998.

as 2011 minus current age in the case of Taiwan, as this survey was implemented later, see Table 2).

## Appendix C: Anecdotal evidence of small self-reporting bias in East Asia, especially in South Korea and Taiwan

One explanation for this small bias is the fact that East Asians are measured repeatedly throughout their lifetimes (e.g. during regular medical checkups in companies as well as due to the mandatory military draft in the case of Taiwan and South Korea). For example, South Korean teachers in schools used to make students stand during mandatory morning exercises in their height order. Height is also commonly entered in job applications in East Asia, whereas in Western Europe and North America, this is uncommon if not illegal. In sum, for various cultural and institutional reasons, East Asians seem to self-report their actual heights quite reliably, meaning that the bias caused by self-assessment is probably not too large.

## Appendix D: Comparison of the new measure with the ratio of male to female height

For early societies, anthropologists also used another measure for gender inequality of height, namely simply dividing male by female height (Gray and Wolfe, 1980; Ruff, 2002). This measure is highly correlated with our new measure (correlation coefficient is 0.86, see also Appendix Figure A.4) and has often been applied to early societies not displaying a strong upward trend in average height (Ruff, 2002). However, when applied to the 20th century, the simple ratio between male and female heights was shown to be much less correlated with other measures of gender inequality (Baten, 2018). Hence, we conclude that the gender inequality of height measure presented in formula (1) is the preferred indicator when considering the 20th century. We compared the trend estimates presented below with the simple ratio of male to female heights and observed almost identical results (Appendix Figure A.5).

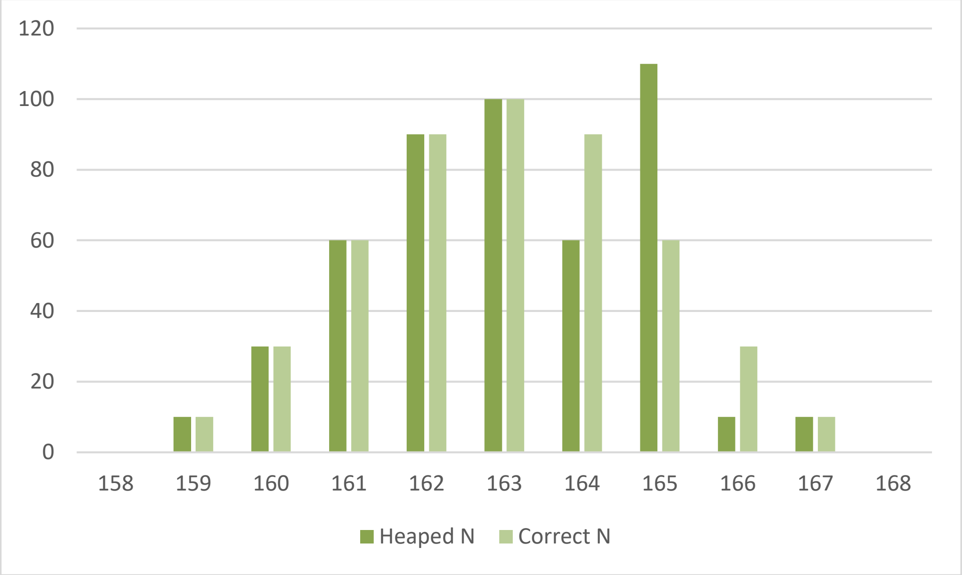
## Appendix E: Height rounding only has small effects on the estimates of height averages

Age heaping on preferred numbers is very similar to age rounding, in which the preferred number is often a full number, and the post-decimal numbers are then zero (when many people say “I am 45” instead of giving their true age of perhaps 44 or 46, a “heap” is created in the histogram, a higher bar than the others). This is similar for height rounding and heaping. Of course, when an average is calculated, not only is the heaped/rounded value influenced, but the surrounding values as well. Schneeweiss et al. discussed how strongly the degree of rounding/heaping needs to be to influence the mean, and find that it was insufficient in many real samples.

This can also be illustrated by a simple example. Imagine a height distribution with 480 observations, in which the true mean is 163 cm, but we add a substantial rounding on 165 cm: 50 observations are moved from the surrounding centimeter bins to the 165 cm bin. As a result, there are 11 times more individuals for whom 165 cm is reported, than for whom 166 cm is reported, and the mode is now 165 instead of the 163 cm. However, the mean (which also takes into account the surrounding observations) in the “heaping” sample is 163.02 cm, only 0.02 cm higher than the true one! This is robust to using alternative heaping patterns (for example, if the heaping is on 166 cm, the mean is still close with only 0.10 cm deviation).

| Height bins | Heaped N | Correct N | N*H heap | N*H correct |
|---|---|---|---|---|
| 158 | 0 | 0 | 0 | 0 |
| 159 | 10 | 10 | 1590 | 1590 |
| 160 | 30 | 30 | 4800 | 4800 |
| 161 | 60 | 60 | 9660 | 9660 |
| 162 | 90 | 90 | 14580 | 14580 |

| | | | | | |
|---|---|---|---|---|---|
| | 163 | 100 | 100 | 16300 | 16300 |
| | 164 | 60 | 90 | 9840 | 14760 |
| move 50 obs. | 165 | 110 | 60 | 18150 | 9900 |
| | 166 | 10 | 30 | 1660 | 4980 |
| | 167 | 10 | 10 | 1670 | 1670 |
| | 168 | 0 | 0 | 0 | 0 |
| | | | | | |
| | | 480 | 480 | 163.02 | 163.00 |



## Appendix F: Comparison of measured and self-reported height trends in China

We further checked our results comparing self-reported and measured heights, paying particular attention to China. We employed the same specifications as much as possible. How did heights develop in China using both self-reported and measured heights over time? Appendix Figure A.2 depicts an upward development from the 1960s to 1980s. Both self-reported and measured heights displayed the same trend for males (Panel A), although the latter series was consistently around 1.5 cm lower. The acceleration in welfare improvement after the 1970s is visible in both series. This was slightly less in the case of females (Panel B), for whom we found a slightly faster increase in self-reported heights in the later period, and even less so for measured heights. This might be due to the fact that the NCDRisk was based on the Sino-MONICA series sample for earlier birth decades and thus included a higher number of poorer provinces within China.