



Evolution of living standards and human capital in China in the 18–20th centuries: Evidences from real wages, age-heaping, and anthropometrics

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ABSTRACT

This article mobilizes and integrates both existing and new time series data on real wages, physical heights and age-heaping to examine the long-term trend of living standards and human capital for China during the eighteenth to twentieth centuries. Our findings confirm the existence of a substantial gap in living standards between China and North-western Europe in the eighteenth and nineteenth centuries. They also reveal a sustained decline in living standards and human capital at least in South China from the mid-nineteenth century followed by a recovery in the early twentieth century. However, comparative examination of age-heaping data shows that the level of Chinese human capital was relatively high by world standard during this period. We make a preliminary exploration of the historical implication of our findings.

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1. Introduction

One prominent feature that underpins the phenomenal catch-up of East Asia from very low levels of per capita incomes after World War II is the rapid accumulation of physical and human capital. [Godo and Hayami \(2002\)](#) compiled data on average years of schooling to show that the Japanese catch-up in average years of schooling preceded that of per capita income relative to the US in the pre-War period. Unfortunately, works with such a long-term perspective are relatively scarce given the paucity of systematic and comparable data, especially for China.¹ Similarly, despite the voluminous literature on China's long and tumultuous nineteenth century, which saw social and economic dislocation from the onslaught of Western imperialism and the devastating domestic rebellions, quantitative indications of a systematic kind are sorely lacking for long-term trend in welfare and living standards.

Our paper represents the first attempt to construct a more comprehensive profile of the evolution of Chinese living standards and human capital in the nineteenth and twentieth centuries based on the integration of large-sample based real wage and anthropometric evidences. Our data series confirm a general decline in living standards and human capital after the mid-nineteenth century followed by a recovery only at the turn of the century. Our real wage data also reveal Chinese living stan-

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¹ [Godo \(2006\)](#) extended the average years of schooling data to colonial Taiwan and Korea. For physical capital accumulation in East Asia, see the controversial summary article by [Paul Krugman \(1994\)](#). For a summary of the East Asian path of labor-intensive industrialisation based on quality human capital formed in the traditional sector, see [Sugihara \(2007\)](#), "The Second Noel Butlin Lecture."

dards were probably closer to the relatively backward parts of Europe but lower than North-western Europe in the eighteenth and nineteenth centuries. So contrary to recent revisionism (Pomeranz, 2000; Lee and Wang, 1999), our studies confirm the traditional view that the divergence in living standards and per capita incomes between Europe and China already existed before the industrial revolution and only widened from the nineteenth century and afterward. However, in contrast to the findings based on real wages and heights, our age-heaping index – a measure of Chinese numerical abilities – reveals a relatively high level of Chinese human capital, which was closer to that of North-western Europe for eighteenth and nineteenth centuries than countries with a comparable low level of living standards.

We explore the historical implication of this intriguing combination of relatively low living standards but high human capital in China at the time. The concluding section makes some preliminary discussion on the unique institutional features in traditional China, such as the Civil-Service Examination, a unified character-based language and a precocious government bureaucracy, as factors that contributed to relatively higher level of literacy and numeracy without necessarily generating sustained economic growth to support a higher living standard in the early modern era. We posit that this large reservoir of human capital in early modern China and East Asia formed important strategic factors to underpin the region's rapid economic catch-up in the modern era once the institutional and ideological changes were accomplished.

The rest of the paper is divided into three sections to discuss the findings derived from real wage, heights and age-heaping, followed by a concluding section.

2. Real wages

In the debate on the comparative standard of living of Asians and Europeans on the eve of the Industrial Revolution, a recent wave of revisionist scholarship has claimed Asian living standards were on a par with those of Europe in the eighteenth century. However, the evidence brought to this debate is fragile, using indirect comparison of scattered output, consumption or demographic data. This contrasts with our knowledge of real incomes in Europe where scholars since the mid-nineteenth century have been compiling databases of wages and prices for European cities from the late Middle Ages into the nineteenth century when official statistics begin.²

The ideal measure for comparison would be per capita GDP, which has the advantage of being the most acceptable measure of the overall economy and productive capacity, despite the long-held caveats that it was not able to capture non-market income often crucially important for developing economies, and distributional dimensions. Unfortunately, there are no meaningful GDP series for China before the twentieth century.³ The influential estimates by Maddison are largely guess-work based on backward projection from twentieth century estimates. While highly questionable, they might still be useful as a guide for rough comparisons across benchmark years, but they give little indication of fluctuations between the benchmarks.

Recent studies by Allen et al. (2007, 2009) represent the most ambitious attempt to use real wages to fill this gap for China in the eighteenth and nineteenth centuries. The wage series in these studies are constructed from data obtained from Chinese imperial ministry records, merchant account books and local gazetteers, which have been deflated using appropriate cost of living indices reconstructed from consumption baskets. The Allen et al. paper concentrates on the wage histories of Canton (south China), Beijing (north China), and Suzhou and Shanghai in the lower Yangzi (east China), because they are comparable to the large cities in Europe and Japan for which we have similar information.

While the Allen et al. study is the most comprehensive so far in terms of data coverage and methodology, their comparison concentrates only on the real wage of urban unskilled workers in major cities of Europe and China. This raises questions of the representativeness and comparability of their findings.⁴ Despite these qualifications, which were extensively discussed in the Allen et al. paper, we have reason to believe their finding represent a better approximation of the relative levels of real income at the two ends of Eurasia for the eighteenth and nineteenth centuries than any available alternative estimates. Clearly, future research is needed to produce more definitive findings in this area. Fig. 1 reproduces one of their real wage comparisons, which paint a less optimistic picture of Chinese or Asian performance than the revisionists suggest.

Fig. 1 confirms the traditional view that the divergence in living standards between major urban centers of China and those of the Netherlands and England was already present in the eighteenth century. The standard of living of workers in London and Amsterdam was much higher than that of workers in Beijing or Suzhou in the eighteenth century. But a major surprise is that unskilled laborers in major cities of China – poor as they maybe – had roughly the same standard of living as their counterparts in central and southern Europe, the Ottoman Empire, India, and Japan for the larger part of the eighteenth century.⁵

Secondly, from the mid-nineteenth century, real wages in the industrial core of Western Europe such as Leipzig began to overtake those of China. In contrast, Milan remained at a similarly low level as China during this period. By the twentieth century, enough progress had occurred in even the backward parts of Europe (as shown in Milan) and Japan that their stan-

² See Allen et al. (2007) and (2009) for a review of the data issues and Ma (2004) for a general review of the revisionist scholarship.

³ See Fukao et al. (2007) for a review of GDP data in East Asia.

⁴ One obvious question is the representativeness of the largest and fastest growing cities in Europe. Allen (2001) has shown that in smaller English cities such as Oxford, real wages were much lower than those in London, but they were still higher than in China (also see Bassino and Ma, 2005).

⁵ See Allen et al. (2009), Fig. 6 for other Asian cities. As their paper finds no major differences in levels of real wages among the three cities of Beijing, Canton and Suzhou/Shanghai, the real wage series for Canton is omitted in Fig. 1.

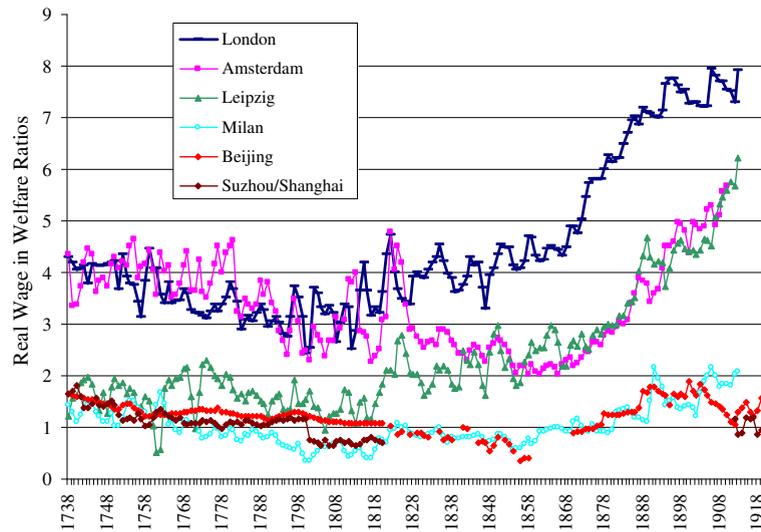


Fig. 1. Real wage trends in China and Europe. Source: Allen et al., 2009. Notes: All real wages are converted to welfare ratios. A welfare ratio of one indicates subsistence. For details on welfare ratios, see Allen et al., 2009.

dards of living were beginning to creep above those in China, while London increased the lead over Beijing. This is what we term as the second divergence in the modern era.

Thirdly, and most relevant for our perspective, is the trend in the real wage series for Beijing (Fig. 1). This series is composed of three series linked together: the first one for the eighteenth century based on the average of large number of scattered wage information; the second series based on Sidney Gamble (1943), which runs from 1807 to 1903, and the third series is for 1900–1925 from Meng and Gamble (1926). Among these series, the Gamble (1943) series most importantly spans the entire nineteenth century. As seen in Fig. 1, it points to a clear and sharp drop in real wages during the mid-nineteenth century, a period known for the severe economic dislocation caused by Taiping Rebellion that devastated large swathes of southern and eastern China.

3. Heights

Historical data on heights have long been an important complementary measure of living standard (Fogel, 1994; Komlos, 1994; Steckel, 1995, 2009; Komlos and Baten, 1998; Komlos and Cuff, 1998). While heights do not measure the purchasing power aspect of living standard, they are better at capturing the ‘biological’ component of welfare such as health, life expectancy and the quality of nutrition. Compared with GDP, height is particularly sensitive to the economic inequalities and the welfare development of the lower income strata, which corresponds more closely to the groups of unskilled workers in the real wage study.⁶

Care needs to be taken about interpretation of heights in international comparison due to differences in intergenerational height transmission and nutritional habits, which might not be directly related to economic scarcities, at least in the short run. For example, the Dutch and Scandinavians today still consume far more milk than Southern Italians and Japanese, possibly a legacy of economic scarcity of the past.⁷ Even within China, there exist regional differences with Northerners far taller than people in the South. Nonetheless, with rapidly changing nutritional and economic conditions, there has been a narrowing of regional differences in heights as well as a convergence of Chinese heights to the European and North American level more recently.⁸

For this research, we mobilize several large data sets of heights of Chinese who migrated from South China to the United States, Australia and Indonesia during the nineteenth and twentieth centuries, or who worked in modern organisations in

⁶ Height is closely correlated with income; the poorer strata of a population on average are shorter than those in the better off strata. In a low income economy, an increase in income will raise average height, other things being equal. Average height will also increase if income distribution improves such that the lower income strata are better able to acquire the inputs necessary for human growth. Conversely, where inequality worsens average height might decline even in the presence of increasing GDP. See Steckel (1995).

⁷ Lactose intolerance, the inability to drink milk without diarrhoea, may have played a limited role in genetically predisposing some populations to shorter stature. East Asians, Native Americans and some African people suffer from lactose intolerance (see Mace et al., 2003).

⁸ In the early twentieth century the difference between north and south China was in the order of 6 cm, compared with about 3 cm in 2000 for populations of roughly the same socioeconomic status (Morgan, 2009, Table 7). Also, contemporary educated young male adults in Beijing are not much shorter than white American males. The average height of the birth cohort of 1978–81 in urban Northern China was 173.0 cm (ranged from 171.2 to 175.8 cm) for the pooled ages age 19–22 years, which is only 2.2 cm shorter than the United States average in the 1980s (175.8 cm); Beijing urban males were 175.5 cm on average (China, Ministry of Education, 2002). Large-scale anthropometric surveys of children 7–22 years have been conducted in China since the late 1970s about every five years. Analysis of the 1979–1995 surveys and survey methodologies is reported in Morgan (2000).

China. We believe that the reported height trend and – with certain qualifications – their levels during the nineteenth–twentieth century is likely to be a robust long-term indicator for nutritional quality and *ceteris paribus* the living standards at least for the Southern Chinese. Below we explain our data sets in six different categories.

- (1) *Immigrants to Indonesia*: Baten and Hira (2008) made use of a large data set of Chinese migrants to Indonesia originally measured by the anthropologist Bernhard Hagen in the 1880s. Most of the observations were made in 1885 and 1886, with some perhaps in 1887.⁹ The occupations of the Chinese were described as “mainly agricultural.” Fortunately, Hagen reported the ages so that the approximate birth years can be calculated. Overall, Hagen measured no less than 15,722 Chinese males who had migrated to Indonesia. Our data set made use of 12,678 subjects, aged from 23 to 50 years. We discarded all those above 50 and below 23 years of age to exclude the effects of residual growth in our data set. We also collected a much smaller data set of migrants to Suriname (159 cases) for the birth cohort of 1830–1834 to 1845–1849. As explained later, they reveal similar height features to migrants to Indonesia.
- (2) *Prisoners in the United States*: Carson (2006) collected a sample of 1472 Chinese male immigrant workers who were incarcerated in the United States mostly for petty crimes.
- (3) *Prisoners in Australia*: Morgan (2009) compiled a data set of 1492 Chinese imprisoned in Australia between the 1850s and 1920s, who were from South China and who were mostly born between the 1810s and 1880s. Many arrived during the “Gold Rush” period of the 1850s. When the alluvial gold petered out, those who remained in Australia mostly turned to rural occupations and were generally in a lower socioeconomic group than Chinese migrants who arrived from the 1880s.
- (4) *Migrants to Australia*: In the later decades of the nineteenth century another wave of Chinese migrants, also mainly from South China, arrived in Australia. Somewhat different from the prisoners’ sample, they included many small merchants, market gardeners and tradesmen who went to destinations such as Melbourne and Sydney (Morgan, 2006a). Those who settled in northern Australia, such as Queensland or the Northern Territory, were engaged in mining and agriculture and they were more typical of the earlier gold-rush period migrants; they were also shorter than those residing in Melbourne or Sydney. The current dataset numbers 3692 subjects.¹⁰
- (5) *Migrants to the US*: From the *National Archives and Records Administration* (NARA) archive of the Pacific Region, we obtained a small data set of heights ($N = 360$) from the ship lists of Chinese migrants to the US or returning to China. Moreover, this archive also holds the National Archives microfilm publications of passenger manifests for ships arriving at San Francisco, 1893–1957. The manifests list the height and age of each passenger from 1907 to 1948, and the same is true for most of the immigration files.
- (6) *Employees of Government Organisations in China*: The last data set discussed comes from government enterprises and agencies, who measured their employees in the 1930s and 1940s as part of a medical examination system. Most of them were born between the 1890s and the 1920s, with some teenagers from the early 1930s (Morgan, 2004). The largest group was railway workers, but there were also employees of government, financial or other institutions.

The region of birth is relatively homogenous: the south, and the province Guangdong in particular.¹¹ Only in the case of the government employees (sample 6) was the regional spread larger, but we took care to extract a regionally homogenous series – unskilled railway workers from South China. We can therefore assume that the estimates approximate trends in Southern China.

Fig. 2 gives a plot of the trend level of different time series of Chinese heights as described in the sample. Two features stand out. Firstly, the shortest Chinese were those who went to Indonesia as contract worker as well as those that went to Suriname.¹² The heights of prisoners in both Australia and the United States were the second shortest. Clearly, among the tallest are the migrants to the US and Australia. Interestingly, migrants to the Australian Northern territory were shorter than those that resided in Melbourne and Queensland. Finally, the railroad employee data set for South China had relatively high values.

We believe the observed differences in our samples seem a reasonable reflection of the selectivity biases among the migrants who comprise the samples used here. It is likely that those who went to more attractive locations had to incur higher costs of migration and thus might have been slightly positively selected. This might have been the case for Chinese migrants to the United States and Australia, many of whom funded their passage through debts securitised against property or other family assets (summarized in Morgan, 2009). Those in Northern Territory, who were the shortest of the later migrants to Australia, are a case in point: they could reach Port Darwin more cheaply via Singapore than the eastern seaboard cities of Melbourne or Sydney, and they were mostly engaged in mining or remote area agriculture rather than in urban commer-

⁹ Murray (1994) found a citation to the study in another anthropological study of the 1920s, and we were able to locate the original text (in German) at the University Library Hamburg.

¹⁰ The data are from the National Archives of Australia (NAA) series B13/0, B78/1, J2482, and E752/0, which comprise ‘Certificate Exempting from Dictation Test’ (CEDT) and a ‘Statutory Declaration’ for Chinese resident in Australia after 1901 who wish to leave Australia and return. Detailed description of these series can be obtained from the NAA online search facility at www.naa.gov.au and the use of the Australian immigration records for anthropometric research is discussed in Morgan (2006b).

¹¹ All measured Chinese immigrants were reported to have come from the South (usually Canton) or simply “China”. Our statistical *t*-test reveals that the differences in mean heights for migrants identified as Canton or another place in South China and “China” groups as indistinguishable at the 1 per cent level. For the predominance of Guangdong and Fujian origin of overseas Chinese migrants in the nineteenth century, see Ge et al. (1999), pp. 191–201.

¹² The Surinam sample not shown in the figure confirms a similar height levels with a clear downward trend from the 1840s, see Baten and Hira (2008).

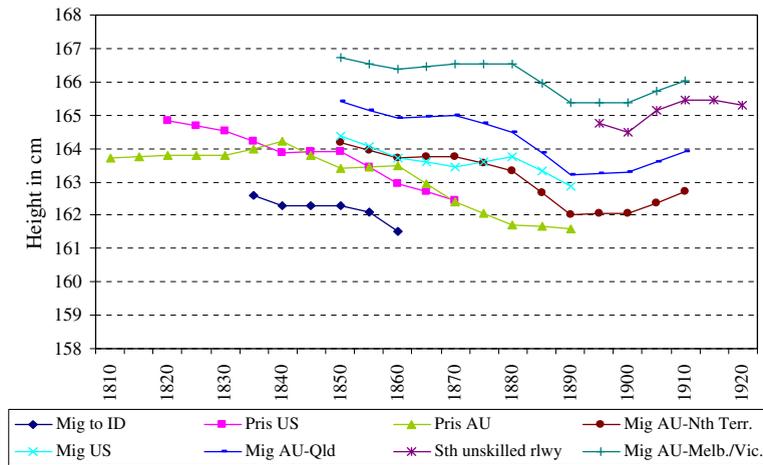


Fig. 2. Trends of Chinese height samples by Birth Cohort. Source: See text. Notes: Mig to ID, Migrants to Indonesia; Pris US, Chinese prisoners in the United States; Pris AU, Chinese Prisoners in Australia; Mig US, Migrants to the United States; Sth unskilled rlwy, unskilled railway workers from south China; Mig AU-Nth Terr, Migrants to Australia's Northern Territory; Mig AU-Melb./Vic., Migrants to Melbourne/Victoria; Mig AU-Qld, Migrants to Queensland; The reported height of the Chinese to Australia for both prisoners and migrants were adjusted for age-related shrinkage as explained in Morgan (2009).

cial activities. Finally, the relatively high value of the unskilled railroad workers in South China can be explained by the fact that these government employees were often regarded as a kind of elite workers with literacy level higher than the average working population (Morgan, 2004).

Secondly, despite this heterogeneity, we can discern clearly a broad common trend among these different series. While the height trend seems to have been stable up until the 1830–1840s, all series started to decline from the mid-nineteenth century, which coincided with the devastating Taiping rebellion. Moreover, an unexpected finding is that most of the series, following what seems like a stagnation – at best a mild recovery – in heights during the 1860s and 1870s, revert back into a fairly substantial and sustained decline all the way into the 1880s and even 1890s. This decline seems to have bottomed out towards the turn of the last century with a rebound and recovery in the first two decades of the twentieth century. The comovement of these series is remarkably consistent.

We believe that systematic selection biases in any one direction are less likely as our data sets consist of large numbers of South Chinese migrants who went to different locations in both developed and developing countries with varying entry dates and measured by different authorities.¹³ We also make a cross-check against the only independent height series for non-overseas migrant available during the nineteenth century: Chinese residents (largely of Cantonese and Fujianese origin) in Taiwan still under Qing rule (Olds, 2003). Measured by Japanese colonial authority in the early twentieth century, the height trend for male and female reveal nearly identical patterns of decline from the mid-nineteenth century, followed by stagnation during the 1860s and 1870s, and a renewed and sustained decline in the 1880s and 1890s.¹⁴

In Fig. 3, we summarize these disparate sample series into a single continuous but notional series that we believe is representative of the height trend of the lower and working class Southern Chinese male in 1810–1920, but with sufficient human capital and wealth to move to Australia. The series splices together the Australia prisoner series for 1810–1840 with the migrant series estimated for migrants in the Northern Territory, whose occupation backgrounds is similar to the prisoners, and the gap 1840–1850 is filled by simple linear interpolation.¹⁵ We also plot this trend line against other height series for international comparison. These series were adult males of broadly comparable social class to our Southern Chinese series and regionally representative for their country population as a whole (see Baten, 2006).

Fig. 3 clearly indicates that the northern Europeans (Netherlands) were taller and became even taller after the mid-century. The southern Europeans (Italy) were shorter than the Chinese with little upward movement in stature until the 1860s, after which their heights began to rise above the Southern Chinese. Fig. 3 thus confirms the so-called second divergence where both Dutch and Italian heights starting an upward trend from the mid-nineteenth century following rapid industrialization, while Chinese height stagnated or declined thereafter.¹⁶

¹³ See Fig. 8 in Morgan, 2006a for the year of arrival for some of Chinese immigrants in Australia.

¹⁴ See Olds (2003), Figs. 2 and 3, which are partly reproduced in Fig. 3 in this article.

¹⁵ The original series were estimated in decadal units. Linear interpolation between the decal mid-points have been used to create a five-year series.

¹⁶ We can place our Southern Chinese height data in a larger sample of the heights in all European countries. An appendix to Baten (2006) presents the height estimates for all European countries with 500,000 and more inhabitants for the birth cohorts 1850, 1890, and 1920 (available from: <http://www.wiwi.uni-tuebingen.de/cms/fileadmin/Uploads/Schulung/Schulung5/Paper/eurohgt.pdf> accessed May 7th, 2009). In 1850, the Southern Chinese height of around 164 cm, is shorter than the average height of 168–169 cm in those European countries with tall inhabitants (Scandinavia, Ireland, some parts of later Yugoslavia) but surpasses the 160–162 cm average attained in those countries with short populations (Portugal, Spain, Italy). Overall, seven out of 36 countries or about one fifth of European countries had lower heights than those of Southern China. By 1890, however, all European populations except Portugal were taller than Southern China, and by 1920, Southern China stood at the bottom of the European height distribution.

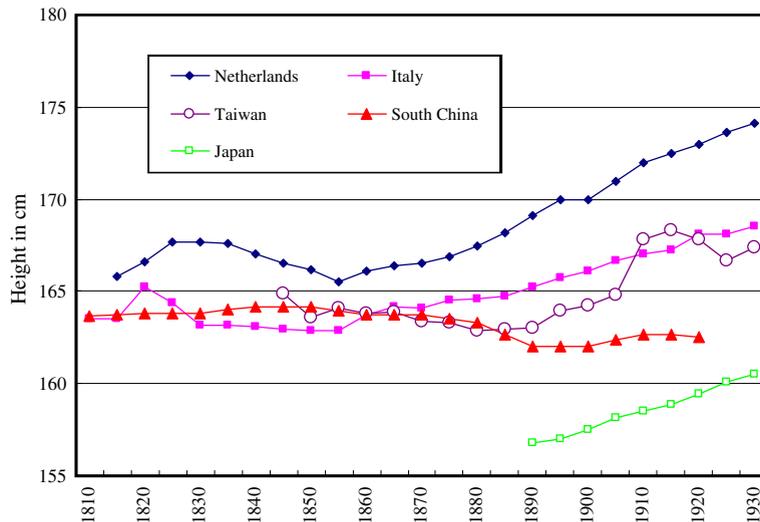


Fig. 3. A notional trend of secular height of Southern Chinese in 1810s–1920s in comparative perspective. *Notes:* Italy – calculated from A'Hearn (2003), Netherlands – calculated from Drukker and Tassenaar (1997), For Taiwan, 1845–1900 from Olds (2007 Model 2 for Male in Table 3. 1900–1930 from Morgan and Liu (2007); South China see text and Fig 2; Japan is calculated from Bassino (2006) and Shay (1994).

Perhaps more interesting is that the Southern Chinese seemed to perform poorly in the East Asian context. As shown in the data, although the Japanese started as unusually short, they managed to grow at a rate of about 1.0 cm a decade from the late nineteenth century. More strikingly, heights of Chinese in Taiwan (largely of South China origin) are almost non-distinguishable both in trend and level during the nineteenth century but grew rapidly from the early decades of Japanese colonialism from the beginning of the twentieth century (Olds, 2003; Morgan and Liu, 2007). Overall, we see a case of China lagging behind the better performers during the nineteenth–twentieth centuries.¹⁷

4. Age-Heaping

Recently, new research based on the use of age-heaping measurement has made it possible to quantify numeracy in comparative and long-term perspectives. This line of research was pioneered by Mokyr (1983) in the modern economic history context, and by Duncan-Jones (1990) for the study of ancient economies (after some earlier demographic studies, see Bachi, 1951). But recently, Crayen and Baten (forthcoming-a,b) have compiled large international data sets that allow global comparisons. The age-heaping strategy is based on the tendency of poorly educated people in the past to round their age. For example, when asked their age they answer more often “40”, when their actual age may in fact be 39 or 41 years. Conversely, better educated people are more likely to report their exact age. The age-heaping index (also called a Whipple index) is a measure of the concentration or degree of age-heaping between 23 and 62 years inclusive and is represented as follows:

$$WI = \frac{5 * \text{number of ages ending in a 0 or a 5}}{\text{number of all ages}} * 100 \quad (1)$$

Therefore, an index equal to 100 indicates the absence of age-heaping and magnitude of the index being above 100 indicates the degree of age-heaping.

A wide range of research has confirmed a strong relationship between illiteracy and age-heaping especially for Less Developed Countries (LDCs) after 1950. For example, a correlation coefficient of 0.63 has been found for a sample of about 270,000 individuals, organized by 416 regions, ranging from Latin America to Oceania. The data from the PISA (Programme for International Student Assessment) results for numerical skills yielded an even higher correlation coefficient (A'Hearn et al., 2009, Appendix). This correlation has also been confirmed for the nineteenth century data (A'Hearn et al., 2009; Crayen and Baten, forthcoming-b). Age-heaping index reflects numerical skills even more than literacy skills, which could be more important for technical, commercial and craftsmen activities than literacy.

The appeal of age-heaping methods is the ready availability of age-information for countries such as China where systematic sources of historical numeracy or literacy information are largely absent. Before we present our findings, it is important to clarify some specific issues related to the use of age-heaping measures in the context of traditional China. We perform a test to examine the linkage between literacy and numeracy using an exceptional sample of Chinese migrants in the US,

¹⁷ The unusually short level of Japanese heights in the nineteenth and twentieth centuries has been much noted and may be associated with a lack of protein in a largely vegetarian diet until quite recently. Here our comparative analysis focuses on its trend, which is unequivocally from the 1880s.

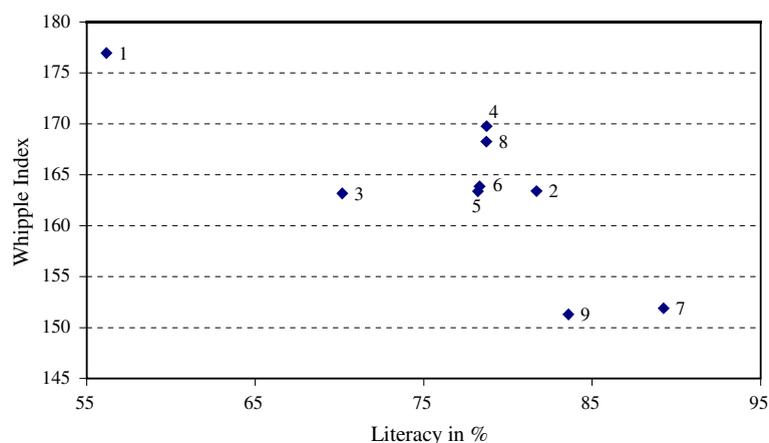


Fig. 4. Literacy and Age-heaping (Whipple Index) by nine different occupational classes among Chinese immigrants to the U.S. *Notes:* See the text. The sample size for the nine occupational categories (from one to nine) is: 178, 153, 239, 268, 202, 415, 158, 627, and 195. The nine occupational categories contain all together 150 different specific categories with category 1 having the lowest average income and group 9 the highest.

which provide not only age-information but also literacy (which includes both Chinese as well as English reading and writing skills) and occupational categories. This is a data set of 2435 Chinese males in the United States, 220 of whom were US born. The data, extracted from the Individual Public Use Microdata Set (IPUMS) data set of 1850–1910, are a representative sample based on the US censuses (Ruggles et al., 2004). We exclude the females (their number was too small for reliable analysis) before calculating age-heaping for those of the birth decades of the 1830s–1880s.

For our purpose, we use the standard occupational classification used by the US Census to create nine categories for the 2435 Chinese males between 23 and 72. The occupations ranged from income level of 600 dollars per year in 1950 prices (group 1) to between 1500 and 2000 (group 5), and to more than 2500 (group 9). The distribution of incomes was not linear, and some occupations accounted for a large share of the Chinese population, so we took care that sufficient numbers of observations fell in each group.

Fig. 4 reveals a high negative relationship (with a correlation coefficient of -0.8) between literacy rates and Whipple Index for these nine occupation categories.¹⁸ More interestingly, this correlation seems actually tighter than the correspondence between income categories and literacy rates. While the higher income groups 7 and 9 had the highest literacy rates, and the poorest group 1 has the lowest rate, occupation categories 4 (mainly launderers) and 8 (mainly miners) or group 2 (domestic servants) in fact have similar levels of literacy rates. Thus, we are reasonably assured that age-heaping index is good predictor for literacy rates and human capital in China.¹⁹

Below we describe six different data sets for our age-heaping series:

- (1) The Qing archives of the Imperial Board of Punishment contain a record of criminal cases of Chinese farmers and peasants involved in various property crimes, rental conflicts, usury or domestic conflicts during the late seventeenth and eighteenth centuries. The court files as published covered a large number of Chinese regions. Overall, we have 602 reported ages between 23 and 72, which allows some point estimates for the late seventeenth and early eighteenth century.²⁰
- (2) The data file for immigrants to Indonesia is the same as those for the height series.
- (3) We collected a smaller data set of 193 Beijing Chinese soldiers born in mid-nineteenth century. Although a small sample, these data are particularly valuable as other nineteenth century data consisted mostly of overseas migrants. The sources are from the Qing archive and consisted of soldier lists from the Chinese army (partially Manchu), which were taken by Chinese officers between 1902 and 1911.²¹

¹⁸ Without using the classification of occupational categories, we can also confirm this negative relationship with a logit regression, which regresses a dummy variable of people who reported their ages in the multiples of 0s and 5s on a dummy variable of literacy. Our result shows that people who reported ages in 0s and 5s are 3% less likely to be literate than those who did not, which is statistically significant at 10% level. The small marginal effects (3%) are expected given that this is a fairly literate sample and that not all people who reported their ages in round numbers are illiterate.

¹⁹ We also checked whether the Chinese use of animal cycles for their birth years may lead to age-heaping of a different sort rather than on multiples of 5s or 0s. We checked the age-heaping around the dragon year of birth – the most popular and auspicious animal sign for a birth year – for Chinese migrants to the US and found they were far less marked than heaping on multiples of 5s.

²⁰ The censorial section of the board of punishment (*Xingke tiben*) is an important archival source for a number of reasons, not only the age statements. The memorial documents contain information on land prices, land rents, interest rates ('usury'), among other personal and household data, covering all Chinese administrative regions. A small part of these memorials, especially from the Qianlong period (1735–95) have been published (Historical Archive No. 1 1981). Allen et al. 2007 also made use of wage information from these sources. Ages we used in those sources only include self-reported ones by "criminals" still living at the time.

²¹ The No. 1 Historical Archive, Beijing, Shuntian Fu archive, microfilm reel No. 254. We thank Hans-Ulrich Vogel for helping with the access to this valuable source.

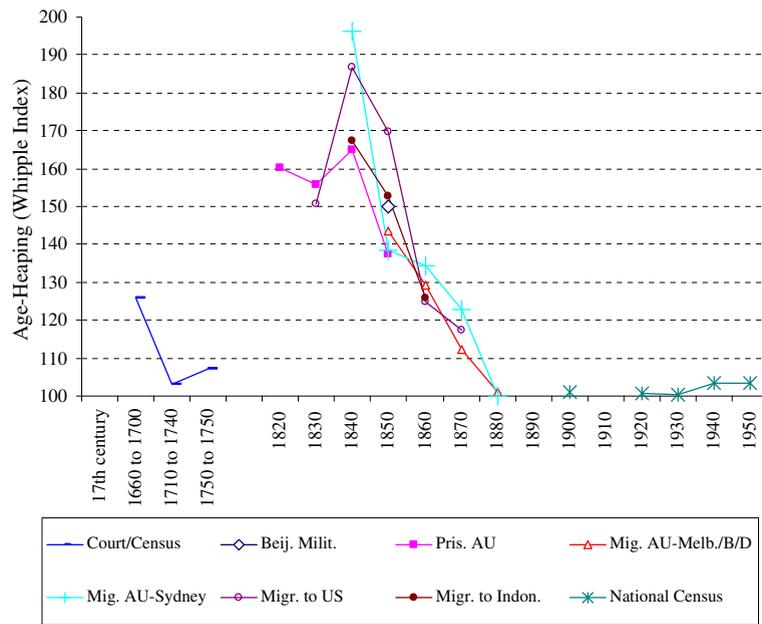


Fig. 5. Trends of age-heaping among a variety of Chinese samples by Birth Cohort. Note: see the text. “Mig. AU-Melb./B/D” were there migrants recorded in the archives of Melbourne, Brisbane, and Darwin. Age-heaping samples below 50 were discarded.

- (4) Two data series for Chinese immigrants to Australia are used to estimate age-heaping. The first is the same as the height series discussed above for migrants to Melbourne, Brisbane and Darwin. The second series is a recently compiled dataset of 8209 Southern Chinese immigrants who lived in Sydney, or elsewhere in the state of New South Wales in Australia, from the ST84/1 series at the NAA, Sydney Office. This series has only been used to estimate age-heaping and is independent of the first series used to report heights.²²
- (5) The data set of 2435 Chinese males in the United States as described earlier.
- (6) We use the first Chinese nationwide census undertaken in 1953 to calculate Whipple Index for those born in the 1900s and 1910s, in order to complement the eighteenth and nineteenth century data with an endpoint in the early twentieth century.

Fig. 5 plots the Whipple indices of the different data series.²³ The late seventeenth and early eighteenth century data from the Board of Punishment files reveal a rather modest level of age-heaping of about 110. It is important to note that most European countries reached such a low level not before the late eighteenth century, whereas the early eighteenth century levels of France and Germany were much higher (in the range of 160–220).²⁴ We do not have data for the period between the early eighteenth century and the 1820s. But for series starting from the 1820s, the picture that emerged in Fig. 5 is that for almost all series of age-heaping indices as organized by birth-decades rose and peaked around the 1840s, with that of the US migrants rising to as high as 170–190.²⁵ A similar spike in age-heaping is also confirmed for the Beijing soldiers in the period 1840–60, with a value at 150. But from the 1860s (birth cohorts) onward, Fig. 5 reveals a huge improvement in age-heaping almost

²² The Sydney ST84/1 series only contains the CEDT (also known as a Form 21) and does not include the Statutory Declaration (Form 22), which shows data related to occupations, residences, and other information useful for analysing height trend.

²³ For calculating age-heaping, we aggregate all age statements into the age groups such as 23–32, 33–42, and 53–62, and denote those born mostly in the 1850s as “1850” in the graph (even if this sometimes refers to those born actually 1847–56). This methodology is common in the age-heaping literature to ensure that age-heaping is estimated more conservatively than the obvious alternative to estimate age brackets 20–29, 30–39, 50–59 and so on. The problem with the alternative method is a strong age-heaping on, for example, age 50, in societies with low life expectancies leaving fewer survivors past age 53. Similarly, there will be more survivors at age 55 rather than age 59. Thus, taking age brackets 23–32 etc. places the most strongly preferred age 30 and 25 to the middle of the distribution, hence minimizing this bias.

²⁴ We also located a very small data set of about 50 seamen who found shelter in Japan during a storm. Their Whipple Index turned out to be as high as 213. The sample size is too small to be meaningfully included here. But it is plausible that levels of literacy and numeracy were very low among the class of seamen or pirates who were usually social outcasts barred, for example, from taking part in the Civil-Service Examination system, see Wakeman (1997), chapter 1. Data on Chinese seamen are from Ryūkyū ōkoku hyōjōsho monjo henshū iinkai (1988).

²⁵ For the US migrant sample, average age by birth decade is relatively constant at 30–36 (except for the middle cohort of those born in the 1860s, with an average age of 41), so we believe that our result is not biased by possible differences in the age composition of the various samples.

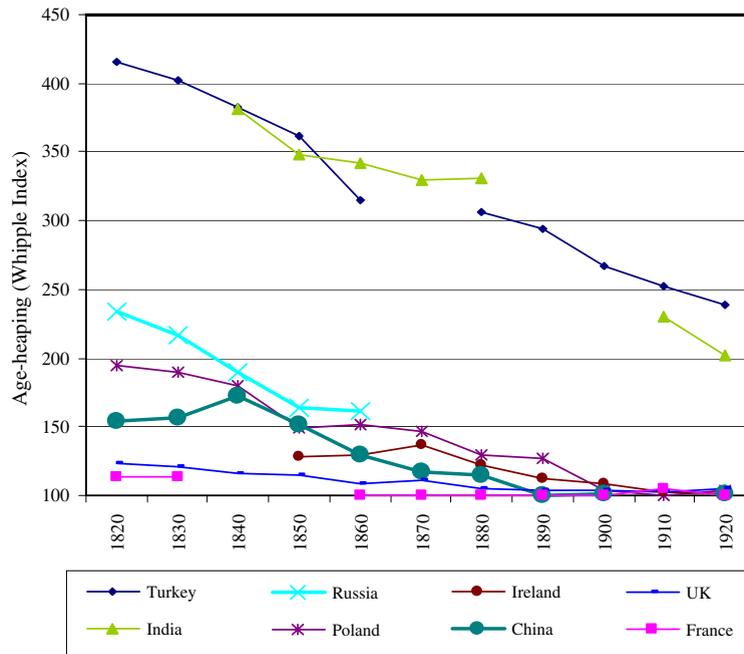


Fig. 6. Age-heaping in China in international comparison. Sources: China is an average from the data reported in the text. The sources for the other countries are provided in Crayen and Baten (2009). For India, this includes only the part of the country included in the late-nineteenth C censuses (age-heaping might have been higher for other regions). Poland refers to a weighted average of Russian, Habsburg, and Prussian Poland. Russia reflects the provinces which form today's Russia. Ireland excludes North Ireland. The Turkish values reflect the whole country after the 1880s, and the province of Kars before that (which Crayen and Baten, 2009 judge as broadly representative for the Turkish average). We thank Dorothee Crayen for assisting us with relevant data and information.

across all the data series.²⁶ By the early twentieth century, age-heaping seems to have largely disappeared based on the National census data of the 1950s.²⁷

Fig. 6 organizes the various age-heaping measures for China into one single notional series to cast it in international context. Taking an average of the Chinese age-heaping values reported above yields values around 160 during the 1820s, rising to 170 during the mid-century crisis period, and declining afterwards until full age numeracy is reached among the birth cohort of the 1890s (with a Whipple Index of 100). Despite the mid-nineteenth century surge, the Chinese degree of age numeracy thus measured were impressive by international comparison, being among the highest in the world along with Western and Eastern Europe in the nineteenth century (see Crayen and Baten, forthcoming-b). In fact, we could make a general case for East Asia. The earliest source on Japanese age-heaping in 1879 (published 1882 for the region which is now Yamanashi) that could be located so far did not show any age-heaping for the birth cohorts of the early nineteenth century, nor did the Taiwan list from 1905, taken by the Japanese colonial government.²⁸ Fig. 6 shows that while UK and France were achieving better values already in the early nineteenth century, Poland, Russia (European part) and Ireland were actually doing worse than China, with India or Turkey (with per capita income possibly comparable to that of China) faring far worse.

The anthropometric, age-heaping, and real wage evidences presented in this article now allow us to piece together a quantitative profile of Chinese welfare and human capital for the eighteenth to twentieth centuries when historical evidences presented so far have been descriptive, indirect and scattered. Our findings confirm and revise traditional historiography as well as reveal new insights.

Firstly, our study quantitatively confirms the large and sustained decline in living standards and human capital during the mid-nineteenth century, an era of political and economic crises brought by the Opium War and the devastating Taiping Rebellion. The Taiping rebels originated in the southern province of Guangxi in 1850 and spread north into east China and beyond. By the time of their military defeat in 1864, the entire rebellion and its suppression led to a halving of the population of the lower Yangzi provinces of Jiangsu and Zhejiang and possibly 30 million deaths nationwide. For Guangdong province and the city of Canton, the rebellion of Red Turbans associated with Taiping movement caused large-scale destruc-

²⁶ Although not sufficient in numbers, we also calculated the level of United States born Chinese for the 1870s and 1880s. Interestingly, their age-heaping is not lower than those Chinese born, but rather higher, with values of 167 of those born in the 1870s, and 136 in the 1880s.

²⁷ We also calculated Whipple Index for the data series of the railway and other modern organisations for the early twentieth century and also confirmed that there was no age-heaping. This is not surprising given that the average literacy level for the Chinese national railways was about 70%, and 100% for the professional staff. More importantly, these data also recorded birth dates and years, making the calculation of age-heaping index highly problematic.

²⁸ We thank Osamu Saito for providing those lists on Japan and Taiwan.

tion of lives and properties during the mid-1850s (Spence, 1999; Wakeman, 1966). Our data reveals the severe negative impact of mid-nineteenth century crisis on the 1840s Chinese birth cohort's capacity to acquire numerical and literacy skills possibly due to malnutrition and breakdown of social order and traditional school system during their formative decades of the 1850s and 1860s. Such an experience is not peculiar to China as witnessed by the surge in age-heaping among the Irish inflicted by the famine crisis of the 1840s and also for Spain on a milder scale (Manzel, 2008).

Secondly, the different patterns of the three data series as revealed in our study contribute new historical insights. Among the three series, real wage and age-heaping indices bounced back from the 1860s, but the fall in height trend seems to have sustained throughout the latter half of the nineteenth century. The rapid recovery of the first two series seems to confirm the traditional historiography that emphasized the relative success of the so-called 1862–1874 Tong-Zhi restoration in returning the post-Taiping China to peace and normalcy (Wright, 1962). A hallmark of the Restoration was the rejuvenation of traditional governmental bureaucracy as severely compromised by the massive sale of official titles in the war era for revenue purpose and reinstatement of the millennium-old national Civil-Service Examination system as suspended during the War era (Wright, 1962, chapter 5). It is likely that these policies have restructured incentives for human capital accumulation and contributed to the drastic improvement in age-heaping indices.

The somewhat surprising finding of a sustained decline in heights into the 1880s and 1890s seems to stand in contrast to the rapid recovery of age-heaping (and the real wage series) in the post-Taiping Rebellion era. While it is plausible this decline may be more region-specific to South China (including Taiwan) with Canton losing her eminent trading port status to Shanghai or other treaty ports in the post-Opium War era, we believe that our empirical finding merits serious future academic research, which may well lead to a more pessimistic profile of living standards during the latter half of the nineteenth century.²⁹ In fact, despite the high-profile attempts to modernize her military and other limited industrial sectors, the general outlook and policy of Qing under the so-called late-nineteenth century self-strengthening movement remained conservative, especially in contrast to contemporaneous Meiji Japan. Not only did they resist any fundamental institutional reform, but also obstructed the construction of modern infrastructures such as railroads. Modern public infrastructures constructed mostly after the beginning of the twentieth century, as emphasized recently by Ge et al. (1999), would have allowed effective relief efforts to avert the kind of massive human and material losses incurred by disaster and famine in the latter half of the nineteenth century.³⁰ In this context, the recovery in heights from the beginning of the twentieth century – an era marked by the imminent dynastic collapse and national disintegration – does not come as total surprise. Recent scholarship has emphatically shown that the first three decades of the twentieth century – despite the political and civil strife – were marked by the onset of a region-based spurt of industrialization and modernization (Rawski, 1989; Ma, 2008).

5. Conclusion: towards an integrated narrative of living standards and human capital

By placing our new time series data in an international context, our article reveals a rather intriguing combination of relatively low living standards with high human capital in traditional China. While our finding of a relatively low standard of living counters the argument of recent revisionism, the case for a relatively high level of human capital seems to echo other historical studies. For example, Ronald P. Dore's landmark study in 1965 offered a remarkably optimistic reassessment of Japanese education in the Tokugawa period (1603–1868). The school enrolment data in 1868 led him to conclude something like 43% literacy rate for male and 19% for girls, a remarkably high level by early modern standards (Hayami and Kito, 2004). Other studies have also pointed to the existence of a dynamic book publishing industry and book rental market as well as near ubiquitous presence of book-keeping and accounting practise among business and domestic households, and the widespread use of farm manuals (Hayami and Kito, 2004; Smith, 1988).

Evelyn Rawski's 1979 study in many ways echoed the Japanese assessment for the case of China. Based on admittedly fragmentary and circumstantial evidence, Rawski put the basic literacy level of Chinese males at 30–45 percent and females at 2–10 percent for China as a whole (Rawski, 1979, p. 22–23). According to her, both opportunities for education and schooling had expanded during the Ming (1368–1644) and Qing (1644–1911) period. More importantly, education went way beyond the elites in preparation for the prestigious civil-service examinations and spilled over to a wide spectrum of the society to fulfill demand for commerce, local administration or even agricultural production (Rawski, 1979, chapter 1, Li, 2004). In comparison with Japan, Rawski argued that “if a stratified, status-fixed society such as Japan's experienced this great demand for basic skills in reading, writing, and arithmetic among townsmen and farmers (in the Tokugawa period), a relatively open society such as China's, where education was the key to upward social mobility, should have stimulated a similar if not greater effective demand for literacy” (p. 5). In other studies, both Rawski (1985) and Li (2004) detailed

²⁹ For regional differences in height trend in the first three decades of the twentieth century, see Morgan (2004).

³⁰ Ge et al. (1999), noted the importance of modern health facilities and public infrastructure in the early twentieth century for disaster and famine relief. For wars and disasters occurring during the period of 1870–1890, see Cao (2001), chapters 13–15, on the prolonged Muslim rebellions in South- and North-western parts of China and severe drought leading to famine in five provinces of Northern China in the late 1870s which claimed tens of millions of lives. Finally, cross-national factors could be at work as well: waves of rinderpest (cattle plague) seemed to have swept across parts of Asia and Africa where we observed similar decline in heights in the 1880s and 1890s period (Spinage, 2003). Rinderpest was enzootic to hooved animals in China's central plains and the Mongolian steppes. Its presence was first observed in outbreaks in Hong Kong and Shanghai in the 1860–70s, and transmitted to Japan through imported cattle with epizootic effect, though there were earlier suspected outbreaks (Spinage, 2003; MacPherson, 1987; Kishi, 1976). A foreign medical missionary (Bliss, 1922) described rinderpest as having a more debilitating affect on Chinese agriculture than floods and drought, primarily by depriving farmers of ox and buffalo for ploughing fields and pumping water, which could reduce grain yield.

the development of a thriving private and commercial publishing industry to satisfy the demand of a large reading public forged by the homogeneity of the Chinese written character. Book publishing was highly differentiated, from scholarly encyclopedias, histories and philosophical treatises to morality plays, romance novels, Buddhist sutra and primers for all sorts of trades. In addition, cities and towns “had an abundance of posted regulations, shops signs, advertisements, and other material to read for profit and amusement” (Naquin and Rawski, 1987, pp. 58–59) and publishing was further aided by the relatively low cost of paper and Chinese style of woodblock printing (Rawski, 1985). Commercial publishing in the Yangzi region, for example, catered not only for the literate elite, but also for merchants, artisans and other non-elite readers (Li, 2001).³¹

Besides literacy, scholars have also presented direct historical evidence of numeracy. Li (2004), in particular, noted the widespread diffusion of popular arithmetic textbooks, the spread of abacus, and the adoption of various special numerals for book-keeping and accounting during the late Ming and Qing. A series of new research have now begun to utilize long-ignored surviving account books, which meticulously recorded transactions and various summary accounts with sophisticated traditional accounting techniques (Guo, 1982, 1988; Gardella, 1992, for China; Jun and Lewis, 2006, for Korea). The important role of a lunar calendar in daily lives and in fact, the numerology and number-mysticism, for whatever its dubious claim to prediction, predisposed Chinese thinking to a numerical framework for scientific inquiry (Ronan and Needham, 1978).

In fact, the combination of high human capital and low income level is not merely a historical phenomenon. Drawing on the results of standardized international tests, Hanushek and Woessmann (2008) show that the average test scores of Chinese students today ranked among the top end of those from OECD countries whose per capita income are several fold higher than in China. Further research should explore the possible historical root of this relatively high level of human capital accumulation, in particular its linkage with long-lasting institutions in traditional China, such as a relatively open Civil-Service Examination, a unified written character and a precocious government bureaucracy. The rise of an independent small-holding peasantry under this institutional framework turned each household into a self-contained producing and marketing unit in direct interaction with both the market and state (for taxation).

It is important to note that these institutional features in traditional China had been largely designed for social control and discipline for an agrarian empire. But its unintended legacy – a relatively large reservoir of human capital in early modern China and East Asia – may have facilitated their rapid economic catch-up of in the modern era once required institutional and ideological changes were accomplished. In fact, the lags and differential pace of economic catch-up within East Asia over the past two centuries may well be an outcome of the differential timing of the institutional and ideological change. This intricate relationship between human capital and institutions for China and East Asia is a confirmation of recent theoretical and empirical insights as expounded in Glaeser et al. (2004). It serves as a fresh reminder that by focusing exclusively on the comparison of national income per capita, we may be missing the most crucial and essential factor that accounts for both the early modern great divergence and the recent convergence between the two ends of Eurasia.

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³¹ A large literature on the Chinese book, publishing and reading has emerged in recent years in both Chinese and English, but is beyond the scope of this article to summarise. Recent English-language studies include Brokaw (2007), Brokaw and Chow (2005), Chia (2002) and McDermott (2006).

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