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Back to the 'Normal' Level of Human-Capital Driven Growth? A Note on Early Numeracy in Korea, China and Japan, 1550–1800

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Abstract

This paper draws on a unique data set, hojok (household registers), to estimate numeracy levels in Korea, 1550–1630, and evidence on Japan and China from the early modern period until 1800. We found that a substantial share of East Asians rounded their ages to multiples of five. However, the extent of age-heaping was quite low by global standards, even considering the potential sources of upward bias inherent in the data. Therefore, the unusually high level of numeracy in East Asia in the early 21st century was already present in the early modern period. The findings imply that in the Korean case, for example, the foundations of the human-capital based catch-up growth were laid very early. More broadly, we argue that Korea, Japan, and China returned to the growth-path at different points of the 20th century, and this return was pre-determined by their early numeracy development.

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I. Introduction

This paper first employs Korean household registers (hojok) to measure numeracy levels during the period of 1606–1717. No prior attempt has been made to measure numeracy in Korea during such an early period. Next, we compare Japanese and Chinese numeracy figures to obtain a general view of East Asian numeracy. Baten et al. (2010) estimated that, despite its relatively low living standards as measured by real wages and stature, the Chinese level of human capital, measured by age-heaping, was relatively high by global standards in the 19th century. They argued that China's high level of human capital might have facilitated the rapid economic catch-up once the appropriate institutions were established in the 1980s. Korea also achieved rapid economic catch-up slightly earlier than China, and Japan did so even earlier (see Amsden 1992). It seems likely that the three East Asian giants might have followed similar "return-to-normal"-mechanisms but at different points in time.

A number of previous studies considered the human-capital growth mechanism but were unable to include data on Korea. Baten and van Zanden (2008) examined whether human capital — proxied by an indicator of advanced human capital, 'book production' — can account for economic growth in the 19th century. Their data set also included a number of European and non-European countries. Relatively reliable GDP estimates were available for the period 1820–1913 (Figure 1). The relationship between human capital — proxied by book production — in the second half of the 18th century and the growth in GDP per capita over the following period were quite obvious. Countries with a low level of human capital formation were unable to participate in the industrialization process that transformed the global economy, whereas countries with better starting positions managed to catch up with Great Britain or even overtake it. It is interesting to note that Japan invested heavily in schooling as early as the 18th century, which is evident from the existence of a mass market for books. The high level of schooling in pre-Meiji Japan is also confirmed by other evidence (Hayami and Kitô 1999). Apparently, Japan's high level of education formed the basis for the country's successful modernization, whereas other Asian countries failed to industrialize in the 19th century. Using regression analyses, Baten and van Zanden also examined whether a higher rate of book production in the 18th century implied more rapid GDP growth in the 19th century. To address this question, they controlled for the initial level of GDP per capita, which was available for 15 countries, and tested the book variable against this initial level effect (their Table 4). Book production was still positive and significant.

It is important for our study on East Asia that China is clearly an outlier in Figure 1. It had already accumulated a substantial stock of human capital, but it did not manage to grow in the period from 1820 to 1913. However, China has grown substantially since 1980. It seems as if Japan was able to transform human capital into growth relatively early, whereas the process occurred later in China. Korea (and South Korea in particular) was situated between Japan and China. However, the book per capita figure is only one indicator, and to establish the stylized fact of high early modern human capital in East Asia, we need supportive evidence.

In the following Sections, we will first review the literature on East Asian education and human capital before explaining the age-heaping methodology in Section 2. In Section 3, we will discuss the new evidence on Korea, and Section 4 discusses the results. Section 5 presents new evidence on Japan and compares it to existing studies on China and Europe. We present our conclusions in Section 6.

II. Literature Review: Early Human Capital Formation in East Asia

Ronald P. Dore's (1965) landmark study offered a remarkably optimistic reassessment of Japanese education in the Tokugawa period (1603–1868).[1] The school enrollment data for 1868 led him to estimate a literacy rate of 43% for males and 19% for females, a remarkably high level by nineteenth-century standards (Hayami and Kitô 1999). Another piece of evidence is provided by studies assessing the existence of a dynamic book publishing industry and book rental market. These studies also conclude that businesses and domestic households were familiar with earlier forms of accounting and bookkeeping and the use of farm manuals (Hayami and Kitô 2004; Smith 1988). A study by Rawski (1979) extends these findings to the case of China, although she emphasizes that her results are based on fragmentary and circumstantial evidence. She observes a literacy rate of approximately 30–45 % for males and approximately 2–10 % for females (Rawski 1979). Rawski also reports that educational and schooling opportunities improved during the Ming (1368–1644) and Qing (1644–1911) periods. Due to an increased demand for commerce, local administration and agricultural production, there was an educational spillover to the broader society, which implied that not only the elites had access to education, but also other groups of society could obtain basic skills (Rawski 1979; Li 2004). Rawski argues that Chinese demand for education and literacy should be greater than or at least similar to that of Japan in the Tokugawa period. She bases her argument on the fact that Chinese society, in which education was an important condition for upward social mobility, was relatively open compared to the more status-

[1] The following discussion is adapted from Baten et al. (2010).

oriented Japanese society.

There are further studies by Rawski (1985) and Li (2004) that also address the issue of a growing and prosperous publishing industry in China, with book publication ranging from encyclopedias or histories to romance novels or Buddhist sutras. 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, 58–59). In addition to other aspects, the relatively low cost of paper and woodblock printing helped to fulfill the demand from the large reading public, which no longer solely consisted of the literate elite but also included non-elites, such as merchants (Rawski 1985; Li 2001). Furthermore, Li (2004) accounts for the spread of arithmetic textbooks and abacuses and the spread of numerals for bookkeeping and accounting during the Ming and Qing periods, which provides direct evidence on numeracy in this period. More evidence on numeracy can be found in other studies on China and Korea that demonstrate the use of traditional accounting techniques by analyzing surviving account books (Guo 1982, 1988; Gardella 1992 for China; Jun and Lewis 2006 for Korea). Ronan and Needham (1978) argue that the importance of a lunar calendar, numerology and number-mysticism in daily life numerically influenced Chinese thinking (Ronan 1978).

If we consider contemporary human capital levels, Chinese students are found to perform very well on international standardized tests and are consistently ranked near the top of all students worldwide. This fact holds even when compared to OECD countries with higher per capita incomes than China (Hanushek and Woessmann 2008). Juif and Baten (2012) found that early numeracy rates from around 1820 are highly correlated with contemporary cognitive skills, especially in the areas of math and science (Figure 2).

Moreover, Korean (“kr” in Figure 2) and Japanese (“jp”) math and science test results were among the highest ranked in the figure. The origin of the high numeracy levels in East Asia, however, has yet to be thoroughly and quantitatively studied. The impact of long-lasting institutions in traditional China, such as civil service examinations or government bureaucracy, could be of particular interest. The institutional framework and the appearance of an independent peasantry gave rise to the transformation of households into self-contained units, which were in direct contact with the market and the state. Although the main reason that these institutions were developed was to control and discipline the society of an agrarian empire, the establishment of these institutional features led to a large stock of human capital in early modern China and East Asia.

III. Age-heaping

The use of age-heaping measurements in the context of modern economic history has recently experienced spectacular growth.[2] Age-heaping measurements have been employed to understand numeracy in France and the US from the 17th to the 19th centuries and in China from the 18th to the 20th centuries (Crayen and Baten 2010a; Baten et al. 2010). Beyond individual countries, scholarly interest has extended to Latin America, Europe, and even worldwide (A’Hearn, Baten, and Crayen 2009; Crayen and Baten 2010b; Manzel, Baten, and Stolz 2012).

Measuring the ‘human capital’ production factor has never been simple, as advanced forms of skill are difficult to compare. Therefore, economists have resorted to the use of

[2] Mokyr (2006) pioneered their use, and Duncan-Jones (1990) applied them to study ancient economies.

proxy indicators, such as years of schooling or, in long-run studies, the share of individuals signing a marriage register. We will explain the advantages and caveats in somewhat greater detail, as the application of this method in economic history is still relatively new.

This approach employs a set of methods that developed around the phenomenon of "age-heaping," i.e., the tendency of poorly educated people to erroneously round their ages. For example, less educated people are more likely than people with a greater human capital endowment to state their age as "30," even if they are in fact 29 or 31 years old (Mokyr 2006).[3] The ratio between the preferred ages and the others can be calculated using several indices, one of which is the Whipple index.[4] Thus, the index measures the proportion of individuals reporting an age ending in a five or zero, assuming that each terminal digit should appear with the same frequency in the "true" age distribution.[5]

$$(1)\quad Wh = \left(\frac{(Age25 + Age30 + Age35 + ... + Age60)}{1/5 * (Age23 + Age24 + Age25 + ... + Age62)} \right) \times 100$$

For an easier interpretation, A'Hearn et al. (2009) suggested another index called the ABCC index.[6] It is a simple linear transformation of the Whipple index and yields an estimate of the

[3] Among demographers, this specific type of age misreporting constitutes "one of the most frustrating problems" (Ewbank 1981, 88). It is treated as a source of distortion in age-specific vital rates that needs to be removed, or at least minimized, to study family or household variables.

[4] A'Hearn, Baten and Crayen (2009) found that this index is the only one that fulfils the desired properties of scale independence (a linear response to the degree of heaping) and that it reliably ranks samples with different degrees of heaping.

[5] A value of 500 means an age distribution with ages only ending in multiples of five, whereas 100 indicates no heaping patterns on multiples of five, that is, exactly 20 percent of the population reported an age ending in a multiple of five.

[6] The name results from the initials of the authors' last names plus that of Gregory Clark, who suggested this in a comment on their paper.

share of individuals who report their ages correctly:

$$(2)\quad ABCC = \left(1 - \frac{(Wh - 100)}{400}\right) \times 100 \ \text{ if } \ Wh \geq 100\text{; else } ABCC = 100\,.$$

A'Hearn et al. (2009) found that the relationship between illiteracy and age-heaping for Less Developed Countries after 1950 is very close. They calculated age heaping and illiteracy for no fewer than 270,000 individuals who were organized into 416 regions, ranging from Latin America to Oceania. The correlation coefficient with illiteracy was as high as 0.7. The correlation with the PISA results for numerical skills was as high as 0.85; hence, the age-heaping measures are more strongly correlated with numerical skills.

A'Hearn et al. (2009) used a large U.S. census sample to perform a detailed analysis of the relationship between age-heaping and illiteracy. They subdivided the sample by race, gender, high and low educational status, and other criteria. In each case, they obtained a statistically significant relationship. It is also remarkable that the coefficients are relatively stable across samples, i.e., a unit change in age-heaping is associated with similar changes in literacy across the various tests. Those results are not only valid for the U.S.; there was substantial age-heaping in all countries that have been explored thus far, and the correlation was found to be both statistically and economically significant.[7]

To assess the robustness of these results from the U.S. census and the similar conclusions that could be drawn from the less developed countries of the late 20th century, as mentioned in the introduction to this study, A'Hearn et al. (2009) also assessed age-heaping and literacy in 16 different European countries between the Middle Ages and the early 19th

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[7] On Argentina's regions, see, for example, Manzel et al. (forthcoming).

century. Again, they found a positive correlation between age-heaping and illiteracy, although the relationship was somewhat weaker than for the 19th- or 20th-century data. It is likely that the unavoidable measurement error when using early modern data produced the reduced statistical significance (Baten and Szołtysek 2012).[8]

The broadest geographical sample studied thus far was created by Crayen and Baten (2010b), who were able to include 70 countries for which both age-heaping and schooling data (and other explanatory variables) were available. In a series of cross-sections between the 1880s and 1940s, they found that primary schooling and age-heaping were closely correlated, with R-squared values between 0.55 and 0.76 (including other control variables, see below). Again, the coefficients were shown to be relatively stable over time. This large sample also allowed for the examination of various other potential determinants of age-heaping. To assess whether the degree of bureaucracy, birth registration, and government interaction with citizens are likely to influence the knowledge of one's exact age, independent of personal education, Crayen and Baten used the number of censuses performed for each individual country up to the period of study as an explanatory variable for their age-heaping measure. Except for countries with a very long history of census taking, all of the variations in this variable were statistically insignificant, which would suggest that an independent bureaucracy effect was rather weak. In other words, it is likely the case that societies with a high number of censuses and an early introduction of birth registers had a high degree of age

[8] The experience of historical demographers shows that data from premodern periods were often very rough, imprecise, or fragmentary. Even 18th-century statistical materials still contain a host of uncertainties and traps, as they were frequently collected haphazardly and analyzed without skill; as a result, they often only encompass a part of the phenomenon, which is incomplete (Szołtysek 2011). This refers in particular to the quality of data on age.

awareness. Those societies also introduced schooling early, and this variable clearly exhibited greater explanatory power than the independent bureaucracy effect. Crayen and Baten also tested whether the general standard of living influenced age-heaping tendencies (using height and GDP per capita as welfare indicators) and found a varying influence: in some decades, there was a statistically significant correlation, while in others, there was none.

In conclusion, the correlation between age-heaping and other human capital indicators is well established, and the 'bureaucratic' factor does not invalidate this relationship. A caveat relates to other forms of heaping (apart from the heaping on multiples of five), such as heaping on multiples of two, which is quite widespread among children and teenagers and to a lesser extent among young adults in their twenties (Baten and Szołtysek 2012). This demonstrates that most individuals knew their ages as teenagers, but only in well-educated societies are they able to remember or calculate their exact age later in life. At higher ages, this heaping pattern was mostly negligible, but it was, interestingly, somewhat stronger among populations who were numerate enough not to round to multiples of five. We will exclude those below age 23 and above 72, as a number of possible distortions affect those specific age groups, leading to age reporting behavior different from that of the intermediate adult group. Many young males and females married in their early twenties or late teens, when they also had to register as voters, military conscripts, etc. On such occasions, they were, in some instances, subject to minimum age requirements, a condition that gave rise to increased age awareness. Moreover, individuals in this age group were growing physically, which makes it easier to determine their ages with a relatively high level of accuracy. All of these factors tend to deflate age-heaping levels for children and young adults, compared to the age reporting of the same individuals at higher ages. The aged should also be excluded because the age-heaping pattern of very old individuals is subject to upward and downward bias for the reasons mentioned above.

There remains some uncertainty over whether age-heaping in the sources contains information about the numeracy of the responding individual or about the diligence of the reporting personnel who wrote down the statements. The age data for the relevant age groups 23–72 were normally derived from statements directly from the person. However, it is possible that a second party, especially the husband, may have made or influenced the age statement or even that the enumerator estimated the age without asking the individual. If the latter occurred, we would not be able to measure the numeracy of the person interviewed. In contrast, if the enumerator asked and obtained no response, a round age estimated by him would still measure basic numeracy correctly. A large body of literature has investigated the issue of people reporting on others' age. Recently, Friesen, Prayon, and Baten (2012) systematically compared the evidence of a gender gap in numeracy and literacy for the early 20th centuries, and found a strong correlation. They argued that there is no reason why the misreporting of literacy and age should have yielded exactly the same gap between genders. A more likely explanation is that the well-known correlation between numeracy and literacy also applies to gender differences. For our study, the question of whether the women themselves responded is slightly less important, as we only seek to estimate male numeracy.

Of course, a potential bias always exists if more than one person is involved in the creation of a historical source. For example, if literacy is measured by analyzing the share of signatures in marriage contracts, there might have been priests who were more or less interested in obtaining real signatures, as opposed to crosses or other symbols. We find it reassuring that previous studies have generally found much more age-heaping (and less numeracy) among the lower social strata and among the half of the sample population who had lower anthropometric values (Baten and Mumme 2010). Moreover, the regional differences in age-heaping are similar to the regional differences in illiteracy. It can be concluded that the method of age-heaping is a useful and innovative tool for assessing human capital.

IV. Data on Korea

The data for this paper were collected through a system of household registers implemented for the purposes of taxation and corvee labor service, called hojok (Table 1). The system attempted to collect data from all individuals, including slaves. The registration was supposed to be conducted every three years, but only fragments of hojok remain. Individual-level data for the county of Dansung were digitized by the Daedong Institute for Korean Studies. Dansung was a rural county, and literati sharing the same family names resided along with other ordinary people. The digitized data irregularly cover years from 1606 to 1888, but we decided to use only the first two years for reasons explained below.

However, some caveats regarding the data source are in order. One issue is whether household heads reported ages with or without asking the other household members. The procedure for collecting the census information was as follows. Local officials distributed the form to each household. Then, the household completed the form. The local officials then collected the completed form. Given the absolute authority that the head of household commanded in Korea during this period, it is likely that the head of household generally completed the forms. However, we do not know whether the head of household asked for the ages of other household members before they reported the number on the form. If the other household members were not asked in most cases, this could imply an upward bias, as the head of household likely had higher basic numeracy. Calculating the ABCC index for household heads alone, as opposed to all household members, we obtain values that were 4–5 percentage points higher for the former (Table 2). Therefore, the estimate for the whole population of approximately 89–90 percent has to be considered a lower bound, whereas the 94 percent estimate for the heads of household likely reflects an upper bound estimate. We considered only including the heads of household in our statistics, as those persons were most likely to report their own ages. However, as our main argument in the present study is that East Asian basic numeracy was high in the early modern period, we will include the "lower-bound" estimate of the whole population in the following figures because it represents a "conservative" value that does not risk providing inappropriate support for our argument.

This is also a promising strategy, as there are other potential sources of upward bias. For example, some individuals avoided being registered to avoid taxation and corvee labor service despite heavy punishments and monitoring systems. Some hid in the mountains, and others wandered around. If they were less numerate than registered individuals, numeracy would be over-estimated.

Unfortunately, the Korean system of registering individuals every third year might have provided the possibility for government officials to countercheck age statements. Therefore, the best strategy is to focus exclusively on the first year following a massive Japanese invasion during the late 16th century, which destroyed a number of the hojok registers. Therefore, instead of using data from the whole period ranging from 1606 to 1888, this paper focuses only on 1606 for the regular Korean population. Although Korean household registers were more or less continuously maintained long before 1606, the Japanese invasion had very adverse effects on Dansung, and many official documents, including the hojok registers, were destroyed (Kim 2001). Thus, it is likely that the process of household registration was re-started from scratch after 1606. This suggests that more realistic age-heaping values can be obtained after the break in the registration system. In contrast to 1606, authorities were subsequently able to verify responses with age statements from previous years, which could result in an upward bias in the numeracy values for the later years. The Korean example of 1606 is in line with other historical evidence on realistic numeracy values after a “break” in age reporting for various political and economic reasons, e.g., in Japan (Hayami 2001).

We also employed a second data set on monks. In 1675, King Sook Jong approved the registration of monks in the hojok registers. Because the reason for this decision is relevant for numeracy, we provide some historical background. A series of adverse events threw 17th-century Korea into complete disarray. The negative consequences of the Japanese invasion still lingered, and China also invaded Korea in 1627 and 1636. Small and large rebellions were not uncommon across the country, and one of the largest was the rebellion led by Lee Kwal in 1624. To make matters worse, natural disasters, famines, and diseases abounded. All of these adverse events can be understood as part of the general crisis of the 17th century (Parker and Smith 1997). Under the circumstances, an increasing number of people were dead, hid in the mountains, or became vagabonds. However, the registration system failed to keep pace with the changes. As a result, each individual who had been properly registered suffered more from corvee labor service. One way to circumvent this aggravating situation was to register and recruit monks for the service. This idea was appealing because monks had already experienced corvee labor service on a few occasions (albeit unsystematically). In addition, a growing number of people simply became monks to avoid permanent corvee labor service. Registering them would allow the government to identify, control, and exploit monks more systematically. Hyu Yun proposed the idea of registering monks in the hojok, and King Sook Jong approved of the plan on May 9, 1675.[9]

The registration of monks was one aspect of the overhaul of the hojok system. In 1675, King Sook Jong issued a law (o-ga-tong-sa-mok) according to which five (o) households (ga) were grouped into a higher level of an administrative unit called a tong. The law was an attempt to strengthen the system by correcting inaccurate entries and rebuilding hojok registers that were lost during the Chinese and Japanese invasions. Our data concern the year of 1678, which was the next registration year after 1675. Hence, they may include the first registration of monks in Dansung. The data set on monks is useful for our research because it provides numeracy values from the beginning of the registration process and is therefore unlikely to be biased due to authorities being able to countercheck age statements. Moreover, because many ordinary people became monks to avoid corvee labor service, the potential upward bias coming from this selective group could be further alleviated.

As age-heaping reflects a very basic skill that is obtained during first decade of life, we organize all evidence by birth decades. Using the 1606 hojok, we can document the birth decades for the regular Korean population born from the 1550s to the 1570s, and we can document the same information approximately for the birth decade of the 1630s for Korean monks (Figure 3). The numeracy values for these observations seem to be quite constant over

[9] For the approval, see Sook Jong Year 1 May Jungmyo (9) day, Sook Jong Sillock, vol. 3; for the general circumstances, see discussions recorded around the Jungmyo day.

time and have numeracy values of approximately 80 to 90 percent, which is relatively high by historical standards.

V. Comparison of Human Capital Development in Korea, Japan, China, and Europe

A comparison of the results to those of similar studies conducted for Japan and China sheds further light on the cross-country variation in human capital development. Japanese age statements are reported in Table 3, which is taken from Hayami (2001). The data were collected in population registers in the Bungo Province in 1622. Assuming that the average age in Japan of those 21 and older at that time was approximately 35, the data are centered on those born during the 1590s. This makes the data suitable to compare Japanese human capital formation to the newly estimated numeracy levels for the Korean population in 1550–1570. The reported age statements indicate clear age-heaping on 0 (21.4%) and 5 (13.8%). In addition to heaping on numbers ending in 0 or 5, Table 3 also displays heaping on numbers ending in 8. The reason for this additional heaping is that 8 was considered to be a number associated with luck and fertility. In other Asian societies, the number 8 also stood for prosperity and good fortune (Hayami 2001). Conversely, the digit 4 was avoided because this number sounds similar to the Japanese words for death and suffering, and hence reported ages ending in 4 are relatively rare (Hayami 2001).

A graphical comparison of human capital development in Korea, Japan, and China is displayed in Figure 4. Although the age reports for the Korean population and the monks came from different centuries, the numeracy values indicate similar human capital levels. The Japanese numeracy levels are approximately 10% lower than the Korean levels.

For China, Baten et al. (2010) used an important source: the censorial section of the board of punishment, where not only information on age statements can be found in memorial documents but also information on land prices, land rents, interest rates, and other personal and household data for all Chinese administrative regions. Only a small part of these documents, especially from the Qianlong period (1735–95), have been published (Historical Archive No. 1, 1981). These sources have been used in different studies, for example, by Allen et al. (2007) to estimate real wage developments. The ages that we used from these memorials are self-reported by persons in court (i.e., they were still alive at the time).

Baten et al. (2010) analyzed whether these sources can be used in age-heaping studies. For example, they asked whether animal cycles for birth years in China might have caused age-heaping in a form other than stating ages ending in 0 or 5. To measure this impact, they used data on age-heaping for the most popular animal sign, the year of the dragon. They studied the age reporting behavior of Chinese migrants to the US, with the result that a preference for dragon years was visible but much less important than age-heaping on multiples of 5. The same result was obtained for the Chinese preference for 8 and desire to avoid 4. Using data from the board of punishment for the late 17th and early 18th centuries, it can be seen that the degree of age-heaping was relatively low.

If we compare East Asia with trends in three European regions, we arrive at the conclusion that Korea, Japan and China were similar to the most advanced European regions in northwestern Europe (Figure 4). For Europe, the centuries between the late 15th and the early 19th century represent a human capital revolution. European numeracy rates grew from approximately 50% to approximately 95%. This is a true revolution because the nearly 50 percentage point magnitude is comparable to the difference between the poorest and the wealthiest economies of the early 20th century (Crayen and Baten 2010b: South Asia had a numeracy rate of 52% in the 1940s, whereas the richest countries had reached full numeracy). Therefore, Europe transitioned from a half numerate to a mostly numerate continent during this revolution. The differences between the European regions are also interesting: southern Europe was the best in the late Middle Ages and the early Renaissance, but the well-known ascendancy of northwestern Europe is also visible in the numeracy record. In the 16th and 17th centuries, Korea and Japan had already covered half the distance of this human revolution, even if we take into account the potential biases mentioned above.

VI. Conclusion

This paper employs a unique data set to estimate numeracy levels in Korea in the late 16th and 17th century, using age-heaping as a proxy. We find that Koreans during this period exhibited age-heaping, but the extent of inaccurate age reporting was relatively small.

Baten et al. (2010) argue that numeracy levels were relatively high in East Asia by world standards and cite the Chinese, Japanese, and Taiwanese levels. However, their reference period primarily spans the 19th and 20th centuries. Our findings support their generalization but emphasize that East Asians actually achieved high levels of numeracy quite early. In light of the rapid economic catch-up in East Asia, the findings also highlight the importance of human capital in economic growth.

Although the primary initial reason that these human-capital-creating institutions were developed in East Asia was to control and discipline the subjects of an agrarian empire, the establishment of these institutional features created a large stock of human capital in early modern China and East Asia. Due to this human capital stock and additionally required institutional and ideological changes, it might have been easier for China and East Asia to rapidly catch-up in terms of economic growth during the modern era. The timing of institutional establishments and changes and the timing of ideological changes may be reasons for the differences in economic catch-up rates in East Asia over the last century.

Theoretical and empirical studies can be confirmed by our finding of a connection between early human capital and institutional development in China and East Asia (Glaeser et al. 2004). Furthermore, it indicates that an exclusive focus on differentials in per capita income would have caused a very important factor in the modern divergence and recent convergence of the two ends of Eurasia to be overlooked.

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Table 1: Numbers of cases of age statements used in this study

Country	Source	Reporting year	Birth decades	N
Korea	Hojok, Daegong, population (except monks)	1606	1550s-1570s	1133
Korea	List of Monks	1678	around the 1630s	70
Japan	Population register, Bungo Province	1622	around the 1590s	551
China	Board of punishment	1735–95	1660s-1700s	163
			1710s-1740s	383
			1750s-1770s	56

Table 2: ABCC value of various groups in Korea

Subsample	ABCC Index	N of Obs.
All Household Members (birth decade 1550s)	90.1	387
All Household Members (birth decade 1560s)	89.3	445
All Household Members (birth decade 1570s)	89.7	301
Household heads	94.1	174
Monks	94.6	70

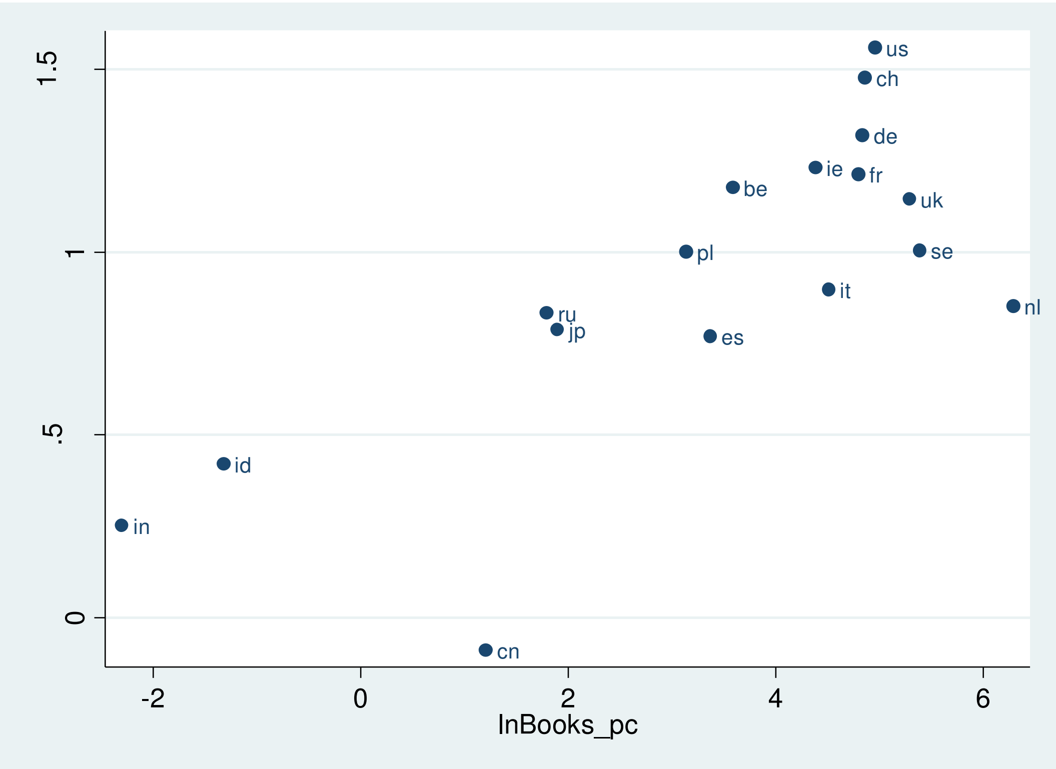
Note: Following the literature, we first calculated ABCC values by age group (23-32, 33-42, etc.) and then determined birth decades by selecting those in which the majority of individuals were born. We also performed an adjustment for the 23-32 age group, as suggested by Crayen and Baten (2010b).

Table 3: Japanese population distribution by the last digit of a person's age

Last Digit of Age	Total 21 or older (Number Persons)	Ratio of Population (in %)
0	118	21.4
1	67	12.2
2	45	8.2
3	61	11.1
4	18	3.3
5	76	13.8
6	37	6.7
7	20	3.6
8	82	14.9
9	27	4.9

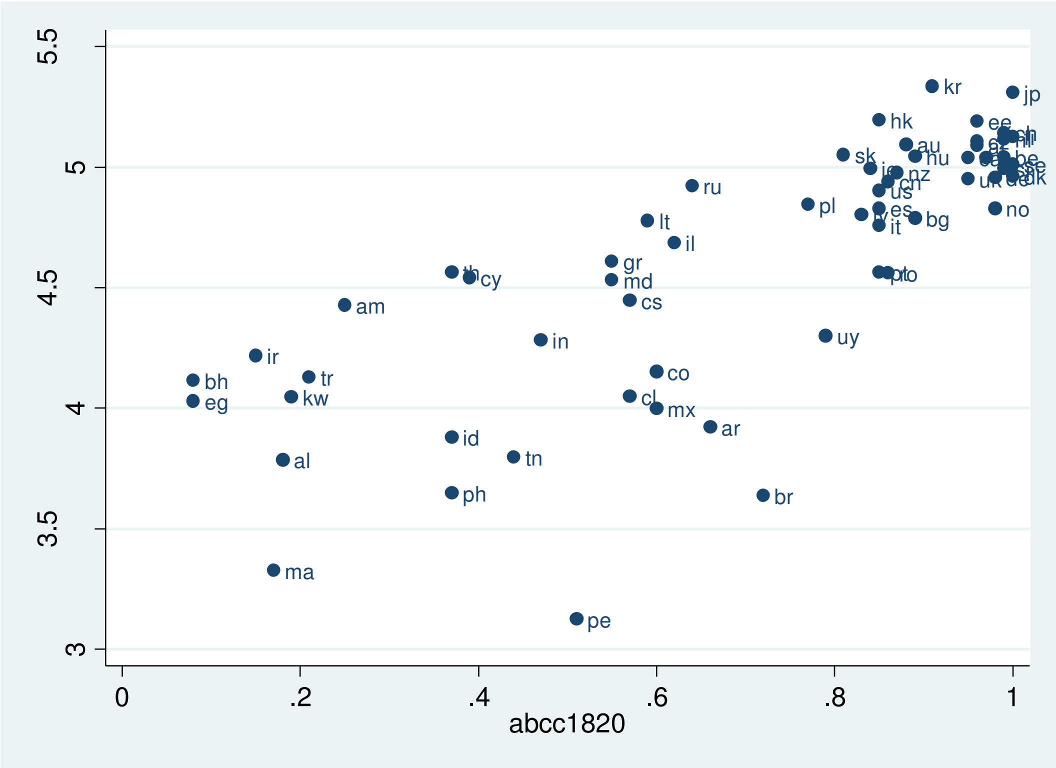
Source: Hayami, 2001, p. 25. (based on the population register, Hayami gun, Bungo Province, 1622.)

Figure 1: Book production per capita between 1750 and 1800 and GDP per capita growth 1820-1913 (books on log scale).



Source: Baten and van Zanden (2012)

Figure 2: Numeracy (ABCC) in 1820 and math- and science-oriented skills during the late 20th century.



Source: Juif and Baten (2012)

Figure 3 New evidence on numeracy in Korea and Japan

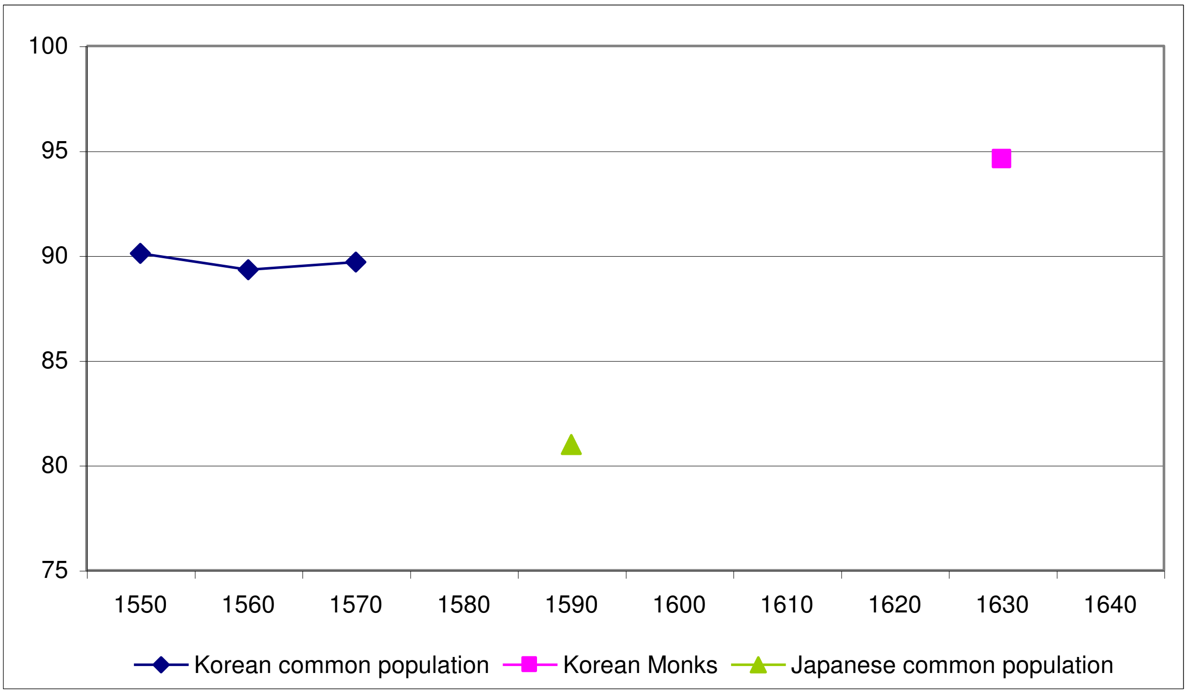
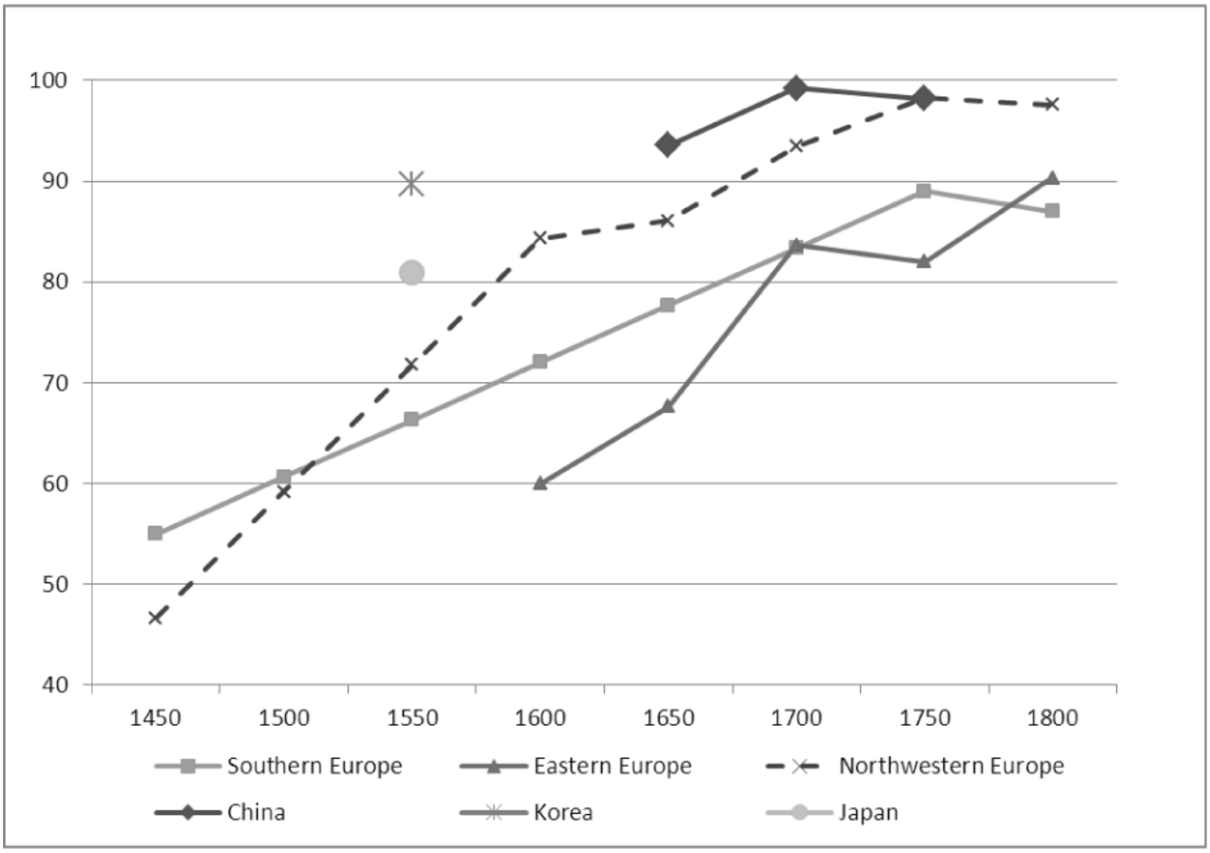


Figure 4 East Asian and European numeracy comparison



Notes: Values refer to half centuries of birth around the years noted. The evidence is based on A'Hearn, Baten and Crayen (2009), Table 4. We included all the countries for which longer series or at least early values were available: "Northwestern Europe" is the UK, the Netherlands and Protestant Germany, and "Southern Europe" is northern Italy. "Eastern Europe" is the average of Russia, Bohemia and Austria (from approximately 1600). "Average" is the average of those three regions. When values between the benchmark dates were missing, they were interpolated. Weak estimates (in italics in Table 4 of A'Hearn et al.) were omitted. For the UK and the Netherlands before 1600, the benchmark year is 1600 in the UK, and the changes are calculated based on Protestant Germany.