Japan and the World Economy 43 (2017) 14–22

Contents lists available at ScienceDirect

Japan and the World Economy

journal homepage: www.elsevier.com/locate/jwe

Numeracy in early modern Korea, Japan, and China: The age-heaping approach

Jörg Baten[a,*], Kitae Sohn[b,c]

[a] University of Tuebingen, CEPR and CESifo, Germany
[b] Konkuk University, Republic of Korea
[c] Curtin University, Australia

ARTICLE INFO

Article history:
Received 16 November 2016
Received in revised form 21 August 2017
Accepted 24 August 2017
Available online 4 September 2017

JEL classification:
O15
O40
I21
N35
N30

Keywords:
Human-Capital
Development
Growth
Numeracy
Korea
China
Japan

ABSTRACT

This study first draws on a unique data set, *hojok* (household registers), to estimate numeracy levels in Korea from the period 1550–1630. We add evidence from Japan and China from the early modern period until 1800 to obtain human capital estimates for East Asia. We find that numeracy was high 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, with implications for our understanding of Asian growth processes.

1. Introduction

This study first employs Korean household registers (*hojok*) to measure numeracy levels during the period of the 16th and 17th centuries. We further compare Japanese and Chinese numeracy figures to obtain general estimates of early East Asian numeracy. We find that numerical human capital was quite high in East Asia in the early modern period (1550–1800).

Why did this not result in early economic growth in East Asia? After all, the relationship between human capital and growth in GDP per capita is well established in modern growth regressions (Hanushek and Woessmann, 2012). The impact of human capital on income growth has also been confirmed for historical periods. For example, focusing on the second half of the 18th century, Baten and van Zanden (2008) found that higher human capital (measured by books per capita) caused higher GDP growth over the following period (Fig. 1).[1] Countries with low levels 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 or even to overtake Great Britain.

It is an important motivation for our study that China is clearly an outlier in this type of growth regression for the 18th and 19th centuries. China already accumulated a substantial stock of human capital, but did not manage to grow in the period from 1820 to 1913. However, China has grown substantially since 1978. Japan

* Correspondence to: Melanchthonstr. 30, 72074 Tuebingen, Germany.
E-mail address: joerg.baten@uni-tuebingen.de (J. Baten).

[1] 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 included a number of European and non-European countries. Relatively reliable GDP estimates were available for the period 1820–1913 (Fig. 1). 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). The coefficient on book production was positive and statistically significant.

http://dx.doi.org/10.1016/j.japwor.2017.08.001
0922-1425/

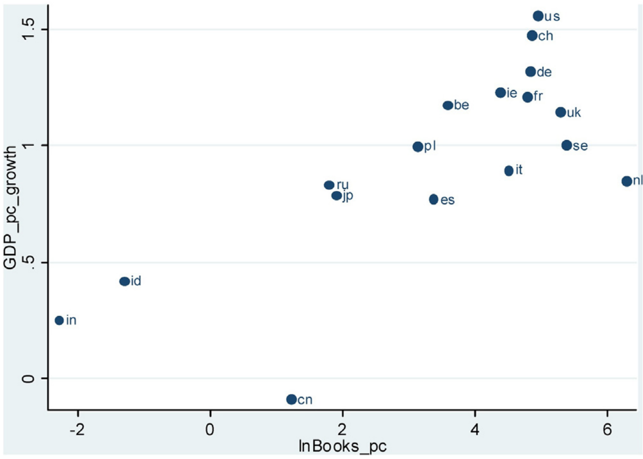

Fig. 1. Book production per capita between 1750 and 1800 and GDP per capita growth 1820–1913 (books on log scale).
Source: Baten and van Zanden (2012).

already started its impressive catch-up growth after the Meiji Restoration in 1868 and achieved convergence to the rich countries during the mid-20th century; South Korea followed shortly thereafter. Japan was able to transform human capital into growth relatively early, whereas the process occurred later in China. Arguably, institutional and cultural factors prevented these East Asian countries from joining early the club of rapidly growing countries, despite their high numerical human capital (Acemoglu et al., 2005; but see Li and van Zanden, 2012). Our findings imply that in East Asia, the foundations for human capital-based rapid catch-up growth were laid very early. Future studies might explore whether Korea, Japan, and China returned to the growth path because of their early numeracy development.

The main value-added of this study, however, is to measure basic mathematical skills in early-modern Korea and Japan. We then compare the results with China and Europe and eventually obtain a global evaluation of early human capital development. In this endeavour, we need to define that we actually identify a very basic form of numeracy here, which represents the ability to add and subtract small integer numbers. In the agricultural society of the early modern period, it is not self-evident that even basic numeracy developed in all countries. For example, in many countries of West Asia and South Asia, numeracy was surprisingly low even in the 19th century (Crayen and Baten, 2010). The inability to perform simple mathematical operations was a hurdle in developing new (and often calendar-based) techniques in agriculture. But we would not expect more advanced math skills, such as differentiation, for large parts of the early modern population. This cannot be expected for Korea, Japan, or China, and also not for any other country of the early-modern period.

Not many studies focused on mathematical skills in early modern Korea. Two short studies described the evolution of the mathematical elite and mathematics in Korea (Kim 1986, 2008; on Japan and China, see Bréard and Horiuchi, 2014). Kim (1986) found that Korea did not have a high number of mathematical geniuses during the early modern period. Instead, Korean mathematics before the 20th century was mostly oriented towards the needs of agriculture and governmental bureaucracies, following similar ideals as traditional Chinese mathematics. While the development of academic mathematic research was limited in early modern Korea, the advantage was that a division between a mathematical elite and the other parts of the population was not as rigid as in other countries, such as in France during the 18th century. The pragmatic mathematical insights of the elite could be more easily communicated to decision-makers, such as farmers, in the normal Korean population. However, this positive aspect of mathematics in modern Korea lacked quantification. We attempt to present rough estimates of this aspect.

In the following Section 2, we first explain the age-heaping methodology. In Section 3, we discuss the new evidence on Korea. Section 4 presents new evidence on Japan and compares it with existing studies on China and Europe. We then assess the plausibility of our results by comparing them with the literature on East Asian education and human capital (Section 5), and we present our conclusions in Section 6.

2. Age-heaping

The so-called age-heaping strategy allowed us to obtain insights into the numerical abilities of Koreans living during the period 1550–1800. It 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 to state their age as “30” if they are actually 29 or 31 years old compared with people who have a greater human capital endowment (Mokyr, 2006). The most widely used numerical index to measure this is the Whipple index:

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

A’Hearn et al. (2009) suggested an index called the ABCC index.[2] It is a simple linear transformation of the Whipple index. It is easier to interpret and yields an estimate of the share of individuals who report their ages correctly[3]:

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

A’Hearn et al. (2009) found that the relationship between illiteracy and age-heaping for Less Developed Countries after 1950 was very close. 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 strongly correlated with numerical skills.[4]

3. Data on Korea

Measuring Korean numeracy for the early period of 1550–1800 required age statements in sufficient numbers. The data for this study were collected from 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.

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

[3] We exclude ages below 23 and above 72 because a number of possible distortions affect those specific age groups, leading to age reporting behavior different from that of the intermediate adult group. On the one hand, young individuals are likely to have recently passed landmarks at which their ages were ascertained, such as marriage, military service, or immigration. In other cases, parents respond to the age question for children, so the evidence does not allow one to measure the basic numeracy of children. Old individuals on the other hand may firstly be more likely to forget their ages. Secondly, the healthier and perhaps more educated might survive longer. Thirdly, the extremely old sometimes deliberately exaggerate their ages and round them to 100 or similar numbers. Hence, it is common in the literature to exclude very young and old individuals from the sample (for more, see A’Hearn et al., 2009).

[4] Sohn (2014) also applied the index and found that it provided reasonable estimates of the human capital of black soldiers during the American Civil War.