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Abstract

This paper traces the human capital development of 14 Asian countries for the period of 1900-60, using the age-heaping method. We place special emphasis on the gender gap in numeracy and its determinants. In particular, we test the validity of a 'U-hypothesis of gender equality', implying that gender equality in numeracy declines at initial stages of development and increases again with higher numeracy levels. The U-shaped pattern is strongly confirmed by our data.

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Introduction

Gender inequality is one of the large burdens for economic development, because the economic potential of women does not become part of a country's growth capacity, as Klasen[1] argued. Especially South Asian countries could have grown by 0.9 percentage points per year faster if they had started off with better educational levels in the 1960s. Gender inequality in education excludes women from educational opportunities. Since women raise future generations, female education has also important implications for the education of both genders.

Today, most world regions show gender inequalities in education (Figure 1). The magnitude of the gender gap in South and West Asia is striking, where the difference between male and female literacy rates amounts to 21.6 percentage points. The gender gap in literacy in East Asia and the Pacific constitutes less than a third of the figure for South and West Asia.

This raises a number of questions which require an economic history approach: Did those disparities in education already exist in earlier times? Did culture and historical events account for the different levels of educational attainment of men and women? How did the gender gap develop over time?

We explore the human capital development in 14 Asian countries during the period of 1900-60. We place special emphasis on the gender gap in education that arises from distinct opportunities open to men and women. Since literacy information is rare for the decades before 1950 and especially not available disaggregated by gender, we use the age-heaping method to estimate the basic human capital level of different Asian countries. The age-heaping method assesses the basic numerical skills of a population by looking at the share of

[1] Klasen, *Low Schooling for Girls*. For the effect of gender inequality on development, see World Bank, *Engendering Development*.

persons reporting an exact age. Less numerate populations tend to round their ages to multiples of five.[2]

We find not only that there was a substantial gender gap, but this gap had an interesting development path: at low education levels the gender gap was quite small, but it increased with overall education. Beyond a threshold point it began to narrow again. Goldin[3] hypothesized theoretically such a U-shaped relation between women's labour force participation and economic development: while at low income levels women are highly engaged in the production of goods, notably in the subsistence sector, development in the form of an expansion of the industrial sector leads to an initial fall in the female labour force participation. Female labour opportunities are restricted, as the subsistence sector is declining and women's employment in the new manufacturing sector is socially stigmatised. By contrast, men take over blue-collar jobs in the boosting urban agglomerations and earn higher wages so that the need for women to work – and sometimes along with that their social status – might decrease. With further development, accompanied by higher school enrollment rates and increased availability of white-collar jobs in the industrial and service sectors of the economy, women's labour force participation rises again. Mammen and Paxson[4] conclude that the U-hypothesis for female labour force participation and GDP per capita applies to cross-country and individual-level data and additionally find a U-shaped pattern underlying the relation between education and GDP per capita in India and Thailand.[5]

Female labour force participation has implications for the relative educational level of women. Firstly, since expected returns on investment in girls' education, on which parents base their decision on sending a daughter to school or not, are a function of the prospects of female employment, female education might follow the same U-shaped pattern with respect to

[2] Crayen and Baten, *Global trends*.
[3] Goldin, *The U-Shaped Female Labour Force Function*.
[4] Mammen and Paxson, *Women's Work*.
[5] Kingdon (1997) also finds a U-shaped relationship between female education and work participation for women in India. Furthermore, Esteve-Volart (2004) displays the relationship between female formal labour participation rates and logged per capita real output by Indian states.

development. Secondly, the same social stigma that hinders women from accepting jobs in the paid industrial labour force might undermine female education.

Clearly, a number of other variables matter for the relative education of women, such as religion and voting rights, for example. In a regression analysis of the female labour force participation rate on religious variables by Psacharopoulos and Tzannatos[6], a third of the difference in the female participation rates in ninety countries is attributed to religion. The authors also confirm a positive relation between schooling and female labour force participation. Likewise, Dollar and Gatti[7] agree on the explanatory power of religion and societal characteristics on gender inequality in education. We will test both the economic and social aspects on their influence on female numeracy below.

We decided to remove the East Asian countries China and South Korea as well as Vietnam from our analysis, because they had already solved the basic numeracy problem at the beginning of our period.[8] Including them would actually make the results stronger (results available from the authors). The East Asian countries are cases which confirm the U-hypothesis, because they reached relatively good numeracy and gender equality early on: The situation of women in East Asia resembled the conditions in South Asia at the beginning of the nineteenth century, but underwent radical transformations under European and Japanese influence. Even before these changes, some women from the Chinese upper class received lessons in reading, writing, painting, and music so that they could prepare their sons for the highly competitive and prestigious civil service examinations.[9] With the abolishment of these examinations in 1906, Confucian teachings lost their relevance and Western-style education gained popularity. The government founded as well public schools for girls in addition to private and missionary schools for girls.

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[6] Psacharopoulos and Tzannatos, *Female Labour Force Participation*.
[7] Dollar and Gatti, *Gender Inequality*.
[8] Hong Kong is the only exception in the Eastern part of Asia which had high basic numeracy, but still some age-heaping remains. Hence, we included Hong Kong.
[9] Mann, *Women in East Asia*, pp. 49-57.

In Korea, primary schools were established by the Yi government, in addition to Christian missionary schools, before the Japanese annexed Korea and adapted the Korean school system to their modern education system.[10] With the rise of industrialisation under Japanese colonial rule, Korean women started to take up work in factories. After attaining independence Koreans so greatly endorsed educational achievements that parents sold their properties to afford education to their children.[11] Today, Korean students lead with high scores in mathematics and science on international tests.

Gendered Education in Asia?

Before we present our new human capital estimates for Asia, we turn our attention to the country-specific characteristics and historical experiences that shape the attitude of a country's population towards education. In the following overview we outline the situation of formal basic education and shed light on the status of women in society and working life. We present selected interesting cases to show the diversity in Asia in respect to gendered education.

Formal education is determined by supply and demand. On the supply side we have the national and local governments, charities and religious organisations. The demand of education is influenced by economic incentives, such as labour market perspectives, or by economic constraints, such as poverty and the dependence on child labour. In addition, culture and religion play a role, because there is variation in the importance they place on education and the social and (re)productive role they ascribe to women. Profound economic changes that come along with industrialisation can erode cultural traditions and with it the status of women. Furthermore, organisational issues, such as a good infrastructure and the availability of female teachers, clearly matter.

[10] Choi, *Schooling in South Korea*, p. 323.
[11] Kwak, *Korea*, p. 205.

Since we use numerical abilities as a proxy for education, we have to consider that skills of basic numeracy, rather than literacy skills, are not exclusively acquired in schools but also in the household taught by the parents. Therefore, the level of female numeracy might not only depend on formal schooling but also on the social and economic role of women.

Government and religious groups as suppliers of education

What do we know about the educational situation in Asia during the first decades of the 20th century? We will first discuss the general educational situation, before focusing on gender differences below. Given that most of the countries were colonised during the sample period, colonial governments were in the position of providing universal education that had not existed in Asia at that time. However, the colonial administrators established western-style schools only on a small scale, mostly in urban areas, and often exclusively for Europeans and the national aristocracy. This pattern applied to British India (today's Bangladesh, India, and Pakistan), Indonesia, Vietnam, Cambodia, and the Federation of Malaya (today part of Malaysia).

However, as Benavot and Riddle[12] point out, differences in the expansion of primary schooling can be observed among the European powers. In world-wide comparison, Britain pursued a more active education agenda than did France, whose colonies recorded enrolment rates in primary schools in 1940 that the British colonies had already attained by the end of the nineteenth century. Interestingly, this pattern for the worldwide sample of colonies is not confirmed in Asia, as especially British India had low primary schooling rates.[13] Chaudhary explains that the social heterogeneity and the hierarchical differences between the castes exacerbated the provision of primary schools as the elites, such as Brahmans, supported secondary schools for their children instead of primary schools for the masses.

Despite this disappointing situation, educational institutions were built also for women in the 1870s and 1880s and a special commission, the Indian Education Commission, was set

[12] Benavot and Riddle, *The expansion of primary education*.
[13] Chaudhary, *Determinants of Primary Schooling, p. 300.*

up to forward policy recommendations.[14] The Viceroy of India, Lord Curzon, took initiatives to enhance female education with the Resolution on Educational Policy in 1904, which increased public funds for the establishment of girls' primary schools and training colleges for female teachers. The Resolution on Educational Policy of 1913 proposed to grant scholarships to female students but financial problems delayed further achievements.[15] The transfer of responsibility to the provinces, the social awakening of women in the 1920s, and last but not least Mahatma Gandhi's postulation of gender equality helped improve the opportunities for women, though on the whole progress in education was poor before independence.[16] Only 2.9 per cent of Indian women were literate in 1931.[17]

The British Education Inspectors did not make significant efforts to improve education for the Muslim population predominantly situated in (the area of today's) Bangladesh and Pakistan. Despite the Woods Despatch of 1854 which demanded better education (also for girls) and the Resolution on Muslim Education in 1871 which established quotas for Muslim pupils, Muslim participation in education remained low and Muslims continued to be underrepresented in government positions.[18]

In the Philippines we see a different, much more progressive picture. With the Education Act of 1901 American administrators in the Philippines established free public schools staffed with American teachers and with English as the language of instruction. Prior to that, advances in the expansion of primary schools (also for girls) had already been made under Spanish rule since 1863, so that by the end of the nineteenth century the literacy level of Filipinos exceeded that of some European states.[19]

In Cambodia the French introduced modern secular education but did not explicitly support the education of girls. Their interest concentrated on the recruitment of male civil

[14] Agrawal, *Women's Education in India*, p. 21.
[15] Pruthi and Sharma, *Education and Modernisation*, pp. 79-80.
[16] Gosh and Talbani, *India*, p. 167.
[17] Pruthi and Sharma, *Education and Modernisation*, p. 119.
[18] Amin, *Schooling in Bangladesh*, p. 41. Chowdhury, *Pakistan*, p. 189.
[19] Torralba, Dumol and Manzon, *Schooling in the Philippines*, p. 280.

servants for the colonial bureaucracy. At the beginning of the twentieth century *wat* schools (schools in Buddhist monasteries) were modernised, allowing access to education in rural areas of Cambodia. Since Buddhist monks were not supposed to associate with girls, however, girls usually did not benefit from the reforms.[20]

Apart from colonial governments, religious groups, notably Christian missionaries, built schools and taught indigenous pupils. This occurred in all countries – in the colonised and independent ones alike. In harmony with Christian egalitarian precepts, these schools usually admitted girls. Still, the national population often refused to send their children to Western schools.[21]

Afghanistan is an interesting example for the conflict between the clergy and the government when it comes to an attempt to modernize education. Boys were taught reading, writing, and Islamic rituals by the *mullah*, the Muslim clergy, in mosques, while girls received a basic education in reading the Qur'an and praying at home. With the aim to offer free and secular education, King Habibullah (1901-19) made efforts to bring education under the control of the government. He founded several schools but the opposition from the *mullah* slowed the process considerably. When his successor Amanullah (1919-29) wanted to introduce compulsory education for boys and girls and reform the laws and customs that abased Afghan women, he was forced to resign by the *mullah*. Although Zahir Shah (1933-73) managed to increase the number and quality of schools in Afghanistan with international, especially American, help, only five per cent of the primary school-age population was enrolled by the mid-twentieth century.[22]

According to Kazemzadeh, the situation was quite different for women in the neighbouring state Iran: Women in Iran enjoyed mass education after the Constitutional

[20] Sopheak and Clayton, *Schooling in Cambodia*, pp. 41-4.
[21] Law, *Schooling in Hong Kong,* p. 88.
[22] Shirazi, *Schooling in Afghanistan*, pp. 20-6.

Revolution of 1905-11 and by the 1960s even entered blue-collar employment.[23] In Thailand (Siam) the progressive Kings Rama IV (1851-1868) and Rama V (1868-1910) modernised the country's education system in the mid-nineteenth century and suggested a strand of Buddhism compatible with science. The first government school for girls was established in 1901.[24]

Cultural and social norms as barriers for female education

In South and West Asia, the role of women in social, political and economic life was strongly influenced by the Hindu and Muslim religion – and still is today. Most Hindu and Muslim families did not invest in a girl's education because the expected returns to sending a daughter to school did not exceed the costs of doing so.[25] The benefits would go to the husband's family where women resided after marriage.[26] Furthermore, the opportunity costs of sending a girl to school were too expensive for many families, as daughters assumed a great part of the domestic tasks in contrast to their brothers.[27] Early marriage was common and presented another barrier to female education, even after the British colonial government set the age for marriage at 14 years for girls in 1929.[28] Subordinated to the man's will, wives were not supposed to have a higher education than their husband. That made education of girls 'socially costly'.[29] Since Hindus and particularly Muslims adhered to female seclusion and veiling, girls were usually not sent to co-educational schools or to schools lacking female teachers.[30] This norm further restricted educational opportunities for girls, as girls' schools were rare at that time and mostly located in the cities. [31]

[23] Kazemzadeh, *Iran*, pp. 177-8.
[24] Sinlarat, *Schooling in Thailand*.
[25] Hill and King, *Women's Education*, pp. 23-4.
[26] Khan, *South Asia*, p. 228.
[27] Chowdhury, *Pakistan*, p. 202.
[28] Gulati, *Impact of the Development Process*, p. 298.
[29] Chowdhury, *Pakistan*, p. 199.
[30] Ahmed, *Pakistan*, p. 270.
[31] Gosh and Talbani, *India*, pp. 170-81.

Although the above holds true for most of South and West Asia, Southern India and Sri Lanka stand out. The Indian state Kerala had the lowest gender gap in literacy.[32] Ghosh and Talbani attribute this incidence to the matriarchal system, the dominantly Christian population, and the absence of *purdah* (veiling) among the Muslim communities. Even further educational progress was recorded for Sri Lanka that virtually achieved gender equality in education by 1963. Compared to Hindu and Muslim women that usually did not participate in the organised labour force, Sri Lankan, mostly Buddhist, women have traditionally worked with men in the agricultural and industrial sector.[33] In Sri Lanka, missionary education constituted the official school system and influenced society insofar that Saram speaks of a 'Protestant Buddhism' that has shaped Sri Lankan social life.[34]

In Southeast Asia, women enjoyed a relatively higher status in society and had more legal rights than their counterparts in South Asia. They were not concerned by seclusion and separation but managed household finance, had command over productive resources and participated in market activities.[35] In Vietnam for example, daughters could inherit land and wives were allowed to hold a share in family property and participate in religious rituals.[36] As one of the first Asian countries, Thailand introduced universal male and female suffrage in 1932. Buddhism, the major religion in most of the Southeast Asian countries, proscribed – unlike Hinduism – duties for both marriage partners. Not only dowries but also bride prices were paid, hence enhancing women's dignity. Also, women were given a say in the choice of their future husband. Although education was mainly provided for boys in monastic schools

[32] The southern Indian states also have sex ratios above the national average. Rajeswari (*Demographic Perspective*, p. 341) ascribes this fact to the female work participation, which is higher in the south than in the north.
[33] Mittra and Kumar, *Encyclopedia of Women in South Asia*, pp. 33-8.
[34] Saram, *Sri Lanka*, p. 348.
[35] Elson, *International Commerce*, pp. 173-4, see also Boserup, *Woman's role*, p. 91.
[36] Rambo, *Vietnam*, p. 412.

until its secularisation in the late nineteenth century, sophisticated Buddhist monks did not oppose female education in general.[37]

Not all countries in Southeast Asia are characterised by a Buddhist tradition. Filipinos are largely Roman Catholic, whereas Indonesia and Malaysia[38] are predominantly Muslim. Due to American influence, the Philippines encouraged female education.[39] Thirty per cent of working women were employed in the modern sector by the mid-twentieth century – the highest figure among the developing countries.[40] The Muslim societies in Indonesia and Malaysia differed from those in Afghanistan, Bangladesh, and Pakistan in so far that firstly Indonesia was a secular state, where women were active and financially independent members of society and whose princess even advocated the emancipation of Indonesian women.[41] Secondly, the Muslim population in both countries did not practice veiling.[42] And thirdly, Indonesia and especially Malaysia became multiethnic countries with the influx of immigrants, particularly from China.[43] The Chinese supported their children's – also their daughters' – educational aspirations.[44]

It is important to stress that even though women's legal and social status improved in theory in some countries, apparently, the overall demand for the education of girls was low during the period under study.

What do we expect for the gender-specific human capital development in terms of numeracy? First of all, we expect the numeracy level of both men and women to rise in all

[37] Buddhist countries promoted co-education and trained women as teachers and administrators; they did so even better than India, Muslim countries, and many Latin American countries. See Carroll, *Women, Religion and Development*, pp. 89-104.
[38] This paper distinguishes between the Federation of Malaya and Sarawak. Sarawak became part of Malaysia in 1963. If we speak of 'Malaysia', we refer to the Federation of Malaya.
[39] Gomez and Pedro, *The Philippines*, p. 265.
[40] Boserup, *Woman's Role*, p. 182.
[41] Oey-Gardiner and Suprapto, *Indonesia*, p. 95.
[42] Tilak, *East Asia*, p. 269.
[43] The plurality of Malaysian society produced a variety of school types: from public schools to Christian missionary schools and Chinese schools. (Means, *Malaysia*, p. 477.)
[44] Loo, *Schooling in Malaysia*, p. 211.

countries during the sample period. As hypothesized by the U-curve, we anticipate that the numeracy level of men increases more rapidly relative to the numeracy level of women in the first stages of development, which will be reversed later. Secondly, we expect the overall level of numeracy to be relatively low in South and West Asia with the exception of Sri Lanka and possibly Iran, higher in Southeast Asia particularly in the Buddhist countries and the Philippines, and highest in East Asia. Thirdly, the gender disparity might be higher in South and West Asia than in Southeast Asia and East Asia.

Data and Methodology

Do the educational indicators in Asia confirm this review of the literature? According to the estimates of Benavot and Riddle[45] primary school enrolment for both genders varied widely in Asia across countries and over time. Among the countries with available data, Sri Lanka (Ceylon) and the Philippines display the highest enrolment rates during the period 1870s to 1940s. Sri Lanka started with around seven per cent in the 1870s and improved steadily the enrolment ratio up to 54 per cent in the 1940s. Taiwan and Thailand show the strongest increase: within 50 years their governments raised the enrolment ratio from around two per cent to over 50 per cent. India and Burma on the other hand were countries whose enrolment ratios almost stagnated over time: India raised its enrolment rate from the 1870s to the 1940s only by 10 per cent to around 12 per cent. During the 1950s and 1960s most countries could boost their primary school enrolment ratios, but they were all still far from universal education during the mid-20th century. Unfortunately, we do have enrolment data disaggregated for male and female pupils not until the late 1950s for most of the Asian countries.[46]

[45] Benavot and Riddle, *The expansion of primary education*.
[46] UNESCO, *Statistical Yearbook 1963*, pp. 56-57. This is also the time when we have the first data on female literacy, however, for only a few of countries and again not for single age-groups. Ceylon (46 per cent), the Philippines (44 per cent), and Thailand (48 per cent) show the lowest illiteracy rates for women and Sarawak (94 per cent), Nepal (99 per cent), and India (92 per cent) the highest. (UNESCO, *Statistical Yearbook 1963*, p. 28)

The UNESCO Statistical Yearbook of 1963 provides additionally data on the percentage of female teachers employed. Figure 2 displays the relationship between the percentage of female teachers employed and the percentage of female pupils enrolled. Although only data for nine countries are available for the regional area of our interest, a clear positive relationship is visible. This supports the hypothesis that female teachers are important to lower barriers for young girls whose parents would disagree that their daughter is taught by male teachers. As these data stem again from the late 1950s, they give us also hints on the educational status of women in the preceding decades as the female teachers had to go to school of course before they became such.

As just discussed, evidence of conventional human capital indicators (literacy, school enrolment rates or years of schooling) is scarce for the period prior to WWII in this region. Therefore, we will employ a proxy approach in this study, the age-heaping method. This method is based on the phenomenon that people in less educated societies tend to round their age if they are unable to recall or calculate their exact age when they are asked for it. Typically, people choose ages on digits ending in multiples of five, i.e. they state their age as 30 if they are in fact, for example, 29 or 32.[47]

Age-heaping can be used as a human capital indicator: because less educated people often choose ages on digits ending in multiples of five, the share of persons who are able to report their exact age is an indicator for numerical skills.[48] Its usefulness was first suggested by Bachi[49] who found an inverse correlation between age-heaping and educational levels within and across countries and verified in some more studies. Mokyr[50] pioneered its use in

[47] See Figure I in the Appendix for an example of extreme age-heaping.
[48] Most demographers, including those at the UN statistical departments, treat age-heaping as a statistical problem. They calculate Whipple indices to measure the accuracy of age statistics, with high Whipple indices indicating unreliable data. We interpret this phenomenon from a different point of view: we do not associate high Whipple Indices with a data problem but with a lack of numerical skills of the population.
[49] Bachi, *The tendency to round off age returns*.
[50] Mokyr, *Why Ireland Starved*.

economic history. Crayen and Baten found that age-heaping tends to be more pronounced in population groups with lower income and/ or lower-status occupations. [51]

Recently, several studies confirmed a positive correlation between this indicator and other human capital indicators. In their global study on age-heaping for the period 1880 to 1940, Crayen and Baten[52] identified primary school enrolment as a main determinant of age-heaping: an increase of enrolment rates led to a significant decrease of the age-heaping level. This close correlation between schooling and basic numeracy is not only found among this global data set, but is also confirmed by other studies for regional age-heaping subsamples (e.g. Manzel et al.[53] for Latin America around 1870 to 1930, Prayon[54] for early 20th century Africa). A'Hearn, Baten, and Crayen[55] examined the US Census of 1850, 1870, and 1900 and found for the overall sample as well as for subsamples a positive and statistically significant relationship between literacy and basic numeracy.[56] They also went back further in time and studied the relationship of signature ability as a proxy for literacy and age-heaping as a proxy for numeracy in early modern Europe. Here as well they found a positive correlation between the two measures. In a study on China, Baten et al.[57] found a strong relationship (correlation coefficient: -0.8) between the age-heaping and literacy among Chinese immigrants in the US born in the 19th century. Additionally, Hippe[58] examined systematically the relationship of numeracy and literacy in all regions of seven European countries in the 19th century. He found for each country separately a high correlation between the two indicators, and. Similar to

[51] Crayen and Baten, *New evidence.*
[52] Crayen and Baten, *Global trends*. For each decade in the period under investigation the relationship between age-heaping and schooling is remarkably stable and has almost the same coefficient in each period. The coefficient varies only between -0.20 and -0.27 between the 1890s and the 1940s.
[53] Manzel, Baten and Stolz, *Convergence and divergence.*
[54] Prayon, *Human capital development in Africa.*
[55] A'Hearn, Baten, and Crayen, *Quantifying quantitative literacy.*
[56] We collected literacy data for the Asian region to check whether we find here the same positive relationship of basic numeracy and literacy. We took the literacy data from the United Nations Demographic Yearbooks and assigned the age groups to the corresponding birth decades. Comparing the two human capital indicators on the basis of these birth cohorts we find indeed a strong positive correlation (with a Pearson's correlation coefficient of .85). Unfortunately, due to limited data availability only 9 countries with overlapping data are left for this analysis (Figure 3).
[57] Baten, Ma, Morgan and Wang, *Evolution of living standards.*
[58] Hippe, *Numeracy vs literacy.*

A'Hearn, Baten, and Crayen[59] he notes that the upper and lower boundary of the two indicators should be taken into account. It can be concluded that the correlation between numeracy and other education indicators can now be regarded as well-established.

Indeed, the age-heaping method displays advantages that literacy or enrolment evidence lacks. Due to its consistent calculation, age-heaping results might be more easily comparable across countries, whereas comparisons of literacy and enrolment rates might be misleading due to significant measurement differences or different school systems. Further, owing to usually high drop-out rates in developing countries and heterogeneous teacher quality, it can be argued that enrolment rates are less conclusive for our goal as enrolment ratios are an input measure of human capital: Even though a country might have quite high enrolment ratios, it does not tell us something about the quality of education. Age-heaping on the other hand is - like literacy - an output measure of human capital. Another convenient advantage of the method is that it can applied to a wide range of sources, for instance census data, passenger lists, or any other kind of individual age recording. This way we can trace basic numerical skills of populations from periods and areas for which no other human capital indicators exist yet. This applies especially to this study: using the age-heaping strategy it is possible to illustrate the gender differences in basic human capital in Asian societies during the first half of the 20th century. We do not have other human capital indicators that are comparable for this period.

To measure the extent of age-heaping within a certain population, the Whipple index has been developed and became widely accepted:

$$(1) \quad WI = \left(\frac{n_{25} + n_{30} + ... + n_{65} + n_{70}}{1/5 \times (n_{23} + n_{24} + n_{25} + ... + n_{72})} \right) \times 100 \text{ if } WI \geq 100; \text{ else } WI = 100.$$ [60]

[59] A'Hearn, Baten, and Crayen, *Quantifying quantitative literacy.*

[60] Whipple indices below 100 (ABCC indices above 100, respectively) in the 20th century rich countries are normally caused by random variation, hence those values are normally set to 100.

Since mortality increases with higher ages, the frequencies of reported ages ending in multiples of five would augment and lead to an overestimation of the Whipple index. To overcome this problem, we spread the final digits of 0 and 5 more evenly across the age ranges and define the intervals 23-32, 33-42, and so forth. [61]

A'Hearn, Baten, and Crayen[62] propose a more convenient linear transformation of the Whipple index, the so-called ABCC index. This index ranges now between 0 and 100: 0 indicates an age distribution with ages ending only on multiples of five whereas 100 implies no age-heaping at all:

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

What are the determinants of numeracy? We have already addressed two potential determinants of numeracy in section II. Formal education can enhance numerical skills. Numerical abilities can also be taught in the household by the family.[63] A further tool to develop numerical skills is the use of calendars or the knowledge of astrology.

Like other proxies, the age-heaping measure has its limitations. It only captures age-heaping on multiples of five, although people in their late teens and their early 20s tend to round on multiples of two. In addition, some cultures have specific number preferences, for example the 8 or the dragon year in China. But Baten et al.[64] found that it does not distort the index much. Similar, if individuals were asked for their date of birth instead for the age at their last birthday, a birth year-heaping pattern could arise. In both cases the age-heaping method does not return unbiased estimates, so the age-heaping patterns should be checked carefully. Further, due to its upper boundary and therefore lacking variation, we do not get meaningful results in populations that reached full numeracy.

[61] We do not consider people younger than 23 because parents might report their children's age. We also exclude people older than 72 as they frequently forget or overstate their age or might be positively selected.
[62] A'Hearn, Baten and Crayen, *Quantifying Quantitative Literacy*.
[63] A'Hearn, Baten and Crayen, *Quantifying Quantitative Literacy*, p. 15.
[64] Baten, Ma, Morgan and Wang, *Evolution of living standards and human capital in China.*

Relevant for the explanatory power of ABCC indices is the method of data collection. It is important to know if age information is derived by statements from the person herself, from a second party like a wife's husband or by estimates made by the enumerator. Our assumption that most households' members were interviewed separately by the enumerator seems to be very strong. However, several facts about the census data and their collection justify our assumption. First, the 23 censuses used in this study were all conducted between 1947 and 2001, most of them between 1960 and 1990, when most countries had adopted international census standards as promoted by the United Nations. That means that the personnel were trained and briefed before conducting the census what should ensure a certain quality of the data collection procedure.

Second, in countries with prevailing illiteracy censuses are usually conducted with the help of canvassers instead of self-enumeration. This should lower the probability that i.e. the household head made up some answers. However, this could give rise to another possible bias: 'If that [age] is not known, then an estimate of the age is made by the trained canvasser following determined guidelines, for example, that are based on a calendar of local historical events.'[65] It is remarkable that strong age-heaping exists even when the historical calendar method is used in developing countries as one would assume that this should lower age-heaping. Is the historical calendar method therefore a problem for the age-heaping method? We do not think so. It does not make a difference whether the individual or the canvasser reports a rounded age if the true age is unknown. A study by Scott and Sabagh[66] supports this view. They investigate the behaviour of canvassers during the Moroccan Multi-Purpose Sample Survey of 1961-1963 and found that the canvassers were indeed not free of reporting rounded ages of people that did not know their age themselves. The interesting feature in this context is that between 70 and 90 per cent (dependent on the age underlying age group) of the interviewed people did not know their age and the historical calendar method was applied.

[65] Domschke and Goyer, *The handbook of national population censuses*, p. 20.
[66] Scott and Sabagh, *The historical calendar.*

Expressed in ABCC values this would imply an overall numeracy level somewhere between 10 and 30 ABCC points. And indeed, this fits pretty well the calculated age-heaping level observed in Morocco for the census of 1960, namely an ABCC level between 20 and 40.[67]

Using the information on age distributions of the populations from these census data we calculated Whipple and ABCC Indices for each country and birth decade. In the case that data overlap for one or several birth decade within a country because more than one census was available for this country, we calculated the arithmetic average of the indices. Crayen and Baten[68] examined a possible correlation of age and age-heaping and published the results in the Appendix of their study on global trends in numeracy. They found a systematic influence of age on the heaping behaviour among the youngest age group: 23 to 32. People at this age tend to heap their age less than the older age groups. In contrast, older ages rounded on average as strongly as would have been expected for their birth cohort. Based on this observation, Crayen and Baten suggested an adjustment of the numeracy index for the youngest birth cohort.[69] Figure 4 shows three examples from Asia where we have overlapping census data. The youngest age group (i.e. always the last data point of each trend line) underwent already the suggested adjustment. What we can see is that the overall levels of the trends do not differ strongly, although based on different census years. Even in the case of the Philippines, where 42 years are between the first and the second census, the last data point (i.e. the youngest age group) in the trend line of the census of 1948 and the first data point (i.e. the oldest age group) of the 1990 census trend line do not differ much. These trends show that, although the data come from different census years, they correspond quite well, i.e. no effects of better 'census-taking' or learning effects among adults are visible. Generally, our interest is on the overall trends and we do not interpret small changes of the index. This

[67] Prayon and Baten, *Human capital.*
[68] Crayen and Baten, *Global trends.*
[69] For the youngest age group, that is the birth decade closest to the census year, we conducted the age adjustment proposed by Baten and Crayen (2010a, Appendix). They suggested the following adjustment for the youngest age group (23-32): (WI-100)*0.25+WI.

finding is an important difference to literacy. If we do the same procedure with literacy rates, we find often quite strong differences between different census years for the same birth cohorts. Hence, for literacy learning effects later in life are much more common than for basic numeracy.[70] This finding confirms our assumption that the latter is acquired mainly during the first decade of life.

We calculate the gender equality index in numeracy (GE_{num}) as the ratio of the difference between the Whipple index of females (WI_f) and the Whipple index of males (WI_m) to the Whipple index of males, multiplied by -100:

$$(3) \quad GE_{num} = -\left(\frac{(WI_f - WI_m)}{WI_m} \right) \times 100$$

The higher the gender equality index, the more women know their exact age in comparison to men. We expect the gender equality index to be negative; negative gender equality indices imply better numerical discipline for men. Although our countries are rather characterised by gender inequality, we use a gender equality measure to make our results more easily comparable with the literature on female labour force participation by Goldin[71] and Mammen and Paxson[72] and to follow the methodology used by Manzel and Baten.[73] The calculated Whipple and ABCC indices as well as the gender equality indices for the countries under study are available in the Appendix. Figure 5 displays the relationship of gender equality in numeracy and gender equality in literacy. We observe a positive correlation between the two indicators; however, as the upper bound of the numeracy index is usually reached earlier than universal literacy, the scatterplot displays a somewhat 'compressed' pattern.

[70] Stolz and Baten (*Brain Drain, Numeracy and Skill Premia*) find this for migrants to the United States.
[71] Goldin, *The U-Shaped Female Labour Force Function*.
[72] Mammen and Paxson, *Women's Work*.
[73] Manzel and Baten, *Gender Equality and Inequality in Numeracy*.

The Development of Numeracy and Gender Equality in Asia

Figures 6a to 6c display the overall numeracy development of the 14 countries under study for the period 1900 to the 1960s. Most apparent are the large differences in the numeracy level between the countries: whereas most Southeast Asian countries had almost full numeracy in terms of the ABCC index already around 1910, Pakistan and Bangladesh are the countries with the lowest numeracy levels in Asia, ranging between 14 to 47 ABCC points during the studied period. Figure 6a displays all countries with high levels of numeracy: Hong Kong, Cambodia, Thailand, and the Philippines.

Countries that started with lower levels of numeracy at the turn of the century but reached an ABCC index of more than 70 points by the mid-twentieth century are combined in Figure 6b.[74] These countries are mostly located in Southeast Asia. Remarkable to point out is Sri Lanka's rapid improvement in numeracy between 1900 and the 1950s: the country worked its way up from 65 points on the ABCC index at the beginning of the century to a numeracy level of 98 ABCC points in the 1950s. The colonised Federated Malay States and independent Sarawak interestingly show different levels of numerical skills. In the case of the former, it is noteworthy that a great part of the population consisted of well-educated Chinese immigrants.[75]

The third group comprises countries that had quite low numeracy levels (Figure 6c). All of these countries are located in South or West Asia. Although all six countries improved in terms of numeracy during the first half of the twentieth century, numeracy levels remained low; in Bangladesh and Pakistan even below 50 ABCC points.

How about gender equality? No country featured a positive gender equality index over a longer period (Figures 7, a-c): only Hong Kong, the Philippines, Sarawak, and Pakistan

[74] Please note the different scale of Figures 6b and 6c compared to the scale of Figure 6a.
[75] Sidin, *Malaysia*, p. 123.

show a small positive value for one, two or three decades. We see the strongest increase in gender equality over time in the Philippines and in Sri Lanka. Both countries started with very strong negative equality indices at the beginning of the 20th century, but closed this gender gap in the subsequent decades. The Philippines even display a positive equality index in the 1940s, 1950s and 1960s. This development is possibly a consequence of the egalitarian education policies that were implemented in both countries.[76]

Afghanistan and Iran showed the lowest level of gender equality among all countries in our sample. Starting with an index of -11.98 in 1910, gender equality in Afghanistan fell dramatically to -65.18 in 1950.[77] Likewise, gender equality was low in the Federated Malay States and Sarawak as well as in Indonesia.

Interestingly, the high gender equality is also visible in the countries with very low overall numeracy levels. In Pakistan gender equality in numeracy was astonishingly high during the period under study. In India and Bangladesh gender equality was also not as low as expected. When thinking about the literature review in section II, it is surprising to find high gender equality indices in numeracy for South Asian countries. At the same time we can take this incident as a hint on the application of the U-hypothesis that we will further investigate in the next section.

The U-Hypothesis and other Determinants of Gender Equality

As explained in the introduction, Goldin[78] and Mammen and Paxson[79] found a U-shaped pattern for the relationship between female labour force participation and economic development. At low income levels women work in family farms and make up a great part of the labour force. With economic progress, their share in the labour force declines, as the

[76] Jayaweera, *Schooling in Sri Lanka*, p. 221.
[77] We excluded this extreme Afghan value in all the following data analyses to avoid that the results are driven by this outlier.
[78] Goldin, *The U-Shaped Female Labour Force Function*.
[79] Mammen and Paxson, *Women's Work*.

industrial sector expands at the expense of the subsistence economy. Men move into the new blue-collar jobs, while social stigma hinders women from accepting such jobs. At the same time the necessity for women to work might be reduced as a result of higher incomes that men earn during this middle stage of development. Further economic development in the final stage stimulates white-collar employment that is socially attainable for women and economically attractive because of higher wages. Apart from that, economic development is associated with higher educational enrolment and a drop in fertility rates raising also the educational opportunity for women and lowers the time of job market abstinence due to child bearing. [80]

We want to examine if a U-shape can be identified for the relation between average numeracy and gender equality in numeracy. Accordingly, gender equality in numeracy will be high at low numeracy levels but will decline with increasing numeracy levels down to a point at which gender equality starts to rise again. The theoretical consideration behind this process is that parents base their decision regarding the education of their daughter on the labour market and income perspectives for women. If these are promising, parents will send their daughter to school. With the expansion of primary education, boys might be enrolled first while dominant social customs retain girls in the traditional household. Only with further development will social norms be challenged and will girls be enrolled.

In the following we test this U-hypothesis systematically by carrying out a panel data analysis (unbalanced panel) with gender equality in numeracy as the dependent variable.[81] Before we start, we check whether the assumption of a U-shaped function between the overall numeracy level and gender equality in numeracy is visible in the raw data. We apply a

[80] Psacharopoulos and Tzannatos, *Female Labour Force Participation*, p. 192.
[81] We follow here Manzel and Baten (2009) who did similar analyses for Latin America and the Caribbean. As discussed above, we excluded China, South Korea, and Vietnam from the following analyses to reduce the probability that our results are driven by those countries. We decided to keep Hong Kong in the sample as it still shows some variation in the numeracy index and the gender equality index. As a robustness check, we conducted all regressions also with the East Asian countries and Vietnam included and found our results confirmed (results available from the authors).

LOWESS regression smoothing, which works somewhat similar to a moving average in time series analysis. [82] We find indeed a clear U-shaped pattern (displayed by the curve composed of the square symbols in Figure 8): gender equality in numeracy first declines and then increases with the level of numeracy. Hence, using a squared function in our estimation model is justified. The other curve in Figure 8 represents the fitted values of the mere regression of GE_{num} on ABCC and ABCC squared, i.e. without controlling for other possible explanatory variables. The U-curve with the fitted values looks similar in its shape, but with a turning point at the minimum situated left to the one of the LOWESS curve. This deviation can be explained with the quadratic shape which we imposed on the raw data in the regression.

In the next step, we examine potential social, cultural and economic factors that might influence educational gender equality in Asia (Table 1 and 2). As a first factor we consider female voting rights as an indicator for the social status of women within the society.[83] Permitting women political participation can be regarded as a first and important step on the path towards gender equality. In most of the countries under study, voting rights were granted to women between 1930 and 1960.

Next, to measure cultural factors, we include dummies for the five predominant religions in the Asian region: Buddhism, Christianity, Confucianism, Hinduism, and Islam. The dummies take the value of one if the majority of a country's population avowed itself to one of these religions. A priori, we have no clear expectation about the effects of the various religions, but based on our discussion in section II, Islam and Hinduism might have a negative effect on gender equality, whereas Buddhism and Confucianism might have displayed slightly less male preference in relative terms.

As another explanatory variable we include (unadjusted) school enrolment rates in the regression analysis. Enrolment rates are an alternative way of measuring the level of human

[82] LOWESS (**lo**cally **we**ighted **s**catterplot **s**moothing) carries out a locally weighted regression of the dependent variable on the independent variable, i.e. in our case of GE_{num} on ABCC, and displays the graph. Thereby, the LOWESS estimator does not impose a specific functional form (see Cleveland 1979).
[83] See the Appendix for all variable definitions and sources.

capital and the economic impact on GE might be the same as the one of the ABCC variable. We use the estimates made by Benavot and Riddle[84] for the period of 1870-1940 and supplemented their data with unadjusted enrolment rates from the UNESCO Statistical Yearbook of 1963. Since children usually enrol in school at the age of eight to ten, while the ABCC data are constructed on the basis of birth decades, the enrolment rates were postponed by one decade in our analysis.

GDP per capita should have a positive impact on gender equality, since the basic assumption is that female labour market perspectives eventually improve with economic development. Economic progress might additionally subvert cultural traditions. Furthermore, population density might influence positively gender equality in numeracy. For example, it can be argued that with higher population density the availability of schools increases, spreading education more evenly also for girls.

The colonialists in South and Southeast Asia have promoted advanced techniques in agriculture, especially in irrigation. Boserup argues, however, that in this process, the previously important female agricultural skills were not developed further.[85] Hence there might have been the paradoxical effect that higher land productivity could have augmented the differential between men and women, reducing gender equality. To assess this possible influence, we include land productivity - here measured by rice output per rice area - in one of our regression models.

In Table 3 we present the results of our regressions. The Hausman test suggests that fixed effects estimation should be preferred. Still, in model 1 we conducted a random effects estimation to allow the inclusion of time constant variables, such as our religious dummy variables. With model 2 we added a Least Square Dummy Variable estimation in order to check for the robustness of the results of model 1. In all five specifications we see that gender equality in numeracy declines at low numeracy levels – shown by the negative sign of the

[84] Benavot and Riddle, *The expansion of primary education*.
[85] Boserup, *Woman's role*, pp. 54-6.

ABCC coefficient –, and increases at higher levels, as indicated by the positive coefficient of ABCC squared. The dummy for female voting rights indicates a positive influence on gender equality in all the models presented in Table 3. The dummy variables for the religions are not that robust, but indicate that gender equality is lower in Christian and Buddhist countries and higher in Hindu countries than in the reference group, i.e. Islamic countries. The former finding might be quite surprising; however, if we look at our graphs we see that most of the Islamic and Hindu countries belong to group III, with a low overall numeracy level paired with relatively high gender equality. Those countries are mainly situated on the left downward sloped side of the U-curve, i.e. in the period of investigation they still had to undergo the process of an initially widening gender gap until it closes again with further development.

In the fixed effects models 3 to 5 we tested separately the effects of enrolment rates, GDP per capita, and population density together with land productivity. Even though we do not obtain significant results for all variables, we do get the expected signs: all variables show a positive effect on gender equality.[86] Models 6, 7, and 8 are further robustness checks. In model 6 and 7 we reduced the sample further by restricting the included observations to those that have less than 90, respectively 80 ABCC points, i.e. we cut off the upper bound of the ABCC index (the lower bound of 0 is not reached in our sample anyway) to minimize the problems that could arise from bounded variable issues. The results confirm our previous findings. In model 8 we replace the ABCC index with GDP per capita to test whether our U-curve is confirmed, if we consider economic development instead of educational development. Our regression result points in this direction. Summing up, we find the U-hypothesis that gender equality in numeracy first declines and then increases with the level of numeracy confirmed.

[86] In these two regression models we have to keep in mind the problem of multicollinearity, especially between ABCC and GDP per capita. A correlation matrix for all variables used, are presented in the Appendix, Table II.

Conclusion

In this paper, we studied the human capital development of both men and women in 14 Asian countries during the period of 1900-60, with special emphasis on the gender gap in education. As we have seen, education in Asia was characterized by an insufficient supply of and demand for female education. We observed clear tendencies in the development of numeracy levels among the countries: while Southeast Asian countries had high numeracy levels, most South and West Asian countries were characterised by low numerical skills. In terms of gender equality in numeracy, the countries with very low and very high numerical abilities recorded the highest gender equality indices, although the indices were still negative.

We were especially interested whether we can confirm the hypothesis of a U-shaped pattern of gender equality in numeracy in the course of increasing average numeracy levels. We performed a panel analysis and found support of the U-hypothesis for Asia during the early and mid-20th century. Accordingly, at low numeracy levels gender equality declines and increases again with higher numeracy levels. A substantial value added of this study is the finding that South and West Asia were rather egalitarian in the beginning of the development, when both males and females were quite innumerate.

This paper provides substantial insights into the development of numeracy and gender (in-)equality in various Asian countries for the first half of the twentieth century. For the development of a country, numeracy plays an essential role. Both men and women need to have basic numerical knowledge which is a precondition for the acquisition of more advanced skills. Although we excluded East Asia because it had solved already its basic numeracy problem around 1900, its high gender equality described in the introduction confirms the importance of this research: Part of the formula for success of the East Asian economies was the employment of women in export industries. These countries dispose of advanced levels of male and female human capital and boosted incredibly high growth rates from the 1970s until

today. The East Asian miracle can therefore also be partly attributed to the higher educational level of women and their increased participation in economic life.

References

A'Hearn, B., Baten, J., and Crayen, D. (2009) Quantifying Quantitative Literacy: Age Heaping and the History of Human Capital. *Journal of Economic History*, 68, 3: 783-808.

Agrawal, S. P., and Agrawal, J. C. (1992) *Women's Education in India* (New Delhi: Concept Publishing Company).

Ahmed, M. D. (1982) Pakistan: The Dream of an Islamic State. In: C. Caldarola, eds. *Religion and Societies*: *Asia and the Middle East* (Berlin/New York/Amsterdam: Mouton Publishers), pp. 261-88.

Amin, S. (2007) Schooling in Bangladesh. In: A. Gupta, eds. *Going to School in South Asia* (Westport: Greenwood Press), pp. 37-52.

Bachi, R. (1951) The tendency to round off age returns: measurement and correction. *Bulletin of the International Statistical Institute*, 33: 195-221.

Baten, J., Ma, D., Morgan, S., and Wang, Q. (2010) Evolution of Living Standards and Human Capital in China in the 18-20th Centuries: Evidences from Real Wages, Age-heaping and Anthropometrics. *Explorations in Economic History*, 47, 3: 347-59.

Benavot, A., and Riddle, P. (1988) The Expansion of Primary Education, 1870-1940: Trends and Issues. *Sociology of Education*, 61: 191-210.

Boserup, E. (1970) *Woman's role in Economic Development* (London: Allen & Unwin).

Carroll, T. F. (1983) *Women, Religion, and Development in the Third World* (New York: Praeger).

Chaudhary, L. (2009) Determinants of Primary Schooling in British India. *The Journal of Economic History*, 69, 1: 269-302.

Choi, S. (2007) Schooling in South Korea. In: G. A. Postiglione, eds. *Going to School in East Asia* (Westport: Greenwood Press), pp. 320-43.

Chowdhury, K. P. (1996) Pakistan. In: C. L. Mak, ed. *Women, Education, and Development in Asia* (New York: Garland), pp. 187-215.

Cleveland, W. S. (1979) Robust Locally Weighted Regression and Smoothing Scatterplots. *Journal of the American Statistical Association*, 74, 368: 829-836.

Crayen, D., and Baten, J. (2010a) Global Trends in Numeracy 1820-1949 and its Implications for Long-Run Growth. *Explorations in Economic History*, 47, 1: 82-99.

Crayen, D., and Baten, J. (2010b) New Evidence and New Methods to Measure Human Capital Inequality before and during the Industrial Revolution: France and the U.S. in the 17th to 19th Centuries. *Economic History Review*, 53, 2: 452-78.

Dollar, G. and Gatti, R. (1999) Gender Inequality, Income and Growth: Are Good Times Good for Women? In: The World Bank, ed. *Policy Research Report on Gender and Development Working Paper No. 1* (Washington D.C.: The World Bank).

Domschke, E., and Goyer, D.S. (1986) The Handbook of National Population Censuses: Africa and Asia (New York: Greenwood).

Elson, R. E. (1999) International Commerce, the State and Society: Economic and Social Change. In: N. Tarling, ed. *The Cambridge History of Southeast Asia* (Cambridge: Cambridge University Press), pp. 127-89.

Esteve-Volart, B. (2004) *Gender Discrimination and Growth: Theory and Evidence from India.* LSE STICERD Research Paper DEDPS42.

Ghosh, R., and Talbani, A. (1996) India. In: C. L. Mak, ed. *Women, Education, and Development in Asia* (New York: Garland), pp. 165-86.

Goldin, C. (1995) The U-Shaped Female Labour Force Function in Economic Development and Economic History. In: T. P. Schultz, ed. *Investment in Women's Human Capital* (Chicago: The University of Chicago Press), pp. 61-90.

Gomez, F., and Pedro, A. (1992) The Philippines. In: W. Wielemans and P. C.-P. Chan, eds. *Education and Culture in Industrializing Asia* (Leuven: Leuven University Press), pp. 257-86.

Gulati, L. (1993) Impact of the Development Process on the Indian Family. In: N. David and V. Loganathan, eds. *Women and the Economy* (Ayanavaram: The Gita Press), pp. 291-322.

Hill, A. M., and King, E. M. (1993) Women's Education in Developing Countries: An Overview. In: E. M. King and M. A. Hill, eds. W*omen's Education in Developing Countries* (Baltimore: The John Hopkins University Press), pp. 1-50.

Hippe, R. (2011) Numeracy vs. Literacy in a Regional Perspective. Working Paper, University of Tuebingen.

Jayaweera, S. (1996) Schooling in Sri Lanka. In: C. L. Mak, ed. *Women, Education, and Development in Asia* (New York: Garland), pp. 217-44.

Kazemzadeh, M. (2005) Iran. In: S. Joseph and A. Najmabadi, eds. *Encyclopaedia of Women & Islamic Cultures: Family, Law and Politics* (Leiden: Brill), pp. 177-8.

Khan, S. R. (1993) South Asia. In: E. M. King and M. A. Hill, eds. *Women's Education in Developing Countries* (Baltimore: The John Hopkins University Press), pp. 211-46.

King, E. M., and Hill, M. A. (1993) W*omen's Education in Developing Countries* (Baltimore: The John Hopkins University Press).

Kingdon, G. G. (1997) *Does the Labour Market Explain Lower Female Schooling in India?* LSE STICERD 01.

Klasen, S. (2002) Low Schooling for Girls, Slower Growth for All? Cross-Country Evidence on the Effect of Gender Inequality in Education on Economic Development. *The World Bank Economic Review*, 16, 3: 345-73.

Kwak, B.-S. (1992) Korea. In: W. Wielemans and P. C.-P. Chan, eds. *Education and Culture in Industrializing Asia* (Leuven: Leuven University Press), pp. 189-224.

Law, W.-W. (2007) Schooling in Hong Kong. In: G. A. Postiglione, ed. *Going to School in East Asia* (Westport: Greenwood Press), pp. 86-121.

Loo, S. P. (2007) Schooling in Malaysia. In: G. A. Postiglione, ed. *Going to School in East Asia* (Westport: Greenwood Press), pp. 207-32.

Maddison, A. (2001) *The world economy: a millennial perspective* (Paris: OECD).

Mammen, K., and Paxson, C. (2000) Women's Work and Economic Development. *Journal of Economic Perspectives*, 14, 4: 141-64.

Mann, S. (2005) Women in East Asia: China, Japan, and Korea. In: B. G. Smith, ed. *Women's History in Global Perspective,* vol. 2 (University of Illinois Press), pp. 47-100.

Manzel, K., and Baten, J. (2009) Gender Equality and Inequality in Numeracy: The Case of Latin America and the Caribbean, 1880-1949. *Journal of Iberian and Latin American Economic History*, 27, 1: 37-74.

Manzel, K., Baten, J., and Stolz, Y. (2011) Convergence and Divergence of numeracy: the Development of Age Heaping in Latin America from the Seventeenth to the Twentieth Century. *Economic History Review* (forthcoming).

Means, G. P. (1982) Malaysia: Islam in a Pluralistic Society. In: C. Caldarola, ed. *Religion and Societies: Asia and the Middle East* (Berlin/New York/Amsterdam: Mouton Publishers), pp. 445-96.

Mittra, S., and Kumar, B. (2004) *Encyclopaedia of Women in South Asia: Sri Lanka* (Delhi: Kalpaz Publications).

Mokyr, J. (1983) *Why Ireland Starved: A Quantitative and Analytical History of the Irish Economy, 1800-1850* (London: George Allen & Unwin).

Oey-Gardiner, M., and Suprapto, R. A. (1996) Indonesia. In: C. L. Mak, ed. *Women, Education, and Development in Asia* (New York: Garland), pp. 95-118.

Prayon, V. (2011) Human Capital Development in Africa since the late 19th century – New Estimates. *Working Paper, University of Tuebingen*.

Prayon, V., and Baten, J. (2011) Human Capital, Institutions, Settler Human Capital, and Economic Growth in Africa, Asia, and the Americas, 1750-2000. *Working Paper, University of Tuebingen.*

Pruthi, R., and Sharma, B. R. (1995) *Education and Modernisation of Women in India* (New Delhi: Anmol Publications).

Psacharopoulos, G., and Tzannatos, Z. (1989) Female Labour Force Participation: An International Perspective. *The World Bank Research Observer*, 4, 2: 187-201.

Rajeswari, N. (1993) Demographic perspective of women in India. In: N. David and V. Loganathan, eds. *Women and the Economy* (Ayanavaram: The Gita Press), pp. 323-45.

Rambo, A. T. (1982) Vietnam: Searching for Integration. In: C. Caldarola, ed. *Religion and Societies: Asia and the Middle East* (Berlin/New York/Amsterdam: Mouton Publishers), pp. 407-44.

Saram, P. A. (1982) Sri Lanka: The Evolutionary Dialectives of a Buddhist State. In: C. Caldarola, ed. *Religion and Societies: Asia and the Middle East* (Berlin/New York/Amsterdam: Mouton Publishers), pp. 333-70.

Scott, C., and Sabagh, G. (1970) The Historical Calendar as a Method of Estimating age: The Experience of the Moroccan Multi-Purpose Sample Survey of 1961-63. Population Studies, 24, 1: 93-109.

Shirazi, R. (2007) Schooling in Afghanistan. In: A. Gupta, ed. *Going to School in South Asia* (Westport: Greenwood Press), pp. 14-36.

Sidin, R. (1996) Malaysia. In: C. L. Mak, ed. *Women, Education, and Development in Asia* (New York: Garland), pp. 119-41.

Sinlarat, P. (2007) Schooling in Thailand. In: G. A. Postiglione, ed. *Going to School in East Asia* (Westport: Greenwood Press), pp. 378-400.

Sopheak, K. C., and Clayton, T. (2007) Schooling in Cambodia. In: G. A. Postiglione, ed. *Going to School in East Asia* (Westport: Greenwood Press), pp. 41-60.

Stolz, Y., and Baten, J. (2012) Brain Drain, Numeracy and Skill Premia during the Era of Mass Migration: Reassessing the Roy-Borjas Model. *Explorations in Economic History (forthcoming)*.

Tilak, J. B. G. (1993) East Asia. In: E. M. King and M. A. Hill, eds. *Women's Education in Developing Countries* (Baltimore: The John Hopkins University Press), pp. 247-84.

Torralba, A., Dumol, P., and Manzon, M. (2007) Schooling in Philippines. In: G. A. Postiglione, ed. *Going to School in East Asia* (Westport: Greenwood Press), pp. 275-300.

UNESCO (1964) *UNESCO Statistical Yearbook 1963* (Mayenne: Imprimerie Joseph Floch).

UNESCO (2009) *EFA Global Monitoring Report 2009* (Oxford University Press).

World Bank (2001) *Engendering Development* (Washington D.C.: The World Bank).

Tables

Table 1: Summary statistics

	Obs	Mean	Std. Dev.	Min	Max
Gender equality	72	-6.125	6.804	-26.993	2.720
ABCC	72	66.406	26.678	14.484	100
ABCC squared	72	5111.529	3440.440	209.786	10000
Female voting right	72	0.292	0.458	0	1
Hinduism	72	0.139	0.348	0	1
Buddhism	72	0.194	0.399	0	1
Christianity	72	0.097	0.298	0	1
Islam	72	0.472	0.503	0	1
Confucianism	72	0.097	0.298	0	1
GDP per capita	58	997.297	642.421	349	4318
GDP per capita squared	58	1400192	2596016	121801	18600000
Enrolment rates	60	13.166	13.294	0.5	64
Population density	30	72.216	71.962	9.283	399.145
Land productivity	30	1.302	0.402	0.413	2.160

Note: For variable definitions and sources see Appendix.

Table 2: Explanatory variables and their expected signs

Factor	Indicator	Expected Sign
Initial human capital development	ABCC	--
Later human capital development	ABCC squared	+
Female voting right	Dummy	+
Confucianism	Dummy	+
Hinduism	Dummy	--
Buddhism	Dummy	+
Christianity	Dummy	+/--
Islam	Dummy	--
Income	GDP per capita	+
Schooling	Enrolment rates	+
Population density	Population density	+
Land productivity	Rice per area	--

Note: For variable definitions and sources see Appendix.

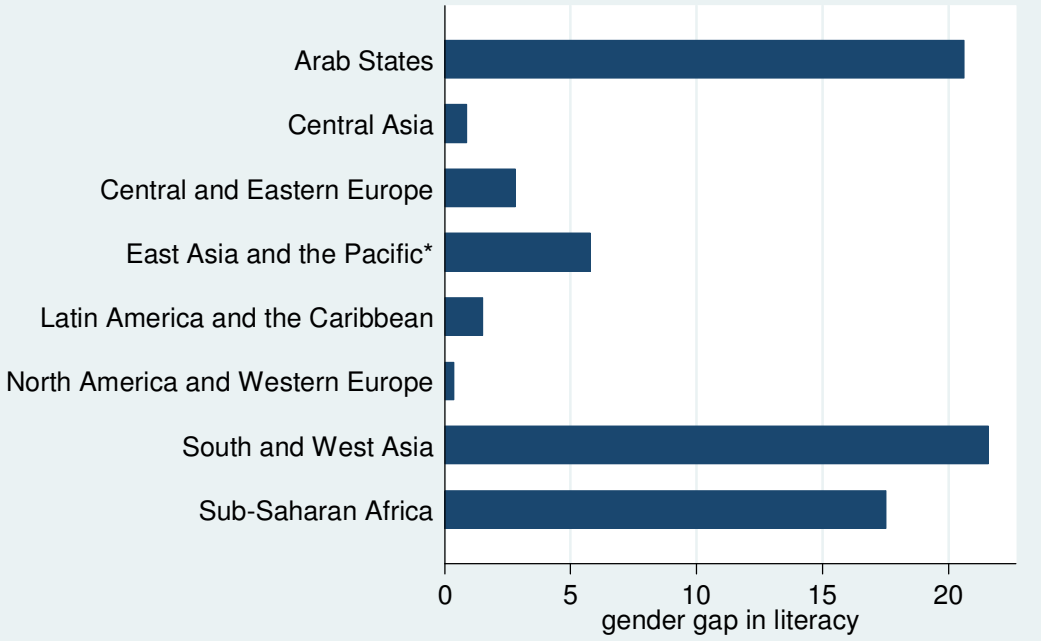
Table 3: Regressions of Gender Equality in Numeracy in Asia, 1900-60

Estimation technique	(1) RE	(2) LSDV country & time FE	(3) FE	(4) FE	(5) FE	(6) RE ABCC<90	(7) FE ABCC<80	(8) FE
ABCC	-0.860***	-0.829***	-0.802***	-0.795***	-0.886***	-0.626***	-0.873***	
	(0.137)	(0.150)	(0.178)	(0.190)	(0.0932)	(0.139)	(0.209)	
ABCC squared	0.00900***	0.00926***	0.00925***	0.00926***	0.00897***	0.00642***	0.00854***	
	(0.00136)	(0.00149)	(0.00186)	(0.00192)	(0.000870)	(0.00147)	(0.00247)	
Female voting rights	2.264**	1.366	0.630	0.504	1.038	1.675	3.217**	4.565*
	(1.031)	(1.777)	(1.262)	(1.459)	(2.488)	(1.386)	(1.370)	(2.184)
Hinduism	6.871*	11.60***				5.960	4.446**	
	(4.023)	(2.638)				(3.636)	(1.792)	
Buddhism	-11.70**	-6.615				-11.78**	-13.80***	
	(5.595)	(7.047)				(4.933)	(3.111)	
Christianity	-12.43	-9.406				-13.19	-22.06***	
	(10.84)	(6.778)				(12.59)	(3.680)	
Confucianism	-11.79*	-9.501						
	(6.575)	(7.211)						
Enrolment rates (log)			0.918					
			(1.107)					
GDP per capita (log)				2.142				-1.594
				(4.369)				(56.36)
GDP per capita (log) squared								0.216
								(3.755)
Population density (log)					3.484			
					(3.081)			
Land productivity (log)					7.480**			
					(2.940)			
Constant	7.396**	-1.178	-3.319	-14.73	-10.90	3.527	11.24***	-6.530
	(3.296)	(4.458)	(4.059)	(27.62)	(12.73)	(3.156)	(3.443)	(210.6)
Observations	72	72	60	58	30	51	44	58
R-squared	0.611	0.838	0.696	0.691	0.899	0.282	0.095	0.206

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. For variable definitions and sources see Appendix. In model 1 and 2 the reference category is an Islamic country with no female voting rights. The R-squared within is reported, except for model 2 (overall R-squared).

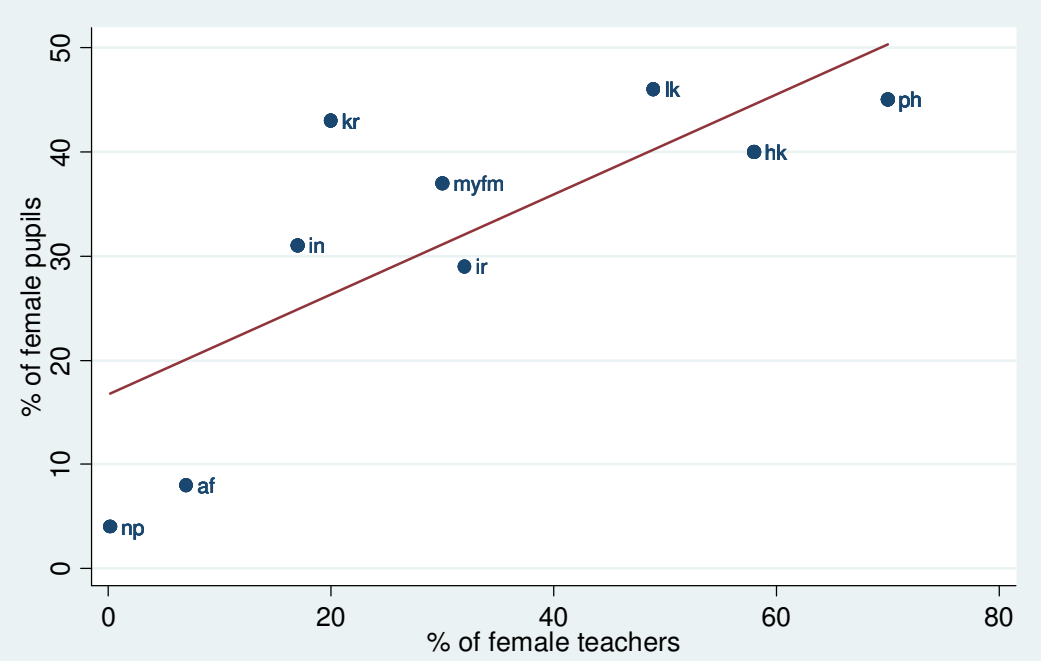
Figures

Figure 1: The gender gap in literacy (age 15 plus, in percentage points), 2000-6



*The developed countries of the region - Australia, New Zealand, Japan, and South Korea - are not included.
Source: Data taken from UNESCO (2009), Annex: Statistical Tables, p.274.

Figure 2: Relationship between the percentage of female teachers employed and the percentage of female pupils enrolled



Note: see Appendix for country codes
Source: UNESCO, Statistical Yearbook 1963, pp.56-57.

Figure 3: Relationship of literacy and the ABCC-index in Asia

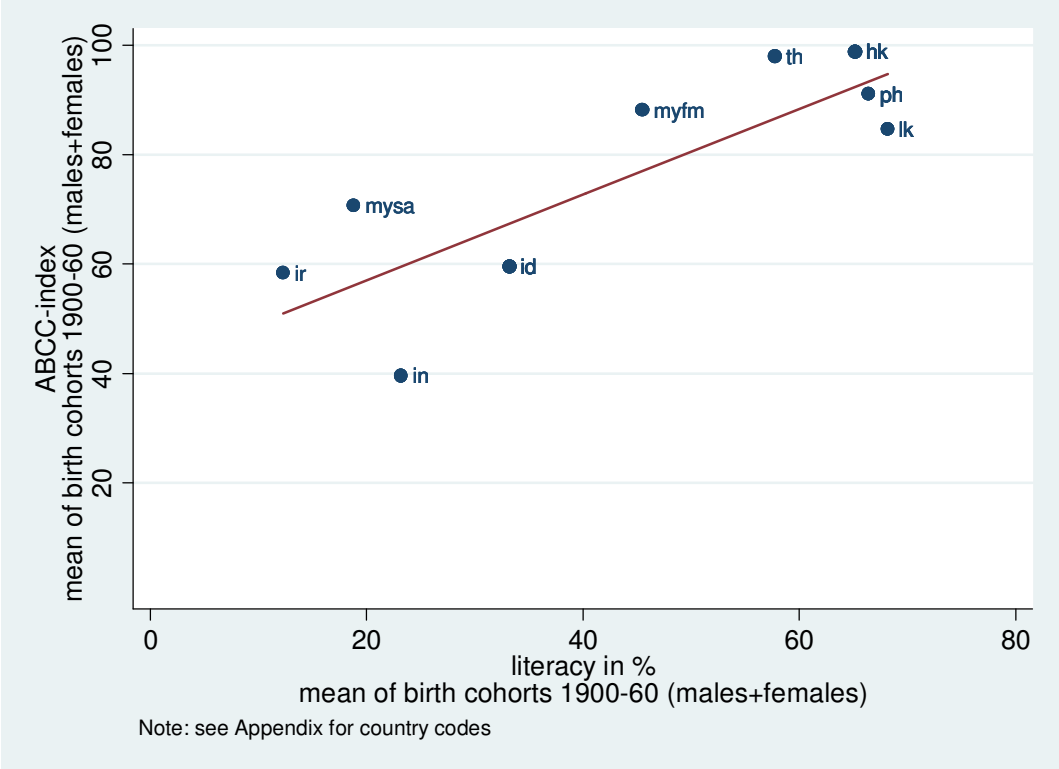


Figure 4: Example for numeracy trends based on overlapping census data

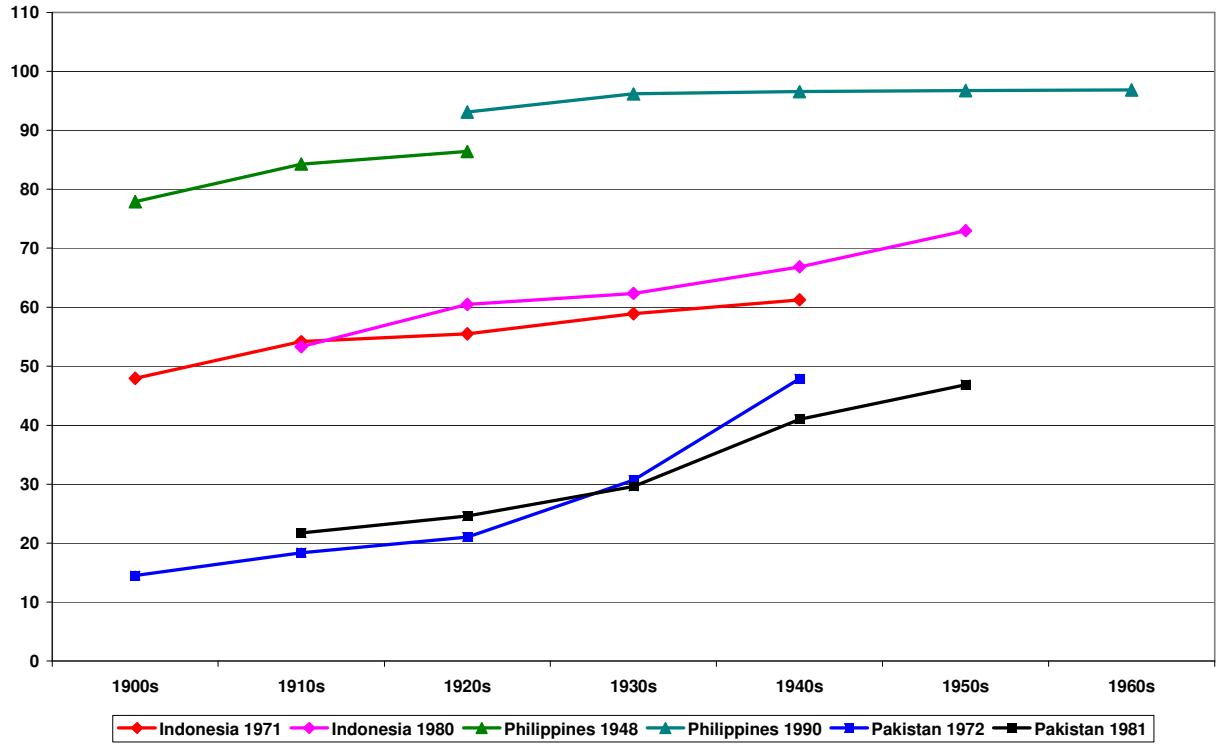


Figure 5: Relationship between gender equality in numeracy and gender equality in literacy, birth cohorts 1900-60

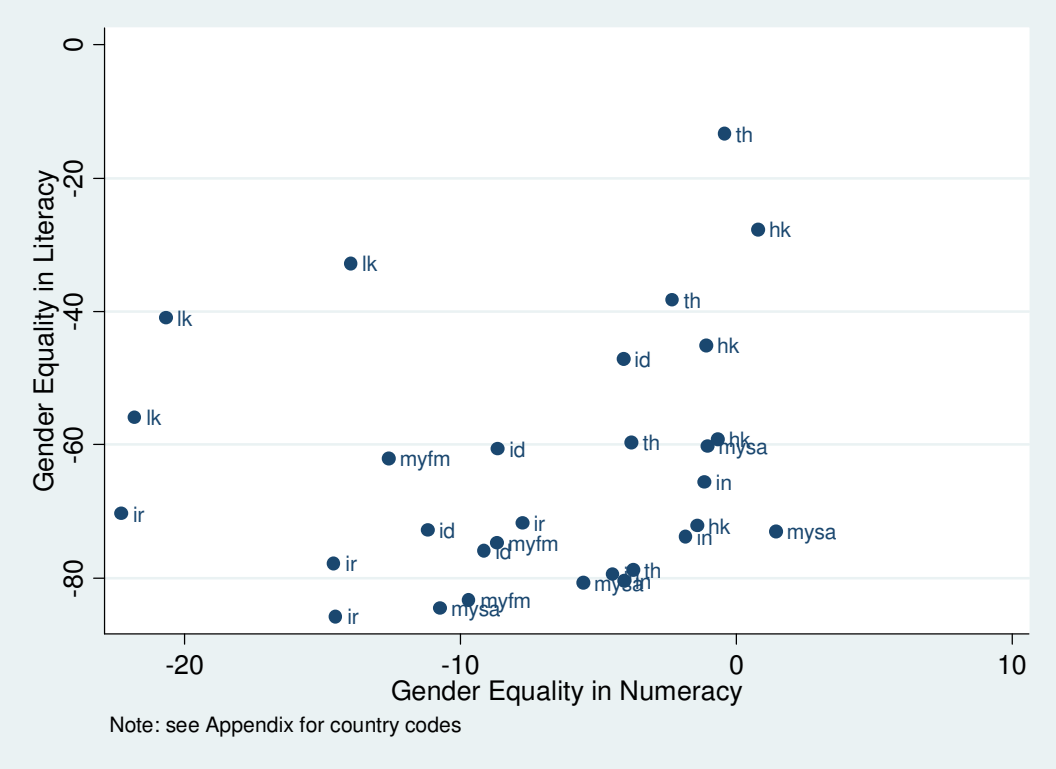


Figure 6a: Numeracy (ABCC index) of the total population, age 23 to 62, birth decades 1900-60 (Group I)

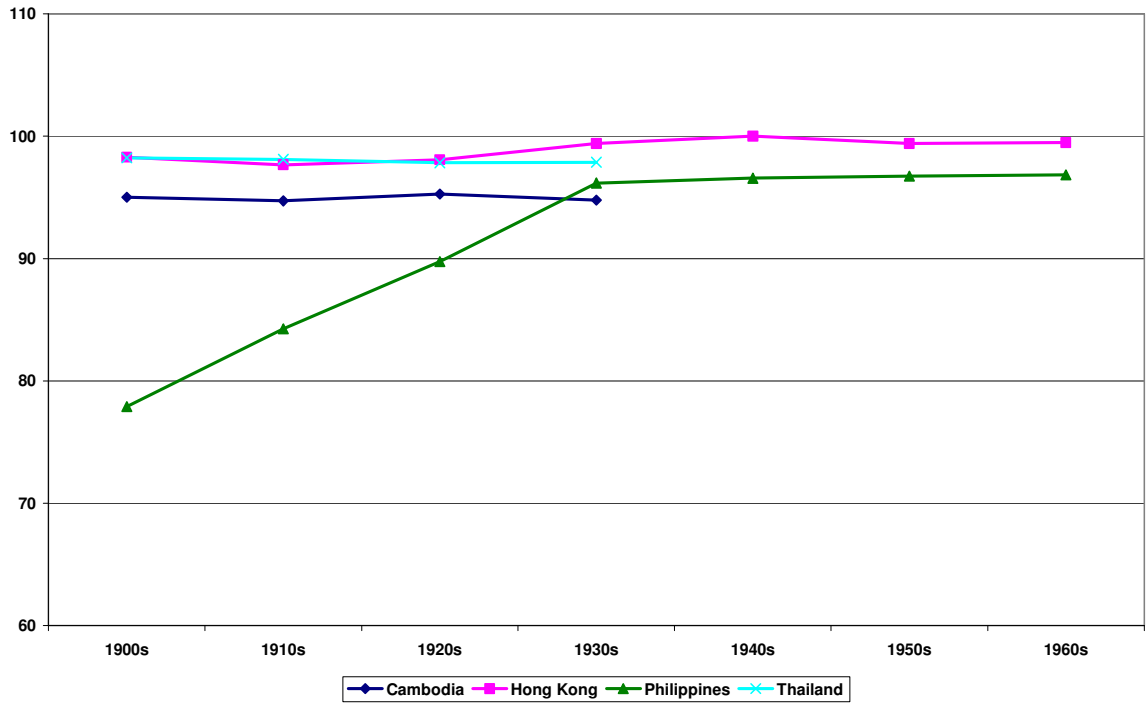


Figure 6b: Numeracy (ABCC index) of the total population, age 23 to 62, birth decades 1900-60 (Group II)

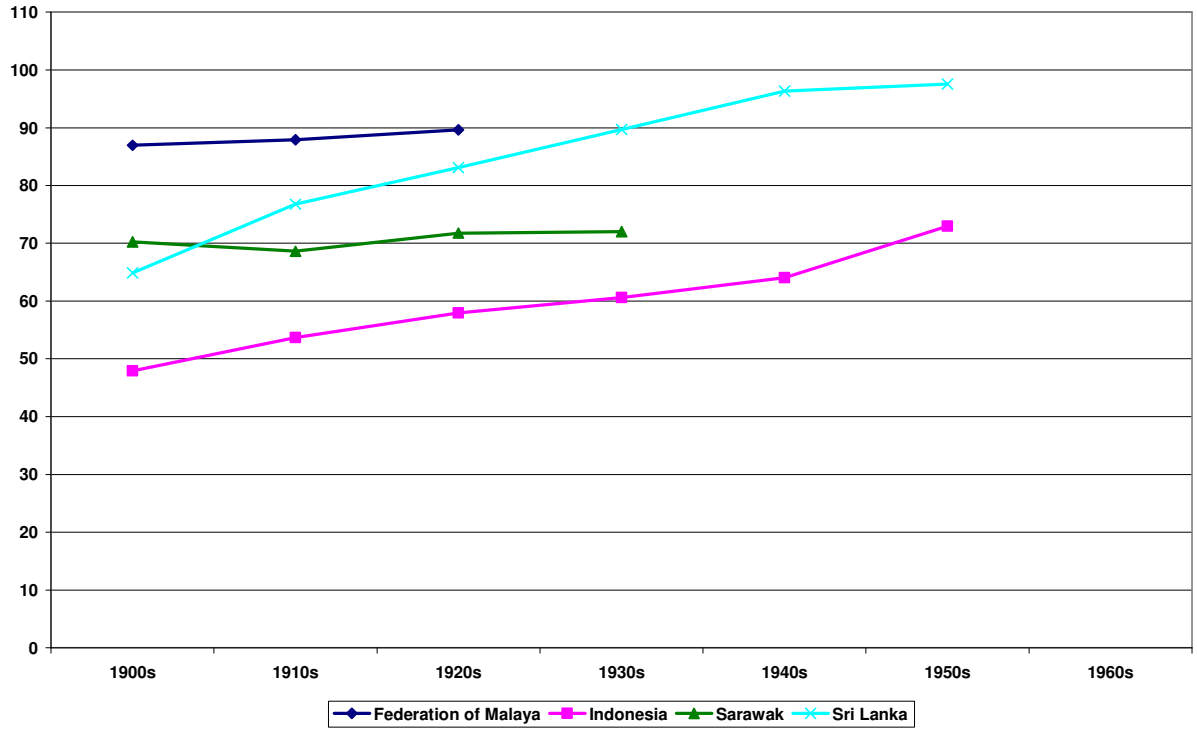


Figure 6c: Numeracy (ABCC index) of the total population, age 23 to 62, birth decades 1900-60 (Group III)

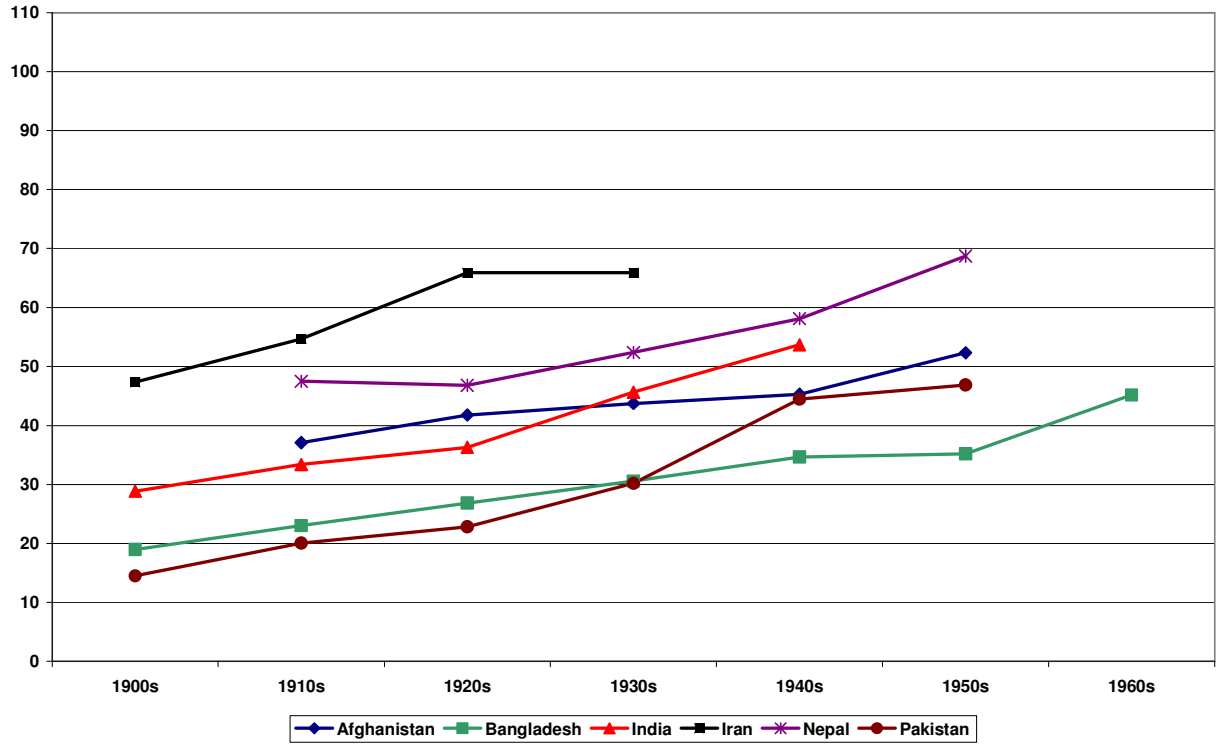


Figure 7a: Gender Equality index of numeracy, birth decades 1900-60 (Group I)

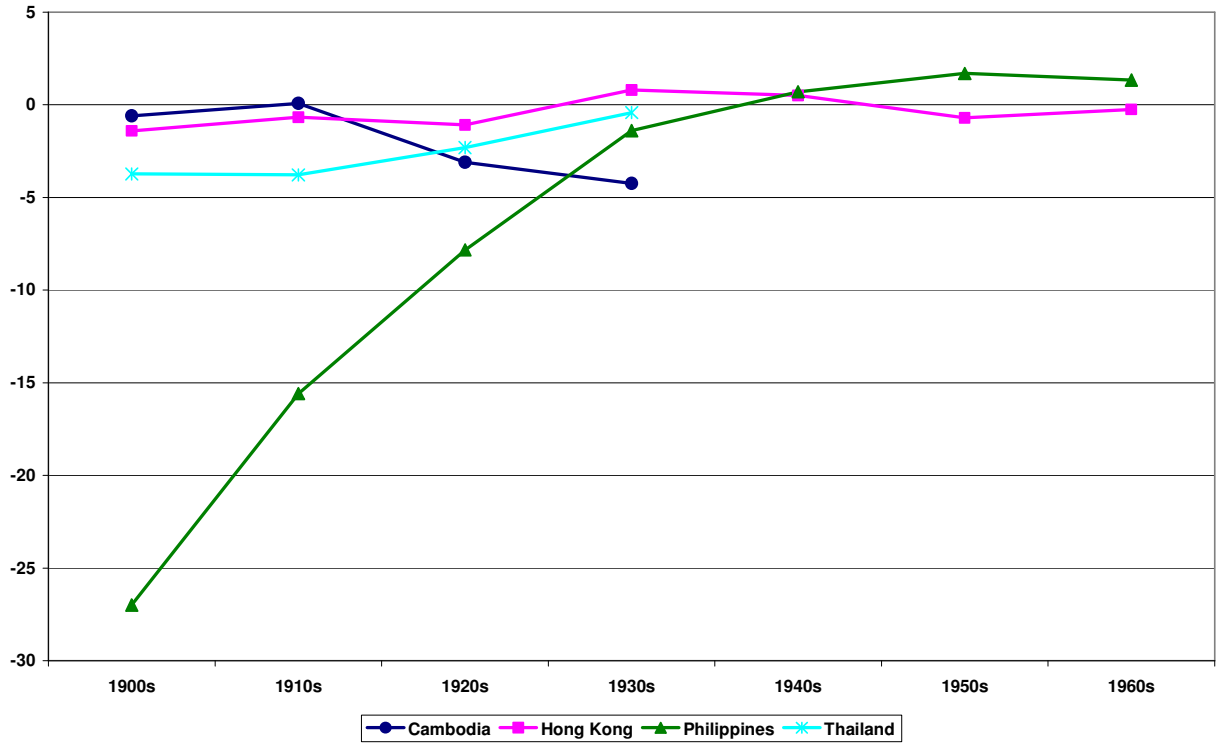


Figure 7b: Gender Equality index of numeracy, birth decades 1900-60 (Group II)

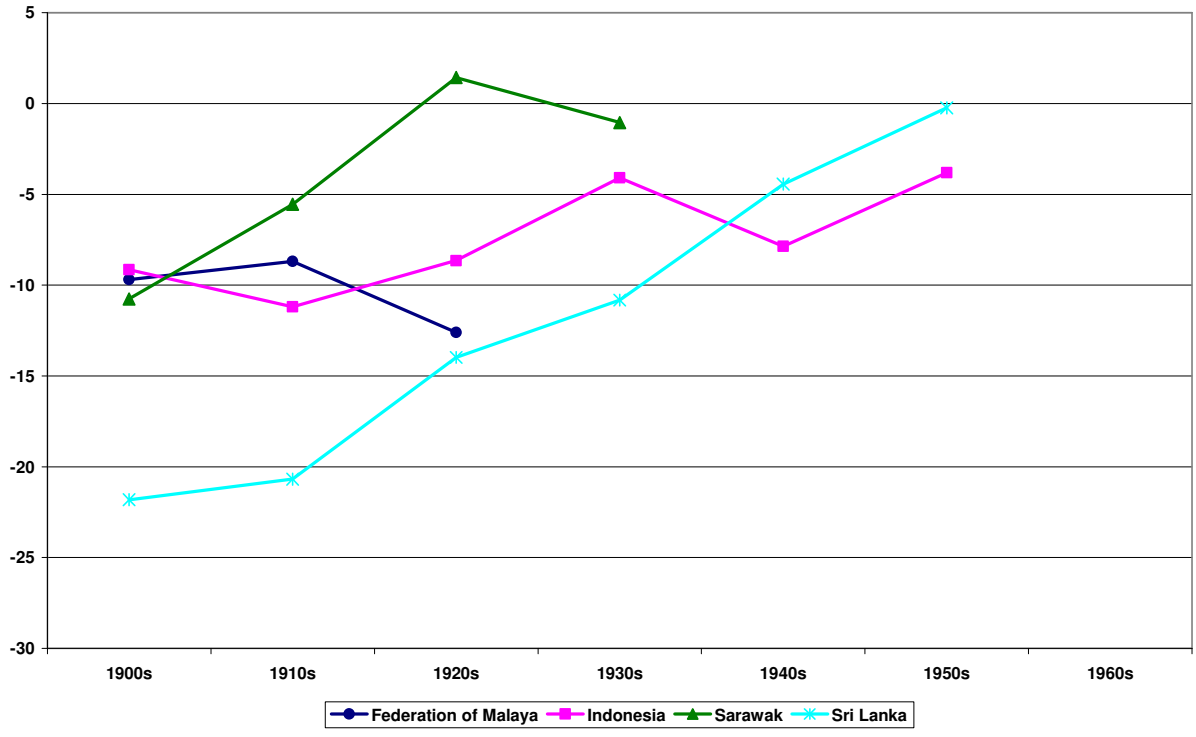


Figure 7c: Gender Equality index of numeracy, birth decades 1900-60 (Group III)

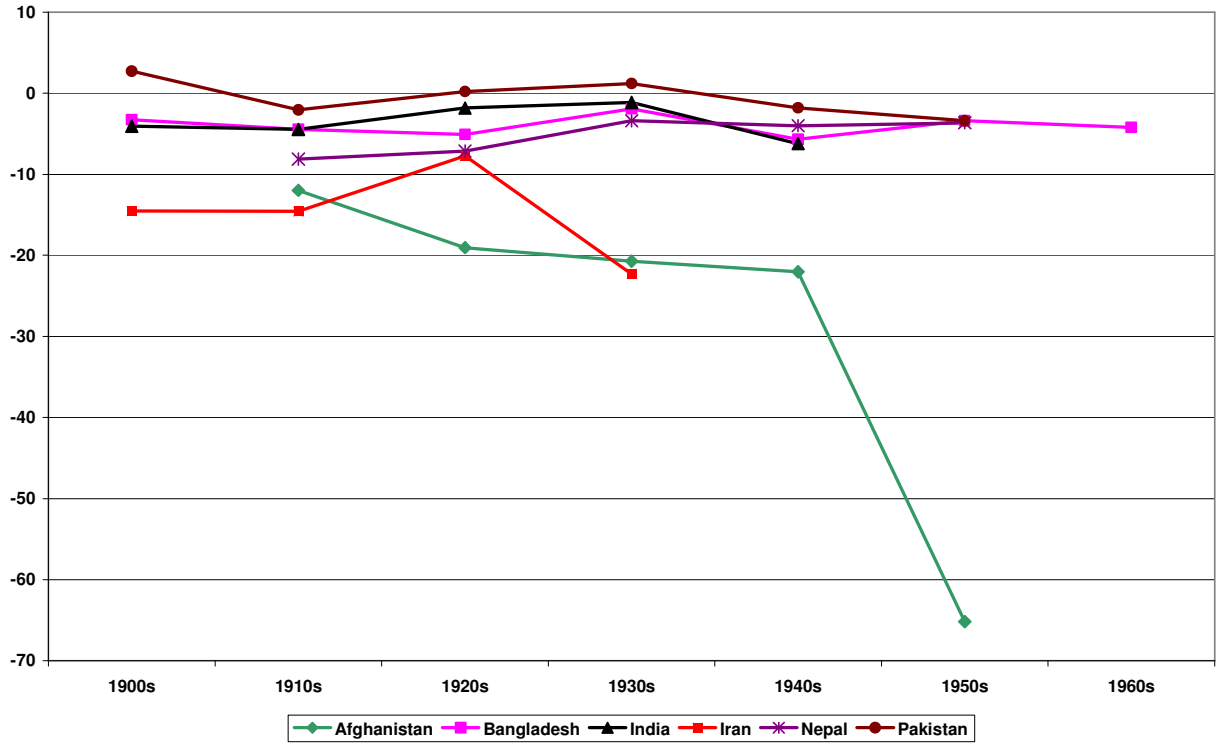
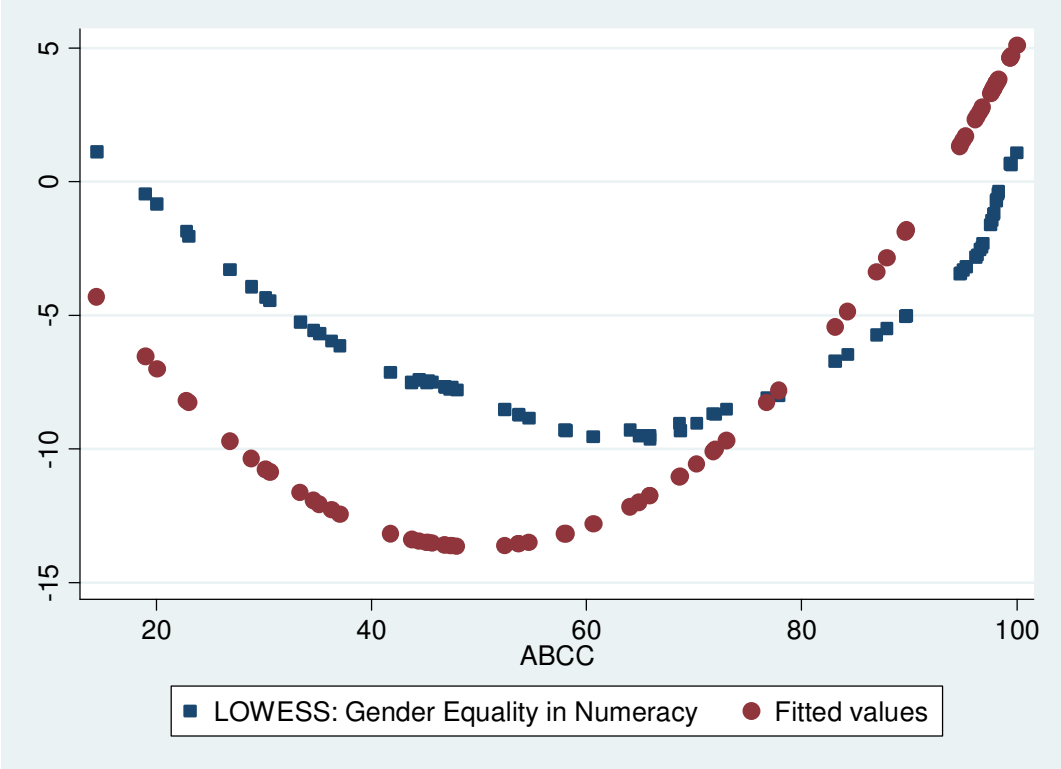


Figure 8: Relationship between gender equality in numeracy and numeracy, LOWESS scatterplot and fitted values



Online Appendix (not included in printed article, but to be published online)

Census Data

East Asia:
Hong Kong (hk): Census of 1976 for birth decades 1900s-40s, Census of 1986 for birth decades 1910s-50s, Census of 1991 for birth decades 1920s-60s.

South Asia:
Bangladesh (bd): Census of 1974 for birth decades 1900s-40s, Census of 2001 for birth decades 1930s-60s; **India (in):** Census of 1971 for birth decades 1900s-40s; **Nepal (np):** Census of 1981 for birth decades 1910s-50s; **Pakistan (pk):** Census of 1972 for birth decades 1900s-40s, Census of 1981 for birth decades 1910s-50s; **Sri Lanka (lk):** Census of 1963 for birth decades 1900s-1930s, Census of 1971 for birth decades 1900s-40s, Census of 1981 for birth decades 1910s-50s.

Southeast Asia:
Cambodia (kh): Census of 1962 for birth decades 1900s-1930s; **Federation of Malaya (myfm):** Census of 1957 for birth decades 1900s-1920s; **Indonesia (id):** Census of 1971 for birth decades 1900s-40s, Census of 1980 for birth decades 1910s-50s; **Philippines (ph):** Census of 1948 for birth decades 1900s-1920s, Census of 1990 for birth decades 1920s-60s; **Sarawak (mysa):** Census of 1960 for birth decades 1900s-1930s; **Thailand (th):** Census of 1947 for birth decades 1900s-1910s, Census of 1960 for birth decades 1900s-1930s.

West Asia:
Afghanistan (af): Census of 1979 for birth decades 1910s-50s; **Iran (ir):** Census of 1966 for birth decades 1900s-1930s

Sources: Data come from United Nations (various issues) *Demographic Yearbook* (New York: UN), supplemented with Bangladesh Bureau of Statistics (2003) *Population Census 2001* (Dhaka), Pakistan Population Census Organisation (1977) *1972 Census Report of Pakistan* (Islamabad), and Pakistan Population Census Organisation (1984) *1981 Census Report of Pakistan* (Islamabad).

Variable Definitions and Sources

ABCC
Proxy for basic numerical skills. Linear transformation of the Whipple index. The ABCC index ranges between 0 and 100 (100 = no age-heaping, 0 = only ages ending on multiples of 5 are reported). See section III for more details.
Sources: See Appendix: Census Data.

GE_{num}
Measure of gender equality in respect of basic numerical skills. See section III for more details.
Sources: same as for ABCC.

GDP per capita (log)
Gross domestic product per capita (measured in 1990 international Geary-Khamis dollars), average over decade. Missing values were generated by linear Interpolation.
Source: Maddison, A. (2001) *The world economy: a millennial perspective* (Paris: OECD).

Population density (log)
Population estimates per land area, average over decade. Missing values were generated by linear Interpolation.
Source: Maddison, A. (2001) *The world economy: a millennial perspective* (Paris: OECD).

Land productivity (log)
Rice output (measured in thousand metric tons) per rice area (measured in thousands of hectares), average over decade.
Source: Mitchell, B.R. (1998) *International Historical Statistics: Africa, Asia & Oceania 1750-1993* (London: Macmillan).

Enrolment ratios (log)
Unadjusted primary school enrolment ratios: percentage ratio based on the enrolment at this level related to the estimated population 5-14 years old.
Sources: For 1870 to 1940 the data come from Benavot and Riddle (1988). The value for the period 1935-1940 was assigned to the decade 1940. For 1950 and 1960 the data come from UNESCO (1964). For 1950 we took the mean of the values of 1950 and 1955, for 1960 we took the value of 1960.

Female voting right
Dummy variable coded 1 for the decades in which female voting rights are granted.
Source: United Nations Development Programme (2009) *Human Development Report 2009* (New York: Palgrave Macmillan), p.186-189.

Buddhism, Christianity, Confucianism, Hinduism, Islam
Dummy variable coded 1 if majority of the population adheres to one of these religions.
Buddhism: Cambodia, Sri Lanka, Thailand. Christianity: The Philippines.
Confucianism: Hong Kong. Hinduism: India, Nepal. Islam: Afghanistan, Bangladesh, Federation of Malaya, Indonesia, Iran, Pakistan, Sarawak.
Source: Barro, R. (2011) Religion adherence data. [Accessed 14 Dec 2011] Available from URL: http://rbarro.com/data-sets/.

Tables

Table I: The data set

Country	Birth decade	ABCC index	Whipple index	Whipple male	Whipple female	Gender Equality numeracy
Afghanistan	1910	37.09	351.65	334.90	375.02	-11.98
Afghanistan	1920	41.77	332.93	307.93	366.62	-19.06
Afghanistan	1930	43.73	325.09	296.51	357.95	-20.72
Afghanistan	1940	45.28	318.88	286.48	349.58	-22.03
Afghanistan	1950	52.30	290.79	218.04	360.16	-65.18
Bangladesh	1900	18.97	424.11	418.32	432.09	-3.29
Bangladesh	1910	23.02	407.91	400.03	417.89	-4.47
Bangladesh	1920	26.85	392.58	383.75	403.26	-5.08
Bangladesh	1930	30.54	377.83	374.43	381.68	-1.94
Bangladesh	1940	34.63	361.47	351.45	371.46	-5.69
Bangladesh	1950	35.19	359.25	353.90	365.98	-3.41
Bangladesh	1960	45.15	319.41	313.29	326.50	-4.22
Hong Kong	1900	98.29	106.86	106.01	107.50	-1.41
Hong Kong	1910	97.67	109.32	108.96	109.69	-0.67
Hong Kong	1920	98.07	107.70	107.15	108.32	-1.09
Hong Kong	1930	99.40	102.41	102.77	101.96	0.79
Hong Kong	1940	100.00	100.00	100.50	100.00	0.50
Hong Kong	1950	99.40	102.41	102.05	102.78	-0.71
Hong Kong	1960	99.48	102.07	101.94	102.19	-0.25
Indonesia	1900	47.96	308.18	294.06	320.96	-9.14
Indonesia	1910	53.72	285.11	269.39	299.54	-11.19
Indonesia	1920	57.98	268.06	256.98	279.20	-8.65
Indonesia	1930	60.63	257.50	252.30	262.60	-4.08
Indonesia	1940	64.05	243.79	233.89	252.25	-7.85
Indonesia	1950	72.98	208.07	204.12	211.89	-3.80
India	1900	28.83	384.67	377.35	392.69	-4.06
India	1910	33.39	366.44	358.91	374.98	-4.48
India	1920	36.28	354.87	352.09	358.54	-1.83
India	1930	45.65	317.38	315.49	319.11	-1.15
India	1940	53.66	285.35	276.61	293.83	-6.22
Iran	1900	47.31	310.74	290.50	332.70	-14.52
Iran	1910	54.64	281.43	263.83	302.32	-14.59
Iran	1920	65.90	236.38	228.36	246.06	-7.75
Iran	1930	65.89	236.44	212.66	260.08	-22.30
Cambodia	1900	95.01	119.94	119.59	120.30	-0.60
Cambodia	1910	94.71	121.17	121.22	121.13	0.07
Cambodia	1920	95.27	118.92	117.11	120.74	-3.10
Cambodia	1930	94.78	120.90	118.33	123.35	-4.24
Sri Lanka	1900	64.87	240.54	219.88	267.85	-21.81
Sri Lanka	1910	76.76	192.97	176.53	213.04	-20.68
Sri Lanka	1920	83.11	167.57	157.29	179.28	-13.98
Sri Lanka	1930	89.68	141.27	134.18	148.71	-10.83
Sri Lanka	1940	96.33	114.67	112.22	117.19	-4.43
Sri Lanka	1950	97.55	109.79	109.67	109.92	-0.23
Federation of Malaya	1900	86.97	152.12	145.86	160.00	-9.69
Federation of Malaya	1910	87.92	148.32	142.32	154.69	-8.69

Federation of Malaya	1920	89.64	141.45	133.04	149.81	-12.60
Sarawak	1900	70.26	218.97	209.05	231.53	-10.75
Sarawak	1910	68.63	225.48	219.87	232.07	-5.55
Sarawak	1920	71.77	212.91	214.42	211.35	1.43
Sarawak	1930	71.99	212.03	210.87	213.08	-1.05
Nepal	1910	47.50	310.00	298.69	322.99	-8.13
Nepal	1920	46.80	312.81	302.73	324.35	-7.14
Nepal	1930	52.38	290.47	285.91	295.62	-3.40
Nepal	1940	58.11	267.57	262.37	272.94	-4.03
Nepal	1950	68.72	225.12	220.94	229.05	-3.67
Philippines	1900	77.90	188.40	166.28	211.17	-26.99
Philippines	1910	84.26	162.96	151.16	174.72	-15.58
Philippines	1920	89.75	141.01	135.50	146.11	-7.83
Philippines	1930	96.17	115.31	114.49	116.09	-1.40
Philippines	1940	96.57	113.71	114.11	113.31	0.70
Philippines	1950	96.74	113.06	114.02	112.09	1.69
Philippines	1960	96.83	112.66	113.42	111.91	1.34
Pakistan	1900	14.48	442.06	440.47	428.49	2.72
Pakistan	1910	20.05	419.81	416.19	424.79	-2.07
Pakistan	1920	22.80	408.79	409.12	408.27	0.21
Pakistan	1930	30.16	379.37	381.47	376.95	1.18
Pakistan	1940	44.44	322.23	319.80	325.55	-1.80
Pakistan	1950	46.86	312.58	307.57	318.07	-3.41
Thailand	1900	98.23	107.10	105.14	109.07	-3.74
Thailand	1910	98.11	107.56	105.54	109.54	-3.79
Thailand	1920	97.82	108.72	107.48	109.97	-2.31
Thailand	1930	97.87	108.53	108.30	108.76	-0.42

Table II: Correlation Matrix

	GEnum	ABCC	Female vot.	Muslim	Hindu	Buddh.	Christ.	Confuc.	Enrolment	GDPc	Pop. dens.	Land prod.
GEnum	1											
ABCC	0.122	1										
Female vot.	0.331	0.196	1									
Muslim	-0.196	-0.587	-0.179	1								
Hindu	0.102	-0.292	0.007	-0.380	1							
Buddh.	-0.023	0.464	-0.006	-0.465	-0.197	1						
Christ.	-0.036	0.307	0.202	-0.310	-0.132	-0.161	1					
Confuc.	0.278	0.403	0.099	-0.310	-0.132	-0.161	-0.108	1				
Enrolment	0.120	0.213	0.546	-0.277	-0.076	-0.140	0.417	0.265	1			
GDPc	-0.064	0.819	0.243	-0.423	-0.315	0.160	0.257	0.606	0.402	1		
Pop. dens.	0.473	0.072	0.458	-0.314	0.080	-0.174	-0.034	0.685	0.582	0.250	1	
Land prod.	0.570	-0.239	-0.011	0.435	0.123	-0.148	-0.419	.	-0.520	-0.266	-0.208	1

Note: Enrolment rates, GDPc, population density, and land productivity are in logs.

Figures

Figure I: Age-heaping behaviour of males (left hand side) and females (right hand side) in Afghanistan according to the census of 1979.