Great Famine, Education and Cognition in Later Life: Evidence from Elder Adults in China[1]

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Abstract

In this article, we study the effects of education on cognition in later life. We find that respondents who finished primary school performed significantly better in cognitive tests than those who did not. The effects of education remain significantly positive, even after controlling for variables such as standard of living, health behavior and the community environment. We use China's Great Famine from 1959-1961 as an instrument to investigate the causality between education and cognition because everyday lives and normal school operations were severely disrupted during this time. The IV estimation finds that respondents who were of primary school age were 12.4% less likely to finish primary school, and results from the two-stage estimates suggest that causal links exist between education and cognition.

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1. Introduction

The positive correlation between education and cognition is already well known. Do educated people maintain their cognitive advantages even when they are elderly Is this correlation due to the casual impact of education on cognition, does the causality relationship reversed, or is there a third factor that influences both? Do cognitive returns on education result from physical changes directly, or do they result from factors that indirectly cause changes such as SES (Social Economic Status), health behavior and community level attributes?

These issues are becoming more important today in the context of global aging—especially as more and more studies show that cognition plays a role in wealth accumulation for older adults. For example, cognitive traits are found to have strong effects on financial outcomes and retirement saving trajectories in later life (Smith *et al*., 2010 and Banks *et al*., 2011). According to these findings, the association of education with elderly cognition is extremely important to China for three reasons. First, with the largest population in the world, China is on its way to becoming an aged country at a rapid pace, which is partially due to its unique one-child policy. Second, the education attainments of elderly people in China are low and unequally distributed. In the CHARLS data we used for this study, 58% of respondents failed to finish primary school and 39% are illiterate. Moreover, in a male-preferred culture, it was more important that sons received an education than it was for daughters. The data also show that 77% of women older than 75 are illiterate, while the percentage of illiterate men is 43%. Third, the tradition of large families is diminishing in China, and, at the same time, a large percentage of the elderly, especially those living in rural areas, are not covered by the social security system. Cognitive function may be an important determinant of accumulated wealth and elderly living costs.

In this paper, we examine education gaps in cognitive functions among middle-aged and elderly people in China. Using data collected in 2008 by the China Health and Retirement Longitudinal Study (CHARLS) pilot survey, the Chinese version of the Health and Retirement Studies (HRS), we find that there are significant differences between the low education group (people who did not finish primary school) and the high education group (primary school graduates and above). This education gap is more than twice as large as the gender gap or the urban-rural gap. The magnitude of the education gap may be due to the low average level of education of the respondents in our sample, which implies that the marginal effects of education may be relatively strong.

We also attempt to analyze the extent to which direct channels, such as physical changes to the nervous system, and indirect channels, such as social economy status, health behavior and community affect elderly cognition. Even after controlling for the indirect channels, we still can observe smaller, but significant, effects. These results support the “use-it-or-lose-it” hypothesis mentioned by Rohwedder and Willis (2010) and are consistent with recent studies in neuroscience (Arvanitakis, *et al*., 2004; Arnaiz, *et al*., 2004). As Scarmeas, *et al.* (2006) discuss in their paper, *“More education trains people to have more efficient circuits of synaptic connectivity or more efficient of alternative brain network.”*

There is little prior research investigating the causal relationship between education attainment and cognitive functions in later life because mechanisms behind the correlation between these two variables are relatively complicated. The correlation may be the result of a causal link from education to cognition, or the causal link may be reversed. The correlation may not even be based on any causal relationship between these two variables. Instead, the cause may be due to a third factor that influences both education and cognition. A widely used strategy to address the possible endogeneity of education is to use instrumental variables. Using the educational differences among peers, we perform two–stage estimations with an instrument for identification of causality: the sharp decline in student enrollment during the great famine, which occurred suddenly in most areas of China from 1959 to 1961. Our results show that education attainment has a positive effect on cognitive function in later life, especially on word recall and drawing.

Our study also contributes to a growing literature on the long-term consequences of China's Great Famine. Unlike most of the previous studies in the literature, which focus on the effects of malnutrition during early childhood or pregnancy, we mainly discuss the consequences of temporary interruptions from everyday life and the education system. Our two-stage estimates imply that the survivors, who were in their primary school years during the famine, are still suffering from impaired cognitive functioning due to limited access to educational resources during their youth.

This paper is organized as follows. Section 2 provides a literature review. Section 3 is an introduction to the CHARLS data used in this paper and shows some summary statistics. Empirical models and results are presented in Section 4. Section 5 discusses endogeneity problems and the background of the Great Famine, and then provides the results of IV estimation. A discussion and conclusion comprise Section 6.

2. Background

2.1 The neurology of cognition and education

Studies concluded by neurologists mainly focus on the role of education and the risk of symptoms of some "organic and progressive" diseases such as Alzheimer's disease (AD) and dementia. These studies usually focus on one of two topics or both: how education affects the risk of getting a disease and how it affects the severity of the symptoms once people are diagnosed and examined.

Most literature on the first topic concludes that less-educated people face a higher risk of getting Alzheimer disease or dementia (Stern Y, Gurland B, *et al*., 1994; Zhang, 1990). Recently, Caamaño-Isorna, *et al.* (2006) reexamined the relationship between education level and risk of dementia using the meta-analytic method. Based on 19 observational studies published before October 2005, they confirm that a negative relationship exists.

Moreover, researchers are also interested in the relationship between education level and rates of cognitive decline in patients with Alzheimer's disease. That is, given the same level of pathology, can educated patients perform better cognitively than less-educated patients? However, the answer to this question was not conclusive. Some studies say "yes" (Fritsch, 2002), some arrive at the opposite conclusion (Small, *et al.,* 1999; Unverzagt, 1998), and some studies are inconclusive (Filley, 1985). The controversy continued until 2003, when Arvanitakis, *et al.* (2003) provided some direct evidence of the link between education and cognition rates in AD patients. Unlike previous studies, researchers in this study were able to observe brain slides from 130 elderly Catholic clergymen, who donated to the study directly. They found that education actually modifies the relationship between AD pathology and the level of cognitive function: patients with more years of education require a stronger pathology to reach any level of cognitive impairment (Arvanitakis, *et al*., 2003).

An experiment on animals (Arnaiz, 2004) also provides some direct evidence related to this topic. The experiment finds that rats that are raised in a more enriching environment perform better in the labyrinth test. The study provides an explanation to support this conclusion: education is a stimulus that can modify neural connectivity and plasticity.

However, neurological studies have some limitations. The sample sizes are usually small. Most individuals in the sample are patients, and, as a result, the results may not explain normal cognitive declines without pathology. Importantly, most studies do not address the causal link between education and cognition.

2.2 Cognitive differences as a consequence of social inequality

In contrast, social scientists often view differences in cognitive function as an example of how social inequality affects health. Unlike the neurologists described above, social scientists employ a different methodology: social scientists perform more complicated regressions on survey data with large sample sizes and measure cognitive performances using questions as outcome variables.

Most of the studies that are conducted by social scientists support the theory that early education is positively associated with cognitive function late in life. This conclusion is confirmed by studies that were performed in both rich and poor countries. However, this issue is more meaningful in poor countries, where educational resources are limited and compulsory education law does not exist or cannot be enforced effectively. Under these circumstances, the opportunity to receive an education depends upon a family's allocation of resources as well as regional and societal resource allocation—especially across gender, ethnicity, residence and class. Furthermore, no matter how educational resources are distributed, education inequality usually creates new inequalities and some long-term consequences, such as differences in cognitive functioning.

In some developing countries, boys are given priority in regard to obtaining an education. The gender gap is quite large when resources are scarce. Alderman, *et al.* (1996) find that a significant gender gap in cognitive ability exists in Pakistan and that it is much larger in those regions that lack education resources. They find that the availability of local schools during childhood can explain for approximately one-third of the total gender gap in adult cognitive achievement and for over two-fifths of the gender gap in numeracy. Yount (2008) also arrived at a similar conclusion with data from Egypt (18% of the gender gap is explained by differences in education levels). Wang (2006) finds that gender differences in the cognitive functioning of old people exist in China even when variables such as age, daily activity, disability and rural residence are controlled. These studies argue that these differences are mainly caused by women's lower socioeconomic status from childhood. Moreover, these studies also find that social networks and participation in leisure activities (especially mental activities) in later life also partially account for the gap. Using the same data employed in our study, Lei, *et al.* (2011) find a female deficit in cognitive skills that increases with age and is especially prevalent in the poorer communities in China.

Differences in cognitive functioning across groups also exist in developed countries. In the United States, people raised in higher socioeconomic communities display better cognitive functioning when they are old (Bennett *et al.*, 2006). Using data from the UK, Singh-Manoux, *et al.* (2005) find that childhood SEP (a measure of socioeconomic status) has few positive effects on cognitive aging directly, but it has a substantially positive “indirect effect” mediated by education and adult socio-economic status.

Occasionally, education inequality can be caused by historical events such as wars and natural disasters. For example, the outbreak of World War II forced some French students to leave school at an earlier age than normal (Lequien, 2011), which may have caused differences in mortality in later life. However, there is little literature that investigates the impact of large events on the cognitive skills of elderly adults.

3. Data

The data we employed are from the 2008 wave of the China Health and Retirement Longitudinal Study (CHARLS) pilot survey. The data are publicly available at http://charls.ccer.edu.cn/charls, and includes a detailed users’ guide (Zhao, *et al*. 2009). The design of this survey is quite similar to the widely used American Health and Retirement Survey (HRS). The 2008 wave of the CHARLS is a pilot survey, and it was conducted in Zhejiang and Gansu Provinces. The study included 2685 individuals (1302 males and 1383 females) in 1570 households in the two provinces. The response rate was over 80%. Detailed information about the sampling procedures can also be found on the website. The survey aims to be a representative sample of residents who are 45 and older. If one member of a household aged 45 or over is sampled, then his/her spouse is also included no matter how old she/he is. However, we only use the sample of respondents who are at least 45 years old for our empirical analyses. Figure 1 shows the age distribution of respondents. According to this figure, we can observe that most respondents fall into the 45- to 70-year-old age range.

[insert Figure 1]

3.1 The measure of cognition

In science, *cognition* refers to mental processes that involve several dimensions. McArdle, *et al.* (2002) divide these dimensions into two categories: fluid intelligence (G*f*) and crystallized intelligence (G*c*). The first category refers to the thinking part of cognition and includes memory, abstract reasoning and executive function. The second category is the knowing part, which is the accumulation of influence from education and experience. According to *McArdle*, *et al.'*s work, questions listed in the CHARLS survey are related to both types of intelligence, but they are more closely related to the fluid type of intelligence. Figure 2 confirms that the relationship between age and our measurements is more consistent with the pattern of fluid intelligence. That is, elements of fluid intelligence are thought to peak early in life and then steadily decline thereafter with age.

[insert Figure 2]

One important advantage of CHARLS data for our purposes is that it provides a four-page-long set of questions to test respondents' cognitive functioning. These questions are quite similar to those from the HRS. In this paper, we rely on four measures of cognition functioning: *mental status, episodic memory, numeracy* and *drawing*.

- *Metal status* measures the intactness of individuals. In CHARLS, respondents were asked to name the date (including year, month, day and season). Answers to these questions are aggregated into a single *mental status* score, ranging from 0 to 5.
- *Episodic memory* consists of two parts: immediate and delayed word recall. A list of ten nouns is read by the interviewers, and respondents are asked immediately to recall as many of the words as they can in any order. A few minutes later, after the respondents had finished measurements of self-reported depression, numeracy and drawing, they were asked again to recall as many of the original words as possible. For our purposes, the measure of episodic memory is the sum of the number of words repeated in immediate recall and in delayed recall. Thus, the episodic memory scores range from 0 to 20. However, a small proportion of respondents skipped some of the questions related to word recall. We address this problem through two approaches. In one approach, we don't include these respondents into our sample, and in the second approach, we assumes these respondents scored a 0. However, we find that these two approaches achieve almost the same results. As a result, we only report the results of the first approach.

- The measure of *numeracy* is based on a serial 7 subtraction from 100 (up to five times). The number of correct calculations is aggregated into a single score, which ranges from 0 to 5.
- In the survey, a picture of two overlapped pentagons is shown, and the respondents are asked to draw the same picture. If he/she can finish this task successfully, the score of the *drawing* is 1. Otherwise, the score is 0.

3.2 Analysis of education and cognition

As mentioned above, the average level of education attained by our respondents is relatively low. More than half failed to finish primary school, and only one in ten people received a high school level education or above. Thus, we divide the respondents in our sample into two groups based on whether they had finished primary school. Table 1 shows the mean of our cognitive measures by education group.

[insert Table 1]

From Table 1, we can see that individuals who finished primary school displayed better cognitive skills in all of the areas than those who did not complete primary school. Then, we move to a comparison of cognitive skills between groups separated by education and gender. In general, gender also affects cognitive skills and seems to affect women more than men. Educated women have cognitive skills that are as strong as educated men, but less-educated women perform worse than less-educated men. Compared to women, men show a slight advantage in numeracy skills only. Moreover, the bottom row of Table 1 shows how sons are more likely to have access to educational resources than daughters. More than half of the men had received at least a primary school education, while only one quarter of the women had received a primary school education.

[insert Table 2]

Table 2 presents the correlation matrix of our cognitive variables and education. Cognitive skill correlation ranges from 0.13 to 0.4, which shows that these four cognitive scores are positively related, but they measure different dimensions of cognition. We also find that *mental status*, *word recall* and *drawing* are closely related to each other (with correlations of 0.39, 0.4 and 0.36). In contrast, *numeracy* seems to measure a dimension with more distance than the other three (with correlations of 0.13, 0.17 and 0.22). In general, high education attainment is positively related to each dimension of cognitive functioning.

The positive relationship between education and cognition is common sense, and it is confirmed by a large amount of literature. We are more interested in the education gap on cognitive skills when people are old. Do these differentials remain significant even in very later life, or do they narrow gradually as a retrogressive process in the nervous system? Figure 2 provides a description of the relationship between cognitive skills and age. Obviously, the education gap remains significant in every dimension of cognitive functioning. Only *episodic memory* shows a pattern of converging in very later life. The *mental status* of educated people seems to decline more slowly than it does for non-educated people. Though *mental status* does not control other variables that are closely related to education, it still shows that education may play a role in explaining cognitive differences among elderly adults.

4. Baseline Estimation Specifications and Results

This section presents empirical specifications and results of the OLS estimates and aims to identify the relationship between education and cognition. As discussed in section 3, we use *mental status*, *episodic memory, numeracy* and *drawing* to describe the respondents' level of cognitive functioning. Additionally, we summarize these four dimensions to obtain a measurement of overall cognitive ability. Then, we estimate separate models for the four dimensions and the overall score.

4.1 Baseline OLS Estimation

Table 3 presents the results for the baseline OLS estimates of the relationship between education and cognitive skills. The estimated coefficients and associated *t* values are listed in the table. The key variable is "education" (primary school or above =1). Other variables included in our models are standard ones: gender (male=1), marriage status (married=1), urban/rural (urban=1), age and a quadratic in age (divided by 100 for scaling). Fogel (1994) suggests that height can serve as a measurement of malnutrition and health. To control for the relationship between physical health and cognitive functioning, we also include height in our model. For those respondents who did not provide their height, we assign the mean height by gender and county and denote them with a missing value indicator (equal to 1). The county-level fixed effects are controlled.

Results of the baseline OLS estimate show that cognitive skills, regardless of dimension, tend to be higher for people who are educated, male, urban-dwellers and tall. The coefficients of education and urban living are positive at a 1% significance level in all dimensions of cognitive functioning. The magnitude of the educational effects on *episodic memory* and *drawing* are relatively high and are 31.6% and 53.6% of the mean of "primary school unfinished" group, respectively. Moreover, the negative signs before the coefficients of the age quadratics imply that the speed of cognitive decline accelerates as people age.

4.2 The indirect effects from education to cognition

In this study, we are also interested in the mechanisms behind educational effects. As discussed in Section 2, some neurologists suggest that education serves as mental training for the nervous system to improve its efficiency in particular physical conditions. However, we cannot observe the operation of the brain directly in our study. Our method includes variables of indirect channels in our models, and we then investigate whether the educational effects are eliminated. Based on previous literature, we consider three indirect effects in our model as follow:

- *Income effect* refers to the positive effects from income to cognitive functioning. In short, educated people have better a chance of finding higher-paid jobs, and they can then afford more nutritious foods and increased mental activity, both of which are helpful for cognitive functioning. Considering the existence of various transfers within and outside of the family, we use a more direct measure: a log of monthly expenditures (Ln expenditure) to capture this effect.
- *Health behavior* can be a channel of indirect effects from education to cognition. Education is believed to be negatively related to hobbies that are bad for cognitive health, such as smoking and drinking. For example, Anstey *et al* (2007) find, relative to non-smokers, current smokers have risks of 1.79 for incident Alzheimer's disease, 1.78 for incident vascular dementia, 1.27 for any dementia, and a greater likelihood of declines in mini-mental state examinations. Thus, we include smoking and drinking as variables in our model.
- *Community and social networks* also may partially account for cognitive differentials in later life. Wang (2006) argues that social networks and participation in leisure activities (especially mental activities) can partially explain for gender differentials. Rohwedder and Willis (2010) empirically prove that maintaining an engaged life style (involving active,

intellectually stimulating activities) is good for slowing the decline of cognitive abilities. Usually, educated individuals have a higher likelihood of living in good communities and of being involved in social networks with a higher percentage of educated people. On the other hand, both a good community and social networks with educated people provide more opportunities to access resources to promote an engaged life style. To capture this channel of indirect effects, we construct two indicators for the quality of community. The first is the log of family per capita expenditures for the corresponding community (Ln PCE of community), and the second is the average level of education of the respondents living in the community.

[insert Table 4]

Table 4 presents the results for the extended empirical model. Consistent with the discussions above, income, health behavior and community quality are all positively related to cognitive functioning. The coefficients of consumption expenditure are significant in all dimensions of cognition except numeracy. Smoking has significant effects on each dimension, but drinking does not. In particular, the coefficients of Ln PCE for a community seem to be larger than those of Ln expenditure of individuals. Such a result implies that community quality plays an important role in explaining differences in cognitive abilities. This finding is consistent with Lei, *et al.* (2011). Using the same dataset, they find that gender differences in cognition are especially concentrated within poorer communities in China, and gender differences are more sensitive to community level attributes than to family level attributes. We have run regressions by adding these control variables one by one, and we find consistent results throughout.

Compared with the results in Table 3, the coefficients of education are only slightly smaller, but they are significant. In general, the indirect channels listed above can only explain approximately 20% of the educational effects. This finding is consistent with the argument of Scarmeas, *et al.* (2006) that education can influence the nervous system. In spite of these empirical results, our findings suggest that education has a strong influence on cognitive skills after controlling for these variables. In the next section, we will attempt to investigate the causal link from education to cognition using the instrumental variable method.

5. Empirical Problems and IV Estimation

The results of OLS estimation provide us with clues about the relationship between education and cognition. However, these results are challenged by empirical problems: endogeneity, reverse causation and selective survivorship. First, because both education and cognition are both determined by similar factors, it is difficult to determine whether education affects cognition or whether some lurking variable is correlated with both education and cognition. Second because a cross-sectional dataset is used, reverse causation may be a problem. In other words, the other causal link may be that individuals with better cognition have a higher probability to achieve educational attainments. Finally, because the mortality rate among the elderly is related to both education and cognitive functioning, the people who are missed in sampling due to death are selective.

The last problem does not detract from our conclusion because most investigators in the literature find that both education and cognitive functioning are negatively related to mortality. Therefore, individuals who are uneducated and have poor cognitive-functioning have a higher probability of dying In this sense, selective survivorship will cause our results to be underestimated, not overestimated. The instrumental variable method is widely used to solve for endogeneity and reverse causation. In this paper, we use great famine that occurred almost fifty years ago as our instrument. The background and validity of IV will be discussed in this section.

5.1 The background of China's Great Famine during 1959-1961

In 1958, a nationwide "Great Leap Forward" movement began, and all rural residents were organized into People's communes that typically contained thousands of households. However, this movement did not cause China to "Leap Forward," but rather to "Leap Backward." Over the following three years, grain production dropped sharply and a great famine occurred in almost every region of China. Several studies were conducted to determine the factors responsible for causing the famine. The studies often provided the following reasons: "bad weather, excessive procurement by the state, delayed response to the food shortage, weakened production incentives due to the sweeping collectivization program in 1958, and resource diversion as a result of massive industrialization." (Chen and Zhou, 2007).

[insert Figure 3]

This nationwide famine caused an unprecedented number of deaths, and the worst case scenario occurred in 1960. Lin and Yang (2000) showed that the national death rate rose sharply in 1959 and reached its peak (approximately 25 per thousand) in 1960. Moreover, the situations in Zhejiang and Gansu, where the baseline survey of CHARLS were performed, were quite different during the famine. Zhejiang had the reputation of being a grain-producing location for hundreds of years, and, historically, society there was much better organized. It is not surprising that Zhejiang suffered much less from the famine than Cansu. The "Great Famine" not only brought an unprecedented number of deaths but also caused malnutrition and social disorder.

The long-term consequences of malnutrition on the survivors have been studied in several recent articles. One interesting study by Qian (2008) used the Great Famine (1959-1961) in China as an exogenous shock. In her paper, Qian identified a negative association between the price of tea and a sex imbalance in China because China’s government exogenously paid more attention to the production of grain in provinces that suffered heavily from the Great Famine. Moreover, there are a number of studies discussing the long-term effects (especially the health outcomes) of the “Great Famine” on the survivors, and these studies find that the effects of malnutrition are extremely strong for people who were infants during the famine (Chen and Zhou, 2007; Almond, *et al.*, 2007; Meng and Qian, 2009). A similar conclusion is also found from studies of the Greek famine from 1941 to 1942 (Neelsen and Stratmann, 2011).

[insert Figure 4]

However, very few studies address the long-term consequences of social disorder. One aspect of social disorder was the impact on the education supply: schools may have closed, teacher attendance may have declined, and students may have spent more time farming. Therefore, children left their schools and lost opportunities to invest in their own human capital because schools did not operate normally at that time. Hannum (1999) found that school enrollment during the famine declined sharply, and he concluded that it "stemmed from both school closings and hardships". From Figure 4, we can observe that enrollment numbers dropped sharply during the famine, especially in 1960, when the Great Famine was at its most difficult. This result supports the theory that the famine significantly affected education attainment for school children during that time.

5.2 The validity of the Instrumental variable

A similar strategy is used by Lequien (2011), in which he uses World War II as an exogenous shock on French educational attainments. Comparatively, using famine as our instrument is similar but has several advantages. First, the great famine was almost completely beyond expectation. As Lin (1990) shows, China's agricultural output kept growing at 3-4% per year from 1952-1958, and the growth rate in 1958 was 2.8%. However, this number dropped sharply to -14% in 1959 and to -13% in 1960. Second, China's hukou system placed strong constraints on population mobility even within same county. Thus, it was impossible for people to escape from the great famine by migration. Third, the *Compulsory Education Law* was not established in China until 1986, and, before that, households had the choice to decide whether to send their children to school.

In our paper, respondents who were of primary school age during the famine are categorized as the "treated group." In China, children usually enter school at 6-years-old. Thus, the "treated group" includes respondents who were born between 1948 and 1953. In other words, these respondents were between 7 and 12 years old in 1960, the peak year of the famine.

A valid instrument must satisfy two criteria. The first is to be correlated with the endogenous variable. In other words, the Famine must exert some influence on some of the respondents' educational attainments. As shown in Figure 5, that is indeed the case. The proportion of primary graduates is relatively low for the "treated" cohorts, regardless of whether the comparison was done on the cohorts before or after. This negative effect seems to be stronger for boys. It may have been that sons were preferred due to the insufficiency of educational resources at that time. In other words, girls had fewer opportunities to go to school, even before the famine. For example, for respondents who were born in 1952 and who entered primary school one year before the great famine began, primary school attendance for boys is as 2 times high as that for girls. Figure 4 also provides some information to support this fact. For example, the number of primary school enrollments dropped by as much as 20 percent in 1960, which is the peak year of the Great Famine.

[insert Figure 5]

The second criterion is that the instrument must not be linked to cognition through channels other than education. The main concern is that the famine may physically affect cognitive functioning through malnutrition. Our argument is that most literature finds that the effects of malnutrition are most severe in individuals who are under 5-years-old or prenatal (Grantham-McGregor *et al*, 2007). However, respondents in our "treated group" were already older than seven during the famine. If the respondents in our “treated group” suffered more physical damage during the famine, we should expect to observe that they are shorter than their cohorts before or afterward. However, Figure 6 shows that respondents in the “treated group” are almost as tall as the cohorts close to them. This implies that the effects of physical damage are not strong enough to make our instrument invalid.

5.3 The results of IV estimation

Table 5 presents the results of IV estimation. The results from one stage least square estimation show that our instrument satisfies the first criterion. On average, respondents in the “treated group” were 12.4% less likely to finish primary school. Moreover, males in urban areas had significantly more opportunities to receive an education. Consistent with common sense, education is positively related to both marriage status and to height.

The coefficients of education in 2SLS are all positive in every dimension of cognition, and the coefficients of other variables are consistent with the results of the OLS estimate. The coefficients of education from regressions on drawing and overall cognition are significant, and the effect of regression on episodic memory is almost significant (t value equals 1.62). Thus, the results of IV estimation support our hypothesis that a causal link exists from education to cognition. Moreover, the coefficients of gender are not significant in all of the regressions except the one regarding mental status. This result implies that gender discrimination in the distribution of educational opportunities is one of the main sources of the gender gap on cognition in China.

[insert Table 5]

6. Conclusion and Discussion

Using the recently released CHARLS dataset, we find that a positive return of education on cognitive functioning in later life exists. In this paper, we use China’s Great Famine from 1959 to 1961 as an exogenous shock. For respondents affected by our instrument, the conditional probability of receiving a primary education is 12.4% lower. This means that the famine of 1959-1961 in China not only killed a large number of people, but it also damaged the cognitive functions of survivors in later life through social disorder. We also find that education may explain the gender gap in cognition in China. Admittedly, our instrument is not perfect. However, our study contributes a piece of the explanation of the causal relationship between education and cognition while very few previous studies address this causality.

Our study also has some limitations. First, the CHARLS 2008 dataset we employed is not longitudinal. Thus, we cannot completely exclude cohort-based differences. Second, as a pilot survey, CHARLS 2008 only covers two provinces: Gansu and Zhejiang. As a result, we are unable to use geographic variations during the Great Famine to provide a more precise estimate. After new waves of CHARLS data are released, our study can be extended. Another limitation is that the Great Famine may have had stronger mental effects on teenagers than on infants. In other words, the instrument may have affected respondents who were better able to comprehend the mental stress during the famine. Stress may have some effect on cognitive development, or it may change respondents' attitudes about risk and the future, which in turn may affect decisions related to human capital investments.

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Figure 1: Age Distribution of CHARLS Respondents (2008)

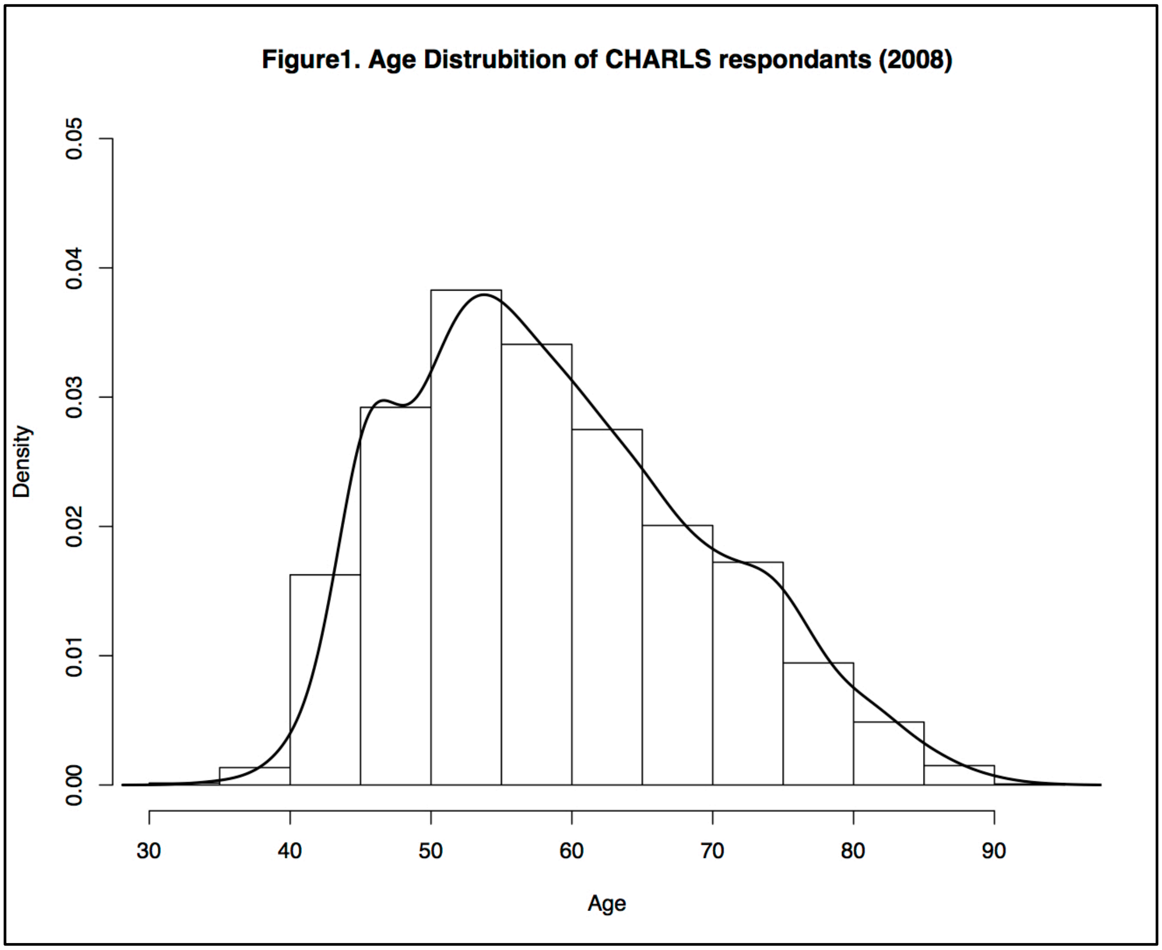
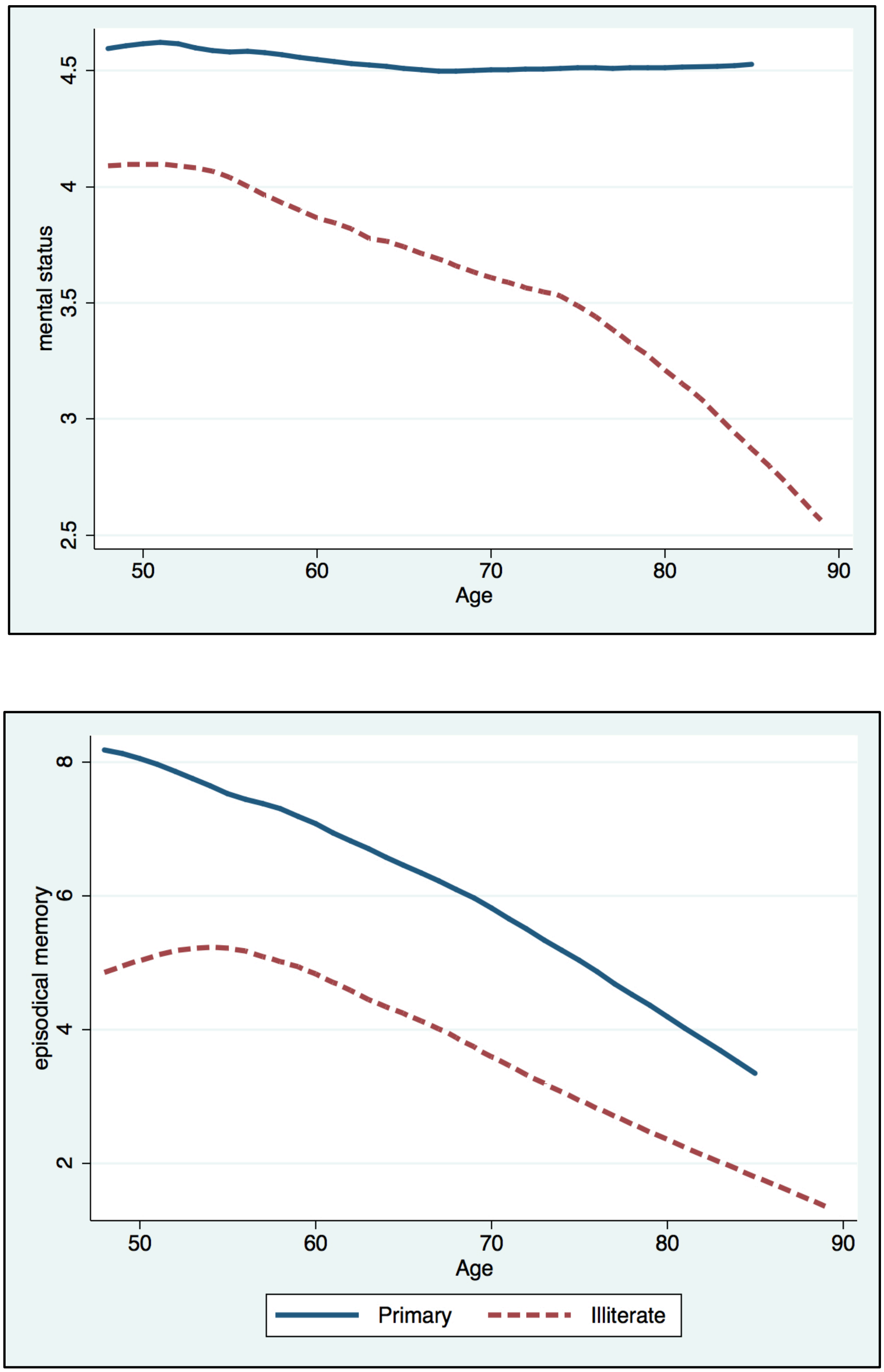


Figure 2. The age pattern of cognitive skills



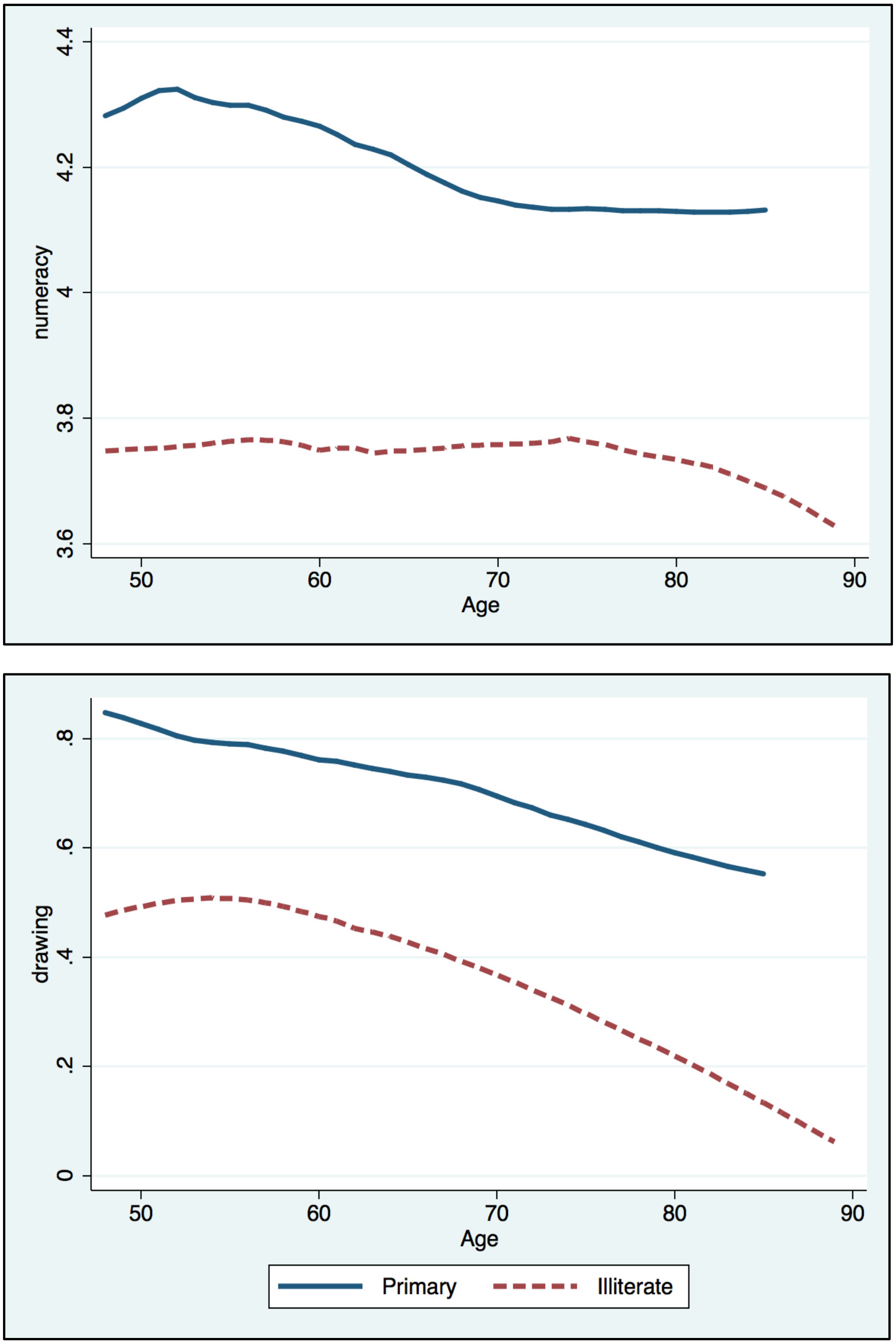

numeracy
4.4
4.2
4
3.8
3.6
50
60
70
80
90
Age
drawing
.8
.6
.4
.2
0
50
60
70
80
90
Age
Primary
Illiterate

Figure 3. Death Rates of Zhejiang and Gansu: unit 0.1% (1954-1966)

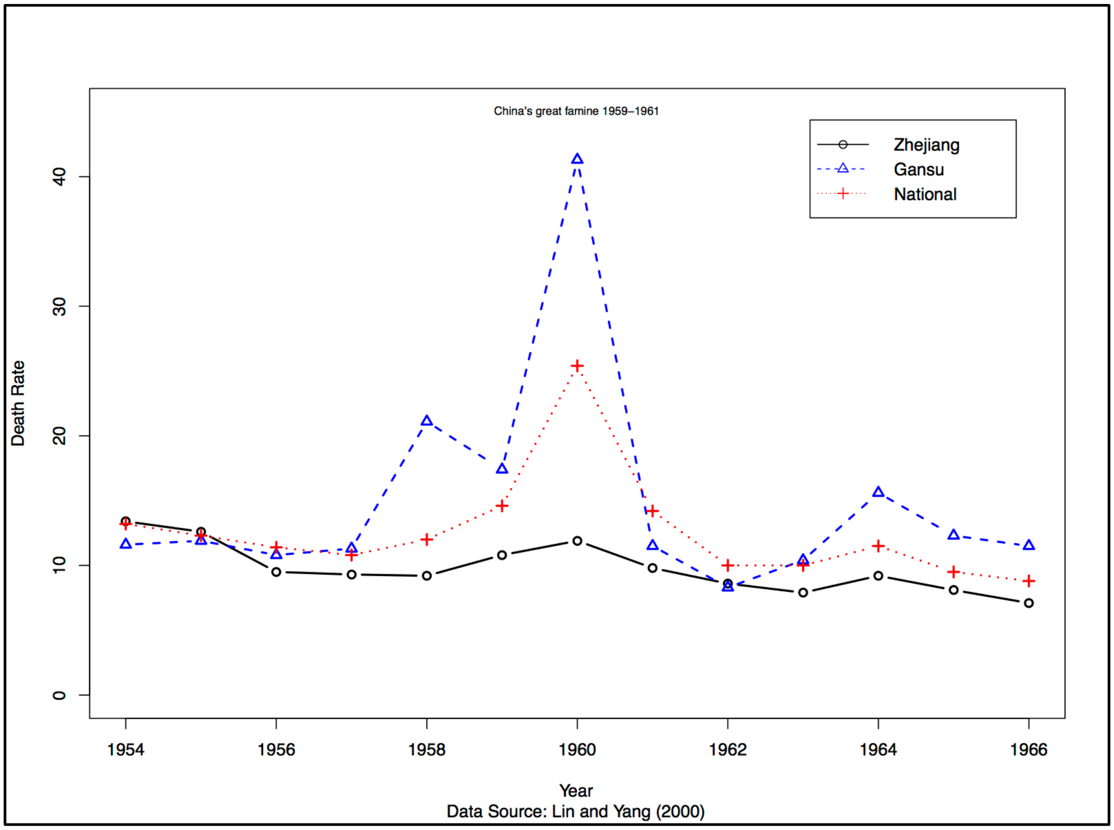


Figure 4. The growth rate of primary enrollment, 1949-1982

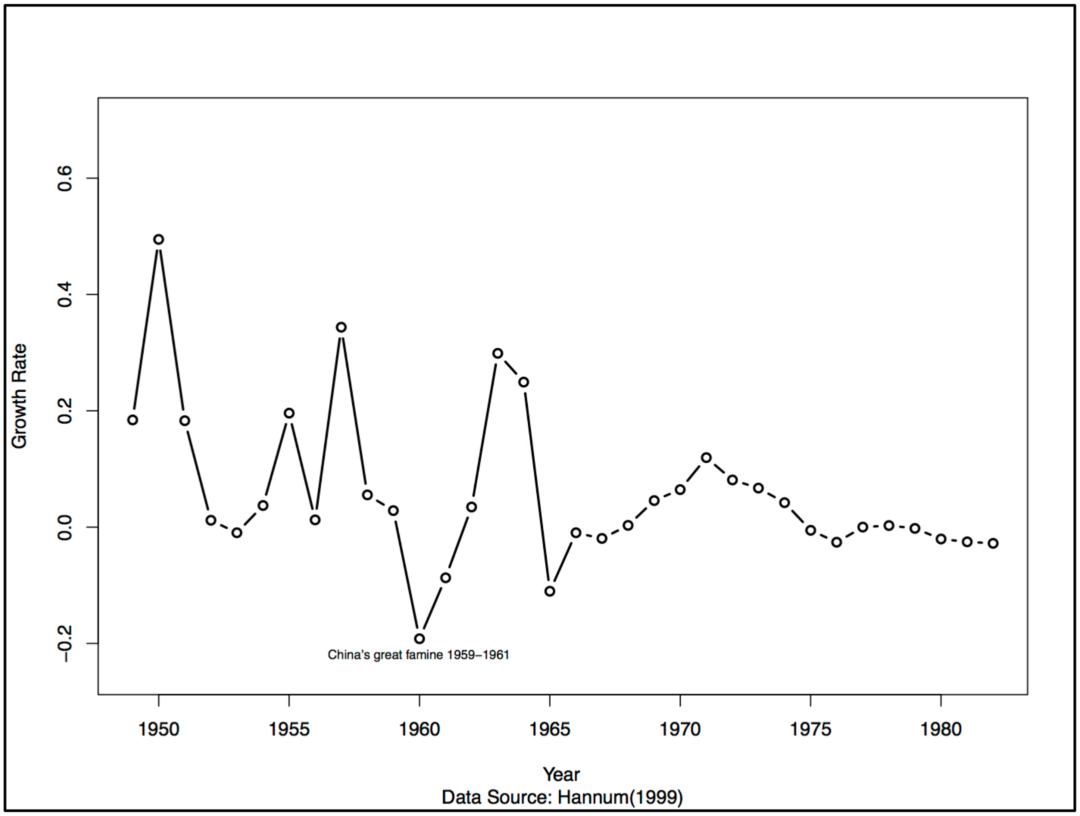


Figure 5. The proportion of primary graduates by cohort

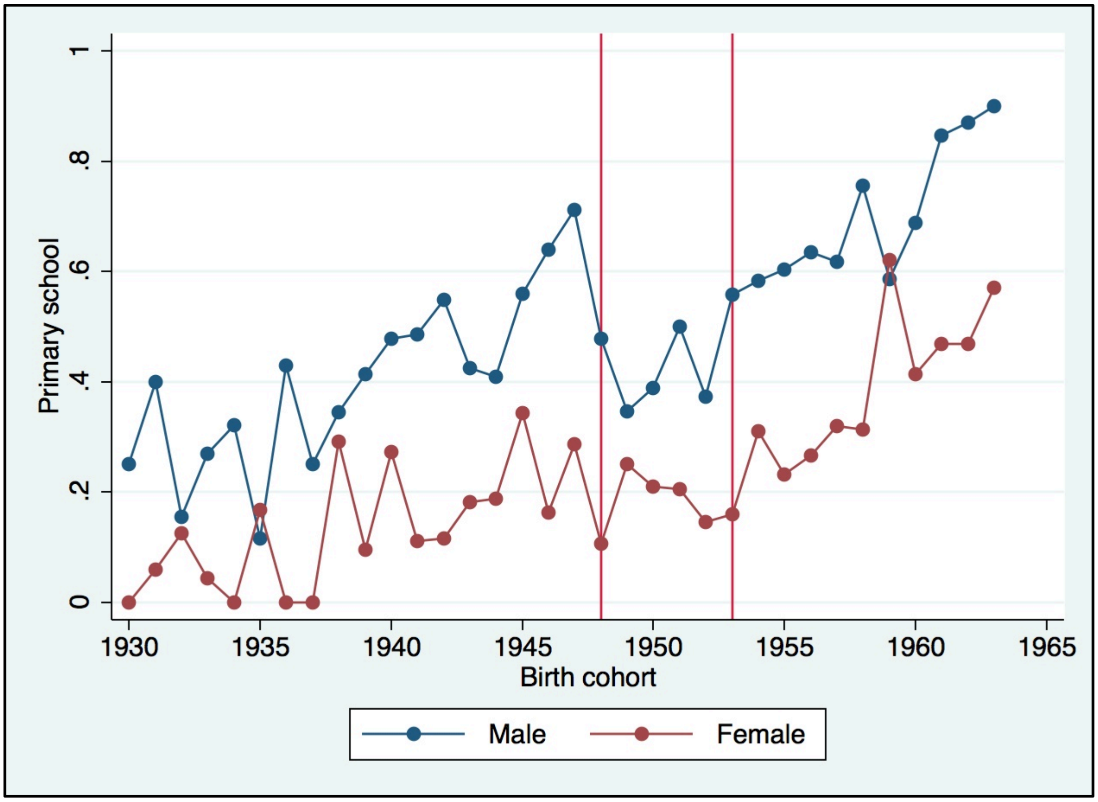


Figure 6. The means of heights by cohort and gender

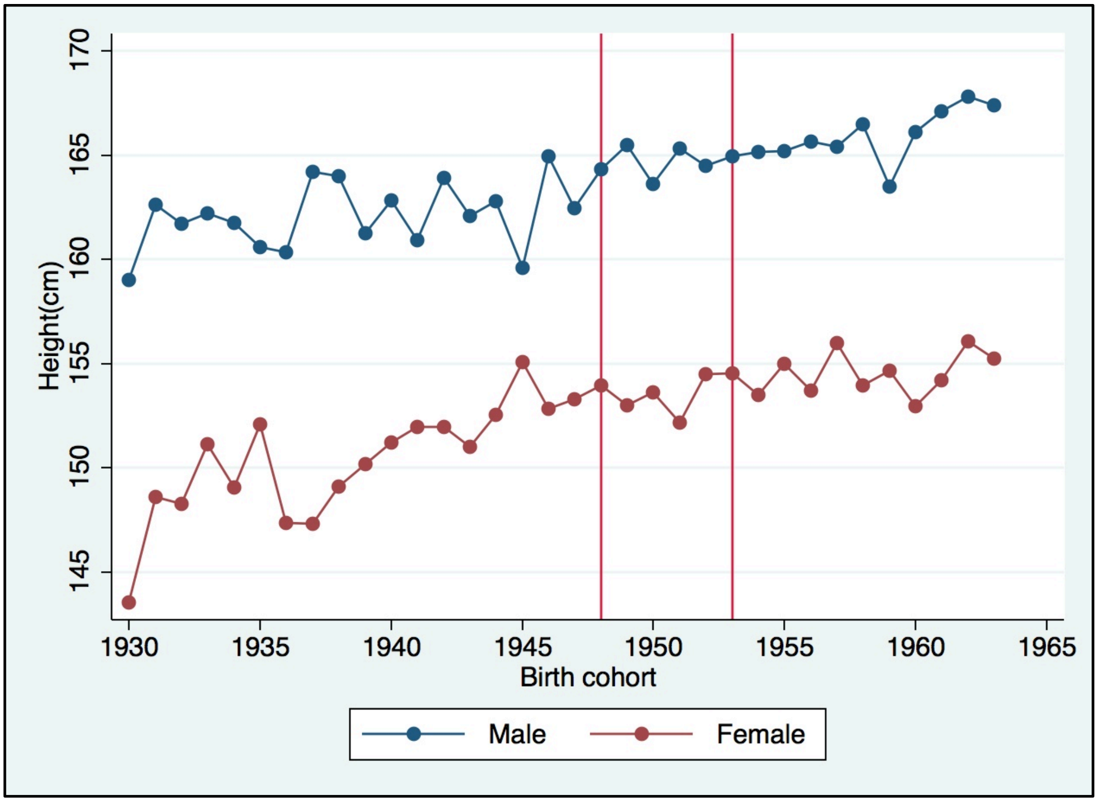


Table 1: Means of Cognitive Variables by Education and Gender

			Male		Female	
	Primary or above	Primary Unfinished	Primary or above	Primary Unfinished	Primary or above	Primary Unfinished
Mental status (0-5)	4.3176	3.9574	4.5414	4.0496	4.6196	3.691
Word Recall (0-20)	6.6129	6.1851	7.5635	5.3678	8.403	5.188
Numeracy (0-5)	4.1	3.8285	4.3094	3.8491	4.1848	3.6851
Drawing (0-1)	0.6725	0.5	0.7878	0.5345	0.7935	0.3819
Observations	1276	1270	655	621	316	954

Table 2. Correlation Matrix of Cognitive Skills and Education

	Mental Status	**Word Recall**	**Numeracy**	**Drawing**	**Primary or above**
Mental Status	1				
Word Recall	0.3892	1			
Numeracy	0.1278	0.173	1		
Drawing	0.4015	0.363	0.2221	1	
Primary or above	0.2588	0.3445	0.2281	0.3472	1

Table 3. The Baseline OLS Estimates of the Educational Effects on Cognitive Skills

	Mental Status		Episodic Memory		Numeracy		Drawing		Overall	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Education	0.538	8.19	1.953	10.67	0.398	7.25	0.268	12.07	3.163	3.16
male	0.217	2.61	-0.28	1.17	0.0494	0.7	0.0872	3.05	0.0578	0.19
married	0.00313	0.04	0.213	0.87	0.0963	1.34	0.0273	0.94	0.327	1.04
urban	0.271	4.01	0.898	4.7	0.149	2.6	0.0933	4.02	1.432	5.84
height	0.00742	1.42	0.0455	3.03	0.0123	2.76	0.00363	2.02	0.0686	3.57
height missing	-0.477	6.34	-0.464	2.12	0.081	1.27	-0.0412	1.6	-0.968	3.46
age	0.0705	2.09	0.167	1.68	0.014	0.49	0.0232	2	0.246	1.94
age^2/100	-0.0752	2.74	-0.206	2.54	-0.0144	0.62	-0.0258	2.74	-0.296	2.85
Constant	0.896	0.68	-4.481	1.17	1.227	1.09	-0.803*		-2.335	0.48
County dummies	Yes		Yes		Yes		Yes		Yes	
N	1,982		1,765		1,982		1,982		1,765	
R-Squared	0.201		0.233		0.104		0.242		0.306	

Table 4. An extended OLS estimation of the educational effects on cognitive skills

	Mental Status		Episodic Memory		Numeracy		Drawing		Overall	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t	Coef.	t
education	0.43	6.34	1.74	9.00	0.37	6.39	0.25	10.72	2.80	11.36
male	-0.0496	0.49	-0.65	2.20	0.16	1.84	0.0279	0.80	-0.611	1.63
married	0.0189	0.23	0.233	0.96	0.0950	1.32	0.0294	1.01	0.374	1.21
urban	0.0890	1.19	0.59	2.74	0.0923	1.43	0.07	2.78	0.89	3.21
height	0.00477	0.92	0.04	2.73	0.01	2.67	0.00	1.80	0.06	3.20
height missing	-0.49	6.59	-0.50	2.27	0.0587	0.91	-0.0405	1.56	-1.02	3.65
age	0.06	1.89	0.146	1.47	0.0143	0.50	0.02	1.85	0.21	1.67
age^2/100	-0.07	2.52	-0.19	2.33	-0.0151	0.65	-0.02	2.59	-0.27	2.57
log of expenditure	0.08	2.50	0.24	2.40	-0.0228	0.83	0.02	1.70	0.29	2.35
smoking	0.46	5.59	0.65	2.73	-0.13	1.76	0.09	3.18	1.20	3.91
drinking	0.0888	0.98	0.314	1.20	-0.0639	0.82	0.0384	1.22	0.401	1.20
education (community)	0.291	1.13	0.802	1.09	0.254	1.15	0.0357	0.40	1.524	1.63
log of expenditure (community)	0.38	3.28	0.434	1.27	0.0725	0.73	0.0381	0.94	0.86	1.96
constant	-2.400	1.53	-9.02	1.98	0.812	0.60	-1.19	2.18	-10.26	1.76
County dummies	Yes		Yes		Yes		Yes		Yes	
N	1,982		1,765		1,982		1,982		1,765	
R-Squared	0.201		0.233		0.104		0.242		0.306	

Table 5. The results of IV estimation

	First Step		Second Step									
VARIABLES	**Education**		**Mental Status**		**Episodical Memory**		**Numeracy**		**Drawing**		**Overall**	
	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t
IV dummy	-0.124	5.54										
education			0.235	0.44	2.307	1.62	0.322	0.72	0.373	2.05	3.324	1.82
male	0.218	8.83	0.286	1.96	-0.361	0.90	0.0666	0.54	0.0633	1.26	0.0210	0.04
married	0.0488	1.98	0.0218	0.24	0.191	0.74	0.101	1.32	0.0209	0.67	0.317	0.96
urban	0.152	7.49	0.317	3.05	0.852	3.23	0.161	1.84	0.0777	2.18	1.411	4.17
height	0.00597	3.73	0.00916	1.51	0.0434	2.55	0.0127	2.49	0.00303	1.46	0.0676	3.10
height_mi	0.0651	3.26	-0.446	4.87	-0.502	1.89	0.0885	1.14	-0.0516	1.64	-0.985	2.90
age	-0.0273	2.74	0.0574	1.41	0.183	1.55	0.0107	0.31	0.0278	1.99	0.253	1.68
age2	0.0114	1.43	-0.0674	2.21	-0.216	2.42	-0.0125	0.48	-0.0285	2.71	-0.3	2.63
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.462	-1.15	1.174	0.83	-4.827	1.19	1.296	1.09	-0.899	1.86	-2.492	0.48
N	2,546		1,982		1,765		1,982		1,982		1,765	
R-squared	0.250		0.192		0.231		0.103		0.233		0.306	