The Impact of Retirement on Health: Evidence from China

Xiaoyan Lei
xylei@ccer.pku.edu.cn
Li Tan
litan0403@gmail.com
Yaohui Zhao
yhzhao@ccer.pku.edu.cn
China Center for Economic Research, Peking University
Beijing 100871，China

Current version: March 2011

Abstract: This study identifies a short-term causal effect of retirement on health. Exploring China's mandatory retirement policy with a regression discontinuity design, we focus on sharp contrasts in retirement between men just under and just over the mandatory retirement age. This strategy lets us more clearly identify the effect than has previous literature. Results show that retirement has an immediate negative effect on self-reported health status, but not on any functional limitations. Income and health insurance do not fully explain the effect; the driving force is likely psychological. We further find that the educated more effectively overcome the retirement shocks. The negative effect of retirement despite the full foresight of retirees is a puzzle, similar to the retirement-consumption issue, and warrants further investigation.

Keywords: Retirement policy, Health, Regression Discontinuity Design
JEL Classification: J26, I10, J14

The Impact of Retirement on Health: Evidence from China

1. Introduction

With rapidly aging populations and strained social security balance sheets, proposals to increase official retirement ages have sprung up around the world. However, with few exceptions they have been met with strong political resistance. A fundamental issue behind this debate is whether or not retirement benefits retirees at all. In this paper, we focus on the health implications of retirement. Evidence from both medical and economic literature has been conflicting, due largely to the endogeneity of retirement status caused by the voluntary nature of retirement in Western countries. This paper attempts to achieve clarity using the mandatory retirement system in urban China. We use research discontinuity (RD) design and a large dataset containing abundant observations around the cutoff point to study the effect of retirement on health outcomes.

Retirement might affect health in multiple ways. It can liberate people from the pressures and stresses of work so that life becomes more enjoyable, and it can give people more time to adopt a healthier lifestyle through exercise, better eating, and sleeping, resulting in improved physical and psychological health. On the other hand, retirement can cut stimuli and social support associated with a work environment, or give people a sense of uselessness realizing that they are nearing the end of their life, resulting in worsened psychological health. Current theories therefore do not predict an absolute positive or negative net effect.

The main empirical difficulty is the endogeneity problem due to reverse causality and omitted variables. Recent economics literature have exploited discontinuous retirement incentives at certain ages (Charles 2004; Bound and Waidman 2007; Coe and Lindeboom 2008; Coe and Zamarro 2008; Neuman 2008; Johnston and Lee 2009). However, because retirement is voluntary in these countries of study, the discontinuity is often obscure. China provides a better opportunity to employ research discontinuity (RD) design due to the mandatory nature of its urban retirement system. Unlike Western retirement systems, as soon as urban Chinese workers subject to retirement policy reach the retirement age, they have no choice but to leave their current jobs. If retirees decide to continue working, they must find alternate employment, which can be difficult to find. This results in a sharp discontinuity in retirement status around the mandatory retirement age.

This dramatic effect of the mandatory retirement policy is illustrated in Figure 1, which shows retirement rates for urban men from the 2005 One Percent Population Survey in China. A clear discontinuity point appears at age 60; retirement jumps from 60 percent at age 59 to 83 percent at age 61. This sharp discontinuity allows us to apply regression discontinuity (RD) design to better identify the impact of retirement on health outcomes.

The One Percent Population Survey is the main dataset used in this study. With a very large sample size, this dataset is ideal for RD design. We focus on men because the statutory retirement age for women varies by occupation, and our dataset does not contain pre-retirement occupation information.

The rest of the paper is organized as follows: we begin with a literature review in Section 2, followed by a description of institutional background in Section 3. We describe our empirical strategy and data in Section 4. Estimation results, validity checks, and robustness tests are provided in Section 5. Section 6 explores channels through which retirement affects health. Section 7 then provides a brief discussion on the results, and Section 8 concludes.

2. Literature Review

There is a large medical and gerontology literature base on the relationship between health and retirement, and the conclusions are contradictory. Some researchers claim a significant positive association between retirement and health (Bossé et al. 1989; Midanik et al. 1995; Mein et al. 1998), while others report a negative association (Ross and Mirowsky 1995; Butterworth et al. 2006). Some studies even argue that retirement has no effect on health (Palmore et al. 1984).

The main difficulty in identifying a causal relationship is endogeneity in retirement status. As has been shown in economics literature, retirement is likely to be caused by a decline in health (Sickles and Taubman 1986; Smith 1999; McGarry 2004; Disney et al.

2006), leading to the reverse causality problem. In addition, there may be unobserved factors such as individual preferences and health endowments that can simultaneously affect health status and retirement decisions, resulting in omitted variable bias.

Economists have tried using the panel data method, e.g., fixed effect estimation, to control for endogeneity (Kerkhofs and Lindeboom 1997). The problem with this approach is that unobserved time-varying heterogeneity cannot be controlled for, which is likely to be important in retirement decisions and health outcomes. Dave et al. (2006), in addition to using fixed effects models, restrict their samples with similar pre-retirement health statuses in order to control for unobserved time-variant health shocks across individuals between waves. Another approach used is matching. Behncke (2009) uses a large set of observable variables as a control base to match retirees and workers from the first three waves of the English Longitudinal Study of Ageing (ELSA), and finds that retirement significantly increases the risk of chronic conditions, particularly cardiovascular disease and cancer. The advantage of matching is its ability to obtain an average treatment effect (ATE) rather than a local average treatment effect (LATE). The disadvantage is its inability to deal with biases from unobservable characteristics, which may prove to be important in this study.

In recent years, studies have increasingly employed RD design, utilizing discontinuity of retirement status at retirement ages set by the government. Under the assumption that all factors but retirement are smooth functions of age, RD has the potential to identify the short-term causal effects of retirement on health. However, due to the voluntary nature of retirement in Western countries, the discontinuity is often not sharp enough for a strict application of this method. Instead, researchers have used observations across a wide band of ages and instrumental variable (IV) estimations to achieve identification, with the instruments being the ages at which retirement incentives change due to government policy. For example, Charles (2004) uses a set of binary variables describing whether the person is at least 62, 65, 70, or 72 years old, as well as retirement policy changes in the 1980s as instrumental variables in identifying the impact of retirement on mental health in men. Using a two-stage least squares (2SLS) estimate, he finds that retirement improves psychological wellbeing. Neuman (2008), instrumenting retirement status using age-based exogenous variation in public and private pensions,[1] also finds that the health impact of retirement is, at the very least, nonnegative. Bound and Waidmann (2007) explore the exogenous variation of pension eligibility in England to determine whether there are different health trends in the years following the normal retirement age. Under the RD framework, Coe and Zamarro (2008) use early and full statutory retirement ages in 11 countries in Europe's social security scheme as instrumental variables, and conclude that retirement has a health-preserving effect.

One concern of these papers is that anticipation of the pension age may bias estimates upwards. Coe and Lindeboom (2008) circumvent the anticipation problem by using windows of retirement incentives offered by firms as an instrument. With U.S. data, they find no significant retirement effects.

Due to the lack of sharp cutoff points and large enough datasets, these studies all include observations across a wide band of ages. Considering that health itself is a function of age, polynomials of age are often employed to control for the age effect (Charles 2004; Bound and Waidman 2007; Coe and Zamarro 2008).

A strict application of the RD design requires observations to be within a narrow age band immediately above and below the retirement age. This guarantees similarity in health outcomes, except when caused by a change in retirement status. In other words, by narrowing the gap between the control and treatment groups and specifying the function of age, an RD design alleviates the confounding effects of age and unobserved age-related factors on health. To our knowledge, Johnston and Lee (2009) is the only study that follows a strict RD design to study the effect of retirement on health, though they restricted their sample to those in England without a university degree since the discontinuity was not otherwise sharp enough. They found that retirement lowers the probability of being in bad or very bad health for this group of people.

The Chinese institution provides us with a unique opportunity to apply the RD strategy to study the effect of retirement on health. Unlike many other countries, China still maintains a mandatory retirement policy. Most employees eligible for retirement

[1] There are three sets of instruments in this paper: 1) Indicators for whether a respondent is aged 62 to 65, and thus eligible for early entitlement to Social Security benefits, and whether he/she is older than 70 and is thus no longer subject to the earnings test; 2) indicators for whether the spouse of a respondent has worked for at least 10 years and is therefore independently eligible for Social Security benefits, and whether he/she is within the age ranges of 62–64, 65–69, or over 70; 3) indicators for whether a respondent is beyond the early or normal entitlement age of his/her private pension, and whether he/she is over the self-reported usual retirement age on the particular job.

pensions are currently required to give up their jobs upon reaching the retirement age. This is different from many developed countries, where mandatory retirement policies have been abolished and retirement is incentive-based. As a result, the mandatory nature of China's retirement policy arguably provides a more exogenous variation in retirement, which we will use to study its effect on health.

3. Institutional Background

The Chinese retirement system was established in the 1950s to cover government employees and urban workers in government-run enterprises. As is the case with many other forms of social protection, farmers are left to fend for themselves, as they have not been included in any substantial government-run retirement system. For a brief period in the 1990s, the government experimented with a defined contribution and fully funded rural pension program, but both scale and coverage were minimal and insignificant.[2] We therefore exclude farmers from our analysis, but do include them in a placebo test.

In the urban sector, because the government nationalized nearly all private businesses in the 1950s and self-employment was nearly eliminated, the retirement system effectively covered all workers before the economic reform. Thus, any urban worker who started 10 years prior—the minimum years of work to qualify for retirement –to the retirement age expected to receive a pension. But because it was a young system, in the first several decades most elderly did not qualify for any retirement pensions.

Although management of the pay-as-you-go retirement system has gone through dramatic changes, program rules governing retirement age and benefits have remained relatively stable. The program was initially administered by the national government. Because hardly anyone had become eligible for retirement in the initial years, management was mere personnel record keeping. During the chaotic Cultural Revolution (1966–1976) and the near collapse of central authority, management of enterprise pensions was delegated to individual firms, while government employees remained the responsibility of the central government. In the 1980s, a large number of workers reached retirement age, and at the same time, financial difficulties surfaced as a result of market

[2] The government is currently piloting a rural pension system with the eventual goal of covering all rural populations. Details are not presented, as they are not relevant to this analysis.

competition introduced by the economic reform. This made it difficult for many firms to distribute the pensions promises to retirees. Starting in the late 1980s and into the 1990s, the government gradually elevated the pooling of enterprise pensions from individual firms to government level management. County or city level governments now primarily administer the pension pools, and a small portion of contributions is in individual accounts.

China has some of the world’s youngest official retirement ages: age 60 for men, age 50 for blue-collar women, and age 55 for white-collar women. The retirement ages have not changed since the retirement system’s inception in the 1950s. According to the China Health and Retirement Longitudinal Study (CHARLS) conducted in 2008, the actual retirement age for urban men is not only lower than that of their rural counterparts in China and other developing countries, but also that of developed countries such as the United States, South Korea, and Japan, and is similar to retirement age seen in Western Europe (Zhao 2009). Urban Chinese women retire even earlier than Western European women. However, the situation is unsustainable since China is quickly becoming an aging society, though proposals to increase the official retirement age have repeatedly failed to gain political backing.

In the state sector consisting of government and state-owned enterprises, the retirement age ceiling is strictly enforced. Anyone who reaches retirement age has no choice but to process retirement and end employment relations with the employer. Theoretically, the same employer can rehire a worker after retirement, but this rarely happens. There is usually little incentive to keep a retiring worker, since these older employees are most likely overpaid. The state sector traditionally has little wage flexibility, and salaries tend to highly reward seniority. Although processing retirement does not prevent someone from taking a new job or becoming self-employed, it usually involves a significant decline in earnings.

While the state sector usually enforces mandatory retirement ages due to wage inflexibility, the private sector is free to set wages and thus may not have incentives to let workers go at the official retirement age. The urban private sector grew from almost nothing at the beginning of the economic reform, to a significant employer of urban workers in the 1990s. They first appeared in the service sector, and then expanded to manufacturing with an inflow of foreign investment. The largest boost in manufacturing employment was in the mid to late 1990s, caused by massive privatization and restructuring of state owned enterprises. Another increasingly important form of employment was self-employment. Because our identification relies on the enforcement of mandatory retirement, and because the private sector is less likely to enforce it, if the majority of workers falls into this category then the retirement system will become voluntary similar to those studied in the existing literature. Fortunately for us, the majority of workers around retirement age still worked for the state sector, while non-state employment was more common among younger workers in our data period. Using the 2005 One Percent Population survey, Figure 2 shows that the proportion of state sector employment was 35 percent at age 20, but increased steadily with age, reaching 70 percent at age 60. Even for workers classified as having worked for the private sector, many of them may still have been subject to rules similar to those of the state sector. This is because many private enterprises are former state-owned enterprises, and have inherited the original workforce and pay scale as part of the privatization agreement. These firms also have strong incentives to enforce mandatory retirement ages. Purely private enterprises—including foreign funded enterprises—typically attract young workers, and although the government has started to include them in the government run pension system, little progress was made until recently. Thus, 2005 is too soon to see private enterprises employees retire with the new pension scheme.

The growth of private sector employment is not the only force that weakens the discontinuity of retirement at the mandatory retirement age. Early retirement produces the same effect; government policy allows workers to retire 5 years before the official retirement age if they are in jobs that are dangerous, harmful to their health, or extremely onerous.[3] Civil servants also qualify for early retirement if they have worked for 30 years and are within 5 years of the retirement age. Early retirement must be approved first by the employer, then by the government social insurance administration. Early retirement was granted much more liberally for a short duration in the 1990s when Chinese state-owned enterprises experienced massive financial difficulties, and many went through

[3] Completely disabled workers qualify for early retirement if they satisfy a minimum work duration requirement and are medically certified.

painful restructurings and bankruptcies. In order to smooth out the shocks of these downsizings and bankruptcies, the government granted early retirement if workers were within five years of the normal retirement age. In circumstances where early retirement could not be granted by the government, many firms let redundant workers retire before the normal retirement age at the firms' expenses, and let the workers turn to the Social Insurance Administration for retirement pensions after reaching the normal retirement age, a practice called "internal retirement." According to data from the China Health and Retirement Longitudinal Study (CHARLS), in a random sample of approximately 1,600 households with members aged 45 and older, collected in 2008 in Gansu and Zhejiang provinces, 29 percent of processed retirements occurred before the normal retirement age.[4]

Despite the weakening of discontinuity deriving from early retirement provisions that resulted in less than universal retirement at the official retirement age of 60, as evident from Figure 1, a sharp discontinuity remains, meaning retirement age regulations remain effective and most comply with it. This is reassuring because a relatively large complier group should be a key characteristic of a mandatory retirement system that gives us cleaner identification than does previous literature.

We now turn to other features of the retirement system in order to give readers a more complete view of it. The replacement rate (pension as a percent of pre-retirement wage) largely depends on the duration of pension participation. To be eligible for a retirement pension, one must participate in the program for a minimum of 10 years.[5] A worker with 10 years of social insurance participation receives 60% of the pre-retirement wage, and the replacement rate goes up to 70% at 15 years or more. Replacement rates also vary by the pre-retirement occupation. For example, the maximum replacement rate for civil servants is 88%, for government-financed institutions is 90%, and for enterprises is 70%. A small number of workers—those who had started working for the Communist Party before the Communist victory—get a 100% replacement rate. One cannot infer from these numbers that replacement rates are high in China, because wages that are

[4] We considered the possibility of studying discontinuity at the early retirement age, but decided against it, as there is less self-selection at the normal retirement age, i.e., nearly everyone must leave their career job regardless of income, social status, and health. We only consider the discontinuity caused by the normal retirement age.

[5] For those joining the workforce after 1993, though the minimum years of contribution to be eligible for a pension is 15, these people are too young to be included in our analysis.

replaced by the pension system are only "official wages," or the parts of wages paid by the government to civil servants and employees of government financed institutions, or wages reported to the government by the private sector, which may only be a fraction of actual earnings. Civil servants and employees of government-financed institutions might receive wages that are greater than just government wages, for example from self-generated revenue, and enterprises routinely underreport wages in order to evade taxes.

Another institution relevant to our study is medical insurance. Medical insurance for workers past retirement has gone through many changes. The regulation most relevant to our analysis is the one from 2005, which makes a worker qualify for retirement health insurance if he/she has continuously participated in the social insurance program for a minimum number of years (20 to 25 years for women; 25 to 30 years for men, with regional variations). It appears that the qualification for health insurance is stricter than for retirement pensions; although the replacement rate can vary greatly according to the number of years worked, health insurance is equal for everyone. However, unlike pre-retirement health insurance, a qualifying retiree does not need to pay premiums out of pocket; retirements are paid for by the employer with which the worker processes retirement.

4. Empirical Strategy and Data

To see how discontinuity in retirement status can be exploited to estimate the health effects of retirement, consider the problem of estimating a causal effect of treatment D (e.g., retirement status) on outcome Y (e.g., health). The relationship can be formally shown as

$$Y = Y_0 \cdot (1-D) + Y_1 \cdot D = Y_0 + (Y_1 - Y_0)D \qquad (1)$$

where Y_0 indicates the potential outcome when D=0, and Y_1 the potential outcome when D=1. Let z be the cutoff point, i.e., age 60, and X the "forcing variable," i.e., age. Under local continuity assumption, that is, $E[Y_0 \mid X]$ and $E[Y_1 \mid X]$ are continuous at z, if the treatment effect is homogenous ($Y_1 - Y_0 = \theta$), then at the cutoff point z, we have:

$$\lim_{x \downarrow Z_1} E[Y \mid X] - \lim_{x \uparrow Z_1} E[Y \mid X] = \theta \cdot [\lim_{x \downarrow Z_1} E[D \mid X] - \lim_{x \uparrow Z_1} E[D \mid X]] + \lim_{x \downarrow Z_1} E[Y_0 \mid X] - \lim_{x \uparrow Z_1} E[Y_0 \mid X]$$

As long as there is a jump at z in the probability of retirement D, in which case $\lim_{x \downarrow Z_1} E[D \mid X] - \lim_{x \uparrow Z_1} E[D \mid X] \neq 0$, under the continuity assumption, $\lim_{x \downarrow Z_1} E[Y_0 \mid X] - \lim_{x \uparrow Z_1} E[Y_0 \mid X] = 0$, the treatment effect can be expressed as:

$$\theta = \frac{\lim_{x \downarrow Z} E[Y \mid X] - \lim_{x \uparrow Z} E[Y \mid X]}{\lim_{x \downarrow Z} E[D \mid X] - \lim_{x \uparrow Z} E[D \mid X]} \qquad (2)$$

As shown by Hahn et al. (2001), in the case of the heterogonous treatment effect ($Y_{i1} - Y_{i0} = \theta_i$), adding a local monotonicity assumption similar to the one leading to the identification of a local average treatment effect (Imbens and Angrist 1994), equation (3) identifies the local average treatment effect at X=z:

$$\theta = \frac{\lim_{x \downarrow Z} E[Y \mid X] - \lim_{x \uparrow Z} E[Y \mid X]}{\lim_{x \downarrow Z} E[D \mid X] - \lim_{x \uparrow Z} E[D \mid X]} = \lim_{e \to 0} E[Y_1 - Y_0 \mid D(z + e) - D(z - e) = 1] \qquad (3)$$

where e is a small constant. In other words, this treatment effect represents the average treatment effect of the "compliers," which is the subgroup of individuals whose treatment status changes discontinuously at the cutoff age. In our case, this represents individuals around the retirement age whose retirement status is dependent only on whether their age is just below or above the cutoff point.

Figure 1 provides evidence for the existence of the discontinuity. The retirement rate goes up smoothly with age, but shows a sharp jump at age 60. After 60, it returns to its normal trend, with a slightly lower gradient. From our discussions of the institutional background, we can argue that the sudden jump in retirement status is attributed to the retirement policy, and that the retirement rate would have gone up smoothly without it. When we restrict the comparison to people just above and just below the retirement age, we ensure that these people are similar in all other ways except retirement status, thus making sure the effects we identify are the sole cause of retirement.

To estimate the treatment effect of retirement on health as mentioned above, we employ an econometric model:

$$Y_i = a_0 + \theta \cdot D_i + a_1(P)(X_i - z) + a_2(P)(X_i - z)S_i + u_i \qquad (4a)$$

$$D_i = \beta_0 + \pi \cdot S_i + \beta_1(P)(X_i - z) + \beta_2(P)(X_i - z)S_i + \varepsilon_i \qquad (4b)$$

where $z-h \le X_i \le z+h$ limits the sample within an age bandwidth, h is the bandwidth, and $a_1(P), a_2(P), \beta_1(P), \beta_2(P)$ are polynomials of $X-z$ in Pth order. S is an indicator variable, which equals 1 if $X \ge z$. In our context, S is a dummy variable indicating that a person is older than 60, the mandatory retirement age. Following Angrist and Imbens (1995), θ is the weighted effect of local average treatment effects across ages.

If we have enough observations around the cutoff, we do not need polynomial controls and a simple Wald estimation is sufficient for the RD design. However, in many applications, as in our case, the treatment determining covariate should be discrete, or researchers will not be able to get enough observations around the cutoff. This makes it impossible to compare outcomes for observations "just above" and "just below" the treatment threshold, and requires researchers to choose a functional form for the relationship between the treatment variable and the outcomes of interest. Here we choose polynomials to control the possible effects of age on health. In addition, we add interactions for whether one is passing age 60, and polynomials to capture the possible structure change of the age effect around the cutoff.

Equations (4a) and (4b) contain two identification strategies. First, we restrict the sample to a small age bandwidth surrounding the mandatory retirement age. When using the 2005 One Percent Population Survey, the bandwidths chosen are ±1 to ±5. The small interval around the cutoff point guarantees that the samples selected are similar and the exogenous shock from the retirement age policy (S) can be utilized to identify treatment effects. This identification strategy is emphasized by Lee and Lemieux (2009) as local experiment design.

Second, because people above the retirement age are older than those below and there are direct age effects on health, we use a smooth function of age to control for the effect of age on health (as reflected in the polynomials of age). When choosing the best possible order of polynomial functions, we adopt a formal specification test to assess the validity of the restrictions (Lee and Card 2008). The basic idea is to compare the fitted model (the polynomial function) with raw dispersion in the mean outcome at each value of the forcing variable. Formally, this statistic is represented as:

$$G = \frac{[(ESS_R - ESS_{UR})/J - K]}{[ESS_{UR}/N - J]} \quad (5)$$

where ESS_R is the restricted error sum of squares from the reduced form of estimating (4) with a polynomial function, and ESS_{UR} is the unrestricted sum of squares from regressing outcome Y on a full set of dummy variables for the J values of X. Under normality (and homoskedasticity) of the error term, this statistic is distributed as $F(J-K, N-J)$, where K is the number of parameters estimated in the reduced form of equation (4), and N is the number of observations. If the statistic exceeds the critical value, the polynomial function is too restrictive.[6] Results of the tests suggest that a linear control function is good for the estimation with a ± 1 year band and a squared control function is for other bands (see Table A). We also tried different specifications of the age profile, for example including a cubic function of age, but this specification does not have a large effect.

The main dataset used for this study is one fifth of the 2005 One Percent Population Survey. The advantage of the One Percent Population Survey is its large sample, facilitating the use of local estimation in an RD design. As mentioned earlier, we focus on men because we cannot identify the exact cutoff points for women. We also restrict our sample to the urban sample as defined by registration status, because mandatory retirement does not apply to rural Chinese.

We construct the age variable up to quarters using birth year and month, which enables a more precise separation of people on both sides of the cutoff point. We define retirement to be both not working and not looking for a new job. There is an important distinction between processed retirement and stopping work; a man who has processed retirement and has started to collect a pension is not considered retired if he continues to work. There may also be measurement errors with the retirement variable. For example, there may be people who have not worked their entire life due to functional limitations. However, this does not affect our analysis, since the rate of functional limitations is unlikely to be a breaking point that coincides with our cutoff point.

Health status in the One Percent Population Survey comes from the question called "Status of Health." Respondents choose from four options according to their health over

[6] The basic idea is to compare the fitted model (a polynomial function) with the raw dispersion at the mean

the past month, and interviewers' instructions give specific meanings for each choice:

1. "Health is good," meaning the respondent has no problems taking care of work and daily life;

2. "Can basically maintain normal living and work," meaning that health is not good, but the respondent can still take care of him/herself;

3. "Cannot carry out normal work or cannot take care of own daily living," meaning that health was bad during the previous month. This is where either the respondent is unable to work, or is limited in daily living such as eating, dressing, and moving around, or limited in both working and living.

4. "Hard to say," meaning that health fluctuates over the course of a month and cannot be described by any of the above choices.

This question does not intend to conform to standard measures of health commonly seen in international surveys. It contains elements of self-reported general health questions, as well as activities of daily living (ADL). While ADL questions usually measure physical functional limitations, the general health variable can have variations in the absence of functional limitations. Thus we define two different dichotomous health variables from this question: one is called "in good health," which equals 1 if the respondent chooses "health is good" and 0 otherwise; the other is "functionally limited," which equals 1 if the respondent chooses "Cannot carry out normal work or cannot take care of own daily living" and 0 otherwise. The variable "in good health" measures health problems at a less advanced stage than the variable "functionally limited" and is also more subjective. As shown below, we find effects of retirement on "in good health" but not on "functionally limited."

Basic descriptive statistics of the main variables using different samples by bandwidth are shown in Table 1. According to the last column, which contains the largest sample for a bandwidth of ±5, i.e., people aged 55–65, 66 percent are retired. The retirement rate is 52 percent for people within the 5-year period prior to the retirement age, but rises to 84 percent if within the 5 years following the retirement age. The difference becomes smaller as the bandwidth narrows, but it remains sharp at 14 percentage points even at a bandwidth of ±1. Eighty-nine percent of the sample report to be in good health, and only 2 percent are functionally limited. The average monthly income is 400 RMB, and that figure is much higher for those not yet retired. There is no discernable difference in demographic characteristics. On average, 25 percent of our sample have a primary school level education or below, 35 percent have a junior high school education, 23 percent have a senior high school education, and 17 percent have a college degree or above. As for marital status, 95 percent remain married, 3 percent are widowed, 1 percent remains single due to divorce, and 1 percent has never married. The average household size is 3.3 persons. The last two rows show trends of being "in good health" and being "functionally limited," estimated by averaging the health differences between the older quarter age and the younger quarter age in that bandwidth. It is easy to see that the trend of being both "in good health" and "functionally limited" worsen past age 60.

5. Estimation Results and Robustness Tests

5.1 Estimation Results

Estimation results are presented in the following order. We first examine the large impact that mandatory retirement policies have on retirement. We then present the reduced-form effect of the mandatory retirement policy on health. We find noticeable effects on self-reported health, but not on physical impairment. Finally, we estimate the main equation and investigate the effect of retirement on health.

5.1.1 Effect of Mandatory Retirement Policy on Retirement (First Stage Results)

We begin with a graphical presentation of the effect of the mandatory retirement policy on retirement behavior. Figure 1 illustrates the relationship between retirement and age. The solid line is a parametric estimate of the conditional expectation of retirement given age. The parametric estimate corresponds to least squares fitted values in equation (4b). The control variables are education levels, marriage status, and other demographic variables.[7]

Several aspects of the figure are worth noting. First, there is a clear discontinuity in retirement at age 60. This fact is confirmed by local estimates given in the first row in

[7] In Section 5.2 we demonstrate that these controls are smooth functions of age.

Table 2. The table presents results with five different interval widths (±1, ±2, ±3, ±4, ±5 years), with "±e" meaning that the sample age is restricted to [60-e, 60+e]. Robust standard errors are presented in parentheses, and additional control variables include education level and marital status. From the first row of Table 2, we see that upon reaching the mandatory retirement age of 60, the rate of retirement increases by 6 to 9 percentage points. We calculate the percent effects with the younger than 60 mean rate of retirement. As shown in the square brackets below marginal effects in Table 1, the retirement policy increases retirement by 10 to 17 percent, which is a large and significant effect.

A second noteworthy aspect of the figure is that there is no evidence of discontinuity at ages other than the mandatory retirement age. This supports the interpretation of the retirement discontinuity as being directly attributable to the mandatory retirement policy.

It is also worth noting that a significant number of men retire before reaching the mandatory retirement age. As mentioned in the "Institutional Background" section, early retirement is granted quite liberally during times of economic transition. However, the existence of a significant number of early retirees does not affect our results. The important fact is that despite early retirement, there is still a large discontinuity in retirement induced by the mandatory retirement policy, and thus we have a strong first stage in estimating the effect of retirement on health.

5.1.2 Effect of Mandatory Retirement Policy on Health (Reduced-Form Results)

If retirement has large effects on health, then the mandatory retirement policy should have a reduced-form effect on health as well. Following our previous analysis, we begin with the graphical illustration of the relationship between health indicators and age shown in Figure 3. Similar to retirement, we observe a discontinuity point for being "in good health" at age 60, though the size of the discontinuity is smaller than that for retirement. The discontinuity for being "functionally limited" is less obvious, but the slope is steeper past age 60.

To estimate the magnitude, we first estimate the reduced form of equations (4a) and (4b) (see Table 2). We can see that the mandatory retirement policy causes a statistically significant decline in the probability of being in good health by about 3 percentage points.

Because the mean probability of being in good health is high at 89 percent for the ±5 age range, the percent effect is high at 3.4 percent. However, we do not see a statistically significant change in the probability of being functionally limited.

To investigate whether the retirement policy has any effect on the speed of health deterioration with age, Table 2 also reports the estimated coefficients of the interaction of age and the dummy variable indicating whether a respondent is older than 60. The trend for good health does not show any statistically significant change, but the trend for being "functionally limited," is statistically significant at the 10 percent level.

To summarize, it seems that reaching the mandatory retirement age brings about an immediate downward adjustment in subjective health evaluations, but does not affect the speed of the decline. On the other hand, reaching retirement age does not immediately cause a more subjective measure of health—being "functionally limited"—to decline, but the trajectory is revised downward. In the main regressions, we include as additional controls the polynomial functions of age, the age cutoff dummy, and the interactions of these two to capture the effect of retirement on the health-age gradient.

5.1.3 The Effect of Retirement on Health

We now turn to estimating the effects of retirement on health with the RD framework. The procedure is the same as the two-stage least squares estimation with the retirement policy serving as an instrument variable for retirement. The only difference from the IV estimation is that observations close to the cutoff point of mandatory retirement age and polynomial functions to control for the age effect are used.

Having shown first-stage results in Table 2, we present second-stage estimates in Table 3. Our results indicate that retirement reduces the probability of being in good health by approximately 25 to 40 percentage points. Because the mean rate of being in good health is 90 to 91 percent right before reaching retirement age, this represents a 27 to 47 percent reduction. These are fairly large effects considering that we are looking at a short time span. Looking at retirement's effects on being "functionally limited," however, none of the models produces statistically significant effects. Our interpretation is that although retirement immediately causes a downward revision in self-evaluated health, it is unlikely to manifest as a functional limitation because disabilities tend to be severe and take time to develop.[8] In Section 6, we provide additional evidence from another dataset for the effect of retirement on another more direct measure of subjective wellbeing: happiness.

5.2 Validity Tests and Robustness Checks

In this section, we present some necessary validity tests on the RD assumptions and robustness checks on the estimation results.

5.2.1 Validity Tests on the RD Assumptions

One concern of using the mandatory retirement policy to infer the causal effect of retirement is that factors other than a retirement event may also change discretely at age 60, thus confounding the comparisons of people on either side of the cutoff age. By fitting a model such as (4b) for suspected variables to test for jumps at age 60, this possibility can be assessed.

We first demonstrate that individuals are not manipulating the forcing variable, age. Although the actual age cannot be manipulated, the recorded age may be misreported, causing the measurement error to be related to retirement. For example, if people were able to change their recorded ages in order to qualify for pensions, our identification strategy would be threatened. One method of inspecting the potential problems of self-reported age is to look at the population density of age (Imbens and Lemieux 2008; McCrary 2008). If the individual density function of age is smooth at the cutoff, which means there was no manipulation, the population density function of age should also be smooth at the cutoff. Figure 4 gives the density function of age. There is little evidence that the density of age has jumped at 60, which supports the validity of our method.

Another test implied by valid RD estimation involves testing the null hypothesis of a zero average effect on pseudo outcomes known to be unaffected by the treatment. Such variables include covariates or pre-determined characteristics, such as education, marital status, and family structure that are, by definition, not affected by the mandatory

[8] There is much psychology literature documenting the associations between psychological wellbeing and physical health (Bloom and Kessle, 1994; Schulz and Williamson, 1991)). Although it is an interesting research question, our identification strategy does not allow us to examine self-evaluated health’s long-term effects on functional limitations.

retirement policy. More specifically, we estimate equation (4b) with the dependent variables being these pseudo outcome variables. Table 4 gives test results for variables we find in the 2005 One Percent Population Survey: marital status (married, never married, divorced, or widowed), education level (college degree or above, high school, or primary school or below), and family size. The results are encouraging: no significant results are found in this table, suggesting no discontinuity on these characteristics that may confound our analysis.

5.2.2 Robustness Checks on the Results

In this section, we run two robustness tests to dispel any ideas that our estimation results come from randomness derived from a large sample size or pure luck, and not actual causal effects.

First, we choose alternative ages as pseudo cutoff points, and run estimations of retirement against these cutoff points using the same method as the reduced-form estimation. Specifically, we choose 58, 59, 61, and 62 as the possible cutoffs together with the appropriate bandwidths. As shown in Table 5, none of these coefficients is significant, and their magnitudes are all close to zero.

The second test uses rural people in the same regressions. We have excluded rural workers because they are not covered by the mandatory retirement policy, and the identification strategy would not work on them. We first choose rurally registered residents as the analytic sample, excluding those who reported to have never worked. Figure 5 describes the relationships between retirement, health, and age for these rural people. We first note that the rate of retirement is much smaller compared to urban workers. At age 59, only 4% stopped working. This is consistent with what has been found in the literature; the rural elderly have much higher rates of labor force participation than do their urban counterparts (Benjamin et al. 2003). Most importantly, we do not detect any discontinuity in retirement at age 60, both in retirement and health. To confirm the result, we report local estimates in Table 6. The first row shows that mandatory retirement policy has no effect on the retirement behavior of rural populations at all. The reduced-form results of the mandatory retirement policy show no effect on "good health" either. Recall that we find a large and significant effect of mandatory retirement policy on “good health” for urban workers, as well as a large and significant effect on retirement. Not finding any reduced-form effect on rural workers when there is no first stage gives us additional confidence that the reduced-form effect of urban workers is indeed through retirement. Similar to the results for urban workers, the effect of mandatory retirement policy on functional limitations is non-existent.

6. Mechanisms

Given the negative impacts we have found of retirement on self-reported health, the next question is “Why?” Retirement is a big life event, and may cause various changes that may be correlated with health. In this section, we explore several potential channels through which retirement plays a role (e.g., income and medical insurance), and factors that may mediate these negative health effects, such as education.

6.1 Medical Insurance

Retirement can affect health through changes in medical services. As described in Section 2, for some people, retirement leads to the loss of medical insurance. For others, it can mean more generous coverage. Therefore, medical insurance could be one of the channels through which retirement affects health. The survey asks one question regarding medical insurance (“Are you covered by any medical insurance?”). We examine whether there is a discrete change in the probability of having insurance at the mandatory retirement age. We run the same set of regressions as those used for Table 4—also reporting the results in this table—using coverage by medical insurance as the dependent variable. As shown in the last row, the probability of having medical insurance does not jump at the cutoff. Thus, participation in medical insurance is not likely to be the channel through which retirement has a negative effect on health. Another concern is that even though insurance participation remains constant before and after retirement, the costs of medical services may change. For example, compared to a pre-retirement worker, retirees have lower deductibles and co-payments, and their time cost of seeking medical treatment is also lower. However, these factors reduce the cost of medical care rather than increase it. Therefore, if anything, a change in medical costs should be beneficial to health, and our results would be strengthened absent this factor.

6.2 Income Effect

Although retirees continue to receive incomes following retirement, pension amounts are very small compared to pre-retirement salaries. From our sample, people between ages 60 and 61 have an average monthly income of 251 RMB, only about half that of workers age 59 (479 RMB/month). This sharp decline in income at the retirement age can be clearly seen in Figure 6, where we graph income by age. To the extent that income levels affect health, the sharp decline in income can explain the health changes caused by retirement. To explore this channel, we include income as a control variable in a two-stage estimation of the effect of retirement on health(see Table 7).[9] Compared to the results in Table 3 where income is not controlled for, the coefficient of retirement is reduced either in magnitude or in significance level. However, even though income explains part of the effect, the majority of the effect remains unexplained.

6.3 Spousal Health Effect

To provide further evidence that income decline is not the whole story behind why retirement affects self-assessed health, we examine the impact of a husband's retirement on his wife's health. Because the husband and wife share household incomes, if a decline in income explains the effect on his health, then we should expect to see the same effect on his wife. To test this hypothesis, we run the following regressions on spousal health status:

$$Y_i^w = a_0 + \theta \cdot D_i + a_1(P)X_i^w + u_i \qquad \text{(6a)}$$

$$D_i = \beta_0 + \pi \cdot S_i + \beta_1(P)X_i^w + \varepsilon_i \qquad \text{(6b)}$$

where D_i is the retirement status of a husband, and S_i is the indicator of whether he passes age 60. Y_i^w is the health status of his wife, and X_i^w includes a set of control variables for the wife. Polynomial functions are applied to control for the age effect. For

[9] We recognize that this method has a "bad control" problem, because retirement is the cause of change in income, and thus the estimations here may not be consistent. Nevertheless, the only purpose here is to explore whether the entire effect of retirement comes from income changes, or if there are other channels through which retirement affects health.

an estimation of ±1, only wives of married men between ages 59 and 61 are chosen, and likewise for the other age ranges.

The results of the estimations (6a) and (6b) are reported in Table 8.[10] Not surprisingly, we see only a very small effect of husbands' retirements on wives' self-reported health, with the magnitude being one fifth to one sixth that of the husbands.

6.4 Retirement and Happiness

After excluding several hypotheses, we now turn to the psychology of retirement. It is well documented that retirement induces a sense of uselessness or a feeling of nearing the end of one's life. This may also explain why these effects are observed only on self-reported health, and not on functional limitations.

Because the 2005 One Percent Population Survey does not contain any variables indicating psychological wellbeing, we test this hypothesis using another dataset, the 2002 Chinese Household Income Project (CHIP) urban survey,[11] which contains a measure of happiness. It asks, "In general, do you feel happy?" Respondents are given the choices: 1) "Very happy," 2) "Fairly happy," 3) "Neither good nor bad," 4) "Fairly unhappy," 5) "Very unhappy," and 6) "Hard to tell."[12] We define the variable "happiness" to be 1 if the respondent chooses option 1 or 2, and as 0 otherwise.

Compared to the 2005 One Percent Population Survey, the CHIP sample is relatively small. We therefore cannot use local regressions in small ranges. Instead, we use ±5 to ±9 year bandwidths. To avoid potential bias because of this extension, we use cubic polynomial functions of age.[13] Similar sample restrictions and variable definitions are applied. One difference is that the CHIP dataset has only years of age reported, so we can use only years as our basic scale for age rather than quarters. Basic descriptive statistics are provided in Table 9. The rate of having a college degree or above and that of retirement past 60 in CHIP is higher in CHIP data than in the One Percent Population Survey. Marital statuses are similar in the two datasets. The differences in education and retirement statuses may come from compositional difference between the two samples.

[10] As this analysis applies only to households where a wife is present, the sample size is smaller.
[11] In CHIP, urban and rural areas have different questionnaires.
[12] The happiness variable in the CHIP dataset is thoroughly investigated by Knight (2007, 2010).
[13] We have conducted polynomial function tests. Results are available upon request.

The CHIP sample is comprised of more urban residents than is the One Percent Population Survey.

Before getting to the regressions, we first look at the basic relationship between age and retirement, as well as happiness in this dataset (Figure 7). Consistent with what is observed in the 2005 One Percent Population Survey, a big jump in retirement at age 60 is clearly seen. Interestingly, happiness also has a sharp discontinuity at age 60. The estimation results verify this impression. As shown in Table 10, there is a significant jump in retirement at age 60 (the first stage), and it has a large and statistically significant negative effect on happiness (the second stage). Retirement reduces the probability of being happy by approximately 42 to 56 percentage points (or a 66 to 93 percent effect). This supports the hypothesis that the health effect is due in large part to psychological reasons.

6.4 The Role of Education

We next explore the differential impact of retirement by education. The highly educated might better prepare for post-retirement life, and may better adjust their feelings and behaviors to adapt to retirement. If this is true, then we expect to see a smaller negative health effect from retirement for this group of people than for their less educated counterparts.

In order to test whether education can mediate the health effect of retirement, we conduct a test with the main dataset—the One Percent Population Survey—by interacting retirement with the education categories (college or above, senior high, junior high, and primary school or below). The instrumental variables used are thus the interactions of these education variables with the age cutoff of 60. The estimation samples are again restricted to ± 1 to ± 5 quarter bandwidths, and results are shown in Table 11.

Not controlling for income, Panel A shows that the effect of retirement on self-reported health declines with education. Taking the model with ± 3 age range as an example, retirement reduces the probability of being in good health by 30 percentage points for the least educated group (primary school or below), while that for the college-educated group is 20 percentage points. Because income varies by education, the impact of education via non-income factors could be underestimated. Furthermore, the income loss at retirement is larger among more educated retirees,[14] which implies that the differential impact of retirement on health among the various education groups might also be underestimated. To obtain a purer effect of education without the income effect, we add income as a control variable to Panel B. Not surprisingly, after controlling for income, the effect of retirement becomes larger by education level across all models. Again, taking the model with a ±3 age range as an example, the negative retirement effect increases to 44 percentage points for the least-educated group (a primary school education or below), and the negative effect for those with a college degree or above rises to 33 percent percentage points. Interestingly, the differences between educational groups remain more or less the same.

Our results indicate that better educated people are indeed more capable of smoothing the impact of retirement. They may be more adept at finding meaningful things to do in post-retirement.

7. Discussions

Our estimation results differ from what most recent literature has reported. For example, using IV estimation, Charles (2004) finds a positive effect on mental health, Neuman (2008) reports at least no negative impact from retirement, and Johnston and Lee (2009) find a positive influence on self-reported health for workers without a college education.

One possible explanation as to why our findings differ from these existing studies is that the true effects indeed are different. The statutory retirement age is younger (60) for Chinese men than for those in the U.S. and U.K. (65 or older), and it is possible that the negative effect of retirement is stronger in younger workers. Secondly, opportunities and support for the retired are different between countries, and there is no clear prediction as to which direction the effect of retirement goes. On one hand, American and British elderly have more available resources in retirement, and can afford to take vacations to fill the void created by leaving a beloved job, a luxury not available to many elderly

[14] Our data shows that retirees with college degrees or above lose approximately 53 percent of their pre-retirement income (from 1,307 RMB to 620 RMB), those with senior high school educations lose approximately 41 percent (from 462 RMB to 272 RMB), those with junior high school educations lose approximately 41 percent (from 257 RMB to 152 RMB), and those with primary school educations or below lose approximately 36 percent of their income (from 192 RMB to 123 RMB).

Chinese. On the other hand, Chinese elderly enjoy more frequent social interactions, such as with their children, grandchildren, and neighbors, who can offset the loneliness and feeling of worthlessness caused by retirement.

Another potential explanation for our differing results is a difference in methodology. The voluntary nature of retirement in the U.S. and U.K. implies that the decision to retire is endogenous. If a worker anticipates health problems caused by retirement, he/she will ignore incentives offered by a retirement policy, and continue to work. IV estimations identify local average treatment effects (LATE) on compliers (Imbens and Angrist 1994) who are least likely to be affected by retirement, hence the small negative and even positive effects.[15] The selection of a sample based on the existence of a sharper discontinuity as in Johnston and Lee (2009) may suffer from the same problem. In addition, under a voluntary retirement regime the number of compliers may be small, causing estimation results to inaccurately approximate for the entire population. However, under a mandatory retirement regime, the proportion of compliers is larger. We therefore may be better able to capture the causal effect of retirement on health outcomes of a large population.

Since previous literature captures the effect of retirement on health under a voluntary retirement system, it is plausible that our results are relevant only under a mandatory retirement system, such as that of China. The differential effects of a voluntary vs. mandatory retirement system have been noted by Kasl and Jones (2000), who distinguish unplanned and involuntary, or “off-schedule” retirement from planned and “on-schedule” retirement. Charles (2004) explains the positive effect of retirement on mental health as “perfectly consistent with the description of a voluntary retirement decision.” We argue that our estimation, derived from utilizing the mandatory retirement system in China, is not only more accurate methodologically, it is also potentially the one most relevant to policy debates in Western countries. What we identify is the effect on health of an exogenous shift in retirement that is applicable to the population. All policy proposals around the world have one common characteristic, which is to compel workers to retire later than is currently permitted. Although the instruments that governments use to postpone retirement differ across the world—some are outright compulsory while

[15] This point was made by Behncke (2009).

others are changes to incentive design—they universally involve elements of involuntary compliance that are intended to push back the average age of retirement by a certain number of years. We otherwise we would not be seeing the protests that are currently happening. Therefore, to gauge the impact of large-scale postponing of retirement, a strategy similar to ours is most likely to yield consistent estimations.

8. Conclusions

Taking advantage of China’s mandatory retirement policy, this paper uses a regression discontinuity design to identify the short-term impact of retirement on health. A large dataset from the 2005 One Percent Population Survey allows us to focus on sharp contrasts in retirement between individuals with ages just under and over the mandatory retirement age, avoiding potential confounding effects driven by differences in other factors. Our identification, based on the mandatory nature of the Chinese retirement system, is cleaner than that of existing literature that is based on the voluntary systems of Western countries. These estimates pass various validity and placebo tests, thus lending credibility to the robustness of the results.

Our results suggest that although retirement does not immediately lead to functional limitations in retirees, it has an immediate, large negative impact on self-reported health. Further, although we find that this effect can be partly explained by a sharp income decline after retirement, non-income factors, most likely psychological ones, play an important role. We also find that education is an important mediator that helps to smooth the transition to retirement, and its role is strengthened after income is controlled for.

Because poor psychological health may lead to deterioration in physical health, it is possible that retirement may have a large impact on functional limitations in the longer run. We find that that although there is no clear break in the rate of functional limitation around retirement age, the downward slope of functional limitation does become steeper, and despite a large decline in the rate of self-reported good health by age, the trajectory remains stable. Therefore the whole story of the impact of retirement on health may be that retirement causes an immediate downward revision of subjective health and a more gradual decline in physical health. The two are equally important but the RD design only allows us to identify the former. Methodological innovations are called for to identify the latter.

Our results poses a puzzle: Given that retirement policies are common knowledge among the public, why do the reactions to retirement appear to be a shock? Life-cycle theory predicts that with full information, people will take appropriate actions to prepare for retirement so that actual retirement is smooth. A similar phenomenon has been documented in the retirement-consumption puzzle and extensively researched. The retirement-health puzzle that we have documented in this paper similarly warrants further investigation.

Although our results are based on the situation in China, they may be relevant for the worldwide debate over retirement age. They imply that opposition against increasing the retirement age may not be justifiable from a health standpoint.

Reference:

Angrist, J. D. and G. W. Imbens. 1995. Two-Stage Least Squares Estimation of Average Causal Effects in Models with Variable Treatment Intensity. *Journal of the American Statistical Association* 90(430): 431-442.

Behncke, S.. 2009. How Does Retirement Affect Health?. IZA Discussion Papers 4253, Institute for the Study of Labor (IZA).

Benjamin, D., L. Brandt and J.-Z. Fan. 2003. Ceaseless Toil? Health and Labor Supply of the Elderly in Rural China. William Davidson Institute Working Papers Series 2003-579, William Davidson Institute at the University of Michigan

Bloom, J. R. and L.Kessler.1994. Emotional support following cancer: A test of the stigma and social activity hypotheses. *Journal of Health and Social Behavior* 35:118-133.

Bossé, R., C. M. Aldwin, M. R. Levenson and K. Workman-Daniels. 1989. How Stressful Is Retirement? Findings From the Normative Aging Study. *Journal of Gerontology* 46(1): 9-14.

Bound, J. and T. Waidman. 2007. Estimating the Health Effects of Retirements. Michigan Retirement Research Center Working Papers wp168, Michigan Retirement Research Center at the University of Michigan

Butterworth, P., S. C. Gill, B. Rodgers, K. J. Anstey, E. Villamil and D. Melzer. 2006. Retirement and mental health: Analysis of the Australian national survey of mental health and well-being. *Social Science & Medicine* 62(5): 1179-1191.

Charles, K. K.. 2004. Is Retirement Depressing?: Labor Force Inactivity and Psychological Well Being in Later Life. *Research in Labor Economics* 23(2004): 269-299.

Coe, N. B. and M. Lindeboom. 2008. Does Retirement Kill You? Evidence from Early Retirement Windows. IZA Discussion Papers 3817, Institute for the Study of Labor (IZA).

Coe, N. B. and G. Zamarro. 2008. Retirement Effects on Health in Europe. RAND working paper series 588, RAND Corporation Publications Department.

Dave, D., I. Rashad and J. Spasojevic. 2006. The Effects of Retirement on Physical and Mental Health Outcomes. NBER Working Papers 12123, National Bureau of Economic Research, Inc.

Disney, R., C. Emmerson and M. Wakefield. 2006. Ill health and retirement in Britain: A panel data-based analysis. *Journal of Health Economics* 25(4): 621-649.

Hahn, J., P. Todd and W. Van der Klaauw. 2001. Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design. *Econometrica* 69(1): 201-209.

Imbens, G. W. and J. D. Angrist. 1994. Identification and Estimation of Local Average Treatment Effects. *Econometrica* 62(2): 467-475.

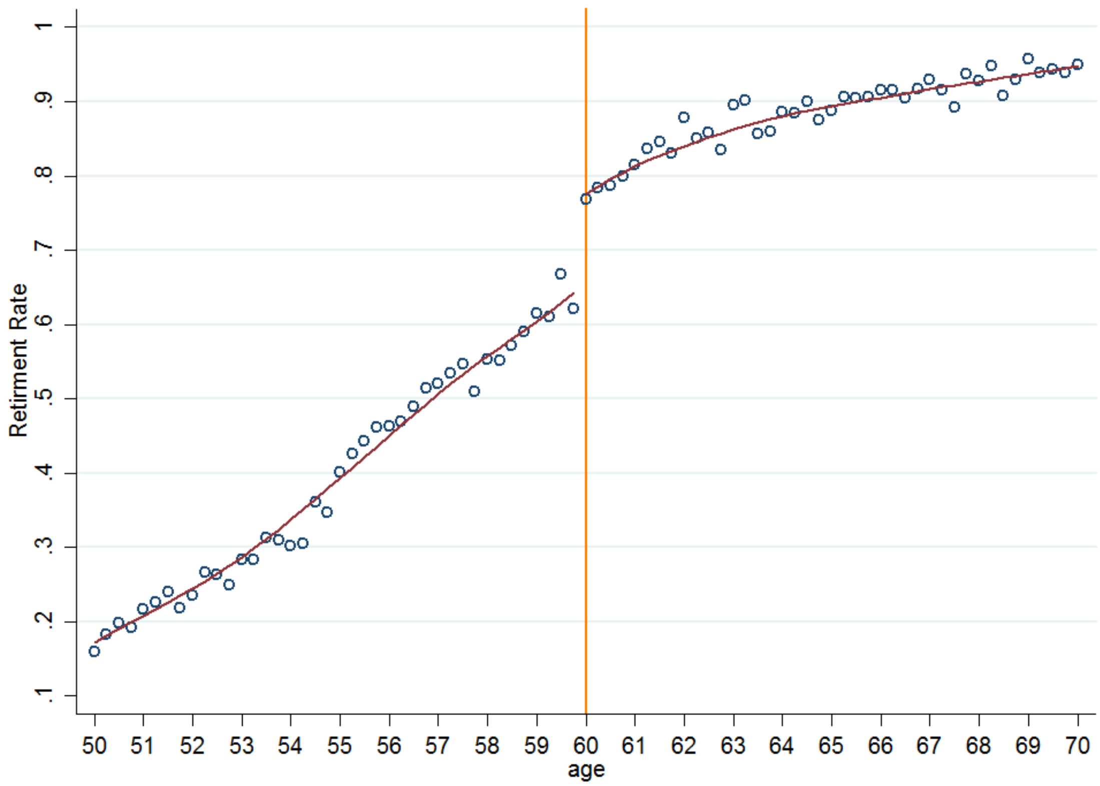
Imbens, G. W. and T. Lemieux. 2008. Regression discontinuity designs: A guide to practice. *Journal of Econometrics* 142(2): 615-635.

Johnston, D. W. and W.-S. Lee. 2009. Retiring to the good life? The short-term effects of retirement on health. *Economics Letters* 103(1): 8-11.

Kasl, S. V. and B. A. Jones. 2000. The Impact of Job Loss and Retirement on Health. in *Social Epidemiology*, ed. L. F. Berkman and I. Kawachi: Oxford University Press.

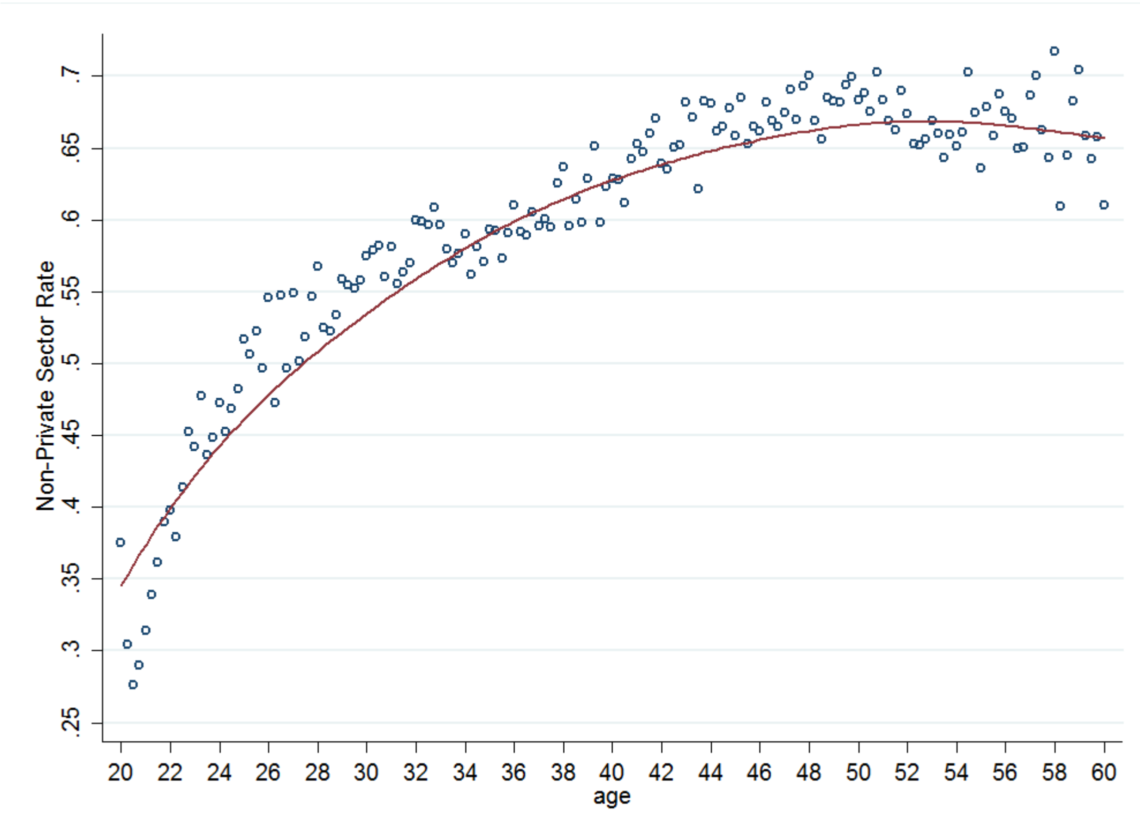
Kerkhofs, M. and M. Lindeboom. 1997. Age related health dynamics and changes in labour market status. *Health Economics* 6(4): 407-423.
Knight, John and Ramani Gunatilaka. 2010.Great Expectations? The Subjective Well-being of Rural-urban Migrants in China. Discussion Paper 322, Department of Economics, University of Oxford
Knight, John, Lina Song and Ramani Gunatilaka. 2007. Subjective Well-being and its Determinants in Rural China. Discussion Paper 334, Department of Economics, University of Oxford
Lee, D. S. and D. Card. 2008. Regression discontinuity inference with specification error. *Journal of Econometrics* 142(2): 655-674.
Lee, D. S. and T. Lemieux. 2009. Regression Discontinuity Designs in Economics. NBER Working Papers 14723, National Bureau of Economic Research, Inc.
McCrary, J.. 2008. Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics* 142(2): 698-714.
McGarry, K.. 2004. Health and Retirement: Do Changes in Health Affect Retirement Expectations? *Journal of Human Resources* 39(3): 624-648
Mein, G., P. Higgs and S. A. Stansfeld. 1998. Paradigms of retirement: the importance of health and ageing in the whitehall ii study. *Social Science & Medicine* 47(4): 535-545.
Midanik, L. T., K. Soghikian, L. J. Ransom and I. Tekawa. 1995. The Effect of Retirement on Mental Health and Health Behaviors: The Kaiser Permanente Retirement Study. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 50(1): S59-S61.
Neuman, K.. 2008. Quit Your Job and Get Healthier? The Effect of Retirement on Health. *Journal of Labor Research* 29(2): 177-201.
Palmore, E. B., G. G. Fillenbaum and L. K. George. 1984. Consequences of Retirement. *Journal of Gerontology* 39(1): 109-116.
Ross, C. E. and J. Mirowsky. 1995. Does Employment Affect Health? *Journal of Health and Social Behavior* 36(3): 230-243.
Schulz, R. and G. Williamson,. 1991. A 2-year longitudinal study of depression among Alzheimer's disease caregivers. *Psychology and Aging* 6:569-578
Sickles, R. C. and P. Taubman. 1986. An Analysis of the Health and Retirement Status of the Elderly. *Econometrica* 54(6): 1339-1356.
Smith, J. P.. 1999. Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status. *Journal of Economic Perspectives* 13(2): 145-166.
Zhao, Y.. 2009. Bulletin of The Second International Seminar on Health and Retirement in China. Bulletin 2009-69. National School of Development at Peking University.

Figure 1: Retirement Rate by Age – Urban China



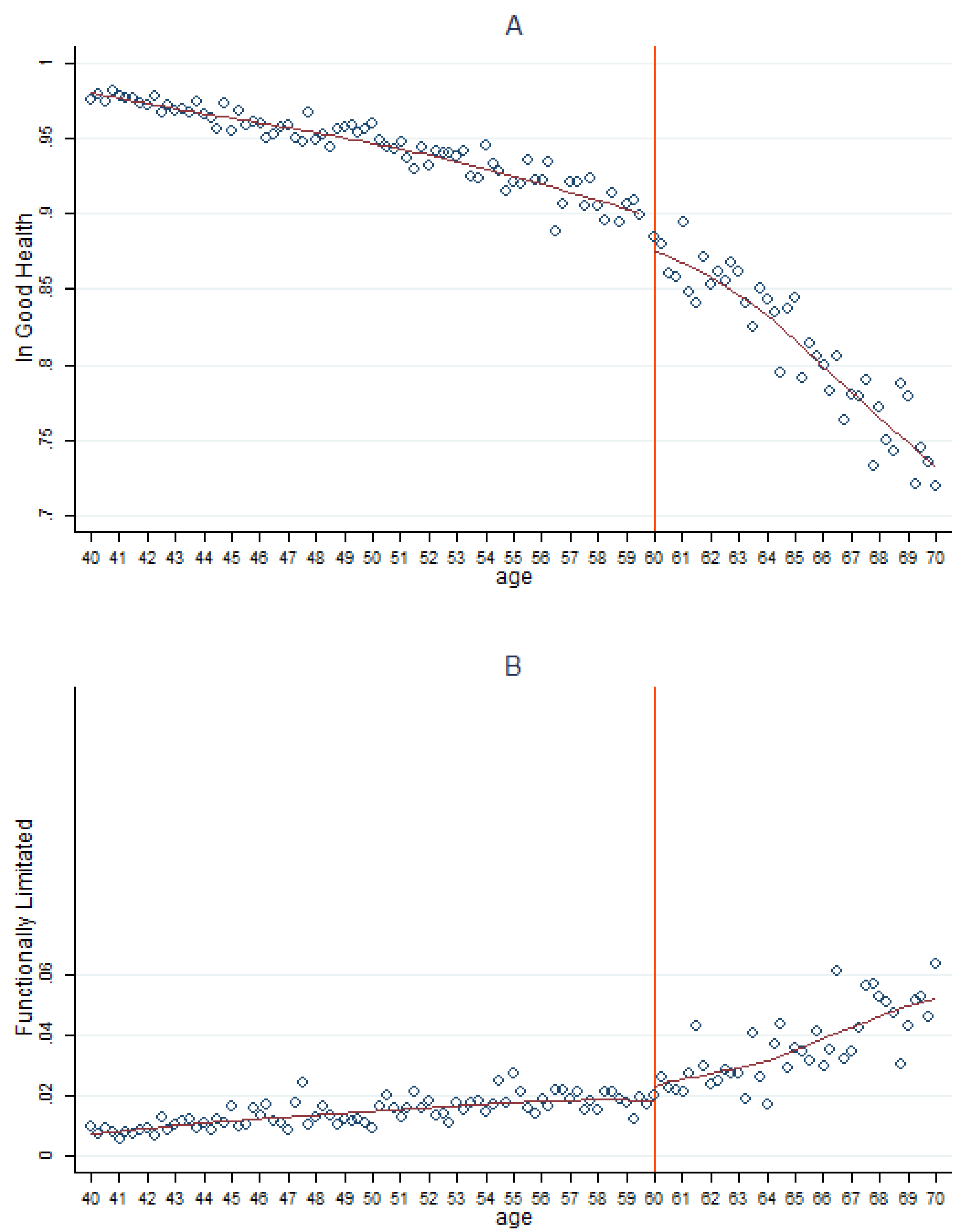
Data source: 1/5 Sample of 2005 One Percent Population Survey.

Figure 2: Proportion of Non-Private Sector Employment by Age



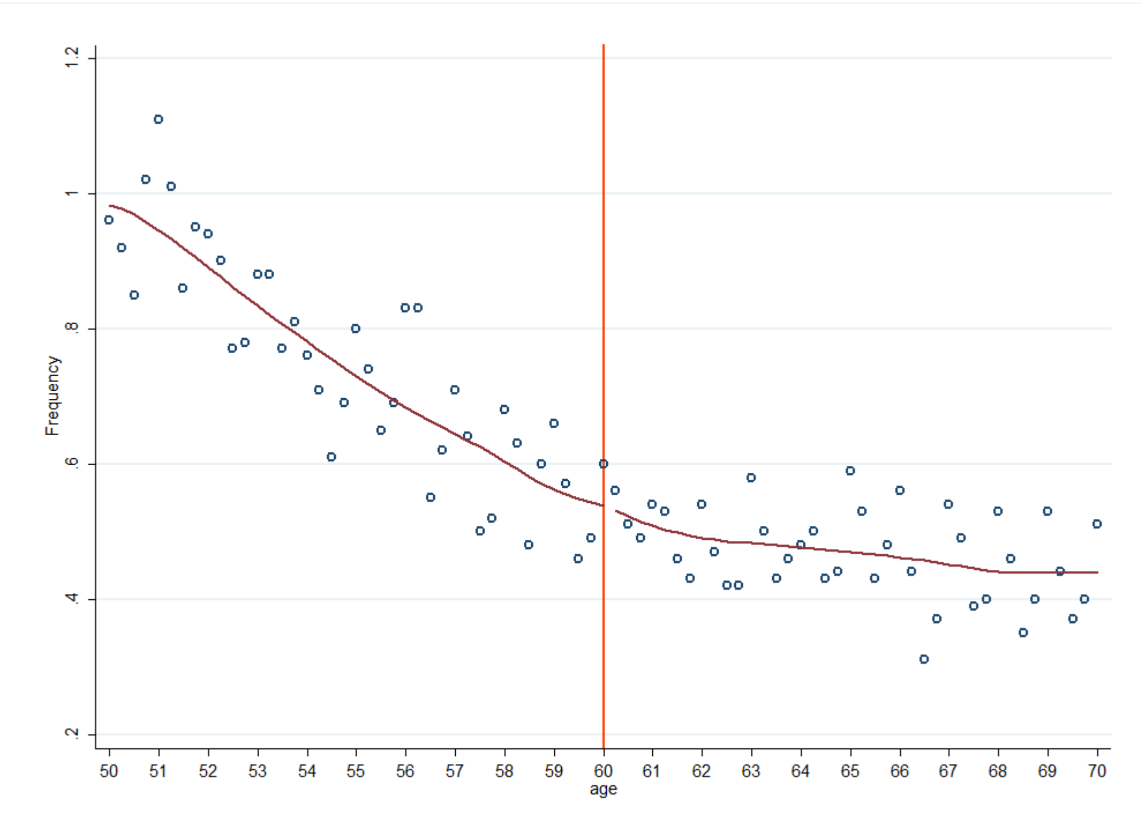
Data Source: 1/5 Sample of 2005 One Percent Population Survey.

Figure 3: Health Status by Age



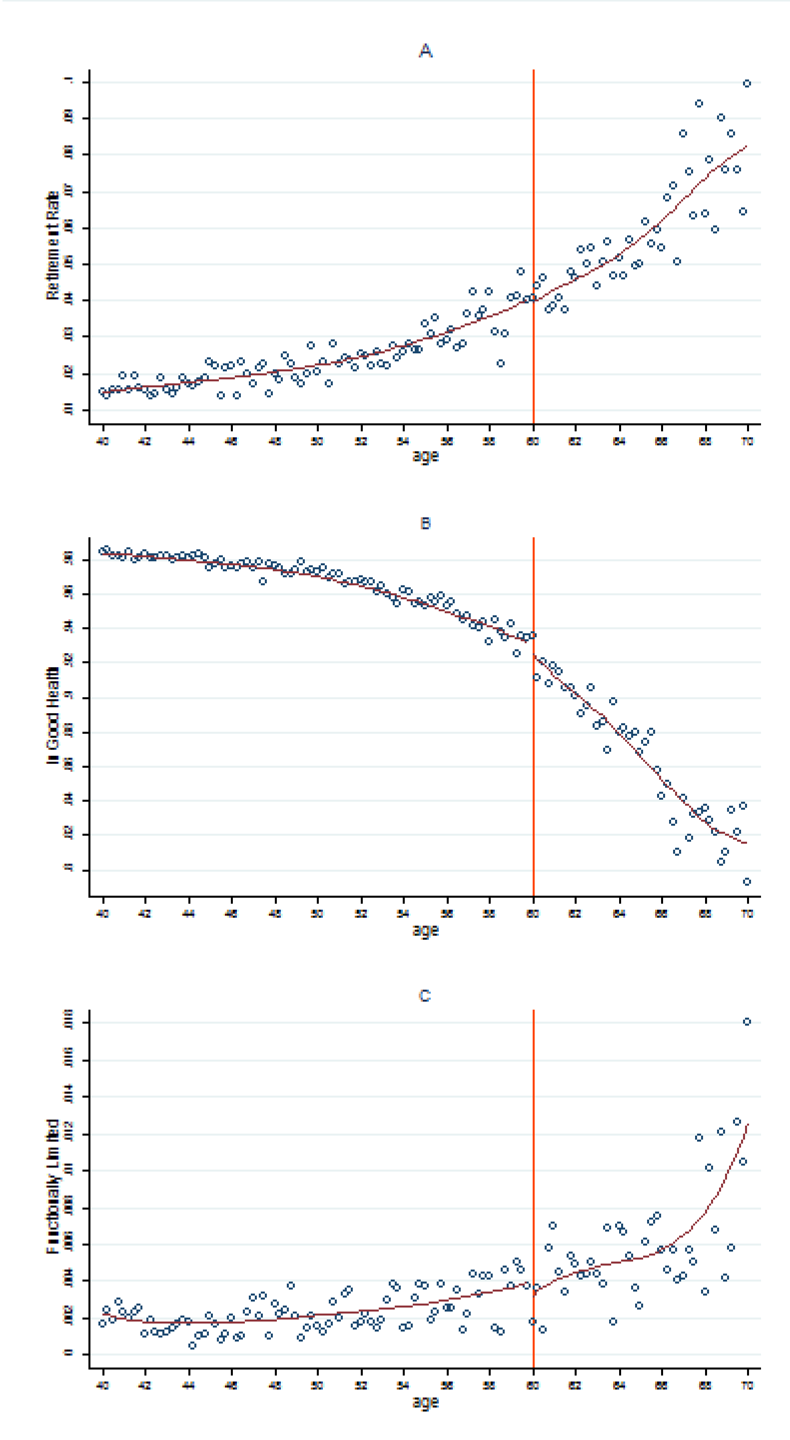
Data Source: 1/5 sample of 2005 One Percent Population Survey.

Figure 4: Density Function of Age



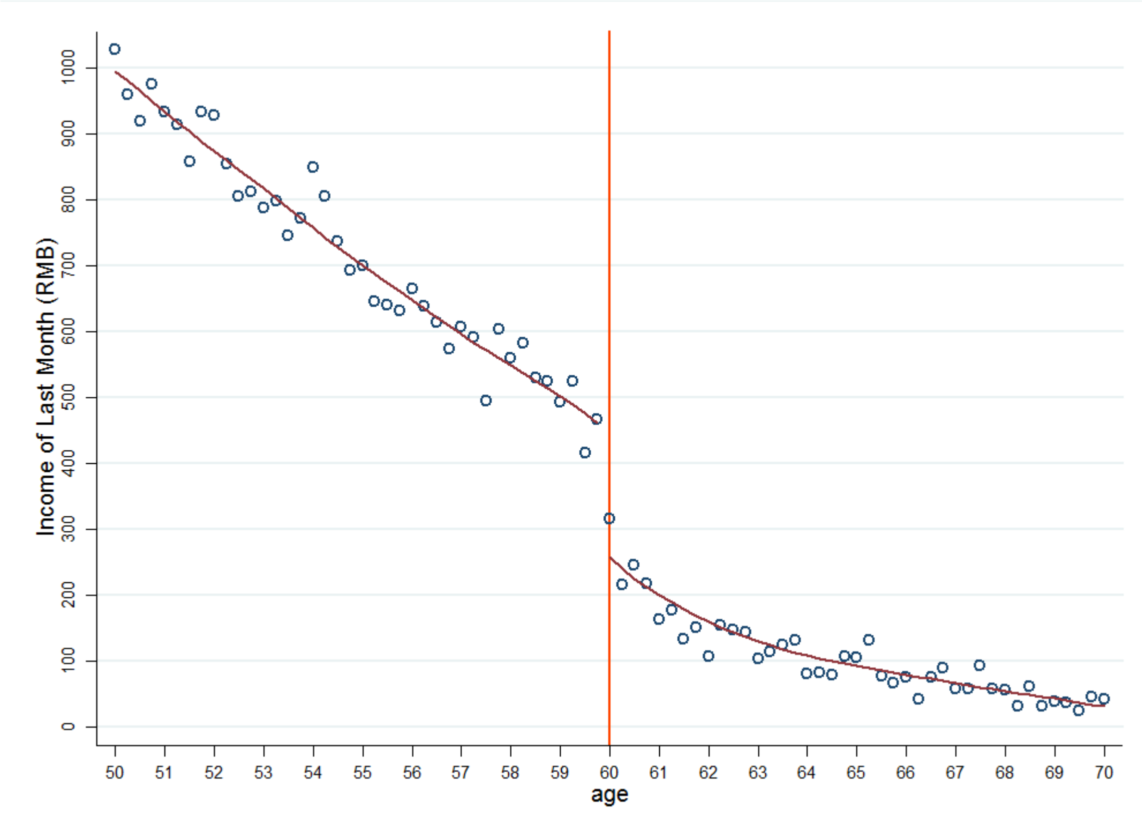
Data Source: 1/5 Sample of 2005 One Percent Population Survey.

Figure5: Retirement Rate by Age – Rural China



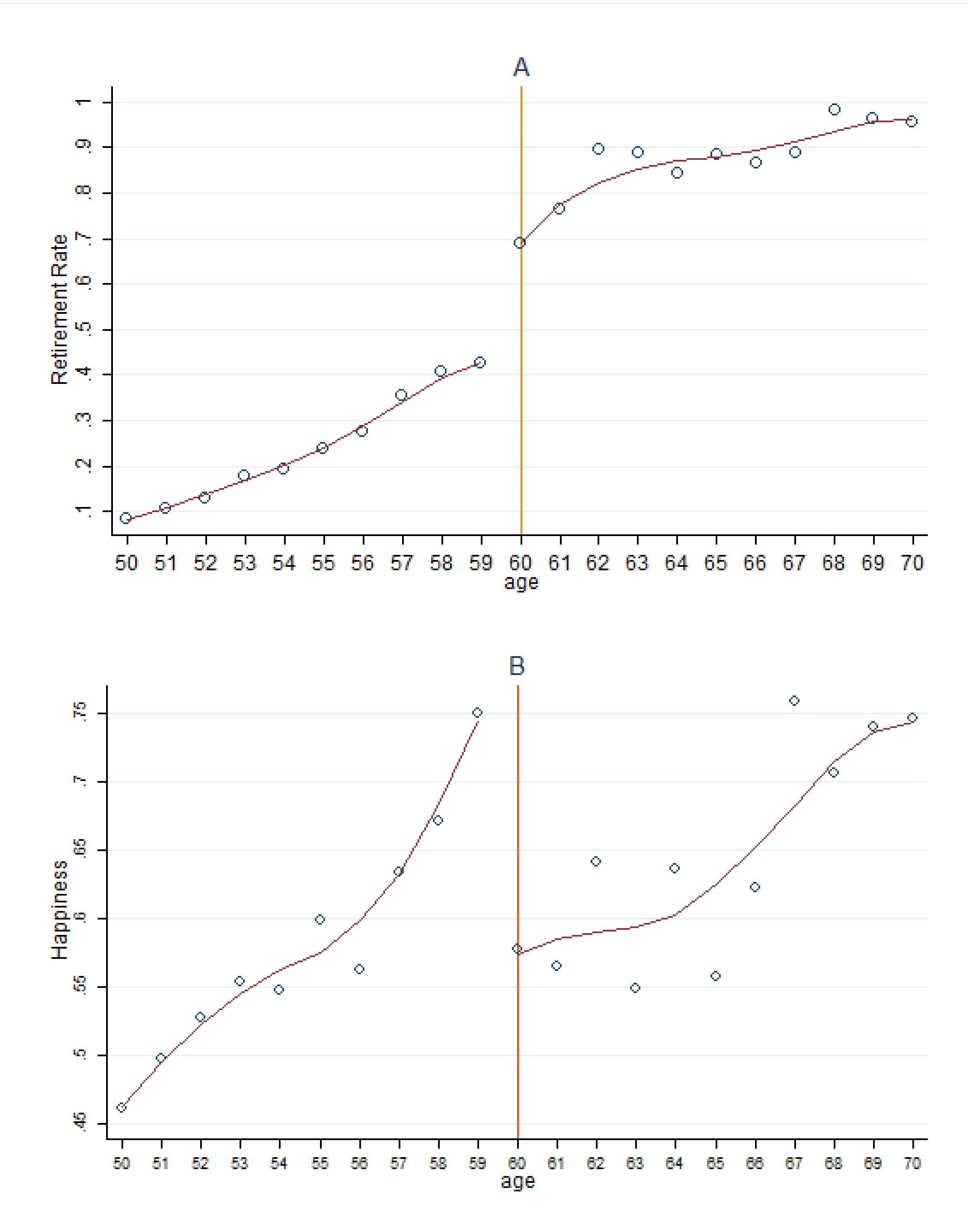
Data Source: 1/5 Sample of 2005 One Percent Population Survey.

Figure 6: Income by Age



Data Source: 1/5 sample of 2005 One Percent Population Survey.

Figure 7: Retirement Rate and Happiness by Age



Data Source: 2002 China Household Income Project (CHIP).

Table 1

Descriptive Statistics, 2005 1% Population Survey

	+1	−1	+2	−2	+3	−3	+4	−4	+5	−5	[−5,+5]
Retired	0.77	0.63	0.80	0.59	0.82	0.57	0.83	0.55	0.84	0.52	0.66
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
In Good Health	0.87	0.90	0.87	0.90	0.86	0.91	0.86	0.91	0.85	0.91	0.89
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Functionally Limited	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.02
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Income (RMB) Last Month	251.0	478.7	206.1	516.4	184.5	537.6	167.7	563.5	152.3	584.5	407.2
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
College Degree or Above	0.18	0.18	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Senior High School	0.20	0.23	0.21	0.24	0.22	0.24	0.23	0.24	0.24	0.23	0.23
	(0.07)	(0.07)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Junior High School	0.37	0.34	0.36	0.35	0.36	0.35	0.35	0.37	0.34	0.37	0.35
	(0.08)	(0.08)	(0.06)	(0.06)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Primary School or Below	0.25	0.25	0.27	0.24	0.25	0.24	0.25	0.22	0.25	0.23	0.25
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Married	0.94	0.94	0.95	0.95	0.94	0.95	0.94	0.96	0.94	0.96	0.95
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Never Married	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Divorced	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Widowed	0.04	0.03	0.03	0.03	0.04	0.02	0.04	0.02	0.04	0.02	0.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Household Size	3.31	3.30	3.34	3.32	3.35	3.32	3.33	3.30	3.32	3.30	3.30
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Good Health Trend (thousandth)	−8.89	−3.01	−1.84	−5.05	−1.48	−2.01	−2.20	−2.46	−2.46	−1.62	
Functional Limitation Trend (thousandth)	0.61	−0.55	1.39	−0.17	0.68	−0.40	0.42	−0.19	0.47	−0.00	
Observations	7651		13618		20218		27728		35128		35128

Data source.– 1/5 sample of 2005 1% population survey

Note.– Standard deviations are in parentheses

Table 2

The Impact of Retirement Policy on Retirement and Health

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
			Dependent variable: retired		
Older than 60 dummy	0.07**	0.06***	0.06***	0.08***	0.09***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
	[0.11]	[0.10]	[0.11]	[0.15]	[0.17]
			Dependent variable: in good health		
Older than 60 dummy	-0.03*	-0.03**	-0.03**	-0.03**	-0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Interaction of age with	0.03	-0.01	-0.02	-0.00	0.00
older than 60 dummy	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Interaction of age2 with		-0.04	0.02	-0.01	-0.02
older than 60 dummy		(0.03)	(0.07)	(0.03)	(0.02)
			Dependent variable: functionally limited		
older than 60 dummy	0.01	0.00	0.00	0.00	0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
	[0.5]	[0.32]	[0.5]	[0.5]	[0.4]
Interaction of age with	-0.01	0.01*	0.01*	0.01*	0.00*
older than 60 dummy	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Interaction of age2 with		0.01	-0.02	-0.01	-0.00
older than 60 dummy		(0.05)	(0.03)	(0.02)	(0.01)
Observations	7651	13618	20218	27728	35128

Data source. - 1/5 sample of 2005 1% population survey

Note. - (1) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (2) All estimations include education and marital status as control variables. (3) Standard errors are presented in parentheses. (4) Percent effects are shown in brackets.

* p<0.1.

** p<0.05.

*** p<0.01.

Table 3

The Impact of Retirement on Health Status

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
	Dependent variable: in good health				
Retirement	-0.38**	-0.32**	-0.40*	-0.34**	-0.25**
	(0.22)	(0.14)	(0.24)	(0.16)	(0.11)
	[-0.42]	[-0.36]	[-0.44]	[-0.47]	[-0.27]
Interaction of age with older than 60 dummy	0.04	-0.01	-0.01	0.01	0.01
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Interaction of age2 with older than 60 dummy		-0.04	-0.16	-0.08	-0.05
		(0.03)	(0.18)	(0.06)	(0.03)
	Dependent variable: functionally limited				
Retirement	0.08	0.06	0.08	0.08	0.07
	(0.09)	(0.11)	(0.11)	(0.07)	(0.05)
	[4.00]	[2.51]	[4.00]	[4.00]	[3.52]
Interaction of age with older than 60 dummy	-0.01	0.01*	0.01*	0.01*	-0.00*
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Interaction of age2 with older than 60 dummy		0.01	0.01	0.01	0.01
		(0.05)	(0.07)	(0.03)	(0.01)
Observations	7651	13618	20218	27728	35128

Data source. -1/5 sample of 2005 1% population survey

Note. - (1) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (2) All estimations include education and marital status as control variables. (3) Standard errors are presented in parentheses. (4) Percent effects are shown in brackets.

* $p<0.1$.

** $p<0.05$.

Table 4

Robustness Tests: Smoothness of Control Variables

Dependent variables	+/- 1	+/- 2	+/- 3
Married	-0.01	0.00	0.00
	(0.01)	(0.01)	(0.01)
Never Married	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
Divorced	-0.00	-0.01	-0.01
	(0.00)	(0.00)	(0.00)
Widowed	0.01	0.00	0.01
	(0.01)	(0.01)	(0.01)
College or above	0.02	0.01	0.01
	(0.02)	(0.01)	(0.02)
High School	-0.01	-0.00	-0.01
	(0.02)	(0.02)	(0.02)
Primary School or below	-0.01	-0.01	-0.01
	(0.02)	(0.01)	(0.02)
Family Size	0.06	0.06	0.08
	(0.08)	(0.06)	(0.07)
Medical Insurance	0.03	0.02	0.02
	(0.02)	(0.02)	(0.02)

Data source. -1/5 sample of 2005 1% population survey

Note. - (1) Each row contains estimated coefficients of older than 60 dummy on the dependent variable listed in the first column. (2) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (3) All estimations include education and marital status as control variables. (4) Standard errors are presented in parentheses.

Table 5

Robustness Tests: Coefficients of Alternative Age Cutoff Points

	+/- 1	+/- 2
Cutoff of 58	-0.00	-0.02
	(0.02)	(0.02)
Cutoff of 59	0.02	
	(0.02)	
Cutoff of 61	0.00	
	(0.02)	
Cutoff of 62	0.01	-0.02
	(0.02)	(0.01)

Data source.- 1/5 sample of 2005 1% population survey
Note. - (1) The numbers are estimated coefficients of being in good health against alternative age cutoff. (2) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (3) All estimations include education and marital status as control variables. (4) Standard errors are presented in parentheses.

Table 6

Robustness Test: The Effect of Being Older than 60 on Rural Men

	+/- 1	+/- 2	+/- 3
Retirement	0.00	0.00	0.00
	(0.61)	(0.06)	(0.06)
Good Health	-0.01	-0.01	-0.01
	(-0.88)	(-1.47)	(-1.62)
Functional Limitation	-0.00	-0.00	-0.00
	(-1.18)	(-1.08)	(-0.52)
Observations	14789	26926	40162

Data source. - 1/5 sample of 2005 1% population survey
Note. - (1) The numbers are the estimated coefficients of the older than 60 dummy on the dependent variables listed in the first column using equation (4b). (2) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (3) All estimations include education and marital status as control variables. (4) Standard errors are presented in parentheses.

Table 7

The Impact of Retirement on Being in Good Health with Income Controlled

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
Retirement	-0.35	-0.55*	-0.30**	-0.20*	-0.19**
	(0.42)	(0.31)	(0.15)	(0.11)	(0.10)
Income	-0.08	-0.13	-0.06	-0.03	-0.03
	(0.13)	(0.09)	(0.04)	(0.03)	(0.03)
Observations	7651	13618	20218	27728	35128

Data source. - 1/5 sample of 2005 1% population survey.
Note. - (1) For the ±1-year range, a linear function is used, and for other ranges, square control functions are applied. (2) All estimations include education and marital status as control variables. (3) Standard errors are presented in parentheses.

* p<0.1.
** p<0.05.
*** p<0.01.

Table 8

The Effect of a Husband's Retirement on Wife's Health Status

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
	Dependent Variable: Wife in Good Health				
Husband retired	-0.05	-0.07*	-0.07***	-0.06***	-0.06***
	(0.06)	(0.03)	(0.03)	(0.02)	(0.02)
Observations	4015	7615	11201	15176	19218

Data source. - Married men from 1/5 sample of 2005 1% population survey.
Note. - (1) Control variables include wife's education and husband's self-reported health. Whether the husband is age 60 or older is the instrument for husband's retirement status. (3) Standard errors are presented in parentheses.

* p<0.1.
*** p<0.01.

Table 9

Descriptive Statistics, 2002 CHIP

	+5	−5	+6	−6	+7	−7	+8	−8	+9	−9	[−9,+9]
% Retirement	0.84	0.22	0.82	0.29	0.82	0.27	0.83	0.24	0.84	0.22	0.42
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
% Happiness	0.62	0.58	0.59	0.61	0.59	0.60	0.61	0.59	0.62	0.57	0.59
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
% College Degree or above	0.24	0.26	0.24	0.29	0.23	0.28	0.23	0.27	0.23	0.28	0.25
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
% High School Degree	0.33	0.29	0.36	0.31	0.36	0.30	0.34	0.29	0.33	0.29	0.30
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
% Middle School Degree	0.29	0.37	0.27	0.31	0.28	0.33	0.29	0.35	0.29	0.37	0.35
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
% Married	0.97	0.99	0.97	0.99	0.97	0.99	0.97	0.99	0.97	0.99	0.98
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
Observations	986		1187		1415		1661		1912		1912

Data source. - 2002 China Household Income Project (CHIP).

Note. - Standard deviations in parentheses.

Table 10

The Impact of Retirement on Happiness

	+/- 5	+/- 6	+/- 7	+/- 8	+/- 9
			Dependent Variable: Retirement		
Older than 60 dummy	0.20**	0.29*	0.29**	0.21*	0.19*
	(0.10)	(0.18)	(0.14)	(0.12)	(0.11)
	[0.91]	[0.97]	[1.00]	[0.88]	[0.86]
			Dependent Variable: Happiness		
Retirement	-0.56**	-0.53**	-0.48***	-0.42***	-0.44***
	(0.26)	(0.22)	(0.18)	(0.17)	(0.16)
	[-0.93]	[-0.66]	[-0.77]	[-0.76]	[-0.86]
Observations	986	1187	1415	1661	1912

Data source. - 2002 CHIP.

Note. - (1) All estimations use cubic control functions used with the control variables education, marital status, and whether a cadre or work type. (2) Standard errors are presented in parentheses and percent effects are shown in brackets.

* p<0.1.

** p<0.05.

*** p<0.01.

Table 11

Differential Effects of Retirement on Being in Good Health by Education

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
Panel A: Without income control:					
Retirement*College Degree or Above	−0.37	−0.31	−0.20**	−0.16**	−0.14**
	(0.24)	(0.20)	(0.09)	(0.07)	(0.05)
Retirement*Senior High School	−0.36*	−0.31**	−0.22**	−0.18***	−0.18***
	(0.22)	(0.14)	(0.08)	(0.06)	(0.05)
Retirement*Junior High School	−0.36*	−0.32**	−0.24***	−0.20***	−0.18***
	(0.22)	(0.14)	(0.08)	(0.06)	(0.05)
Retirement*Primary School or Below	−0.42*	−0.38***	−0.30***	−0.25***	−0.24***
	(0.21)	(0.14)	(0.08)	(0.07)	(0.06)
Panel B: With income control:					
Retirement*College Degree or Above	−0.65	−0.53*	−0.33*	−0.24**	−0.21*
	(0.51)	(0.31)	(0.16)	(0.12)	(0.10)
Retirement*Senior High School	−0.67	−0.55*	−0.35**	−0.26**	−0.23*
	(0.53)	(0.32)	(0.17)	(0.12)	(0.11)
Retirement*Junior High School	−0.69	−0.58*	−0.38**	−0.30**	−0.26**
	(0.54)	(0.32)	(0.17)	(0.13)	(0.11)
Retirement*Primary School or Below	−0.76	−0.65*	−0.44**	−0.35***	−0.32**
	(0.55)	(0.33)	(0.18)	(0.13)	(0.11)

Data source. - 1/5 sample of 2005 1% population survey.

Note. - (1) Estimation model is the same as in Table 3, except for the interaction terms used. The IVs for these interactions are interactions of age cutoff and education categories. (2) For the ±1 year range, a linear function is used, and for other ranges, square control functions are applied. (3) All estimations include education and marital status as control variables. (4) Standard errors are presented in parentheses.

* p<0.1.

** p<0.05.

*** p<0.01.

Table A

Test Statistics of Robustness of Polynomial Functions

	+/- 1	+/- 2	+/- 3	+/- 4	+/- 5
Retirement	1.18	1.38	0.96	1.33	1.27
	(0.09)	(0.17)	(0.50)	(0.12)	(0.14)
Income	1.57	1.27	1.27	1.25	1.14
	(0.16)	(0.23)	(0.20)	(0.18)	(0.26)
In Good Health	1.09	1.26	1.00	1.37	1.18
	(0.37)	(0.23)	(0.45)	(0.10)	(0.21)
Functional Limitations	0.71	1.32	0.98	0.95	0.97
	(0.62)	(0.20)	(0.48)	(0.53)	(0.51)

Data source. - 1/5 sample of 2005 1% population survey

Note. - (1) This table reports a test of the robustness of the polynomial approximation introduced by Lee and Card (2008). Each entry in the table is an F-statistic that compares the fit of a completely saturated model in age to the more parsimonious model underlying the estimates of reduced form in Table 2. (2) The first column includes the dependent variables. (3) P-values are given in parentheses.