Mandatory Retirement and the Consumption Puzzle: Prices Decline or Quantities Decline?

Yingying Dong, Dennis Yang[*†]

University of California Irvine and University of Virginia

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Abstract

This paper investigates household consumption changes at retirement by drawing on a comprehensive, diary-based household survey from China. The study has several unique features: (a) although existing research on the retirement - consumption puzzle primarily uses expenditure data, the Chinese survey contains both consumption quantity and price information; (b) the mandatory retirement policy in China provides a quasi-experimental setting for nonparametric identification of the causal effects of fully anticipated retirement on consumption; and (c) different social norms, such as the dress code for work and affordable public transportation, provide special circumstances to explore consumption changes at the time of retirement. Using regression discontinuity (RD) analyses, we find that food expenditure declines significantly at retirement, particularly among the low education group, but not clothing and transportation expenses. We further show that average prices for different categories of food decline, but not quantities. Additional data reveal an increase in food shopping time upon retirement among the low education households, consistent with price and quantity patterns. These findings have important implications for policy and welfare because they indicate changes in the time uses of the elderly rather than a drop in their real consumption.

JEL Codes: J26, C21
Keywords: Retirement-consumption puzzle, Mandatory retirement, Regression discontinuity, Consumption vs. expenditure, Time use, Home producation

[*]Yingying Dong, Department of Economics, University of California Irvine, yyd@uci.edu; Dennis Yang, Darden School of Business, University of Virginia, YangD@darden.virginia.edu.

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1 Introduction

Many empirical studies show that consumption (typically food consumption) drops significantly at retirement. This finding is referred to as the "retirement-consumption puzzle," because a systematic fall in consumption is inconsistent with consumption smoothing suggested by the life cycle/permanent income hypothesis (PIH, Friedman 1956, Hall 1978). According to the PIH, the marginal utility of consumption should stay constant over the life cycle, so rational people are expected to smooth consumption through borrowing and (dis)saving, and consumption should not fall when retirement is anticipated.

This 'puzzle' has been documented using various data sets from many different countries, including the UK, the US, Italy, Canada, and Germany.[1] These studies all use expenditure data, which do not allow one to separate price changes from quality changes at retirement.

Whether consumption prices or quantities decline have very different welfare implications, since they bear on whether the elderly experiences a real consumption drop vs. just changes in time use (e.g., shopping for bargains or increased home production). In an influential paper, Aguiar and Hurst (2005) suggest that retired households have considerably more leisure time, so they can shop for bargains and thereby pay lower prices for the same quantity and quality of goods. In this case, consumption expenditure declines at retirement, but actual quantity and quality do not. They also argue that retired households can engage in more home production, which enables them to substitute home meals for restaurant meals. In another paper, Aguiar and Hurst (2007) show that average prices paid for goods decrease while shopping time increases over the life cycle, and that purchase prices decline significantly around the retirement age.

Following the insights of these two influential papers, we provide the first direct

[1]See for example, Banks, Blundell, and Tanner (1998), Smith (2006) for evidence in the United Kingdom, Bernheim, Skinner, and Weinberg (2001), Aguila, Attanasio, and Meghir (forthcoming), Ameriks, Caplin, and Leahy (2007), Haider and Stephens (2007), Hurd and Rohwedder (2008) for evidence in the United States, Battistin, Brugiavini, Rettore and Weber (2009), Miniaci, Monfardini, and Weber (2009), Borella, Moscarola, and Rossi (2011) for evidence in Italy, Robb and Burbridge (1989) for Canada , and Schwerdt (2005) for evidence in Germany.

causal evidence on the proposed explanation of the consumption decline at retirement. In particular, we separate price changes from quantity changes at retirement, utilizing the mandatory retirement policy in China for identification and a large confidential dairy based consumption data set for estimation. We also document food shopping time changes upon retirement, which supports our findings about the price and quantity changes at retirement.

The mandatory retirement policy provides a unique quasi-experimental setting for non-parametric identification of the true causal effects of fully anticipated retirement on consumption outcomes. This policy requires workers retire at a certain age. Intuitively, workers who just turn the retirement age and those who are just under are comparable except for their retirement status, so their mean outcome difference should be induced by retirement at that age. The identified effects are for those compliers whose retirement is turned on by their age exceeding a predetermined threshold rather than endogenous factors, such as health shocks or being laid off. Further, retirement at the required age is fully anticipated by Chinese workers because the policy has been in effect since the 1950s. This helps clarify consumption changes when retirement is foreseen vs. when it is unforeseen.

Compared with most of the pension eligibility rules in the West, the retirement mandate in China induces a larger change in the retirement probability and hence a more pronounced first stage. The mandatory retirement can therefore help more precisely identify the impact of retirement and provide implications for a broader group of compliers. In addition, the mandatory retirement in China is entirely based on age. Age is well defined and is not easily susceptible to individuals' manipulation as discussed later, which makes our RD design highly credible.

Existing studies are almost exclusively based on developed Western countries. This study provides the first evidence from a large developing country.[2] The case of China is interesting due to its unique social, cultural, and economic environment, which differs in many ways from developed Western countries. For example, Hurd and Rohwedder

[2]Wakabayashi (2008) is the only study that looks at a developed Eastern country, Japan.

(2008) show that in the US the consumption decline at retirement is mainly induced by work related expenditure, such as clothing and transportation, and that once these are taken into account, there is no significant decline in consumption expenditures among those who retire voluntarily. In contrast, in China workplaces typically do not impose dress code and most Chinese rely on cheap public transportation or bicycle to commute to work, so cessation of work may not induce significant declines in these work-related expenditures.

In addition, Chinese people have the tradition of saving for old ages, which is reflected in their very high saving rates. Several studies show that the age profile of the saving rate in China is U-shaped, and that those close to retirement age people are among the highest saving rate groups (see, e.g., Chamon and Prasad, 2010). If the observed consumption decline in the West is entirely induced by inadequate savings upon retirement, high saving rates in China may help alleviate the problem. Due to these dramatically different social norms and deeply-rooted tradition, it is unclear whether existing conclusions would apply to China.

Using data from the Urban Household Survey (UHS) in China, we show that the mandatory retirement policy in China induces a significant sharp increase in the retirement rate, which provides strong identification for causal impacts of retirement. Similar to the documented evidence in the west, we find that food expenditure has a significant decline at retirement; however neither clothing and nor transportation expenditure declines, which deviates from the typical findings in developed Western countries.

Further analysis shows that prices paid instead of quantities purchased for food decline significantly at retirement. Food prices decline particularly among household heads without a college education. This is largely consistent with the existing findings of the heterogeneity in the retirement effects. Existing studies tend to show that consumption declines concentrate in the disadvantaged group, such as the low pre-retirement wealth group, blue collar workers, workers with low education or low retirement savings (see, e.g., Bernheim, Skinner and Weinberg 2001, Borella, Moscarola, and Rossi 2011, Robb and Burbridge 1989 and Schwerdt 2005).

Once assuming that retirees pay the same prices as prime-age working individuals, we find no declines in the predicted food expenditure. In contrast, a constructed food consumption index, which aggregates various foods consumed by a household but takes into account price heterogeneity, is shown to have a small but significant decline among the non-college education group. This result again suggests that the observed food expenditure decline is driven by price declines, not quantity declines. Consistent with the price decline, we show that time spent on shopping for food increases significantly at retirement among the non-college education group.

We also discuss estimating time-varying retirement effects by extending the standard RD analysis. We show that there are little variable delayed effects of retirement on prices and quantities. This supports the existing literature in focusing on the short-run impacts of retirement on consumption.

The rest of the paper proceeds as follows. Section 2 briefly reviews the literature; Section 3 introduces the institutional background in China and describes the data; Section 4 discusses identification and empirical specification of the one-time (static) retirement effects; Section 5 investigates expenditure changes; Section 6 investigates price and quantity changes; Section 7 investigates changes in the food consumption index and predicted food expenditure; Section 8 investigates changes in food shopping time; Section 9 discusses identification and estimation of the time-varying retirement effects. Section 10 investigates the validity of our RD design; Short concluding remarks are provided in Section 11.

2 Relationship to Existing Studies

There is a large literature on the retirement-consumption puzzle. Existing studies largely rely on structural models for identification (a summary of the existing studies is provided in the Appendix). The only study that, similar to ours, utilizes an RD design is Battistin, Brugiavini, Rettore and Weber (2009). Whether the observed consumption decline is a puzzle is highly debated. Hurst (2008) after reviewing the existing studies based on developed countries' data concludes that the large body of existing work represents "the retirement of a consumption puzzle." We contribute to the literature by providing direct causal evidence on the suggested justification for the expenditure decline at retirement.

As noted in Hurst (2008), the consumption decline is mainly a decline in nondurable consumption, particularly food and work-related consumption. The estimated sizes of the decline vary dramatically across studies. They fall anywhere between less than 10% to more than 30%. There also appears to be great heterogeneity. Consumption generally declines more among the disadvantaged group. For example, in the US, Bernheim, Skinner and Weinberg (2001) show that the consumption decline is negatively correlated with retirement savings and income replacement rates. Borella, Moscarola, and Rossi (2011) find that consumption drops more among the low wealth group in Italy. Robb and Burbridge (1989) find that consumption declines significantly only among the blue-collar households in Canada. Schwerdt (2005) shows that consumption drops more than 30% for the low income replacement group in Germany, while it increases more than 10% for high income replacement individuals.

Various explanations have been proposed to reconcile the observed expenditure decline. Except for those related to cessation of work (so work-related expenditure declines) and time use changes (such as shopping for bargains and increased home production), French (2005) and Blau (2008) emphasize that retirees enjoy increased leisure time, and so can reduce consumption without having their utility level affected, assuming non-separability of preferences for leisure and for consumption.

An alternative explanation emphasizes that workers under-save for their retirement either because they lack self control (Angeletos et al. 2001) or because they fail to adequately foresee the income decline at retirement (see, e.g., Bernheim, Skinner and Weinberg, 2001). Consistent with the latter, Gustman and Steinmeier (2001) find that misinformation or lack of information about retirement benefits is the norm among US workers. Lusardi (1999, 2000) finds that, ceteris paribus, households who have given little thought to retirement have far lower wealth than those who have given the subject more thought.

The closest study to ours, Battistin, Brugiavini, Rettore and Weber (2009) exploit the pension eligibility rule in Italy for identification and investigate expenditure changes at retirement. The expenditure information is derived from recall questions. Unlike mandatory retirement, pension eligibility in Italy is determined by both age and contribution years, and the resulting constructed running variable for their RD design is found to have measurement errors. They carefully derive conditions under which the measurement error only leads to a fuzzier RD design.

In contrast, we focus on separating prices changes from quantity changes at retirement when retirement is fully anticipated. We also investigate how food shopping time changes. Our analysis utilizes detailed consumption diary information from a large confidential data set in China. Interestingly, Battistin, Brugiavini, Rettore and Weber (2009) show that in Italy retirement induces a significant drop in the number of grown children living with their parents, causing a change in household composition and household size, which partly causes consumption to decline. We show later that household size does not have a significant change when household heads retire in China.

3 Institution Background and Data Description

In China, the official retirement age is 60 for male workers, 55 for white-collar female workers, and 50 for blue-collar female workers, with some exceptions applying to certain occupations and to disabled workers.[3] These mandatory retirement ages have not changed since they were established in the 1950s. Mandatory retirement is strictly enforced in the state sector, including the government organizations and state-owned enterprisees (SOE's); whereas workers in the private sector have more flexibility. In our sample, the majority (78%) of workers around retirement age work for the state sector. Working for the private sector is more common among younger workers, since the private

[3]Those who have jobs that are risky, harmful to their health, or extremely physically demanding can retire 5 years before the official retirement ages, i.e., 45 for blue-collar female workers and 55 for male workers. Male workers who become disabled and hence are unable to do their work can apply to retire at 50, while disabled female workers can retire at 45. Civil servants also qualify for early retirement if they have worked for 30 years and are within 5 years of their retirement age.

sector in China virtually did not exist until the 1980s.

Workers may retire earlier before they reach the mandatory retirement age. Retirees may also take a new job or may even be re-hired by the same employer after their official retirement, so the change in the retirement rate is less than one at the mandatory retirement age, which entails a fuzzy RD design.

In China, the replacement rate (pension as a fraction of a worker's pre-retirement income) depends on the duration of pension program participation and on pre-retirement occupation. To be eligible for pension, one must participate in the program for a minimum of 10 years.[4] Typically, a worker with 10 years of participation receives 60% of the pre-retirement wage, and the replacement rate goes up to 70% for 15 years or more pension contribution. The maximum replacement rate for civil servants is 88%, for government institution workers is 90%. A small number of workers, those who started working for the Communist Party before 1945, get a 100% replacement rate.

We use data from the China Urban Household Survey (UHS). The UHS is an on-going national annual survey of urban households conducted by the China National Bureau of Statistics (NBS). The first wave of the UHS was conducted in 1988. The UHS surveys a large representative sample of urban households and provides detailed information on household consumption, income, as well as household member's education, employment and demographic information etc. One unique feature of the UHS data is that the food consumption is collected through consumption diary, and so it has not only expenditure information but also information on quantities purchased for detailed consumption categories. Unlike data collected through recall questions, the data are less likely to have recall errors. The UHS data have been used to compile CPI and monitor consumption changes over time. The rich information in the UHS allows us to consistently investigate consumption expenditure, quantity, and price changes for refined categories and conduct RD analyses.

Limited by data availability, the data we use here is a subset of the UHS, representing

[4]For those joining the workforce after 1993, the minimum years of contribution required is 15, but this is irrelevant for the retiree cohorts we are looking at.

urban households in five provinces and one municipality.[5] Selection into the sample of urban residents at retirement is not an issue here. Due to the restricted household registration or HuKou system in China, workers rarely ever move to rural or other areas upon retirement. We choose the sample period 1997 to 2006, mainly because the UHS questionnaires changed a few times over years, the questionnaires are largely consistent for the period of 1997 to 2006. In addition, the pension system in China changed in 1997. Starting 1997, the Chinese government adopted a system that combines individual accounts and social pooling to provide retirement funds. Before that, pensions were provided entirely by employers.[6]

We focus on male workers who are household heads for clean identification. Female workers' labor supply is more complicated and their mandatory retirement age varies across occupations. However, this may cause another sample selection issue, i.e., the reported household head may change with the head's retirement status, which would invalidate our research design. If this is true, we would expect the probability of being a household head change at the mandatory retirement age 60. To make sure the sample selection does not undermine our identification, we plot the fraction of household heads at each age among the full UHS sample of males. As shown in Figure 1-(a), the probability of being a household head changes smoothly with age and there does not appear to be visible changes at the mandatory retirement age 60.

Eligible male workers can start their retirement paperwork at the beginning of the month they turn 60. Typically the paperwork is processed within the same month, and eligible workers start to receive pension the following month after they turn 60. Retirement is a binary indicator of the reported retirement status. It equals one when a male household head's employment status is retiree and zero otherwise. Consumption outcomes we look at include expenditures, quantities and prices. All categories of expenditure and prices are adjusted for regional specific inflation and are in 1996 constant

[5]The five provinces are Liaoning, Zhejiang, Guangdong, Shanxi, Sichuan, and the one city is Beijing.

[6]Since we are looking at close to retirement age individuals, even if this change has any effects on the size of the compliers at the mandatory retirement, it should not invalidate our identification. Including or dropping year 1997's data is not found to affect our results much.

Chinese Yuan.

4 Identification and Empirical Specification

4.1 RD Model Identification and Specification

As a quasi-experimental approach, a standard RD design identifies the effect of a binary treatment when the assignment of treatment is determined by an observed covariate, the so-called "running variable" exceeding a known threshold. RD identification associates a discrete change in the treatment probability at the threshold with a corresponding discrete change in the mean outcome. Here the treatment is whether a male household head is retired or not. The running variable is household heads' age.

For now, we consider the standard static RD model, which identifies the immediate effect of retirement on household consumption at the mandatory retirement age 60. Time-varying effects of retirement is discussed later in Section 9.

Let Y be household consumption. Let T be a binary indicator that equals 1 if a household head is retired and 0 if not. Let X be a household head's exact age relative to the mandatory retirement age 60. Also define $D = I(X \geq 0)$, where $I(\cdot)$ is an indicator function that equals 1 if its argument is true and 0 otherwise. So $D = 1$ for household heads who are at or above the mandatory retirement age, and $D = 0$ otherwise. Assume household consumption changes smoothly with a household head's age, which may also depend on the head's retirement status, so we have the following local polynomial regression

$$Y = f(X) + \tau_0 T + \varepsilon, \tag{1}$$

where $f(X)$ is a low-order polynomial function of X, and ε captures all other smooth factors that determine a household's consumption. Note that the standard argument applies – in the above eq. (1), τ_0 captures the average effect of retirement on consumption at the mandatory retirement age, even if the true consumption model the retirement effect is heterogenous, so there are interaction terms between T and covariates (such as age X).

Assume the following local polynomial regression for retirement with a uniform kernel

$$T = \sum\nolimits_{j=0}^{J} a_j X^j + \sum\nolimits_{j=0}^{J} b_j X^j D + v, \tag{2}$$

where J is the order of polynomial, and v is a smooth regression error.

Plug eq. (2) into the eq. (3), we have the reduced-form consumption equation,

$$Y = \sum\nolimits_{j=0}^{J} c_j X^j + \sum\nolimits_{j=0}^{J} d_j X^j D + u. \tag{3}$$

For simplicity, assume that it is a local polynomial regression of order J, though one could allow the order of polynomials to differ for the retirement and the consumption. In this case, J can be taken as the higher order of the two.

Both consumption Y and retirement T could depend on other covariates, which are suppressed for now, since a generic virtue of the RD approach is that inclusion of other covariates (assumed to be smooth) only affects efficiency but not consistency of estimated RD treatment effects. The above equations allow the slopes and higher order derivatives of the retirement and the consumption profiles to differ at either side of the age threshold.

Given smoothness of $f(X)$ and ε in eq. (1), any observed discontinuity in the mean consumption can be attributed to the change in the retirement rate. So the ratio of the mean consumption change to the retirement rate change at the mandatory retirement age identifies the average effect of retirement on consumption at that age (see Hann, Todd, and Van der Klaauw 2001 and Dong 2014b for discussion of identifying assumptions of standard RD designs). Then we have

$$\tau_0 = \frac{b_0}{d_0}. \tag{4}$$

4.2 Issues with Using Age in Years

The UHS records age in years, similar to many surveys. Age in years can be seen as the exact age rounded down to the nearest integer, so for example, a worker who is reported to be 60 in the survey can have a true age anywhere between 60 and 61 minus one day. However, RD model identification crucially relies on a continuous running variable. Using a rounded or discretized running variable may lead to biased estimates.

Given a discrete running variable, one does not observe data arbitrarily close to the cutoff even if one has an arbitrarily large sample. Extrapolation based on functional forms is unavoidable. Intuitively, rounding down means that each age is not centered at the mean or midpoint of the corresponding age cell. Even if one can re-center the integer age to be the mid-point of the age cell (by adding 0.5 to each integer age), the curvature or non-linearity of the age profiles can cause further problems. An illustration of the problem along with a description of a bias correction procedure utilizing the moments of the birthdate distribution within a year is provided in the Appendix. The bias correction procedure follows the general approach discussed in Dong (2014a), but is adapted to facilitate obtaining standard errors directly.

4.3 The Retirement Rate Increase at the Mandatory Retirement Age

Identifying the retirement effect using an RD model requires a discrete change in the retirement rate at age 60. That is, a significant fraction of male workers need to comply with the mandatory retirement policy and retire once they turn 60. Figures 1-(b), (c), and (d) show the age profiles of household heads' retirement rates, pensions and wages, respectively. Dots in these figures represent mean values at each age. There is a clear jump in the retirement rate at age 60. Similarly, average pensions and wages change discontinuously at the same age. Consistency of all three figures suggests that household heads' retirement status is not systematically mismeasured.

The UHS is an annual survey. It records individuals' retirement status by the end of a survey year. In theory, a household head can retire any time during the year, so household consumption at 60 is generally a mixture of pre- and post-retirement consumption. When a household head retires at the end of the year, the consumption at 60 captures entirely pre-retirement consumption. We therefore drop observations at 60. This ensures that all observations below 60 are drawn from the pre-mandatory retirement profile, and all observations above 60 are drawn from the post-mandatory retirement profile. The difference in the two profiles evaluated at 60 yields the exogenous change induced by mandatory retirement policy. We accordingly estimate the polynomial regressions using data from ages 59 and below and ages 61 and above, and evaluate changes at 60 by extrapolating these regression curves to the cutoff age of 60.[7]

We consider widely varying ranges of age for the retirement equation, 6, 10, and 15 years above and below the cutoff, corresponding to age ranges 54 - 66, 50 - 70, and 45 - 75. The sample sizes corresponding to the three windows are 12,050, 21,576, and 33,149, respectively. On average, there are more than 2,000 observations at each age. In practice, there is a tradeoff regarding what range of age around the threshold to include in the model. A wider range provides more observations, thereby adding to the precision with which the model coefficients can be estimated. However, the further away the included ages are from the threshold, the more likely the correct model specification for these distant observations will differ from the correct specification near the threshold, risking specification errors.

The estimated increases in the retirement rate at the mandatory retirement age are reported in Table 1a. For comparison purposes, we also report in Table 1b estimates using the observed age in years without any bias correction.

Overall we have 21 different specifications, depending on the order of polynomials, bandwidths and including covariates or not. The full set of covariates include year fixed

[7]We use a uniform kernel for convenience, since more complicated weighting or different kernels rarely make much difference in practice. The only difference between regressions using a uniform kernel and those using more complicated kernels is that the latter puts more weight on observations closer to the cutoff. An arguably more transparent way of putting more weight on observations closer to the cutoff is simply to re-estimate a model with a uniform kernel using a smaller bandwidth. If using different weights makes a difference, it likely suggests that the results are highly sensitive to the choice of bandwidth, a point made by Lee and Lemieux (2010).

effects, province fixed effects, year-province interactions, household size, household size squared, and heads' education levels in three categories, i.e., college or above, high school, and less than high school (the default).[8] Goodness of fit measures (adjusted R2 and AIC) suggest that the second order polynomial is preferable when using the short 6 years' window, while the third order polynomial fits better when using the 10 or 15 years' window.

The estimates do not vary much across specifications. It is estimated that close to 30% of male workers retire at age 60. In contrast, the estimates in Table 1b without correcting for rounding bias seem to systematically underestimate the true increase in the retirement rate. These estimates are also sensitive to different specifications, ranging from 13.0% to 26.4%.

5 Expenditure Changes at Retirement

We first investigate whether consumption expenditures drop at all at the mandatory retirement age in China. Following the large body of the existing literature, we divide the total expenditure into four categories: food, clothing, transportation, and the remaining expenditure.

5.1 Food, Work-related and Other Expenditure

The age profiles of these four categories of expenditure are presented in Figures 2-(a), (b), (c) and (d), respectively. Food expenditure has an obvious drop at the mandatory retirement age 60. In striking contrast to food expenditure, clothing expenditure decreases smoothly with age. Transportation expenditure also does not appear to change discontinuously. These preliminary findings suggest that our results may differ from the typical findings from the wealthy Western countries. Quite a few existing studies based

[8] For the short 6 years' window, the fourth order polynomial obviously overfits the curve, while for the 15 years' window, a quadratic seems to greatly underfit the curve. We omit results from those specifications.

on developed Western countries find that work related expenditure, particularly clothing and transportation expenditure, drops significantly at retirement (see, e.g., Battistin, Brugiavini, Rettore and Weber, 2009, for RD evidence in Italy).

The effects of retirement are estimated using the bias corrected regressions described in the previous section. We jointly estimate the outcome and the retirement equations using GMM to maximize efficiency. Household consumption crucially depends on household size and other covariates, so in these regressions we control for household size, size squared, head's marital status, year fixed effects, province fixed effects, as well as year-province fixed effects. Later we show that household characteristics are smooth at the mandatory retirement age, so omitting these covariates does affect consistency. However, covariates help reduce the sampling variation of the outcome variable, and hence may provide more precise estimates.

We report estimates separately for college educated household heads and non-college educated heads. We show that these two groups respond to retirement very differently, consistent with the documented heterogeneity in the existing literature.

To facilitate comparison, we restrict the bandwidth to be the same (age range 45 - 75) for the large number of outcomes we examine. For each outcome, we choose the optimal order of polynomial based on commonly used goodness of fit measures.

Table 2 reports the estimated changes in the four categories of expenditure when household heads retire.[9] A small (4-5%) decline is found in food expenditure, particularly among the non-college education group. This is consistent with the typical findings from developed Western countries. For example, after inspecting the existing findings based on developed countries, Hurst (2008) concludes that the "retirement-consumption puzzle" is mainly a "retirement-food consumption puzzle." In contrast, among the college education group, food expenditure is shown to have a positive yet insignificant change.

Clothing and transportation expenditure, which arguably is 'work-related,' does not

[9]For food, clothing and other expenditure, we use logged values as our dependent variables. About 9% of the households reported zero spending on transportation in our sample. To avoid dropping observations with zero spending or transforming them differently, we use level instead of logged value of transportation expenditure as the dependent variable. This ensures comparability of means across age points. We then convert the estimated level changes into percentage changes to facilitate interpretation.

show any significant declines in China. This differs from the typical findings from the west. However, the different findings are not surprising, and are in fact consistent with the social norm in China. Work places in China typically do not impose dress code, so workers do not purchase business attires particularly for work. In addition, the majority of workers in China either bike or rely on affordable public transportation to commute to work. Household transportation expenditure is very low. In our sample, the median transportation expenditure among the pre-retirement age working households is only 266 Chinese Yuan (less than 50 US dollars) per year. Due to these social norms, cessation of work at retirement does not induce both categories of expenditure to drop much. In addition, even if retirees can search for lower prices for clothing, one may not see a discrete change in clothing expenditure, since clothing is a semi-durable.

5.2 Food at Home and Away from Home

Food expenditure declines significantly at retirement, but it is not clear whether food consumed at home or away from home declines. Figures 3-(a), -(b) and -(c) show the age profiles of these two types of expenditure. Food away from home shows dramatic declines at the mandatory retirement age, while food at home shows only a small decline.

Note that expenditure for food at home increases steadily with age before reaching the mandatory retirement age (roughly by 14% over 15 years of age), and then declines quickly. This may reflect the hump-shaped life cycle profile of household non-durable consumption (Fernandez-Villaverde and Krueger, 2007). Or the curvature may capture some of the time trends or cohort effects. We explicitly take the hump-shaped age profile into account by including polynomial functions of age. We also control regional specific year fixed effects. Since cohort is a perfect linear function of year and age, cohort effects are in part captured in our specifications by the flexible smooth function of age and year fixed effects. It is worth emphasizing that the standard RD model still correctly estimates the local average treatment effect of retirement even when any smooth cohort or time effects are omitted (and hence are captured by the error term). This point is further discussed in Section 9.

Estimated changes in spending on food at home and food away from home are reported in Table 3. Among the non-college education group, food at home shows small but insignificant declines, while food away from home shows significant declines – the total eating-out expenditure declines by about 20%, and that at non-workplace restaurants declines by about 27%. In contrast, the college education group does not experience any significant declines in either type of food expenditure.

6 Price vs. Quantity Changes at Retirement

Among the non-college education household heads, food expenditure for eating out declines dramatically upon retirement. If they substitute home meals for restaurant meals, one should see an increase in home production upon retirement, which may not be reflected in the expenditure data if prices change. This section disentangles real quantity changes from price changes at retirement.

We first look at quantities purchased and average prices paid for each category of food for some major food categories. One advantage of this aggregation is that it takes into account the substitutability of different types of food within a category. Another advantage is that it reduces heterogeneity in consumption across households, since specific food consumed by each household varies greatly. The retirement effects on quantities and prices can therefore be much more precisely estimated by looking at food categories. The disadvantage of focusing on food categories is that it masks any compositional changes within a category. To overcome this problem, we next look at prices and quantities of some commonly consumed food.

6.1 Prices and Quantities of Major Food Categories

We look at five major food categories, including staple, vegetable, oil, meat and poultry and fruit.[10] Figures 4 and 5 show how the quantity purchased and average price paid for

[10]Staple includes rice, flour, and other grain or grain product; meat includes pork, beef, lamb and other meat or meat product; poultry includes chicken, duck, other poultry o poultry product. All age profiles of quantities are quantities per household member.

each category of food change with household head's age using the full sample. Figures 6 and 7 present similar figures but for the non-college educated heads only, while figures 8 and 9 for the college educated heads only.

In Figure 4, average prices for all food categories show big declines at the mandatory retirement age. In striking contrast, quantities do not appear to decline discretely in Figure 5. There might even be small increases in quantities, if any, at the mandatory retirement age. Figures 6 and 7 for the low education sample largely mimic the quantity and price patterns in Figures 4 and 5 based on the full sample; whereas Figures 8 and 9 for the college education sample show no discrete changes in either prices or quantities at the mandatory retirement age, though the data is rather noisy due to a smaller sample size.

Tables 4 reports the estimated changes in the average price for each food category at retirement. Consistent with the visual evidence, prices paid by the non-college education group are estimated to decline significantly for all food categories except for staple. In contrast, prices paid by the college education group are estimated to be mostly positive yet insignificant.

The estimated price declines for the low education group also vary a lot across categories. For example, meat and oil are estimated to have small declines of 2.8% and 4.1%, respectively, while vegetable and fruit are estimated to have declines of 7.1% and 10.6%, respectively among the non-college education group. The varying sizes of the price declines are consistent with possible price variations in China. For example, staple, oil and meat prices are largely regulated and hence have small price dispersions, so greater search effort may not lead to greater price reduction. In contrast, vegetables and fruits can be purchased through a variety of channels, including some local farmer's markets; therefore purchase prices can vary a lot depending on when are where they are purchased.

Table 5 reports the estimated changes in the quantities. Quantities for almost all categories, except for fruit, are estimated to increase significantly among the non-college education group, but no significant changes are found among the college education group.

Overall, these results suggest that average prices but not quantities of these categories of food decline among the low education group. Quantities may even increase upon retirement, which can offset the the significant decline in meals out particularly among the low education group. These results are consistent with a substitution of home meals for restaurant meals upon retirement among the low education group.

6.2 Prices and Quantities of Specific Food

The average price for a food category is constructed by dividing the total expenditure by the total quantity, and therefore represents a unit value (see Deaton, 1988 for discussions on unit values). In practice, prices within a category vary across different types of food. A decline in a unit value can therefore be driven either by real price declines within a category or by compositional changes, i.e., retirees may substitute relatively cheaper foods for more expensive foods within a category.

To investigate whether there are any real price declines or just compositional changes, we look at some commonly consumed food, including rice, potato, pork, beef, and lamb. As shown in Figure 10, prices still show obvious declines at the mandatory retirement age.

Table 6 reports the estimated changes in prices of these specific types of food. The estimates are all negative among the non-college education group, though not precisely estimated. Table 7 reports the estimated changes in the quantities of these specific types of food. No significant declines are found for quantities among the non-college education group.

7 Food Consumption Index and Predicted Expenditure

The analysis so far focuses on either major food categories or a few selected types of food. To aggregate various types of food a household consumes, we follow the approach in Aguiar and Hurst (2005) to construct a food consumption index. We also construct a predicted expenditure holding prices fixed (assuming that the retirement age individuals pay the same prices as prime age working individuals).

The food consumption index is constructed as a weighted average of various quantities of food purchased and prices paid by a household. As shown in Aguiar and Hurst (2005), household consumption (quantities and prices) has a significant forecasting power for permanent income, therefore one can compute the implied permanent income of the retirement age households based on their consumption baskets.

We obtain the required weights by projecting the logarithm of permanent income on quantities and expenditure of various foods consumed by working age household heads. Including food expenditure takes into account price heterogeneity across households. The unit of the consumption index is therefore log permanent income. Also included in the projection is a vector of taste controls and a smooth polynomial function of household heads' age. That is, given permanent income I^{perm}, we can estimate the following equation to get the weights used later in constructing the consumption index for the retirement age household heads,

$$\ln(I^{perm}) = \eta_0 + \eta_{\mathbf{Q}}\mathbf{Q} + \eta_{\mathbf{E}}\mathbf{E} + \eta_{\boldsymbol{\pi}}\boldsymbol{\pi} + m(X) + \epsilon, \tag{5}$$

where $\mathbf{Q}$ and $\mathbf{E}$ are vectors of food quantities and expenditure, respectively, $\boldsymbol{\pi}$ is a vector of taste parameters, and $m(X)$ is a low order polynomial of household head's age.

Permanent income is not directly observed for working age individuals. In order to estimate eq. (5), we need to obtain $\ln(I^{perm})$ first. We first estimate a regression of log household income on household head's eduction, birth cohort, industry and occupation controls, and the full set of occupation-industry interactions, using data on male household heads aged between 25 and 45 who report working fulltime (16,772 individuals). We then take the fitted value as (estimated) permanent income and replace the unknown $\ln(I^{perm})$ in the above eq. (5) with the estimated value. $\mathbf{Q}$ and $\mathbf{E}$ consist of quantities and expenditure of 45 types of food, using the same sample. The vector of taste controls includes household size, household size squared, marital status and province of residence. We next apply the estimated coefficients $\widehat{\eta}_{\mathbf{Q}}$ and $\widehat{\eta}_{\mathbf{E}}$ to quantities purchased and prices paid by the retirement age household heads in our RD sample (19,887 non-college heads and 6,178 college heads).

We also obtain a predicted food expenditure for the retirement age household heads using the estimated coefficients on food quantities $\eta_{\mathbf{Q}}$ in the above equation (5). Recall that equation (5) is estimated based on the sample of prime age working household heads, so these weights can be taken as the average prices paid by these working households. Therefore, the predicted food expenditure assumes that the retirement age households pay the same price as the prime age working households.

Once we construct the food consumption index and predicted expenditure for our RD sample, we use those as our outcome variables in our RD analysis and test whether they decline significantly at retirement. We estimate both changes separately for the college and the non-college education groups. These estimates are given in Table 8.

The estimated changes in the predicated food expenditure are small and insignificant for both the college and the non-college education group. Therefore, had the retirement age individuals paid the same prices for food as the prime age working individuals, we would not see a decline in their food expenditure at retirement. In contrast, the consumption index is estimated to decline significantly by 2.2% among the non-college group, compared with the insignificant decline of 0.4% among the college education group.[11] Since the only difference between the food consumption index and the predicted expenditure is that the latter holds prices fixed, the differential responses provides strong evidence that the observed decline in food expenditure is driven by price declines, not quantity declines. Therefore, consistent with what is documented in Aguiar and Hurst (2005), households in response to forecastable income changes, smooth consumption, but not necessarily expenditures, as predicted by the standard PIH augmented with home

[11]Although we do not report here, the estimated changes based on the full sample are insignificant, similar to the findings in Aguiar and Hurst (2005) based on the US data. In particular, the estimated change in the consumption index for is -0.005 with standard error 0.007, compared to -0.006 with standard error 0.02 reported in Aguiar and Hurst (2005).

production.

8 Food Shopping Time Change at Retirement

Another caveat of the previous analysis is that price differences may reflect quality differences. Without detailed quality measures, we cannot really tell whether retirees pay lower prices because they buy lower quality of the same goods, or they shop for bargains, and thereby pay lower prices for the same quantity and quality of goods. For example, if retired households buy ordinary cut meat, instead of premium cut meat, it would not be captured in our estimation.

To investigate whether retirees shop for bargains, we examine food shopping time changes upon retirement. We use data from the China Health and Nutrition Survey (CHNS), which contains information on food shopping time.[12] In particular, the CHNS asks "during the past week, how much time (minutes) did you spend per day, on average, to buy food for your household?"

The CHNS is an ongoing project that surveys households in nine provinces.[13] These nine provinces cover similarly geographically diverse areas as the UHS. So far eight waves of data are released for years 1989, 1991, 1993, 1997, 2000, 2004, 2006 and 2009, overlapping with our UHS sample period from 1997 to 2006. Ideally we would want to use data of the same years as our UHS sample. However due to the relatively small sample of the CHNS, we use all years of data. Here our main goal is to provide suggestive evidence on food shopping time changes at retirement among urban males, rather than estimate how shopping time affects food prices causally. The CHNS contains households in both urban and rural areas. We limit our sample to the urban male household heads to make it comparable to our UHS data. The sample size is 4,742, including 4,240 non-college educated household heads, 502 college educated heads.

[12]CHNS is an open cohort, international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention.

[13]These include Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou.

Figure 11-(a) presents the age profile of the retirement rate in the CHNS sample. Similar to what we find in our UHS data, the retirement rate jumps by about 30% at the mandatory retirement age, though at each age, the retirement rate is a bit lower, which could be due to different provinces and time periods covered.

Figures 11-(b) and -(c) show the age profiles of food shopping time for the non-college and the college educated household heads, respectively. The average time spent on shopping for food clearly increases at the mandatory retirement age among the non-college education group, but not among their college-educated counterparts.

Table 9 reports the estimated changes in the probability of shopping for food at all last week and in the average time spent on shopping for food at retirement. Both are positive and significant among the non-college educated group. In particular, the average time spent on shopping for food is estimated to increase by about 22 minutes per day and the probability of shopping for food last week is estimated to increase by 22.9% (The sample mean conditioning on shopping for food at all is 49.96 minutes per day, and is 22.98 minutes per day unconditionally). No significant changes are found for the college education group. The probability and average time spent on shopping for food increase only among the non-college education group at retirement, consistent with the significant price decline among this group. Aguiar and Hurst (2007) show an inverse relationship between life cycle prices and shopping time. Therefore, the price decline observed among the low education group is at least in part induced by retirees shopping for bargains.

9 Time-Varying Effects of Retirement

We investigate immediate changes in average consumption at retirement, using the standard RD design. However, there may be variable delayed effects, and so the long-run effect may be different than the short-run effect. Focusing entirely on immediate changes may under- or over-estimate the full effects of retirement, depending on how the retirement effects evolve with time. This section extends the previous analysis to incorporating time-varying effects of retirement. We first show that even if retirement effects change with time, the previous analysis using standard RD models still correctly identifies the immediate or short-run effect of retirement on consumption. We then discuss estimating the time-varying effects of retirement with our cross-sectional data (and hence without knowing at what age one is retired or how long one has been retired at the time of survey).

Let X^0 be a household head's retirement age minus 60, so e.g., $X^0 = 1$ for some one who is retired at 61. Recall that X is one's true age at the time of survey minus 60, so $X - X^0$ measures how long one had been retired at the time of survey. Note that subtracting off 60 is a free normalization so that everything is centered at the mandatory retirement age.

Assume that household consumption depends on the household head's age X, whether the head's is retired or not T and other factors that changes smoothly with age υ. Further assume that retirement effects vary with at what age one was retired X^0, and how long one has been retired $X - X^0$, where the latter captures time-varying retirement effects. Then we can rewrite the consumption model as

$$Y = g(X) + h\left(X^0, X - X^0\right)T + \upsilon, \tag{6}$$

where $g(\cdot)$ and $h(\cdot)$ are assumed to be some smooth functions of their arguments. For convenience of illustration, assume a uniform kernel, then we can have the following local polynomial approximation of the above eq. (6)

$$Y = \sum\nolimits_{k=0}^{K} \lambda_k X^k + \sum\nolimits_{k=0}^{K} \sum\nolimits_{j=0}^{k} \tau_{kj}\left(X^0\right)^j \left(X - X^0\right)^{k-j} T + \varpi. \tag{7}$$

The average retirement effect at age 60 for those who retire at this mandatory retirement age (those with $X = X^0 = 0$) is then τ_{00}.

Assume that the retirement effect on consumption depends on retirement age and on how long one has been retired. The immediate or local effect of retirement on consumption at the mandatory retirement age 60 is still identified by the standard RD estimator, i.e.,

$$\tau_{00} = \frac{\lim_{x \to 0^+} E\left[Y \mid X = x\right] - \lim_{x \to 0^-} E\left[Y \mid X = x\right]}{\lim_{x \to 0^+} E\left[T \mid X = x\right] - \lim_{x \to 0^-} E\left[T \mid X = x\right]}. \tag{8}$$

Intuitively one can show that $\sum_{k=1}^{K} \sum_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j}$ or more generally terms involving X_0 and $X - X_0$ in eq. (6) are smooth at the (normalized) mandatory retirement age $X = 0$ and so they drop in the difference in the numerator. A quick proof is provided in the Appendix.

Assume a local linear approximation (i.e., $K = 1$) of the true consumption model, then

$$Y = \lambda_0 + \lambda_1 X + \tau_{00} T + \tau_{10} \left(X - X^0\right) T + \tau_{11} X^0 T + \varpi. \tag{9}$$

Assume further $\tau_{10} = \tau_{11}$, i.e., the retirement effect heterogeneity in retirement age is assumed to be the same as the time-varying effect of retirement, then eq. (9) reduces to $Y = \lambda_0 + \lambda_1 X + \tau_{00} T + \tau_{10} XT + \varpi$. For example, the retirement effect at age 61 is the same for those who retire at age 61 and those who retire at 60 but now at age 61. As restrictive as this may sound, without this restriction, in general with only cross section data as ours, one cannot separate how the retirement effect changes with time for those "compliers" who retire at age 60 from retirement effect heterogeneity in the retirement age.

We estimate the immediate effect τ_{00} and the time varying effect τ_{10} in eq. (9), using the mandatory retirement dummy D as an IV for retirement status T. In this case, the coefficient of T still identifies the immediate effect of retirement on consumption at the mandatory retirement age.

These estimates are presented in Tables 10 and 11. We focus on the prices and quantities of major food categories to obtain relatively precise estimates. As we can see, incorporating the time varying effect of retirement does not significantly change the estimated short-run effects. For both prices and quantities, the estimated coefficients of XT are small, so the retirement effects do not seem to change much over time. For example, for food prices, the estimates among the low education group range from 0 to -0.3%, so food prices decline a bit more the longer one has been retired. The estimates are mostly small and insignificant among the college education group. For food quantities, the estimates among the non-college education group are about -2%, relative to the initial increases, which are over 10% on average, so for them, the initial increase in the quantities of food for home cooking has a small decline over time. Overall, the immediate changes in food prices and quantities upon retirement seem to quite persist over time.

10 Validity of the RD Design

We estimate RD models to investigate the impacts of retirement. The validity of RD models require that individuals in the sample do not systematically sort around the mandatory retirement age, so that the density of household head's age and the conditional means of pre-determined covariates are smooth (see e.g., McCrary 2003, Lee 2008 and Dong 2014b).

If any covariates change discontinuously in response to household heads' retirement status here, they would confound our findings. For example, if male retirees systematically move in with adult children or if their spouses retire jointly with them, then the estimated retirement effects would be questionable.

We examine the smoothness of the density of household heads' age and the smoothness of pre-determined covariates, including household head's education level, marital status, spouses' retirement status, and household size. Although we condition on head's education, marital status, and household size in our analysis, a discontinuity in these variable means at the retirement age threshold would indicate incomparability of households just under and just above the retirement age threshold and hence would cast doubt on the validity of our RD models.

Figure 12 presents the empirical density of household heads' age, or the fraction of observations in each age cell and the age profile of covariate means. There are no obvious discontinuities or bunching around the mandatory retirement age 60.

We formally test the smoothness of the density of age and these covariate means. We use the empirical density, or the fraction of observations at each age, as the dependent variable and then regress this density on a polynomial function of age and the full set of interactions between this polynomial function and the binary indicator for being 60 or older. The coefficient of this binary indicator represents the potential discontinuity in the density of age at the age threshold.

To test the smoothness of pre-determined covariate means, we do parallel RD estimation using now these covariates as dependent variables. These tests are essentially falsification tests. False significant retirement effects on these pre-determined covariates would indicate discontinuities in these covariate means at the RD threshold. Note that in all these estimation, we take into account the fact that we use rounded age in years instead of true age as the running variable, and hence do similar bias corrections as described previously. The test results are presented in Table 12. None of the estimates are statistically significant, so the density of household heads' age and covariate means are smooth, which supports the validity of our RD analysis.

11 Conclusions

This study investigates how consumption and shopping time change at retirement. Mandatory retirement and social norms in China provide a unique quasi-experimental setting to investigate consumption declines at retirement, which has been documented extensively in the developed Western countries. Our analysis represents the first effort in providing evidence from a large developing country and more importantly in separating price changes from quantity changes.

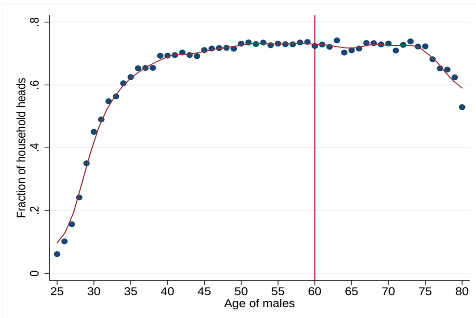
Based on regression discontinuity analysis and detailed consumption diary information, we first show that food expenditure declines significantly at retirement in China, but not clothing and transportation expenditures and that the decline concentrates among the low-education group. We then show that average prices paid for food decline but not quantities. In contrast, quantities of food purchased for home cooking may even increase, which is accompanied by a sharp decline in meals out among the low education group.

One key issue is whether the lower prices paid for food at retirement is due to retirees shopping for bargains or they purchasing to lower quality of food. Although we can not directly examine quality changes at retirement, we show that average time spent shopping for food increases significantly at retirement among the low education group, suggesting that the price declines observed for this group are induced at least in part by shopping for bargains.

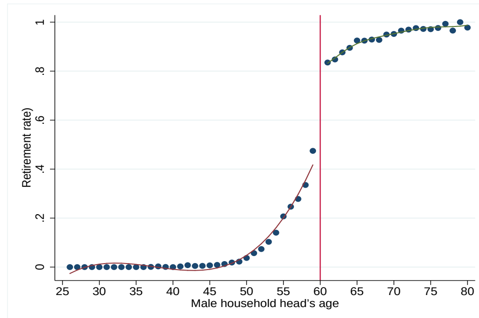
We also show that the one-off changes in food prices and quantities at retirement persist over time, and that there are little time-varying effects. Overall evidence suggests that there is a change in time use rather than a real consumption decline among retirees and that retirement does not appear to come as a surprise in this case. These results also confirm what is highlighted in Aguiar and Hurst (2005), i.e., given home production, expenditures on food are poor proxies for actual household consumption and mask the extent to which individuals smooth consumption in practice.

Finally food consumption consists of about 45% of the total consumption in our urban household sample. Over three fourth of the household heads do not have a college education in urban China in our sample period. Investigating the impact of retirement on food consumption particularly among the low education group has broad social and policy impacts in China.

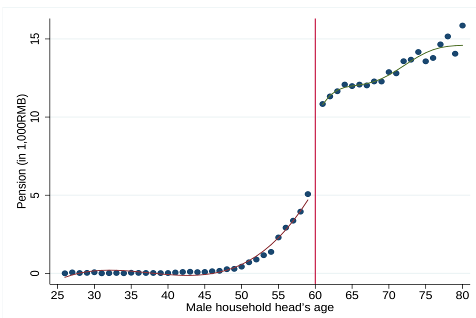
12 Appendix I



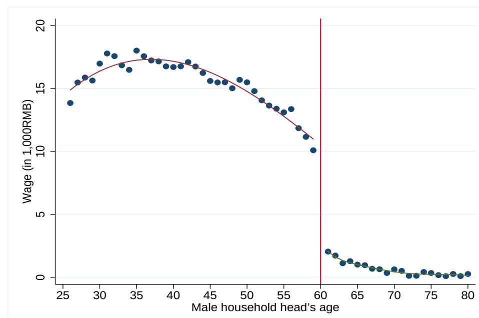
(a) Age distribution of household heads



(b) Retirement rate

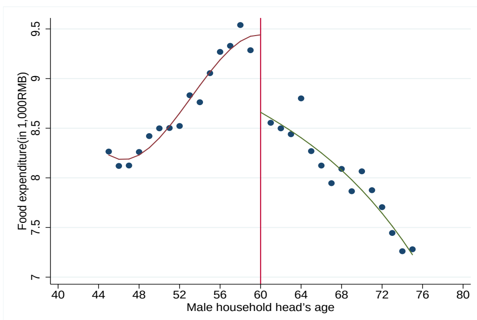


(c) Pension income

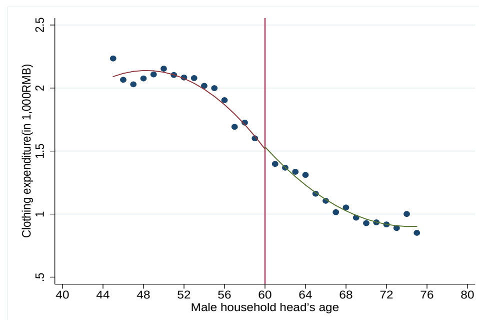


(d) Wage income

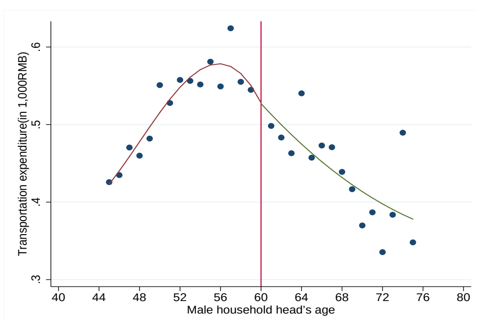
Figure 1: Age profiles of factions of household heads, heads' retirement rate, wage, and pension income, UHS 1997 - 2006



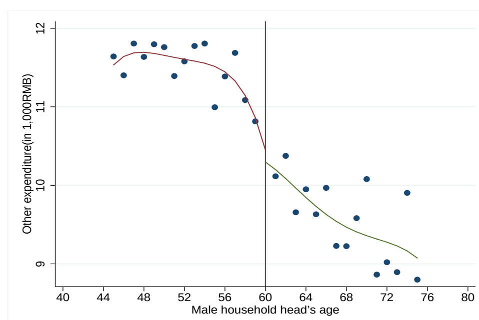
(a) Food



(b) Clothing

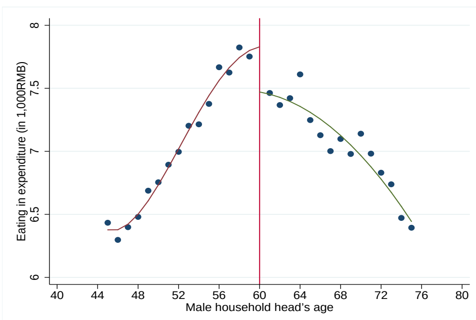


(c) Transportation

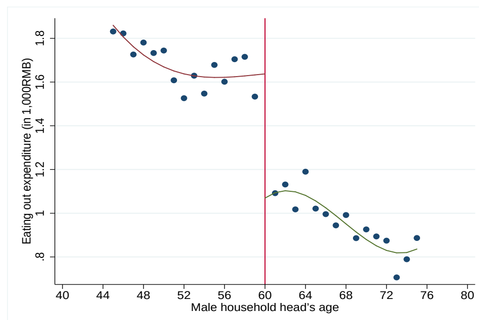


(d) Other

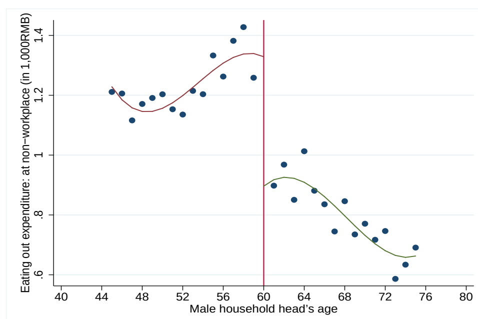
Figure 2: Age profiles of consumption expenditure: male household heads, UHS 1996 - 2007



(a) Food at home

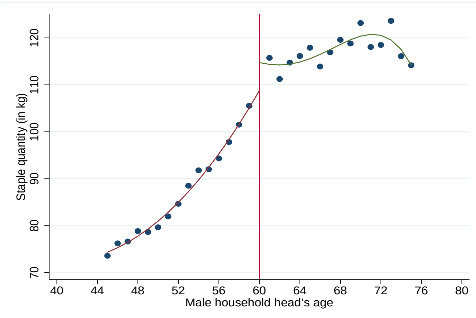


(b) Eating out

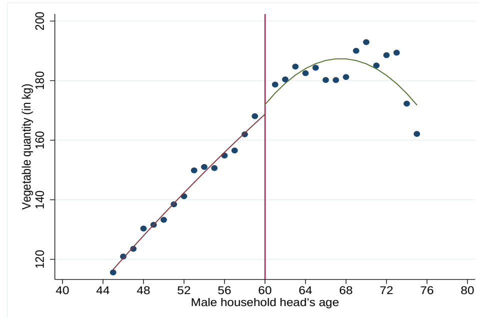


(c) Eating out: non-workplace restaurants

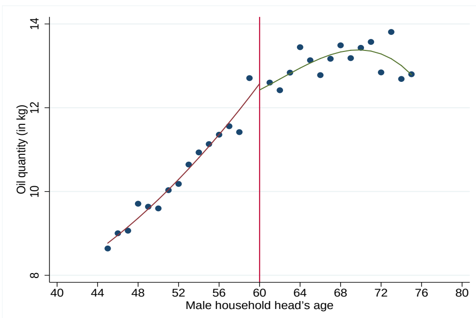
Figure 3: Age profiles of food expenditure: male household heads, UHS 1997 - 2006



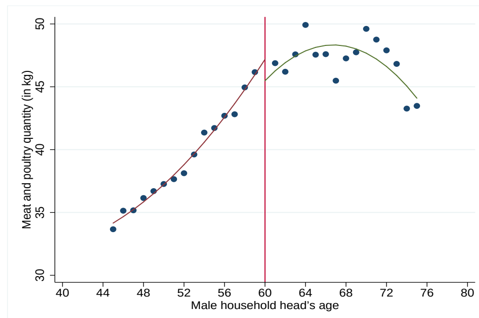
(a) Staple Quantity



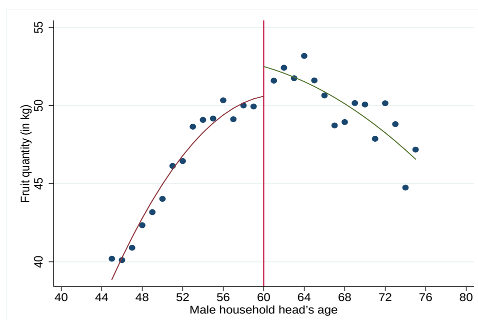
(b) Vegetable Quantity



(c) Oil and Fat Quantity

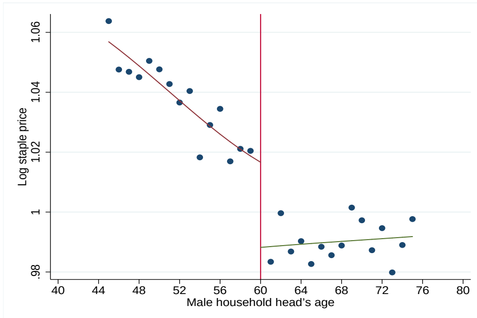


(d) Meat and Poultry Quantity

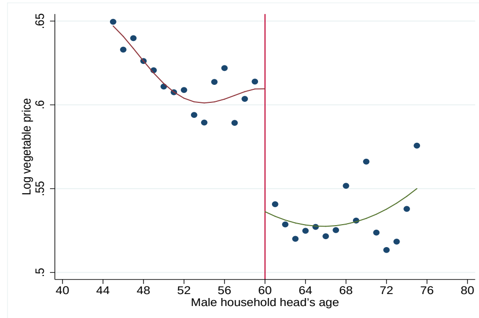


(e) Fruit Quantity

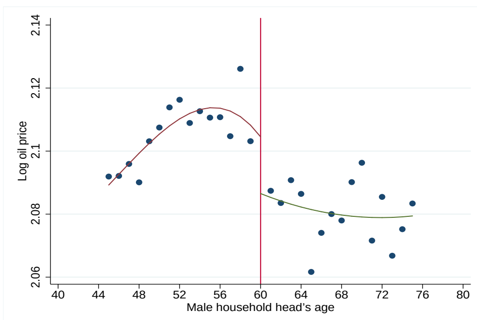
Figure 4: Age profiles of quantities purchased of different categories of food: male household heads, UHS 1997 - 2006



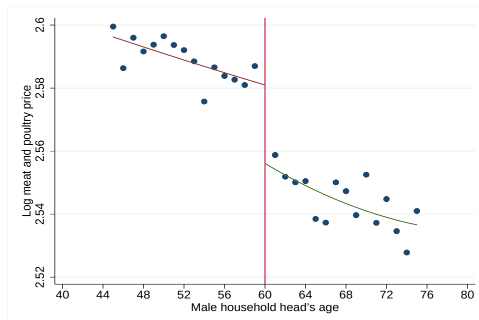
(a) Staple price



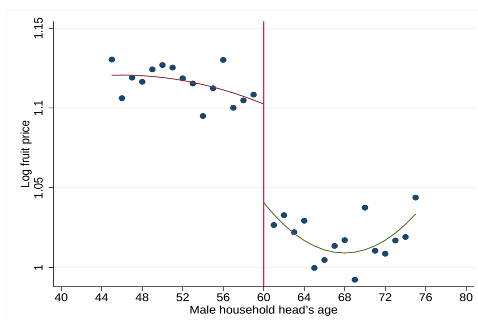
(b) Vegetable price



(c) Oil and fat price

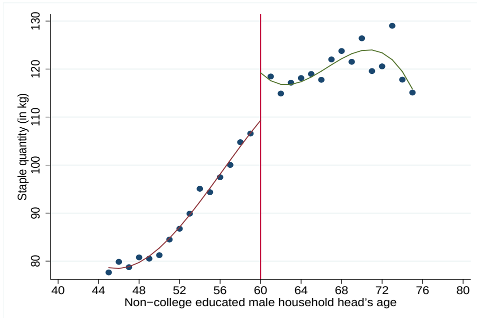


(d) Meat and poultry price

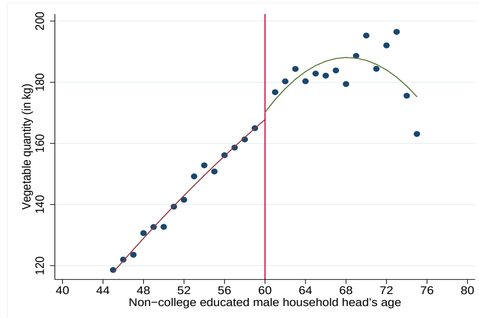


(e) Fruit price

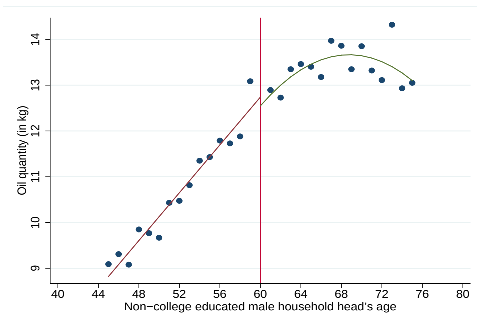
Figure 5: Age profiles of prices paid for different categories of food: male household heads, UHS 1997 - 2006



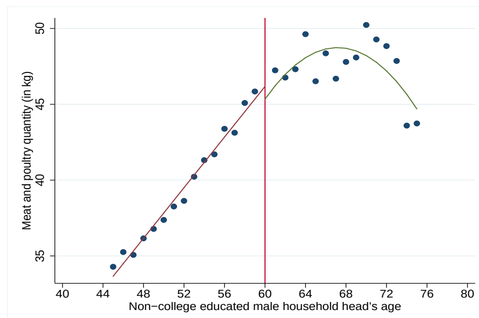
(a) Staple quantity



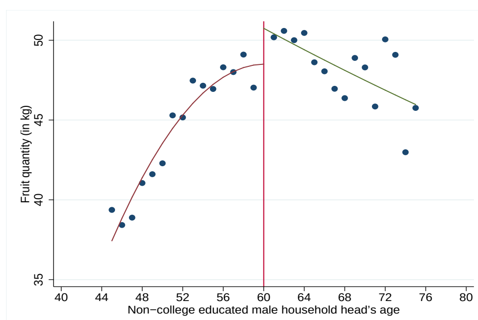
(b) Vegetable quantity



(c) Oil and fat quantity

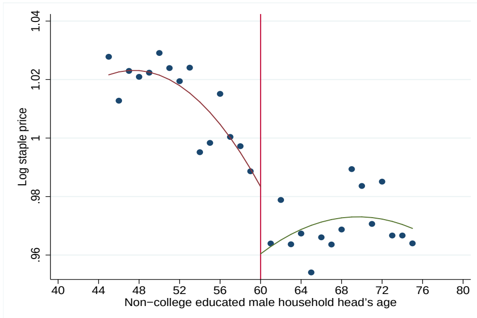


(d) Meat and poultry quantity

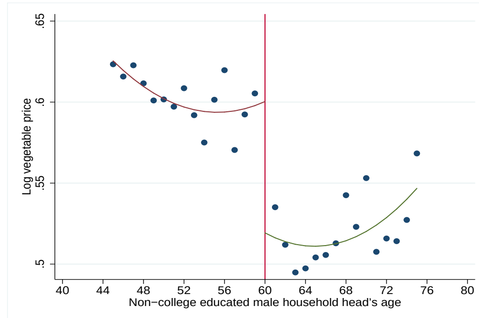


(e) Fruit quantity

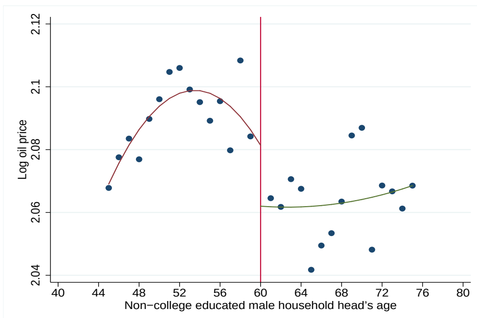
Figure 6: Age profiles of quantities purchased of different categories of food: Non-college educated male household heads, UHS 1997 - 2006



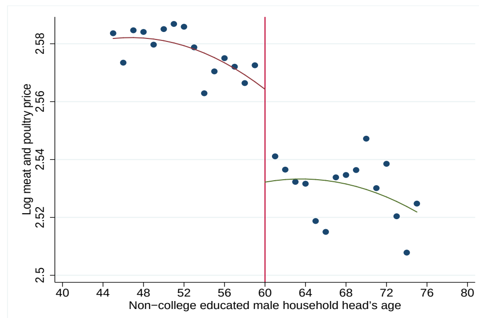
(a) Staple price



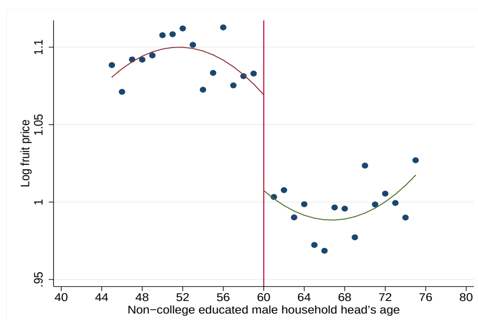
(b) Vegetable price



(c) Oil and fat price

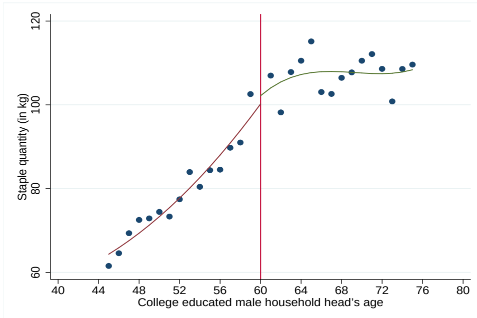


(d) Meat and poultry price

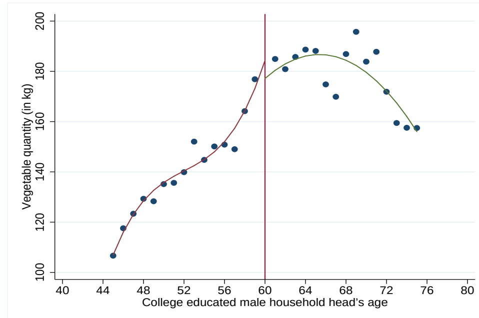


(e) Fruit price

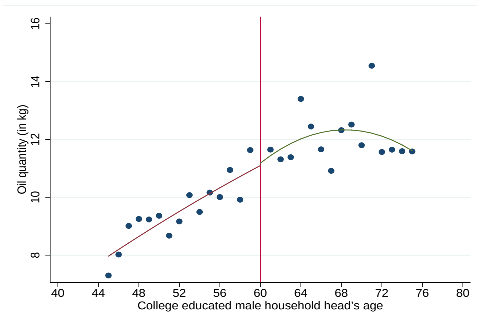
Figure 7: Age profiles of prices paid for different categories of food: Non-college educated male household heads, UHS 1997 - 2006



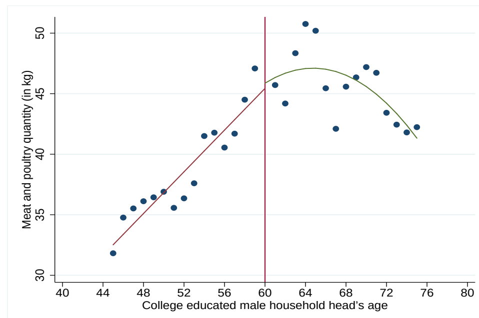
(a) Staple quantity



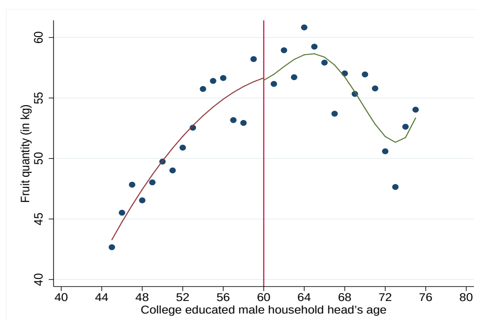
(b) Vegetable quantity



(c) Oil and fat quantity

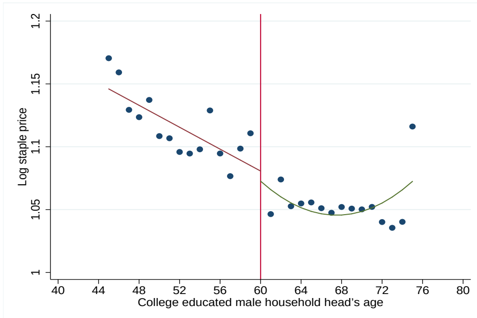


(d) Meat and poultry quantity

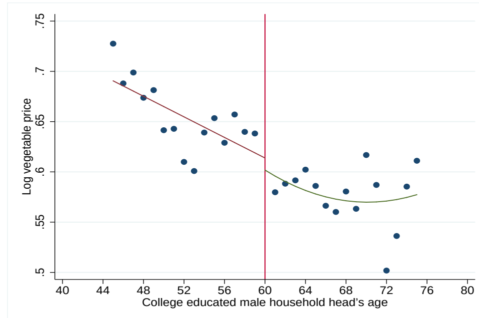


(e) Fruit quantity

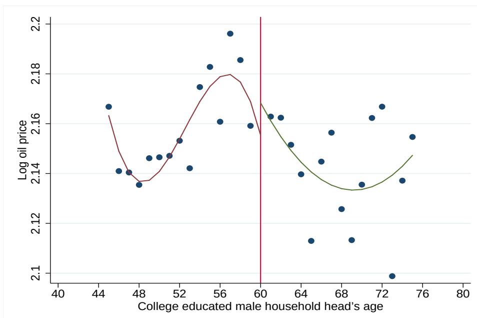
Figure 8: Age profiles of quantities purchased of different categories of food: College educated male household heads, UHS 1997 - 2006



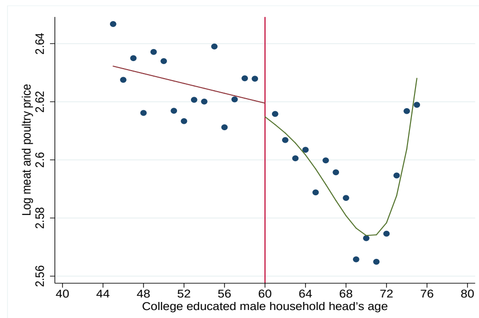
(a) Staple price



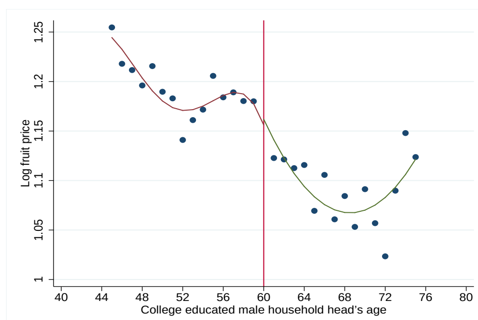
(b) Vegetable price



(c) Oil price

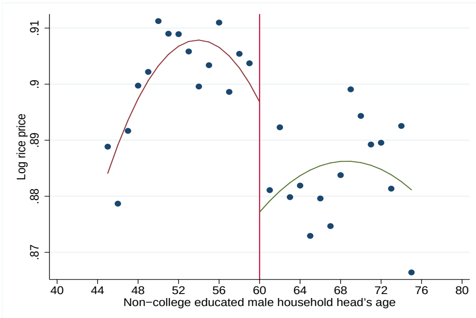


(d) Meat and poultry price

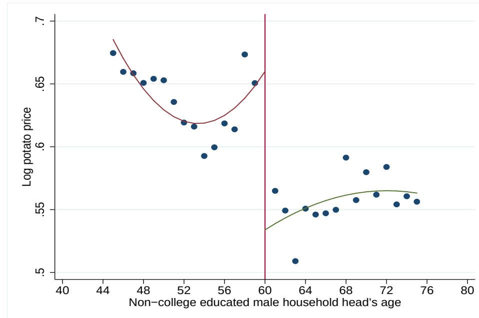


(e) Fruit price

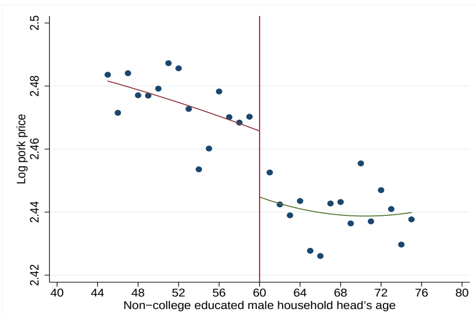
Figure 9: Age profiles of prices paid for different categories of food: College educated male household heads, UHS 1997 - 2006



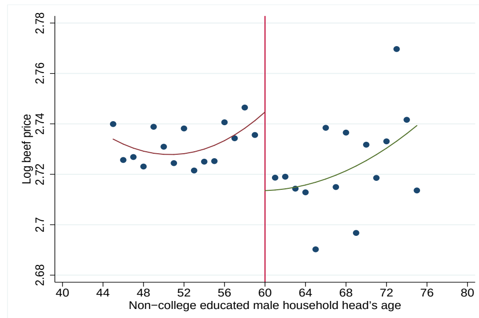
(a) Rice price



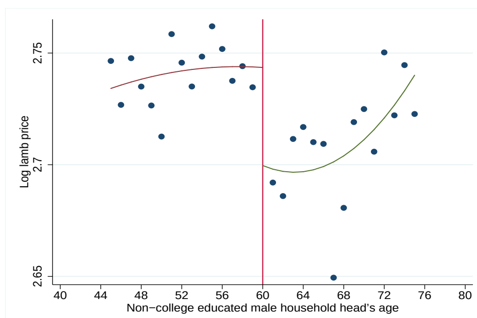
(b) Potato price



(c) Pork price

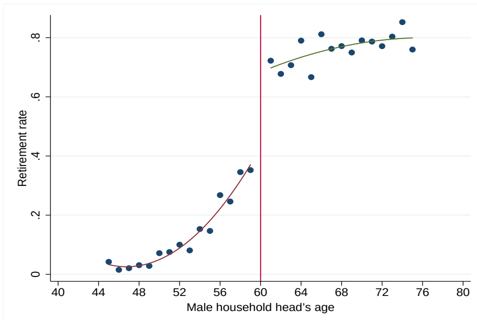


(d) Beef price

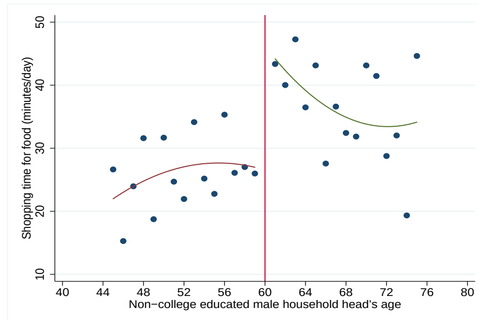


(e) Lamb price

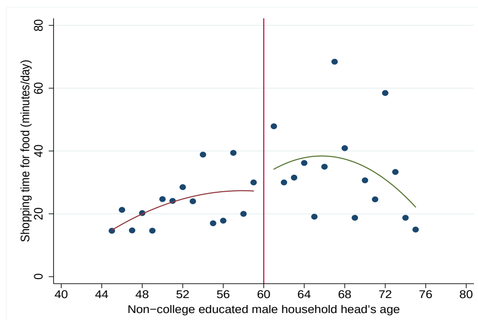
Figure 10: Age profiles of prices paid for food: Non-college educated male household heads, UHS 1997 - 2006



(a) Retirement rate in the CHNS sample

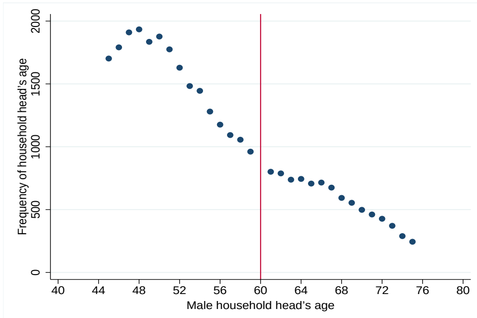


(b) Average daily shopping time for food: Non-college educated household heads

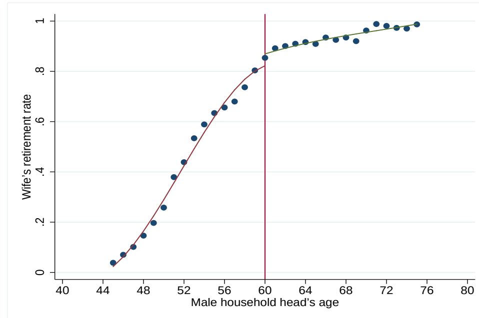


(c) Average daily shopping time for food: College educated household heads

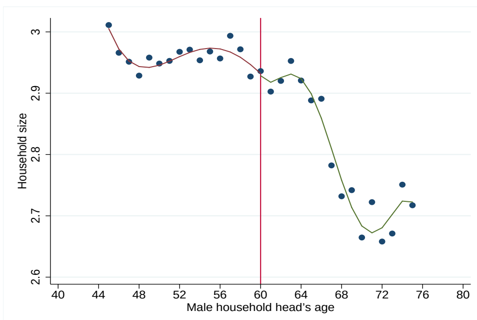
Figure 11: Age profiles of retirement rate, shopping time for food: male household heads, CHNS 1989-2009



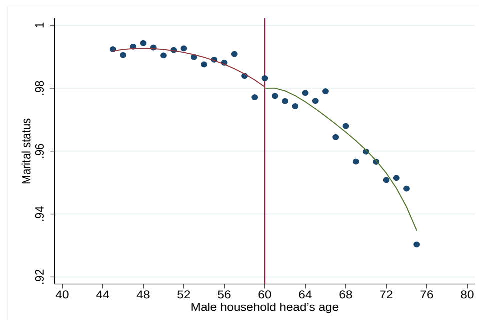
(a) Frequency of age



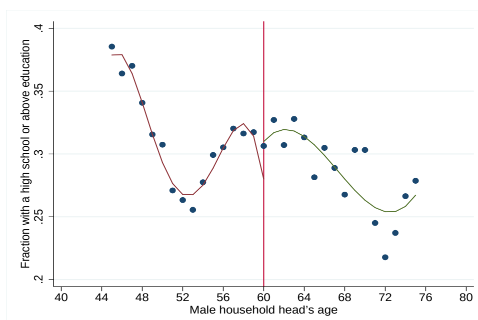
(b) Wife's retirement rate



(c) Household size



(d) Marital status



(e) Household head's education

Figure 12: Age profiles of the empirical density of age and covariate means: male household heads, UHS 1997 - 2006

Table 1 The retirement rate increase at the mandatory retirement age 60 for male household heads

2nd order Polynomial	0.290	0.288	0.280	0.307	0.301	0.294			
	(0.037)***	(0.036)***	(0.036)***	(0.020)***	(0.020)***	(0.020)***			
3rd order Polynomial	0.285	0.294	0.295	0.277	0.275	0.269	0.295	0.292	0.285
	(0.085)**	(0.084)**	(0.084)**	(0.036)***	(0.035)***	(0.035)***	(0.020)***	(0.020)***	(0.020)***
4th order Polynomial				0.301	0.306	0.307	0.270	0.269	0.254
				(0.068)***	(0.068)***	(0.067)***	(0.033)***	(0.033)***	(0.033)***
Year fixed effects	N	Y	Y	N	Y	Y	N	Y	Y
Province fixed effects	N	Y	Y	N	Y	Y	N	Y	Y
Year-province fixed effects	N	N	Y	N	N	Y	N	N	Y
Demographic controls	N	N	Y	N	N	Y	N	N	Y
Bandwidth	6	6	6	10	10	10	15	15	15

Note: Male household heads, UHS 1997-2006; Demographic controls include head's education, marital status, family size, and family size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 1b The retirement rate increase at the mandatory retirement age 60 for male household heads, without correcting for discrete age bias

2nd order Polynomial	0.251	0.249	0.241	0.278	0.271	0.264			
	(0.033)***	(0.033)***	(0.033)***	(0.019)***	(0.019)***	(0.018)***			
3rd order polynomial	0.133	0.137	0.130	0.241	0.238	0.232	0.262	0.258	0.252
	(0.067)**	(0.066)**	(0.066)**	(0.031)***	(0.031)***	(0.030)***	(0.018)***	(0.018)***	(0.018)***
4th order polynomial				0.188	0.195	0.191	0.236	0.233	0.228
				(0.052)***	(0.052)***	(0.052)***	(0.028)***	(0.027)***	(0.027)***
Year fixed effects	N	Y	Y	N	Y	Y	N	Y	Y
Province fixed effects	N	Y	Y	N	Y	Y	N	Y	Y
Year-province fixed effects	N	N	Y	N	N	Y	N	N	Y
Demographic controls	N	N	Y	N	N	Y	N	N	Y
Bandwidth	6	6	6	10	10	10	15	15	15

Note: Male household heads, UHS 1997-2006; Demographic controls include head's education, marital status, family size, and family size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 2 Retirement effects on different categories of expenditure

	Non-college group			College group		
Food	-0.041	-0.053	-0.047	0.031	0.045	0.052
	(0.027)	(0.025)**	(0.025)**	(0.039)	(0.038)	(0.038)
Clothes	0.222	0.191	0.198	0.028	0.072	0.079
	(0.182)	(0.176)	(0.178)	(0.189)	(0.192)	(0.192)
Transport	0.021	0.023	0.060	0.158	0.159	0.192
	(0.210)	(0.212)	(0.217)	(0.258)	(0.258)	(0.258)
Other	0.115	0.214	0.276	0.053	0.103	0.129
	(0.233)	(0.228)	(0.228)	(0.258)	(0.255)	(0.247)
Year fixed effects	Y	Y	Y	Y	Y	Y
Province fixed effects	Y	Y	Y	Y	Y	Y
Demographic controls	N	Y	Y	N	Y	Y
Year-province fixed effects	N	N	Y	N	N	Y

Note: Male household heads, UHS 1997-2006; Demographic controls include head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 3 Retirement effects on different categories of food expenditure

	Non-college group			College group		
Food at home	-0.026	-0.033	-0.031	0.025	0.029	0.039
	(0.025)	(0.024)	(0.024)	(0.036)	(0.035)	(0.035)
Food out (total)	-0.229	-0.250	-0.232	-0.003	0.020	0.047
	(0.070)***	(0.068)***	(0.069)***	(0.116)	(0.118)	(0.117)
Food out (non-workplace	-0.276	-0.300	-0.289	0.092	0.101	0.125
restaurants)	(0.069)***	(0.067)***	(0.068)***	(0.128)	(0.129)	(0.130)
Year fixed effects	Y	Y	Y	Y	Y	Y
Province fixed effects	Y	Y	Y	Y	Y	Y
Demographic controls	N	Y	Y	N	Y	Y
Year-province fixed effects	N	N	Y	N	N	Y

Note: Male household heads, UHS 1997-2006; Demographic controls include head's education, marital status, household size, and household size squared; Food-out expenditure has a non-negligible fraction of zeros and so is not logged in estimation; percentage changes are reported here by converting the estimated average level changes. Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 4 Retirement effects on average prices for different categories of food

	Non-college group		College group	
Staple	-0.013	(0.011)	-0.013	(0.020)
Vegetable	-0.075	(0.016)***	0.006	(0.024)
Oil	-0.041	(0.012)***	0.007	(0.023)
Meat	-0.028	(0.009)***	0.007	(0.014)
Meat and Poultry	-0.025	(0.009)***	0.004	(0.014)
Fruit	-0.106	(0.018)***	-0.022	(0.026)

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 5 Retirement effects on quantities purchased of different categories of food

	Non-college group		College group	
Staple	0.151	(0.078)**	0.055	(0.044)
Vegetable	0.101	(0.026)***	-0.045	(0.138)
Oil	0.109	(0.039)***	0.062	(0.067)
Meat	0.089	(0.029)***	0.053	(0.043)
Meat and Poultry	0.081	(0.028)***	0.033	(0.041)
Fruit	-0.008	(0.035)	-0.008	(0.049)

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 6 Retirement effects on prices of food

	Non-college group		College group	
Rice	-0.015	(0.022)	-0.016	(0.015)
Potato	-0.125	(0.061)**	-0.044	(0.034)
Pork	-0.007	0.022	0.017	(0.012)
Beef	-0.038	0.046	0.000	(0.048)
Lamb	-0.096	(0.083)	0.028	(0.032)

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 7 Retirement effects on quantities of food

	Non-college group		College group	
Rice	0.102	(0.129)	0.096	(0.086)
Potato	0.181	(0.057)***	0.085	(0.084)
Pork	0.090	(0.038)**	0.014	(0.059)
Beef	-0.032	(0.080)	0.051	(0.404)
Lamb	-0.060	(0.080)	-0.186	(0.440)

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 8 Retirement effects on food consumption index and predicted food expenditure

	Non-college group		College group	
log of food consumption index	-0.022	(0.008)***	-0.004	(0.011)
log of predicted food expenditure	0.005	(0.011)	0.008	(0.014)

Note: Male household heads, UHS 1997-2006; Food consumption index is in the unit of permanent income, taking into account both quantities and prices of various foods a household consumed, while predicated food expenditure holds food prices fixed; Detailed construction of both are in the main text; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 9 Retirement effects on time spent shopping for food

	Non-college group		College group	
Time spent on shopping for food	22.04	(6.944)***	8.267	(15.96)
Whether shopping for food last week (0/1)	0.229	(0.077)***	0.031	(0.169)

Note: Male household heads, CHNS 1989-2009; All estimates control for province, year and province-year fixed effects; Robust standard errors are in the parentheses; The average shopping time for the non-college sample is 22.98 minutes per day, and is 49.96 minutes per day among those with positive time, while the average shopping time for the college sample is 26.66 minutes per day and is 45.53 minutes per day among those with positive time. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 10 Time-varying Effects of Retirement on Food Prices

	Non-college group		College group	
	Retire	Retire*(Age-60)	Retire	Retire*(Age-60)
Staple	-0.016	0.002	-0.013	0.004
	(0.011)	(0.001)***	(0.020)	(0.001)***
Vegetable	-0.075	0.000	0.006	0.001
	(0.016)***	(0.001)	(0.024)	(0.002)
Oil	-0.040	-0.001	0.005	-0.002
	(0.012)***	(0.001)*	(0.023)	(0.002)
Meat	-0.026	-0.001	0.006	-0.001
	(0.009)***	(0.000)***	(0.013)	(0.001)
Meat & Poultry	-0.023	-0.001	0.004	-0.001
	(0.009)***	(0.000)***	(0.014)	(0.001)
Fruit	-0.102	-0.003	-0.022	0.002
	(0.017)***	(0.001)***	(0.026)	(0.002)

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 11 Time-varying Effects of Retirement on Food Quantities

	Non-college group		College group	
	Retire	Retire*(Age-60)	Retire	Retire*(Age-60)
Staple	0.204	-0.031	0.052	-0.019
	(0.079)**	(0.006)***	(0.044)	(0.003)***
Vegetable	0.124	-0.017	-0.037	-0.065
	(0.026)***	(0.001)***	(0.144)	(0.042)
Oil	0.132	-0.017	0.060	-0.013
	(0.040)***	(0.002)***	(0.067)	(0.005)***
Meat	0.110	-0.016	0.050	-0.017
	(0.030)***	(0.001)***	(0.043)	(0.003)***
Meat & Poultry	0.101	-0.015	0.030	-0.017
	(0.029)***	(0.001)***	(0.041)	(0.003)***
Fruit	0.022	-0.023	-0.011	-0.023
	0.036	(0.002)***	(0.049)	(0.003)***

Note: Male household heads, UHS 1997-2006; All estimates control for year fixed effect, province fixed effect, year-province fixed effects, a low order polynomial of household heads' age, head's education, marital status, household size, and household size squared; Robust standard errors are in the parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 12 Estimated discontinuities in the density of age and retirement effects on covariate means

Density of age	-0.005	(0.003)	Married	0.003	(0.008)
College education	-0.055	(0.057)	Wife retired	-0.106	(0.221)
High school education	-0.012	(0.063)	Household size	0.026	(0.056)

Note: Male household heads, UHS 1997-2006; The regression estimate density of age controls for a smooth polynomial age function, while all other GMM IV estimates additionally control for year fixed effects, province fixed effects and province-year fixed effects. Robust standard errors are in the parentheses.

13 Appendix II

The following provides a quick summary of the literature on the "retirement-consumption puzzle" based on developed countries' data.

In a seminal paper based on the British Family Expenditure Survey (BFES) data, Banks, Blundell and Tanner (1998) show that when households heads retire consumption falls more than predicted by a forward-looking consumption smoothing model. Using a different data set, the British Household Panel Survey (BHPS) data, Smith (2006) compares food spending of male workers retiring involuntarily (due to poor health or being laid off) with spending of male workers who retire voluntarily. He finds a significant fall in spending only for those who retire involuntarily in the UK.

Many more studies are based on US data, including the Panel Study of Income Dynamics (PSID), the Health and Retirement Study (HRS), the Retirement History Survey (RHS), the Consumption and Activities Mail Survey (CAMS), a supplemental survey to the HRS, the Consumer Expenditure Survey (CES), and the survey data on participants of Teachers Insurance and Annuity Association – College Retirement Equities Fund (TIAA-CREF). Bernheim, Skinner and Weinberg (2001) find a consumption drop at retirement in the US, using the 1978-1990 PSID data. Haider and Stephens (2007) employ workers' subjective beliefs about their retirement dates as an instrument for retirement, and find that workers who expect retirement experience a smaller consumption decline, using the HRS data. Using data from the TIAA-CREF, Ameriks, Caplin, and Leahy (2007) show that many working households expect a fall in consumption when they retire, and that the actual decline in consumption at retirement is even smaller than expected declines. Based on the panel CAMS data, Hurd and Rohwedder (2008) examine the actual spending changes around retirement, they show that spending declines at small rates over retirement, at rates that could be explained by the cessation of work-related expenses, unexpected retirement due to a health shock or by the substitution of time for spending. Aguila, Attanasio, and Meghir (2010) use the panel component of the 1980-2000 CES and show that food expenditure declines at retirement but not nondurable consumption.

In Italy, Miniaci, Monfardini, and Weber (2009) document the a one-off consumption drop when household heads retire. Battistin, Brugiavini, Rettore and Weber (2009) also show that nondurable consumption drops when male household heads retire in Italy. Borella, Moscarola, and Rossi (2011) exploit the panel dimension of the Italian Survey of Household Income and Wealth (SHIW) data, and find evidence of a significant drop of nondurable expenditures at retirement for low educated individuals and less wealthy individuals.

In addition, based on the Canadian Family Expenditure Survey (CFES), Robb and Burbridge (1989) show that blue-collar households in Canada experience a sharp consumption decline upon retirement. Schwerdt (2005) finds that consumption on average drops at retirement in Germany, and that the actual drop concentrates in the low income replacement group, using the German Socio-Economic Panel (GSOEP) data.

Wakabayashi (2008) compares average consumption expenditure of retired households with that of working households using the 1996 Survey of the Financial Asset Choice of Households (SFACH). He finds that the average consumption level is indeed lower for retired households in Japan.

14 Appendix III

This Appendix illustrates the bias incurred when using age in years as a running variable and describe a bias correction procedure. For simplicity, consider the following quadratic regression for retirement

$$T = \sum\nolimits_{j=0}^{J} a_j X^j + \sum\nolimits_{j=0}^{J} b_j X^j D + v. \tag{10}$$

Recall that X is the (unobserved) true continuous age. Let $\widetilde{X}$ be the reported age in years minus 60, which is the exact age rounded down to the nearest integer, so $X = \widetilde{X} + e$, where e is the difference between the true age and the rounded age in years, or the rounding error. Assume that one's birth date e is independent of his integer age X, we have

$$\begin{aligned} T &= \textstyle\sum_{j=0}^{2} a_j (\widetilde{X}+e)^j + \sum_{j=0}^{2} b_j (\widetilde{X}+e)^j D + v \\ &= (a_0 + a_1\mu_1 + a_2\mu_2) + (a_1 + 2a_2\mu_1)\,\widetilde{X} + a_2 \widetilde{X}^2 \\ &\quad + (b_0 + b_1\mu_1 + b_2\mu_2)\,D + (b_1 + 2b_2\mu_1)\,\widetilde{X} D + b_2 \widetilde{X}^2 D + w \\ &= \textstyle\sum_{j=0}^{2} \alpha_j \widetilde{X}^j + \sum_{j=0}^{2} \beta_j \widetilde{X}^j D + w, \end{aligned} \tag{11}$$

where $\mu_j = E(e^j)$ for $j = 0, 1, 2$ is the jth raw moments of the birthdate distribution within a year, $\alpha_j \equiv \sum_{k=j}^{2} \binom{k}{j} a_k \mu_{k-j}$ and $\beta_j \equiv \sum_{k=j}^{2} \binom{k}{j} b_k \mu_{k-j}$ for $j = 0, 1, 2$ and $w = T - E(T \mid \widetilde{X})$. Assume that birth dates within a year are uniformly distributed, so that the rounding error e has a uniform distribution between 0 and 1, then the jth moment is $\mu_j = 1/(j+1)$.[14]

If one estimates a polynomial regression of T on the rounded age in years $\widetilde{X}$, or equation (11), then the discontinuity in the retirement rate is $\beta_0 \equiv b_0 + b_1\mu_1 + b_2\mu_2$, which in general would not equal the true change b_0 unless b_1 and b_2 are both zero, given $\mu_1 \neq 0$ and $\mu_2 \neq 0$.

To obtain a consistent estimate of the true change in the mean consumption, one can use β_j in the discrete data regression (11) and the rounding error moments μ_j to back out the true coefficients b_j for $j = 0, 1, 2$. Plugging in these moments and solving the system of equations $\beta_j = \sum_{k=j}^{2} \binom{k}{j} b_k \mu_{k-j}$ for b_j for $j = 0, 1, 2$, one has the true consumption change at the mandatory retirement age is $b_0 = \beta_0 - 1/2\beta_1$. The standard errors can be obtained by the Delta method. A general formula that works for any order of polynomial is Dong (2014a).

[14]There exists evidence of small but statistically significant seasonal departures from uniformity in the distribution of births within a year. However, this seasonal variation appears to have very little impact on the lower order moments. Alternatively, one could estimate those moments using a second source of data where one observe age in days. However, we are not aware of any comparable data sets that have age in days.

15 Appendix III

This appendix shows that the standard RD estimation still provides correct estimates of the immediate effects of retirement on outcomes, even when there exist variable delayed effects of retirement, and when the retirement effects are heterogeneous in retirement age.

Define potential treatment status T_d if $D = d$ for $d \in (0, 1)$. Then we can define four types of individuals as events in a common probability space $(\Omega, \mathcal{F}, P)$ as in Angrist, Imbens and Rubin (1996): always takers (denoted as A) are individuals with $T_1 = T_0 = 1$; never takers (N) are individuals with $T_1 = T_0 = 0$; compliers (C) are individuals with $T_1 = 1, T_0 = 0$; and defiers (D) are individuals with $T_1 = 0, T_0 = 1$.

Given $Y = \sum_{k=0}^{K} \lambda_k X^k + \tau_{00} + \sum_{k=1}^{K} \sum_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} T + \varpi$, the following shows that $\sum_{k=1}^{K} \sum_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j}$ is smooth and so the treatment heterogeneity function will cancel out in the mean difference in Y at $X = 60$.

$$\begin{aligned}
& \lim_{x \to 0^+} E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \lambda_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} T \mid X = x\right] \\
= & \lim_{x \to 0^+} E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \lambda_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} \mid X = x, T = 1\right] \Pr\left(T = 1 \mid X = x\right) \\
= & \lim_{x \to 0^+} E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \lambda_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} \mid X = x, A \cup C\right] \Pr\left(A \cup C \mid X = x\right) \\
= & E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \lambda_{kj} \left(X^0\right)^j \left(-X^0\right)^{k-j} \mid X = 0, A\right] \Pr\left(A \mid X = 0\right) \\
& + E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \lambda_{kj} \left(X^0\right)^j \left(-X^0\right)^{k-j} \mid X = 0, C\right] \Pr\left(C \mid X = 0\right)
\end{aligned}$$

and similarly

$$\begin{aligned}
& \lim_{x \to 0^-} E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} T \mid X = x\right] \\
= & \lim_{x \to 0^-} E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} \mid X = x, T = 1\right] \Pr\left(T = 1 \mid X = x\right) \\
= & E\left[\sum\nolimits_{k=1}^{K} \sum\nolimits_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(-X^0\right)^{k-j} \mid X = 0, A\right] \Pr\left(A \mid X = 0\right)
\end{aligned}$$

Then

$$
\begin{aligned}
& \lim_{x\to 0^+} E\left[\sum\nolimits_{k=1}^{K}\sum\nolimits_{j=0}^{k}\lambda_{kj}\left(X^0\right)^j\left(X-X^0\right)^{k-j}T\mid X=x\right] \\
& -\lim_{x\to 0^-} E\left[\sum\nolimits_{k=1}^{K}\sum\nolimits_{j=0}^{k}\lambda_{kj}\left(X^0\right)^j\left(X-X^0\right)^{k-j}T\mid X=x\right] \\
= \;& E\left[\sum\nolimits_{k=1}^{K}\sum\nolimits_{j=0}^{k}\tau_{kj}\left(X^0\right)^j\left(-X^0\right)^{k-j}\mid X=0,C\right]\Pr\left(C\mid X=0\right) \\
= \;& 0\cdot\Pr\left(C\mid X=0\right)=0
\end{aligned}
$$

where the second equality follows from the fact that compliers retire at age 60, and so have $X^0=0$.

Given $Y=\sum_{k=0}^{K}\lambda_k X^k+\tau_{00}T+\sum_{k=1}^{K}\sum_{j=0}^{k}\tau_{kj}\left(X^0\right)^j\left(X-X^0\right)^{k-j}T+\varpi$, then we have

$$
\begin{aligned}
& \lim_{x\to 0^+} E\left[Y\mid X=x\right]-\lim_{x\to 0^-} E\left[Y\mid X=x\right] \\
= \;& \tau_{00}\left(\lim_{x\to 0^+} E\left[T\mid X=x\right]-\lim_{x\to 0^-} E\left[T\mid X=x\right]\right),
\end{aligned}
$$

where the equality follows from smoothness of $E\left[\varpi\mid X=x\right]$ by assumption, continuity of $E\left[\sum_{k=0}^{K}\lambda_k X^k\mid X=x\right]$ and continuity of $E\left[\sum_{k=1}^{K}\sum_{j=0}^{k}\tau_{kj}\left(X^0\right)^j\left(X-X^0\right)^{k-j}T\mid X=x\right]$ at $x=0$ as shown above.

It follows immediately

$$
\tau_{00}=\frac{\lim_{x\to 0^+} E\left[Y\mid X=x\right]-\lim_{x\to 0^-} E\left[Y\mid X=x\right]}{\lim_{x\to 0^+} E\left[T\mid X=x\right]-\lim_{x\to 0^-} E\left[T\mid X=x\right]}.
$$

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