Understanding the Retirement-Consumption Puzzle through the Lens of Food Consumption − Fuzzy Regression-Discontinuity Evidence from Urban China

Tinghe Deng
Center for Food and Health Economic Research, College of Economics and Management, China Agricultural University, Beijing 100083

Qihui Chen
Department of Applied Economics & Center for Food and Health Economic Research, College of Economics and Management, China Agricultural University, Beijing 100083

Junfei Bai
Department of Agricultural Economics & Center for Food and Health Economic Research, College of Economics and Management, China Agricultural University, Beijing 100083

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Center for Food and Health Economic Research,
College of Economics and Management,
China Agricultural University

Abstract

This paper attempts to provide an understanding of the widely-documented retirement-consumption puzzle from the perspective of food consumption. Exploiting urban China's "forced" retirement system, we use the legal retirement age cut-off as an instrumental variable for one's retirement status to estimate the causal impacts of retirement on four major aspects of food consumption for males aged 50-70 in urban China: food expenditure, time spent on food acquisition, the quantity and quality of food consumed. Our fuzzy regression-discontinuity analysis of the China Health and Nutrition Survey data finds that, consistent with the retirement-consumption puzzle, retirement reduces individuals' total food expenditure by 49%. However, retirement barely changes their quantity of food consumed (measure by total calorie intakes). Serving to reconcile the differential retirement impacts on elderly males' food expenditure and consumption, retirees are found to substitute their time for money in food acquisition upon retirement. However, they have to sacrifice some quality for quantity of food consumption while smoothing the latter. Given the criteria provided by the Chinese Nutrition Association, retirement negatively affects retirees' diet balance. They consume significantly less food with animal origins (and thus less fat and protein) and more grains (and thus more carbohydrate) upon retirement.

Keywords: Food expenditure, Food consumption, Resource substitution, Retirement, Urban China

JEL Classification: E20, J14, J26

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1. Introduction

Both Modigliani and Brumberg's (1954) life-cycle saving model and Friedman's (1957) permanent-income hypothesis predict that rational, forward-looking individuals can smooth their consumption in response to foreseeable income shocks such as retirement. Yet numerous empirical studies have found that a household's expenditure on nondurable goods drops significantly upon the retirement of its members (e.g. Hamermesh, 1984; Schwerdt, 2005; Battistin *et al*. 2009; Wakabayashi, 2008; Cho, 2012). The drop in nondurable expenditure at retirement, often termed the "retirement-consumption" puzzle, has been conventionally interpreted as evidence of a household's failure to plan sufficiently for retirement of its members (e.g. Bernheim *et al*. 2001) or of unanticipated shocks that occur at retirement (e.g. Banks *et al*. 1998).

However, the seminal study conducted by Aguiar and Hurst (2005), among others, cast serious doubt on these conventional interpretations, at least when the term "nondurable goods" is narrowly referred to as *food*. Built upon Becker's (1965) theory of home production and time allocation, which postulates that consumption is indeed the *production* of utility using time and marketed goods as inputs, Aguiar and Hurst argued that the drop in individuals' food expenditure upon retirement does not necessarily imply a drop in their actual amount of food consumed. This is because rational retirees can substitute their increased time resource due to retirement for decreased monetary resource devoted to food acquisition. Based on two nationally representative datasets on households in the United States,[1] Aguiar and Hurst also provided strong empirical evidence to support their argument. First, they showed that individuals' amount of food

[1] The Continuing Survey of Food Intake of Individuals data and the National Human Activity Pattern Survey data.

consumed (measured by total calorie intakes) barely changed at retirement. Second, in accompany with the (17%) drop in households' money spent on food upon their members' retirement, their time spent on domestic food production increases by more than 50%. Viewed from the angle of resource substitution, the widely documented retirement-consumption puzzle is hardly puzzling.

Two important implications can be derived from Aguiar and Hurst's analysis. First, using food expenditure to proxy food consumption in demand analysis may result in misleading assessments of retirees' well-beings in large aging societies such as the United States. On one hand, assessed in absolute terms, food expenditure tends to underestimate the actual amount of food consumed by retirees. On the other hand, relative measures, such as the Engle coefficient, are likely to overestimate the welfare of the elderly, because the drop in their food expenditure at retirement may lead to an underestimation of the (shadow) value of their budget share for non-food and more luxury goods. Second, retirement induces a series of changes in elderly individuals' resource (e.g. time and money) endowments and their everyday life. The change in the *relative* abundance of their resources and the resulted change in the relative (shadow) prices of these resources will urge rational retirees to re-optimize their food consumption behavior in response to these changes. The termination of retirees' employment contracts will also change their food consumption behavior, e.g. reducing the incidence of dining out for work-related meals while increasing time spent in food production at home. However, whether retirees can fully smooth the quantity and quality of their food consumption (which are both key aspects of their well-being) in response to these retirement-induced changes demands empirical scrutiny. In other words, whether retirement and the widely-documented drop in food expenditure upon retirement indeed lead to a decline in elderly individuals' well-being hinges on what is being smoothed upon retirement.

Keeping these implications in mind, one naturally wonders: is American individuals' resource-substitution behavior upon retirement also relevant to other large aging societies, such as China, Japan and Korea, etc. whose retirement systems are quite different from the American system? If so, the conventional practice of using food expenditure or related measures to (partially) assess consumer welfare is likely to yield misleading results for the elderly populations in these societies, for whom the budget share for food is large (Chinese Consumer Association, 2013). To better understand retirees' food consumption behavior upon retirement and to better inform policy, it is necessary to examine this inquiry in the settings of these societies.

To this end, this paper examines the case of China, the world's largest aging society. The institutional setting of urban China renders its elderly residents an interesting population to study, for two reasons. Firstly and empirically, a rapidly aging society means that there will be increasingly more retirees in the near future. Understanding elderly residents' food consumption behavior in such a society is of significant policy relevance in its own right. The associated regulatory bodies may also need to react accordingly in issuing and enforcing related policies. Moreover, if retirement does cause a significant decline in elderly residents' food expenditure and significant changes in the structure of their food demand, then food supply entities in the society may need to adjust their business strategy to meet these changes. From these perspectives, our analysis on elderly residents' behavior related to food consumption upon retirement can provide key information to help draw important implications not only for China but also for other similar societies.

Secondly and methodologically, the "forced" retirement system in urban China's public sector provides a unique opportunity for identifying the *causal* impacts of retirement. Specifically, the retirement system for public-sector employees in urban China sets the official retirement age at 60 for males and 55 (or 50 or even younger, depending on the specific employer) for females (Lei *et al*. 2010). The unique and clearly-defined retirement age cut-off for *male* employees allows us to apply a fuzzy regression-discontinuity (RD) method (Hahn *et al*. 2001; Lee and Lemieux, 2010) to identify the causal effects of retirement.[2] In particular, since a flexible function of age is controlled for in the regression, the fuzzy RD method is able to isolate the impact of retirement from the impact of natural aging.[3]

To the best of our knowledge, direct examination of the retirement-consumption puzzle is sparse in China.[4] To date, only two studies (Li *et al*. 2015; Zou and Yu, 2015) have examined the causal impacts of retirement on households' nondurable expenditure. A desirable feature of these studies is that they both examined separately the impacts of retirement on work-related expenditure, non-work-related expenditure, expenditure on food consumed at home, and expenditure on entertainment. By disaggregating

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[2] As with most of previous studies (e.g. Li et al. 2015), we are unable to apply the fuzzy RD method to estimate the impacts of retirement for females in urban China, for two reasons. First, there exist multiple retirement age cut-offs. Secondly, a significantly fraction of females do not comply with these retirement age cut-offs (see figure 2). These problems make it very difficult to define the expected legal retirement age cut-off (which serves as the instrumental variable for one's actual retirement status) for a given female.

[3] In contexts where no clearly defined retirement age cut-offs are available, the common practice is to use age as an instrumental variable for one's retirement status. But this strategy confounds the impact of age with that of retirement. After all, elder people are more likely to retiree.

[4] A number of recent studies published in Chinese academic journals examined the impact of uncertainty and income shocks on Chinese consumers' consumption in contexts other than retirement, such as the introduction of the New Cooperative Medical Scheme in rural China (e.g. Ma *et al*.2010; Bai *et al*. 2012).

households' total nondurable expenditure into these subcategories, these studies found that, while retirement reduces significantly a household's total nondurable expenditure (by about 20%), more than half of this reduction is due to the reductions in work-related expenditure, which helps explain the retirement-consumption puzzle. However, neither study has investigated into the retirement-consumption puzzle from the perspective of food consumption (especially from the perspective of retirees' resource-substitution behavior). Thus, the present paper is the first to examine the retirement-consumption puzzle by linking together the causal impacts of retirement on various aspects of food consumption, including food expenditure, time spent on food acquisition, nutritional intakes, as well as the structure of food consumed in the context of urban China.

Using data from the China Health and Nutrition Survey (CHNS), a large-scale household survey conducted in nine provinces of China, which contain a wealth of information on surveyed individuals' food consumption, our fuzzy RD analysis yields a number of important findings. First of all, whereas retirement significantly reduces elderly males' total food expenditure (by nearly 50%), it hardly changes their amount of food consumption measured by total calorie intake. This finding echoes that of Aguiar and Hurst (2005). Secondly, also consistent with Aguiar and Hurst's source-substitution interpretation, retirement is found to significantly increase elderly males' (and their wives') time spent on domestic food production (by 36%) in urban China. Thirdly and more importantly, our further analysis discovers that retirement causes a substitution with cheaper foods for more expensive ones, which results in a negative impact on elderly males' diet balance. In particular, they significantly reduce the consumption of foods with animal origins but increase the consumption of food grains. Correspondingly, their consumption of protein and fat declines significantly (by 24% and 15%, respectively) while that of carbohydrate increases significantly (by 26%) upon retirement. This finding implies that the substitution between time and money is insufficient to fully smooth elderly individuals' food consumption upon retirement in terms of dietary quality. Therefore, public policies may need to be designed in order to prevent health problems for retirees as population aging progresses in urban China.

The remainder of this paper proceeds as follows. The next section develops an empirical framework approach for examining the impacts of retirement on food-consumption related behavior of the elderly in urban China. Section 3 describes the data, samples and variables. Section 4presents and discusses our empirical findings. The final section draws conclusions and several policy implications based on our findings.

2. Method

2.1. Conceptual framework

To better understand the retirement-consumption puzzle, we develop our conceptual framework based on two notions. The first is in line with Becker's (1965) theory of home production and time allocation. As with the consumption of many commodities, the consumption of food can be viewed as a process during which the consumer uses time and money (or purchased goods) produce his or her utility. In this process, expenditure (money) is but one input in food production. The second notion concerns the impacts of retirement on retirees' resource endowments and thus their behavior. Not only does retirement introduce a negative income shock to the elderly (and their households), but it also substantially increases their time endowment (at least for activities that are not work-related), because retirees are no longer committed to work. The change in the relative abundance of these two resources results in a change in their relative (shadow) prices, which may in turn induce a series of resource substitution behaviors.

Based on these two notions, we hypothesize that the change in the relative (shadow) prices of time and money due to retirement induces rational individuals to substitute the relatively more abundant (hence, cheaper) resource, time, for the more scarce (hence, more expensive) resource, money, in making decisions related to food consumption.

Nevertheless, while the elderly can substitute time for money in food acquisition upon retirement, whether such a substitution of resources can fully smooth their actual food consumption is theoretically ambiguous. This is because the total effect of retirement on actual food consumption depends on at least three factors that are not readily observable: (1) the (relative) *magnitude* of the retirement-induced changes in one's time and money endowments; (2) the magnitude of the resulted change in the relative (shadow) *prices* of these resources; and (3) the extent to which money and time are substitutes for each other in food acquisition, which depends on other unobserved factors such as one's cooking skills and tastes. Therefore, even if the resource-substitution hypothesis posited above is plausible, whether the elderly can fully smooth the quantity and quality of food consumed upon retirement is ultimately an empirical question.

2.2. Estimating equations

Our empirical analysis attempts to first detect retirement-consumption puzzle and then, if it does exist, to provide a deeper understanding of it by testing the posited resource-substitution hypothesis. Specifically, we estimate the *causal* effects of retirement on four sets of outcome variables (EXP_{ij}, $TIME_{il}$, $NUTR_{ik}$, and $FOOD_{im}$) that reflect various aspects of elderly individuals' food consumption behavior:

$$EXP_{ij} = \alpha_0 + \alpha_{1j}R_i + \mathbf{Z}_i\boldsymbol{\alpha}_{2j} + e_{ij}, \quad (1)$$

$$TIME_{ik} = \beta_0 + \beta_{1k}R_i + \mathbf{Z}_i\boldsymbol{\beta}_{2k} + t_{ik}, \quad (2)$$

$$NUTR_{il} = \delta_0 + \delta_{1l}R_i + \mathbf{Z}_i\boldsymbol{\delta}_{2l} + c_{il}. \quad (3)$$

$$FOOD_{im} = \gamma_0 + \gamma_{1m}R_i + \mathbf{Z}_i\boldsymbol{\delta}_{2m} + f_{im}. \quad (4)$$

The key explanatory variable in each equation above is individual *i*'s retirement status R_i (=1 if retired and 0 otherwise). The set of covariates $\mathbf{Z}_i$ includes individual *i*'s socio-demographic characteristics that serve to proxy this individual's permanent income, such as ethnicity, age, educational attainment, and occupation, etc.[5] The error terms e_{ij}, t_{il}, n_{ik}, and f_{im} capture the influences of unobserved factors that potentially affect their corresponding outcome variables.

Among the outcome variables of interest, EXP_{ij} is individual *i*'s expenditure on food in category *j* (e.g. *j* = total food expenditure or food expenditure away from home, etc.); $TIME_{ik}$ captures individual *i*'s time spent on the k^{th} activity related to food acquisition (e.g. *k* = time spent on domestic food preparation, or participation in food purchasing, etc.); $NUTR_{il}$ is individual *i*'s nutritional intakes (e.g. *l* = total calorie intake,

[5] Controlling for the determinants of one's permanent income is important because the impact of retirement can then be interpreted as the impact of the shocks introduced by retirement to one's permanent income.

amount of carbohydrate consumed, or diet-balance, etc.); $FOOD_{im}$ is the amount of food in category *m* consumed by individual *i*'s (e.g. *m* = fruit, grain, meat products, etc.).

Reflecting different aspects of one's food consumption, the estimated impacts of retirement in Equations (1)-(4) (captured by parameters α_{1j}, β_{1k}, δ_{1l} and γ_{1m}) provide useful explanations to help understand the retirement-consumption puzzle, in four regards. Firstly, when j = total food expenditure, Equation (1) is a generic model commonly adopted to document the retirement-consumption puzzle. A negative retirement impact on total food expenditure (i.e. $\alpha_{1j} < 0$) signifies that puzzle. However, a significant drop in one's total food expenditure upon retirement does *not* necessarily imply that such a drop is (entirely) due to a negative income shock. For example, Hurd and Rohwedder (2006) found that the reduction in total food expenditure is largely driven by a reduction in food expenditure away from home, which is likely to be work-related. Our data (see the next section for more details) also allow us to disaggregate one's total food expenditure into expenditures on food consumed at home and away from home, and to further disaggregate the latter into expenditures on food consumed in canteens (which is most likely to be work-related) and in restaurants (which may or may not be work-related) to reveal more important patterns.

Secondly, as argued above, retirement not only reduces elderly individuals' income but also increases their time endowment. Thus, in order to keep their amount of food consumed from significantly declining, rational retirees can substitute time for money spent on food, and similarly, substitute their own (relatively cheaper) labor for (relatively more expensive) "hired" labor service (provided by, say, cooks and waiters in restaurants). Thus, a positive retirement impact on individuals' time spent on domestic food preparation found using Equation (2), along with a negative retirement impact on food expenditure (especially not work-related expenditure) found using Equation (1), would lend empirical support to the posited resource-substitution hypothesis.

Thirdly, even if elderly individuals can and do substitute their time (or own labor) for money spent on food acquisition (or "hired" labor) upon retirement, they may not be able to fully smooth their actual food consumption, given the absolute reduction in their income. After all, even retirees who have sufficient time and skills to cook all meals for themselves have to purchase inputs such as raw food materials, ingredients and condiments from the market. But their reduced disposable income due to retirement may prevent them from purchasing sufficient inputs for domestic food production. Thus Equation (3) is used for assessing how retirement affects elderly individuals' amount of food consumed. In particular, if individuals are able to smooth the quantity of food consumed upon retirement through resource substitution, one would expect to see little impact of retirement on their total energy intake.

Yet it is still possible that while smoothing the quantity of food they consume upon retirement, elderly individuals have to sacrifice *quality* for quantity to some degree. For one thing, the reduction in income may prevent them from consuming expensive food during retirement, which may lead them to substitute cheaper foods for more expensive ones. For another, those who opt to substitute own labor for hired labor might lack the skills for preparing the full spectrum of foods that they might consume away from home (e.g. sophisticatedly cooked seafood). Thus, they might consume a more limited variety of food during retirement. Therefore, the final issue we examine concerns the change in the structure of food consumption due to retirement. Equation (4) is employed for this purpose. For ease of interpretation, we also compare the impacts of retirement on the consumption of specific food items with the impacts of (permanent) income estimated among a sample of middle-aged (35-55) working individuals in the data.[6] After all, to the extent that retirement constitutes a negative income shock, which induces the elderly to cut back on their food consumption, they are more likely to reduce their consumption of food items with higher income elasticities (hence, more luxury foods) than those with lower elasticities (hence, more necessary ones).

2.3. Identification issues

To test the above predictions, it is crucial to obtain consistent estimates of the causal effects of retirement (captured by α_{1j}, β_{1k}, δ_{1l} and γ_{1m} when Equations 1-4 are correctly specified). However, individuals' retirement status (R_i) may be endogenous if individuals do not comply with the official retirement age cut-off, but instead choose their own retirement age based on factors that are unobserved to the researcher (e.g. unexpected health problems or unexpected wealth gain from wining a lottery). To address potential endogeneity in one's retirement status, we exploit urban China's "forced" retirement system to obtain a source of exogenous variation in R_i. In urban China, official retirement ages are explicitly set for public-sector employees, 60 for males and 55 (or 50 or even younger) for females. Although not all individuals retire at their legally expected retirement age, a significant portion of individuals (especially males) still comply with the legal retirement arrangement, which creates a discrete jump in the rates of retirement

[6] Permanent income is potentially endogenous since it contains a certain amount of measurement errors, which is simply due to the fact that permanent income is not observed for anyone who is still working. Following the common practice in the literature, we instrument the error-ridden measure of permanent income, one's current income, using an individuals' gender, ethnicity, education, types of working unit and age (i.e. the determinants of one's permanent income) as instruments.

at their legal retirement age. Figure 1 (Panel A) indicates a clear jump in the frequency of retirement among urban males at different ages around 60, using the China Health and Nutrition (CHNS) data. In contrast, however, there is no clear discontinuity in the retirement rates for females at the retirement age cut-offs (Panel B), which implies the prevalence of non-compliance among females. In fact, it has been found in previous studies that a non-trivial proportion of females public-sector employees still work after they have reached the legal retirement age; meanwhile, some other female public-sector employees are forced into early retirement due to illness, injury, or financial problems of their employers (Zou and Yu, 2015). Given these observations, our analysis is restricted to urban males in the data.

[*Figure 1 about here*]

Exploiting the jump in the fraction of retirees at the legal retirement age cut-off, we adopt a (parametric) fuzzy regression-discontinuity (RD) method (Hahn *et al*. 2001; Lee and Lemieux, 2010) to identify the causal effects of retirement. More specifically, we instrument one's retirement status (R_i) using an indicator D_i of whether one's age passes the cut-off as the instrumental variable (IV) in the first-stage regression associated with Equations (1)-(4), controlling for a flexible function of age and a set of covariates ($\mathbf{Z_i}$):

$$R_i = \eta_0 + \eta_1 D_i + \eta_2 f(A_i - c) + \mathbf{Z}_i \boldsymbol{\eta}_3 + r_i, \quad (5)$$

where A_i is individual i's age, c is his legally "expected" retirement age cut-off (i.e. 60 in our case), and $(A_i - c_i)$ is the distance from individual i's own age to the retirement age cut-off. The function $f(A_i - c_i)$ is a flexible function, e.g. a high-order polynomial function, of $(A_i - c_i)$.[7] The fuzzy-RD method is able to identify the causal effects of retirement because under the assumption that all factors except one's retirement status R (more precisely, the variation in R that is due to one's age passing the cut-off) vary smoothly when one's age crosses the cut-off, the differences in the outcome variables of interest between retirees and their working counterparts around the age cut-off are due to the discrete change in the retirement rate when crossing the cut-off.[8] Viewed slightly differently, with $f(A_i - c_i)$ absorbing the impact of natural aging, the IV for retirement, $D = 1(A_i > c_i)$, isolates the impact of one's age passing the retirement cut-off from that of natural aging.[9]

3. Data

3.1. Survey and data

The data we analyze in this paper are drawn from the China Health and Nutrition Survey (CHNS), an ongoing panel survey project conducted in collaboration between the Caroline Population Center at the University of North Carolina and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention.[10]

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[7] In practice, following Battistin *et al*. (2009) and Zou and Yu (2014), we specify $f(A_i - c_i)$ as a quadratic function of $(A_i - c_i)$, which is also suggested in Panel A of Figure 1. We tried higher-order polynomials, but the results (available upon request) are quite similar to those reported in this paper.

[8] Note that the IV estimates of α_{1j}, β_{1k}, δ_{1l}, and γ_{1m} can be interpreted as the local average treatment effects (LATE) of retirement on those individuals who retired because their age passed the official retirement age cut-off.

[9] This "pure" retirement effect cannot be isolated in the context such as that in Aguiar and Hurst (2005), where voluntary retirement is the dominant form and one's actual age was used as an IV for one's retirement status.

[10] For more details about the CHNS project and data, see: http://www.cpc.unc.edu/projects/china (accessed on August 7, 2015).

The main survey covered nine provinces, namely, Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Guangxi and Guizhou (Figure 2).[11] The target provinces vary substantially in geographical, social and economic characteristics, which can be considered as broadly representative of China as a whole. A multistage, clustered, random sampling procedure was applied in the first round of survey in 1989 to select sample households. Follow-up surveys were conducted in 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011.[12] There are currently about 4,400 households participating in the overall survey, involving some 25,000 individuals.

[*Figure 2 about here*]

The survey collected detailed information on sampled households, all household members in these households, and their communities. One unique feature of the CHNS is that it collected rich information on individuals' consumption on more than 1,500 types of food items during an interview period of three consecutive day.[13] Using the three-day food intake data and the Chinese Food Nutrition Table compiled by Yang (2002), the Carolina Population Center calculated each individual's daily intake of carbohydrates, fat, and protein, as well as total energy intake from these macronutrients.

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[11] Three municipalities, namely, Beijing, Tianjin, and Chongqing, were added to the set of target province-level administrations in 2011, but the number of relevant observations from these municipalities in our final analytical sample is very small.

[12] From 1997 onward, households that emerged from the original households were added to the survey, and new households from the original sites were added to replace those that no longer participated in the survey.

[13] Following a standard procedure, trained investigators recorded each CHNS household's food intake over three consecutive days randomly selected from Monday to Sunday to ensure that they were spread throughout a whole week. The investigator interviewed each household member on each of these days and recorded detailed information on his or her recalled food consumption.

To measure (at least partially) the quality aspect of elderly individuals' diet, we also construct a diet-balance index (DBI) for each individual, based on the criteria recommended by the Chinese Nutrition Association (Yang, 2002). The DBI measures the balancedness of a person's food intake, given this person's gender and age. The Chinese Nutrition Association (CNA) provides recommendations for adequate levels of consumption of 12 specific foods for Chinese residents.[14] The DBI is computed in two steps. First, a score is assigned to a person's consumption of a given food, say, aquatic products. This score will be positive if this person consumes more of that food than the CNA-recommended level and negative if the opposite is true. In the second step, all scores assigned in the first step are combined to yield a weighted average, using weights provided in the Chinese Food Nutrition Table (Yang, 2002), to yield a final DBI index. But since in theory overconsumption of some food items and inadequate consumption of other food items may yield a DBI index that appears to be well-balanced, we also computed indices that reflect separately overconsumption (DBI-H) and inadequate consumption (DBI-L) of foods. The DBI-H index is computed as the weighted average of all positive scores in the first step and the DBI-L index as the weighted average of all negative first-step scores.

Another useful feature of the CHNS for the purpose of this paper is that it collected information on individuals' time allocation on an usual day, which includes their time spent on activities related to food acquisition. Although the CHNS data do not contain direct records of households' food expenditure, we are able to construct food

[14] The DBI index takes into account 12 specific foods including rice, flour, other grains, tuberous crops, vegetables, fruits, beans, dairy products, livestock, poultry, egg, aquatic products. But the consumption of some items (e.g. other grains) is very small. And the consumption for rice and flour is very location specific. Thus, for ease of analysis, we combine rice, flour, other grains, tuberous crops into a single category called "grains", yielding a total of nine categories in analysis.

expenditure measures for all individuals, based on the recorded amount of food items they consumed and the community-level prices of the specific food items consumed.

3.2. Sample

Since the CHNS was not designed for the analysis of food consumption issues of the elderly, we apply a series of restriction to obtain an analytical sample that is suitable for the purposes of this paper. First, because detailed information on food consumption was not collected until 2000, our analysis can use only data collected during the 2000, 2004, 2006, 2009 and 2011 waves. Secondly, because it is conceptually difficult to define retirement for rural individuals (who are essentially self-employed in agriculture) and for private sector employees (who do not have a clearly defined retirement age), our analysis is focused on individuals who were ever employed in the public sector (including retired ones) and hold a legal *urban* residential registration status (*Hukou*). Thirdly, as mentioned above, we exclude urban females because there are multiple retirement ages for them and many of them do not even comply with the "forced retirement" arrangement (see Figure 1, Panel B). Finally, to avoid including too many observations that are far away in age from the retirement age cut-off, which renders themselves less comparable, we restrict our analysis to only urban males aged 50-70. After applying these restrictions, the final analytical sample includes all elderly urban males (aged 50-70) who ever showed up in any of the surveys since 2000. We only use one observation for each individual in the sample. If an individual appeared in the data more than once, we only use information recorded when this individual's age is *closest* to 60. The resulted sample has 1,059 observations.

Table 1 presents summary statistics of major socio-demographic characteristics of individuals in the sample, by their retirement status. It is clearly seen that besides the obvious difference in age, the working elderly are on average better educated (by 1.4 years) than the retirees, and the former has a much higher level of disposal income than the latter (whose disposal income consists of mostly pension sponsored by their previous employers), with a difference of 8,738 *yuan* (or 52% of the latter's mean disposal income).

[*Table 1 about here*]

3.3. Variables on food consumption

To help gain a rough sense of how elderly males' food consumption varies with their retirement status, Table 2 (Panels A-E) presents summary statistics of five sets of variables related to food consumption, as well as the differences in these variables between retirees (column 1) and the working elderly (column 2). Note that the (raw) difference in means (column 3) in a given row is precisely the *bivariate* OLS estimate of the impact of retirement on the particular variable in that row.

Panel (A) concerns food expenditure. It suggests that elderly males' total daily food expenditure declines upon retirement: retirees spend about 6.6 *yuan* (or 15%) less on food than the working elderly.[15] While such a decline is consistent with the retirement-consumption puzzle, it is only marginally significant. A more significant decline is that in food expenditure away from home. On average, retirees spend 14 *yuan* per day on food consumed away from home, which is merely half of the corresponding figure for the working elderly (29 *yuan*/day). This suggests that retirees are substituting food consumed

[15] One US. Dollar ≈ 6.20 *yuan* in 2015.

at home for food consumed away from home upon retirement. Consistent with this resource substitution argument, Panel (B), which concerns individuals' time allocation related to food preparation, indicates that retired males (and their wives) are more likely to participate in food purchasing activities than the working elderly.[16] The former also spend 17 more minutes (or 14%) per day on domestic food production than the latter.

Turning to elderly males' nutritional intakes, Panel (C) indicates that while retirees spend less on food compared to the working elderly, they consumed no less nutrition than the latter. Indeed, retirees on average consume more calorie (85 *j*/day) and carbohydrate (16 *g*/day) than the working elderly. This appears to be consistent with the patterns presented in Panel (E) for individuals' consumption of 12 specific food items, including fruits, dairy and bean products, etc.[17] However, the distributions of DBI scores in Panel (D) suggest that the diet of retirees is not balanced by the standards recommended by the Chinese Nutrition Association. In particular, retirees are more likely to consume an inadequate amount for some food items compared to the working elderly, which seems to be at odd with the patterns found in Panels C and D.

However, it should be realized that the estimated impacts of retirement from bivariate OLS regressions presented in Column (3) of Table 2 may be confounded with potential impacts of natural aging and/or other unobserved factors. Thus, more sophisticated econometric methods are needed to obtain more reliable estimates of the

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[16] Since males are less likely to participate in cooking than females. Thus, this variable includes both elderly males' and their wives time spent on food production.

[17] While the CHNS provides detailed accounts for each of the 1,500 food items, some aggregation was conducted for the ease of analysis. Take fruits for example. The category "Fruits" includes many sub-categories, such as apple and pear in the "Pome fruits" category and watermelon and honeydew in the "Melons" category. But it is unlikely that an individual will consume all (or most) of the items in these sub-categories during the three-day interview period. Thus we restrict our analysis to the incidences of consuming food items in the eight larger categories based on the coding of the CHNS data, including fruits, dairy products, alcohol, bean products, etc.

impacts of retirement. The next section is devoted to the discussion of estimation results obtained using the fuzzy-RD framework outlined in Section 3.

[*Table 2 about here*]

4. Estimation Results

Before turning to the fuzzy RD estimates of the impacts of retirement on food-consumption related variables, it is worth noting the impact of retirement on elderly individuals' disposable income.[18] Even though many public-sector employees in China enjoy a certain amount of pension sponsored by their previous employer, our fuzzy RD estimate reveals that retirement constitutes a serious shock to elderly males' income − retirement reduces their annual disposable income by more than 40% (Table 3, Panel A). How would such an income shock affect elderly males' food-consumption related behavior? The following sections are devoted to answering this question.

5.1. Impacts of retirement on food expenditure: retirement-consumption puzzle?

Turn first to the impact of retirement on elderly males' total daily food expenditure (in log). The fuzzy RD estimate (Table 3, Panel B, 1st row) indicates that, other things being equal, retired males on average spend 49.6% less money on food than do their working counterparts. Such a negative impact of retirement on food expenditure appears to be consistent with the widely-documented retirement-consumption puzzle. Echoing this impact, Panel A of Figure 3, which plots the (reduced-form) relationship between elderly males' age and their total daily food expenditure, also indicates a clear

[18] The performance of our IV in the first stage will be discussed below in the Robustness Check section.

drop in the latter at the age cut-off. Without further information, it is tempting to infer from these results that elderly males in urban China fail to smooth their food consumption upon retirement.

However, disaggregating elderly males' total daily food expenditure into expenditures on food consumed at home and away from home reveals that the retirement-consumption puzzle may not be as puzzling as it appears. Note first that the significant drop in elderly males' total food expenditure at retirement is mostly driven by the reduction (a 48% drop) in their food expenditure away from home (Table 3, Panel A, 3rd row). This impact is hardly surprising because retirees no longer need to go out for work on a daily basis, which limits their likelihood of dining out to a large extent. In particular, retirement reduces elder males' expenditure on food consumed in canteens (mostly work-related) by 25% (Table 3, Panel A, 4th row), suggesting that a substantial part of the reduction in food expenditure away from home is indeed due to the reduction in work-related food expenditure, which is induced by the changes in their daily activities, rather than by income reduction, upon retirement.

Nonetheless, note that income reduction still plays a role, even after considering the impacts of changes in daily activities upon retirement. In particular, elderly males' expenditure on food consumed in restaurants, which is much less likely to be work-related than that in canteens, also declines significantly (by 29%) upon retirement (Table 3, Panel A, 5th row). Moreover, retirement has a negative impact on elderly males' expenditure on food consumed at home (a 12% drop), although this impact is statistically insignificant.

[*Table 3 about here*]

4.2. Resource substitution: time for money?

While retirement introduces a negative shock to retirees' income. Standard economic theory predicts that rational elder individuals will then substitute their scarcer resource (money) with a more abundant one (time). Panel C of Table 3 tests this prediction by estimating the impacts of retirement on elderly males and their spouses' time allocation related to food acquisition. The Fuzzy RD estimates indicate that individuals' time spent on food acquisition does increase significantly upon retirement: compared to their working counterparts, retired males (and their spouses) are 25% more likely to participate in food purchasing activities (Table 3, Panel C, 1st row) and spend 36% (or 24 minutes) more time a day on domestic food production (Table 3, Panel C, 2nd row). The reduced-form retirement impacts on these two time-related variables are visualized in Figure 4. In sharp contrast, the estimated (permanent) income effects on these two time-allocation variables (Table 3, Panel C, Column 2) are both of opposite signs to the estimated retirement impacts, which suggests that retirees' reduced income and their increased time endowment indeed induce substitutions between time and money inputs in food acquisition. Note that the change in the relative abundance in retirees' money and time endowments also lowers the (shadow) value of their own service (labor) relative to the price of restaurant service (provided by workers cooks and waiters), which also helps explain why retirement reduces elderly males' food expenditure in restaurants.

[*Figure 4 about here*]

4.3. Can resource substitution smooth food consumption?

However, discovering that elderly males can and do substitute their own service for restaurant service, as well as their time for money spent on food acquisition, it is natural to ask: can these substitutions fully smooth the quantity and quality of food they consumed? To shed some light on this question, Panel D of Table 3 presents fuzzy RD estimates of retirement impacts on elderly males' quantity of food consumption, measured by their nutrition intakes. The first row indicates that retirement has essentially no impact on one's total calorie intake. However, retirement induces a dramatic change in the *structure* of elderly males' nutrition intakes. More specifically, retirees consume significantly more carbohydrate (a 26% increase) and less fat (a 24% reduction) and protein (a 15% increase) than their working counterparts. Again, comparisons of these retirement impacts with income effects presented in Column (2) of Panel D suggest that such structural changes are likely due to the reduction in income upon retirement, though male retirees in urban China manage to keep their total amount of energy intakes unchanged. The changes are also captured in Figure 5, which provides visualization of the reduced-form impacts of retirement on elderly males' nutrition intakes.

[*Figure 5 about here*]

The changes in the *structure* of elderly males' energy intakes raises another question: do such changes affect the *quality* of the food they consume? In other words, do elderly individuals have to sacrifice some quality for quantity while smoothing their food consumption? To answer this question, we estimate the impacts of retirement on a set of variables that can at least partially reflect the quality aspect of their food consumption, i.e.

the three diet-balance indices (DBI) constructed based on their reported consumption of 12 specific food items in the data. As discussed in the Data section, the DBI indices measure how balanced the a person's food intake is, given this person's age. The total DBI score (DBI-TS) measures the overall diet balance of an individual. It accounts for both adequate and overconsumption of some food items and inadequate consumption of some other food items compared to the CNA-recommended level, allowing for trade-offs among different food items. Panel E of Table 3 indicates that retirement has a significantly negative impact on the overall DBI score. Specifically, retirement reduces elderly males' DBI-TS scores by almost 0.3 standard deviations, suggesting that retirees' overconsumption of certain foods cannot fully compensate their inadequate consumption of other foods, which undermines their overall diet balance. Disaggregating the overall DBI index into tow indices measuring separately adequate or overconsumption (DBI-H) and inadequate consumption of foods (DBI-L) verifies this: while DBI-H index increases only insignificantly, the DBI-L index drops significantly, upon retirement. Figure 6, which provides visualization of the reduced-form impacts of retirement on elderly males' diet balance, echoes these estimation results. Together, these results suggest that, at least in terms of diet balance, some quality of elderly males' food consumption is compromised while they smooth the quantity of their consumption.

[*Figure 6 about here*]

Finally, to understand what is causing the above structural changes in elderly males' nutrition intakes and diet balance, we examine the impacts of retirement on the consumption of a set of nine specific food items.[19] Panel A of Table 4 presents the results for the (log) amount of a food consumed (Column 1) and (log) expenditure on that food (Column 3). Notably, the consumption of the majority of these food items declines. In particular, the consumption of foods with animal origins (e.g. poultry, livestock, and aquatic products) declines substantially (although the impacts of retirement are not all statistically significant). The only consumption that increases substantially upon retirement is that of grains. These findings help explain the significant decreases in elderly males' fat and protein intakes and the significant increase in their carbohydrate intake upon retirement reported above (Table 3, Panel D, Column 1).

The resource-substitution hypothesis posited above also helps explain the structural changes in food consumed. This hypothesis predicts that the direction of changes in the consumption of specific food items will mirror the direction of (permanent) income effects in response to income reduction. After all, if an elderly male decides to cut back on his consumption on some food items in response to a negative income shock, he is most likely to reduce the consumption of those items that have large income elasticities. To see whether this prediction is plausible, Table 4 presents income effects (estimated using a set of middle-aged working males) on the consumption (Column 2) of and expenditure (Column 4) on the nine specific food items. The comparison of Columns (1) and (2) and that of Columns (3) and (4) suggest that the overall pattern of the estimation results is consistent with the prediction of the posited resource-substitution hypothesis. For example, the expenditure on food items with relatively large positive income elasticities (> 0.3) decline substantially. In particular, the expenditure on

[19] As explained in a footnote above, three categories (i.e. tuber crop, nuts and fungi) are treated as part of the category "grains".

livestock and aquatic products decline by 46% and 33%, respectively, upon retirement. Consistent with this, the consumption of these two items decline substantially, by 41% and 55%, respectively. In contrast, expenditures on food items with negative income elasticities, e.g. beans, grains, and vegetables, increase. Most notably, the consumption of grains increases by 32%.

[*Table 4 about here*]

4.4.Robustness checks

The results discussed above suggest that retirees substitute relatively cheaper resources (i.e. time, own service and cheaper foods) for more expensive ones (e.g. money, restaurant service and expensive foods) in food consumption upon retirement. Yet the reliability of these findings hinges on the validity of the fuzzy RD regression results. Thus, we conduct a series of checks to assess the validity of the fuzzy RD results in this section. First, recalling that the causal effects of retirement are identified under the assumption that all factors except the likelihood of retirement vary smoothly across the retirement age cut-off (age 60), we test whether this assumption is plausible. If this assumption is indeed plausible, one would expect no significant jumps in pre-determined characteristics such as education, health, and ethnicity, etc. at the cut-off. Thus, we run a set of fuzzy RD regressions treating these characteristics as the dependent variables (without controlling them on the right hand side of the estimating equation). Panel A of Table 5 presents the main results of this check: all characteristics appear to be well-balanced across the retirement age cut-off. Although it is impossible to conduct a similar check on unobserved characteristics, the "balance" in these observed characteristics at the cut-off suggests that unobserved characteristics are also very likely to be balanced.

Secondly, one might be concerned that the fuzzy RD estimates presented in Table 3 can be biased if we included too many observations that are far away in age from the cut-off. Arguably, 50-year-olds and 70-year-olds may not be very comparable in terms of food consumption behavior. Even though we have controlled for a flexible function of age on either side of the cut-off when estimating the models in Table 3, there is no guarantee that such a conditioning makes these observations sufficiently comparable. To see whether the inclusion of these observations affects the estimation results, Table 5 (Panels B-E) reports fuzzy RD estimates for all outcome variables using different age ranges ([51-69], [52-68], [53-67], [54-66] and [55-65]) other than the one [50-70] used in all regressions reported in Table 3. The results indicate that the point estimates of these estimates in Table 6 are quantitatively comparable to those reported in Table 3, although in general the statistical significance of these new estimates decline when smaller samples are used in the regression.

[*Table 6 about here*]

The final concern is that the IV (i.e. one's age passing the cut-off) for one's retirement status in the first stage might be a weak-IV (Bound et al. 1995). To examine this possibility, Table 6 presents the results of the first-stage regression with different specifications. The IV has strong predictive power for one's retirement status in all regressions. For example, the F statistic associated with the first-stage regression used to obtained our main estimation results (Column 4) is 57.68, far exceeding the rule-of-thumb value of 10, which greatly reduces the concern of this IV being weak.

Simply put, the results of these checks indicate that the potential threats to identification discussed in this section are negligible. Ruling out these concerns greatly strengthens the reliability of our findings discussed above. One is now in a position of drawing conclusions based on these findings.

[*Table 6 about here*]

5. Concluding Remarks

As a populous society, urban China is aging rapidly. Thus, understanding the economics of the elderly residing in urban China is of great policy relevance. Exploiting retirement as a natural experiment that introduces a major shock to the life of the elderly, this paper examines how the elderly respond to the substantial changes in their resource endowments (e.g. the reduction in income and increase in time) in making their food consumption decisions. Our fuzzy regression-discontinuity analysis of elderly males in the CHNS data yields a number of important findings. First of all, while retirement reduces urban males' total food expenditure almost by half, it also increases their daily time spent on domestic food production by 36%. Echoing the finding of Aguiar and Hurst (2005), this finding (Figure 7, Panel A) challenges the conventional interpretations of the significant drop in food expenditure as evidence of elderly individuals' failure to anticipate retirement-induced income shocks. Rather, the elderly respond to the reduction in income by performing resource substitutions. Besides the substitution between time and money, we also found evidence of another two types of resource substitution: the substitution between retirees' own service and restaurant services and that between cheaper and more expensive foods. By turning to these resource substitutions, elderly males in urban China manage to prevent the amount food consumed (measured by total calorie intakes) from significantly declining upon retirement. Viewed from this angle, the widely-documented retirement-consumption puzzle is not as puzzling as it appears.

However, these resource substitutions are not sufficient to fully smooth elderly individuals' food consumption upon retirement. While the elderly are smoothing the quantity of food consumed upon retirement, the *quality* of food they consume is somewhat comprised, at least in terms of diet balance by the criteria set by the Chinese Nutrition Association (Figure 7, Panel B). Specifically, their consumption of protein and fat declines significantly (by 24% and 15%, respectively)upon retirement and the associated decline in the quality of food consumption cannot be compensated by the increase in carbohydrate at the same time.

A number of implications can be drawn from these findings. Firstly and empirically, as population aging in urban China progresses, there will be more and more retirees in this society. To the extent that the negative impact of retirement on elderly individuals' diet balance has potential (long-term) health threats, the government also need to consider how to prevent health problems for retirees. Moreover, the substantial structural changes in elderly individuals' food demand upon retirement predict a sharp decline in the demand for food with animal origins and an increase in the demand for food grains in the near future. Thus, food supply entities in urban China may need to adjust their business strategy to meet these changes. The associated regulatory bodies may also need to react accordingly in issuing related food policies.

Secondly and methodologically, retirement cannot be treated as an event that simply introduces a negative income shock in policy analysis, at least in the context of urban China. Given the series of resource substitutions upon retirement, focusing solely on food expenditure when examining elderly individuals' welfare is likely to suffer from serious "omitted-variable" bias from various sources. An implication for future household surveys is that detailed information on individuals' actual food consumption should be collected to enable more in-depth analyses of the welfare of the elderly.

In closing, we point out two directions for future research. First, more studies on the impact of retirement on the *quality* of food consumed are needed. One limitation of the present study is that the quality of food consumed is not directly observable, and we have to resort to an indirect method (i.e. by resorting the diet-balance indices) to examine this issue. Other datasets containing more direct information (e.g. brand and nutritional content) on different types of food consumed should be analyzed to provide more insights onto the retirement-consumption puzzle. Second, elderly individuals' consumption of other non-durable goods should also be studied. In this paper, we are unable to analyze the impacts of retirement on other types of non-durable consumption due to the lack of information. Other datasets, for example, the China Health and Retirement Longitudinal Study (CHARLS) data, may be able to yield fruitful research results in this direction.

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Table 1. Definitions and Summary Statistics of Demographic and Socio-Economic Characteristics

Sample		(1) Aged 50-70 Retired		(2) Aged 50-70 Working	
Variables	Definition	Mean	SD	Mean	SD
Age	Age in years.	64.29	(4.47)	55.55	(4.02)
Ethnicity	1= Han; 0 =otherwise.	0.95	(0.21)	0.93	(0.26)
Health	1= ill of injured during the past 4 weeks; 0 =otherwise.	0.18	(0.38)	0.18	(0.39)
Education	Years of schooling.	10.63	(6.48)	12.00	(6.54)
Occupation	1= professional (doctor, lawyer, etc.); 2 =administrator, government officials or manager; 3 =office staff or skilled (unskilled) worker; 4 =other.	3.24	(2.02)	3.01	(1.47)
Disposable income (*yuan*)	Annual income from all income sources.	16841.55	(14154.51)	25579.38	(25932.55)
Household size	Number of household members who usually have dinner together.	2.80	(1.24)	3.08	(1.18)
N		442		617	

Source: Author's calculation using the CHNS data.

Table 2. Summary Statistics of Variables Related to Food Consumption (Urban Males Aged 50-70)

Retirement status	(1) Retired		(2) Working		(3) = (1)-(2)	
Variables	Mean	SD	Mean	SD	β	SE
A. Expenditure on food (yuan/day)						
Total expenditure	43.90	(21.58)	50.46	(23.82)	-6.55*	(0.04)
Expenditure on food consumed:						
at home	27.10	(20.00)	26.01	(20.15)	-0.99	(0.12)
away from home	14.08	(10.50)	29.62	(16.80)	-15.54***	(0.00)
away from home (in canteens)	2.03	(0.94)	9.42	(4.45)	-7.39**	(3.01)
away from home (in restaurants)	4.11	(2.65)	14.68	(16.80)	-10.57***	(3.68)
B. Time spent on food acquisition (*male and his wife's*)						
Participation in food purchasing (1=yes)	0.64	(0.40)	0.56	(0.49)	0.13**	(0.06)
Time spent on domestic food production (min/day)	135.61	(99.00)	118.74	(99.34)	16.88*	(8.03)
C. Nutrition intakes						
Calorie (kcal/day)	2322.24	(603.21)	2236.88	(662.65)	85.36**	(42.03)
Carbohydrate (g/day)	292.91	(91.99)	276.611	(94.61)	16.30***	(6.11)
Fat (g/day)	88.30	(36.08)	87.67	(43.05)	0.63	(2.67)
Protein (g/day)	75.99	(26.13)	76.13	(26.91)	-0.13	(1.73)
D. Diet-balance index (*DBI*)						
DBI-TS	-10.18	(9.13)	-6.98	(10.00)	-3.20**	(1.31)
DBI-H	2.88	(2.22)	3.30	(3.68)	-0.42	(0.73)
DBI- L	-31.12	(26.50)	-28.83	(30.92)	-2.23**	(1.09)
E. Consumption of food categories (g/day)						
Fruit	81.05	(137.54)	72.20	(150.21)	8.85	(9.54)
Dairy	46.95	(98.13)	44.52	(94.32)	2.44	(6.23)
Poultry	27.57	(69.74)	26.43	(61.49)	1.14	(4.18)

Livestock	97.22	(89.12)	85.49	(85.22)	11.73**	(5.63)
Aquatic	61.33	(96.96)	53.64	(86.85)	7.69	(5.88)
Vegetable	309.26	(216.15)	252.83	(210.99)	56.43***	(13.86)
Grain	316.49	(209.91)	277.98	(199.99)	38.51***	(13.24)
Bean	69.96	(98.45)	65.66	(92.78)	4.30	(6.17)
Egg	33.38	(42.08)	39.96	(70.65)	-6.58	(4.12)
N	442		617		1,059	

Note: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.
Source: Author's compilation from the CHNS data.

Table 3: 2SLS Estimates of Impacts of Retirement and (Permanent) Income

	(1)	(2)
	Impact of retirement	Impact of log (Income)
Outcome variables:	Aged 50-70	Aged 35-55
A. Income		
Log (Disposable income)	-0.426**	–
	(0.206)	–
B. Expenditure on food		
Log (Total food expenditure)	-0.496**	0.211***
	(0.230)	(0.061)
Log(Expenditure on food consumed at home)	-0.121	0.089
	(0.214)	(0.041)
Log(Expenditure on food consumed away from home)	-0.478**	0.127**
	(0.212)	(0.058)
Log(Expenditure on food consumed in canteens)	-0.251**	0.125***
	(0.110)	(0.043)
Log(Expenditure on food consumed in restaurants)	-0.292**	0.129***
	(0.140)	(0.047)
C. Time spent on food acquisition (male and his wife's)		
Participation in Food purchase (dummy, 1= yes)	0.252**	-0.141*
	(0.126)	(0.771)
Log (Time spent on domestic food production: min/day)	0.364**	-0.204*
	(0.180)	(0.110)
D. Nutrition intakes		
Log(Calorie)	0.050	0.002
	(0.095)	(0.032)
Log(Carbohydrate)	0.259***	-0.080***
	(0.081)	(0.025)
Log(Fat)	-0.237**	0.168***
	(0.118)	(0.043)
Log(Protein)	-0.149**	0.058**
	(0.071)	(0.024)
E. Diet balance		
DBI-TS (standardized)	-0.299**	0.126**
	(0.143)	(0.061)
DBI-H (standardized)	0.187	0.108*
	(0.148)	(0.062)
DBI-L (standardized)	-0.306**	0.144**
	(0.126)	(0.061)
N	1,059	1,053

Notes: 1. All parameters in Column (1) are estimated by 2SLS regressions using a fuzzy regression-discontinuity framework, which uses a dummy variable for "one's age passing the retirement age cut-off" as an instrument variable for one's retirement status and controls for one's age, aged squared, education, health, ethnicity, provincial, and wave

dummies. All regressions reported in Column (2) control for age, education, health, ethnicity, province, and wave dummies.
2. Standard errors in parentheses, adjusted for clustering at the community level.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 4: Fuzzy-RD Estimates of Impacts of Retirementand (Permanent) Income on the Consumption and Expenditure on Specific Food Items

	(1)	(2)	(3)	(4)
	A. Impact of retirement on consumption		B. Impact of retirement on expenditure	
	Aged50-70	Aged35-55	Aged50-70	Aged35-55
Outcome variables	Log(amount consumed)	Log(Income)	Log(expenditure)	Log(Income)
Livestock	-0.406**	0.369***	-0.461**	0.502**
	(0.210)	(0.110)	(0.203)	(0.225)
Poultry	-0.487	0.380**	-0.287*	0.334**
	(0.341)	(0.194)	(0.167)	(0.134)
Aquatic	-0.548*	0.338*	-0.332**	0.286**
	(0.336)	(0.200)	(0.172)	(0.118)
Egg	-0.212	0.013	-0.116	0.262
	(0.285)	(0.152)	(0.242)	(0.166)
Fruit	-0.371	0.514**	-0.203*	0.261**
	(0.408)	(0.239)	(0.120)	(0.115)
Dairy	0.106	0.466***	0.105	0.181*
	(0.315)	(0.202)	(0.183)	(0.110)
Bean	-0.112	-0.123	0.202*	0.086
	(0.335)	(0.188)	(0.120)	(0.144)
Grain	0.315**	-0.149***	0.095	-0.105**
	(0.149)	(0.040)	(0.192)	(0.052)
Vegetable	-0.128	-0.190***	0.127	-0.211*
	(0.128)	(0.061)	(0.188)	(0.122)
N	1,509	1,503	1,509	1,053

Notes: 1. All parameters in columns (1) and (3) are estimated by 2SLS regressions using a fuzzy RD framework, which uses a dummy variable for "one's age passing the retirement age cut-off" as an instrument variable for one's retirement status and controls for one's age, aged squared, education, health, ethnicity and provincial dummies. All regressions reported in columns (2) and (4) control for age, education, health, ethnicityand province dummies.
2. Standard errors in parentheses, adjusted for clustering at the community level.
***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 5: 2SLS Estimates of Impacts of Retirement Using Different Age Ranges

	(1)	(1)	(2)	(3)	(4)	(5)
Age range	[50-70]	[51-69]	[52-68]	[53-67]	[54-66]	[55-65]
A. Socio-demographic characteristics						
Ethnicity	-0.049	-0.072	-0.037	-0.065	-0.104	-0.193
	(0.076)	(0.084)	(0.091)	(0.103)	(0.127)	(0.152)
Years of schooling	0.444	0.527	0.998	1.170	1.333	1.120
	(0.581)	(0.544)	(0.669)	(1.002)	(0.092)	(1.024)
Health status (illness or injury in the past 4 weeks)	-0.043	-0.068	-0.024	0.011	0.074	-0.026
	(0.161)	(0.152)	(0.171)	(0.019)	(0.242)	(0.265)
House size	-0.111	-0.123	0.147	0.176	0.183	-0.145
	(0.431)	(0.432)	(0.498)	(0.562)	(0.688)	(0.745)
B. Expenditure on food						
Log (Total food expenditure)	-0.496**	-0.480**	-0.506*	-0.513*	-0.499	-0.542
	(0.230)	(0.245)	(0.262)	(0.300)	(0.361)	(0.445)
Log(Expenditure on food in canteens)	-0.251**	-0.262**	-0.270***	-0.248**	-0.281**	-0.276*
	(0.110)	(0.120)	(0.103)	(0.121)	(0.129)	(0.154)
Log(Expenditure on food consumed in restaurants)	-0.292**	-0.322**	-0.357**	-0.388*	-0.364	-0.392
	(0.140)	(0.151)	(0.166)	(0.238)	(0.277)	(0.319)
Log(Expenditure on food consumed at home)	-0.121	-0.118	-0.140	-0.148	-0.162	-0.157
	(0.214)	(0.166)	(0.200)	(0.228)	(0.304)	(0.231)
Log(Expenditure on food consumed away from home)	-0.478**	-0.522**	-0.498**	-0.546*	-0.512	-0.564
	(0.212)	(0.241)	(0.254)	(0.303)	(0.328)	(0.360)
C. Time spent on food acquisition						
Participation in Food purchase (dummy, 1= yes)	0.252**	0.291*	0.251	0.305*	0.293	0.297
	(0.126)	(0.157)	(0.160)	(0.178)	(0.218)	(0.246)
Log (Time spent on domestic food production: min/day)	0.364**	0.372*	0.420*	0.386*	0.488	0.514
	(0.184)	(0.206)	(0.238)	(0.205)	(0.314)	(0.406)
D. Nutrition intakes						
Log(Calorie)	0.050	-0.046	-0.027	-0.088	-0.122	-0.078

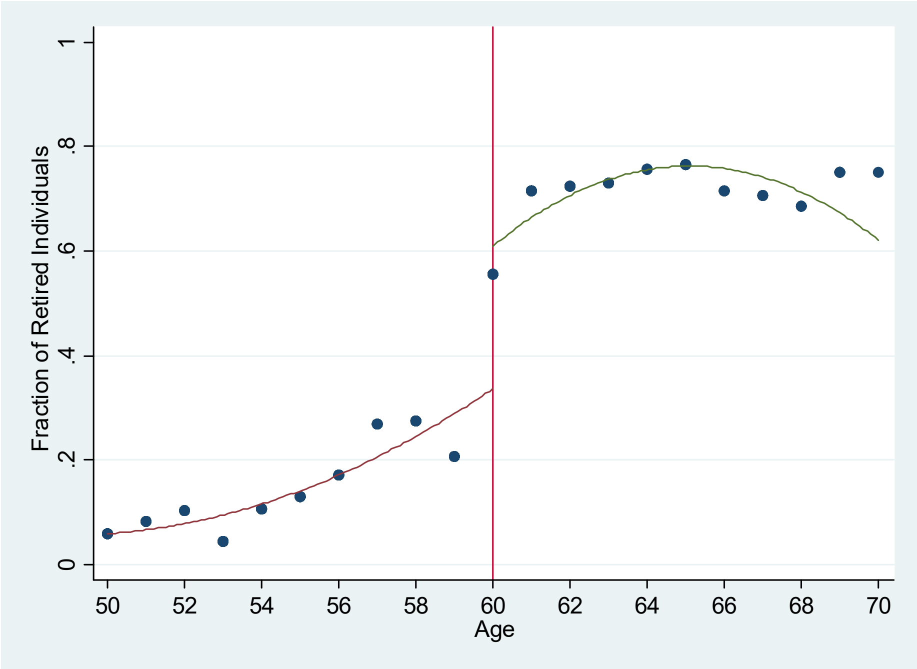
	(0.095)	(0.113)	(0.130)	(0.150)	(0.184)	(0.204)
Log(Carbohydrate)	0.259***	0.275***	0.275**	0.254**	0.195	0.156
	(0.081)	(0.096)	(0.112)	(0.129)	(0.191)	(0.168)
Log(Fat)	-0.237**	-0.254*	-0.262*	-0.284	-0.213	0.197
	(0.118)	(0.136)	(0.157)	(0.182)	(0.213)	(0.237)
Log(Protein)	-0.149**	-0.193**	-0.186*	-0.209*	-0.200	-0.341*
	(0.071)	(0.087)	(0.101)	(0.118)	(0.142)	(0.175)
E. Diet balance						
DBI-TS	-0.299**	-0.324**	-0.318**	-0.336*	-0.417*	-0.436
	(0.143)	(0.154)	(0.162)	(0.186)	(0.234)	(0.289)
DBI-H	0.187	0.196	0.201	0.213	0.242	0.210
	(0.148)	(0.466)	(0.504)	(0.548)	(0.626)	(0.693)
DBI- L	-0.306**	-0.314**	-0.340**	-0.352*	-0.360*	-0.347
	(0.126)	(0.137)	(0.174)	(0.206)	(0.224)	(0.226)
N	1,059	965	864	770	664	550

Note: All parameters are estimated by 2SLS regressions using a fuzzy RD framework, which uses a dummy variable for "one's age passing the retirement age cut-off" as an instrument variable for one's retirement status and controls for one's age, aged squared, education, health, and provincial dummies.
Standard errors in parentheses, adjusted for clustering at the community level.
***significant at the 1% level;**significant at the 5% level;*significant at the 10% level.

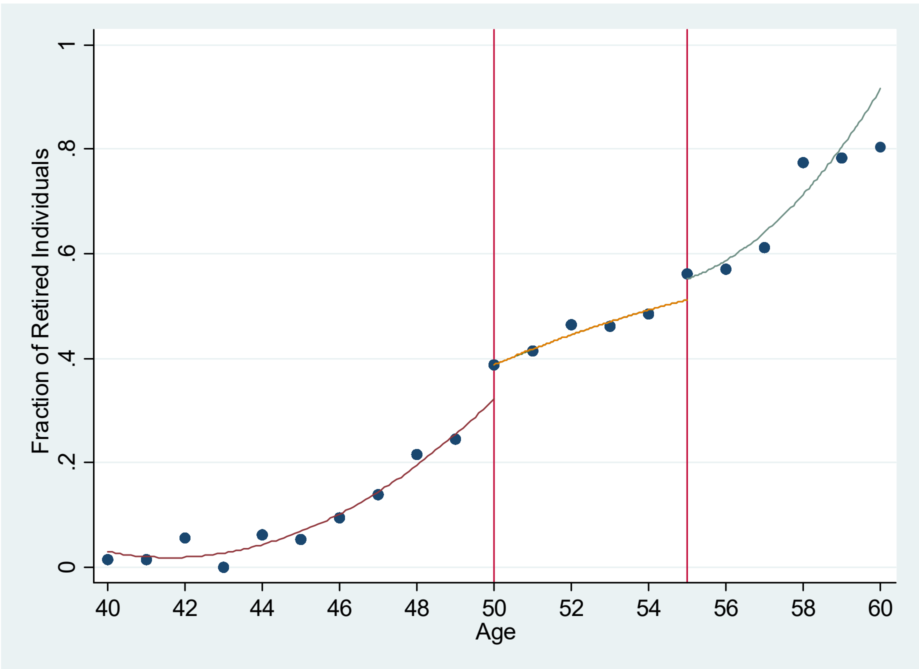
Table 6: Results of First-Stage Regressions

	(1) Retired	(2) Retired	(2) Retired	(3) Retired
Constant	0.244*	0.078	0.461***	0.259*
	(0.104)	(0.086)	(0.097)	(0.149)
D	0.392***	0.345***	0.387***	0.345***
	(0.103)	(0.045)	(0.061)	(0.045)
Age-60	0.018***	0.020***	0.018***	0.020***
	(0.007)	(0.007)	(0.006)	(0.004)
$(\text{Age-60})^2$	0.018***	-0.001***	-0.001***	-0.001*
	(0.007)	(0.0003)	(0.001)	(0.0004)
Ethnic Han			0.035	-0.041
			(0.054)	(0.083)
Education			-0.035***	-0.028**
			(0.100)	(0.011)
Health			-0.074**	-0.053***
			(0.030)	(0.012)
Household size			-0.033**	-0.023
			(0.013)	(0.018)
Province fixed effects	No	Yes	No	Yes
Survey wave fixed effect	No	Yes	No	Yes
N	1,059	1,059	1,059	1,059
R^2	0.331	0.408	0.353	0.421

Note: Standard errors in parentheses, adjusted for clustering at the community level. ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.



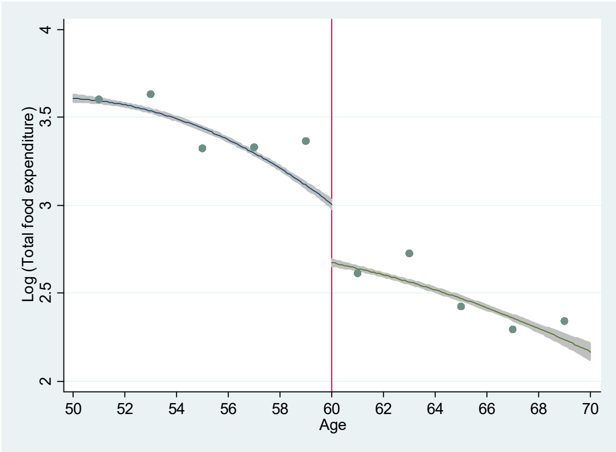
(A) Male (Cut-off = 60)



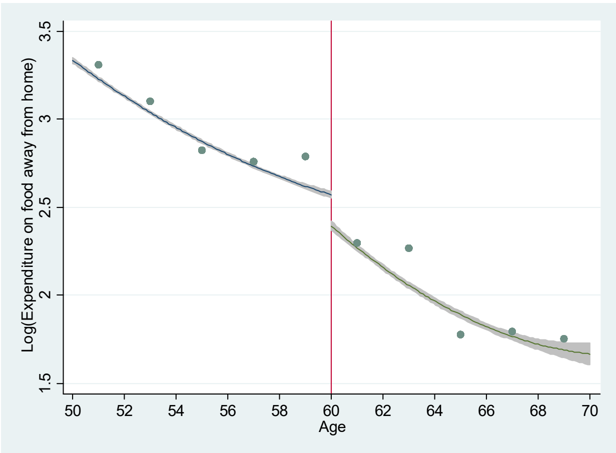
(B) Female (Cut-off = 45/50)

Figure 1: Discontinuity in Retirement Rate at Retirement Age Cut-offs

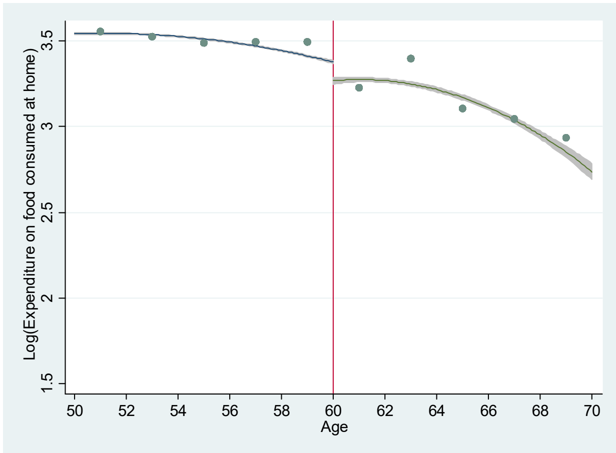
Figure 2: Provinces Participating in the China Health and Nutrition Survey (CHNS)



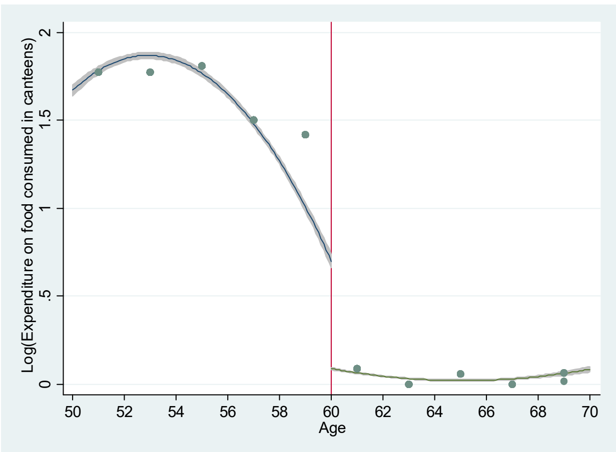
(A) Total daily food expenditure



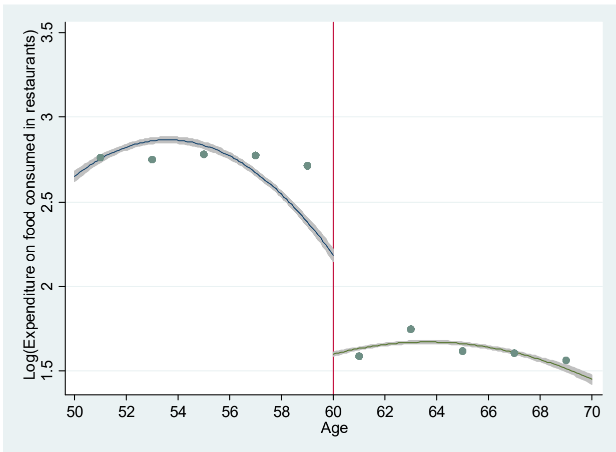
(B) Away from home



(C) At home



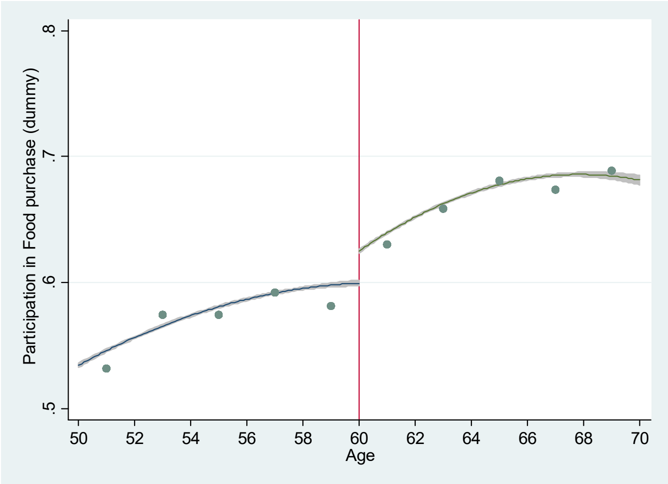
(D) Canteens



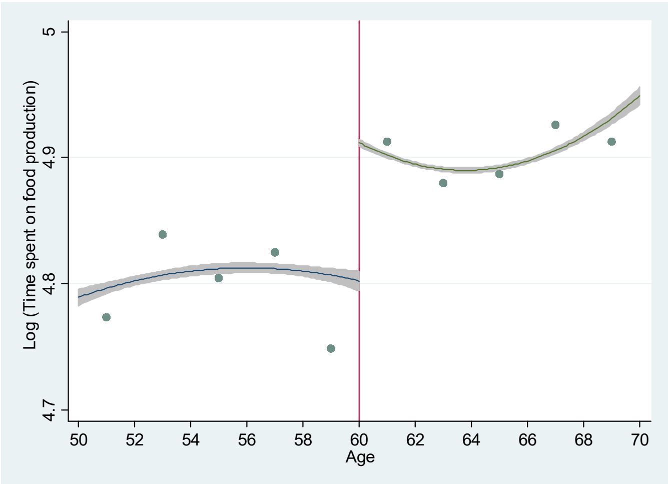
(F) Restaurants

Note: 1. Dots in graphs are sample means of observations within each bin (width=1 year).
2. Curves are fitted regression lines of a quadratic function of age.
3. Shaded areas are 95% confidence intervals of the associated fitted regression lines.

Figure 3: Reduced-form Impacts of Retirment on Food Expenditure



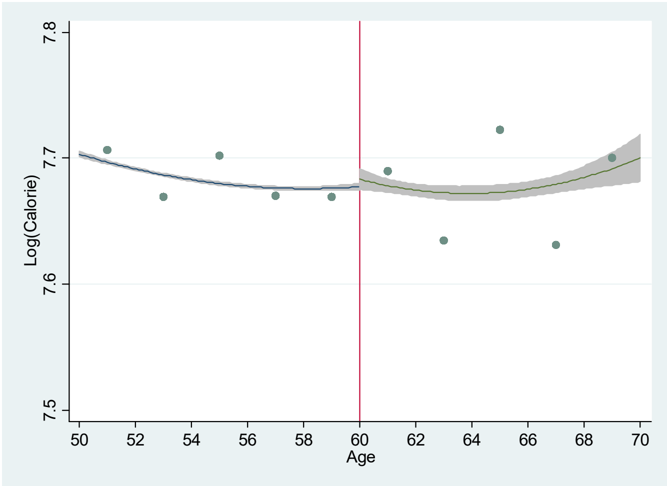
(A) Incidence of participation in food purchase



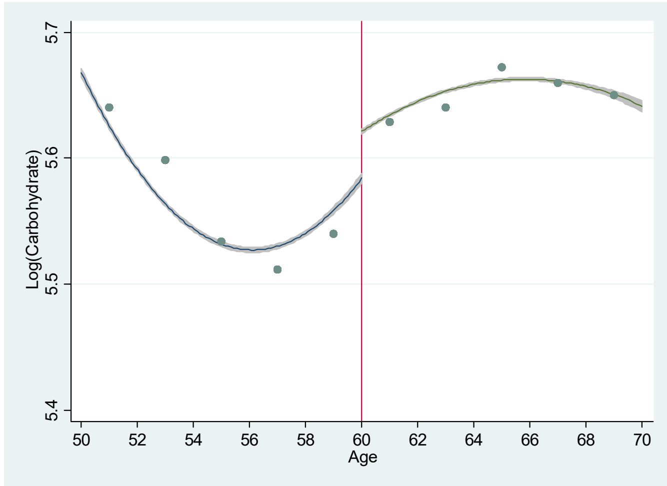
(B) Time spent on demostic food production (males and their wives')

Note: 1. Dots in graphs are sample means of observations within each bin (width =1 year).
2. Curves are fitted regression lines of a quadratic function of age.
3. Shaded areas are 95% confidence intervals of the associated fitted regression lines.

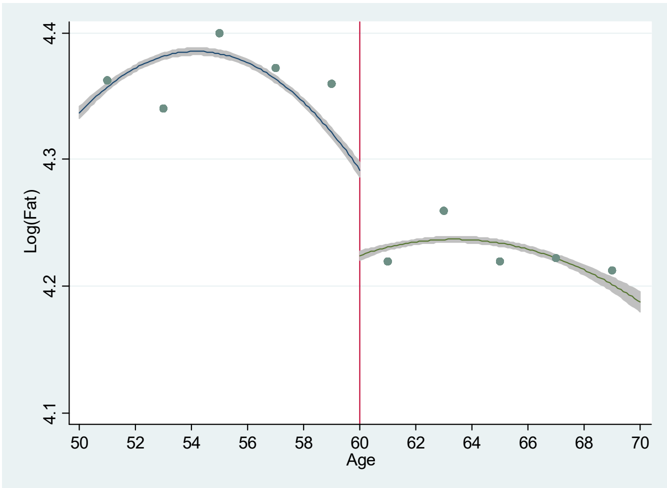
Figure 4: Reduced-form Impacts of Retirment on Time Spent on Food Acquistion



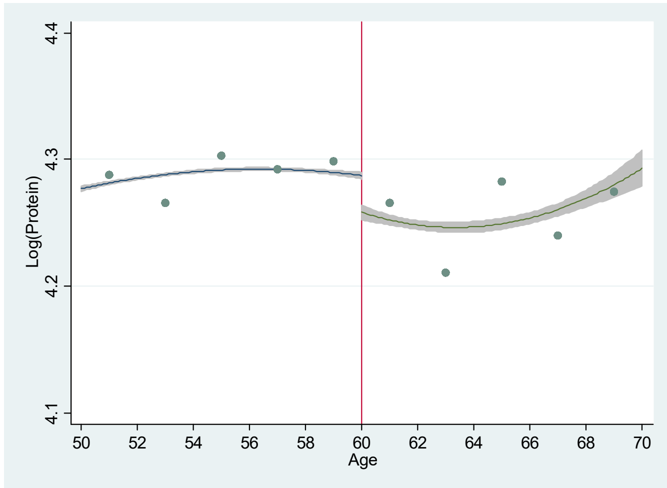
(A) Total nutrition intake



(B) Carbohydrate



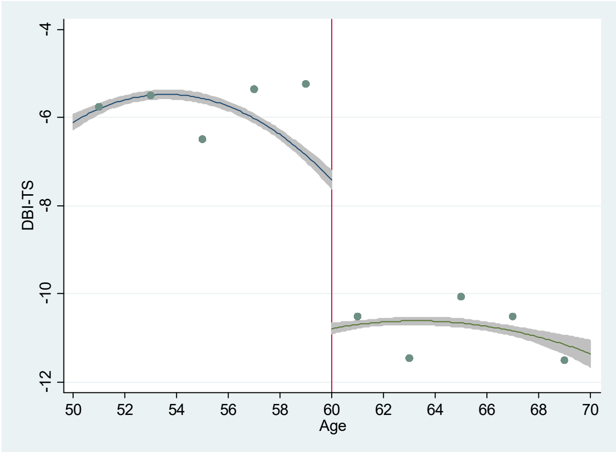
(C) Fat



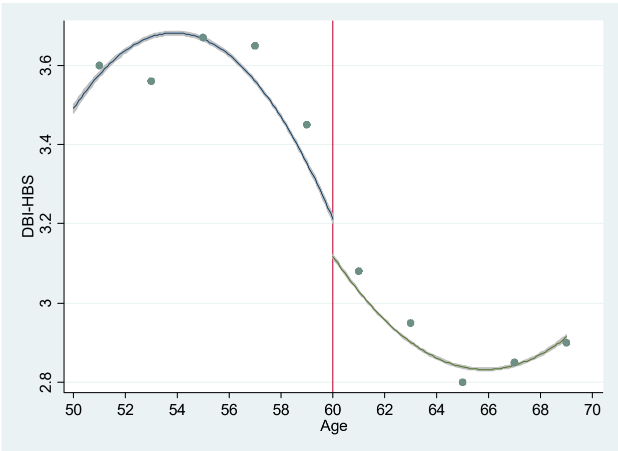
(D) Protein

Note: 1. Dots are sample means of observations within each bin (width=1 year). 2. Curves are fitted regression lines of a quadratic function of age. 3. Shaded areas are 95% confidence intervals of the associated fitted regression lines.

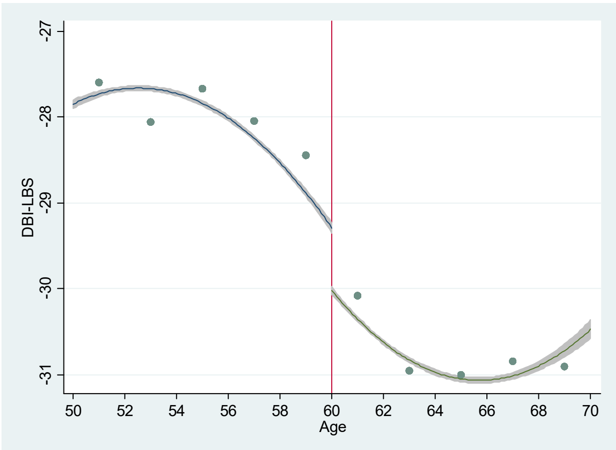
Figure 5: Reduced-form Impacts of Retirment on Nutrition Intakes



(A) Total Biet Balance (DBI-TS)



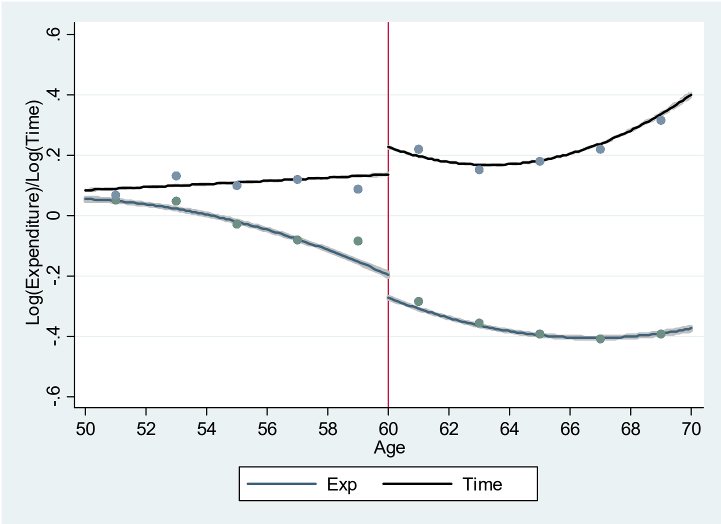
(B) Adequate or Overconsumption (DBI-H)



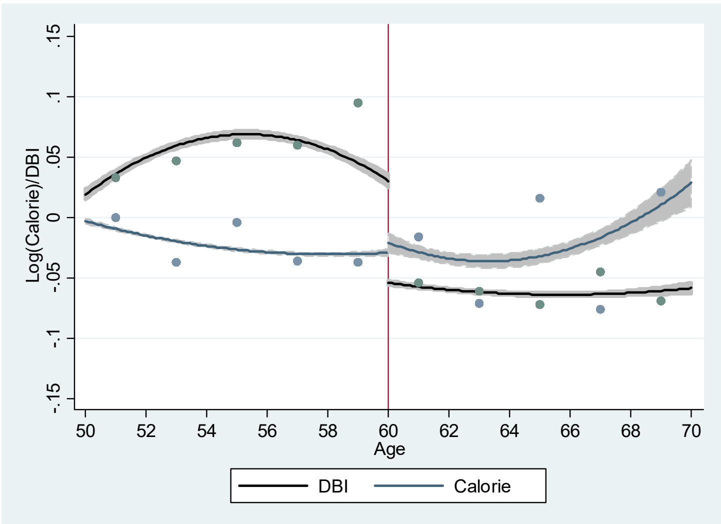
(C) Under consumption (DBI-L)

Note: 1. Dots in graphs are sample means of observations within each bin (width =1 year). 2. Curves are fitted regression lines of a quadratic models of age on either side of the cut-off. 3. Shaded areas are 95% confidence intervals of the associated regression fitted lines.

Figure 6: Reduced-form Impacts of Retirment on Diet Balance



(A) Food Expenditure/Time Spent on Food Production



(B) Calorie intake/ Diet Balance

Note: 1. The value "0" on the vertical axes is referred to as the mean value of the outcome variable under discussion for the 50-year-olds. 2. Dots in graphs are sample means of observations within each bin (width =1 year). 3. Curves are fitted regression lines of a quadratic models of age on either side of the cut-off. 4. Shaded areas are 95% confidence intervals of the associated regression fitted lines.

Figure 7: Reduced-form Impacts of Retirment on Calorite Intake and Diet Balance