# Online Appendices for "Mandatory Retirement and the Consumption Puzzle: Disentangling Price and Quantity Declines"

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## 1 Appendix I: Correcting for the Rounded Age Bias

This appendix illustrates the bias incurred when using age in years as a running variable and describes an alternative bias correction procedure to Dong (2015), which facilitates obtaining the standard error directly. For simplicity, consider the following quadratic regression for retirement

$$T = \sum_{j=0}^{J} a_j X^j + \sum_{j=0}^{J} b_j X^j D + v. \tag{1}$$

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 that $X = \widetilde{X} + e$, where $e$ is the difference between the true age and the rounded age in years, or the rounding error. Assuming that one's birth-date $e$ is independent of his integer

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age $X$, we have

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

where $\mu_j = E(e^j)$ for $j = 0, 1, 2$ is the $j$th raw moments of the birth-date 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 $w = T - E(T|\widetilde{X})$. Assuming 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 $j$th moment is $\mu_j = 1/\left(j+1\right)$.[1]

If one estimates a polynomial regression of $T$ on the rounded age in years $\widetilde{X}$, or Equation (2), 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 that $\mu_1 \neq 0$ and $\mu_2 \neq 0$.

To obtain a consistent estimate of the true change in the mean consumption, one can instead estimate a bias-corrected regression. In particular, assume $E\left[e|\widetilde{X}, D\right] = 0$ and $E\left[v|D, \widetilde{X}\right] = 0$, then

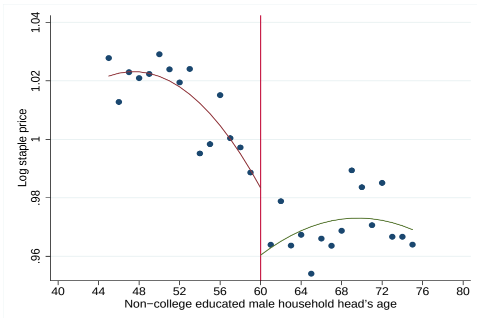
$$
\begin{aligned}
E\left[T|D, \widetilde{X}\right] &= a_0 + a_1\left(\widetilde{X} + u_1\right) + a_2(\widetilde{X}^2 + 2u_1\widetilde{X} + u_2) \\
&\quad + b_0 D + b_1\left(\widetilde{X} + u_1\right) D + b_2(\widetilde{X}^2 + 2u_1\widetilde{X} + u_2)D \\
&= a_0 + a_1 X_1^* + a_2 X_2^* + b_0 D + b_1 X_1^* D + b_2 X_2^* D,
\end{aligned}
$$

where $X_1^* \equiv \widetilde{X} + u_1$, $X_2^* \equiv \widetilde{X}^2 + 2u_1\widetilde{X} + u_2$, $u_1 = 1/2$, and $\mu_2 = 1/3$. Similarly one can bias correct the consumption model. Then estimate the bias-corrected retirement

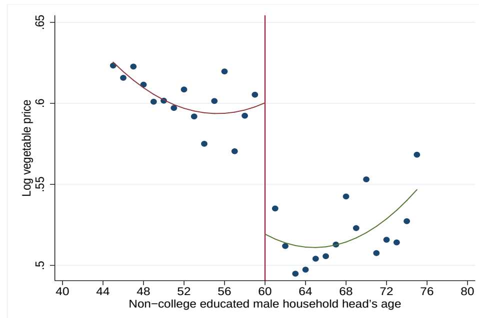
[1] There exists evidence of small but statistically significant seasonal departures from uniformity in the distribution of births within a year. However, this seasonal variation appears to have very little impact on the lower-order moments. Alternatively, one could estimate those moments using a second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

and consumption equation by, e.g., generalized method of moments (GMM). For any $j \geq 3$, one can similarly derive the bias-corrected regressions and proceed with analygous estimation.

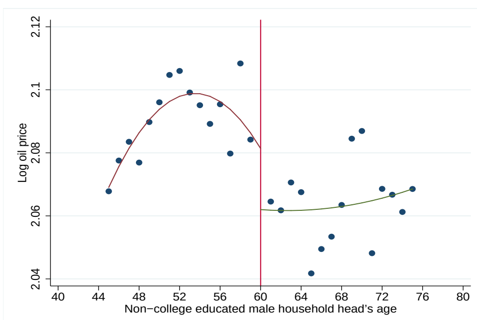
# 2 Appendix II: Consumption Prices and Quantities for Collge- and Non-college Education Groups



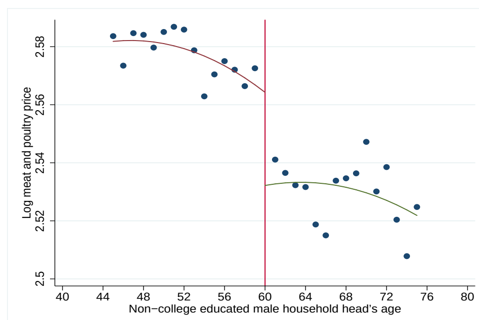

(a) Staple price



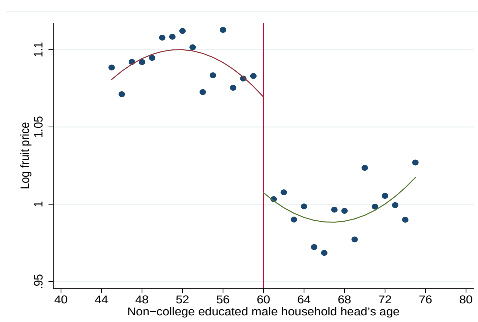

(b) Vegetable price




(c) Oil and fat price

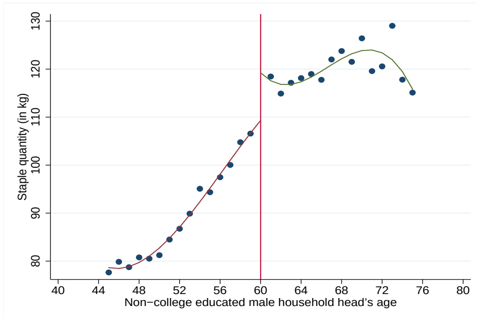



(d) Meat and poultry price

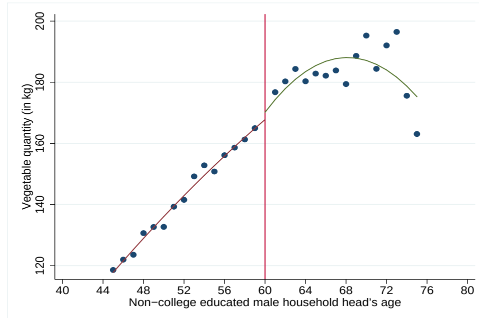



(e) Fruit price

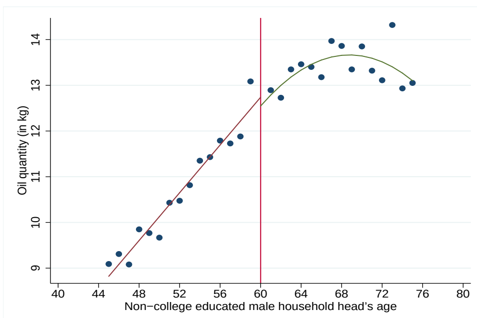
Figure 1: Age Profiles of Food Prices by Category: Non-College-Educated Male Household Heads, UHS 1997-2006



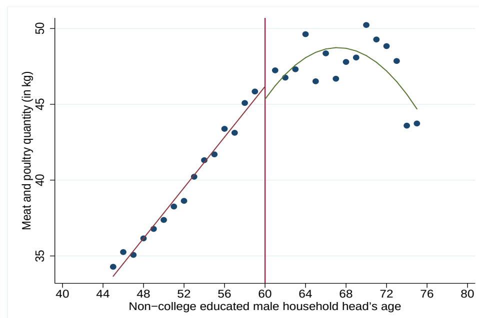

(a) Staple quantity



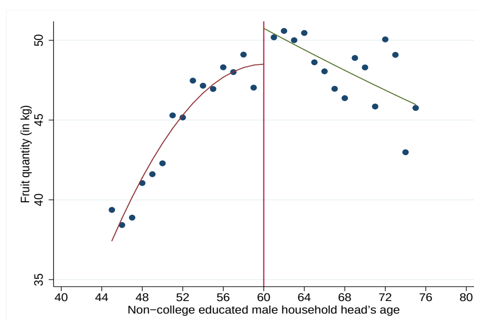

(b) Vegetable quantity




(c) Oil and fat quantity

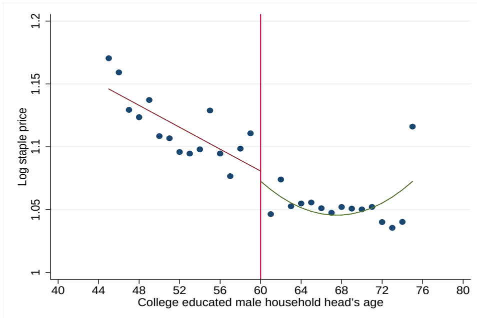



(d) Meat and poultry quantity

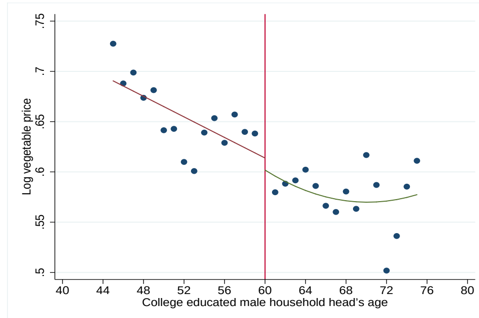



(e) Fruit quantity

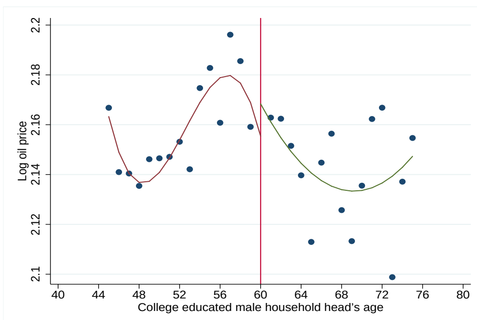
Figure 2: Age Profiles of Food Quantities by Category: Non-College-Educated Male Household Heads, UHS 1997-2006



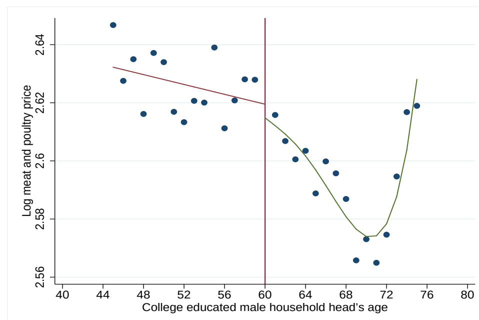

(a) Staple price



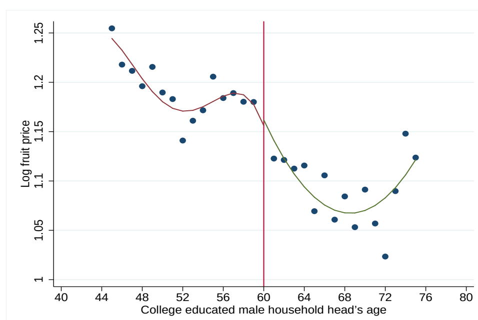

(b) Vegetable price




(c) Oil price

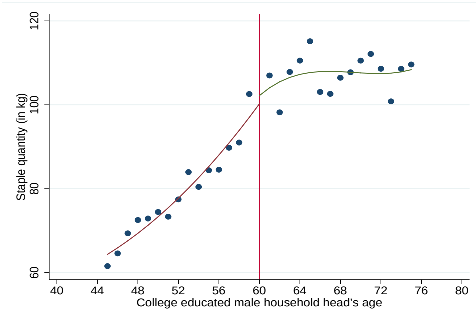



(d) Meat and poultry price

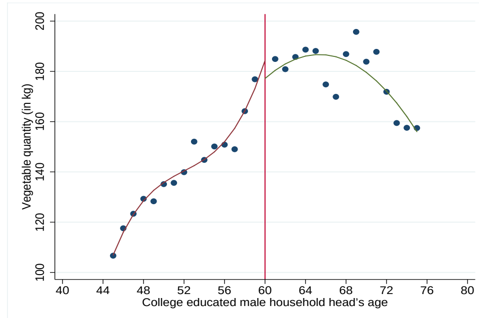



(e) Fruit price

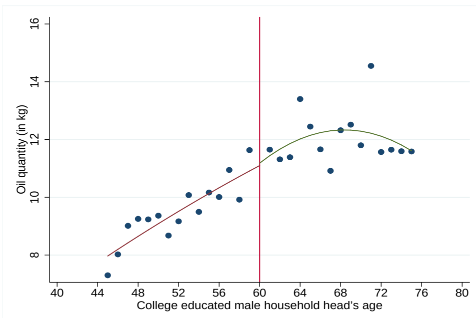
Figure 3: Age Profiles of Food Prices by Category: College-educated Male Household Heads, UHS 1997–2006



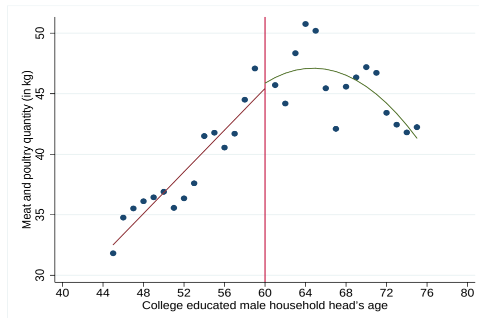

(a) Staple quantity



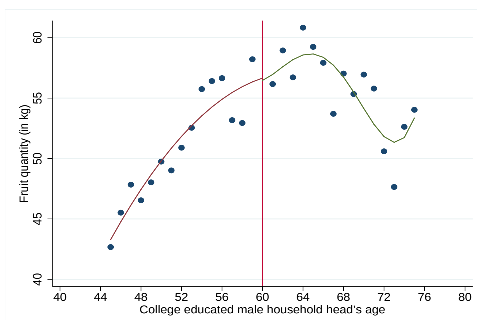

(b) Vegetable quantity




(c) Oil and fat quantity




(d) Meat and poultry quantity




(e) Fruit quantity

Figure 4: Age Profiles of Food Quantities by Category: College-Educated Male Household Heads, UHS 1997–2006

# 3 Appendix III: Time-Varying Effects of Retirement

In our main text, we investigate the immediate average changes in consumption at retirement, using the standard RD design. However, there may be variable delayed effects, that is, the long-run effect may differ from the short-run effect. Focusing entirely on immediate changes may under- or over-estimate the full effects of retirement. For example, the age profiles of various consumption measures show some changes in slopes at the mandatory retirement age. Extrapolating the pre-mandatory retirement age curve to post-mandatory appears to suggest enlarged effects over time. To address this concern, this appendix explores the time-varying effects of retirement. It is worth mentioning that even if the retirement effects change with time, the standard RD design can still correctly identify the immediate or short-run effects of retirement on consumption.

The following discusses estimating the time-varying effects of retirement using our cross-sectional data (and hence without knowing at what age an individual retires or how long he has been retired at the time of the survey). Let $X^0$ denote the age a household head at his retirement minus 60, e.g., $X^0 = 1$ for someone who has retired at 61. Given that $X$ denotes the true age of a household head at the time of the survey minus 60, $X - X^0$ measures how long he has been retired at the time of the survey.

Assume that household consumption depends on the household head's age, $X$, on whether the head is retired or not, $T$, and on other factors that change smoothly with age, $\upsilon$. Moreover assume that retirement effects both $X^0$ and $X - X^0$, where the latter captures the time-varying retirement effects. The consumption model can be written as follows:

$$Y = g(X) + h\left(X^0, X - X^0\right) T + \upsilon, \tag{3}$$

where $g(\cdot)$ and $h(\cdot)$ are smooth functions. For illustration convenience, we assume a uniform kernel. We then obtain the following local polynomial approximation of Equation (3):

$$Y = \sum_{k=0}^{K} \lambda_k X^k + \sum_{k=0}^{K} \sum_{j=0}^{k} \tau_{kj} \left(X^0\right)^j \left(X - X^0\right)^{k-j} T + \varpi. \tag{4}$$

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

The immediate effect of retirement on consumption at the mandatory retirement age of 60 can still be identified using the standard RD estimand:

$$\tau_{00} = \frac{\lim_{x\to 0^+} E\left[Y|X=x\right] - \lim_{x\to 0^-} E\left[Y|X=x\right]}{\lim_{x\to 0^+} E\left[T|X=x\right] - \lim_{x\to 0^-} E\left[T|X=x\right]}. \tag{5}$$

Intuitively, $\sum_{k=1}^{K}\sum_{j=0}^{k}\tau_{kj}\left(X^0\right)^j\left(X-X^0\right)^{k-j}$, or any terms involving $X_0$ and $X-X_0$ in Equation (3), are smooth at the (normalized) mandatory retirement age $X = 0$. Therefore, these terms drop in the difference in the numerator.

Taking a local linear approximation (i.e., $K = 1$) of the true consumption model, we obtain the following

$$Y = \lambda_0 + \lambda_1 X + \tau_{00} T + \tau_{10}\left(X - X^0\right)T + \tau_{11} X^0 T + \varpi. \tag{6}$$

Assuming that $\tau_{10} = \tau_{11}$, i.e., the heterogeneity of the retirement effect in the retirement age is assumed to be the same as the time-varying effect of retirement, then Equation (6) 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 for those who retire at 60 but are now at age 61.[2]

We estimate the immediate effect $\tau_{00}$ and the time-varying effect $\tau_{10}$ in $Y = \lambda_0 + \lambda_1 X + \tau_{00} T + \tau_{10} XT + \varpi$, using the mandatory retirement dummy $D$ as an IV for retirement status $T$. The estimates are presented in Tables A1 and A2. We focus on the prices and quantities of major food categories to obtain relatively precise estimates. 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 change significantly over time. For

[2]Without this restriction, and by using only cross-section data similar to ours, one cannot separate how the retirement effect changes with time for those "compliers" who retire at age 60 from the retirement effect heterogeneity in the retirement age.

example, for food prices, the estimates in non-college-educated group range from 0 to $-0.3\%$, which suggest that the food prices gradually decline the longer an individual has retired. The estimates are mostly small and insignificant in the college-educated group. For food quantities, the estimates among the non-college-educated group are about $-2\%$, compared with the immediate increases of over 10% on average. For this group, the short-run increase in the quantities of food purchased for home cooking slightly gradually declines over time. Overall, the changes in the food prices and quantities upon retirement persist over time.

Table A1 Time-Varying Effects of Retirement on Food Prices

| | Non-college-educated | | college-educated | |
|---|---|---|---|---|
| | 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, household head's education and marital status, household size, and household size squared; Retire is the dummy indicating a household head is retired or not, and Age is the reported household head's age in years; Robust standard errors are in parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table A2 Time-Varying Effects of Retirement on Food Quantities

| | Non-college-educated | | college-educated | |
|---|---|---|---|---|
| | 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 head age, head's education, marital status, household size, and household size squared; Retire is the dummy indicating a household head is retired or not, and Age is the reported household head's age in years; robust standard errors are in parentheses; * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.