Online Appendix: Putting the pension back in 401(k) retirement plans: Optimal versus default deferred longevity income annuities

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Appendix A: Wage rate process modeling

We calibrated the wage rate process using the Panel Study of Income Dynamics (PSID) 1975-2013 from age 25 to 69. During the work life, the individual's labor income profile has deterministic, permanent, and transitory components. The shocks are uncorrelated and normally distributed according to $ln(N_t) \sim N(-0.5\sigma_n^2,\ \sigma_n^2)$ and $ln(U_t) \sim N(-0.5\sigma_u^2,\ \sigma_u^2)$. The wage rate values are expressed in \$2013. These are estimated separately by sex and by educational level. The educational groupings are: less than High School (<HS), High School graduate (HS), and those with at least some college (Coll+). Extreme observations below \$5 per hour and above the 99th percentile are dropped.

We use a second order polynomial in age and dummies for employment status. The regression function is:

$$\ln(w_{i,y}) = \beta_1 * age_{i,y} + \beta_2 * age_{i,y}^2 + \beta_5 * ES_{i,y} + \beta_{waves} * wave\ dummies, \qquad \text{(A1)}$$

where $\log(w_{i,y})$ is the natural log of wage at time *y* for individual *i*, *age* is the age of the individual divided by 100, *ES* is the employment status of the individual, and wave dummies control for year-specific shocks. For employment status we include three groups depending on work hours per week as follows: part-time worker (≤ 20 hours), full-time worker (< 20 & ≤ 40 hours) and over-time worker (< 40 hours). OLS regression results for the wage rate process equations appear in Table A1.

To estimate the variances of the permanent and transitory components, we follow Carroll and Samwick (1997) and Hubener at al. (2016). We calculate the difference of the observed log wage and our regression results, and we take the difference of these differences across different lengths of time *d*. For individual *i*, the residual is:

$$r_{i,d} = \sum_{s=0}^{d-1}(N_{t+s}) + U_{i,t+d} - U_{i,t}. \qquad \text{(A2)}$$

We then regress the $v_{id} = \overline{r_{i,d}^2}$ on the lengths of time *d* between waves and a constant:

$$v_{id} = \beta_1 \cdot d + \beta_2 \cdot 2 + e_{id}, \qquad \text{(A3)}$$

where the variance of the permanent factor $\sigma_N^2 = \beta_1$ and the $\sigma_U^2 = \beta_2$ represents the variance of the transitory shocks.

Table A1: Regression results for wage rates

Coefficient	Male <HS	Male HS	Male +Coll	Female <HS	Female HS	Female +Coll
Age/100	3.146	6.098	9.117	1.253	2.820	4.646
	(0.108)	(0.050)	(0.072)	(0.109)	(0.047)	(0.075)
Age^2/10000	-3.314	-6.581	-9.388	-1.326	-2.997	-4.886
	(0.130)	(0.063)	(0.093)	(0.131)	(0.061)	(0.097)
Part-time work	-0.110	-0.159	-0.086	-0.088	-0.127	-0.088
	(0.020)	(0.009)	(0.012)	(0.006)	(0.003)	(0.004)
Over-time work	0.0044	0.049	0.095	0.017	0.075	0.106
	(0.004)	(0.002)	(0.002)	(0.006)	(0.002)	(0.003)
Constant	1.929	1.468	1.073	2.068	1.968	1.950
	(0.032)	(0.011)	(0.015)	(0.028)	(0.010)	(0.015)
Observations	49,083	315,685	270,352	31,651	279,375	207,640
R-squared	0.068	0.102	0.147	0.033	0.044	0.093
Permanent	0.00907	0.0133	0.0188	0.00747	0.0128	0.0188
	(0.001)	(0.0002)	(0.0003)	(0.001)	(0.0002)	(0.0003)
Transitory	0.0276	0.0307	0.0414	0.0226	0.0275	0.040
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Observations	28,548	170,469	131,836	20,884	170,735	114,700
R-squared	0.214	0.279	0.301	0.157	0.252	0.266

Notes: Regression results for the natural logarithm of wage rates (in \$2013) are based in on information in the Panel Study of Income Dynamics (PSID) for persons age 25-69 in waves 1975-2013. Independent variables include age and age-squared, and dummies for part time work (≤20 hours per week) and overtime work (≥ 40 hours per week). Robust standard errors in parentheses. Source: Authors' calculations.

Appendix B: 401(k) plans tax-qualified pension account

We integrate a US-type progressive tax system into our model to explore the impact of having access to a qualified (tax-sheltered) pension account of the EET type.[1] Here the worker must pay taxes on labor income and on capital gains from investments in bonds and stocks. All values are in \$2013. Relevant amounts are inflation adjusted year by year. During the working life, he invests A_t in the tax-qualified pension account, which reduces taxable income up to an annual maximum amount D_t=\$18,000. Correspondingly, withdrawals W_t from the tax-qualified account increase taxable income. Finally, the worker's taxable income is reduced by a general standardized deduction GD. For a single person, this deduction amounted to \$5,950 per year. Consequently, taxable income in working age is given by:

$$Y_{t+1}^{tax} = \max\big[\max\big(S_t \cdot (R_{t+1} - 1) + B_t \cdot \big(R_f - 1\big);\ 0\big) + Y_{t+1}(1 - h_t) + W_t - \min(A_t; D_t) - GD; 0\big]. \quad \text{(B1)}$$

For Social Security (Y_{t+1}) taxation up to age 66, we use the following rules: when the *combined income*[2] is between \$25,000 and \$34,000 (over \$34,000), 50% (85%) of benefits are taxed.[3] After age 66 we set A_t= 0, i.e. no further contributions in 401(k) retirement plans are possible.

In line with US rules for federal income taxes, our progressive tax system has six income tax brackets (IRS 2012a). These brackets $i = 1, \ldots, 6$ are defined by a lower and an upper bound of taxable income $Y_{t+1}^{tax} \in [lb_i, ub_i]$ and determine a marginal tax rate r_i^{tax}. For the year 2012, the marginal taxes rates for a single household are 10% from \$0 to \$8700, 15% from \$8701 to \$35,350, 25% from \$35,351 to 85,659, 28% from \$85,651 to \$178,650, 33% from \$178,651 to \$388,350, and 35% above \$388,350 (see IRS 2012a). Based on these tax brackets, the dollar amount of taxes payable is given by:[4]

$$\begin{aligned} Tax_{t+1}(Y_{t+1}^{tax}) = \ & (Y_{t+1}^{tax} - lb_6) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_6\}} \cdot r_6^{tax} \\ & + \Big((Y_{t+1}^{tax} - lb_5) \cdot 1_{\{lb_6 > Y_{t+1}^{tax} \geq lb_5\}} + (ub_5 - lb_5) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_6\}} \Big) \cdot r_5^{tax} \\ & + \Big((Y_{t+1}^{tax} - lb_4) \cdot 1_{\{lb_5 > Y_{t+1}^{tax} \geq lb_4\}} + (ub_4 - lb_4) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_5\}} \Big) \cdot r_4^{tax} \\ & + \Big((Y_{t+1}^{tax} - lb_3) \cdot 1_{\{lb_4 > Y_{t+1}^{tax} \geq lb_3\}} + (ub_3 - lb_3) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_4\}} \Big) \cdot r_3^{tax} \\ & + \Big((Y_{t+1}^{tax} - lb_2) \cdot 1_{\{lb_3 > Y_{t+1}^{tax} \geq lb_2\}} + (ub_2 - lb_2) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_3\}} \Big) \cdot r_2^{tax} \\ & + \Big((Y_{t+1}^{tax} - lb_1) \cdot 1_{\{lb_2 > Y_{t+1}^{tax} \geq lb_1\}} + (ub_1 - lb_1) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_2\}} \Big) \cdot r_1^{tax}, \end{aligned} \quad \text{(B2)}$$

[1] That is, contributions and investment earnings in the account are tax exempt (E), while payouts are taxed (T).
[2] Combined income is sum of adjusted gross income, nontaxable interest, and half of his Social Security benefits.
[3] See https://www.ssa.gov/planners/taxes.html
[4] Here we assume that capital gains are taxed at the same rate as labor income, so we abstract from the possibility that long-term investments may be taxed at a lower rate.

where, for $A \subseteq X$, the indicator function $1_A \to \{0, 1\}$ is defined as:

$$1_A(x) = \begin{cases} 1 \mid x \in A \\ \\ 0 \mid x \notin A\,. \end{cases} \tag{B3}$$

In line with US regulation, the individual must pay an additional penalty tax of 10% on early withdrawals prior to age 59 ½ ($t = 36$):

$$Tax_{t+1}(Y_{t+1}^{tax}) = \begin{cases} Tax_{t+1}(Y_{t+1}^{tax}) & t \geq 36 \\ \\ Tax_{t+1}(Y_{t+1}^{tax}) + 0.1W_t & t < 36\,. \end{cases} \tag{B4}$$

The tax brackets and the maximum amount of retirement contributions are normally adjusted annually for inflation. In addition, the tax payments increase during working life ($t < K$) by a fixed health insurance premium of $ 1,200.

Online Appendix C: Population mortality tables differentiated by education and sex

Research has shown that lower-educated individuals have lower life expectancies than better-educated individuals. This is relevant to the debate over whether and which workers need annuitization. To explore the impact of this difference in mortality rates by educational levels, we follow Kreuger et al. (2015) who calculated mortality rates by education and sex ($M_{sex}^{education}$) as below:

$$\begin{aligned} M_{male}^{average} &= 0.1M_{male}^{<HS} + 0.3M_{male}^{HS} + 0.6M_{male}^{Coll+} \\ &= 0.1(M_{male}^{HS} \cdot 1.23) + 0.3M_{male}^{HS} + 0.6(M_{male}^{HS} \cdot 0.94) \\ &= 0.987 \cdot M_{male}^{HS}. \end{aligned} \tag{C1}$$

Next we calculate the mortality for a male with a HS degree as follows:

$$M_{male}^{HS} = \frac{M_{male}^{average}}{0.987} \quad . \tag{C2}$$

Mortality for a male high school dropout or with Coll+ level education is as follows:

$$M_{male}^{<HS} = \frac{M_{male}^{average}}{0.987} \cdot 1.23 \tag{C3}$$

$$M_{male}^{Coll+} = \frac{M_{male}^{average}}{0.987} \cdot 0.94 \tag{C5}$$

Analogously, we calculate for females with different levels of education the following:

$$M_{female}^{<HS} = \frac{M_{female}^{average}}{0.984} \cdot 1.32 \tag{C6}$$

$$M_{female}^{HS} = \frac{M_{female}^{average}}{0.984} \tag{C7}$$

$$M_{female}^{Coll+} = \frac{M_{female}^{average}}{0.984} \cdot 0.92. \tag{C8}$$

We price the annuity as before using average annuitant mortality tables.

References

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