# Online Appendices

# How Would 401(k) 'Rothification' Alter Saving, Retirement Security, and Inequality?

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**Online Appendix A: Wage rate estimation**

We calibrated the wage rate process using the Panel Study of Income Dynamics (PSID) 1975-2015 from age 25 to 69. During the work life, each individual's labor income profile has deterministic, permanent, and transitory components with uncorrelated and normally distributed shocks 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 \$2015. 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 99$^{th}$ percentile are dropped.

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

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

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 individual's employment status, 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 overtime worker (< 40 hours). OLS regression results for the wage rate process equations are provided 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 the regression result, and we take the difference of these differences across different lengths of time *d*. For individual *i,* the residual is:

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

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

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

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 | 3.161*** | 5.972*** | 9.092*** | 1.256*** | 2.767*** | 4.731*** |
| | (0.108) | (0.049) | (0.070) | (0.110) | (0.046) | (0.072) |
| Age²/10000 | -3.329*** | -6.416*** | -9.351*** | -1.339*** | -2.915*** | -4.960*** |
| | (0.130) | (0.062) | (0.089) | (0.131) | (0.059) | (0.094) |
| Part-time work | -0.109*** | -0.153*** | -0.0826*** | -0.0858*** | -0.129*** | -0.0847*** |
| | (0.020) | (0.009) | (0.011) | (0.006) | (0.003) | (0.004) |
| Over-time work | 0.00412 | 0.0506*** | 0.0949*** | 0.0158*** | 0.0748*** | 0.106*** |
| | (0.004) | (0.002) | (0.002) | (0.006) | (0.002) | (0.003) |
| Constant | 1.807*** | 1.435*** | 1.151*** | 2.051*** | 2.015*** | 1.938*** |
| | (0.042) | (0.012) | (0.015) | (0.037) | (0.011) | (0.017) |
| Observations | 48,762 | 327,305 | 293,386 | 31,788 | 290,597 | 225,211 |
| R-squared | 0.069 | 0.102 | 0.147 | 0.032 | 0.044 | 0.092 |
| Permanent | 0.009*** | 0.013*** | 0.019*** | 0.008*** | 0.013*** | 0.019*** |
| | (0.001) | (0.0002) | (0.0003) | (0.0001) | (0.0002) | (0.001) |
| Transitory | 0.028*** | 0.031** | 0.041*** | 0.023*** | 0.028*** | 0.038*** |
| | (0.001) | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) |
| Observations | 28,359 | 175,247 | 140,984 | 20,863 | 176,304 | 123,145 |
| R-squared | 0.214 | 0.283 | 0.307 | 0.146 | 0.255 | 0.264 |

**Notes**: Regression results for the natural logarithm of wage rates (in $2015) are based in on information in the Panel Study of Income Dynamics (PSID) for persons age 25-69 in waves 1975-2015. 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. ***: p>.01. Source: Authors' calculations.

**Online Appendix B: Modeling and taxation of retirement income**

We embed a US-type progressive tax system (under the IRS 2018 rules) in our model to explore the impact of having access to a qualified (tax-sheltered) pension account of the EET versus the TEE (Roth) type.[1] That is, contributions, investment earnings, and payouts of the retirement account are tax exempt (E) or taxed (T). Here the worker must pay taxes on labor income and on capital gains from investments in bonds and stocks. [2] During the working life, he invests $A_t$ in a tax-qualified pension account which reduces in the EET case his taxable income; contributions can be made to an annual maximum amount $D_t$= \$18,500 (and from age 50 an additional \$6,000 catch up is feasible). Correspondingly, withdrawals $W_t$ from the tax-qualified account increase taxable income. In the TEE case matching contribution are part, while own contributions and withdrawals are not part of taxable income. Finally, the worker's taxable income is reduced by a general standardized deduction $GD$. For a single person, this deduction was in (IRS 2018) \$12,000 per year.

Consequently, taxable income during the working age is given by:

$$\begin{aligned}
\text{EET} \quad & Y_{t+1}^{tax} = \max\big[\max\big(S_t \cdot (R_{t+1} - 1) + B_t \cdot \big(R_f - 1\big);\ 0\big) + \\
& Y_{t+1}(1 - h_t) + W_t - \min(A_t; D_t + catch\ up) - GD; 0\big], \text{ and} \\
\text{TEE} \quad & Y_{t+1}^{tax} = \max\big[\max\big(S_t \cdot (R_{t+1} - 1) + B_t \cdot \big(R_f - 1\big);\ 0\big) + M_t + \\
& Y_{t+1}(1 - h_t) - GD; 0\big].
\end{aligned} \tag{B1}$$

For Social Security ($Y_{t+1}$) taxation, we use the following rules: when the retiree's *combined income*[3] is between \$25,000 and \$34,000 (over \$34,000), 50% (85%) of benefits are taxed. After retirement, 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 seven income tax brackets. These brackets $i = 1, \dots, 7$ 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 $r_i^{tax}$. In 2018, the marginal taxes rates for a single household were 10% from \$0 to \$9,225, 12% from \$9,225 to \$38,700, 22% from \$38,701 to \$82,500, 24% from \$82,501 to \$157,500, 32% from \$157,500 to \$200,000 35% from \$200,001 to \$500,000 and 37% above \$500,000 (see IRS 2018). Based on these tax brackets, the dollar amount of taxes payable is given by:[4]

$$\begin{aligned}
IT_{t+1}^{tax} = {} & (Y_{t+1}^{tax} - lb_7) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_7\}} \cdot r_7^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_6) \cdot 1_{\{lb_7 > Y_{t+1}^{tax} \geq lb_7\}} + (ub_6 - lb_6) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_7\}}\right) \cdot r_6^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_5) \cdot 1_{\{lb_6 > Y_{t+1}^{tax} \geq lb_5\}} + (ub_5 - lb_5) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_6\}}\right) \cdot r_5^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_4) \cdot 1_{\{lb_5 > Y_{t+1}^{tax} \geq lb_4\}} + (ub_4 - lb_4) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_5\}}\right) \cdot r_4^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_3) \cdot 1_{\{lb_4 > Y_{t+1}^{tax} \geq lb_3\}} + (ub_3 - lb_3) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_4\}}\right) \cdot r_3^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_2) \cdot 1_{\{lb_3 > Y_{t+1}^{tax} \geq lb_2\}} + (ub_2 - lb_2) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_3\}}\right) \cdot r_2^{tax} \\
& + \left((Y_{t+1}^{tax} - lb_1) \cdot 1_{\{lb_2 > Y_{t+1}^{tax} \geq lb_1\}} + (ub_1 - lb_1) \cdot 1_{\{Y_{t+1}^{tax} \geq lb_2\}}\right) \cdot r_1^{tax}
\end{aligned} \tag{B2}$$

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[1] All values are (as the labor income process) in \$2015 and relevant amounts deflated using the CPI.

[2] Here we assume that capital gains and earnings from investments outside the retirement accounts 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.

[3] Combined income is the sum of adjusted gross income, nontaxable interest, and half of the retiree's Social Security benefit (US SSA nd_c).

[4] For the matching procedure we use the tax-brackets and the GD as valid in 2015 (IRS 2015).

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

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

Additionally, before retirement ($t = \mathrm{K}$) the worker pays payroll taxes proportional to labor income: tax rate Social Security 6.2% (up to a limit of 128,400); Medicare tax rate 1.45% and city/state tax rate 4% (without limit). Overall payroll taxes are modelled as $PT_t^{tax} = 6.2\% \cdot \max(Y_t, 128{,}400) + 5.45\% \cdot Y_t$. and $PT_t^{tax} = 5.45\% \cdot Y_t$ after retirement $t \geq K$. Finally, penalty taxes of 10% on non-compliant early distributions prior to age 59 ½ ($t = 36$) are charged. Unlike the EET case, in the TEE only the portion of the non-compliant early distribution attributable to investment income is subject to the 10% penalty tax. To avoid another state variable in the model, the present value (using a 6% discount rate) of the distribution is assumed for the (age dependent) portion not subject to the penalty tax.

## References


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