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

Vanya Horneff, Raimond Maurer and Olivia S. Mitchell

Abstract

Many nations incentivize retirement saving by letting workers defer taxes on pension contributions, imposing them when retirees withdraw their funds. Using a dynamic life cycle model, we show how 'Rothification' – that is, taxing 401(k) contributions rather than payouts – alters saving, investment, consumption, and Social Security claiming patterns. We find that taxing pension contributions instead of withdrawals leads to delayed retirement, somewhat lower lifetime tax payments, and relatively small reductions in consumption. Indeed, the two tax regimes generate quite similar relative inequality metrics: the relative consumption inequality ratio under TEE is only four percent higher than in the EET case. Moreover, results indicate that the Gini measures are also strikingly similar under the EET and the TEE regimes for lifetime consumption, cash on hand, and 401(k) assets, differing by only 1-4 percent. While tax payments are higher early in life under the TEE regime, they are slightly lower in the long run. Moreover, higher EET tax payments are also accompanied by higher volatility. We therefore find few reasons for policymakers to favor either tax approach on egalitarian or revenue-enhancing grounds.

Key words: pensions; taxes; 401(k) plan; retirement; Social Security claiming; inequality

JEL: C63, D14, G51, H31, H55, J26

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

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1. Introduction

The US has long incentivized retirement saving by deferring taxes on workers' pension contributions until the assets are withdrawn in old age, at which point the withdrawn funds become subject to income tax. In this way, most of the $25 trillion nest egg that workers hold in employer-sponsored defined contribution 401(k) plans and individual retirement accounts (IRAs) are taxed according to an "Exempt-Exempt-Taxed" (EET) regime (ICI 2021):[1] workers contribute out of pre-tax earnings, recognize pre-tax investment earnings in their accounts, and pay income tax on withdrawals during retirement. This policy has a large current fiscal cost: some estimates claim that the US Treasury foregoes over $100 billion per year due to tax-deferred contributions to 401(k) and similar plans (Thornton 2017).[2]

Partly because of current and projected federal budget shortfalls, some policymakers have proposed eliminating or capping tax-qualified retirement plan contributions, a practice termed 'Rothification,' named after Senator William Roth who, in 1997, sponsored legislation permitting this. The Rothification idea has been a topic of considerable recent discussion, with former President Obama recommending a pre-tax pension contribution cap in 2015; related proposals were mooted during the 2017 tax reform debate (Schoeff 2017). Though those proposals were not enacted, the topic is certain to be revisited given the amount of revenue involved and the size of the ballooning fiscal deficit. In addition to analyzing the effect on the fiscal cost of changing tax incentives to promote retirement savings, it is of key importance to

[1] This terminology was introduced by Dilnot (1995) and is widely used in the literature; see OECD (2018). It categorizes the taxable treatment ("T" stands for taxable and "E" stands for exempt) of three income cash flows: contributions, return on investments, and withdrawals from retirement accounts.

[2] The Federal Government does receive some of the deferred tax revenue later when benefits are paid out, but retirees are often in a lower tax bracket than when working. Moreover, the deferral of taxes tends to mean that the revenue is not 'captured' in the traditional 10-year accounting window used for revenue neutrality calculations. Hence moving the tax capture forward is politically appealing to some; see Sibaie (2017).

assess the potential impact on household behavior. This is because if such a reform were to be passed, it could have important behavioral implications with effects that could vary across population subgroups.

This paper investigates the potential impact of treating all future retirement contributions to a "Taxed-Exempt-Exempt" (TEE) regime, in which workers contribute to their pensions out of after-tax income with no additional tax on investment earnings, and withdrawals would be levied thereafter. In an economy without uncertainty, a single proportional tax rate on a household's entire income, the absence of borrowing constraints, and where savings are contributed out of after-tax income versus later in retirement would not change household behavior (Feldstein 1969; Burman et al. 2001). In reality, of course, households are exposed to considerable uncertainty over their lifecycles due to stochastic mortality, health shocks, capital market volatility, and labor income risks. In addition, the US tax system is progressive, imposes different tax rates on different income sources, and embeds numerous nonlinearities. This applies, in particular, to the tax treatment of pension schemes.[3] For example, there are tax-relevant upper and lower limits for contributions into and withdrawals from private or employer-sponsored pension plans. Non-compliance with these limits can attract income taxes and additionally lead to severe tax penalties. Furthermore, tax incentives for funded pension schemes such as 401(k)s with voluntary participation cannot be considered in isolation from the national mandatory retirement system. Social Security taxes are levied in proportion to labor income, but only up to a maximum threshold. Social Security retirement benefits are calculated as a non-linear (concave) function of average lifetime earnings and are only partially included in taxable income, again according to a non-linear formula (on combined income). Moreover, the US Social Security system includes complex financial incentives to encourage delayed

[3] As Smith (2002: 539) from the US Treasury's Office of Tax Analysis opined, "the sections of the US Tax Code and regulations dealing with retirement savings policy are among the most arcane areas of our current tax system."

benefit claiming. As the literature shows (Shoven and Slavov 2014; Hubener et al. 2016), when to exercise this option also depends on financial assets accumulated for retirement.

In a world with uncertainty and where taxes and benefit are highly non-linear, it is less obvious how implementing a move from EET to TEE taxation of funded pension plans would alter household behavior. Specifically, it requires modeling the rich institutional details confronting real-world consumers along with their economic environment, capital and labor market risk, and uncertain lifetimes. Previous research including Dammon et al. (2004), Gomes et al. (2009), Poterba (2004), and Shoven and Sialm (2003), studied the effect of tax-qualified retirement accounts on savings and portfolio decisions for households maximizing lifetime consumption utility, but those studies used the classical EET framework and omitted work and retirement decisions. A recent empirical study by Beshears et al. (2017) documented that adding a Roth contribution option to existing traditional tax-deferred 401(k) plans would not change saving rates, under some circumstances. A simulation study by the OECD (2018) provided a theoretical analysis of the EET versus TEE approach; nevertheless, the metric used by the OECD to compare the two tax regimes - the overall lifetime tax advantage -- did not incorporate household behavioral responses to changes in tax incentives. Lachance (2013) compared investor decisions between a traditional tax-qualified retirement account versus a Roth account, but she did not incorporate Social Security claiming behavior, endogenous work hours, risky labor income, or market return risk, as we do here. Brown et al. (2017) found that there is some uncertainty in future income tax rates, so Roth accounts could be an important vehicle to mitigate the risk resulting uncertainty over future tax schedules.

We add to the literature by delving into possible consequences of such a reform on household behavior in the context of a richly-detailed state-of-the-art life cycle model. This model allows us to analyze of how Rothification could alter utility-maximizing households' consumption and work patterns, taking into account labor income risk, investments in risky stocks and bonds inside/outside retirement accounts, Social Security claiming patterns, and tax

payments. The model also incorporates realistic Social Security contribution structures and benefit formulas including adjustments for early and delayed claiming. Furthermore, our model includes US federal/state income tax and real-world rules characterizing tax-qualified 401(k) accounts, including caps on 401(k) pre-tax contributions and employer matches, as well as penalty taxes on non-qualified early distributions, and Required Minimum Distribution withdrawal amounts. Of key importance is *ex ante* heterogeneity: workers out the outset face different educational and mortality profiles, as well as *ex post* heterogeneity, due to labor income and capital return risk. To this end, we measure how key outcomes differ across several worker-types differentiated by sex and education, since some have argued that "Roths may not, in fact, work out to be a better deal" for low-income people (Tergesen 2017).[4]

It is additionally important to recognize that converting retirement accounts to Roth plans will take place against the backdrop of the income tax structure introduced in 2018, which reduced the tax burden for most earners.[5] That reform changed the relative attractiveness of saving for retirement in an EET environment, since lower marginal tax rates on workers' earnings reduced the attractiveness of saving in 401(k) accounts. Accordingly, our research compares how work, saving, benefit claiming behavior, and tax payments differ in an EET versus TEE setting, for a variety of heterogeneous workers.

In what follows, we first build and calibrate a structural life cycle model assuming an EET framework. Results agree closely with observed consumption, saving, and Social Security claiming patterns of U.S. households, while matching the distribution of 401(k) wealth rather nicely. Next, we develop results under an alternative environment where 401(k) contributions are taxed according to a TEE structure. This permits us to identify differences in behavior for the heterogeneous workers described above, under both tax regimes (EET versus TEE).

[4] Hallez (2017) reports that some predict that low-wage workers would save less in a TEE regime, whereas Statman (2017) concluded the opposite.
[5] This tax reform doubled the standard deduction to calculate taxable income, cut marginal tax rates, and raised tax brackets, especially for high earners (IRS 2018).

Specifically, we assess whether the lower-paid behave differently from the higher-paid in terms of savings inside and outside tax-qualified accounts, as well as in non-pension savings accounts, and whether they would change their Social Security claiming ages. In addition, we are interested in how Rothification would alter the distribution of retirement outcomes relative to the current EET system. For example, the gap between high and low-wage workers' take home pay is not diminished by income taxes under an EET system, whereas it is under a TEE program. Moreover, the Social Security replacement rate formula is concave, as it provides relatively higher benefits for low-wage workers than for the higher paid. Given this, an EET scheme enhances the progressivity of overall old age income (pension account withdrawals plus Social Security benefits), whereas a TEE structure treats retirement benefits more neutrally. Finally, we compare expected household tax payments over the life cycle under both the EET and TEE regimes.

2. The Consumer's Lifecycle Problem: Model and Calibration

This research builds on prior work (Horneff et al. 2019) by exploring the impact of a Rothification reform for 401(k) plans, while accounting for the current US income US tax regime. Our contribution is to develop a structural dynamic consumption and portfolio choice model for an individual maximizing his lifetime utility over consumption and leisure, using a richly specified, sophisticated formulation of lifetime behavior calibrated to US federal/state income tax and Social Security/Medicare premium structures, along with realistic Social Security benefit formulas.[6]

2.1 Preferences

We work in discrete yearly time steps and assume that the worker's decision period starts at $t = 1$ (age 25) and ends at $T = 76$ (age 100). The household has an uncertain lifetime,

[6] In particular, we take account of the nonlinear Social Security PIA and AIME formulas, as well as early and delayed retirement adjustments and full retirement ages.

such that the probability to survive from t until the next year $t + 1$ is denoted by p_t. Survival rates entering into the utility function are taken from the US Population Life Table (Arias 2010). Preferences are represented by a Cobb Douglas function $u_t(C_t, l_t) = \frac{(C_t l_t^{\alpha})^{1-\rho}}{1-\rho}$ based on current consumption C_t and leisure time l_t (normalized as a fraction of total available time). The parameter α measures leisure preferences; ρ is the coefficient of relative risk aversion; and β is the time preference factor. The recursive definition of the value function is given by:

$$J_t = \frac{(C_t l_t^{\alpha})^{1-\rho}}{1-\rho} + \beta E_t(p_t J_{t+1}), \tag{1}$$

with terminal utility $J_T = \frac{(C_T l_T^{\alpha})^{1-\rho}}{1-\rho}$ and $l_t = 1$ after retirement. We calibrate the preference parameters so our results match empirical claiming rates reported by the US Social Security Administration and average assets in tax-qualified retirement plans in the EET setting (for details, see below).

2.2 Time budget, labor income, and Social Security retirement benefits

As in Horneff et al. (2019), our model allows for flexible work effort and retirement ages. The worker allocates up to $(1 - l_t) = 0.6$ of his available time budget to paid work (assuming 100 waking hours per week and 52 weeks per year). Depending on his work effort, the uncertain yearly before-tax labor income is given by:

$$Y_{t+1} = (1 - l_t) \cdot w_t \cdot P_{t+1} \cdot U_{t+1}. \tag{2}$$

Here w_t is a deterministic wage rate component which depends on age, education, sex, and an indicator for whether the individual works full time, part time, or overtime. The variable $P_{t+1} = P_t \cdot N_{t+1}$ is the permanent component of wage rates with independent lognormal distributed shocks $N_t \sim LN(-0.5\sigma_P^2, \sigma_P^2)$ having a mean of one and volatility of σ_P^2. In addition, $U_t \sim LN(-0.5\sigma_U^2, \sigma_U^2)$ is a transitory shock with volatility σ_U^2 and assumed uncorrelated with N_t.

The calibration of the deterministic component of the wage rate process w_t^i and the variances of the permanent and transitory wage shocks N_t^i and U_t^i is based on data from Panel Study of Income Dynamics (PSID). We estimate these separately by sex and educational level, where the latter groupings are less than High School, High School graduate, and at least some college (<HS, HS, Coll+; see Appendix A, Table A1).

Between the ages of 62 and 70, a worker may retire from work and claim Social Security benefits. The benefit formula is an overall concave piece-wise linear function of the worker's average indexed lifetime earnings. This formula generates an annual unreduced Social Security benefit – called the Primary Insurance Amount (PIA) – equal to 90 percent of (12 times) the first $895 of average indexed monthly earnings, plus 32 percent of average indexed monthly earnings over $895 and through $5,397, plus 15 percent of average indexed monthly earnings over $5,397 and up to the cap $10,700 (in 2018).[7] Should an individual claim benefits before (after) his system-defined Normal Retirement Age of 66, his lifelong Social Security benefits are permanently reduced (increased) according to pre-specified factors. If an individual works beyond age 62, the model stipulates that he devote at least one hour per week; also, our model rules out overtime work in retirement (i.e. $0.01 \leq (1 - l_t) \leq 0.4$).

2.3 Taxation and evolution of retirement plans

During the worklife and in retirement, households must pay various taxes (Tax_{t+1}) which reduce cash on hand available for consumption and investment. The amount and timing of these tax payments over the life cycle differ significantly in the case of an EET versus TEE system.

First, workers must pay payroll taxes PT_{t+1}^{tax} amounting to 11.65%, which is the sum of 1.45% Medicare, 4% city and state tax and 6.2% Social Security tax (up to a maximum of

[7] See US SSA (nd a, b). Following Chai et al. (2011), the PIA is approximated using permanent income in the optimization. For the simulation of optimal life cycles, we use the 35 best years of earnings to specify the PIA and adjust the corresponding permanent income state.

$128,400 per year). Payroll taxes are not directly affected by retirement accounts. Second, the individual also pays a progressive federal income tax IT_{t+1}^{tax} based on his taxable income Y_{t+1}^{tax}, seven income tax brackets, and the corresponding marginal tax rates for each tax bracket (for details, see Appendix B). Taxable income is a complex function of labor earnings (including Social Security benefits), income from investments, and contributions into as well as distributions from 401(k) plans.

Under both regimes, for the retirement accounts that we consider, investment earnings on assets are not counted as part of taxable earnings, though the treatment of contributions (including employer matching contributions) and withdrawals differs between the two regimes. In the EET setup, contributions to the retirement account are tax-exempt (E) up to a limit, while withdrawals are part of taxable income (T). Technically, this means that employer matching contributions are not part of taxable income, while own contributions can be subtracted from taxable income. With regard to the tax treatment of withdrawals, in addition to their inclusion in taxable income, two other rules are of great importance. In line with US regulation, the individual must also pay a *penalty* tax of 10% when taking early distributions from 401(k) accounts prior to age 59 ½ ($t = 36$).[8] In addition, to avoid substantial tax penalties from age 70.5 onwards, retirees have conventionally been required to take Required Minimum Distributions (RMD) from 401(k) plans which are based on life expectancy data determined using the IRS (2020) Uniform Lifetime Table.[9]

In the TEE case, contributions (including matching employer contributions) are taxed, but retirement withdrawals are tax exempt.[10] Technically, this means that own contributions

[8] The IRS (2020) defines several exceptions (e.g. some medical expenses, permanently disabled, higher education expenses) from the age 59.5 rule, which may result that parts or all of the penalty tax must not be paid. We do not model such exceptions on early distributions.

[9] This requirement was increased to age 72 with the 2020 SECURE Act.

[10] IRS (2020) regulation requires that a (qualified) distribution from a Roth 401(k) is not part of taxable income if it is made no earlier than 5 years after the plan's inception. Otherwise, the portion of the distribution allocable to investment earnings is included in taxable income and additionally is subject to the 10% penalty tax. We apply this rule to early distributions between age 25 and 30 and refrain from tracking the exact date of the first contribution, which would be computationally expensive and have little influence on the results. Simulations show

cannot be deducted from taxable income, and employer matching contributions are added to taxable income. To sidestep liquidity problems due to back tax payments, we assume that employer contributions are taxed directly at the source, based on the worker's personal income tax rate. This generates a tax burden of M_t^{tax}, which reduces the contribution into the TEE account as well as the income tax amount.[11] Also the 10% penalty tax (on investment returns) must be paid on early distributions from the retirement account before age 59 ½, but there are no required minimum distributions for Roth accounts.[12] In sum, the tax payments for the two tax regimes under consideration are modelled as follows:

$$\underline{\text{EET}} \qquad Tax_t = PT_t^{tax} + IT_t^{tax} + penalty_t \tag{5}$$

$$\underline{\text{TEE}} \qquad Tax_t = PT_t^{tax} + (IT_t^{tax} - M_t^{tax}) + penalty_t$$

Next, we describe the development of tax-qualified retirement accounts over the life-cycle. Prior to the endogenous retirement age $t = K$, the worker's assets in his tax-qualified retirement plan are invested in bonds, earning a risk-free gross (pre-tax) return of $R_{f,}$ and risky stocks paying an uncertain gross return of R_t. The total value ($F_{t+1}^{401(k)}$) of the 401(k) assets at time $t + 1$ is therefore determined by the previous period's value minus any withdrawals ($W_t \leq F_t^{401(k)}$), plus additional own contributions (A_t), plus any employer match (M_t), and returns on stocks and bonds. In the TEE regime, the employer match is reduced by the tax pre-payment M_t^{tax}. The variable ω_t^s denotes the relative exposure of overall assets in the retirement plan allocated to stocks. Overall, the wealth dynamics of the EET or TEE retirement account evolves as follows:

$$\underline{\text{EET}} \qquad \begin{aligned} F_{t+1}^{401(k)} = {} & \omega_t^s\left(F_t^{401(k)} - \mathrm{W_t} + A_t + M_t\right)R_{t+1} \\ & + (1 - \omega_t^s)\left(F_t^{401(k)} - \mathrm{W_t} + A_t + M_t\right)R_f \end{aligned} \tag{6}$$

and

that, because of the matching contributions, almost all households in our model make some contributions to a tax-qualified retirement plan as early as age 25.

[11] Actual Roth 401(k) regulation requires that employer contributions are taxed according to the EET regime, which requires a separate account for own versus employer contributions. This would require an additional state variable in our models, greatly increasing the computational burden required to solve the models, so we do not follow that approach here.

[12] Under current regulation, the RMD rules also apply for Roth 401(k)s, but workers can avoid this requirement by rolling over the assets into a Roth IRA not subject to RMDs. For this reason we do not apply RMDs to the TEE case.

TEE
$$F_{t+1}^{401(k)} = \omega_t^s\left(F_t^{401(k)} - \mathrm{W_t} + A_t + M_t - M_t^{tax}\right)R_{t+1}$$
$$+(1-\omega_t^s)\left(F_t^{401(k)} - \mathrm{W_t} + A_t + M_t - M_t^{tax}\right)R_f.$$

To be considered as a safe harbor 401(k) plan (and therefore avoid complex non-discrimination testing), we assume that employers match 100% of employee contributions up to 5% of yearly labor income.[13] Due to regulation, the matching rate is applied up to a maximum of $275,000, so the maximum employer contribution is $13,750. The matching contribution is then given by:

$$M_t = \min(A_t, 0.05Y_t, \$13{,}750). \quad (7)$$

2.4 Wealth dynamics during the work life.

During the work life, an individual uses current cash on hand for consumption C_t and investment. A portion A_t of the worker's pre-tax salary Y_t can be invested into a tax-qualified 401(k) plan of the EET or TEE type. In addition, the worker can invest in risky stocks S_t and riskless bonds B_t outside the retirement plan. Hence, cash on hand X_t in each year is given by:

$$X_t = C_t + S_t + B_t + A_t. \quad (3)$$

In addition to the usual constraints, $C_t, A_t, S_t, B_t \geq 0$, workers may not contribute more than $A_t \leq \$18{,}500$ in the 401(k) plan (as per US law), but from age 50 onwards they are permitted an additional $6,000 of 'catch-up' contributions. One year later, their cash on hand is given by the value of stocks (bonds) having earned an uncertain (riskless) gross return of R_{t+1} (R_f), plus income from work (after housing costs h_t), plus withdrawals (W_t) from the 401(k) plan, minus any federal/state/city taxes and Social Security contributions, Tax_{t+1}, and health insurance HI_t costs:

$$X_{t+1} = S_t R_{t+1} + B_t R_f + Y_{t+1}(1-h_t) + W_t - Tax_{t+1} - HI_t. \quad (4)$$

[13] See Willson (2019) for 401(k) safe harbor plans. Love (2007) reports a modal value of 6% for matching rates in US defined contribution plans.

Our baseline financial market parameterizations assume a risk-free interest rate of $R_f = 1\%$, and an equity risk premium of 5% with a return volatility of 18%. For stock investments outside tax-qualified retirement accounts, the risk-premium on stocks is reduced by one percentage point to reflect higher management fees. The annual cost of health insurance HI_t is set at \$1,200. We model age-dependent housing costs h_t as in Gomes and Michaelidis (2005) and Love (2010). As in Lusardi et al. (2017), if a worker's cash on hand falls below $X_{t+1} \leq \$5{,}879$, he will receive subsistence support from the government equal to the difference from that amount to ensure a minimum standard of living.

2.5 Wealth dynamics during retirement

Workers can retire and claim Social Security benefits between ages 62 and 70. After selecting their endogenous retirement ages, K, individuals may still choose to save outside their tax-qualified retirement plans in stocks and bonds, as follows:

$$X_t = C_t + S_t + B_t. \tag{8}$$

Their cash on hand for the next period evolves as follows:

$$X_{t+1} = S_t R_{t+1} + B_t R_f + Y_{t+1}(1 - h_t) + W_t - Tax_{t+1}. \tag{9}$$

Old age retirement benefits provided by Social Security are determined by workers' Primary Insurance Amounts (PIAs), which in turn depend on their average lifetime earnings as described above. Social Security payments (Y_{t+1}) in retirement ($t \geq K$) are given by:

$$Y_{t+1} = PIA_K \cdot \lambda_K \cdot \varepsilon_{t+1}\,. \tag{10}$$

Here, λ_K is the mandated adjustment factor for claiming before or after the system-defined Full Retirement Age, which in our model is assumed to be age 66.[14] The variable ε_t is a transitory shock $\varepsilon_t \sim \text{LN}(-0.5\sigma_\varepsilon^2, \sigma_\varepsilon^2)$, which reflects out-of-pocket medical and other expenditure shocks

[14] The factors we use are 0.75 (claiming age 62), 0.8 (claiming age 63), 0.867 (claiming age 64), 0.933 (claiming age 65), 1.00 (claiming age 66), 1.08 (claiming age 67), 1.16 (claiming age 68), 1.24 (claiming age 69), and 1.32 (claiming age 70); see US SSA (nd_c).

in retirement (as in Love 2010). During retirement, benefits payments from Social Security are partially subject to individual federal income tax rates and the 4% city and state and 1.45% Medicare taxes.[15] We model the 401(k) plan assets under both tax regimes as follows:

$$F_{t+1}^{401(k)} = \omega_t^s\left(F_t^{401(k)} - \mathrm{W_t}\right)\mathrm{R_{t+1}} + (1-\omega_t^s)\left(F_t^{401(k)} - \mathrm{W_t}\right)R_f, \quad for\ t < K. \tag{10}$$

For the EET case, we also integrate the US legal provision requiring plan participants to take payouts from 401(k) plans according to the Required Minimum Distribution rules. These rules require that, from age 70.5 onwards, each year's withdrawal must exceed the account balance divided by the participants remaining life expectancy m_t specified by the Internal Revenue Service (IRS) unisex mortality table (IRS 2015). As noted by Brown et al. (2017), tax penalties in case of insufficient withdrawals provide substantial incentives for participants to comply with the RMD rules. Accordingly, we model withdrawals from retirement accounts according to the following constraints: $\frac{F_t^{401(k)}}{m_t} \leq W_t < F_t^{401(k)}\ (for\ t \geq 70)$.

2.6 Calibration of preference parameters and model solution

We posit that households maximize the value function (1) subject to the constraints and calibrations set out above, by optimally selecting their consumption, work effort, claiming age for Social Security benefits, contributions and withdrawals from tax-qualified 401(k)-plans, and investments in as well as redemptions of stocks and bonds. As this optimization problem cannot be solved analytically, it requires a numerical procedure using dynamic stochastic programming. Accordingly, to generate optimal policy functions for each of the six subgroups (male/female with <HS, HS, and Coll+), in each period t we discretize the space in four

[15] For Social Security tax rules see US SSA (nd_d). Up to 85% of Social Security benefits may be subject to income tax for higher-income households, yet due to generous exemptions, most households receive their Social Security benefits tax-free (see Horneff et al. 2019). From age 65 onward, benefits are not taxed by Social Security or Medicare Part A (hospital insurance). Nevertheless, most elderly enroll in Medicare Part B (medical insurance), Part C (advantage plans), and Part D (drug prescription), and pay premiums. To simplify calculations, we assume that these premiums equal 1.45% of benefits.

dimensions 30(X)×20($F^{401(k)}$)×8(P)×9(K), with X being cash on hand, $F^{401(k)}$ assets held in the 401(k) retirement plan, P permanent income, and K the claiming age.

Following Horneff et al. (2019), we calibrate preference parameters (assumed to be unique for each of the six subgroups) in such a way that our model outcomes match empirical claiming rates reported by the US Social Security Administration (US SAA 2015), and they simultaneously average replicate 401(k) account balances reported by the Employee Benefit Research Institute (2017) for 7.3 million plan participants (classified into five age groups: 20-29, 30-39, 40-49, 50-59, and 60-69). For each of our six subgroups, we solve the lifecycle model under the EET tax regime and Social Security rules in place in 2015 (i.e. before the 2018 tax reform), generate 100,000 simulated independent lifecycles using optimal policy functions, and calculate average claiming rates and 401(k) account balances (with respect to three exogenous random variables: stock returns as well as permanent and transitory income shocks). These six subgroups are then aggregated to population levels using National Center on Education Statistics (NCES 2016) weights.[16] Repeating this procedure for alternative sets of preference parameters (ρ, β, α) generates a coefficient of relative risk aversion $\rho = 5$, time discount rate $\beta = 0.96$, and leisure parameter $\alpha = 1.2$, which closely match simulated model outcomes as well as evidence on both (i) average assets in tax-qualified retirement accounts, and (ii) Social Security claiming ages (see Figure 1). Specifically, our model generates the empirically-observed large peak at the earliest feasible claiming age of 62, along with a second peak at the (system-defined) Full Retirement Age (66). Our model also matches rather nicely the empirically-observed distribution of 401(k) wealth by age groups. [17]

Figure 1 here

[16] Specifically, the weights are 50.7% female (61% with Coll+, 28% with HS, and 11% with <HS), and 49.3% male (57% with Coll+, 30% HS, and 13% <HS).

[17] Moreover, these parameters are in line with those used in prior work on life-cycle portfolio choice with risky assets; see for instance Hubener et al. (2016), Gomes (2020), and Gomes et al. (2008, 2009, 2021). Samwick (1998) reports time preference rates for US households at around 3% and 4%. The risk-aversion parameter of $\rho = 5$ is also in line with this literature, though it is high compared to life cycle models that do not allow portfolio choice with risky assets.

3. What Would Rothification Do?

We next illustrate how switching from the *status quo* EET to a TEE tax regime for retirement savings would affect expected outcomes using our lifecycle model. Specifically, we are interested in asset accumulation and consumption patterns, hours of work and claiming ages, and tax payments over the lifecycle. In addition, we evaluate how a TEE versus an EET tax regime for retirement savings might affect inequality. Finally, we examine how sensitive our results are to variations in model assumptions. All calculations are based on a total of 200,000 simulated lifetimes using optimal feedback controls from the respective policy functions, with the number of simulations allocated to the six subgroups according to their population weights.

3.1 Impact on financial assets and consumption

Policymakers provide tax incentives for retirement accounts so households will build financial assets used to finance consumption expenditures in retirement when labor income is no longer earned. It should be noted that, in the US setting, additional saving incentives are usually provided by matching contributions from employers. In addition to the different tax treatment of contributions to and (qualified) distributions from 401(k) plans, there are also disincentives under both tax regimes resulting from the 10% penalty tax for early distributions before the age of 59 ½ and (for EET plans) from the RMD rules in retirement. These give rise to the question as to which tax regime, EET versus TEE, is more effective with respect to this policy goal. In particular, we ask whether moving from a TEE to an EET regime could increase retirement savings and consumption.

Table 1 offers an accounting of how the tax regime change alters asset accumulation patterns in the 401(k) accounts (Panel A), non-tax-qualified assets (Panel B), and consumption (Panel C). Most strikingly, we see that 401(k) plan assets are lower under the Rothification regime, particularly in later life, compared to the higher levels under the EET regime (Panel A). Under EET taxation, households age 50-59 accumulate an average of about $175K in 401(k) accounts,

compared to 22% less under TEE taxation. The main explanation is that, in the TEE regime, employer matching contributions flow (by construction) into 401(k) plans after deducting income taxes, while in the EET case they flow into 401(k) accounts pretax. Furthermore, in the TEE case, employees make slightly more use of early withdrawals, since the penalty taxes only apply to investment income. By contrast, in the EET case, the entire withdrawal amount is taxed.

Table 1 here

Panel B, however, shows that non-qualified assets are lower in the EET world from age 40 onward, and are only about half as much as of age 66 (the Full Retirement Age). We note, however, that the value of retirement plan assets in the EET regime is not directly comparable with that in the TEE regime, since EET payouts must be taxed before they can used for consumption, while withdrawals from TEE assets are tax-free (like those from non-qualified accounts). Therefore, as Poterba (2004) pointed out, a dollar held inside an EET account is less valuable for supporting consumption than a dollar held in a similar asset in TEE or non-tax-qualified accounts. Panel C of Table 1 shows that EET lifetime consumption is below that in the TEE world from age 40 onward.

Table 2 provides a closer look at how financial wealth and consumption profiles differ between the EET and the TEE regimes, for population subgroups. For all three educational subgroups, Table 2 reports average wealth inside and outside tax-qualified accounts as of age 62, as well as average consumption between ages 25-62, and the ETT versus TEE regimes. It also reports how inequality changes under the TEE versus the EET status quo. Following Lusardi et al. (2017), we measure relative wealth and consumption inequality in terms of the ratio of college graduates to high school dropouts, as well as the lifetime Gini coefficients for lifetime consumption, cash on hand, and 401(k) assets under the two tax regimes.[18] All of these calculations are based on 200,000 simulated lifetimes weighted for the six different sex/education sub-groups.

[18] For a discussion of income versus consumption inequality measures using Gini coefficients, see Bowlus and Robin (2004).

Table 2 here

The results generate some interesting conclusions. First, relative inequality measured as the ratio of average 401(k) assets of college graduates to high school dropouts falls by 12 percent in the TEE regime versus the EET regime. Second, relative inequality for cash on hand is seven percent higher. Of course, as noted above, 401(k) assets cannot be directly compared across the two tax regimes, since in the EET world, these are subject to tax on withdrawal but not in the TEE regime. Moreover, the marginal tax rate for <HS individuals having only about $14,000 in their 401(k) accounts is far lower than for their Coll+ counterparts with over $210,000 in their 401(k) accounts. In consumption terms, then, the two tax regimes generate quite similar relative inequality metrics: the relative consumption inequality ratio under TEE is only four percent lower than in the EET case.

The last line of each Panel in Table 2 reports average lifetime Gini coefficients under each tax regime. Rather strikingly, results indicate that the Gini measures are strikingly similar under the EET and the TEE regimes for lifetime consumption, assets in non-qualified accounts, and 401(k) assets, differing by only 1-4 percent. Therefore, we find few reasons that policymakers might favor either tax approach on egalitarian grounds.

3.2 Impacts on work hours and claiming ages

Table 3 depicts average work hours and Social Security claiming patterns under both the EET and TEE regimes. Panel A documents that Rothification induces people to work about one more hour per week until age 61, and three more hours per week during the Social Security claiming window (age 62-69). Panel B shows that Rothification pushes out retirement claiming by almost one year, compared to the EET base case.

Table 3 here

The fact that the TEE regime's lower marginal tax rate on 401(k) payouts induces workers to delay Social Security claiming more than under the EET regime can be explained as follows: some workers with sufficient assets will wish to retire, but they also find it attractive

to wait to claim Social Security so as to boost their benefits via the delayed claiming factor (6-8% increase per year of delayed claiming). Meanwhile, financing consumption during this no- (or low-) work phase requires them to work at least part-time and draw down their 401(k) assets. Under the EET regime, individuals must pay income tax on their pension withdrawals, so the appeal of receiving higher Social Security benefits by delaying claiming must be weighed against the disadvantage of paying high income taxes on withdrawals. If the tax burden on withdrawals is heavier than the advantage of receiving higher Social Security benefits, it is rational to claim earlier. This tradeoff also incorporates the fact that only a portion of Social Security benefits are included in taxable income (up to 50% may be tax-free). Accordingly, the net-of-tax gain from delaying Social Security claiming is relatively small in the EET scenario. Such complex tax considerations are irrelevant under the TEE regime, because pension withdrawals are not counted as part of taxable income. Therefore, given their financial resources to finance consumption until claiming, workers in the TEE scenario base their decisions to delay claiming only on the retirement credits received from deferring Social Security.

Work hours and Social Security claiming ages also differ by educational levels across the two tax regimes, as shown in Figure 2. Panel A shows the difference in claiming ages for workers with <HS, HS, and Coll+ education, while Panel B depicts the corresponding changes in average hours worked during the claiming window. Interestingly, claiming patterns of the least-educated high school dropouts is relatively similar in both tax regimes, mainly because this group saves and accumulates few assets compared to the better-educated, so taxes are less relevant to them. Moreover, the changes in claiming ages for this subgroup are small. For example, high school dropouts claim five months later under the TEE regime, whereas the most educated group (Coll+) defers claiming Social Security benefits by over a year in the TEE versus EET setup. Differences in hours worked follow a similar pattern: the least educated work fewer than two hours per week more, whereas the most educated work more by about four hours

a week. Accordingly, more educated and wealthier workers are predicted to work more and claim substantially later under Rothification, with a much smaller impact on the less-educated.

Figure 2 here

3.3 Impacts on tax payments over the life cycle

In terms of tax payments, there are two conceptual differences between EET and TEE taxation: timing and risk. Focusing first on timing, income tax payments come earlier with TEE, because contributions cannot be deducted from taxable income, and investment returns on accumulated retirement assets have no impact on tax payments. In contrast, under the EET system, tax payments are not due until later in life when withdrawals are made from the retirement savings account in retirement. Furthermore, under EET taxation, future uncertain investment income influences the amount of tax paid via deferred taxation. Tax payments are levied on distributions from qualified retirement accounts; these in turn depend on uncertain investment returns. Because tax-deferred retirement accounts are regularly invested and much of it in risky equity holdings, EET tax payments are subject to the return/risk profiles of the financial markets. This mechanism does not apply to TEE retirement accounts taxed up front.

Of course, tax payments under both regimes do vary with uncertainty in labor income and in both cases, uncertain investment returns affect tax payments for assets outside retirement accounts. To complete the picture, penalty taxes for early withdrawals and payroll taxes must also be considered. We depict the results under both regimes in Figure 3.

Figure 3 here

Specifically, we plot average individual yearly tax payments (payroll taxes, income taxes, and penalty taxes for early withdrawals) based on the 200,000 simulated lifecycle under the EET and TEE regimes. As anticipated, expected tax payments (Panel A) under EET are lower during the first 25 years of the work life, since 401(k) contributions can deducted from taxable income; by contrast, under the TEE regime, workers must pay taxes on own and employer matching contributions. Yet the situation changes around age 50, when tax payments

rise in the EET regime, and the difference is particularly marked between ages 62-70. Thereafter, tax payments in both the EET and TEE scenarios are relatively low.

The explanation for this is that, in both tax regimes, workers begin curtailing their work hours after age 50 and finance some consumption with 401(k) withdrawals. From age 60 onward, 401(k) withdrawals are not subject to the 10% penalty tax, while withdrawals from EET accounts are included in taxable income. The latter results in higher tax payments, as opposed to the TEE world.

The difference in tax payments is particularly large between ages 62 and 70. For example, at age 65, the annual EET tax payment averages $8,000, or about twice as large as in the Roth regime. This is driven by individuals who have relatively large accumulations in their 401(k) plans and use these assets to reduce their work hours, delay claiming Social Security benefits, and spend retirement assets to cover consumption until claiming. From age 70 onwards, their 401(k) assets are mostly spent, so people withdraw only small amounts from their retirement plans. Hence, retirees in the EET world pay only slightly more taxes than those in the TEE world.

Turning to Panel B of Figure 3, we see the standard deviations of yearly tax payments under both tax scenarios. Here the EET regime clearly has more volatility on tax payments resulting from uncertain investment returns over the life cycle. From age 60, when households begin to withdraw from their 401(k) accounts, the volatility of the EET tax payments is significantly higher than that in the TEE regime. From age 70, after all workers are retired and receiving secure Social Security payments, the EET tax volatility is about twice as high as in the TEE case. The reason is that households still hold substantial equity in their 401(k)s later in life. This has a knock-on effect on potential withdrawals and thus, in the EET case, also on tax payments.

Panel C of Figure 3 reports numerical values of the expected present value of lifetime tax payments for the two tax regimes under consideration (as of age 25), assuming a real

discount rate of 1 percent (the risk-free rate). A first observation is that average tax payments are higher (about $10,000 more) under the TEE system until workers reach age 49. Yet between ages 50-69, workers in the EET regime pay $16,000 (in present value) and retirees from age 70 on pay $5,000 more than in the TEE world. Over the complete life cycle, the expected present value of lifetime taxes is 4 percent higher ($12,000) in the EET world. As a result, we conclude that tax payments are initially higher early in life under the TEE regime, but slightly lower in the long run. And as noted above, the overall higher EET tax payments are also accompanied by higher volatility.

A subsequent question would be how to use the initial expected higher tax revenues from Rothification. The possibilities are many, such as reducing the government budget deficit, cutting other taxes, or increasing government spending. Nevertheless, this lies outside the limits of our microeconomic single-generation lifecycle. We leave for future research an extension of our model to an overlapping generations setting, while retaining the realistic (and important) institutional framework.

3.5 Robustness checks

Models such as ours which project possible household economic patterns relies on several assumptions, making sensitivity analysis useful to evaluate the robustness of our findings. To this end, Table 4 reports results for financial assets inside and outside of qualified retirement accounts, as well as average lifetime consumption, using different assumptions regarding mortality, the time discount factor, employer matching contributions, and access to the stock market outside retirement accounts

Table 4 here

To start, we explore how results vary with alternative mortality assumptions by education group. Recent studies report widening mortality differentials by education, raising a question about whether the least-educated would benefit from moving from the status quo to a TEE tax regime. For instance, Kreuger et al. (2015) reported that male high school dropouts

averaged 23 percent excess mortality and females 32 percent, compared to high school graduates. By contrast, those with a college degree lived longer: men averaged a 6 percent lower mortality rate, and women 8 percent. Though only 10 percent of Americans have less than a high school degree and they comprise only 8 percent of the over-age 25 workforce (US DOL 2016), this group is more likely to be poor. Compared to the base case (see Table 2), average lifetime consumption, and financial assets inside and outside 401(k) plans decline slightly for the <HS group (Panel A), while they rise for workers with a Coll+ education. This applies to both tax regimes EET and TEE. Therefore, the relative attractiveness of the two tax regimes barely changes, compared to the base case.

More substantial changes result if we reduce the time preference rate from $1-\beta = 4\%$, as in the base case, to the level of the risk-free interest rate ($1-\beta = r_f = 1\%$). As indicated in Panel B, people in all three education groups and for both tax regimes build up much more financial wealth in retirement accounts compared to the base case. For example, high school dropouts save twice as much ($24,800 instead of $12,300) in their retirement accounts, compared to the base case with $\beta = 0.96$. Workers with a Coll+ education save about 50 percent more. Assets in non-qualified accounts also rise, but much less than retirement assets. The reason is that such assets mostly serve as precautionary savings to allow consumption smoothing against short term shocks in labor or capital income. Average consumption also rises, mostly due to higher average working hours. Although the lower time preference rate does change consumption, labor supply, and financial wealth relative to the base case with a higher time preference rate, these changes have similar impacts under both the EET and TEE regimes. In other words, the relative attractiveness of the two tax regimes barely changes compared to the base case.

Next, we examine what happens when employers do not provide additional incentives to save via matching contributions (Panel C), which allows us to examine the pure tax incentive effect to save for retirement. As expected, in this instance, fewer financial assets are

accumulated in 401(k) plans relative to the base case. Yet clear differences can be observed across educational subgroups. High school dropouts save very little in 401(k) plans: the mean value of about $8,000 in 401(k) plans is lower than the $12,000 accumulated in non-qualified accounts. Interestingly, 401(k) assets for the TEE case are slightly higher ($8,100) for this education group than in the EET case ($8,000). The explanation lies in the relatively low incomes and thus low tax brackets of this lowest-earning group. In fact, many of these workers earn so little that they need not pay income taxes or may rely on government assistance. For them, retirement saving accounts offer few advantages, either tax-wise or through matching contributions, while they do impose liquidity restrictions. Consequently, these people save outside of retirement accounts, if at all. Only for a very few who earn relatively high incomes despite their low education (in the model, resulting from positive permanent income shocks) are the tax incentives sufficient to save for retirement in 401(k) accounts. In this case, TEE accounts are more attractive because they are associated with fewer liquidity constraints and are not taxed in retirement. This also explains the slight increase in consumption under the TEE versus the EET regime.

By contrast, workers with a Coll+ education face a different situation. The attractiveness of 401(k) plans is reduced due to no matching contributions, compared to the base case. Without employer matching contributions, mean 401(k) assets are lower by about 15 percent in the EET case (from $118,400 to $101,400). Yet 71 percent of total financial assets are still invested in retirement accounts; compared to the base case with 73 percent, for a very small reduction of 2 percentage points. In the TEE regime, the consequences are comparable, with about 12 percent less invested in 401(k) accounts, which continue to account (as in the base case) for 63 percent of total financial wealth. Thus, eliminating employer matching contributions does not dramatically change our conclusions about the relative impacts of EET versus TEE taxation.

As a last sensitivity analysis, we evaluate the impact of automatic enrollment in life cycle funds as an alternative to assuming that workers can optimally make saving and portfolio

allocation decisions. That is, to this point our model has assumed that households make rational economic decisions with the traditional expected utility framework, even though behavioral economists show that they sometimes do not, due to a host of reasons including financial illiteracy (Lusardi et al. 2017), inertia (Kim et al. 2016), loss or ambiguity aversion (Barberis and Huang 2009), or ambiguity aversion (Dimmock et al. 2016), among others. Unfortunately, there is no consensus in the literature regarding which and how behavioral aspects should be implemented in forward-looking normative models such as ours.

Accordingly, we focus here on two specific behavioral aspects which we can integrate into our life cycle model in the form of numerically relatively easy-to-handle restrictions.[19] First, evidence documents that many U.S. households do not participate in the stock market, especially with their non-retirement financial assets. To address this point, we now make the simplifying assumption that high school dropouts and graduates can only save in bonds outside their retirement accounts. Second, evidence shows also that some households have difficulty deciding how much to save in 401(k) plans and where to invest the contributions. To address this second point, we assume for the two low-educated groups that five percent of their incomes plus matching contributions are *automatically enrolled* into their 401(k) plan, which is then invested in a *lifecycle fund* with an age-dependent equity exposure according to the 100-age rule.[20] This restricts the decision space for these two population subgroups to work hours, claiming age, consumption, and 401(k) distributions. In this respect, this evaluation is not based on the usual *ceteribus paribus* approach (as in the other sensitivity analyses in Table 4), but rather it involves several model changes at once.

Results in Panel D, Table 4, may be compared with those in Table 2. For high school dropouts, assets in the 401(k) setting are about the same in the EET regime, but about 20 percent

[19] An alternative procedure would be to modify the utility function, but this is beyond the scope of the present paper.

[20] This is a rule of thumb long recommended by investment advisors: the idea is that the equity share in one's retirement portfolio is set to 100 minus their age, with the balance going into low-risk bonds.

higher in the TEE regime. Yet their cash on hand is much lower, averaging about one-third compared to the base case. The high school graduates hold almost 50 percent more 401(k) assets in the EET scenario and 29 percent more in the TEE regime, but their liquid asset holdings drop under both tax regimes. This is not due to low contribution rates, at these are relatively high at 5 percent of salary plus employer matches. Rather, it is the result of the lifecycle fund design: under the 100-age life investment rule, equity shares decline too quickly with age, compared to an optimal equity share. Overall, these changes affect results under both the EET and TEE tax scenarios similarly, and the relative attractiveness of the two tax regimes hardly differs from the base case.

4 Conclusions

This paper has evaluated whether adopting a different tax treatment for retirement plan contributions would materially change work hours, consumption, saving, asset allocations, and Social Security benefit claiming ages for individuals over their lifetimes. We also assess whether the lower-paid would behave differently from the higher-paid, in terms of changes in claiming, saving inside and outside retirement accounts, and non-pension saving.

We show that moving to a TEE system versus the current EET regime will have some interesting impacts on behavior, but modeling these outcomes is required due to the complex nonlinearities of tax and transfer systems in the US. For example, the gap between high and low-wage workers' take-home pay is not diminished by income taxes under an EET system, whereas it is under a TEE program. Moreover, the Social Security replacement rate formula is concave, as it provides relatively higher benefits for low-wage workers than for the higher paid. Given these realities, the EET approach enhances the progressivity of overall old age income (pension account withdrawals plus Social Security benefits), whereas a TEE structure treats pension benefits more neutrally. Accordingly, it is theoretically impossible to predict how Rothification will alter household behavior without taking into account the complex

institutional details confronting real-world consumers, along with the economic environment, capital and labor market risk, and uncertain lifetimes.

Our richly specified sophisticated structural model of lifetime behavior is calibrated to US federal/state income tax and Social Security/Medicare premium structures, along with realistic Social Security benefit rules including PIA and AIME formulas, early and delayed retirement adjustments under Social Security, and real-world rules characterizing tax-qualified DC accounts including the current caps on pre-tax contributions, employer matches, and penalties and taxes on early withdrawals. We find that taxing pension contributions instead of withdrawals leads to delayed retirement, somewhat lower lifetime tax payments, and relatively small reductions in consumption. Indeed, the two tax regimes generate quite similar relative inequality metrics: the relative consumption inequality ratio under TEE is only four percent higher than in the EET case. Moreover, results indicate that the Gini measures are also strikingly similar under the EET and the TEE regimes for lifetime consumption, cash on hand, and 401(k) assets, differing by only 1-4 percent. We therefore find few reasons for policymakers to favor either tax approach on egalitarian grounds.

We also investigate the impact on taxes paid over the complete life cycle, and we document that the expected present value of lifetime taxes is 4 percent higher in the EET world. While tax payments are initially higher early in life under the TEE regime, they are slightly lower in the long run. Moreover, higher EET tax payments are also accompanied by higher volatility. Four different sensitivity analyses show that the relative attractiveness of the two tax regimes hardly differs from the base case.

These quantitative results regarding tax revenues should be interpreted with caution, since our microeconomic single-generation lifecycle model does not take into account potential macroeconomic effects that could arise with overlapping generations. Moreover, our model does not endogenize the impact of changes in the tax rules on the labor, financial, and goods markets. Nevertheless, since individual behaviors transfer to the macroeconomic level, our

results indicate the direction of how Rothification of tax-qualified retirement accounts could affect the federal budget.

References

Arias, E. (2010*). United States Life Tables, 2005. National Vital Statistics Reports* 58(10). US National Center for Health Statistics: Hyattsville, Maryland.

Barberis, N. and M. Huang (2009). "Preferences with Frames: A New Utility Specification that Allows for the Framing of Risks." *Journal of Economic Dynamics and Control* 33 (8): 1555–1576.

Beshears, J., J.J. Choi, D. Laibson, and B.C. Madrian (2017). Does Front-loading Taxation Increase Savings? Evidence from Roth 401(k) Introductions. *Journal of Public Economics* 151: 84-95.

Bowlus, A. and J-M. Robin (2004). Twenty Years of Rising Inequality in U.S. Lifetime Labor Income Values. *Review of Economic Studies* 71: 709-742.

Brown, D.C., S. Cederburg, and M.S. O'Doherty (2017). Tax Uncertainty and Retirement Savings Diversification. *Journal of Financial Economics* 126: 689-712.

Brown, J., J. Poterba, and D. Richardson. (2017). Do Required Minimum Distribution Rules Matter? The Effect of the 2009 Holiday on Retirement Plan Distributions. *Journal of Public Economics* 151: 96-109.

Burman, L.E., Gale, W. G., and Weiner, D. (2001). The Taxation of Retirement Saving: Choosing Between Front-Loaded and Back-Loaded Options. *National Tax Journal*, 54(3): 689-702

Chai, J., W. Horneff, R. Maurer, and O. S. Mitchell. (2011). Optimal Portfolio Choice over the Life Cycle with Flexible Work, Endogenous Retirement, and Lifetime Payouts. *Review of Finance.* 15(4): 875-907.

Dammon R., Spatt C., Zhang H. (2004). Optimal Asset Location and Allocation with Taxable and Tax-deferred Investing. *Journal of Finance* 59: 999-1037

Dilnot, A. (1995). The Taxation of Private Pensions. In: Bodie Z, O. Mitchell, J. Turner, eds. *Securing Employer Based Pensions: An International Perspective*. University of Pennsylvania Press: Philadelphia, PA.

Dimmock, S. G., R. Kouwenberg, O. S. Mitchell, and K. Peijnenburg (2016). Ambiguity Aversion and Household Portfolio Choice Puzzles: Empirical Evidence. *Journal of Financial Economics* 119(3): 559–577.

Employee Benefit Research Institute. (2017). *What Does Consistent Participation in 401(k) Plans Generate? Changes in 401(k) Plan Account Balances, 2010–2015.* EBRI Issue BRIEF No.439, Oct. 2017

Feldstein, M.S. (1969). The Effects of Taxation on Risk Taking. *Journal of Political Economy 77*(5): 755-764.

Gomes, F.J. (2020). "Portfolio Choice over the Life Cycle: A Survey." *Annual Review of Financial Economics* 12 (1): 277–304.

Gomes, F. and A. Michaelides (2005). Optimal Life-Cycle Asset Allocation: Understanding the Empirical Evidence. *Journal of Finance* 60: 869-904.

Gomes, F. J., M. Haliassos, and T. Ramadorai (2021). Household Finance. *Journal of Economic Literature* 59 (3): 919–1000.

Gomes, F. J., L. J. Kotlikoff, and L. M. Viceira. (2008). Optimal Life-Cycle Investing with Flexible Labor Supply: A Welfare Analysis of Life-Cycle Funds. *American Economic Review: Papers & Proceedings.* 98(2): 297-303.

Gomes, F., A. Michaelides, and V. Polkovnichenko (2009). Optimal Savings with Taxable and Tax-Deferred Accounts. *Review of Economic Dynamics.* 12(4): 718-735.

Hallez, E. (2017). How a GOP Roth Plan Could Impact Retirement Savings. *Ignites.com*. https://www.ignites.com/c/1781243/209413?referrer_module=SearchSubFromIG&highlight=How%20a%20GOP%20Roth%20Plan%20Could%20Impact%20Retirement%20Savings

Horneff, V., R. Maurer, and O.S. Mitchell. (2019). How Will Persistent Low Expected Returns Shape Household Economic Behavior? *Journal of Pension Economics and Finance* 18, 612-622.

Hubener, A., R. Maurer, and O. S. Mitchell. (2016). How Family Status and Social Security Claiming Options Shape Optimal Life Cycle Portfolios. *Review of Financial Studies. 29(4): 937-978.*

Internal Revenue Service (IRS 2015). *Retirement Plan and IRA Required Minimum Distributions FAQs*. https://www.irs.gov/pub/irs-prior/p590b--2015.pdf

Internal Revenue Service (IRS 2018). *Form 1040 (Tax Tables): Federal Tax Rates, Personal Exemptions, and Standard Deductions*. Downloaded 08/26/2019. https://www.irs.com/articles/2018-federal-tax-rates-personal-exemptions-and-standard-deductions

Internal Revenue Service (IRS 2020). *Publication 590-B, Distributions from Individual Retirement Arrangements (IRAs)*. Downloaded 07/02/202. https://www.irs.gov/publications/p590b

Investment Company Institute (ICI 2021). *The US Retirement Market: 4Q2021.* https://urldefense.com/v3/__https://www.ici.org/statistical-report/ret_21_q4_data.xls__;!!IBzWLUs!G0oTJQ1CEJHKY8MV6ZcR21BZhf_9ONED-uIRXiI3MMWWezjVen4jldJEjAe6jmcoDLmchsY$

Kreuger, P. M., M. K. Tran, R.A. Hummer, and V.W. Chang. (2015). Mortality Attributable to Low Levels of Education in the United States. PlosOne. July 8. dx.doi.org/10.1371/journal.pone.0131809

Lachance, Marie-Eve. (2013). Roth versus Traditional Accounts in a Life-Cycle Model with Tax Risk. *Journal of Pension Economics and Finance* 12(1): 28-61.

Love, D.A. (2007). What Can Life-Cycle Models Tell Us about 401(k) Contributions and Participation? *Journal of Pension Economics and Finance.* 6(2): 147-185.

Love, D.A. (2010). The Effects of Marital Status and Children on Savings and Portfolio Choice. *Review of Financial Studies.* 23(1): 385-432.

Lusardi, A.M., O.S. Mitchell, and P.C. Michaud (2017). Optimal Financial Literacy and Wealth Inequality. *Journal of Political Economy*. 125(2): 431-477.

National Center on Education Statistics. (2016). *Digest of Education Statistics* 52nd Edition, Table 104.30. https://nces.ed.gov/pubs2017/2017094.pdf (download 09.13.2018).

OECD (2018). *Financial Incentives and Retirement.* OECD Publishing, Paris.

Poterba, J. (2004). Valuing Assets in Retirement Saving Accounts. *National Tax Journal* 57: 489-512.

Samwick, A. (1998). Discount Rate Heterogeneity and Social Security Reform. *Journal of Development Economics* 57, 117-146.

Schoeff, M. (2017). Promises by Congress to Protect Retirement-savings Incentives Don't Ease Advocates. Jul 12. *InvestmentNews.com*. https://www.investmentnews.com/article/20170712/FREE/170719976/promises-by-congress-to-protect-retirement-savings-incentives-dont

Shoven J. and C. Sialm (2003) Asset Location in Tax-deferred and Conventional Savings Accounts. *Journal of Public Economics* 88: 23–38

Shoven, J.B. and S. N. Slavov. (2014). Does it Pay to Delay Social Security? *Journal of Pension Economics and Finance.* 13 (2): 121-144.

Sibaie, A. (2017). *What Rothification Means for Tax Reform*. The Tax Foundation. Washington, D.C. https://taxfoundation.org/what-rothification-means-for-tax-reform/

Smith, P. A. (2002). Complexity in Retirement Savings Policy. *National Tax Journal*. 55(3): 539-53.

Statman, M. (2017). Critically, 'Rothification' of 401(k)’s not Harmful to Lower Incomes. *TheHill.com*. https://thehill.com/opinion/finance/357089-critically-rothification-of-401ks-not-harmful-to-middle-class

Tergesen, A. (2017). How a $2,400 Cap on 401(k) Deductions Would Affect Your Savings. *Wall St. Journal,* Oct. 29. https://www.wsj.com/articles/how-a-2-400-cap-on-401-k-deductions-would-affect-your-savings-1509313100?mg=prod/accounts-wsj

Thornton, N. (2017). Asset Managers’ Profits Threatened by Rothification. *Benefitspro.com*, September. http://www.benefitspro.com/2017/09/07/asset-managers-profits-threatened-by-rothification?t=retirement&slreturn=1508873159&page=3&page_all=1

US Department of Labor (US DOL). (2016). *Economic News Release Table A-4. Employment Status of the Civilian Population 25 Years and Over by Educational Attainment*. Washington, DC.

US Social Security Administration (US SSA). (nd_a). *Primary Insurance Amount*. Washington, DC. https://www.ssa.gov/oact/cola/bendpoints.html

US Social Security Administration (US SSA). (nd_b). *Fact Sheet: Benefit Formula Bend Points*. Washington, DC. https://www.ssa.gov/oact/cola/piaformula.html

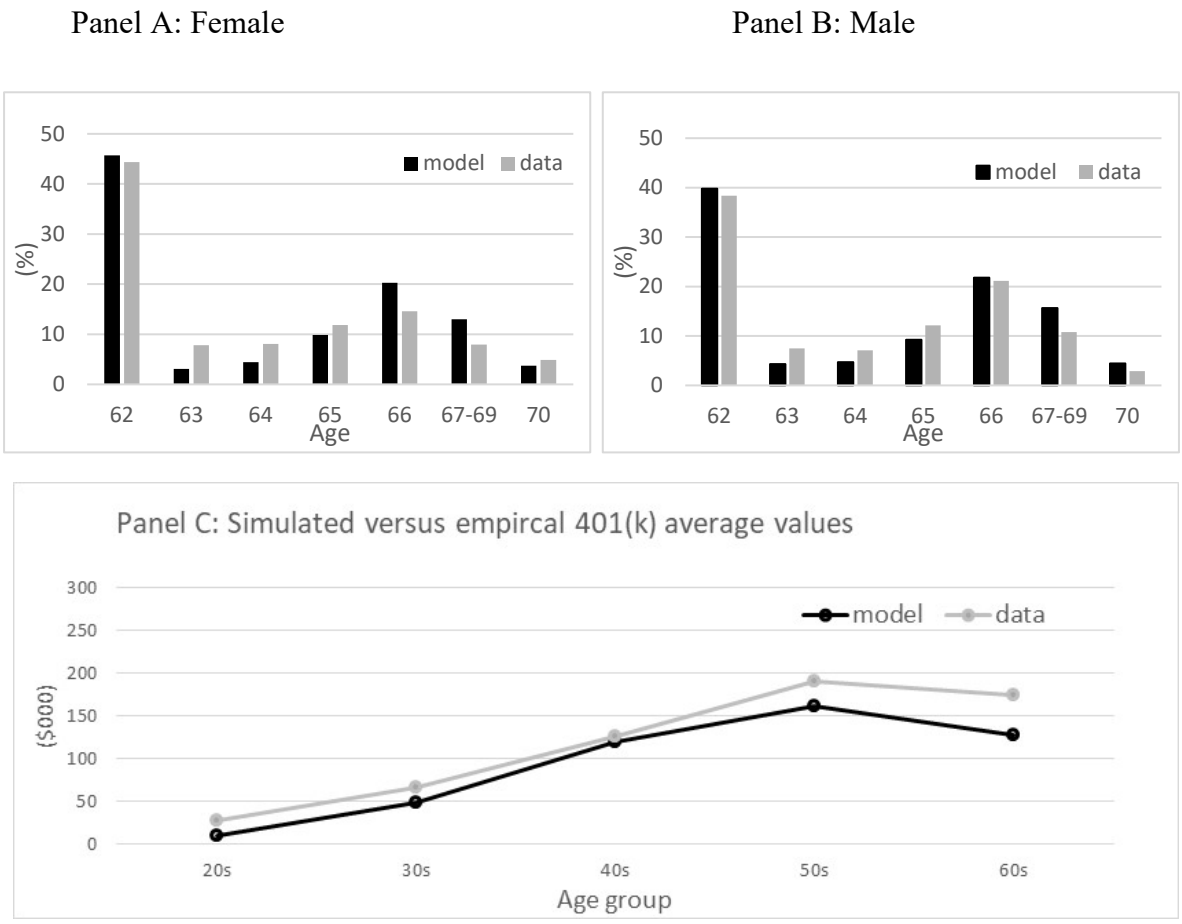
US Social Security Administration (US SSA). (nd_c). *Incentivizing Delayed Claiming of Social Security Retirement Benefits Before Reaching the Full Retirement Age*. Washington, DC. https://www.ssa.gov/policy/docs/ssb/v74n4/v74n4p21.html

US Social Security Administration (US SSA). (nd_d). *Benefits Planner: Income Taxes and Your Social Security Benefit.* Washington, DC. https://www.ssa.gov/planners/taxes.html

.US Social Security Administration. (2015). *Annual Statistical Supplement to the Social Security Bulletin, 2015* (Table 6.B5). Washington, DC.

Willson, N. (2019). Safe Harbor 401(k): The 2019 Guide for Business Owners. *Guideline.com.* https://www.guideline.com/blog/safe-harbor-401k-plan/

Figure 1: Social Security Claiming Patterns by Age for Males and Females, and 401(k) Asset Values *(model vs data)*

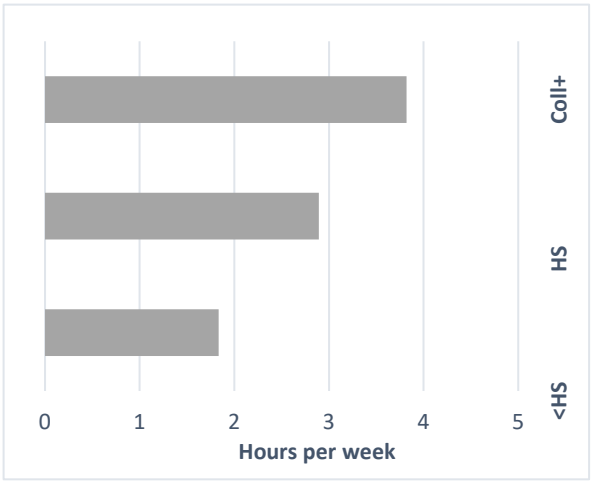


Notes: The top two panels compare claiming rates generated by our life cycle model and empirical claiming rates reported by the US Social Security Administration for the year 2015 (without disability). Expected values are calculated from 100,000 simulated lifecycles based on optimal feedback controls using income profiles and mortality rates for each of six population subgroups (male/female and three education levels). Population averages use education weights for females (males): 61% +Coll; 28% HS; 11% <HS (57% +Coll; 30% HS; 13%<HS); weights for females (males) 49.28% (50.72%) of entire population. Parameters used for the baseline calibration are as follows: risk aversion $\rho = 5$; time preference $\beta = 0.96$; leisure preference $\alpha = 1.2$; endogenous retirement age 62-70. Social Security benefits are based on average permanent income and the bend points in place in 2015; minimum required withdrawals from 401(k) plans are based on life expectancy using the IRS-Uniform Lifetime Table; tax rules for 401(k) plans are as of 2015 as described above. The risk premium for stocks returns is 5% and return volatility 18%; the risk-free rate is 1%. The lower panel compares empirical 401(k) account balances across the US population. Empirical account balance data provided by the Employee Benefit Research Institute (2017); age groups referred to as 20s, 30s, 40s, 50s, and 60s denote average values for persons age 20-29, 30-39, 40-49, 50-59, and 60-69. Source: Authors' calculations.

Figure 2: Differences by Education in Average Work Hours and Claiming Ages under the EET vs TEE Tax Regime

Panel A:
Change in Av. Social Security Claiming Age

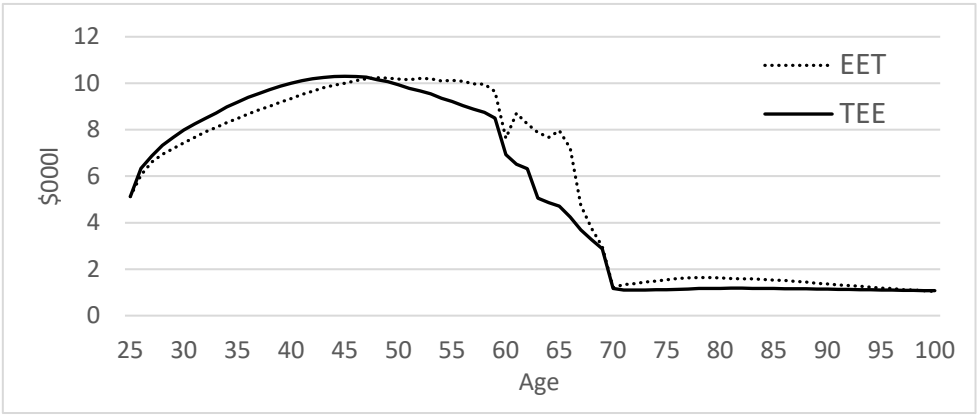
Panel B:
Change in Av. Work Hours (ages 62-69)



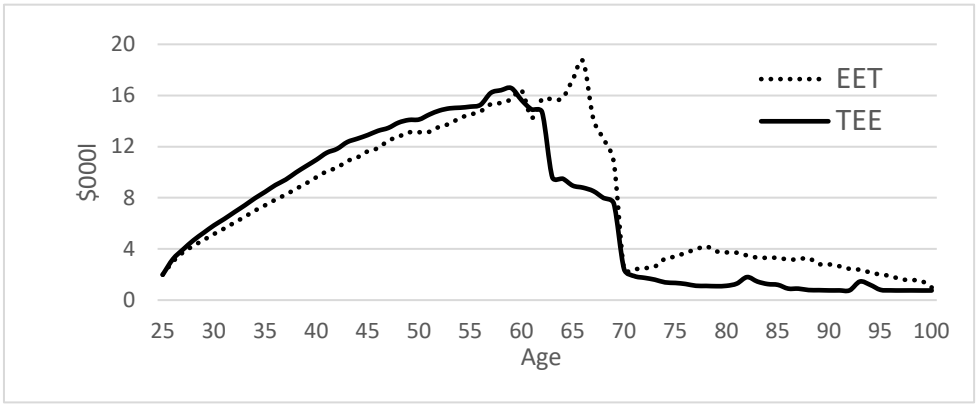
Notes: This Figure reports the average claiming age differences (Panel A) and work hour differences (Panel B) comparing the TEE versus the EET regime, for workers with three education levels. Results are derived from 200,000 simulated lifecycles allocated using population weights to each subgroup based on optimal feedback controls from the life cycle model. The endogenous retirement age is between age 62-70. For other parameters, see Figure 1. Source: Authors' calculations

Figure 3: Average Lifetime Tax Payments by Age under the EET vs TEE Tax Regime

Panel A: Average Tax Payments by Age



Panel B: Standard Deviation of Tax Payments by Age



Panel C: Present Value of Expected Tax Payments by Age Group

	EET	TEE
Age 25-49	187	197
Age 50-69	119	103
Age 70-100	24	19
Age 25-100	**330**	**318**

Notes: Panel A reports average individual annual tax payments (the sum of income taxes, payroll taxes, and taxes on early withdrawals) over the life cycle in the EET versus TEE case. Panel B reports the annual standard deviation of tax payments. Panel C reports the expected present value of taxes paid by age group using a discount rate of 1%. Outcomes are based on 200,000 simulated lifecycles allocated using populations weights to each of the six subgroups (male / female and three education groups) using optimal feedback controls from the life cycle model. For other parameters, see Figure 1. Source: Authors' calculations.

Table 1: Lifecycle Financial Assets and Consumption under the EET versus TEE Tax Regime

	Panel A 401(k) Assets ($000)		Panel B Non-Qualified Assets ($000)		Panel C Consumption ($000)	
	EET	TEE	EET	TEE	EET	TEE
Age 30-39	54.8	44.9	6.3	5.1	24.0	24.0
Age 40-49	130.6	99.6	8.9	13.4	27.8	28.4
Age 50-59	174.7	136.4	8.1	15.4	29.5	31.0
Age 60-69	127.1	88.4	16.7	32.2	27.9	29.3
Age 70-79	87.6	68.3	10.9	14.3	24.8	25.3
Age 80-89	43.6	34.9	7.7	8.1	23.4	24.1
Age 90-99	8.8	6.9	5.4	5.9	20.8	22.1

Notes: Panels A and B show expected assets by age in tax-qualified 401(k) plans and non-qualified assets under the two tax regimes. Panel C shows consumption patterns for the same cases. Expected values are based on 200,000 simulated lifecycles allocated using population weights to the six-subgroups (male / female and three education groups) using optimal feedback controls from the life cycle model. For other parameters, see Figure 1. Source: Authors' calculations.

Table 2: Inequality by Education in Financial Assets and Consumption under the EET versus TEE Regime

	EET	TEE
Panel A: Average 401(k) Assets ($000)		
<HS ($)	12.3	10.5
HS ($)	41.2	32.6
Coll+ ($)	118.4	89.8
Ratio (Coll+/<HS)	*9.65*	*8.51*
Lifetime Gini	*0.660*	*0.688*
Panel B: Non-Qualified Assets ($000)		
<HS ($)	13.8	15.2
HS ($)	25.1	27.1
Coll+ ($)	44.7	52.8
Ratio (Coll+/<HS)	*3.24*	*3.48*
Lifetime Gini	*0.412*	*0.427*
Panel C: Average Consumption ($000)		
<HS ($)	11.1	11.8
HS ($)	18.5	19.1
Coll+ ($)	31.0	32.0
Ratio (Coll+/<HS)	*2.80*	*2.70*
Lifetime Gini	*0.370*	*0.373*

Notes: The first three lines of each Panel report outcomes by educational group for the two tax regimes. The fourth row computes the ratio of Coll+ to <HS. Expected values are based on 200,000 simulated lifecycles allocated using population weights to the six-subgroups (male / female and three education groups) using optimal feedback controls from the life cycle model. The Lifetime Gini coefficient is calculated year-by-year using 200,000 simulations for the entire population and averaged. For other parameters, see Figure 1. Source: Authors' calculations.

Table 3: Social Security Claiming Ages and Work Hours under the EET versus TEE Tax Regime

	EET	TEE
Panel A: Average Work Hours per Week		
Age 25-61	33.8	34.8
Age 62-69	8.8	12.1
Age 25-69	29.4	30.8
Panel B: Average Social Security Claiming Ages		
Claiming Age	64.7	65.6

Notes: Panel A reports average weekly work hours, while Panel B shows average Social Security claiming ages for the two tax regimes. Expected values are based on 200,000 simulated lifecycles allocated using population weights to the six-subgroups (male / female and three education groups) using optimal feedback controls from the life cycle model. For other parameters, see Figure 1. Source: Authors' calculations.

Table 4: Sensitivity Analysis by Education under the EET versus TEE Tax Regime

	Panel A *Heterog. Mortality*		Panel B *Discount Factor 0.99*		Panel C *No Employer Matching*		Panel D *Auto-enrollment in LC funds (<HS; HS)*	
	EET	TEE	EET	TEE	EET	TEE	EET	TEE
Panel A: Average 401(k) Assets ($000)								
<HS	11.2	9.9	24.8	19.7	8.0	8.1	12.1	12.7
HS	40.5	32.2	69.5	55.5	31.9	29.3	21.2	23.2
Coll+	119.8	91.8	173.9	138.4	101.4	79.1	118.4	89.8
Panel B: Non-Qualified Assets ($000)								
<HS	13.3	14.8	16.9	17.6	11.8	12.8	4.8	5.5
HS	24.9	27.2	29.0	31.6	22.1	25.5	15.6	23.9
Coll+	44.9	52.9	50.6	60.9	41.8	46.4	44.7	52.8
Panel C: Average Consumption ($000)								
<HS	10.8	11.7	12.8	13.0	9.9	10.1	10.6	10.5
HS	18.4	19.1	20.6	20.9	16.9	18.3	17.1	18.3
Coll+	31.1	32.2	33.5	34.6	29.4	30.1	31.0	32.0

Notes: The first three lines of each Panel report average lifetime assets in 401(k) accounts, cash on hand (non-retirement financial wealth), and consumption, respectively, by educational groups, for the two tax regimes. The first column labeled *Heterogeneous mortality* assumes higher (lower) mortality rates for workers with <HS (College+) compared to those with a HS education. *Discount Factor 0.99* refers to the case when the subjective discount factor is $\beta = 0.99$. *No employer matching* means no matching contributions are paid by the employer. *Auto-enrollment in LC funds* assumes 5% contribution of labor income is required in 401(k) plans (+ employer match) for the bottom two education groups; the assets are invested into life cycle (LC) funds with age-dependent equity exposure (following the 100-age rule, see text) and only bond investments are held outside the retirement accounts. Expected values based on 200,000 simulated lifecycles allocated using population weights to the six-subgroups (male / female and three education groups) based on optimal feedback controls from the life cycle model. For other parameters, see Table 3. Source: Authors' calculations.

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