Employer 401(k) Matches for Student Debt Repayment: Killing Two Birds with One Stone?

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January 19, 2024

Preliminary version - please do not cite or distribute

Abstract

Almost 50 million Americans owed $1.75 trillion in student loan debt in 2022, and most young workers are burdened by the need to repay these obligations. Yet if the young are to accumulate assets sufficient for retirement, they must also start saving in their employer-provided pension accounts. Using a rich life cycle model of household decision making, we show how workers can manage both debt repayment and saving in tax-qualified retirement accounts, to maximize their lifetime wellbeing. We also show how these choices will be shaped by employer-sponsored matching retirement contributions when workers make qualifying student loan payments, as intended by the 2022 SECURE 2.0 Act. By age 50, employees will reduce own retirement plan contributions by almost half, offset by higher employer-matching contributions that take loan repayments into account; hence pre-retirement financial assets in and outside DC plans barely change. Moreover, prior to retirement, workers' optimal consumption increases by up to 3%. The model also predicts that the reform will not produce earlier loan discharges. Overall, benefit payouts during retirement are not predicted to change materially.

Keywords: lifecycle saving; retirement plan; student loans; household finance
JEL codes: G11, G22, G53, D14, D91

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Acknowledgments: The authors are grateful for comments from Richard Shea and computational support from Yong Yu. We also acknowledge research support from the TIAA Institute as well as funding provided by the German Investment and Asset Management Association (BVI) and the Pension Research Council/Boettner Center at The Wharton School of the University of Pennsylvania. Opinions and any errors are solely those of the authors and not those of any individuals cited or any institutions with which the authors are affiliated. ©2024 Horneff, Maurer, and Mitchell

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The SECURE 2.0 Act of 2022 contained numerous measures intended to enhance Americans' retirement security, one of which offers workers with outstanding student loans the opportunity to repay these loans and receive matching employer contributions in their tax-qualified retirement plans.[1] The growth in defined contribution (DC) plans, especially 401(k)s where employees can decide how much to contribute and often receive employer matching contributions, makes it increasingly important to recognize the fact that close to 50 million Americans owe close to $2 trillion in student loan debt, and most young workers start their work lives facing the heavy burden by of these obligations.[2] To mitigate the concern that indebted workers may be unable to save in their employer-provided pension accounts, this new policy is intended to let employees repay these loans more quickly without undermining the growth of their retirement accounts. Whether workers will achieve this goal is, as yet, unknown.

To address this question, our paper investigates how employees with student loans should optimally manage their choice between debt repayment and retirement saving in tax-qualified accounts, to maximize their lifetime wellbeing. A life cycle model, calibrated using data from the Survey of Consumer Finances (SCF), informs our assessment of how these choices will be influenced by employer-sponsored matching contributions to retirement plans when workers make such qualifying student loan payments. We show that, as intended, the reform will boost peoples' loan repayments, while own retirement plan contributions fall prior to about age 50 and catch up after that. At retirement age, 401(k) assets are similar to those pre-reform, while non-retirement financial assets are slightly lower due to consuming more when young and less in retirement. Overall, we conclude that encouraging workers to discharge their student debts as soon as possible may not be optimal when their employers will match loan repayments in their retirement saving plans.

This paper contributes to the deep and rich literature on household finance (Gomes et al. 2021) and dynamic portfolio choice over the life cycle (Gomes 2020). Though some researchers in

[1] Prior to the passage of this act, a few employers did offer matching contributions, but so-called "non-discrimination rules" made this difficult and costly (Correia 2023).

[2] See Safier and Harrison (2023); Lusardi and Mitchell (2017); Lusardi et al. (2018, 2020); and Mitchell and Lusardi (2020).

this field have considered household balance sheet debt, they focus mainly on mortgage loans used to purchase homes (e.g., Cocco 2005; Kraft and Munk 2018) rather than on education debt.[3] Nevertheless, mortgages differ importantly from student loans, since one's home is an asset that serves as collateral, and mortgage loans may be discharged by transferring the house to the lender, even if the house value is less than the loan. Moreover, the loan amount can be reduced (extended) by selling (buying) the house. None of this is true for student loans.

Our paper also builds on a growing literature regarding the impact of student loans and educational loan subsidies (e.g., Black et al. 2023; Catherine and Yannelis 2023; Cornaggia and Xia 2024; Dynarski 2021; Dettling et al. 2022; Kargar and Mann 2023; Looney and Yannelis 2021), as well as empirical evidence gathered regarding student loan borrowers (e.g., Goodman et al. 2021; Gopalan et al. 2023; Holder and Yannelis 2022). Nevertheless, that research mainly focuses on the distributional effects of student loans, along with adverse selection and moral hazard prompted by alternative loan financing arrangements. To date, few analysts have focused on the interplay between repaying educational loans and saving for retirement; in a single exception, Paluszynski and Yu (2023) explored the case where policymakers seek to design optimal policy to induce present-biased workers to invest more in education. By contrast, our life cycle model incorporates both student loans and incentives for tax-qualified retirement saving in a rich and institutionally-realistic structure with forward-looking agents, as well as uncertain labor earnings, capital market returns, and lifetimes; we also integrate social security taxes and benefits and employer matching behavior (Horneff et al. 2023). The model also incorporates US regulatory thresholds and limits, tax rules on contributions to and withdrawals from tax-qualified DC pension plans, and rules for student loan repayments.

Our comprehensive structure therefore enables us to undertake the first economic assessment of this important aspect of the SECURE 2.0 legislation, as well as to evaluate its impacts on saving and consumption, both prior to and during retirement. We document that this policy can enhance workers' optimal consumption prior to retirement by around 3%. We also predict that it will not lead to earlier loan discharge dates, particularly for women, and it will only slightly reduce non-retirement asset balances. In addition, we show that, until age 50, employees substantially reduce own DC plan contributions, but these reductions are almost fully compensated

[3] Black et al. (2023) also investigate auto loan debt.

by higher employer matching contributions for worker loan repayments. Overall, retirement payouts are not predicted to change materially.

In what follows, we first provide a short overview of how student loans have operated in the US over the last few decades, along with a brief description of 401(k) plans. Next, we outline the methodological foundations of our life cycle model and describe model calibration. The subsequent section provides results regarding the anticipated impacts of the SECURE 2.0 Act reform on student loan repayment patterns, 401(k) contributions, and accumulated retirement plan wealth, as well as non-tax-qualified financial wealth, all over the life cycle. Following a discussion of consumption changes, we offer a sensitivity analysis of alternative parameter settings. A final section concludes and draws out implications.

I. Overview on Student Loans and Tax-Qualified Retirement Plans in the United States

The US student loan market plays a crucial role in enabling individuals to pursue higher education, but, for many borrowers, it also leads to substantial debt. Around half of US college students rely on such loans (Black et al. 2023); the majority of such loans (90%) are federal loans backed by the government,[4] with the remainder offered by private lenders (Dettling et al. 2022). As reported by Catherine and Yannelis (2023), federal student loan interest rates and borrowing limits are set by Congress; interest rates, which are typically lower than on private loans, and do not vary with borrowers' creditworthiness; they are designed to provide access to education financing, though with repayment requirements and consequences for those who fail to meet their repayment obligations. In particular, student loans cannot generally be discharged through bankruptcy.

There are two ways that people can repay their student loans (FSA 2023a): the standard repayment plan, and the income-driven repayment plan (IDR). The former is similar to a 10-year mortgage: borrowers typically make fixed monthly payments until the student loans are repaid. There are, however, numerous exceptions that allow borrowers to extend their loan maturity, permitting them to make lower regular monthly payments over longer than a decade. For example, under an extended or consolidated loan program, the repayment period depends on the total amount

[4] The main two federal lending programs are the Federal Family Education Loan Program (FFEL) and the Federal Direct Loan Program (DL). The FFEL was using private lenders (such as banks) as intermediaries to provide student loans regulated and guaranteed by the government; this program was terminated in 2010. In the DL program, the US Department of Education is the main lender for student loans.

of student loans, and it varies from 10 years (for loans up to $10,000) to 30 years (for loans of $60,000 or more). Additionally, under financial hardship or other conditions satisfactory to the lender, a borrower may temporarily suspend her loan for up to five years, during which time the interest continues to accrue (FSA 2023b). As a result, workers may continue making loan repayments until late in life. It is also possible to repay a student loan early, by making a one-time payment without incurring additional fees. Hanson (2023) reports that the average student takes about 20 years to repay the loan, though there is much dispersion around the average, with some graduates taking over 45 years to repay.[5]

Introduced in 2009, income-driven repayment plans require borrowers to pay 15% (20%) of their discretionary income (defined as income over 150% of the poverty line); any unpaid balance after 25 (20) years is discharged.[6] Even though financial hardship situations are directly included in the repayment formula, temporary suspensions of repayments are also permitted under the IDR program. The importance of these repayment plans has increased significantly in recent years; about 10% of borrowers were in income-driven repayment plans in 2013, and a decade later, this number had increased to 32%. The rise of IDR plans is even more notable when measured by the amount of student debt involved. In 2013, 22% of student debt in repayment was in an income-driven repayment plan, while a decade later, it was almost 54%.

In what follows, we focus first on the traditional standard loans with fixed monthly repayments, since "[t]hroughout the history of the student loan program, most borrowers have enrolled in 10-year fixed-payment plans; … [and] most borrowers are enrolled automatically" (CBO 2020: 6). Moreover, as we describe below, the dataset we use for model calibration was collected in 2022, so most of the student loans observed were likely taken out before the rise of IDRs. Next, we turn to an assessment of how results differ in the case of workers who took out IDR loans.

Our analyses implement the key features of tax-qualified retirement plans in the private sector. Federal regulation allows workers to contribute to these plans using pre-tax income up to certain limits, often with contribution rates set by default.[7] Currently two-thirds (67%) of the

[5] This analysis abstracts from the Biden Administration's efforts to enact student loan relief that met resistance from the US Supreme Court (Lobosco 2023).
[6] It should be noted that the total amount repaid under an IDR loan could exceed the amount that would have been paid under the standard plan, and a borrower could be required to pay income tax on amounts forgiven; see Gunn et al. (2021) and Herbst (2023).
[7] Under so-called Roth plans, employees contribute to the pension plan from their after-tax income, with no later tax on investment income or withdrawals. Our analysis does not focus on these accounts.

private sector workforce has access to DC plans (US BLS 2023), wherein employers frequently match employee contributions up to a legally-set limit with the most prevalent pattern being dollar-for-dollar or $0.50 per dollar match rates (Vanguard 2020). Access to retirement plan assets is restricted and tax-penalized prior to specified ages, and there are also requirements regarding minimum distributions after retirement. To date, these plans have amassed $37 trillion in DC plans and Individual Retirement Accounts (ICI 2023).

Using the nationally representative Survey of Consumer Finances, a detailed cross-sectional dataset on income, assets, debt, and demographic characteristics of US families gathered by the Board of Governors of the Federal Reserve System, we have computed the fraction of college-educated respondents having access to retirement accounts and which also have a student loan outstanding (see Table 1). Half of the sample age 20-29 had student loans outstanding in 2019, and almost two-thirds (61%) of those in their 30's. Loan prevalence does decline at older ages, though by their 50's, over one-quarter (27%) of workers still had student loans, and 14% in their 60's. Hence there is substantial potential for the SECURE 2.0 Act to improve both loan repayments and retirement wellbeing.

Table 1 here

II. Life-Cycle Model: Methodology

Our discrete-time dynamic portfolio and consumption model assumes a utility-maximizing college-educated worker who decides how much to consume and how much to invest in risky stocks, bonds, and a 401(k) plan over her lifetime, taking into account that the individual must make student loan repayments.[8] We posit that the individual's decision window runs from $t = 1$ (age 25) and ends at $T = 76$ (age 100); accordingly, each period corresponds to a year. The individual's lifetime can be divided into two phases: the work life (age 25-66), and retirement (from age 67). The individual's utility depends on her consumption and bequests, while constraints include a realistic characterization of income profiles, income and social security taxes, and the opportunity to invest in risky stocks and riskless bonds in a DC tax-qualified retirement plan (up to a limit) as well as in a non-tax-qualified account. This framework additionally takes into account the Required Minimum Distribution (RMD)

[8] This paper does not examine which workers take out what kind of student loan; for additional discussion on that topic, see Herbst (2023) and Amromin and Eberly (2016).

rules relevant to the US DC setting, as well as a realistic formulation of social security benefits and sex-specific mortality.[9]

Preferences

Preferences at time *t* are measured by a recursive *CRRA* utility function defined over current consumption, C_t, and level of bequest, Q_{t+1}, should the individual passes away at time $t+1$. Formally, the value function of the individual is given by:

$$J_t = \frac{(C_t)^{1-\rho}}{1-\rho} + \beta \sum_i \Pi_{ij,t}\, E_t \left(p_t^s J_{t+1} + (1-p_t^s) b \frac{(\phi + Q_{t+1}/b)^{1-\rho}}{1-\rho} \right), \quad (1)$$

The parameter ρ represents the coefficient of relative risk aversion, and β is the subjective time preference rate on future utility. The preference weight on bequest, which consists of terminal financial assets minus any outstanding debt from student loans, is controlled by the parameters b and ϕ, with the latter denoting whether a bequest is a luxury good (Ameriks et al. 2011). Conditional on being alive at time *t*, the individual's subjective probability of survival to time $t+1$ is denoted by p_t^s. Finally, $\Pi_{ij,t} = Prob(l_{t+1} = i | l_t = j)$ is a time-dependent transition matrix representing the probability of moving from current (t) income level *j* to income level *i* one year later $(t+1)$.

Student Loan Debt

After graduating from college, the individual starts to work at age 25 with a student loan of $23,000, computed as the average loan size held by college-educated individuals with positive DC retirement savings in the SCF.[10] There are two ways to repay the loan. In the first case, we assume that the worker takes the *standard repayment plan* requiring a fixed annual regular repayment of 8% of the initial amount borrowed, determined using an assumed student loan annual interest rate of 5% plus an initial repayment amount of 3%. This is in line with an extended repayment period of about 25 years. In practice, there are several reasons that borrowers may suspend loan repayments, including financial hardship, unemployment, home purchase, or other reasons with permission from the lender. To take such a possibility into account, the model permits the worker to choose between regular repayments or suspension within the first 6 years of the loan, until she attains age 30. Thereafter, suspension is permitted only if the worker's cash on hand falls below 150% of the federal poverty threshold, which (in 2019) was equal to $19,000. Any suspension results in the outstanding loan amount growing by

[9] Throughout this paper, we work in real terms (e.g., for labor income and asset returns). This is justified since the social security bend points, brackets for income taxation, and maximum contribution limits to retirement plans are updated annually for inflation.

[10] Specifically, this is the average student loan amount at that age for college-educated workers with a DC retirement account (or IRA) across SCF waves 2007-2022 (in $2019).

the interest rate. Alternatively, if the worker has sufficient cash on hand (X_t), she could repay her remaining student debt (SLD_t) in full. In sum, depending on the worker's age and cash on hand, she can decide whether to suspend her repayment ($LR_t = 0$), make a regular repayment ($LR_t = RP$), or repay the loan in full ($LR_t = SLD_t$), as follows:

$$LR_t = \begin{cases} \text{suspend}, & X_t \leq RP \\ \text{suspend or regular}, & X_t \leq SLD_t \; and \; X_t > RP \\ \text{suspend or full}, & X_t > SLD_t \; and \; RP > SLD_t \\ \text{suspend or regular or full}, & X_t > SLD_t > RP \end{cases} \quad t \leq 6 \tag{2a}$$

$$LR_t = \begin{cases} \text{suspend}, & X_t \leq RP \\ \text{suspend or regular}, & X_t \leq SLD_t \; and \; RP < X_t \leq 19K \\ \text{suspend or full}, & X_t \leq 19K \; and \; X_t > SLD_t \; and \; RP > SLD_t \\ \text{regular}, & 19K < X_t \leq SLD_t \\ \text{regular or full}, & X_t > 19K \; and \; X_t > SLD_t \\ \text{suspend or regular or full}, & RP < SLD_t < X_t \leq 19K \end{cases} \quad t > 6 \tag{2b}$$

The repayment reduces the student loan debt SLD_t, hence, the development of the account is as follows:

$$SLD_{t+1} = (SLD_t - LR_t) * R_{sld}, \tag{3}$$

where R_{sld} denotes the yearly gross interest rate on the student loan debt.

In addition, we also model an *income driven repayment plan*. Here we follow Catherine and Yannelis (2023) and assume the following repayment formula ($6 < t \leq 31$) is applied after a six-year suspension phase:

$$LR_{t+1} = \min\left(0.1 \cdot max(Y_{t+1} - \$19{,}000;\ 0); LR^{max}; SLD_t \cdot (R_{SLD})\right). \tag{4}$$

If the worker's income exceeds \$19,000 (about 150% of the federal poverty line), the repayment is set at 10% of the corresponding excess amount. If income falls below this threshold, the required repayment is zero. Also, the repayment is limited to the amount L^{max} the worker would have to pay under the 10-year standard plan. Assuming an initial loan of \$23,000 and a 13% fixed repayment rate, the cap is equal to \$2,990. Again, we assume that the worker does not start repaying until six years after leaving college, so her first repayment occurs at age 31. Furthermore, the repayment amount may not exceed the respective residual debt $LR_{t+1} \leq SLD_t \cdot R_{SLD}$. Finally, all outstanding student loans are

forgiven 25 years after the start of repayment.[11] Assuming that the repayments are made at the end of each year, the development of the student loan account is as follows:

$$SLD_{t+1} = \begin{cases} SLD_t * R_{SLD} - LR_{t+1} & if\ t \leq 31 \\ 0 & else \end{cases} \quad (5)$$

Cash on Hand

Prior to retirement at age 66 ($t = K = 41$), the worker can allocate current cash on hand X_t to student loan repayment LR_t, for consumption C_t, investments in risky stocks $S_t \geq 0$, and riskless bonds $B_t \geq 0$. In addition, she may contribute ($A_t \geq 0$) to a tax-qualified DC retirement plan up to a yearly limit ($A_t \leq A_t^{max}$) until age 51, and extra retirement plan 'catch-up' contributions are permitted after age 51 (here we assume all workers have access to tax-qualified DC retirement plans). After retirement, no further contributions into 401(k) plans $A_t = 0$ ($t \geq K$) are possible. Formally, cash on hand reduced by student loan repayments that year is given as follows:

$$X_t - LR_t = \begin{cases} C_t + S_t + B_t + A_t, & t < K \\ C_t + S_t + B_t, & t \geq K. \end{cases} \quad (6)$$

In the following year, the individual's cash on hand consists of stocks having earned an uncertain gross return R_t, bonds plus the earned riskless return R_f, labor income (including social security benefits) Y_{t+1} reduced by age-dependent housing costs h_t (modeled as a percentage of labor income as in Love 2010), and withdrawals W_t from DC plans, minus income IT_{t+1}^{tax}, and payroll taxes PT_t:

$$X_{t+1} = S_t R_{t+1} + B_t R_f + Y_{t+1}(1 - h_t) + W_t - IT_{t+1}^{tax} - PT_t. \quad (7)$$

Payroll taxes $PT_t = 0.062 \cdot \max(Y_t, Y^{cap}) + 0.0545 \cdot Y_t$ reduce labor income proportionally during the work life ($t < K$) by social security contributions of 6.2% (to a cap of Y_t^{cap} per year), Medicare premiums (1.45%), and city/state taxes (4%). After retirement ($t \geq K$), payroll taxes fall to $PT_t = 0.0545 \cdot Y_t$, as social security contributions are no longer paid. In addition, the worker must pay income taxes (IT_{t+1}^{tax}) according to US federal progressive tax system rules (for details, see Appendix A). Prior to retirement, the worker may save in a tax-qualified DC plan, while non-pension saving in bonds and stocks is allowed over the entire life cycle. Following Horneff et al. (2023), here we model the exogenously-determined labor income process for college-educated workers using a discrete Markov-switching income process, $Y_{t+1} = I_{t+1}^l \cdot U_{t+1}^{MS}$. Here I_t^l represents the sex- and age-dependent permanent income levels which can switch between three states according to a matrix of

[11] The alternative with a higher income-dependent repayment rate of 15% and loan forgiveness after 20 years is not considered here.

transition probabilities $\Pi_{ij,t}$. Transitory shocks U_{t+1}^{MS} depend on the worker's age and sex. The parameters of the income process are calibrated using data from the Panel Study of Income Dynamics (PSID) data.[12] In retirement, the individual consumes and can save in stocks and bonds. She also receives her lifelong social security benefits as determined by the Primary Insurance Amount (PIA), a function of her average indexed lifetime earnings (AIME).[13] Her social security payments (Y_{t+1}) in retirement ($t \geq K$) are given by:

$$Y_{t+1} = PIA_K^l \cdot \varepsilon_{t+1}, \tag{8}$$

where ε_t is a lognormally-distributed transitory shock $\ln(\varepsilon_t) \sim \mathrm{N}(-0.5\sigma_\varepsilon^2, \sigma_\varepsilon^2)$ with a mean of one reflecting out-of-pocket medical and other expenditure shocks (Love 2010). During retirement, social security benefits are taxed (to a limit)[14] at the individual federal income tax rate as well as at the city/state/Medicare tax rate.

We assume that annual IDR repayments are made at the end of each year and all remaining loan debt is forgiven after age 55 ($t > 31$), so the budget equations for cash on hand are slightly different:

$$X_t = \begin{cases} C_t + S_t + B_t + A_t, & t < K \\ C_t + S_t + B_t, & t \geq K. \end{cases} \tag{9}$$

where

$$X_{t+1} = \begin{cases} S_t R_{t+1} + B_t R_f + Y_{t+1}(1 - h_t) + W_t - IT_{t+1}^{tax} - PT_t - LR_{t+1}, & t \leq 31 \\ S_t R_{t+1} + B_t R_f + Y_{t+1}(1 - h_t) + W_t - IT_{t+1}^{tax} - PT_t, & t > 31 \end{cases} \tag{10}$$

Tax-Qualified DC Plan

The tax-qualified DC retirement account evolves over time as follows:

$$L_{t+1} = \begin{cases} \omega_t^s(L_t - W_t + A_t + M_t)R_{t+1} + (1 - \omega_t^s)(L_t - W_t + A_t + M_t)R_f, & t < K \\ \omega_t^s(L_t - W_t)R_{t+1} + (1 - \omega_t^s)(L_t - W_t)R_f, & t \geq K \end{cases} \tag{11}$$

Prior to retirement, the worker's total value (L_{t+1}) of her DC assets at time $t + 1$ is determined by her previous period's value, minus any withdrawals ($W_t \leq L_t$), plus additional contributions (A_t), and returns from stocks and bonds. Retirement plan assets are invested in a Target Date Fund having a relative stock exposure (ω_t^s) that declines according to age, following the popular "125-Age rule"

[12] The Panel Study of Income Dynamics is a project of the National Institute on Aging, fielded at the University of Michigan (see Institute for Social Research, nd).

[13] The US Social Security benefit formula is a piece-wise linear function of the Average Indexed Monthly Earnings providing a replacement rate of 90% up to a first bend point, 32% between the first and a second bend point, and 15% above that.

[14] For detail on how we treat social security benefit taxation, see Appendix A.

($\omega_t^s = (125 - Age)/100$).[15] Wealth dynamics for the DC account after retirement are given by the previous year's value L_t, withdrawals W_t, and investment returns on stocks and bonds.

To be considered as a 'safe harbor' DC plan and hence avoid complex non-discrimination testing, we assume that employers match 100% of employee contributions up to 5% of yearly labor income up to a maximum compensation of $\$M^{max}$ per year.[16] The matching amounts prior to the SECURE 2.0 reform, and afterwards, are then given by:

$$M_t = \begin{cases} \min(A_t, 0.05Y_t, M^{max}), & pre\ reform \\ \min(A_t + LR_t, 0.05Y_t, M^{max}) & post\ reform \end{cases} \quad (12)$$

After retirement, no additional own or matching retirement plan contributions are possible ($A_t = M_t = 0$). In sensitivity analysis, we also explore results using a less generous (50%) matching rate.

As of 2019, the US Treasury required DC participants to take required minimum withdrawals (RMDs) from their plans from age 70.5 onwards or pay a substantial tax penalty (50%); the withdrawal amount was determined as a specified age-dependent percentage (m_t) of plan assets. Therefore, to avoid the excise penalty, plan payouts in the model are set so that $mL_t \leq W_t < L_t$.[17]

Numerical solution

We solve the optimization problem recursively via backward induction separately for four subgroups using discrete-time dynamic programming: the subgroups are workers with income profiles characteristic of college-educated males and females, with either the standard or income-driven repayment programs. The numerical procedure used to generate the optimal policy functions in each period assumes a five-dimensional discrete state space grid 40(X)×20(L)×20(SLD)×3(I^l)×76(t), with X being cash on hand, L referring to 401(k) assets, SLD Student Loan Debt, I^l income level, and t is time. The decision variables are consumption, student loan repayments (up to age 30), investments in stocks and bonds, and contributions to/withdrawals from 401(k) accounts. Since the model uses non-linear functions for taxes, contribution matches, and other institutionally appropriate thresholds, it is not possible to reduce the dimensionality of the problem by normalization of other variables by permanent income (as in Cocco et al. 2005). The expectation of the multivariate log-normally distributed random variables is therefore computed using Gauss-Hermite quadrature with nine quadrature nodes per

[15] This approach satisfies the Qualified Default Investment Alternative (QDIA) rules as per US Department of Labor regulations (nd).
[16] See Willson (2019) and 401k Help Center (2017).
[17] More recently, the SECURE 2.0 Act raised the RMD age to 73, which will rise to age 75 by 2033; in addition, the penalty tax was reduced to 25%.

dimension. To evaluate the value function at points that do not lie on the grid, we use cubic spline inter- and extrapolation.

Model calibration

To calibrate model parameters, we adopt the conventional two-stage approach (e.g., Catherine 2022 or Love 2010, among others). First, we estimate and calibrate parameters related to labor and retirement income, housing costs, mortality rates, financial market returns, and institutional rules including tax and benefit regulations using U.S. data, as these can be identified without explicitly solving the model. Next, we structurally estimate preference parameters given the first-stage parameters using the simulated method of moments (SMM) approach with respect to our two empirical target variables, 401(k) wealth and outstanding student loans held by American college-educated workers at different ages.

First stage parameters: To calibrate the first stage, and consistent with previous life cycle models (e.g., Inkmann et al. 2011; Horneff et al. 2023), we set financial market parameters of the risk-free interest rate at 2% and an equity risk premium at 5% with a return volatility of 18%, in line with a diversified stock portfolio. The interest rate on student loans is equal to 5%. In addition, we use data from the PSID data to calibrate the labor income process,[18] along with the (2019) institutional tax and benefit rules. Survival rates are taken from the US Population Life Table 2019 (Arias 2022) with heterogeneity by sex and education (Krueger et al. 2015). Social security retirement benefits are based on the 35 best years of income and the bend points as of 2019 (US Social Security Administration, nd_a and _b).[19] The maximum labor income on which social security tax is levied is $Y_t^{cap} = \$132{,}900$. Housing costs parameters h_t are calibrated as in Love (2010). All dollar figures are reported in \$2019.

The age-dependent percentages (m_t) for Required Minimum Distributions from DC plans are calculated as 1 divided by the retiree's remaining life expectancy, as per Internal Revenue Service rules (IRS 2019a). US federal income taxes are based on the household's taxable income, six income tax brackets, and the corresponding marginal tax rates for each tax bracket (see Appendix A). According to IRS (2019b), the worker's maximum permitted own contribution to the DC account is A_t^{max} = \$19,000 to age 51, with additional retirement plan 'catch-up' contributions after the age of 51

[18] As in Horneff et al. (2023), we generated the labor income process using PSID waves from 1975-2019; see Institute for Social Research (nd.)

[19] Accordingly, the annual Primary Insurance Amount (or the unreduced Social Security benefit payment) equals 90 percent of (12 times) the first \$926 of average indexed monthly earnings, plus 32 percent of average indexed monthly earnings over \$ 926 and through \$5,583, plus 15 percent of average indexed monthly earnings over \$5,583 and through the cap \$11,075. All dollar values are reported in \$2019.

(up to \$6,000). The maximum employer matching contribution to the worker DC plan is $M^{max} =$ \$14,000.

The labor income process during the work life has both permanent and transitory components with uncorrelated and normally distributed shocks as $\ln(\mathrm{N_t}) \sim \mathrm{N}(-0.5\sigma_n^2,\ \sigma_n^2)$ and $\ln(\mathrm{U_t}) \sim \mathrm{N}(-0.5\sigma_u^2,\ \sigma_u^2)$. For college-educated females and males, we follow Horneff et al. (2023) who used the 1975–2019 PSID to simulate a Markov-switching model generating labor income profiles with three income levels (*I*), to generate the time-dependent transition matrices for permanent income as well as the age-dependent transitory shocks. At age 66, the worker retires and receives social security benefits and DC plan withdrawals. The variance of transitory shocks for college graduates during retirement is set equal to $\sigma_\varepsilon^2 = 0.0767$ (as in Love 2010).

Second stage preference parameters: For the second stage analysis, values of the preference parameters for the four subgroups (males/females with standard/income-driven loan repayment programs) are selected so that the model generates student loan debt and DC wealth profiles consistent with empirical evidence. Specifically, we calibrate the model to the 2007-2022 waves of the SCF on average DC plan asset values and SLD for five age groups (20-29, 30-39, 40-49, 50-59, and 60-69). In the model, our population consists of four subgroups: college-educated men and women (each with a weight of 50%), having either a student loan with fixed repayments (weight 60%) or income-based repayments (weight 40%).

We fix the parameter for relative risk aversion at $\rho = 5$ and the discount rate $\beta = 0.98$, in line with the literature on comparable life cycle models (e.g., Cocco et al. 2005; Inkmann et al. 2011). Next, for each subgroup, we solve the model for various sets of preference parameters b and ϕ, generate 10,000 simulated independent optimal life cycles with respect to the exogenous random variables (stock returns, labor income), and calculate averages for retirement assets and student loans. We repeat this procedure to minimize the value of the distance function $\theta = \frac{1}{10}\sum_{j=1}^{10} \left|y_j^{model} - y_j^{data}\right| / y_j^{data}$, which is the average absolute deviation across the five age groups of the simulated DC assets ($j = 1,..,5$) and SLD ($j = 6,..,10$) from the model y_j^{model} minus that from the corresponding SCF data y_j^{data}.

We find that the bequest parameters b = 3 and ϕ = \$19,000 minimize the distance function (θ = 0.3391) within the range of preference parameters tested. These are consistent with the research cited above and they also closely match simulated model outcomes to empirical evidence. Figure 1 displays simulated and empirical data for the five age groups and confirms that our simulated outcomes, both

for retirement assets and outstanding student loans, are remarkably close to the empirically-observed values (for additional detail on lifecycle patterns, see Appendix B).

Figure 1 here

III. Results: Impact of the SECURE 2.0 Reform

The SECURE 2.0 reform of particular interest here gives workers with outstanding student loans the opportunity to receive employer matching contributions in their tax-qualified retirement plans, when they make qualified student loan repayments. The purpose of this policy is to enable employees to repay these loans more quickly, without undermining the growth of their retirement accounts. In what follows, we examine the potential effects of this reform on key financial variables over the life cycle. First we focus on individuals having standard loans with fixed repayments. Specifically, we are interested in the repayment behavior of student loans, contributions to and asset accumulations in DC pension plans, other financial assets held outside of pension plans, and consumer spending patterns. Additionally, we compare these variables before versus after the reform for a simulated population of 10,000 workers making optimal decisions over their lifetimes.

Figure 2 displays the profiles of loan repayment behavior. Specifically, we illustrate the frequencies (y-axis) by age (x-axis) where workers pay the regular repayment amount (orange bars), suspend repayment (blue bars), or repay the student loan in full (black bars), with females (on the left) and males (on the right). In the pre-reform case, most people suspend student loan repayments within the first five years, and at age 30, only 18% (5%) of females (males) make regular repayments. From age 31, repayment suspension is only possible in the event of financial hardship, defined as having cash on hand $X_t < \$19{,}000$. However, due to the relatively high labor incomes received by the college-educated, this rarely occurs (in fewer than 1% of simulated cases); therefore, most workers make the regular fixed repayments. We also see that, as workers age, they increasingly select the option to pay off their remaining loans in one lump sum: only a few do so before age 30, but between ages 31-40, around 61% of women and 63% of men do so. On average, women repay their entire loans after 13.3 years, and men after 14.7 years. This can be explained by the fact that peoples' earnings rise rapidly from the age of 30, giving them the chance to repay their loans (with a relatively high interest rate) in full.

Figure 2 here.

Post-reform, when workers can receive employer matching contributions in their 401(k) retirement plans while repaying their student loans, significantly fewer people suspend loan

repayment early in their careers. That is, the proportion of 30-year old women making regular repayments rises from 15% (pre-reform) to 51% (post-reform), and from 5% to 13% of men; the increase in regular repayments continues thereafter. In contrast to the pre-reform situation, many fewer repay their loans in one lump sum: almost none do so early on, and even by age 40, fewer than 1% of women and 1.6% of men repay their entire loans all at once. Loan periods are also much longer post-reform, by about 13 years: on average, women take 26.2 years to repay on average, and men take 26.4 years. Overall, therefore, after the reform people optimally repay their loans more regularly, but more slowly.

This pattern also shapes the outstanding student loan profile over the lifecycle. Figure 3 provides information about the average outstanding debt by age for men and women before (solid line) and after the reform (dashed line). Pre-reform, outstanding loan balances rise until age 30, as many workers suspend their student loan repayments resulting in compound interest effects increasing debt levels. This is also observed after the reform, although the increase in debt is significantly lower (especially for women), due to their more regular repayment pattern. From age 30 on, average debt levels pre-reform fall significantly, as suspensions are only possible in hardship situations and workers increasingly make use of one-time repayments. Post-reform, levels of outstanding student debt also fall after age 30, but far more slowly compared to before the reform. The explanation is that workers make significantly less use of one-time repayments.

Figure 3 here

Yet one might ask, why do workers post-reform have less incentive to repay their loans early and in full? To answer this question, we examine interactions with other financial assets, both inside and outside retirement accounts. After the reform, Panel A of Figure 4 shows lower own contributions in 401(k) plans until age 50; thereafter, they are very similar to the pre-reform case. At the same time, Panel B shows that 401(k) account balances are not significantly lower; indeed, in some cases, workers even have slightly more retirement assets around age 65 than pre-reform, despite having made lower own contributions. The explanation for this apparent contradiction lies in the generous employer matching contributions, displayed in Panel C of Figure 4. These are much higher after the reform, as employers now provide matching contributions on employees' relatively low own contributions as well as on workers' student loan repayments. The sum of both components implies that total contributions to retirement accounts are similar before and after the reform, which explains why 401(k) account balances differ very little, pre- and post-reform.

Figure 4 here

To illustrate with an example, before the reform, the average male employee age 40 contributed $1,800 to his 40(k) account and received the same employer matching contribution. Post-reform, employer matching contributions for the same individual would total about $2,400, while the worker would contribute around $600 per year. The difference, $1,800, is attributable to the worker's regular loan repayment (of $1,800). In both instances, the annual contribution of $3,000 paid to the retirement account is roughly the same. The similar 401(k) asset accrual pattern over the life cycle also means that employees do not use the additional SECURE 2.0 option to build up *more* retirement savings. Furthermore, Figures 2 and 3 confirm that workers repay their student loans more regularly after the reform, but overall, more slowly.

Figure 5 depicts the development by age of average financial balances in workers' non-tax-qualified accounts. These assets (held in stocks and bonds) are neither tax-privileged nor subject to employer contributions, but they are liquid, since, unlike 401(k) assets, they can be used for consumption at any time without restrictions or penalties. Interestingly, it turns out that both men and women hold fewer liquid financial assets during their working lives in the post-reform case, compared to before the reform.

Figure 5 here

Since workers do not appear to be saving more in their retirement accounts, pay off their loans faster, or hold more liquid financial assets after the reform, one might ask what changes? Figure 6 provides an insight by comparing consumption profiles, reported as differences by age and sex for 10,000 simulated optimal lifecycles of college-educated employees post- versus pre-reform. The fan charts illustrate the probability distribution (90%; 10% quantiles) of the resulting consumption differences; darker areas represent higher probability mass and the solid white line represents the zero difference line. Entries below (above) the line indicate lower (higher) consumption levels after the reform. Panel A clearly documents that, during the work life, consumption levels until age 66 are higher in most cases. During the retirement phase, positive and negative deviations from the zero line are roughly balanced. This means that individuals taking advantage of the new opportunity to repay their student loans and receive 401(k) employer matching contributions can also boost their annual consumption prior to retirement.

Figure 6 here

This is due to the following consideration: although the 401(k) is financially very attractive due in large part to the employer matching contributions, it is still a comparatively illiquid asset during the work life. Early withdrawals are only possible in financial hardship situations and only

up to maximum limits, and there are also penalty taxes on early withdrawals. This means that employees must wait until they attain age 60 before they can use their 401(k) money to cover consumption needs. At the same time, workers also need to pay off their student loans. Both factors reduce consumption options. Therefore, pre-reform, workers do not take full advantage of employer matching contributions and tax benefits through their own 401(k) contributions. After the reform, by contrast, loan repayments also generate employer matching contributions, thus "killing two birds with one stone." This new opportunity helps boost consumption among the younger workforce, with a noticeable impact on lifetime utility. For example, yearly consumption between ages 30-50 increases by up to 3% post-reform.[20]

The same pattern pertains to the IDR plan, depicted in Panel B of Figure 6. Rather than contributing more to her 401(k) plan or accumulate more liquid financial assets post-reform, the worker instead consumes more at younger ages. Specifically, mean consumption differences are positive during the work life (dark area), and in most cases, higher than pre-reform. It is also worth noting that the chance that a student loan will be forgiven after 25 years is not altered much by the reform. That is, before and after the SECURE 2.0 change, many women (39% of the cases) still have a positive student loan after 25 years, while for men this is rarer (9 % of cases) due mainly to their due to their higher earnings.

IV. Discussion and Conclusions

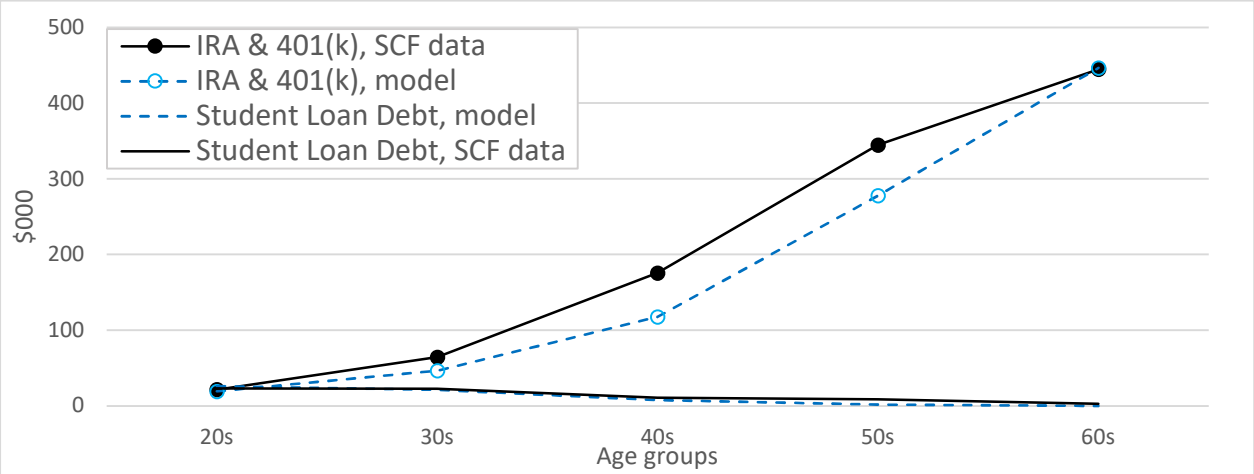
The SECURE 2.0 Act allows employers to deposit contributions into their employees' DC retirement accounts when workers repay their student loans. Our model offers the first economic assessment of this important aspect of the SECURE 2.0 legislation, focusing on its impacts on saving and consumption, both prior to and during retirement. Our calibrated life cycle model that embodies key aspects of US tax and benefit regulation predicts that this policy can enhance workers' optimal consumption by up to 3% prior to retirement. Workers reduce their own contributions until the middle of their work lives by almost 50%, yet the reductions are compensated by higher employer matching contributions that subsidize loan repayments. We also expect that the reform will not lead to earlier loan discharge dates, particularly for women, and it will only slightly reduce non-retirement asset balances. Overall, income payouts in retirement are not predicted to change materially.

[20] Bequests, the second component of the utility function, play an important role only in later life when mortality probabilities rise with age.

This research will be of great relevance to a variety of stakeholders in the retirement community. Financial institutions are clearly interested in the savings behavior of Millennials and younger workers, many of whom do not start saving for retirement early in life due to heavy debt burdens. Additionally, we emphasize that this is a voluntary benefit: employers have the option to match loan repayments, but they are not obliged to do so. Since these matching contributions will not be cost-free to plan sponsors, DC plan service providers will also need to build in new systems to make this feasible in practice (Correia 2023). Nevertheless, loan repayment matching could be an attractive employee benefit offering, since student debt is known to contribute to borrowers' financial distress and mental health problems shaping worker behavior on the job (Balloch et al. 2022; Bogan and Fertig 2013; Daniels and Kakar 2022). The policy could also help attract and retain workers given the tight US labor market and the relative dearth of younger employees (Ellis 2023), as well as enhance opportunities for women and minority workers who tend to hold more student debt than their majority counterparts (Ceron 2023). Our research will also be invaluable for professional financial planners helping to guide clients as they make debt repayment, saving, and retirement plan decisions. In particular, we show that encouraging workers to discharge their student debts as soon as possible need not be optimal, when their employers match loan repayments in company-sponsored retirement saving plans.

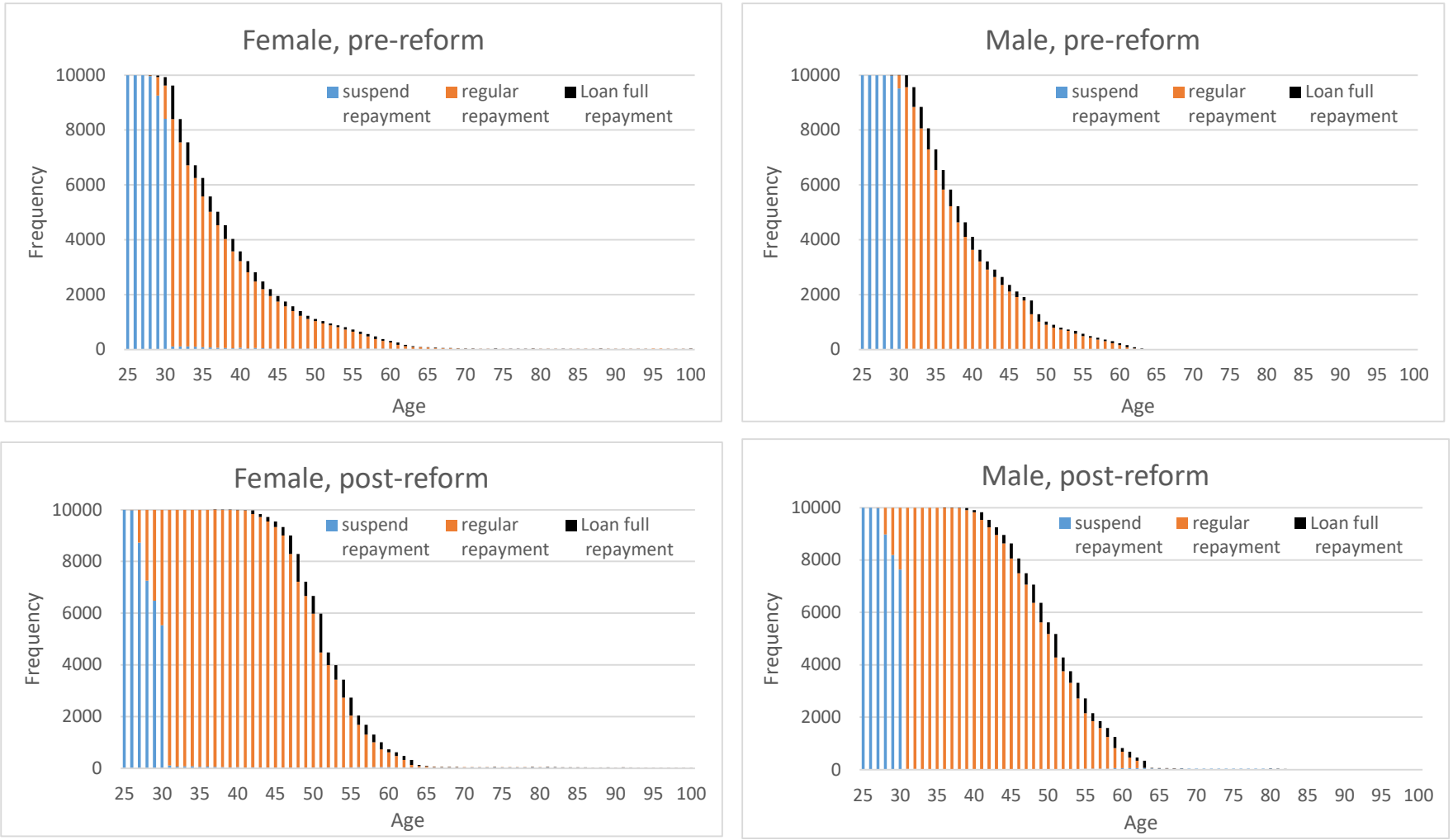
Future work will evaluate the sensitivity of our results to different employer match policies, interest rates, and capital market returns. Finally, inasmuch as most employees having access to employer provided retirement plans are located in higher income deciles (Bhutta et al. 2020), this regulatory change may contribute to an increase in the retirement wealth gap between the low- and the highly-paid workforce.

Figure 1: Simulated results versus data: DC plan wealth and outstanding student loan balances



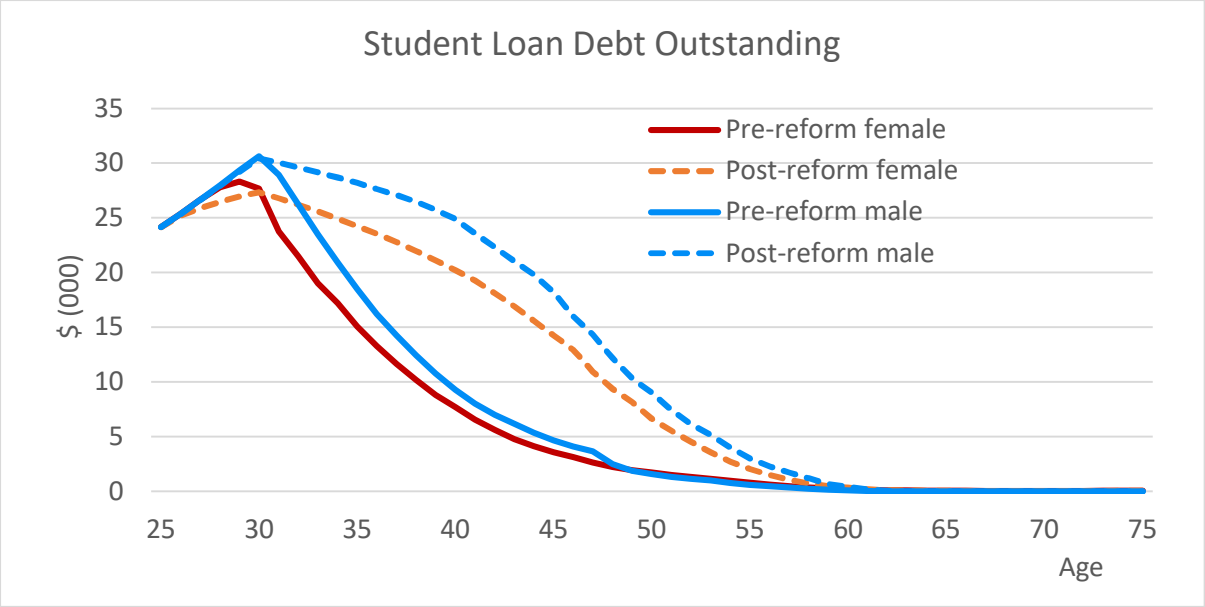
Note: The figure shows empirical DC tax-qualified account balances for college-educated individuals (black solid line with circle) and student loan debt (black solid line), by age group, computed for college-educated workers with a DC retirement account (or IRA) across all SCF waves 2007-2022. The dashed lines depict average outcomes for the same outcomes from our life-cycle model simulations based on average defined contribution asset levels and outstanding student loans, from simulated optimal lifecycles (weighted by sex and repayment program; see Section II above). Preference parameters: risk aversion $\rho = 5$, bequest strength $b = 3$, luxury bequest parameter $\phi = \$19{,}000$, discount rate $\beta = 0.98$. Risk-free interest rate 2%; equity risk premium equals 5% with volatility of 18%; interest on student loans 5% see text. All values in $2019.
Source: Authors' calculations.

Figure 2: Impact of the SECURE 2.0 reform on student loan repayment behavior: Post- versus pre-reform



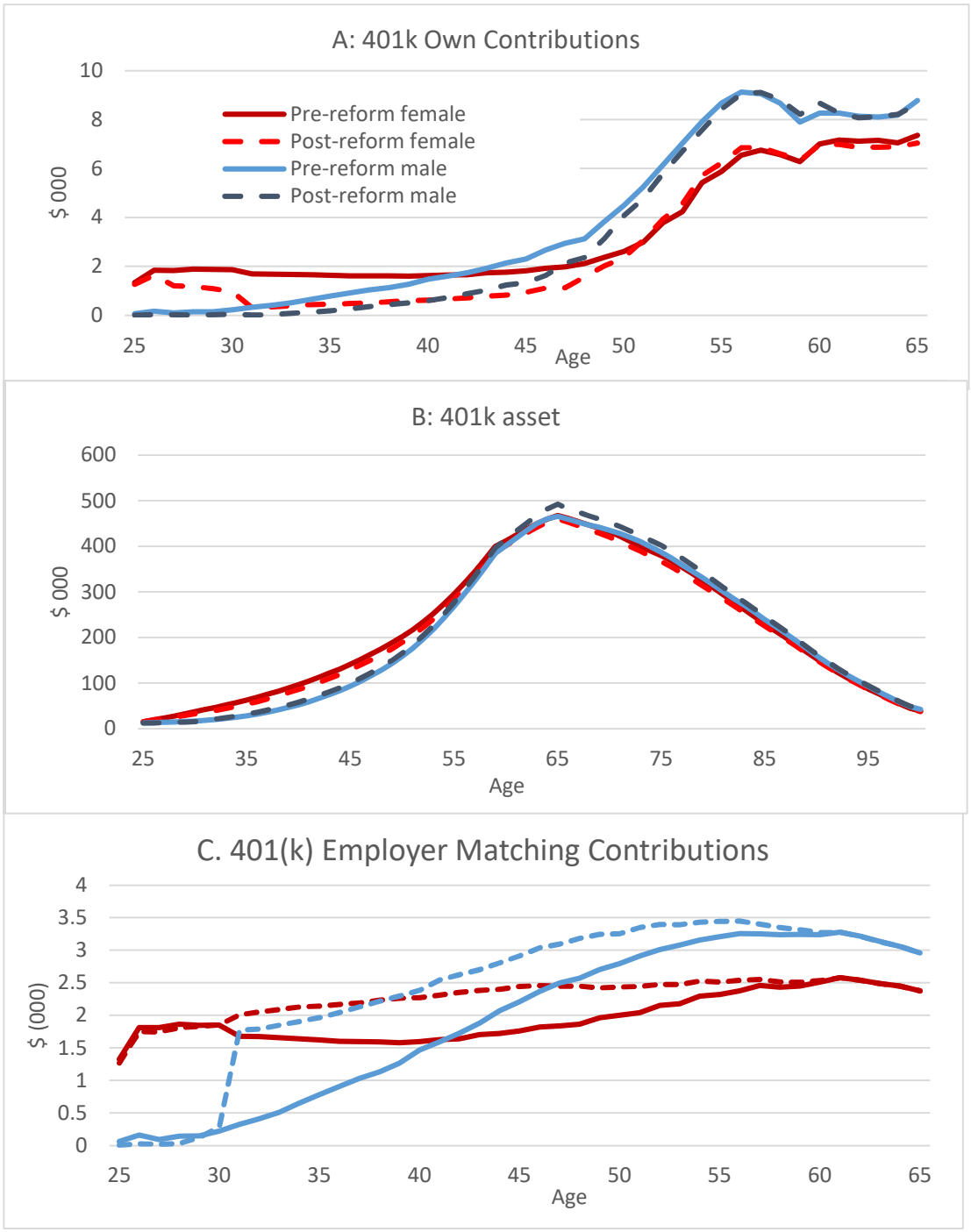
Note: This figure shows 10,000 simulated student loan repayment outcomes (suspend, regular fixed payment, or full repayment) for college-educated men and women in the standard repayment program with access to DC retirement accounts by age. Prior to the reform, loan repayments do not receive employer matching DC contributions, while after the reform, repayments are matched (to the legal limits) by employer DC contributions. See Figure 1 for additional modelling assumptions.
Source: Authors' calculations.

Figure 3: Impact of the SECURE 2.0 reform on average student loans outstanding: Post- versus pre-reform



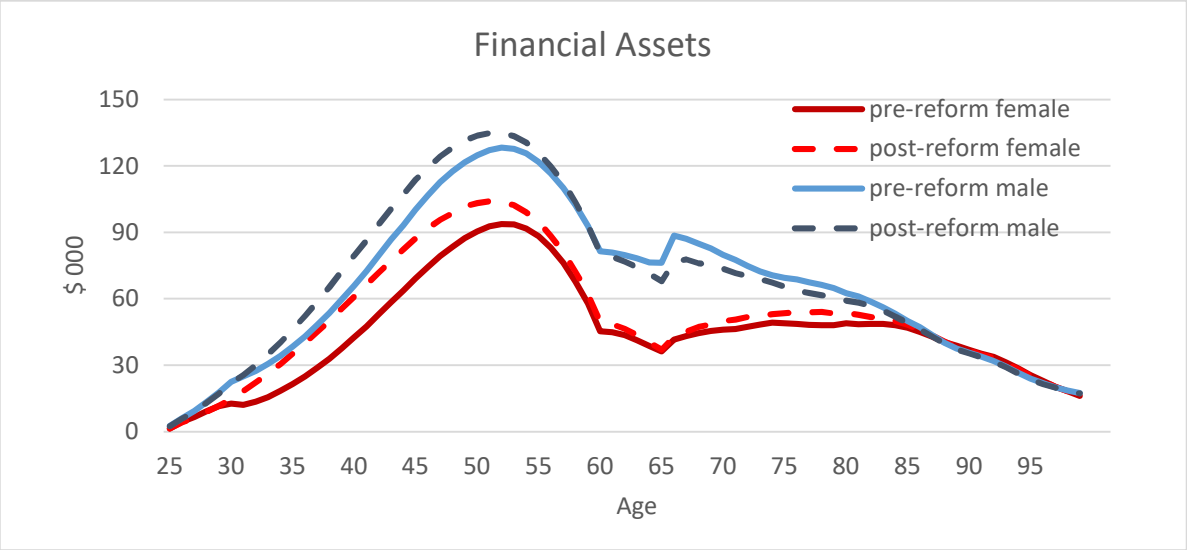
Note: This figure shows the average of 10,000 simulated outstanding student loans for college-educated men and women in the standard repayment program with access to DC retirement accounts by age. Prior to the reform, loan repayments do not receive employer matching DC contributions, while after the reform, repayments are matched (to the legal limits) by employer DC contributions. See Figure 1 for additional modelling assumptions; all dollar values in $2019.
Source: Authors' calculations.

Figure 4: Contributions to DC retirement accounts and accumulated assets in these accounts: Post- versus pre-SECURE 2.0 reform



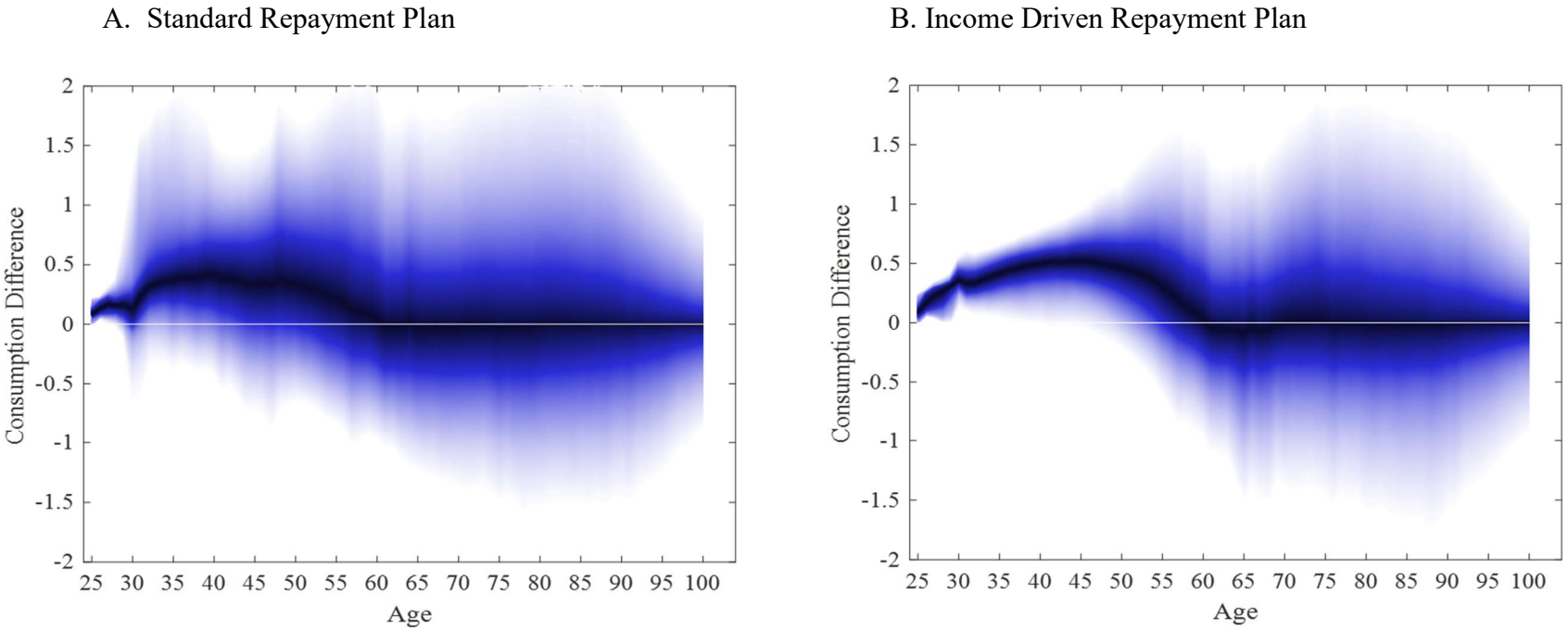
Note: For tax-qualified DC retirement accounts, this figure depicts average own contributions by the employee (Panel A), levels of accumulated assets (Panel B), and employer matching contributions (Panel C) for college-educated men and women holding student loans. Prior to the reform, loan repayments do not receive employer matching DC contributions, while after the reform, repayments are matched (to the legal limits) by employer DC contributions. See Figure 1 for additional modelling assumptions; all dollar values in $2019.
Source: Authors' calculations.

Figure *5:* Financial assets outside tax-qualified DC retirement accounts: Post- versus pre-SECURE 2.0 reform



Note: This figure shows average financial wealth held in bonds and stocks outside tax-qualified retirement accounts for college-educated men and women holding student loans. Prior to the reform, loan repayments do not receive employer matching DC contributions, while after the reform, repayments are matched (to the legal limits) by employer DC contributions. See Figure 1 for additional modelling assumptions; all dollar values in $2019.
Source: Authors' calculations.

Figure 6: Differences in consumption: Post- versus pre-SECURE 2.0 reform



Note: This figure shows the probability distribution of consumption differences pre- versus post-reform for college-educated workers (male and female) holding student loans and with access to DC retirement accounts by age. The fan charts illustrate the probability distribution (90%; 10% quantiles) of differences in optimal consumption for the 10,000 simulated lifecycles; darker areas represent higher probability mass. The panel on the left (right) illustrates differences for workers with a standard (income driven) repayment plan. Prior to the reform, loan repayments do not receive employer matching DC contributions, while after the reform, repayments are matched (to the legal limits) by employer DC contributions. See Figure 1 for additional modelling assumptions; all dollar values in $2019.
Source: Authors' calculations.

Table 1. Percent of college-educated SCF respondents with access to retirement accounts and holding a student loan

Age	Total sample	1. #With college+	2. #With college+ & retirement account assets>0	3. #With college+ & retirement account assets>0 & education loans	Ratio (2/1)	Ratio (3/1)	Ratio (3/2)
20-29	484	155	75	45	48%	29%	60%
30-39	864	359	95	44	26%	12%	46%
40-49	971	450	89	29	20%	6%	33%
50-59	1,242	573	87	14	15%	2%	16%
60-69	1,218	615	108	11	18%	2%	10%
70+	983	501	140	4	28%	1%	3%
Total	5,762	2,653	594	147	22%	6%	25%

Note: Number of households with retirement accounts and education loans reported in the 2019 SCF. Retirement accounts include both defined contribution and individual retirement accounts. Source: Authors' calculations using 2019 SCF data.

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Appendix A: Modeling taxes

This section builds on Horneff et al. (2023) with a few modifications. Specifically, we take into account the tax-relevant dimensions for student loans. We look at US-workers having access to a qualified tax-deferred retirement account (TDA) and who pay federal income taxes on taxable income. All values are in $2019 and relevant amounts are inflation adjusted yearly. Taxable income is a complex function of labor income (minus housing costs), Social Security benefits, and returns from investments in bonds and stocks.[21] Contributions A_t (up to D_t = $19,000) to the TDA reduce and withdrawals W_t from the TDA increase taxable income. For taxation of Social Security (Y_{t+1}) benefits after retirement, we use the following rules: when the retiree's *combined income* is between $25,000 and $34,000 (over $34,000), 50% (85%) of benefits are part of taxable income**.** Combined income is sum of adjusted gross income and half of Social Security benefits (US SSA nd). Negative returns from equity investments held in non-tax-qualified accounts are offset against positive returns from bonds.

Interest on student loans D_{t+1}^{SDL} can be deducted from taxable income within limits discussed below. Finally, a general standardized deduction GD = $12,250 reduces the worker's taxable income, which is given by:

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

The income tax has $i = 1, \ldots, 7$ brackets (IRS 2019c) defined by a lower and an upper bound of taxable income $Y_{t+1}^{tax} \in [lb_i, ub_i]$ and a marginal tax rate r_i^{tax}. In 2019, the marginal taxes rates for a single household were 10% from $0 to $9,700, 12% from $9,701 to $39,475, 22% from $39,476 to $84,200, 24% from $84,201 to $160,725, 32% from $160,726 to $204,100 35% from $204,101 to $510,300 and 37% above $510,301 (see IRS 2019c).

Based on these tax brackets, the dollar amount of income taxes payable is given by:

[21] For simplicity, we do not distinguish between different taxation of dividends and capital gains on stocks; rather, we assume that all investment earnings (if positive) are part of taxable income at the source. This is consistent with the assumption that equity investments are held in mutual funds (or ETFs), which due to tax requirements must distribute their income (dividends, realized capital gains) to their shareholders at least once a year. Here we assume that the investment funds have only short-term capital gains (SEC 2016).

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

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

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

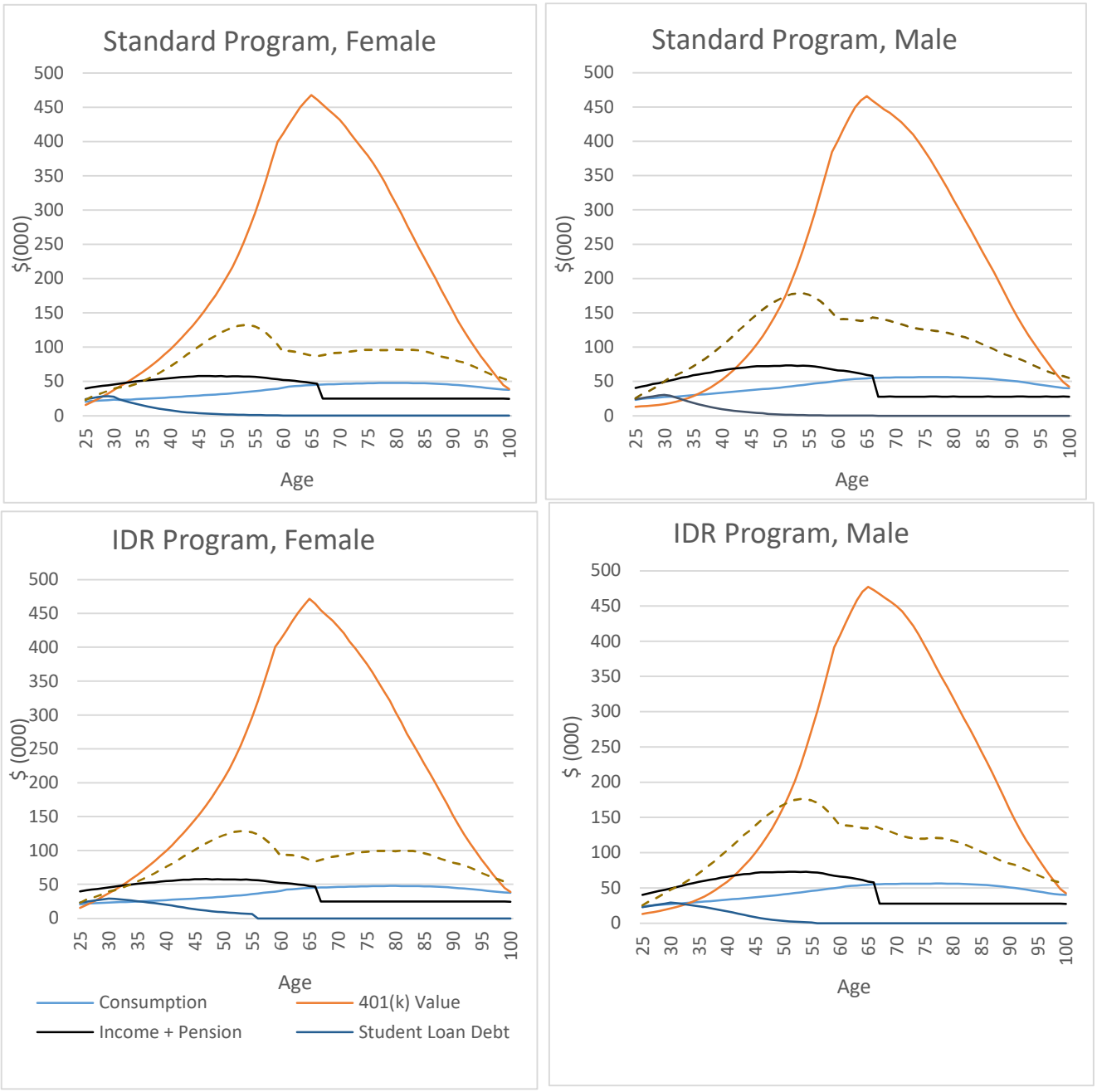
Additionally, before retirement ($t = \mathrm{K}$) the worker pays payroll taxes proportional to labor income: the tax rate for social security is 6.2% (up to a limit of 132,900); the Medicare tax rate is 1.45%; and city/state tax rate is 4% (without limit). Overall payroll taxes are modelled as $PayT_t^{tax} = 6.2\% \cdot \max(Y_t, 132{,}900) + 5.45\% \cdot Y_t$ before retirement, and $PT_t^{tax} = 5.45\% \cdot Y_t$ after retirement ($t \geq K$). Finally, penalty taxes are 10% on early retirement account withdrawals prior to age 59 ½ ($t = 36$). To avoid penalty taxes, 401(k) withdrawals must be at least as high as the required by RMD rules.

Interest on student loans can be deducted from taxable income up to $2,500 per year, if the individual makes repayments and her modified adjusted gross income ($MAGI_{t+1}$) is below $70,000.

$$
MAGI_{t+1} = \max\big(S_t(R_{t+1} - 1) + B_t\big(R_f - 1\big), 0\big) + Y_{t+1} + W_t. \tag{B4}
$$

$$
D_{t+1}^{SDL} = \begin{cases} min(SLD_t * 0.05, \$2{,}500), & if\ LR_t > 0\ \&\ MAGI_{t+1} < \$70{,}000 \\ 0 & else \end{cases}. \tag{B5}
$$

Appendix B: Life cycle consumption, income, and other financial patterns



Note: Optimal lifecycle patterns for males and females in the standard repayment program and income driven repayment program. See Figure 1 for additional modelling assumptions; all dollar values in $2019. Source: Authors' calculations.